Aug. 1, 1944. J. I. BELLAMY 2,354,660

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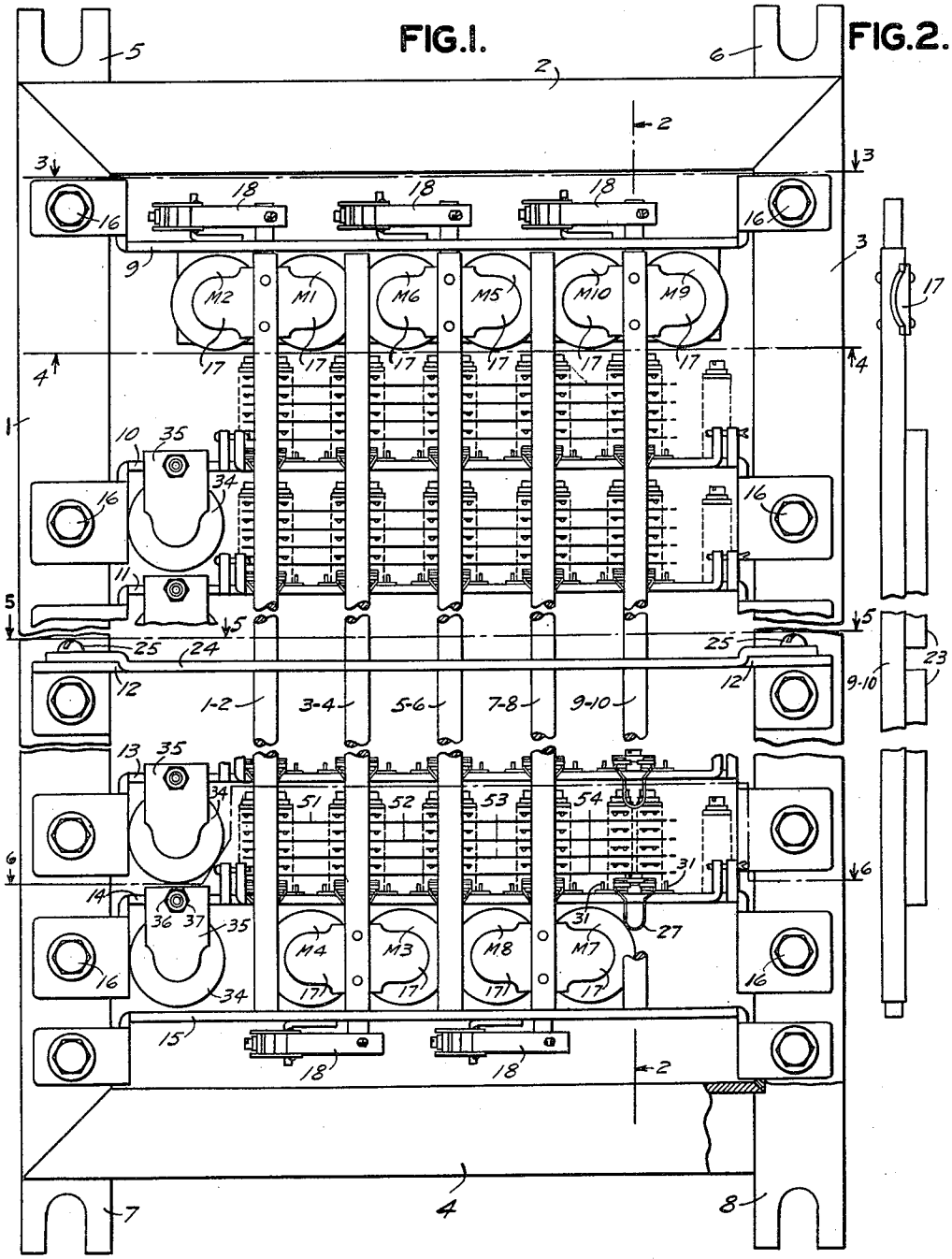
FIG.1. FIG.2.



Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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FIG.3.

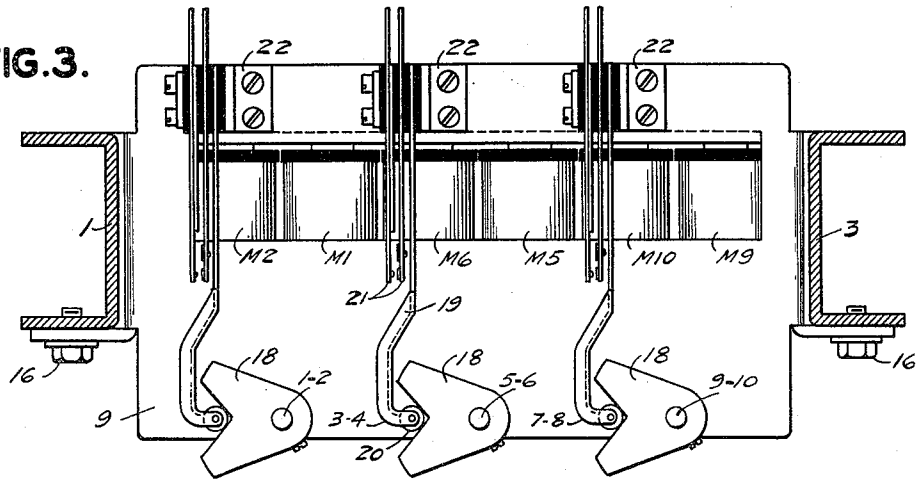


FIG.4.

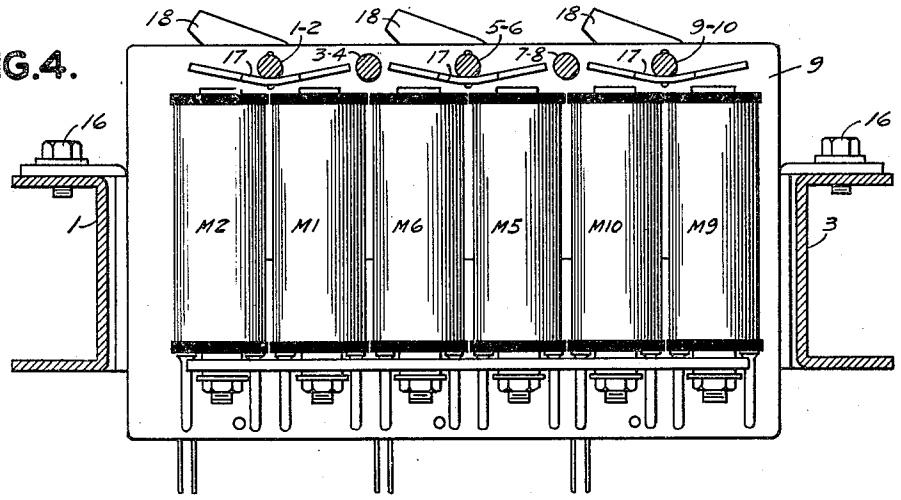
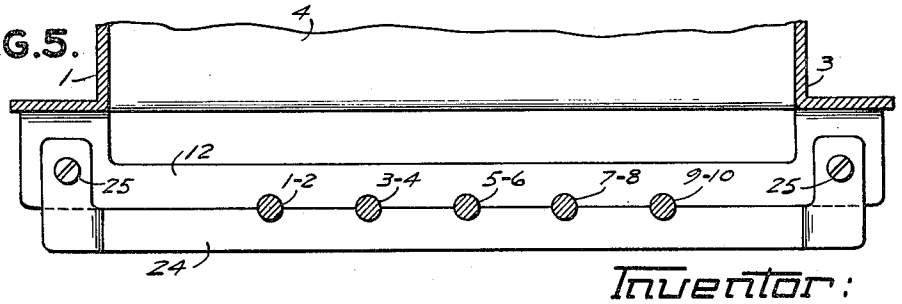


FIG.5.



Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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FIG.6.

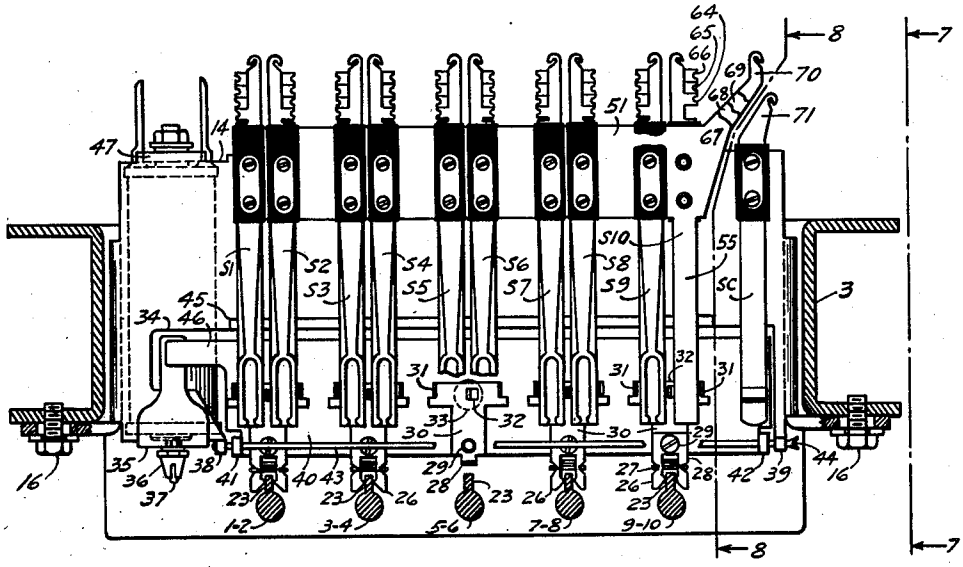


FIG.7.

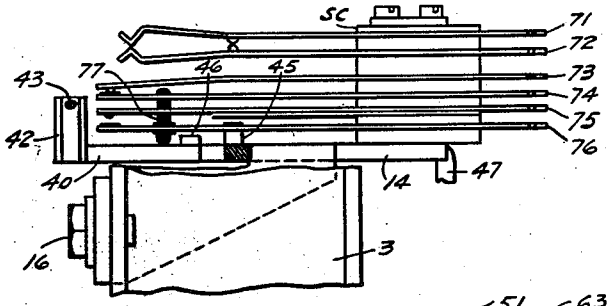
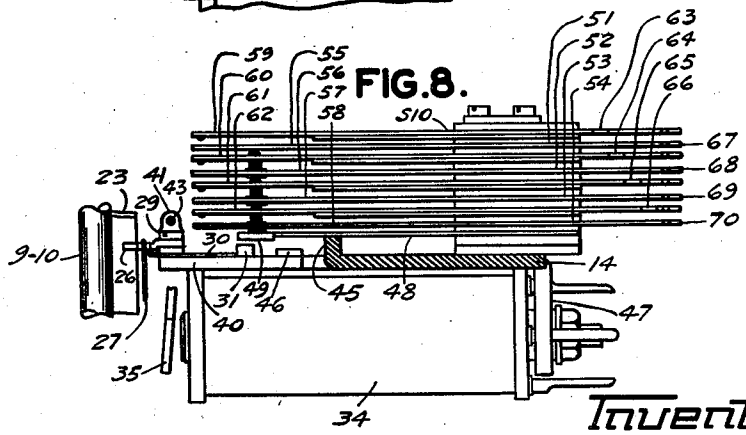


FIG.8.



Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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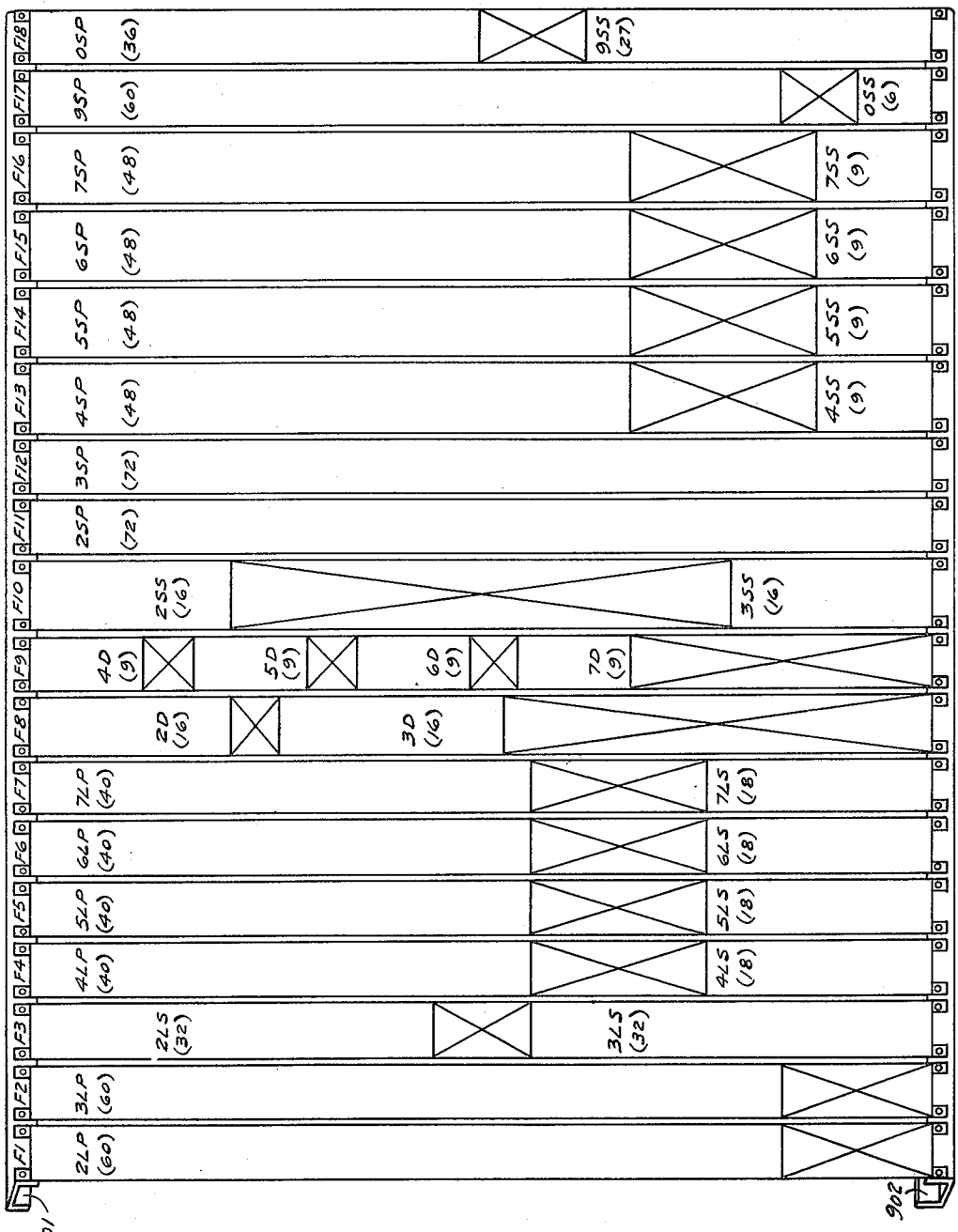

FIG. 9.

Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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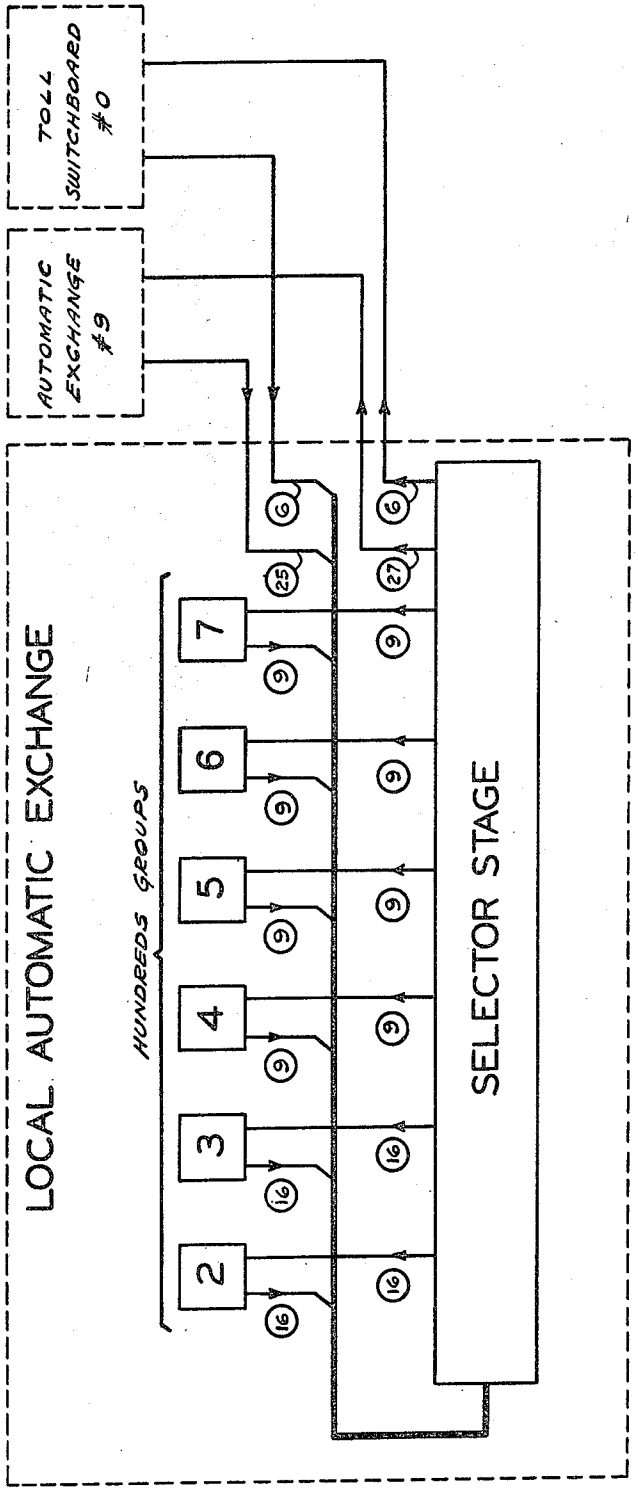

FIG. 10.

Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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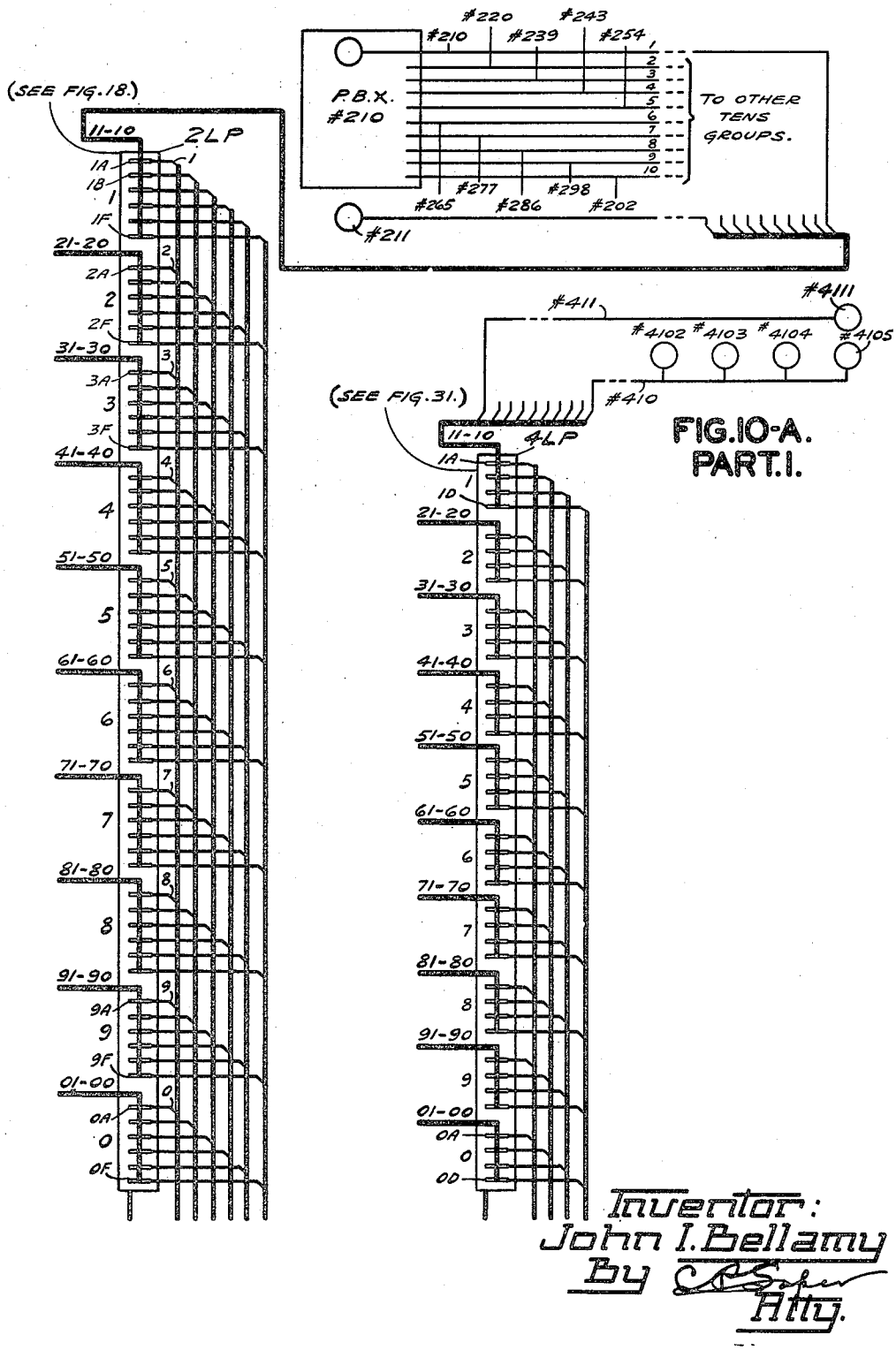

FIG. 10-A. PART. I.

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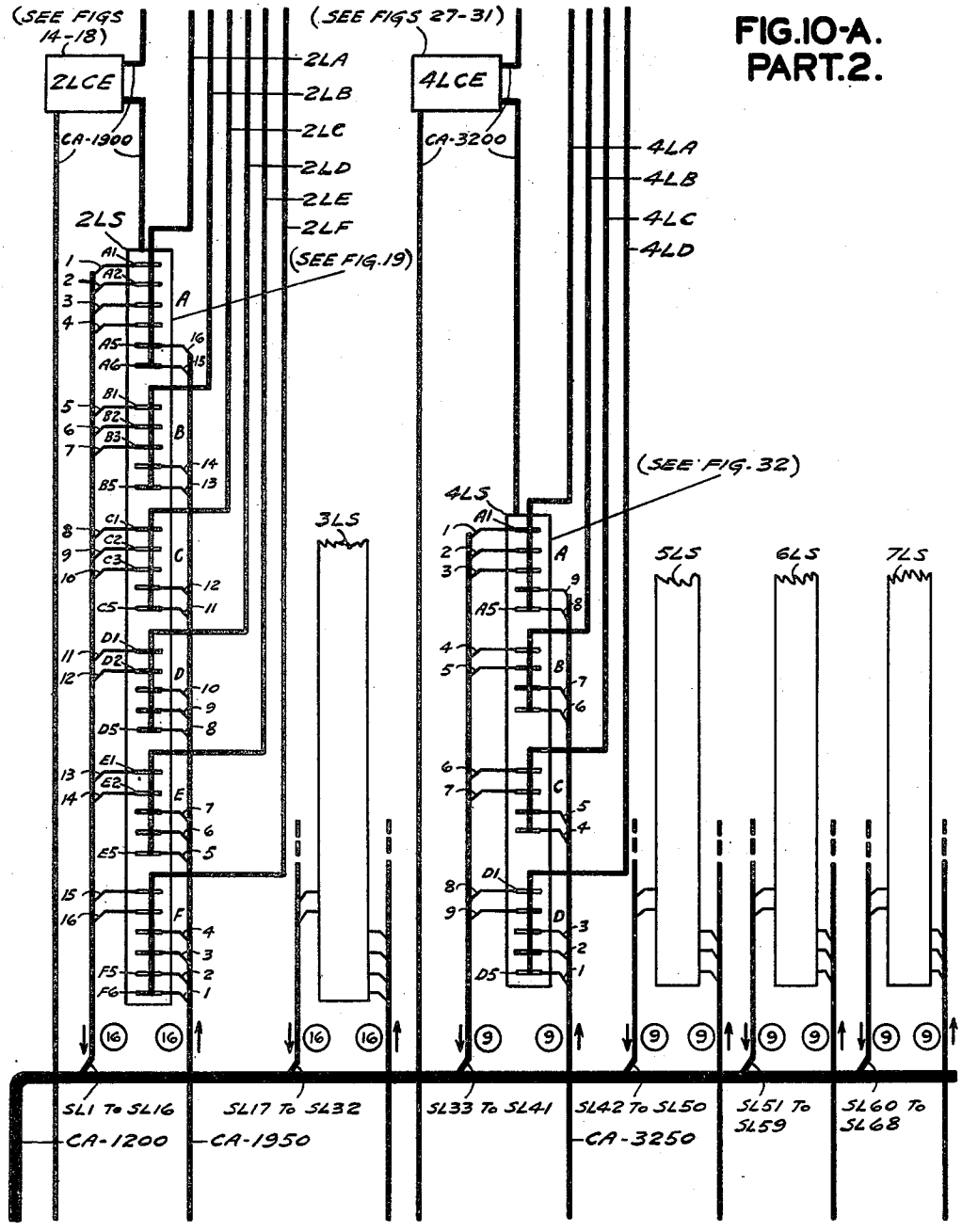
FIG.10-A. PART.2.



Inventor:
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By
Atty.

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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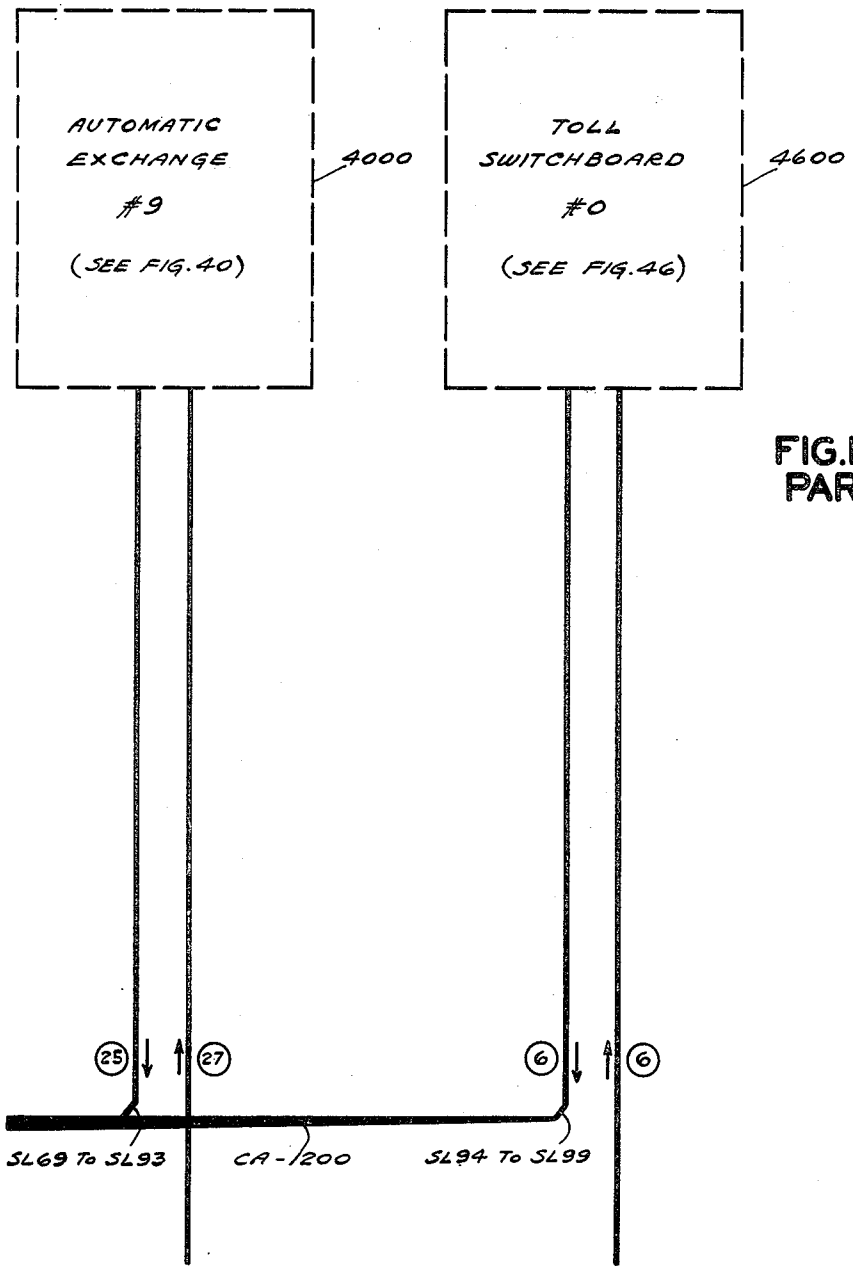

FIG. 10-A. PART. 3.

Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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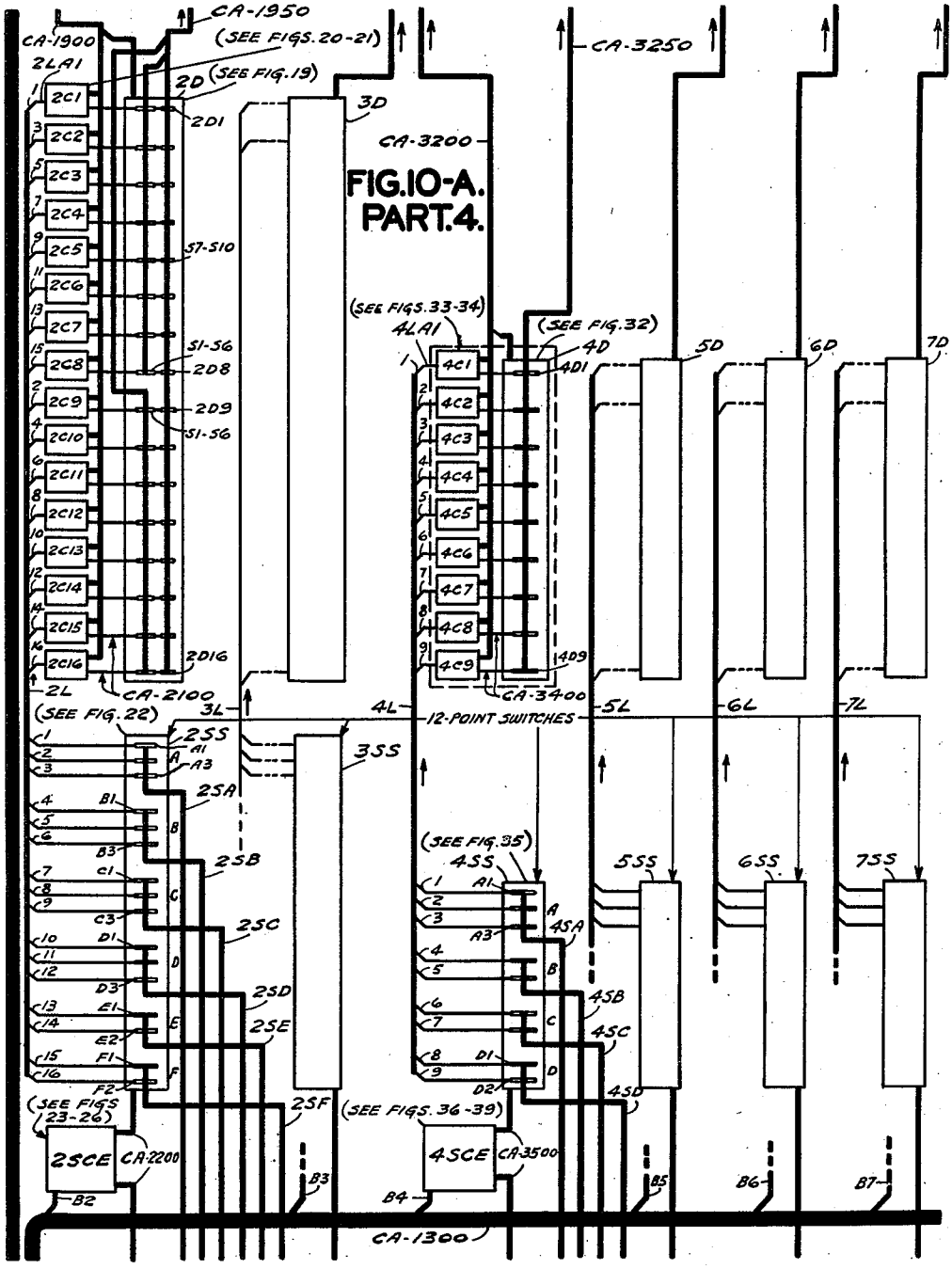

Inventor:
John I. Bellamy
By C. A. Sofen
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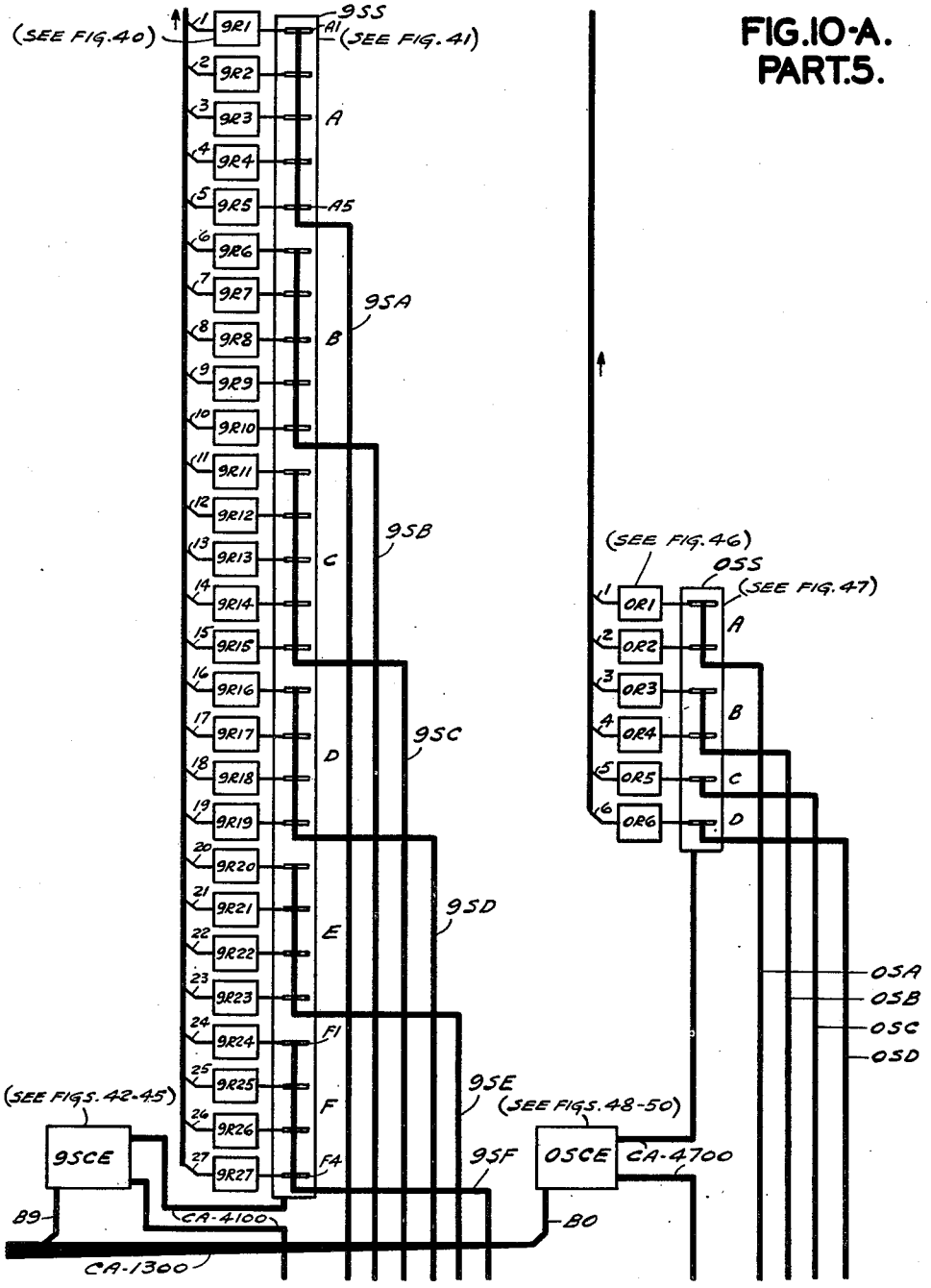
FIG. 10-A. PART 5.



Inventor:
John I. Bellamy
By C. P. Sykes
Atty.

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FIG.51.

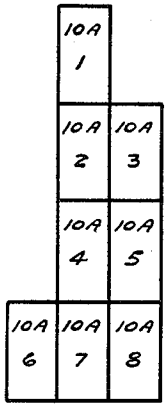
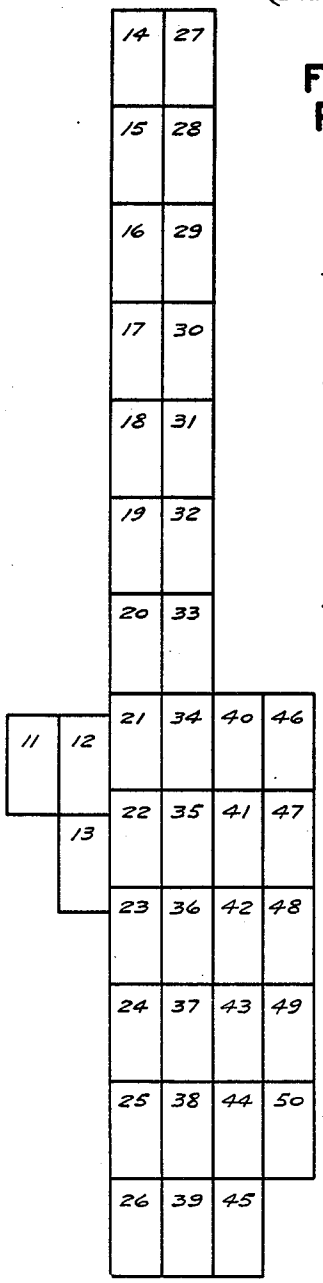


FIG.52.



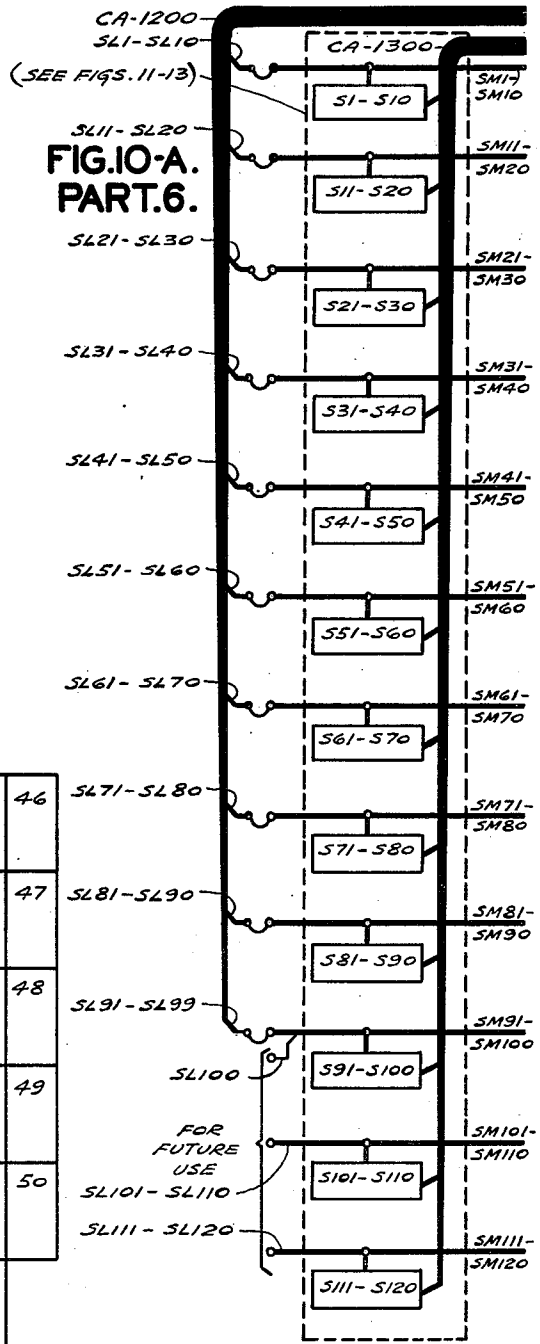


FIG.10-A. PART.6.

Inventor:
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By C. C. Soper
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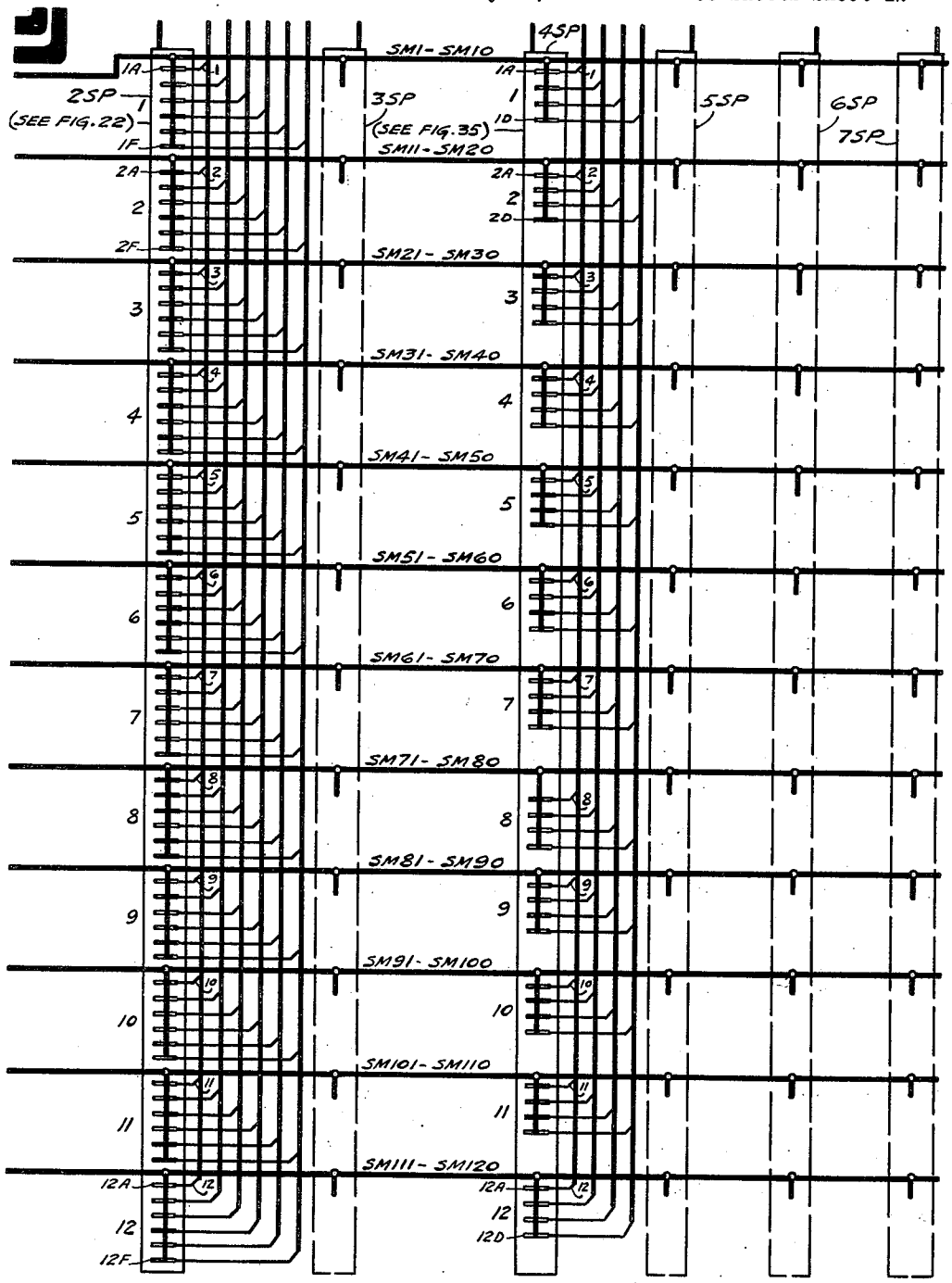

FIG. 10-A.
PART. 7.

Inventor:
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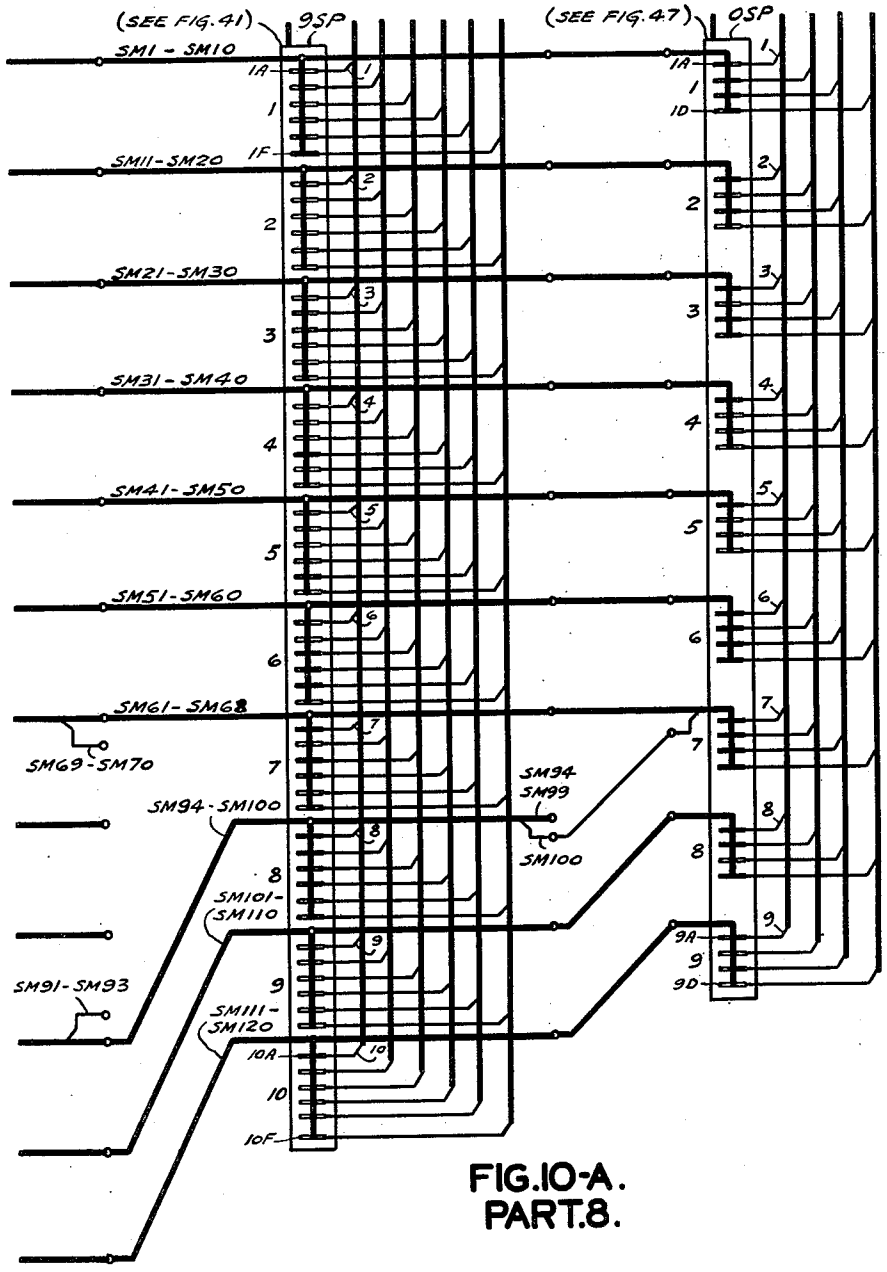

FIG. 10-A.
PART. 8.

Inventor:
John I. Bellamy
By C. C. Sober
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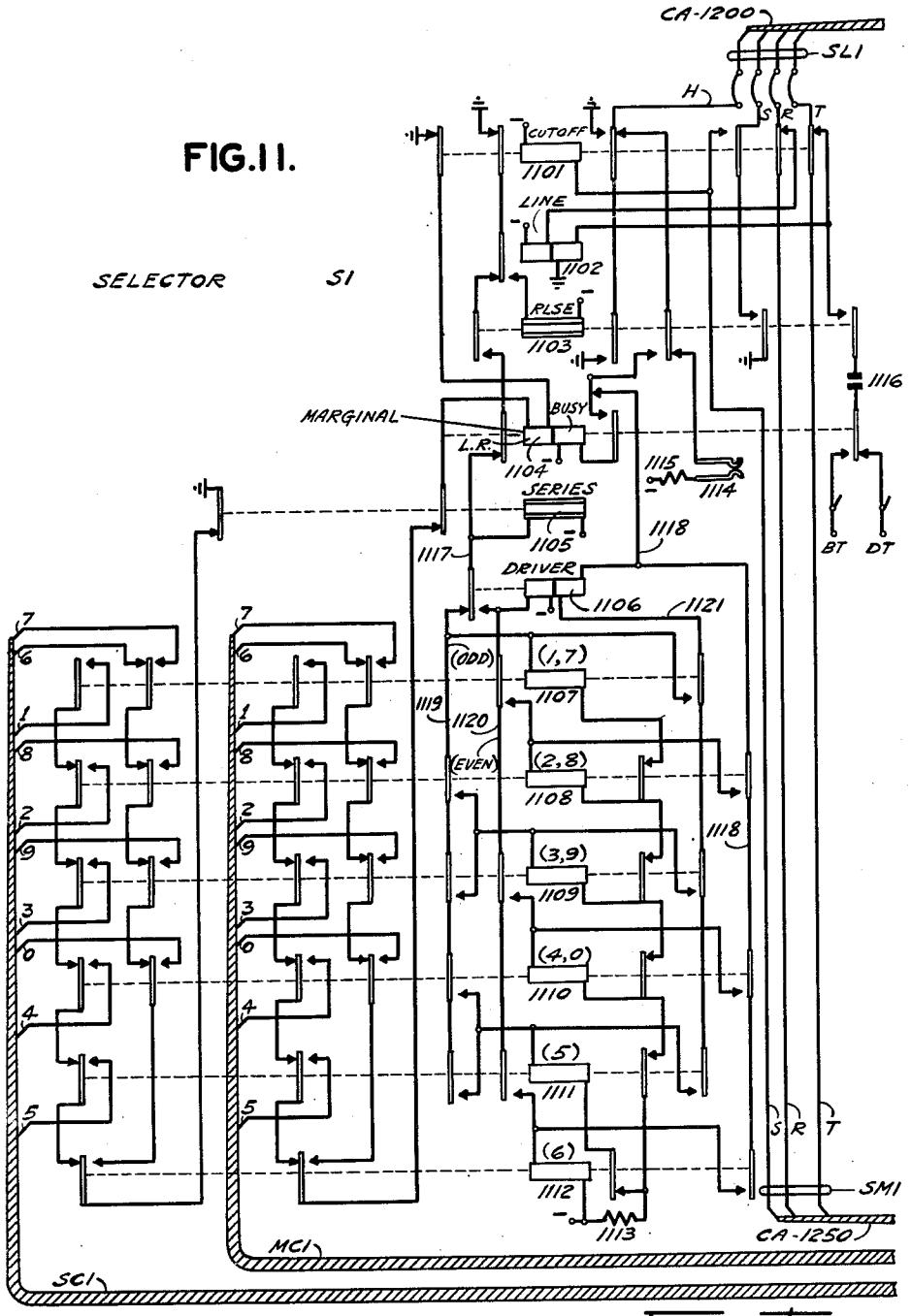
FIG. 11.



Inventor:
John I. Bellamy
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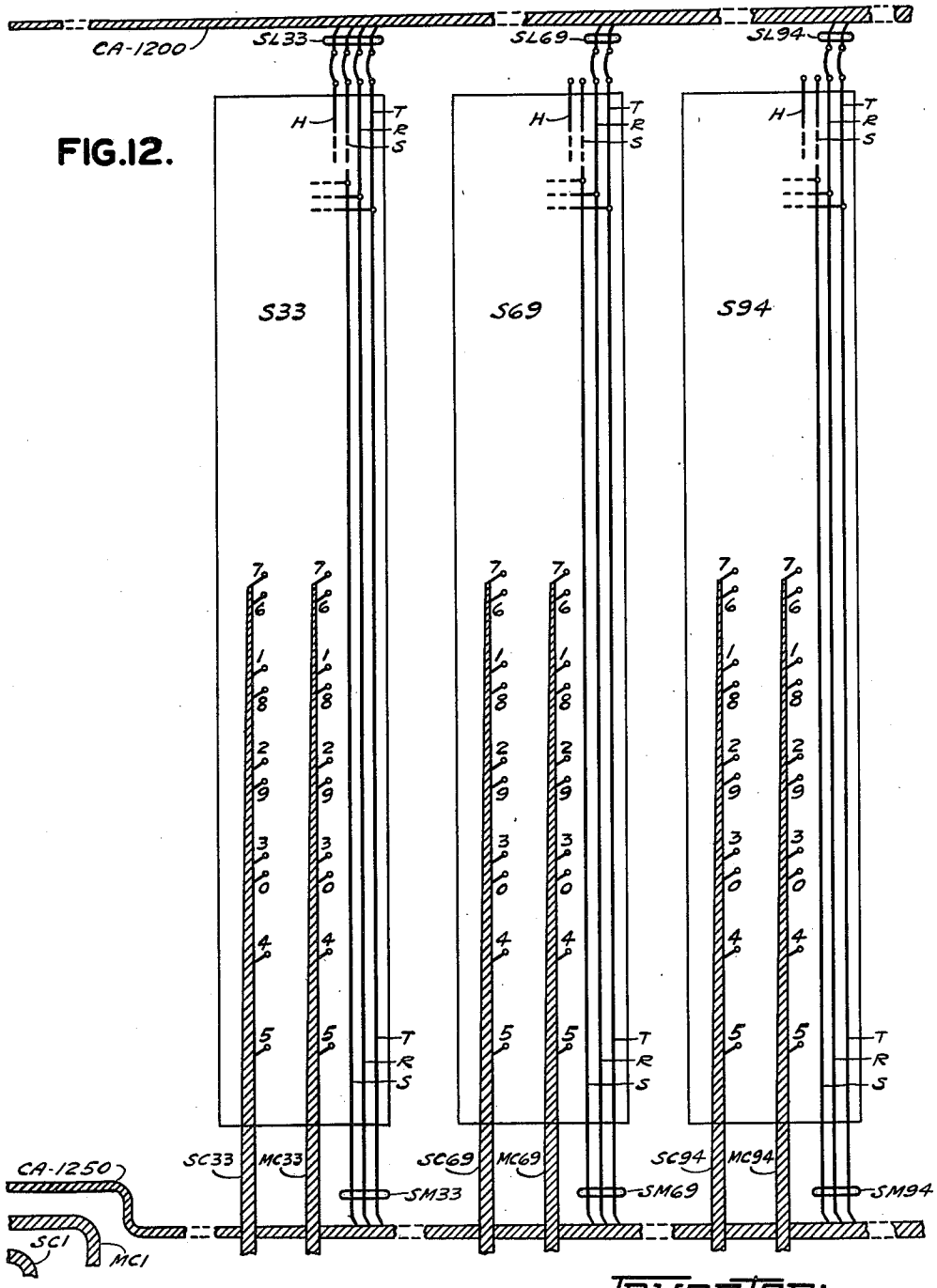
FIG.12.



Inventor:
John I. Bellamy
By C. B. Sofield
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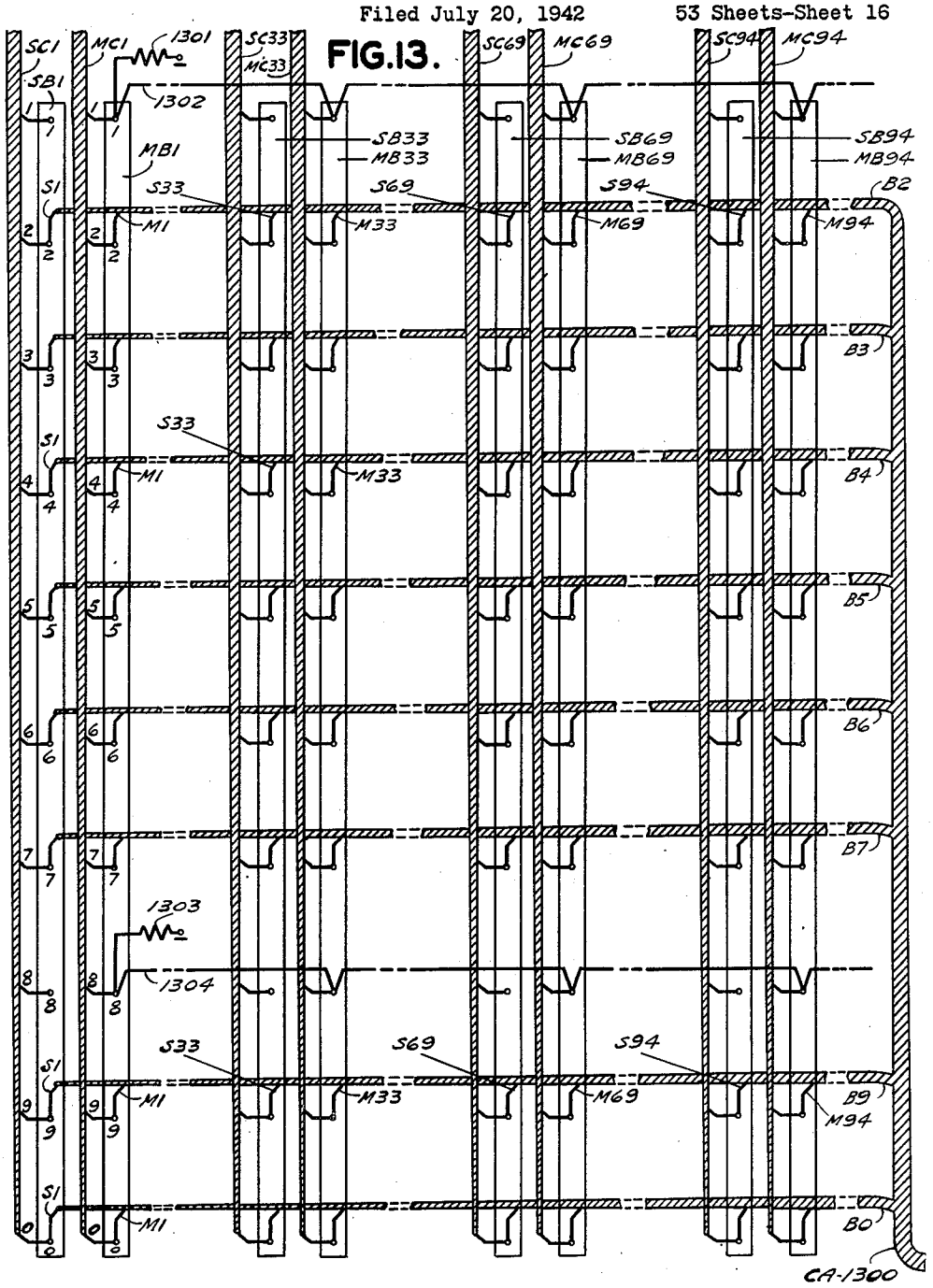
FIG.13.



Inventor:
John I. Bellamy
By C. A. Sofen
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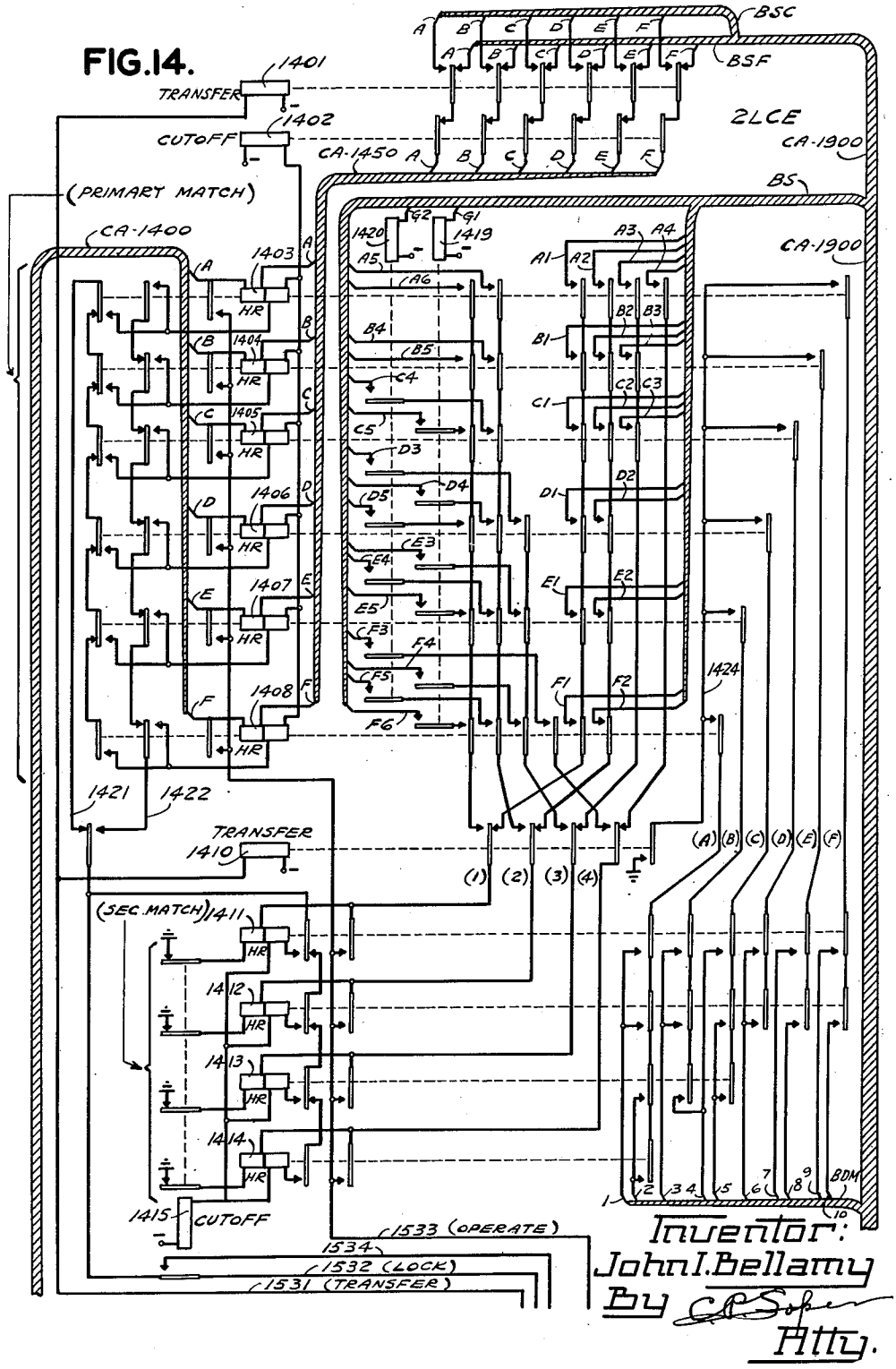
FIG.14.



Inventor:
John I. Bellamy
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Atty.

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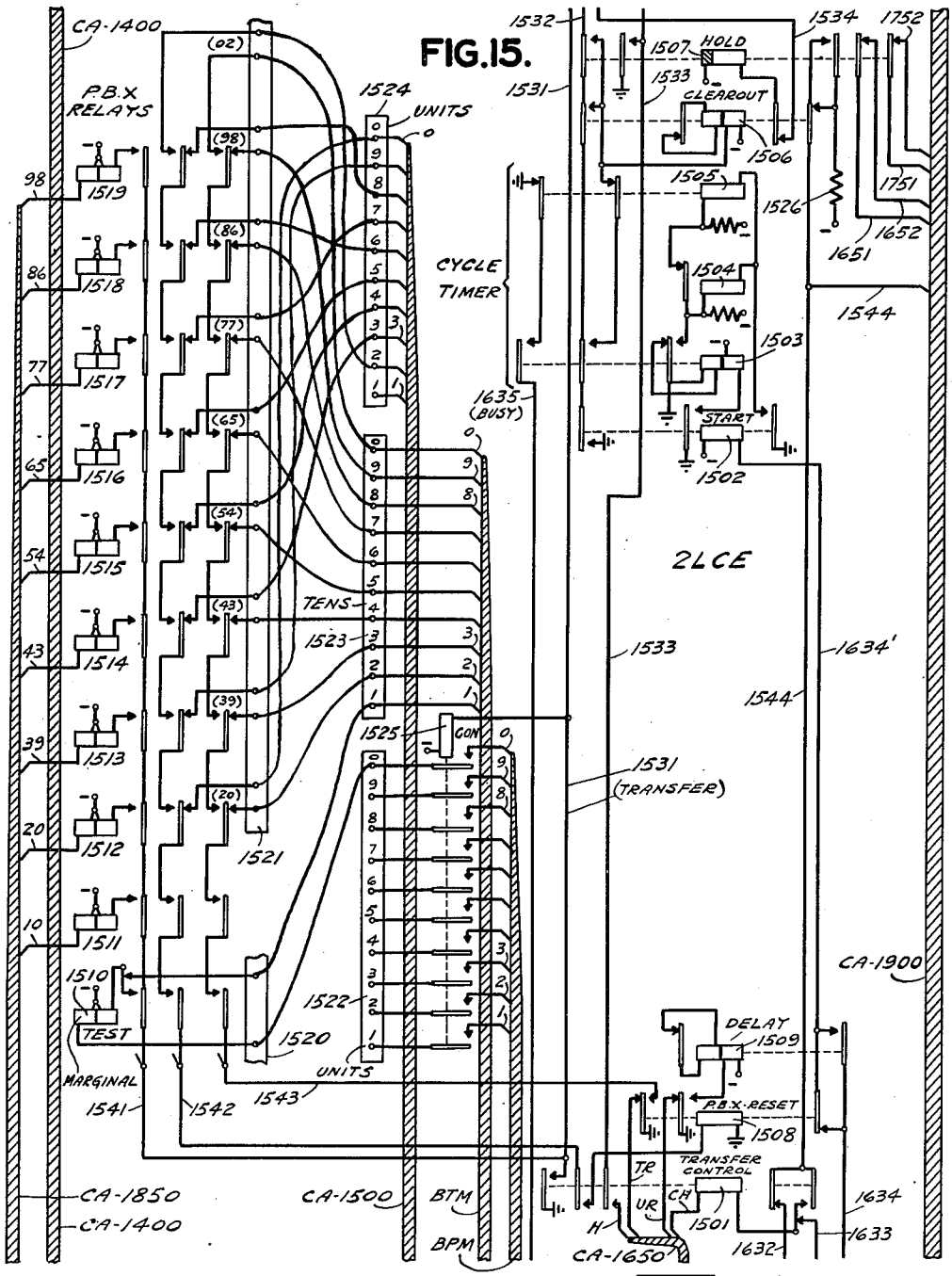
FIG.15.



Inventor:
John I. Bellamy
By C. P. Sohon
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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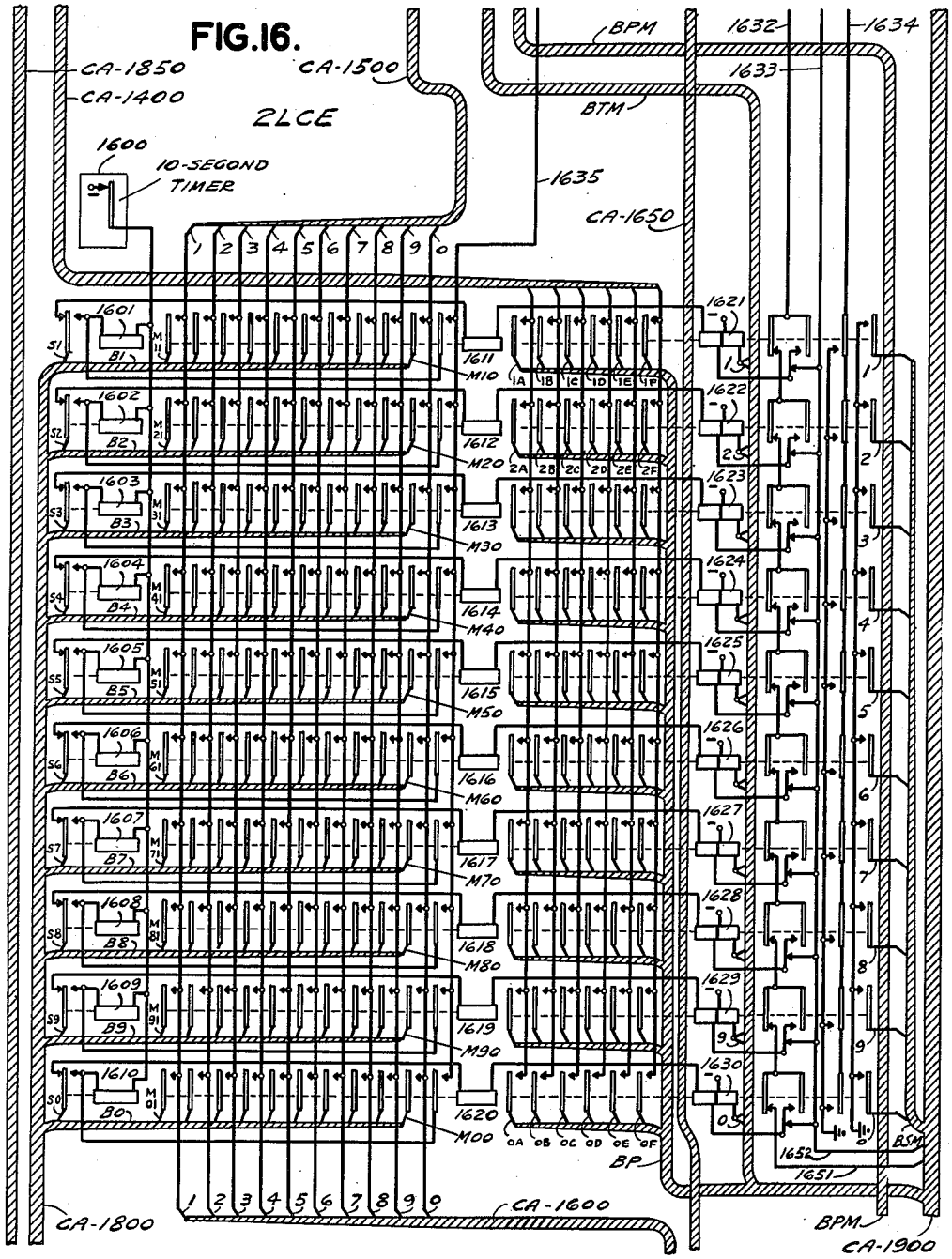
FIG.16.



Inventor:
John I. Bellamy
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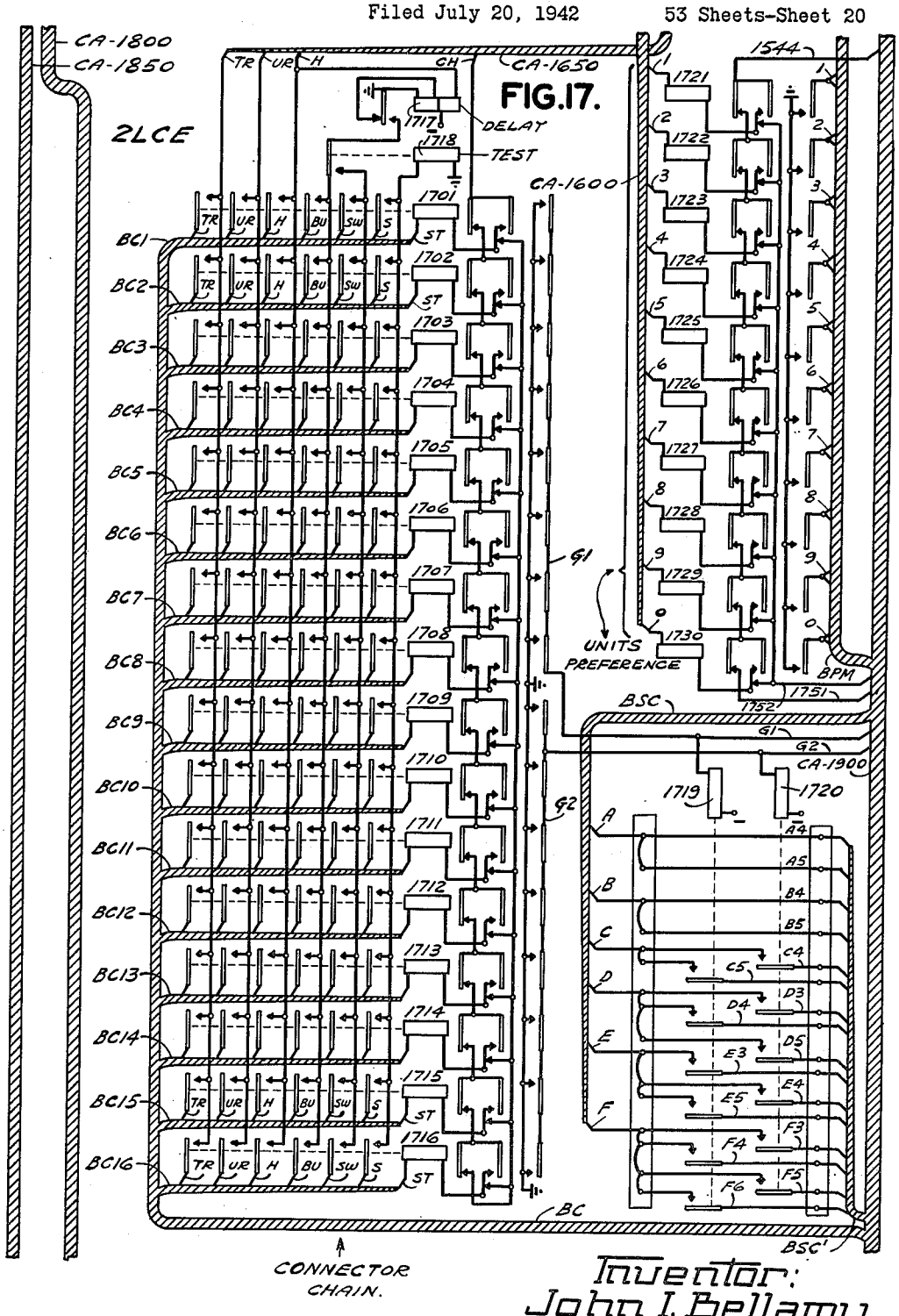

FIG.17.

Inventor:
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By C. C. Soper Atty.

Aug. 1, 1944. J. I. BELLAMY 2,354,660

AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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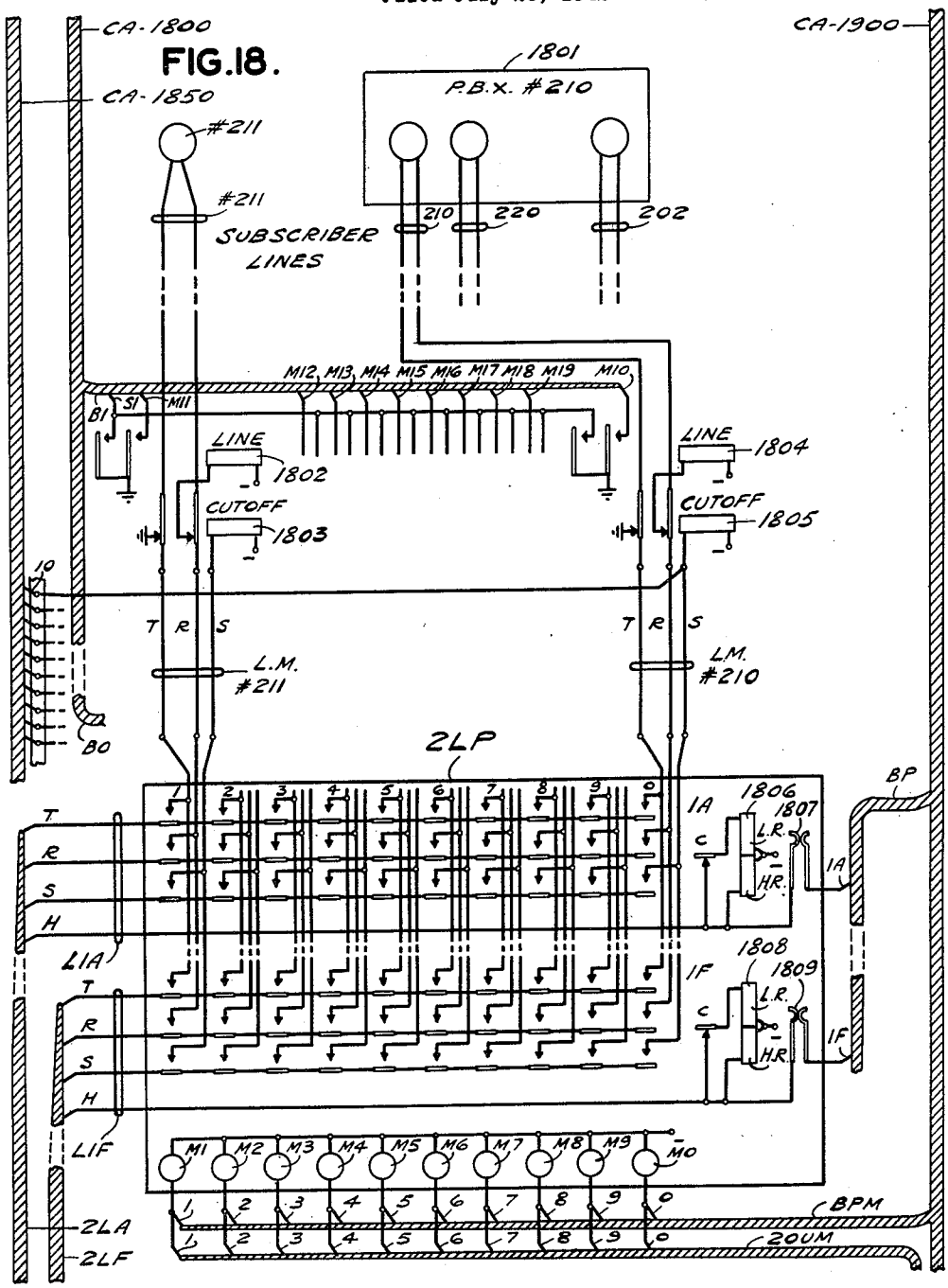
FIG. 18.



Inventor:
John I. Bellamy
By C. P. Sohn
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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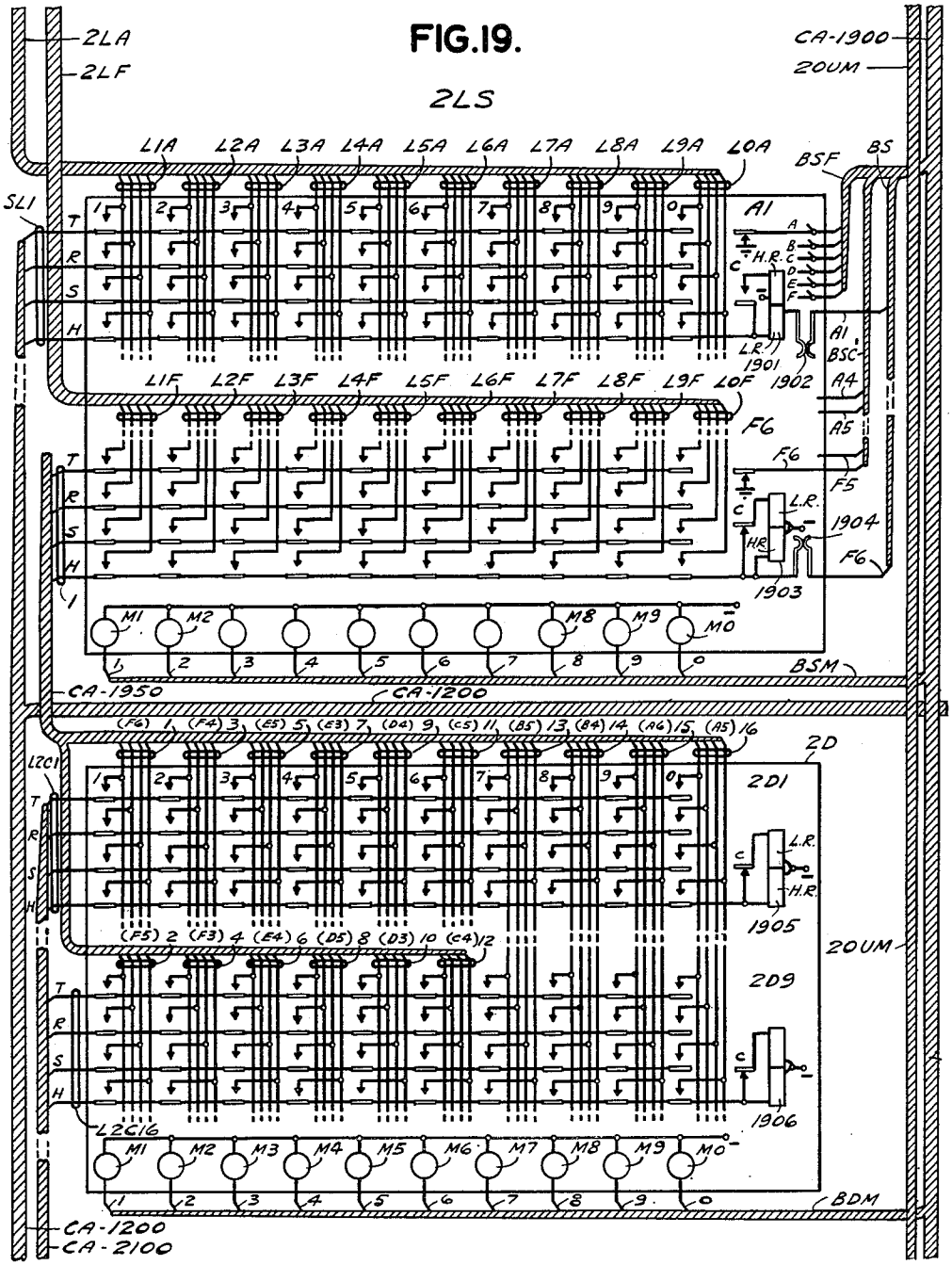
FIG.19.



Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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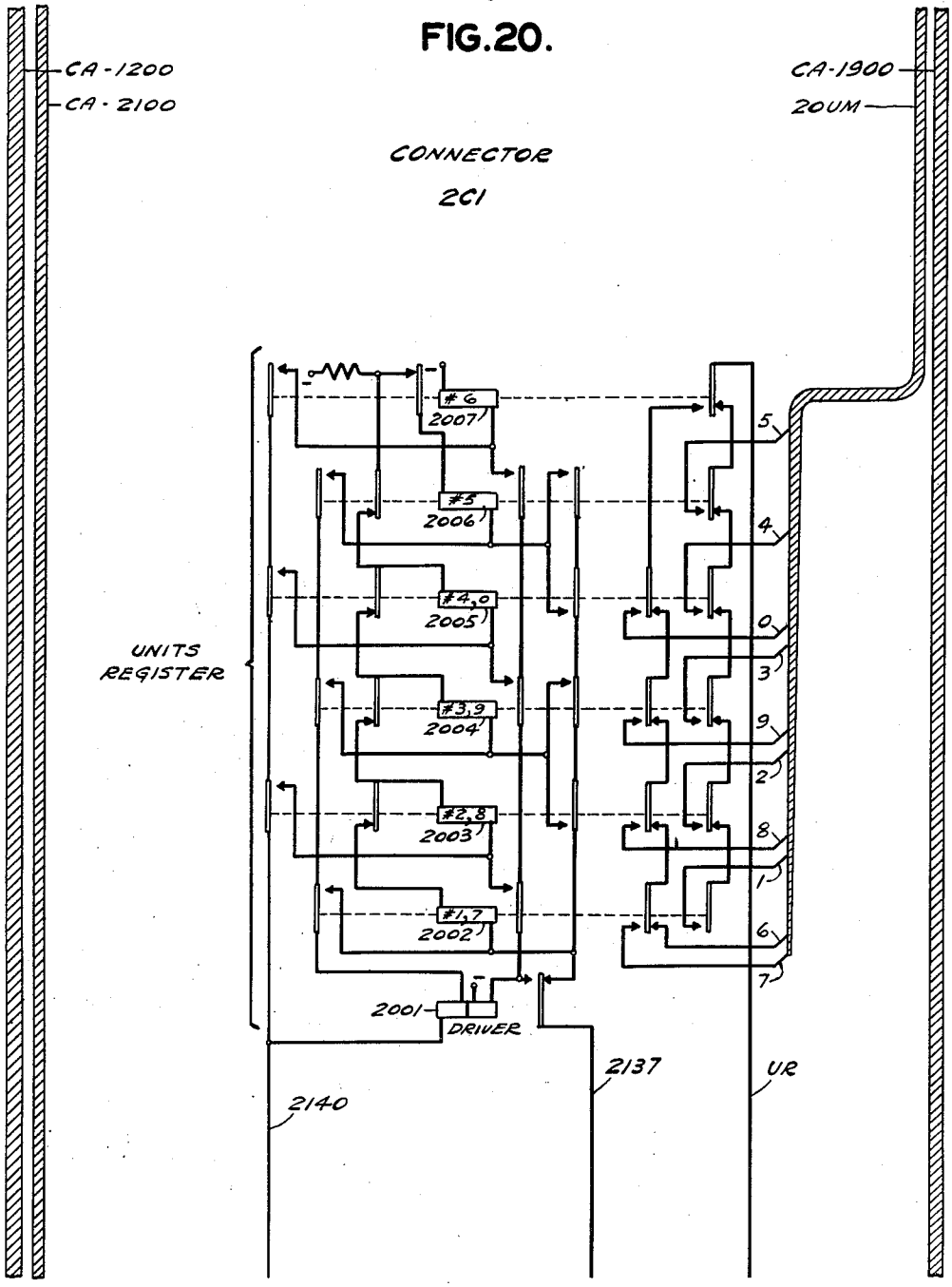
FIG.20.



Inventor:
John I. Bellamy
By C. B. Sofen
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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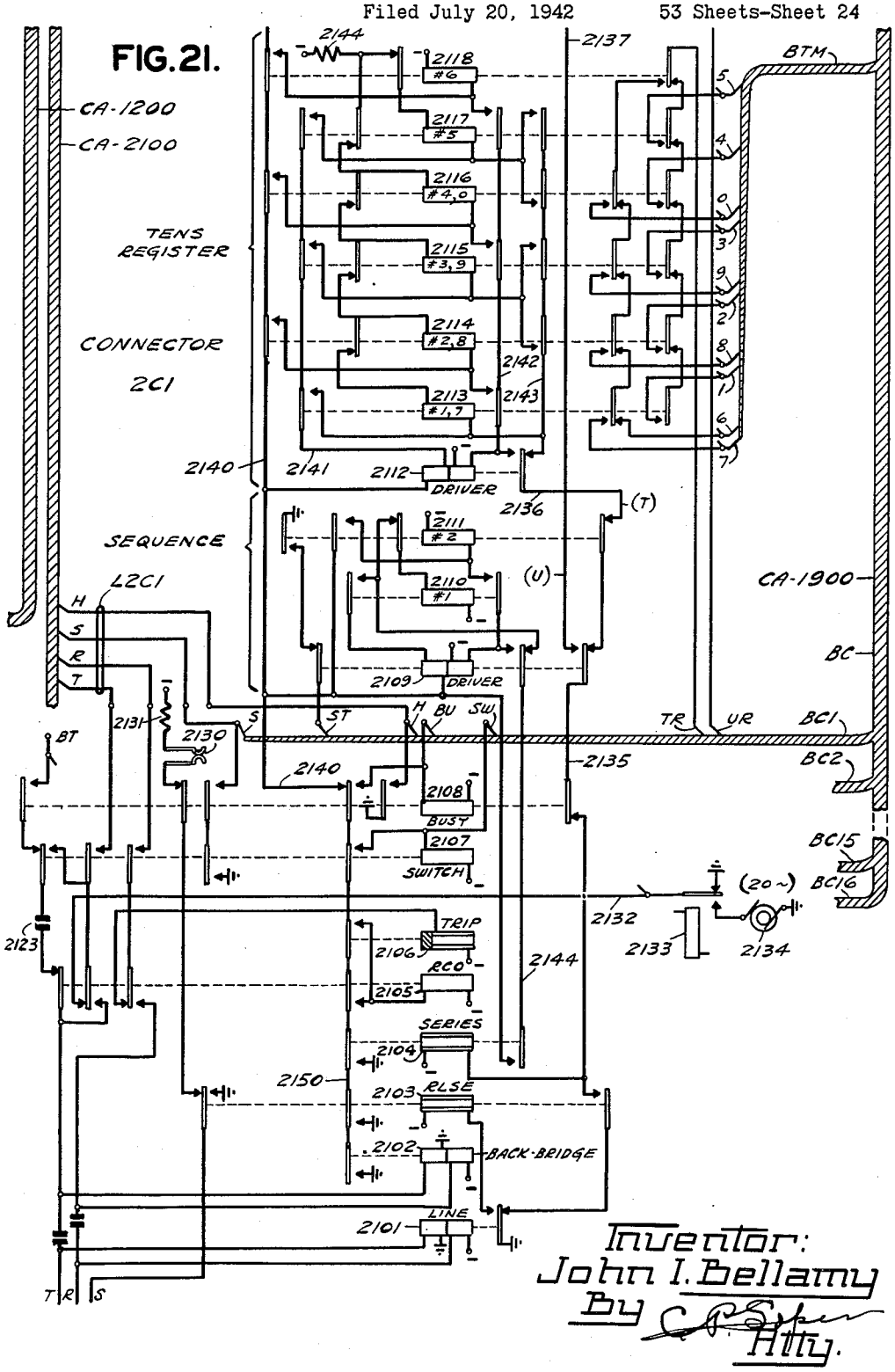
FIG. 21.



Inventor:
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By C. S. Sykes
Atty.

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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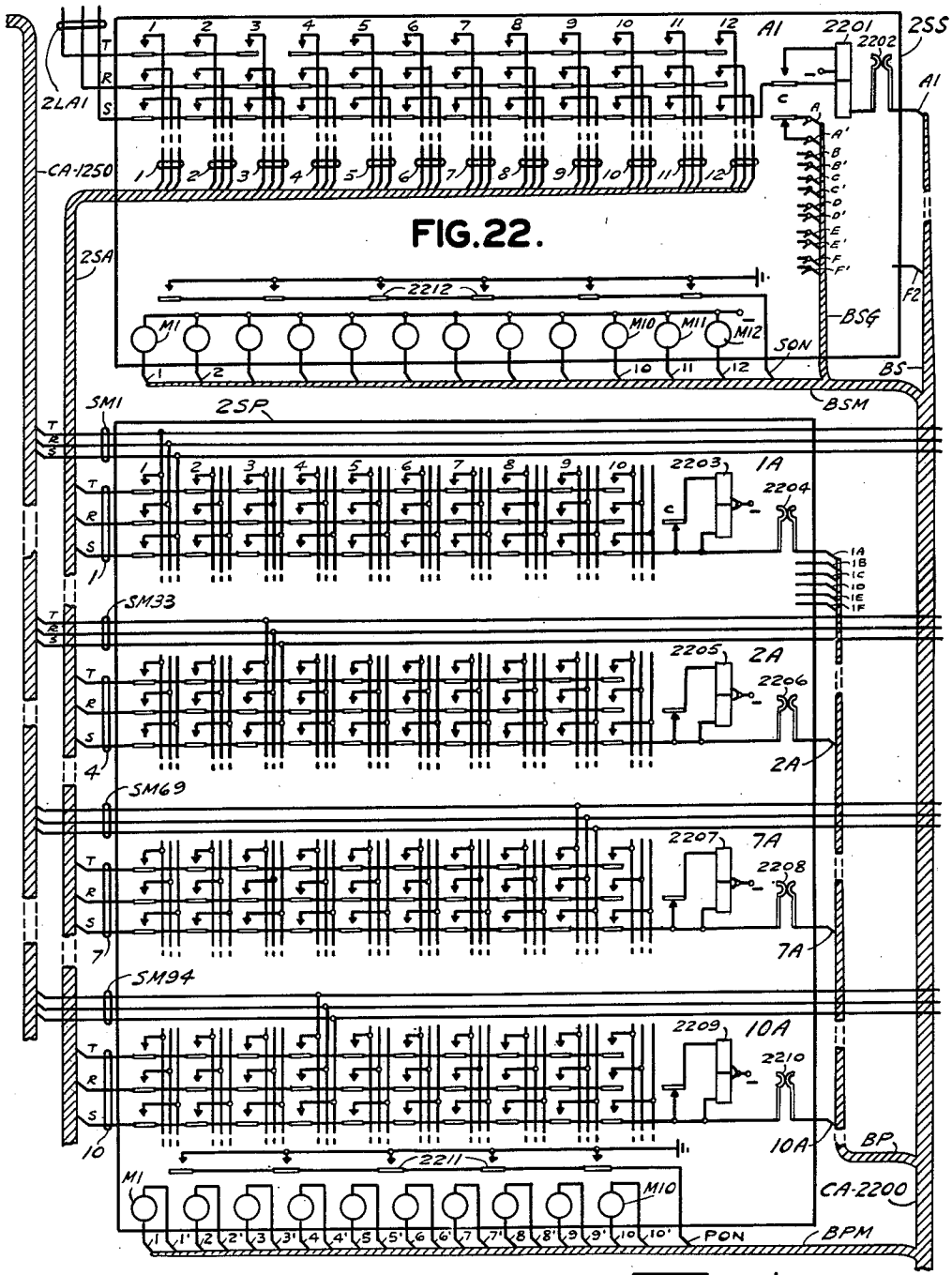

FIG. 22.

Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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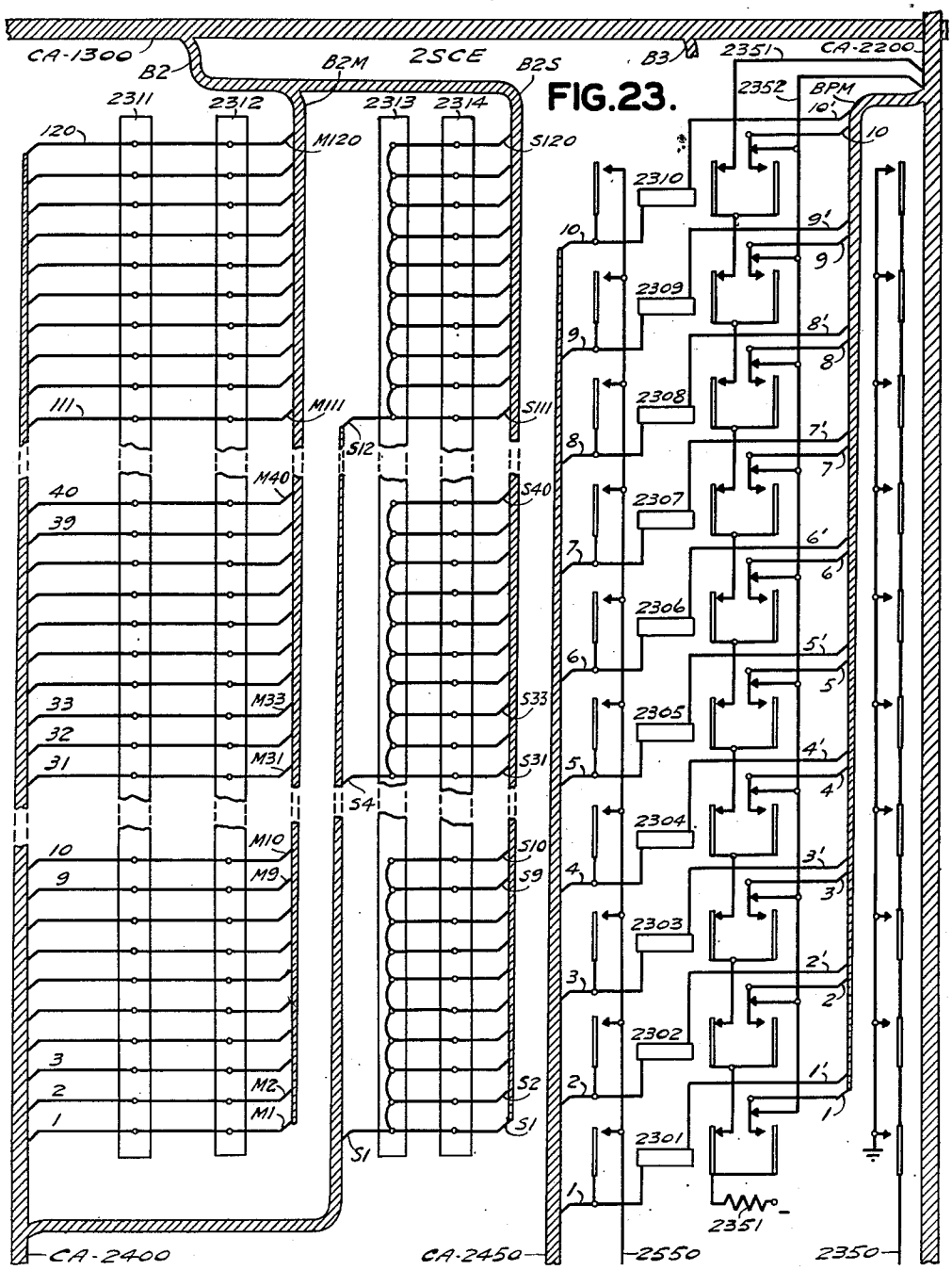

FIG.23.

Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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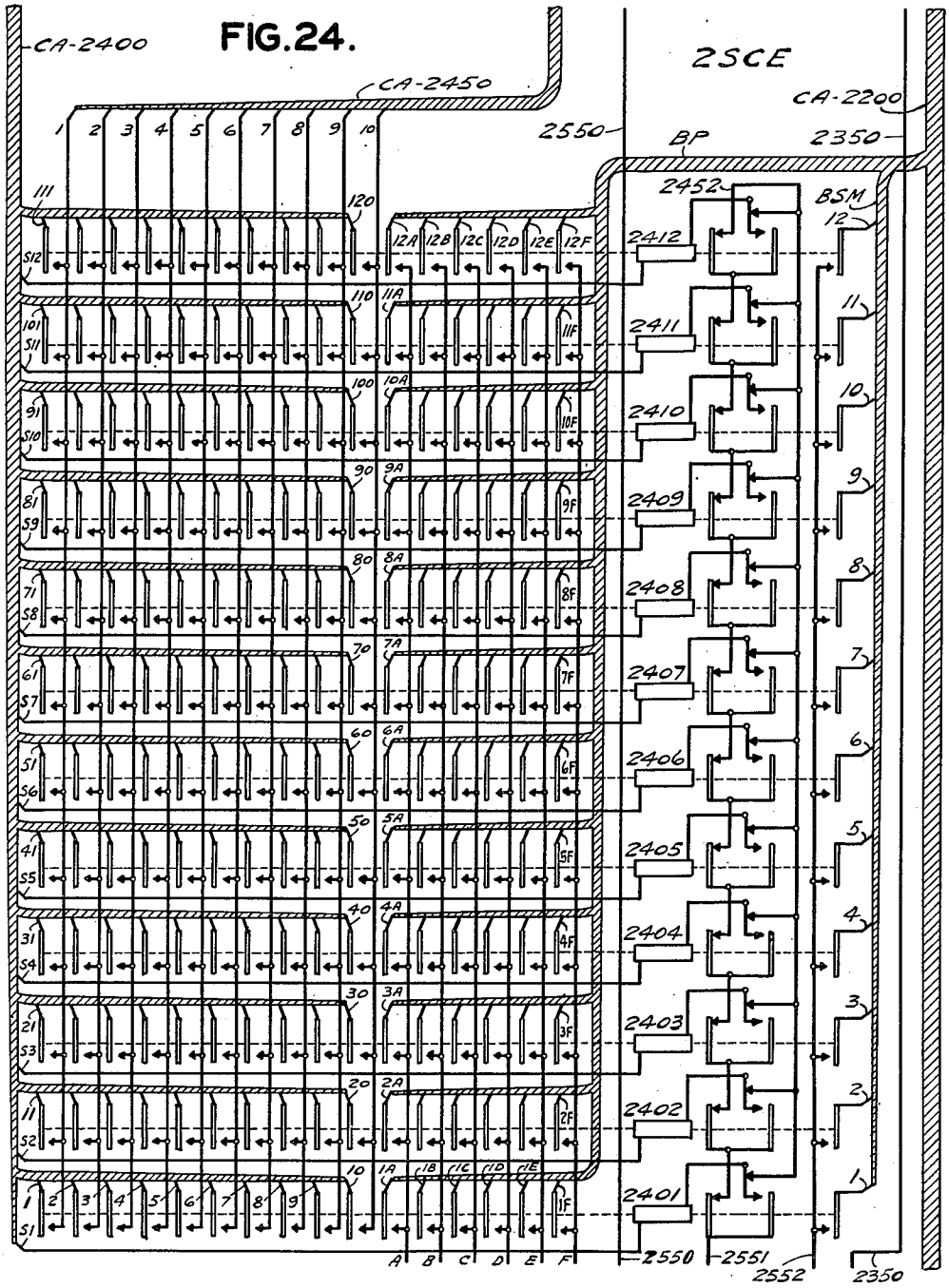
FIG. 24.



Inventor:
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By C. P. Sofen
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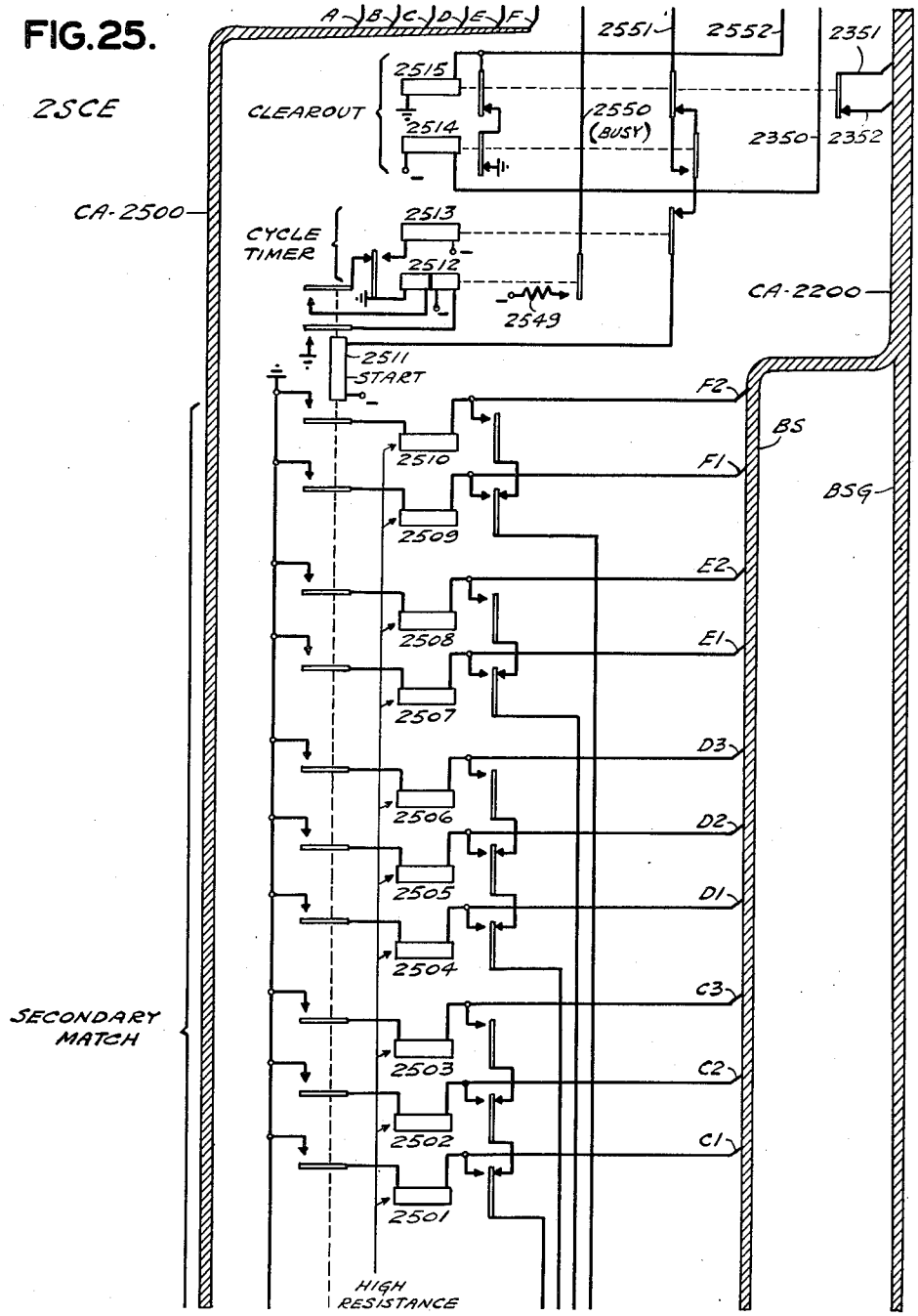
FIG. 25.



Inventor:
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By C. C. Sober
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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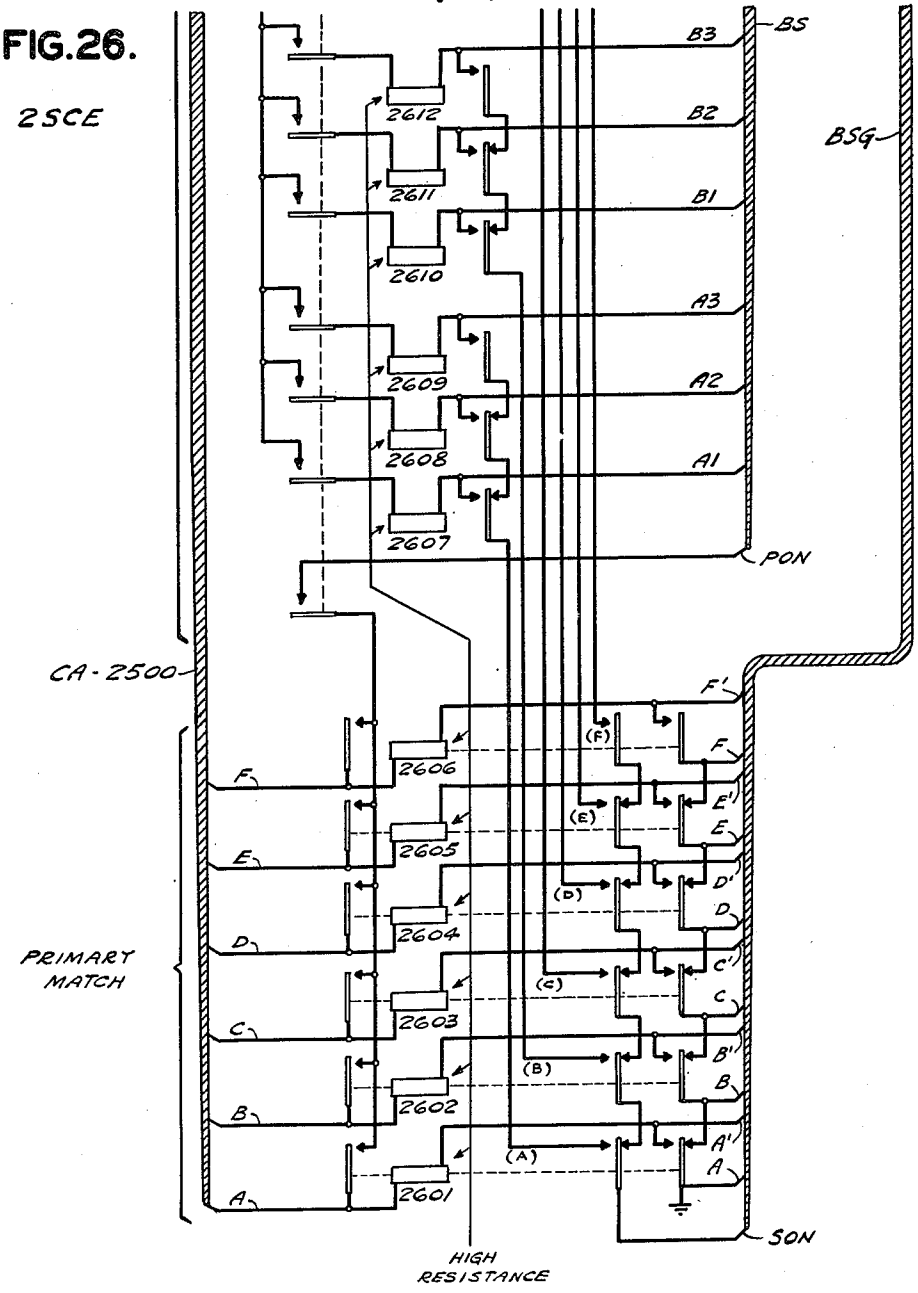
FIG. 26.



Inventor:
John I. Bellamy
By
Atty.

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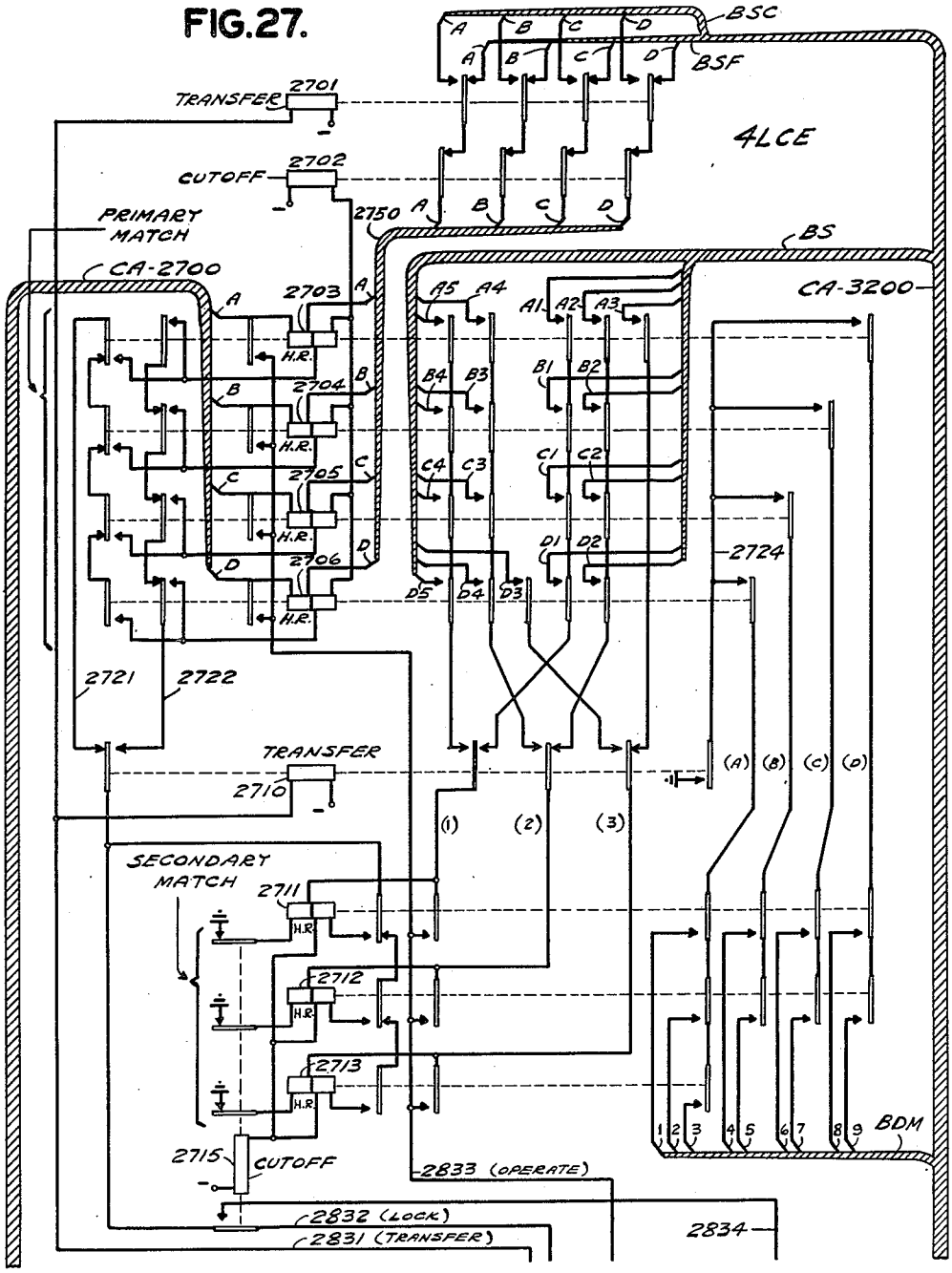
FIG.27.



Inventor:
John I. Bellamy
By C. P. Sofer
Atty.

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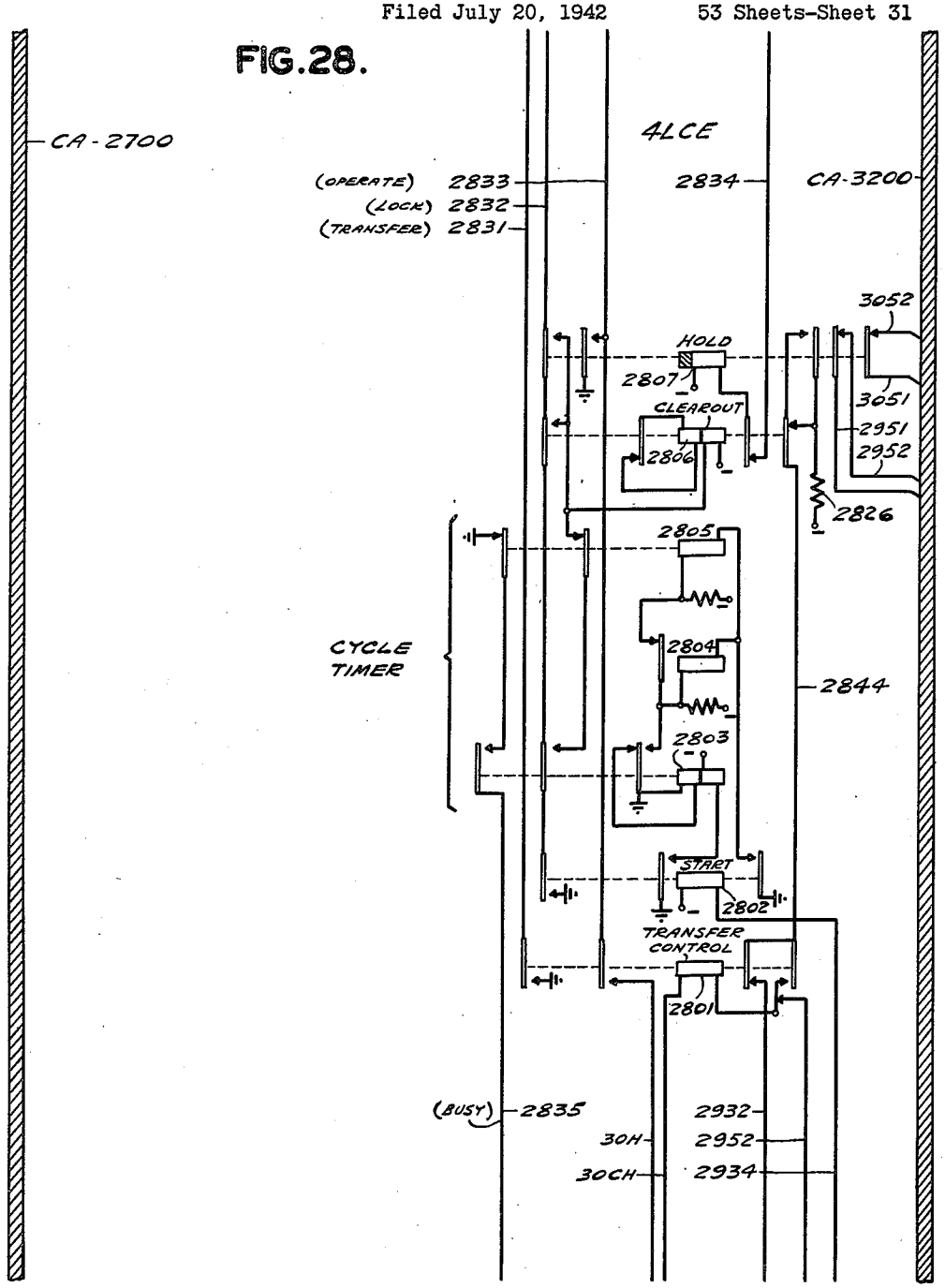
FIG. 28.



Inventor:
John I. Bellamy
By C. A. Sheen
Atty.

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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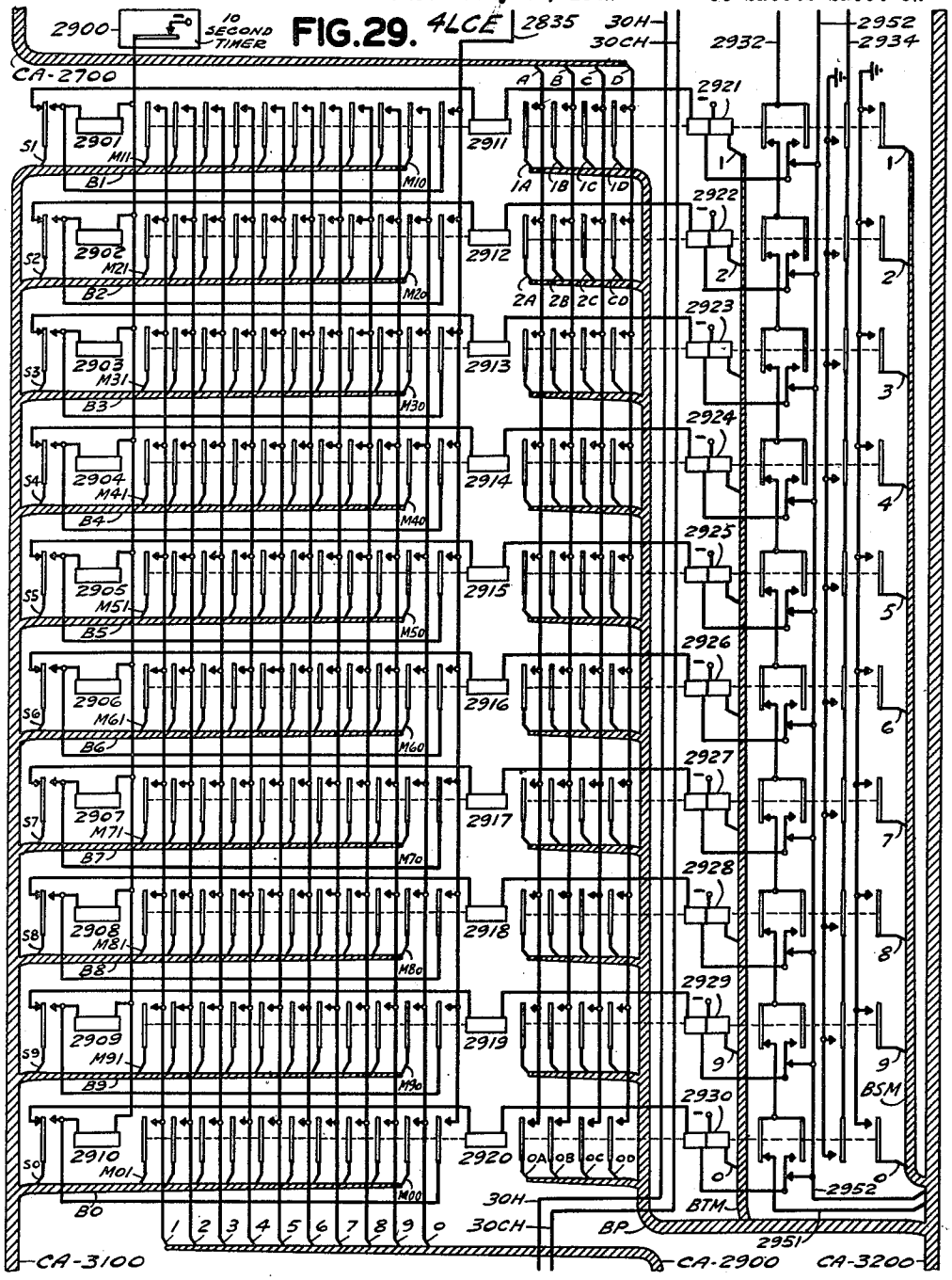
FIG.29.



Inventor:
John I. Bellamy
By C. C. Soper
Atty.

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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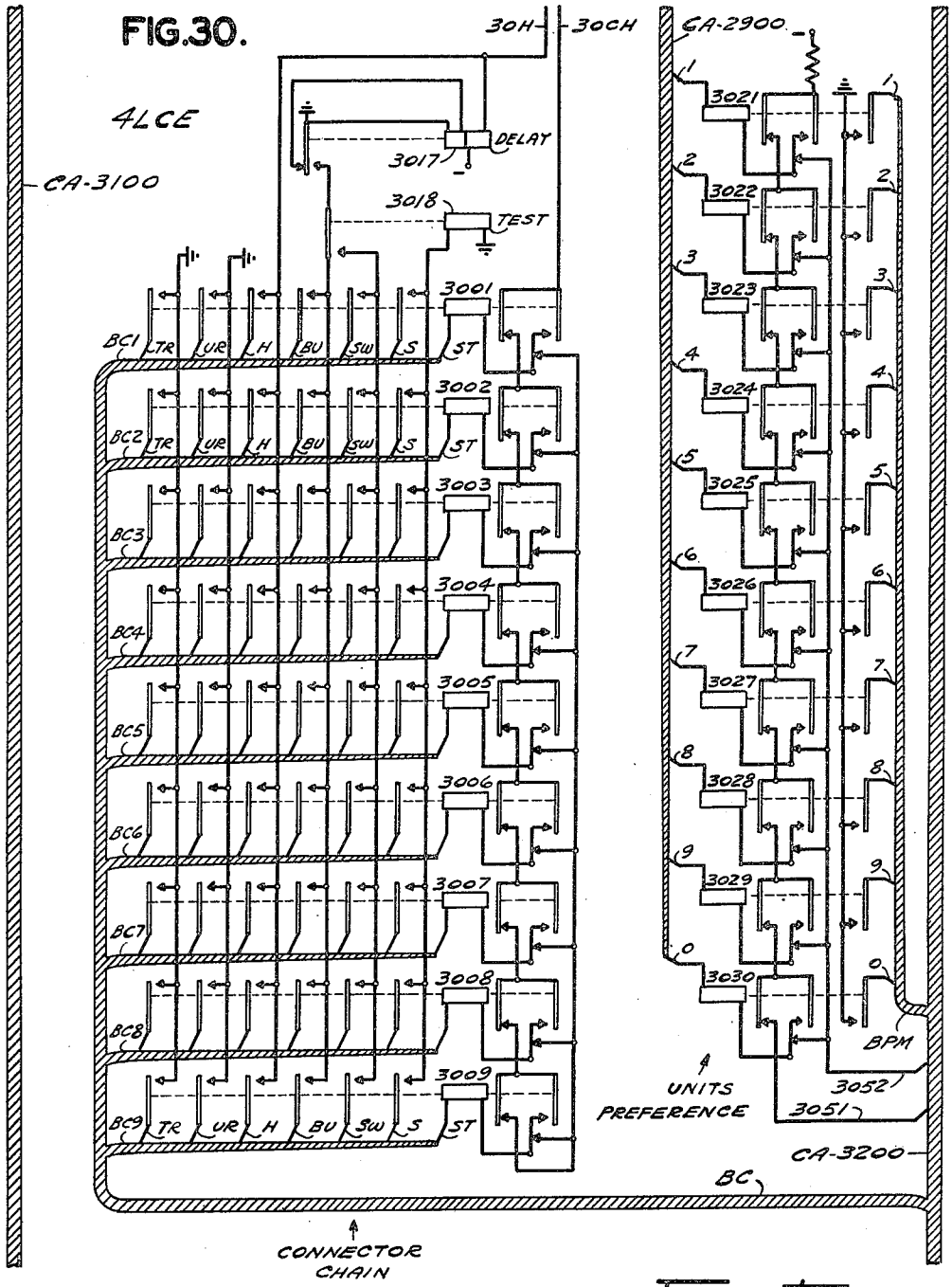
FIG.30.



Inventor:
John I. Bellamy
By C. A. Safer
Atty.

Aug. 1, 1944. J. I. BELLAMY 2,354,660

AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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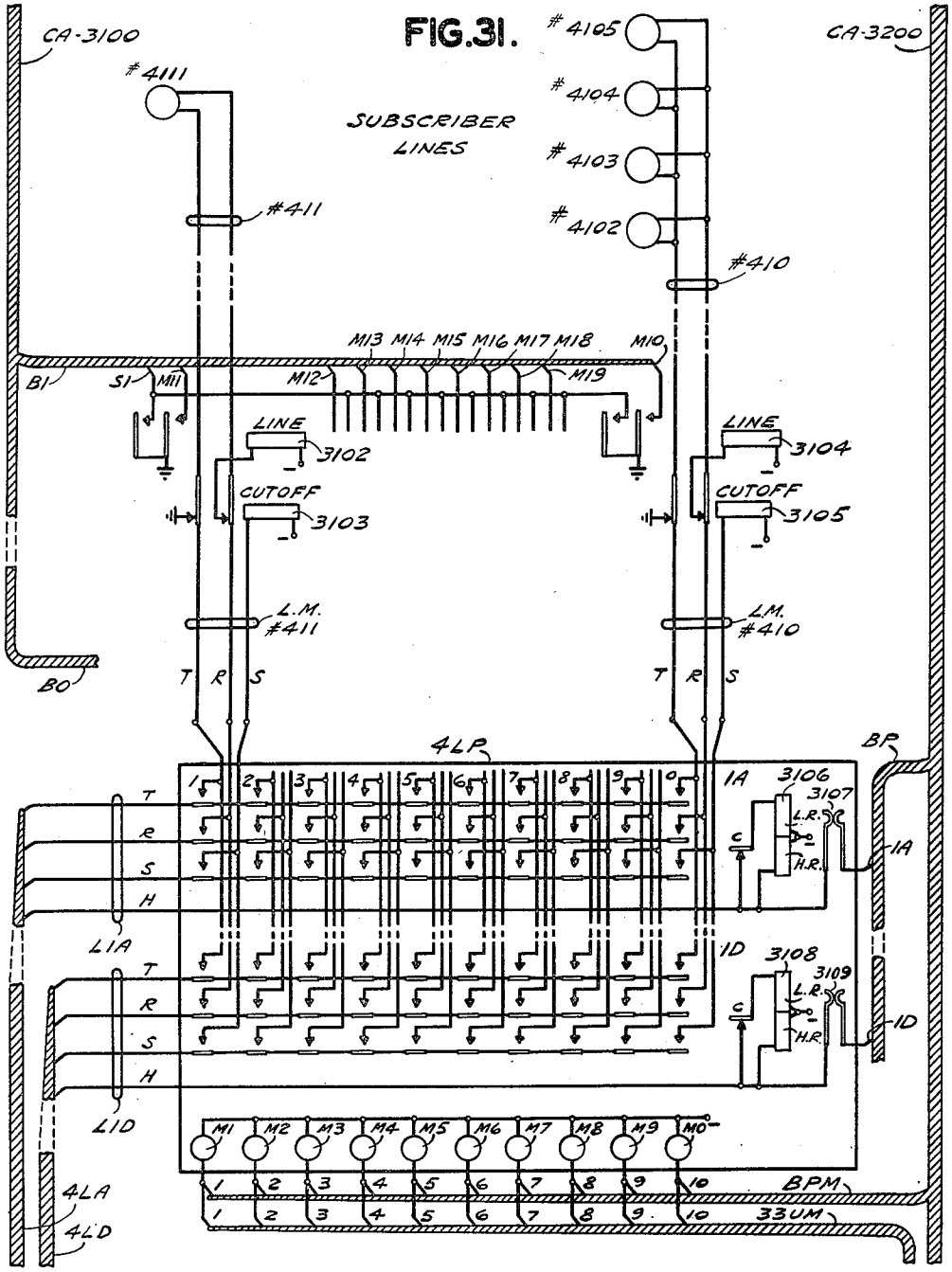
FIG. 31.



Inventor:
John I. Bellamy
By C. P. Soper
Atty.

Aug. 1, 1944. J. I. BELLAMY 2,354,660

AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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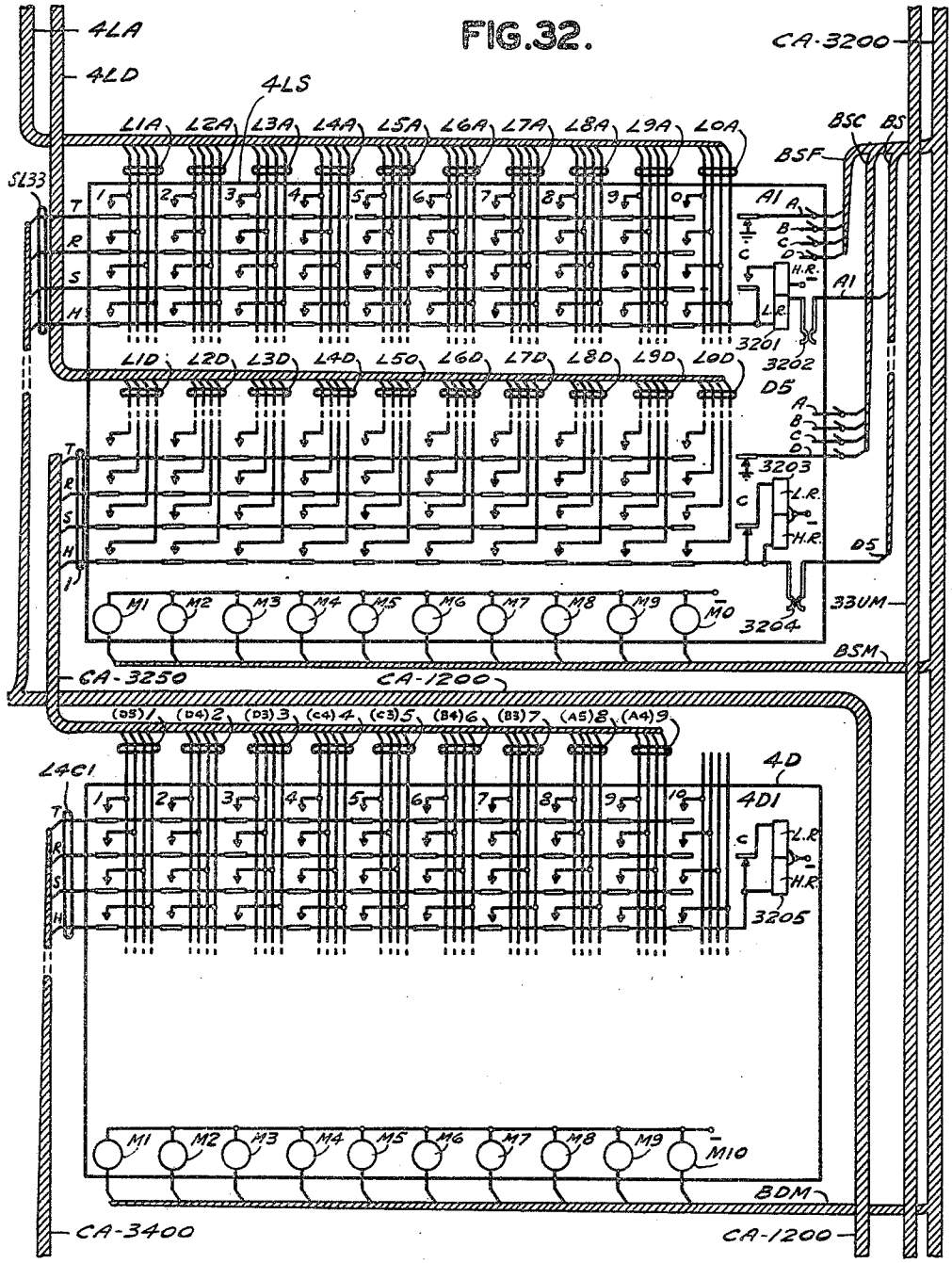
FIG. 32.



Inventor:
John I. Bellamy
By C. P. Sahm
Atty.

Aug. 1, 1944. J. I. BELLAMY 2,354,660

AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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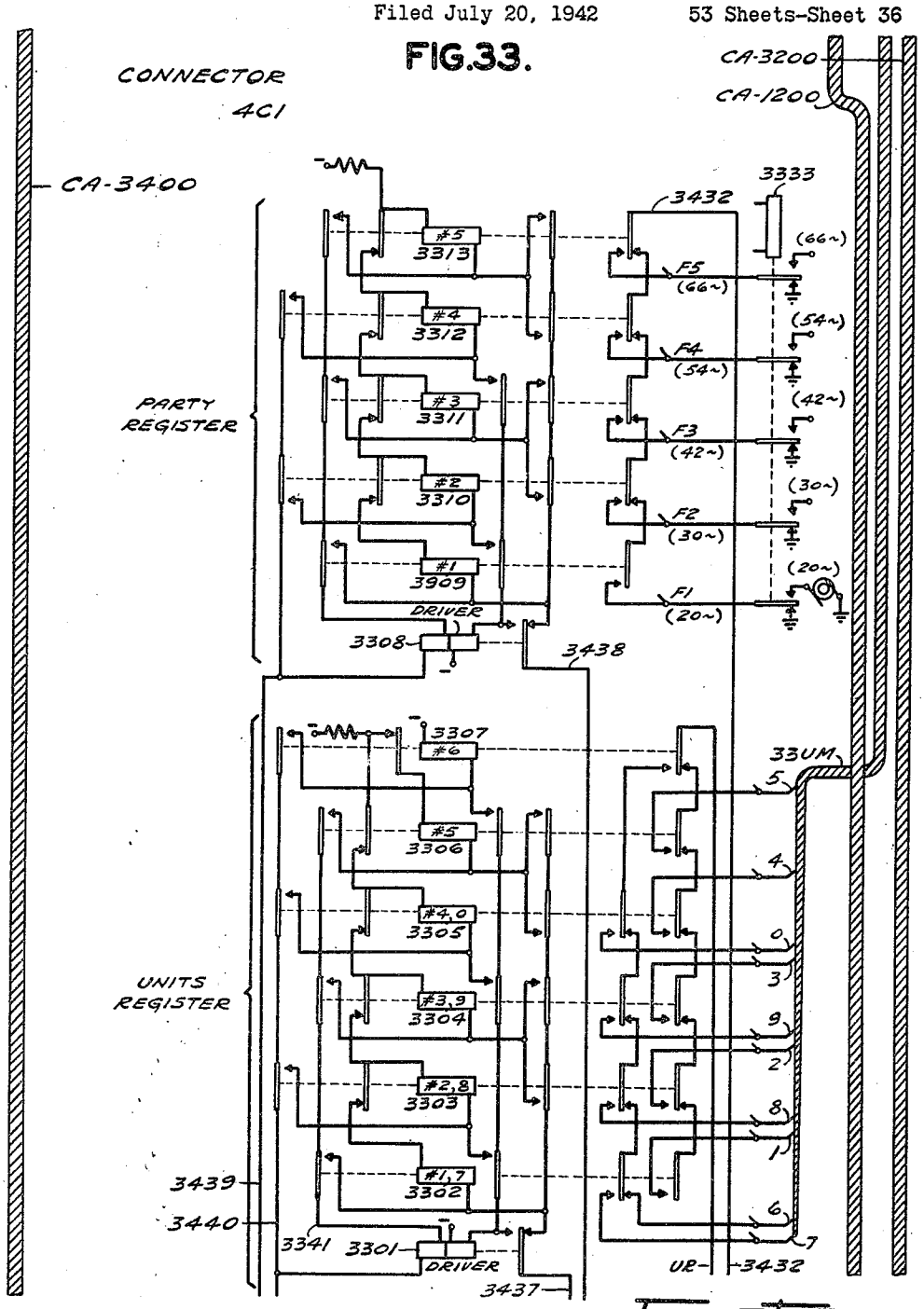
FIG.33.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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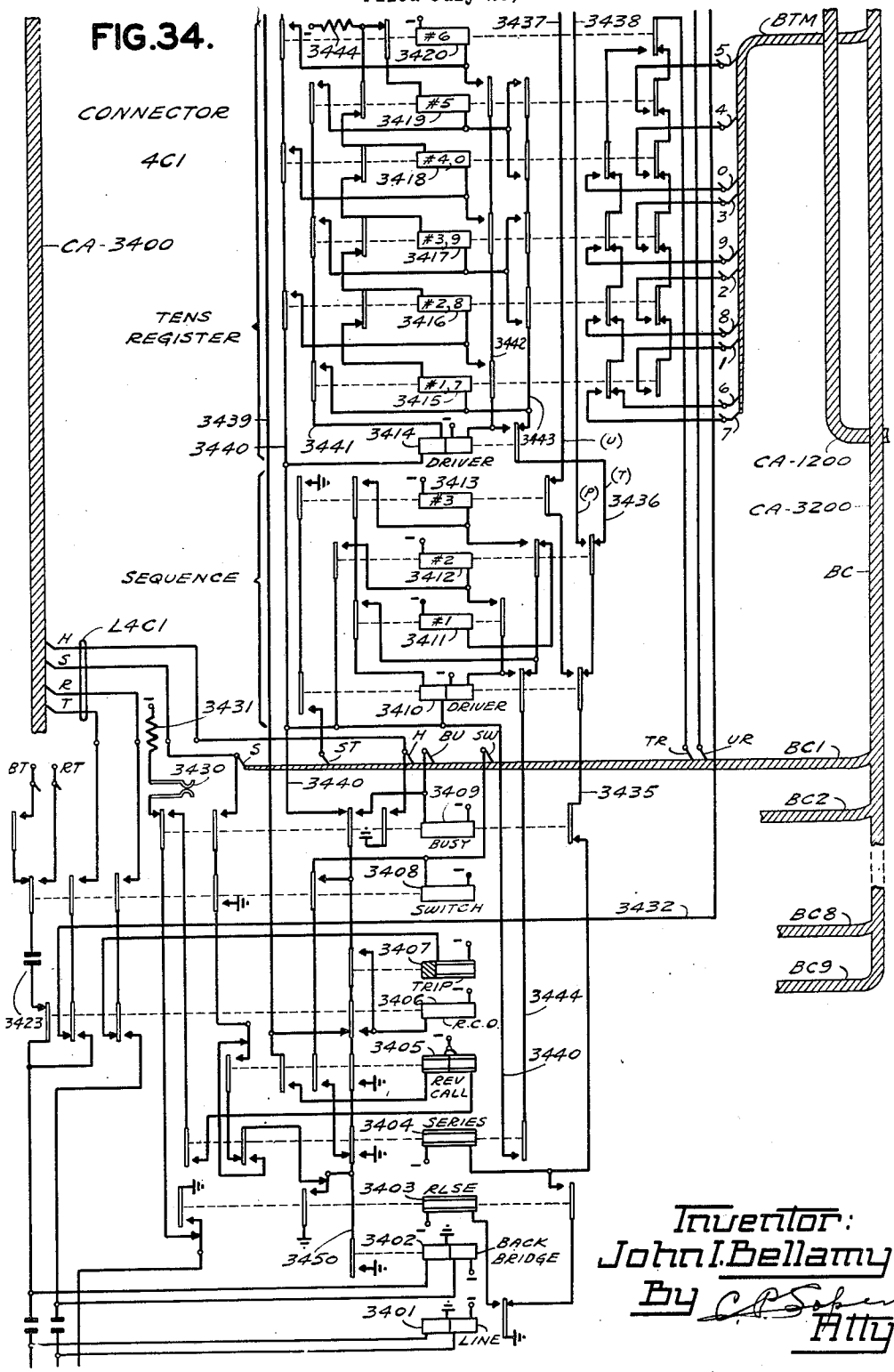
FIG.34.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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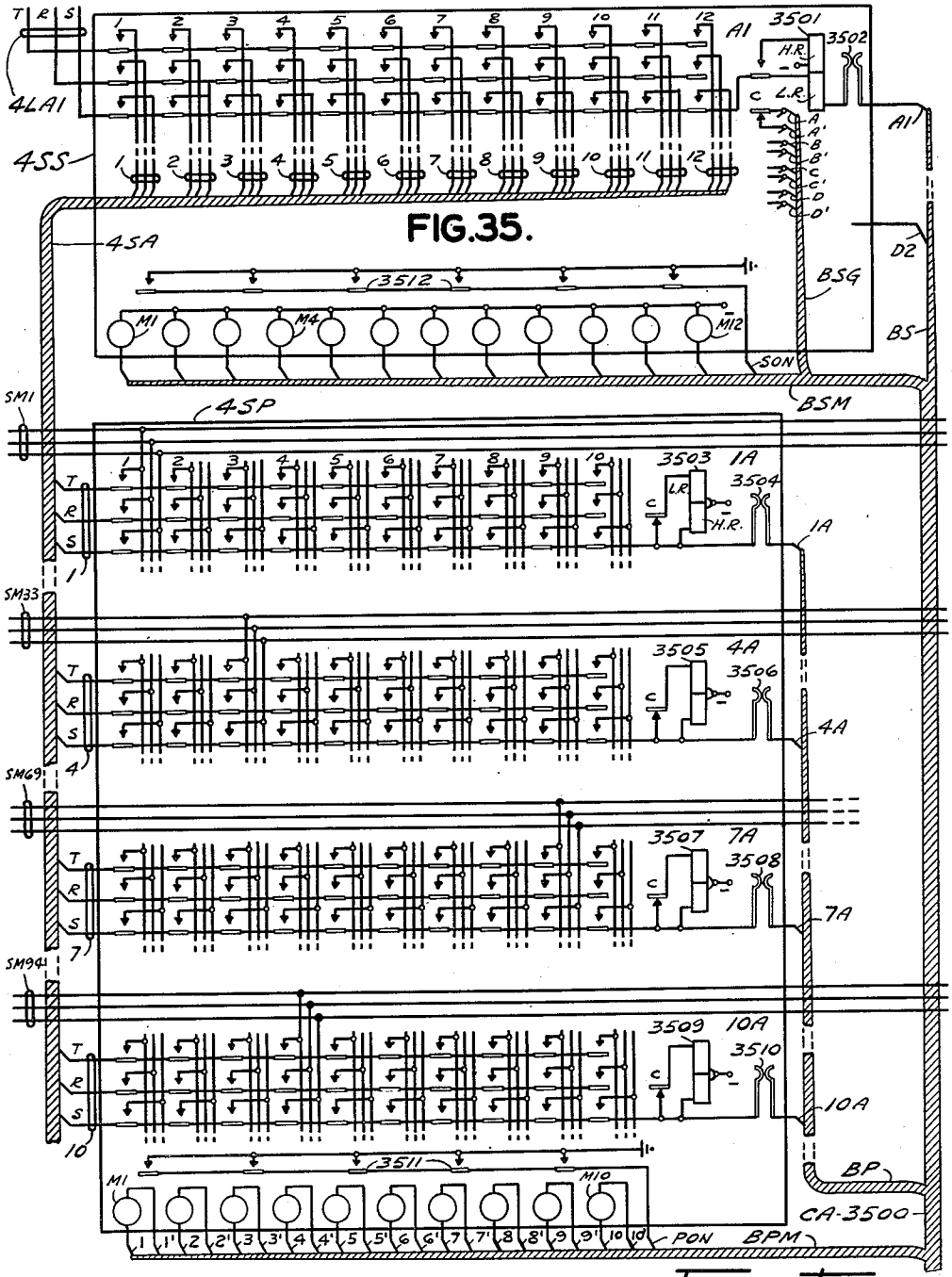

FIG.35.

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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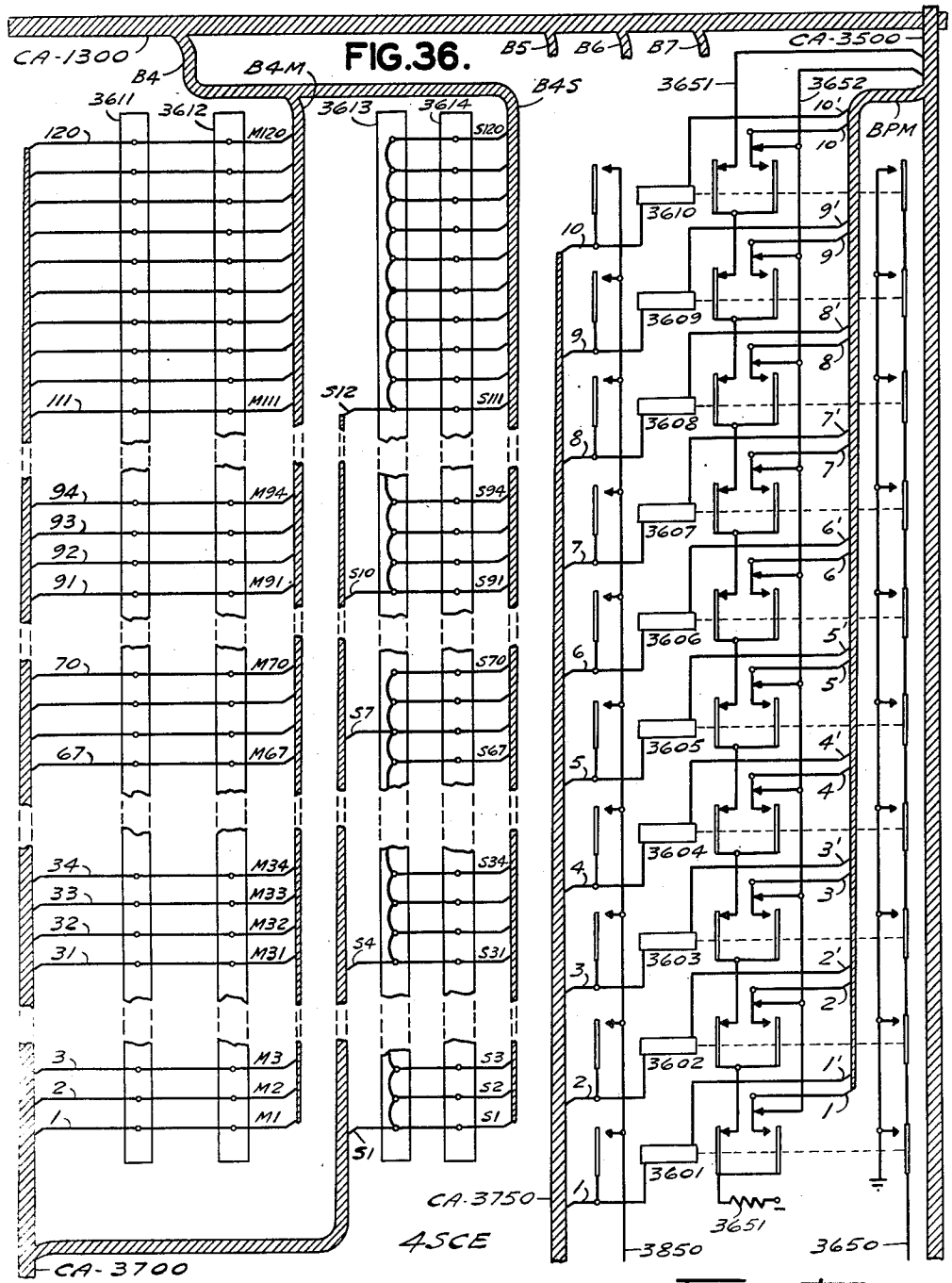
FIG.36.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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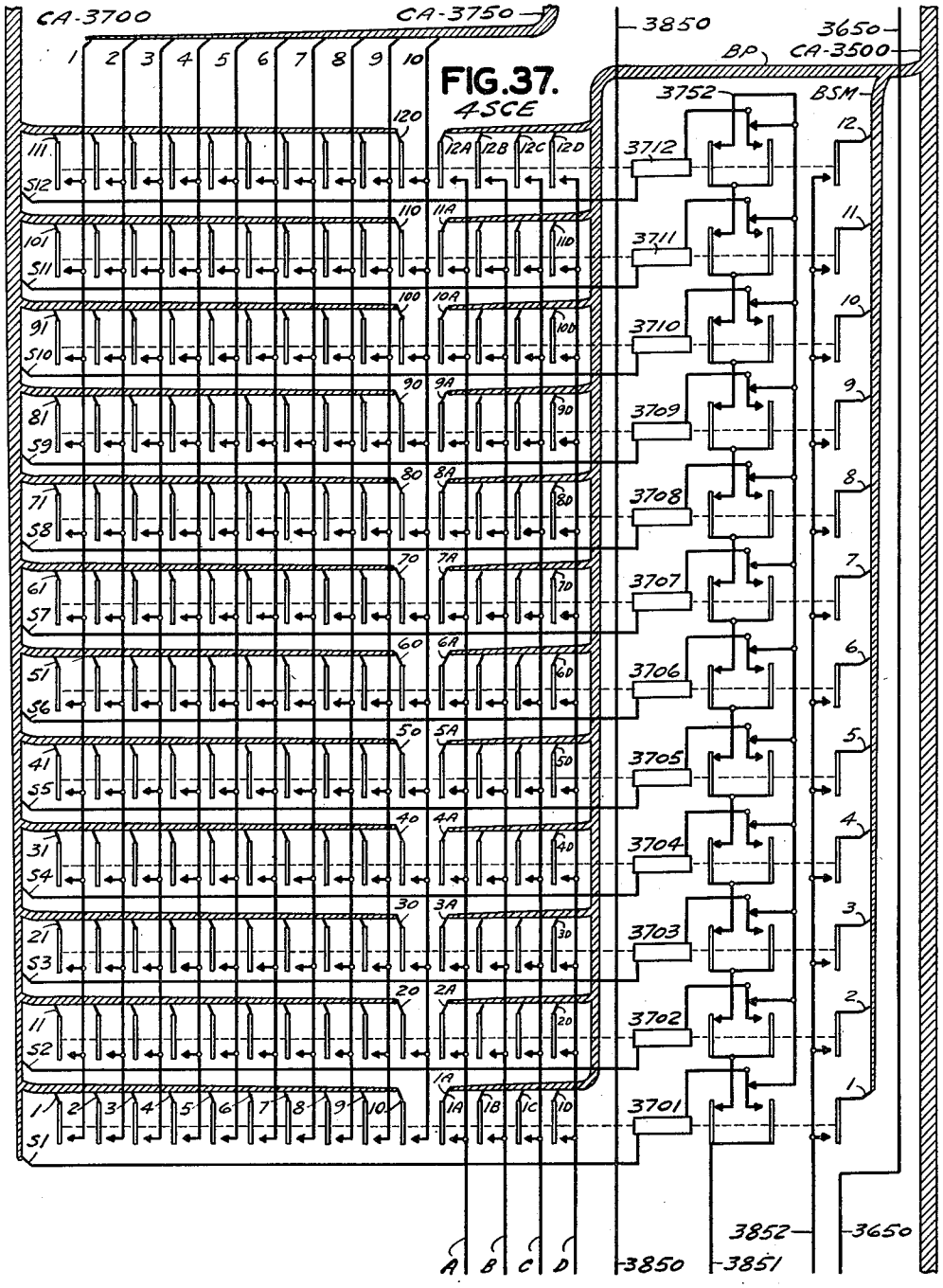

FIG. 37.
4SCE

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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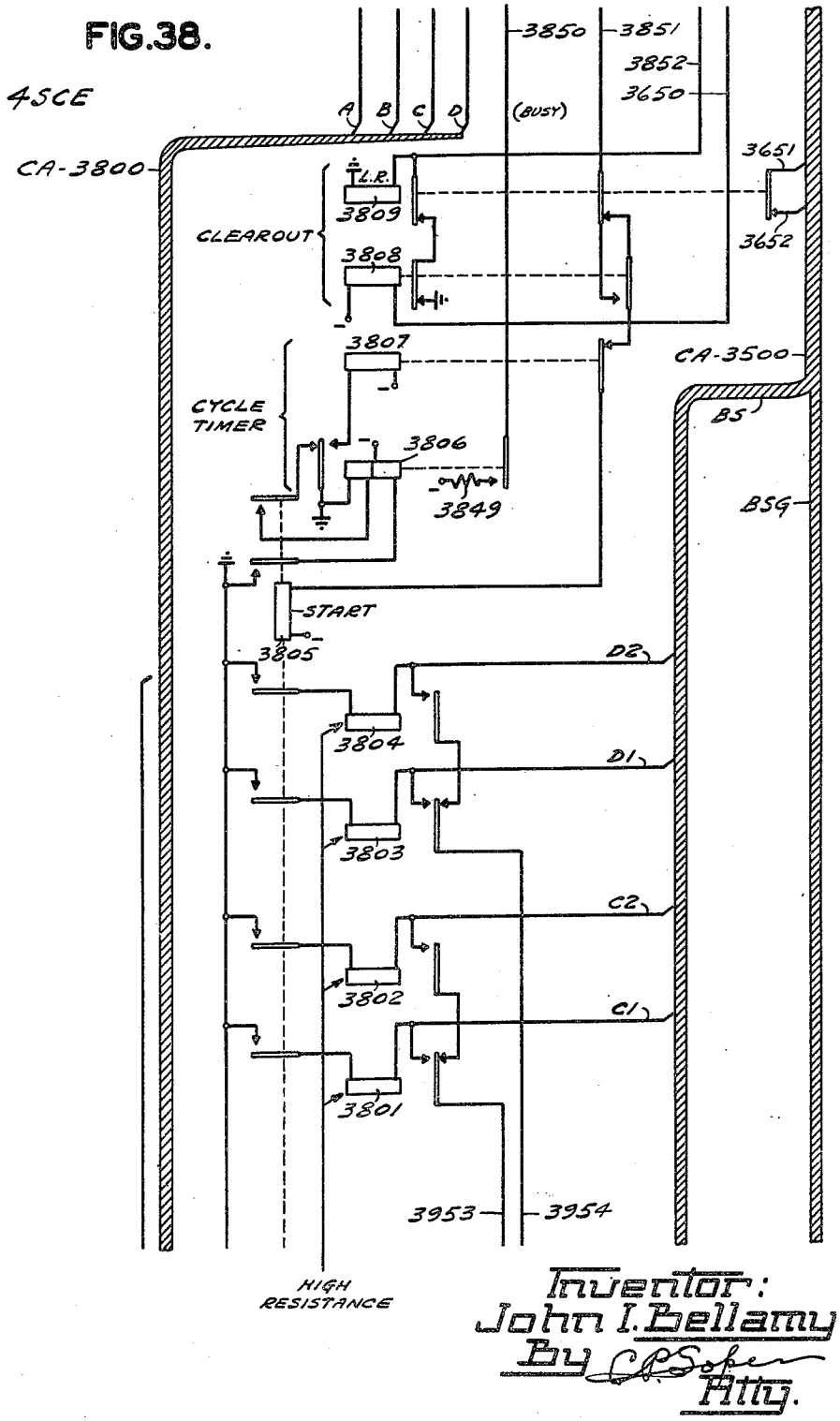
FIG.38.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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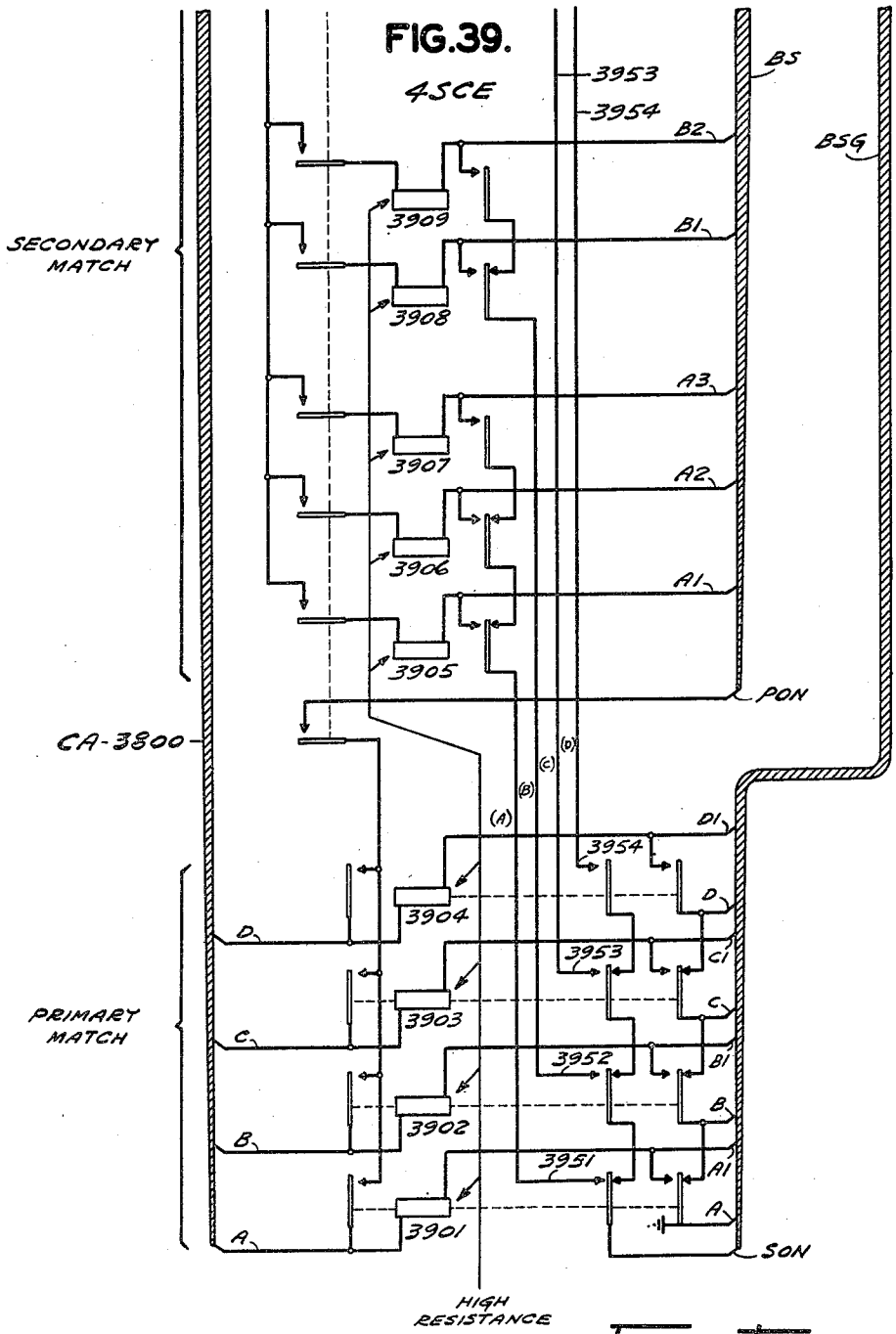
FIG.39.

45CE



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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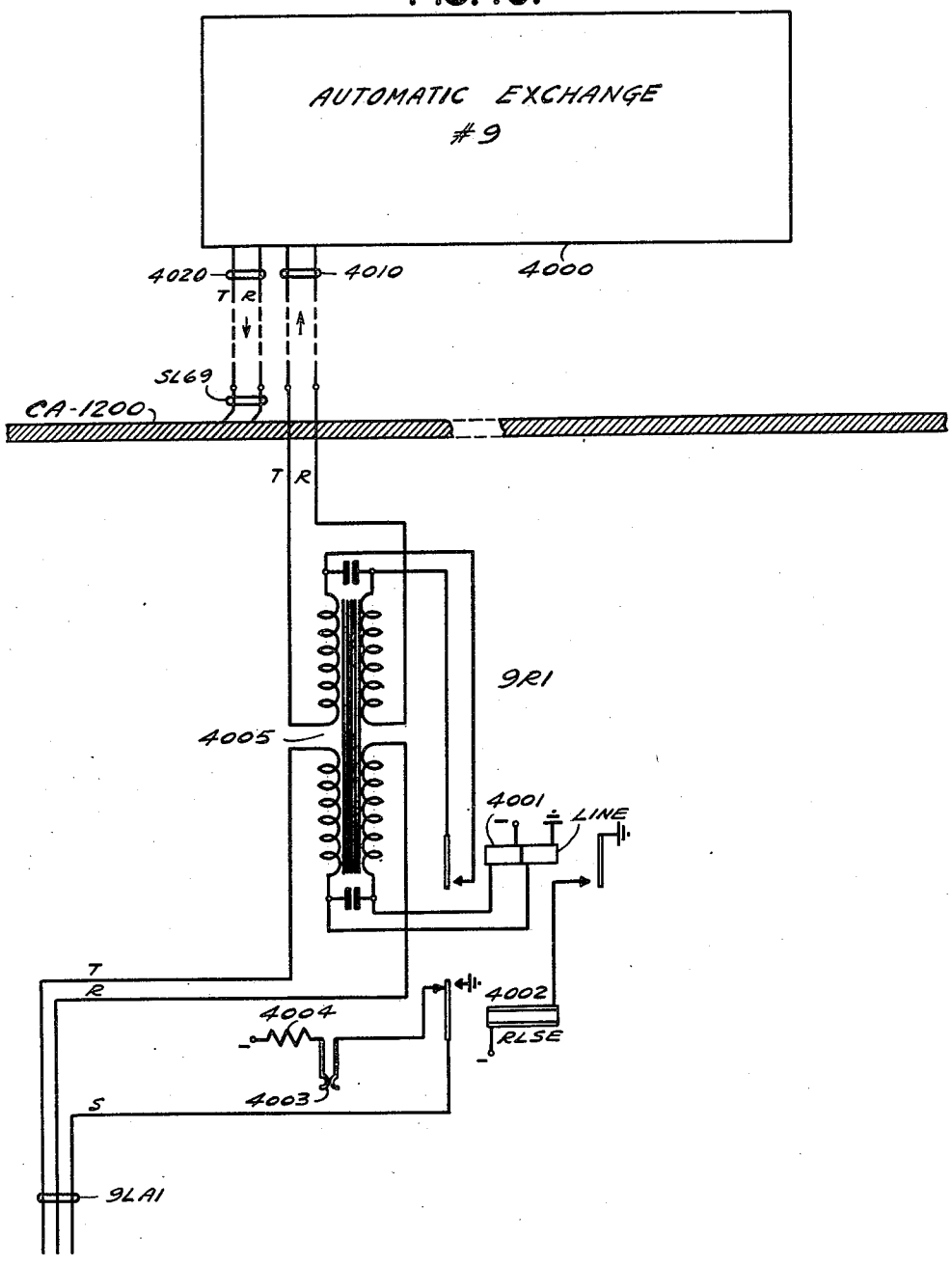
FIG.40.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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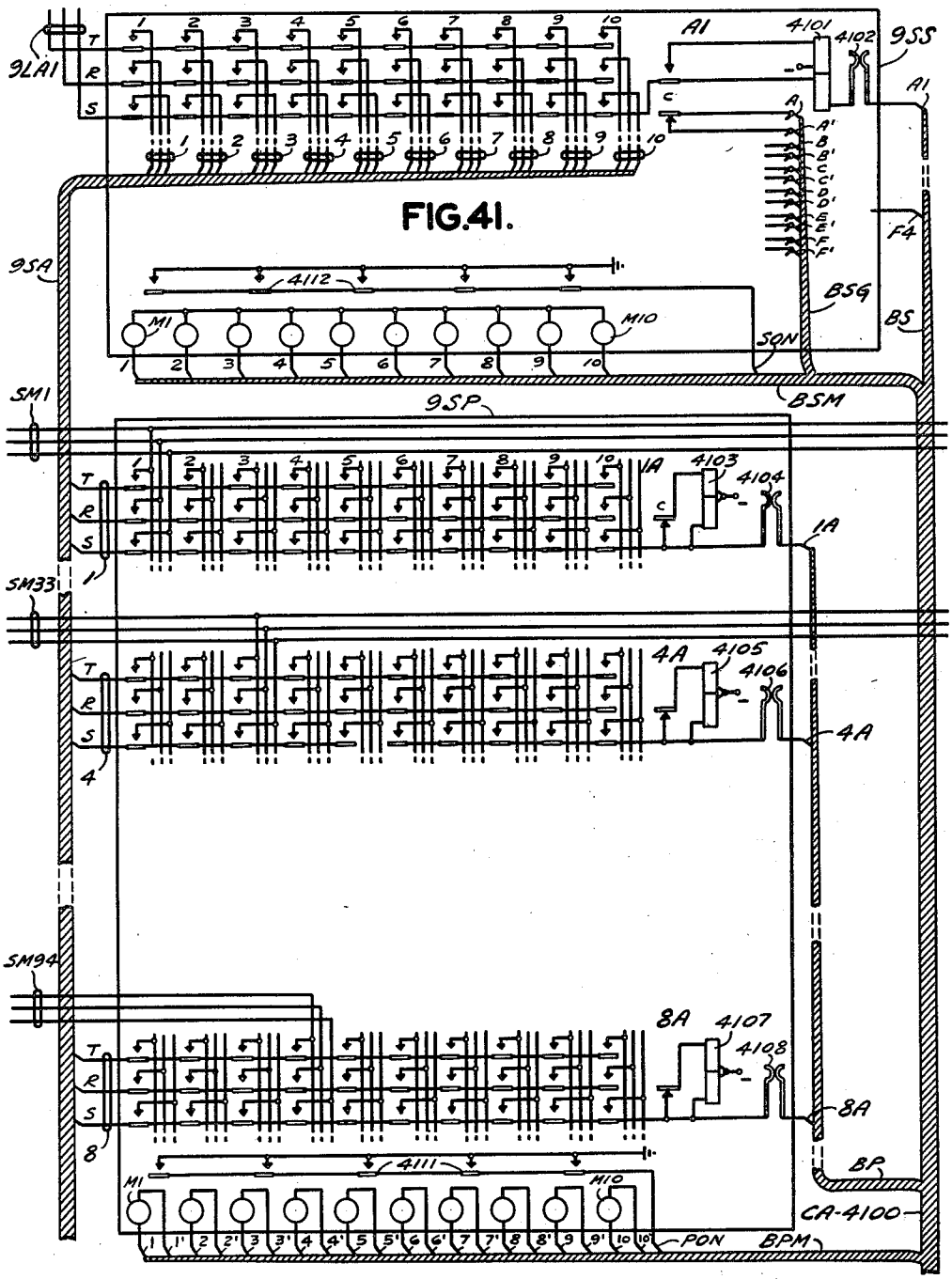

FIG.41.

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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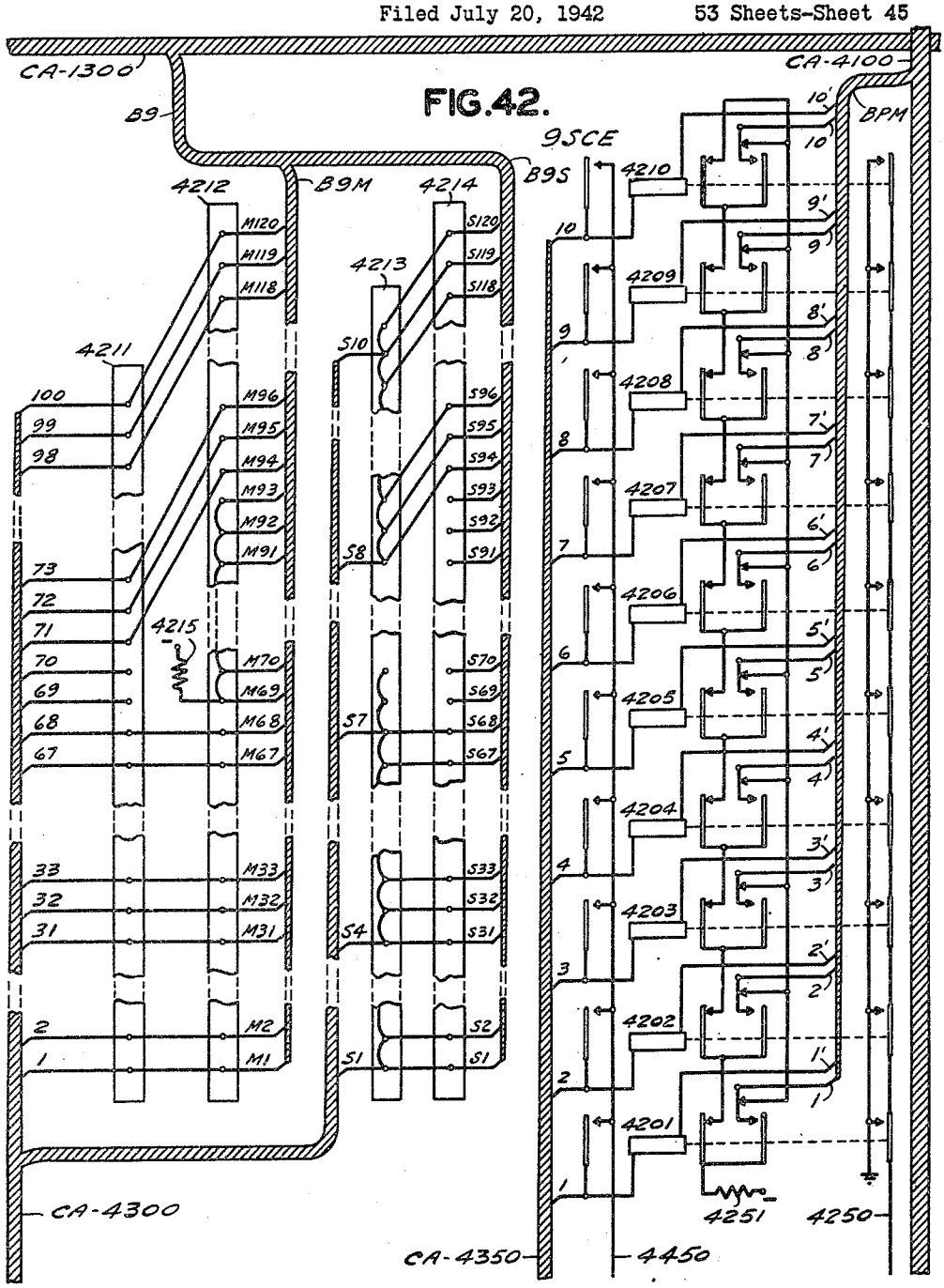
FIG. 42.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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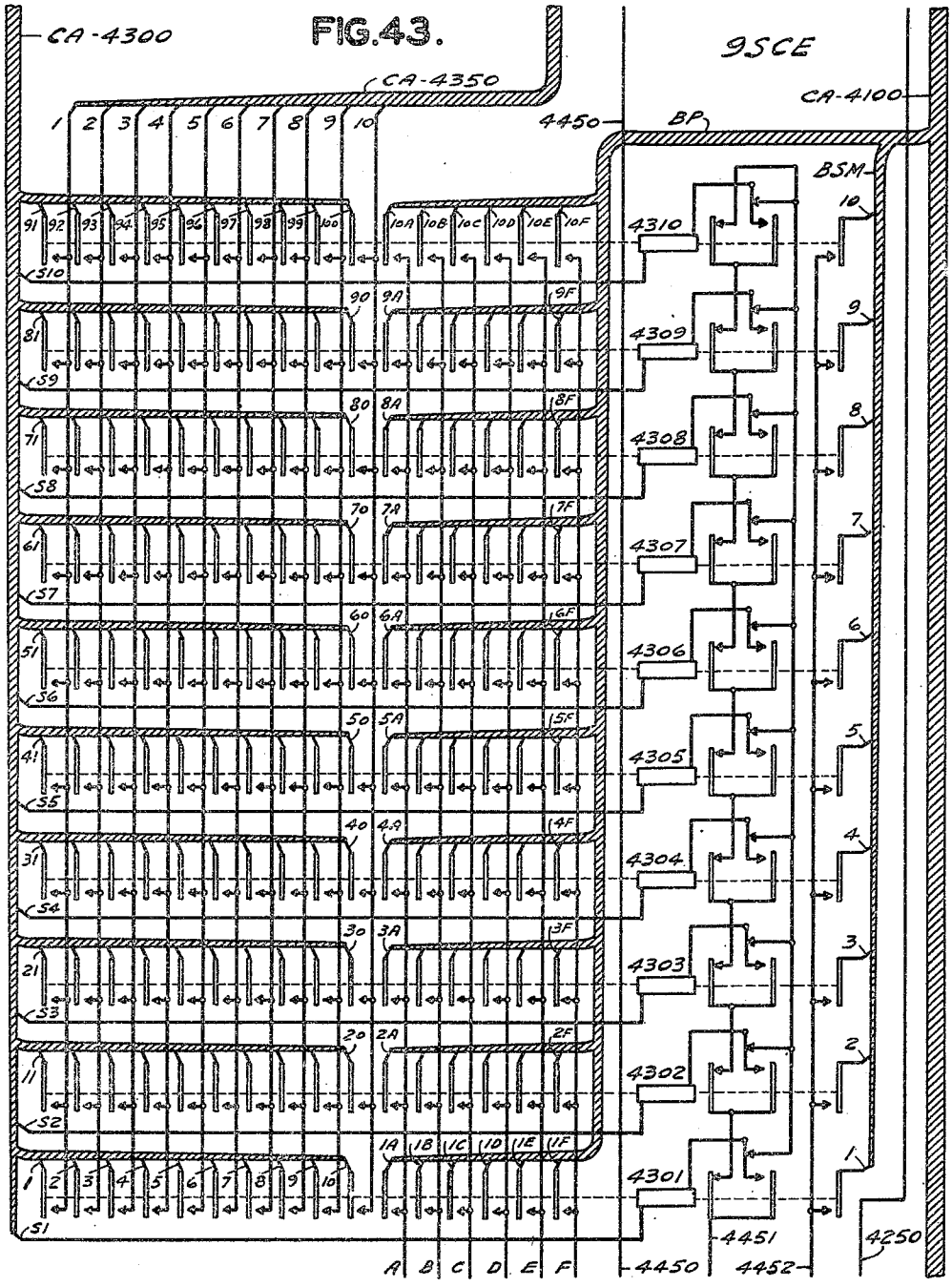
FIG. 43.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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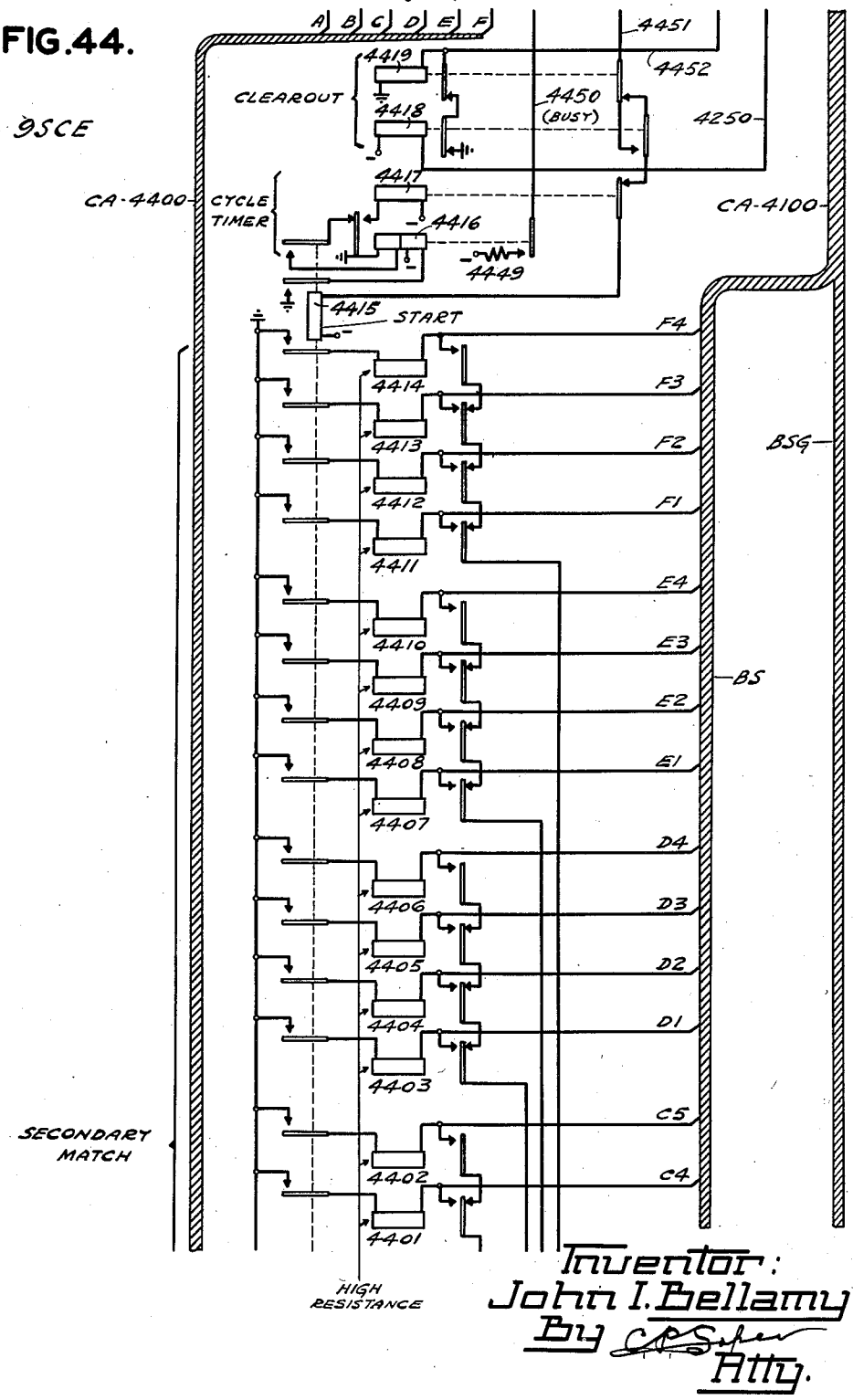
FIG.44.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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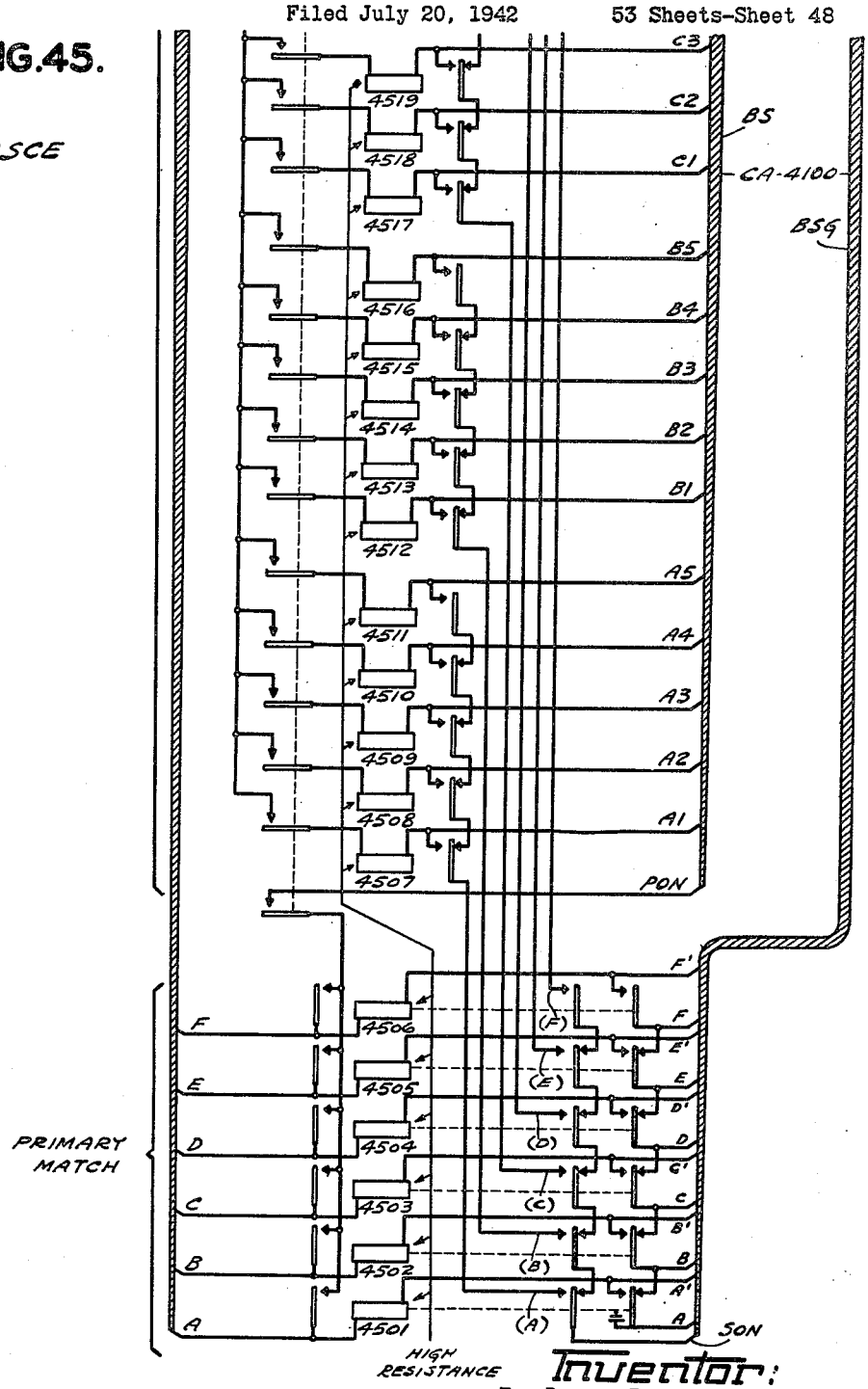
FIG.45.

9SCE



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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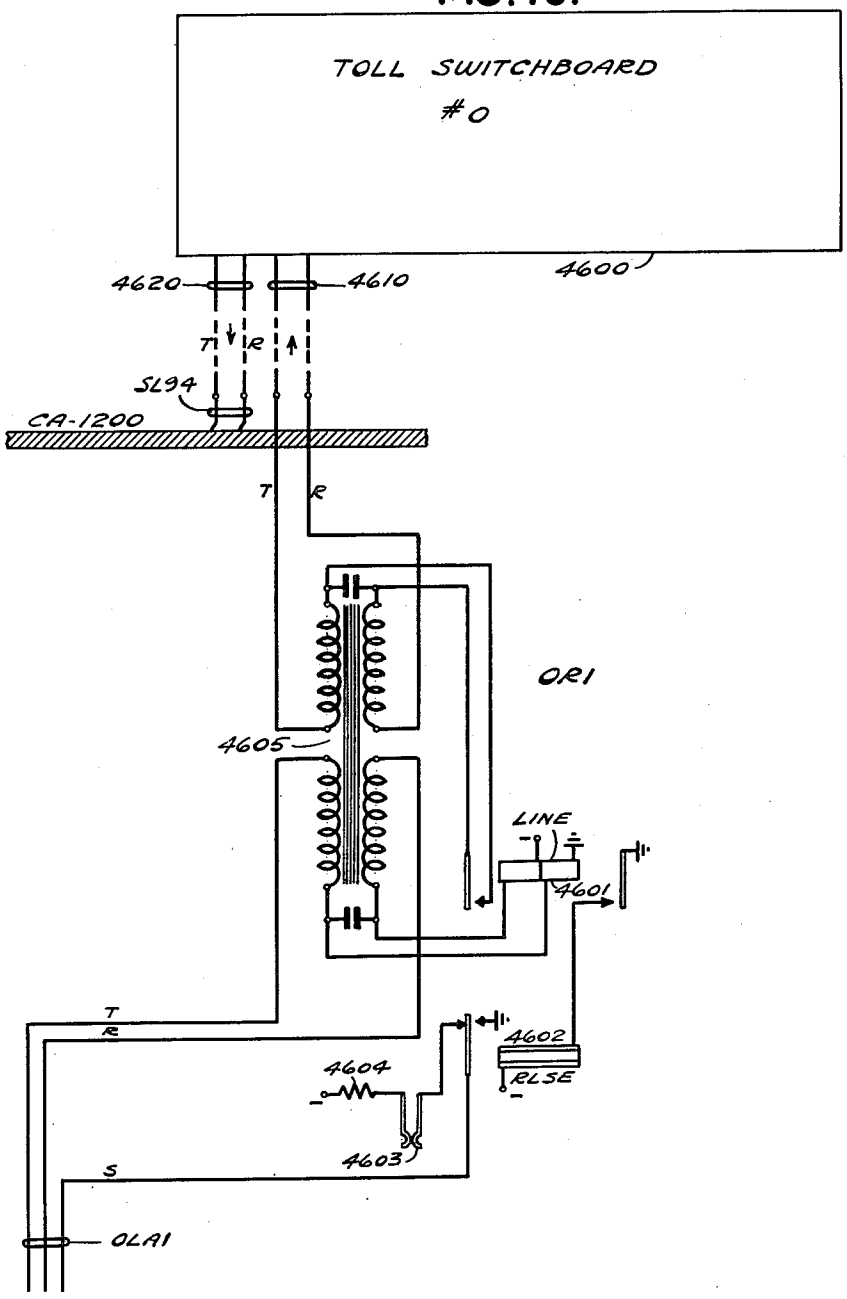
FIG. 46.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

Filed July 20, 1942 53 Sheets-Sheet 50

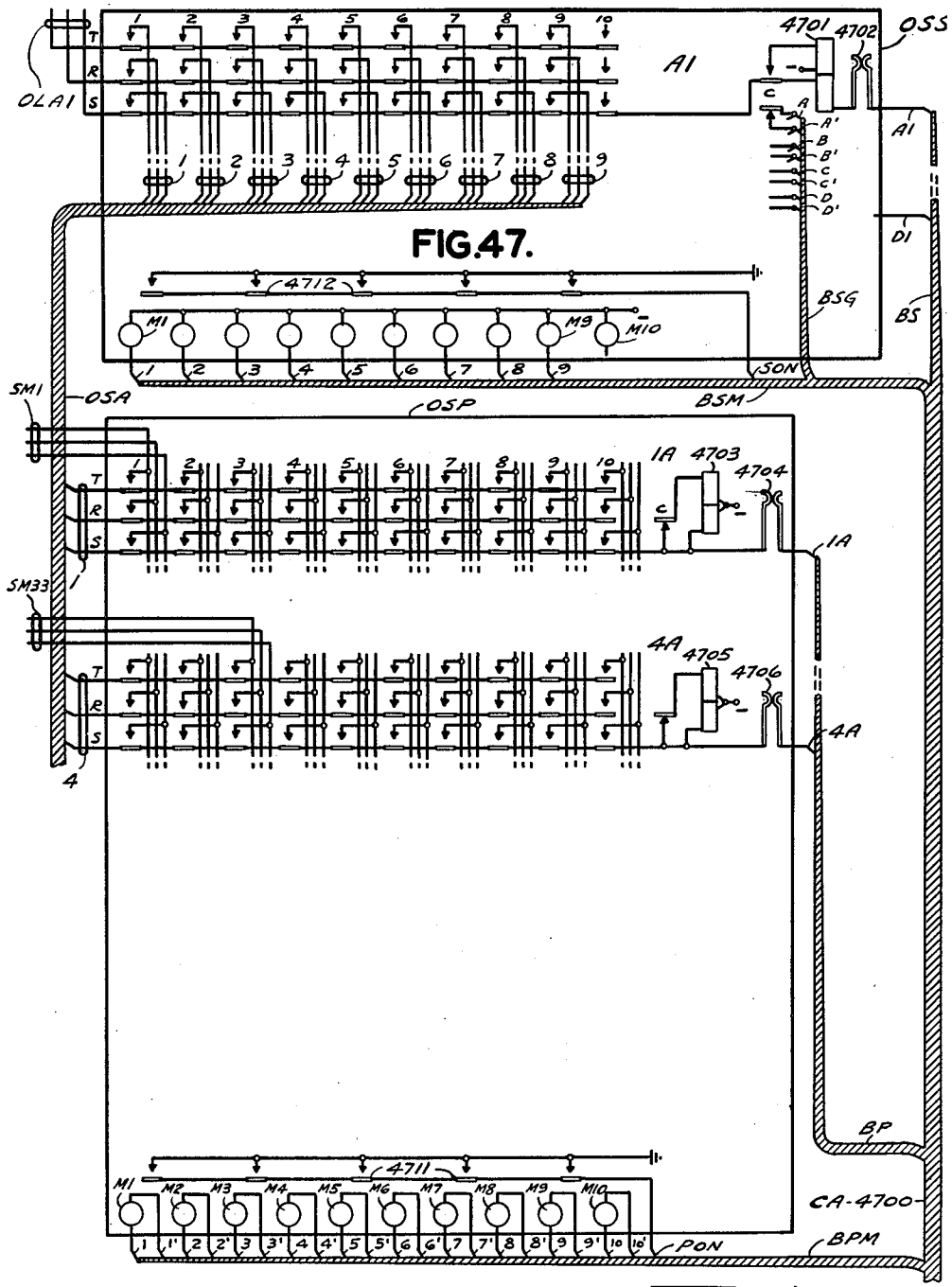

FIG. 47.

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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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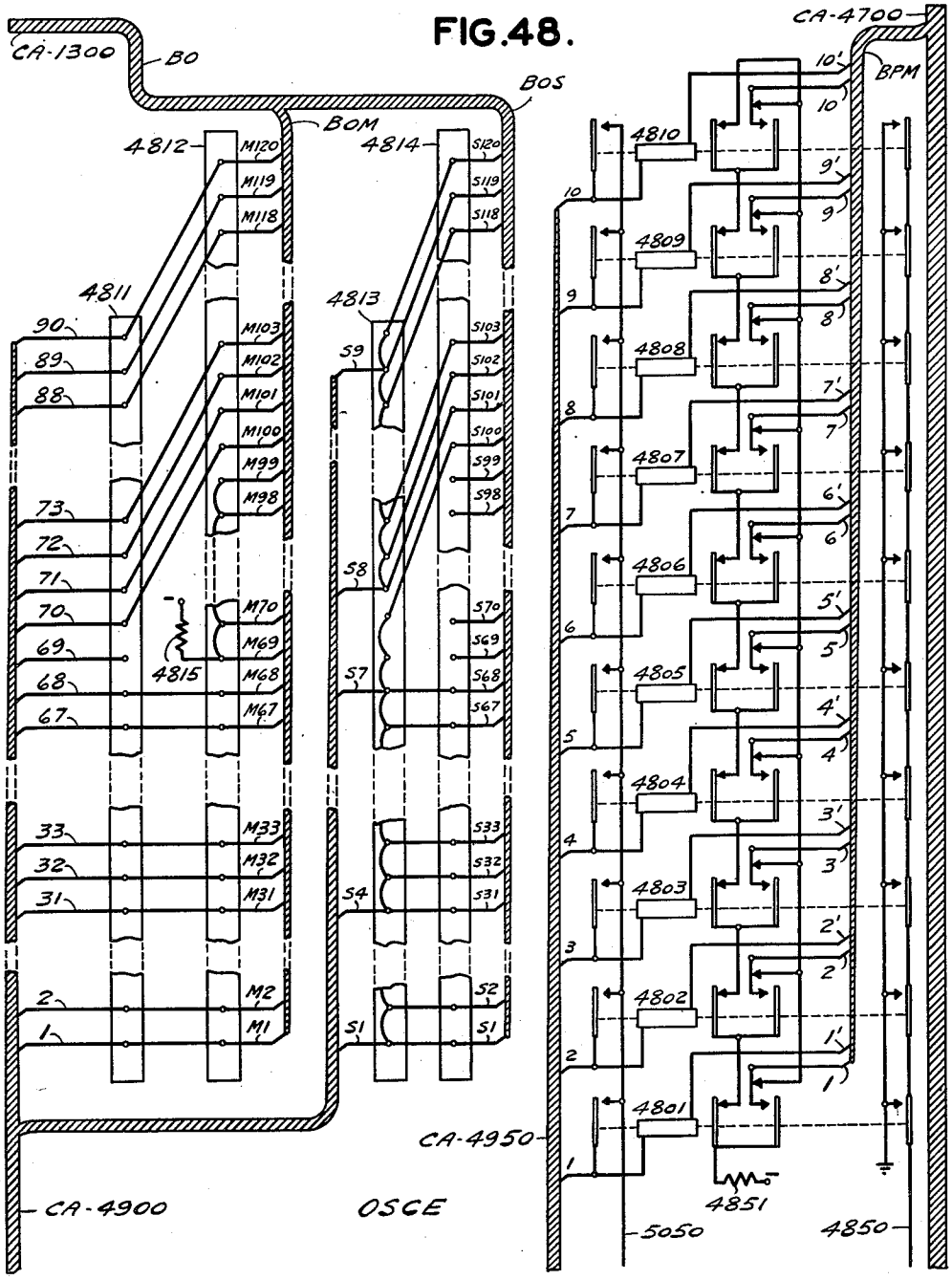
FIG. 48.



Inventor:
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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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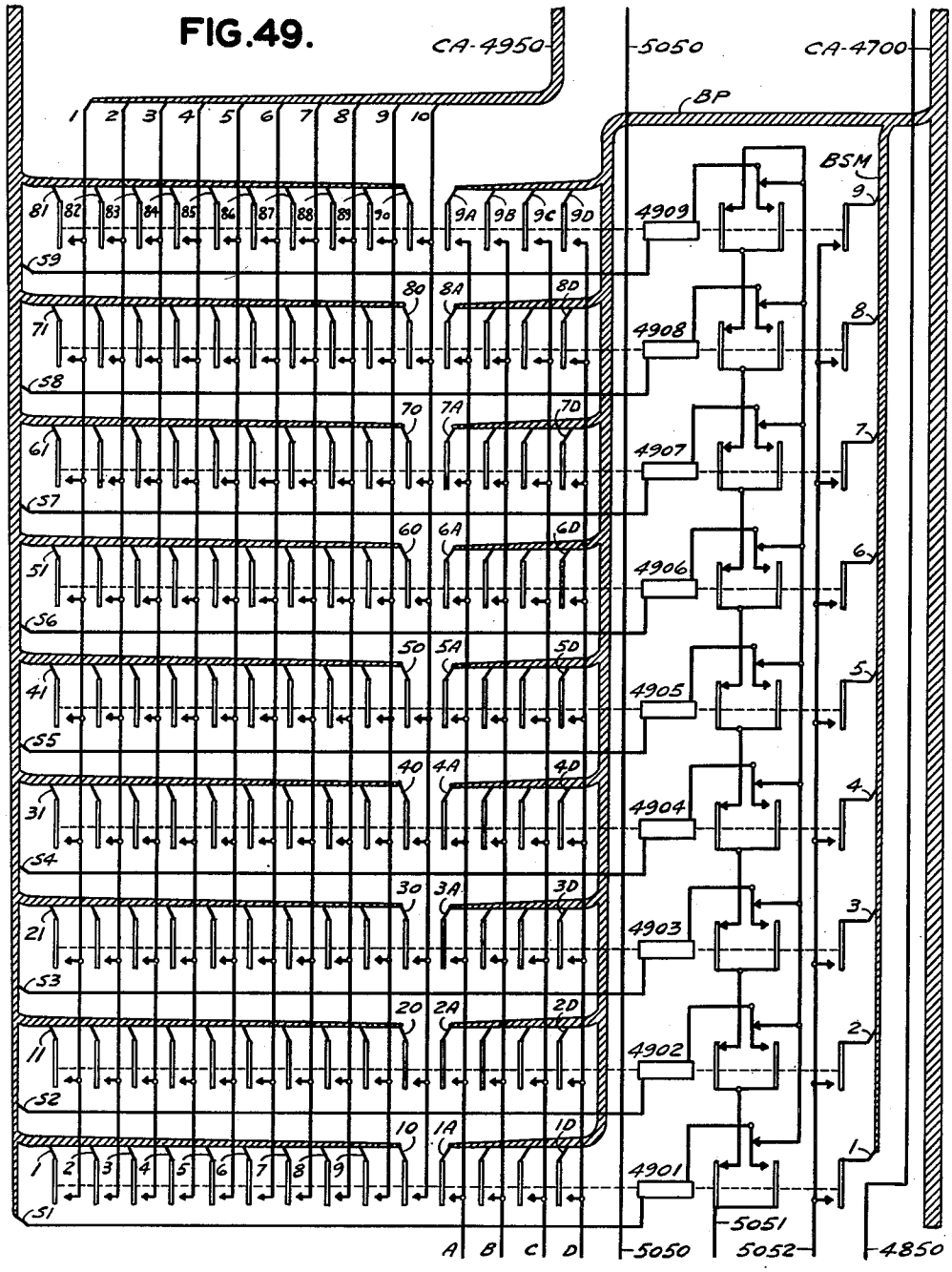
FIG.49.



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AUTOMATIC TELEPHONE SWITCH AND SYSTEM

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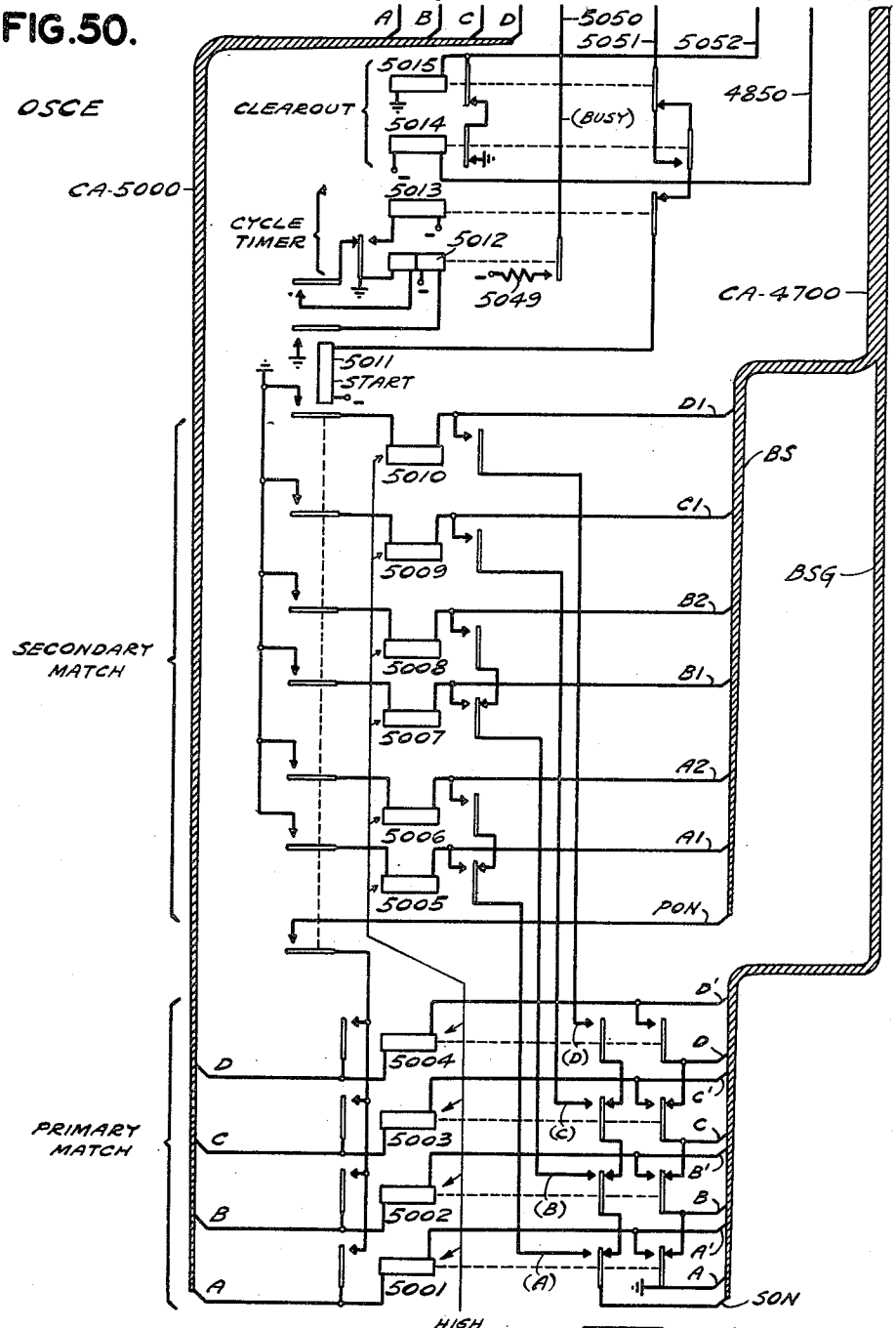
FIG.50.



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Patented Aug. 1, 1944 2,354,660

UNITED STATES PATENT OFFICE

2,354,660

AUTOMATIC TELEPHONE SWITCH AND SYSTEM

John I. Bellamy, Brookfield, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application July 20, 1942, Serial No. 451,565

39 Claims. (Cl. 179—22)

This invention relates to automatic telephone switches and systems. The general object of the invention is the production of a new and improved automatic switch and an improved automatic telephone system having circuit arrangements utilizing the advantages of the improved switch.

A specific object is the production of an automatic switch having such a structure that a group of them may be compactly mounted and controlled by common selecting apparatus.

A further specific object is the production of an automatic telephone system utilizing groups of the improved switches and arranged to control the individual switches and their common selecting mechanisms to provide the switching stages necessary in a telephone system of any size.

A further object is the provision of a system in which serially related primary and secondary switches are arranged in groups at each switching stage, with control mechanisms common respectively to the several groups, each such mechanism being effective to operate the associated switches to set up connections successively.

A further object is to so arrange the system that each switching stage may comprise serially related small-capacity primary and secondary switches, and that the switching operations at any intermediate switching stage occur with sufficient rapidity that they may be accomplished readily during the time interval elapsing between successive digit-trains of impulses.

Other objects and features will appear hereinafter.

GENERAL DESCRIPTION

The switch structure herein is an improvement on the switch structure shown in the United States patent to George R. Eaton, No. 2,281,564, issued May 5, 1942, while the automatic telephone system utilizing the improved switch structure is an improvement on the automatic telephone system shown in the copending application of George R. Eaton, Serial No. 412,103, filed September 24, 1941, and on the copending applications of Norman H. Saunders, Serial No. 400,990, filed July 3, 1941, and Serial No. 429,232, filed February 2, 1942.

A. The Switch Structure

As shown in the Eaton patent above referred to, a number of separate ten-point automatic switches are controlled by the same common stepping shaft, such shaft being positionable to preliminarily select any one of the ten stackups of contacts in each of the associated switches, the preliminarily selected stackup of contacts in any desired idle switch being then operated by the individual magnet of such switch. The common shaft is thereafter free to select a stackup for operation in any other idle associated switch.

The improved switch structure herein disclosed is such that as many individual switches as desired may be mounted one above the other with their corresponding stackups in vertical alignment. The horizontally disposed rotatable shafts of Eaton are replaced by vertically extending shafts, each of which has a slight angular movement in either of the two directions to select preliminarily one stackup or the other of a pair in each of the switches across the front of which the shaft extends. Five such vertical shafts suffice for a group of switches having ten selective stackups each. Each such shaft is provided with a pair of magnets for giving it its two rotational selective movements respectively.

The improved arrangement enables the individual switches to be assembled more compactly; enables selection of stackups to be accomplished instantaneously by a single shaft movement, rather than by a step-by-step shaft movement; and enables the number of switches whose contacts are to be multipled together to form a section within the group to be chosen as desired, such multipling being accomplished by conductors extending vertically between adjacent stackups.

Other features of improvement in the switch structure will be brought out hereinafter.

B. The System

In the automatic telephone systems shown in the copending Eaton application and in the copending Saunders applications referred to, the use of small-capacity primary and secondary switches as a switching stage is confined to the switching stage called the line-finder stage for originating calls and called the connector stage for terminating calls.

In the Eaton system, the major portion of the selector switching stage is represented by selectors each comprising a number of Eaton's small-capacity switches controlled by a common shaft, each such switch representing a separate choice in any selected group of links. Such a system obviously becomes expensive if a large number of choices is provided for each selector, while efficiency is sacrificed if the number of choices is low.

In the portion of Eaton's selector switching stage used to extend calls to the operator's switchboard, small-capacity primary and secondary switches are used to interconnect the operator trunks with calling ones of the links incoming to the switching stage. When used in this portion of a switching stage, the hunting time of the primary and secondary-finder switches is of little importance, because such hunting is not required to be accomplished in an inter-digit interval.

In the systems disclosed in the copending Saunders applications hereinbefore referred to, no attempt whatever is made to use the small-capacity switches at the selector stage, recourse being had to expensive large-capacity selectors of conventional construction.

The operation of the small-capacity switches disclosed herein is sufficiently rapid that any selector stage may be represented by serially related groups of primary and secondary switches, such groups of switches corresponding respectively to the separately designated groups of links outgoing from such switching stage. The switching arrangement at any group is such that as many choices are offered as there are links outgoing from the group.

The arrangement disclosed herein is such that the required primary and secondary switches at a selector switching stage are operated simultaneously rather than consecutively, thus avoiding adding the small switching time intervals together. The only additional time interval consumed at a selector switching stage is that required for the operation known as matching, which consists in selecting an idle primary switch and a matched idle secondary switch. This matching operation is rapidly accomplished by a small number of fast relay operations, and the total time consumed at the switching stage is well within the inter-digit dialing interval.

Other objects and features of the disclosed automatic telephone system will appear hereinafter.

C. The Drawings

The accompanying drawings, comprising Figs. 1 to 52, show sufficient of the mechanical and circuit apparatus of a telephone system embodying the features of the invention to enable the invention to be understood.

Figs. 1 to 8 show views of a group of individual switches constructed according to the features of the invention, together with the common selecting mechanism and the frame on which the group is mounted;

Fig. 9 shows a switchboard made up of a sufficient number of frames of switches constructed according to Figs. 1 to 8 to provide the groups of switches necessary in a specific automatic telephone system embodying the invention;

Fig. 10 shows the arrangement of exchanges, and the grouping within one exchange, of the specific telephone system in which the invention is embodied;

Fig. 10A, comprising parts 1 to 8, is a schematic showing of the switching arrangement of the local exchange shown in Fig. 10.

Figs. 11 to 50 are circuit drawings of sufficient of the apparatus of Fig. 10A to enable the system to be understood;

Fig. 51 shows how the parts of Fig. 10A are intended to be arranged; and

Fig. 52 shows the intended arrangement of the sheets on which Figs. 11 to 50 are drawn.

DETAILED DESCRIPTION

A. The Switch Structure

The switching equipment shown in Figs. 1 to 8 will now be described. Fig. 1 shows a front view of an upright switch frame with a number of switches mounted thereon, together with their common operating mechanism. The switch frame is of rectangular construction, being composed of vertical side members 1 and 3, and horizontal end members 2 and 4. These frame members may be of U-shaped cross-section, as shown for members 1 and 3 in Figs. 3, 4, and 6.

The frame members 1 to 4 may be cut to desired length from standard U-bar stock and welded together at their points of intersection to form a rigid mounting frame. The rear web of vertical members 1 and 3 may be extended at the top and bottom of the frame to provide lugs 5 to 8 by means of which the frame can be mounted alongside other similar frames to make up a switchboard as shown in Fig. 9.

The front web of frame members 1 and 3 is suitably drilled and tapped to enable individual switches, such as 10, 11, 13, and 14, to be mounted compactly within the frame by bolts 16. All of such switches are identical with each other, and appear in plan view as shown in Fig. 6.

Each of the individual switches has a number of selectable stackups of contact springs S1 to S10. These stackups are arranged in pairs on each of the switches, and the corresponding pairs on the several switches are in vertical alignment, as shown.

Each of the switches is provided with a magnet 34 having an armature 35 arranged to operate any selected one of the selectable stackups of the switch.

Five vertical selecting shafts (1—2, 3—4, 5—6, 7—8, and 9—10) are provided, one for each vertical row of pairs of stackups. These shafts are of a cross-section seen best in Fig. 6. Each shaft carries a longitudinal blade 23, such as may be provided readily in one piece with the shaft by the forming process known as extruding. The fifth shaft (9—10) is shown in profile view in Fig. 2.

As will later appear, selection of one or the other of the two vertically aligned rows of stackups associated with a shaft may be effected by a slight turning movement of the shaft in the corresponding direction from its normal position, such turning movement being through an angle of about ten degrees, for example.

Selecting magnets M1 to M10 are provided in five pairs for performing the turning movements of the shafts pursuant to selection. Each shaft is provided with a double armature 17 near its end. Such armature has one end adapted to extend in front of one selecting magnet of a pair to turn the shaft in one direction, and another end adapted to extend in front of the adjacent operating magnet of the pair to turn the shaft in the other direction. The pairs of selecting magnets for alternate shafts (beginning with the first) are located at the top of the frame, while the pairs of operating magnets for the remaining shafts are located at the bottom of the frame.

The magnets M1 to M10 are secured to detachable brackets 9 and 15. These brackets serve also as bearing plates within which the shafts are journaled at their reduced end portions.

A plan view of bracket 9, with its associated equipment, is shown in Fig. 3, while a bottom

view of the same bracket is shown in Fig. 4. As may be seen in Fig. 4, the magnets M2, M1, M6, M5, M10, and M9 are mounted on a downwardly extending integral portion of bracket 9 at the rear thereof, with the front of the magnets in suitable location for attraction of the associated double armatures 17 in either direction, depending upon which magnet of a pair is energized.

Each selecting shaft has a restoring cam 18 adjustably attached thereto by a set screw. As seen in Fig. 3, each such cam has a V-shaped notch into which the roller 20 of the associated cam spring 19 rides. The springs 19 are fastened respectively in cam-spring brackets 22, located on the rear portion of mounting brackets 9 and 15. Each cam spring 19 is tensioned to hold its roller 20 normally in the bottom of the V notches of the associated cam 18. When any of the shafts is turned in either direction, the concerned shaft roller 20 rolls up the corresponding side of the notch in the cam against the tension of its cam spring 19. Spring 19 brings the roller promptly to the bottom of the notch when the magnet is deenergized, restoring the shaft promptly to its normal position.

Each of the cam-spring brackets also contains a pair of off-normal springs 21, the innermost one of which has an insulating bushing adapted to be engaged by restoring spring 19 to close the off-normal contacts 21 slightly before the shaft reaches its operated position in either direction. Off-normal springs 21 are used to close control circuits for purposes which will appear hereinafter.

An intermediate-bearing bracket 12 (Fig. 1) is provided. This bracket is shown in plan view at Fig. 5. It provides split bearings for the selecting shafts, one-half of each bearing being in the main bracket portion 12, while the other half of each bearing is in the removable portion 24, attached to part 12 by screws 25. As shown in Fig. 2, the blade 23 of the shafts is removed at the location of the intermediate bearing bracket 12, as well as for a suitable distance from each end of the shaft.

At this point, the intended operation of the switching arrangement is described briefly. When any one of the individual switches mounted on the frame shown in Fig. 1 is to be operated, the desired one of the five selecting shafts is turned in the desired direction whereby the corresponding one of the ten vertical rows of stackups of contacts (one stackup in each individual switch) is selected. Such selection has no effect on the stackups of any switches already operated, and has no immediate effect on the stackups of any unoperated ones of the switches.

Following the making of the selection, the operating magnet 34 of a desired individual switch is energized, causing operation of the selected stackup of contacts of such switch, the other selected stackups being unaffected. The magnet 34 is maintained energized for as long a time as it is desired to have the operated condition of the individual switch to continue, but the common selecting shaft is promptly restored to terminate the selection made by its operation.

Fig. 6, taken along line 6—6 of Fig. 1, shows a plan view of individual switch 14 (Fig. 1), similar to the other individual switches. Switch 14 has selective stackups S1 to S10, and common stackup SC, mounted thereon. Such stackups are actuatable by plate 40, actuatable in turn by armature 35 of magnet 34. Actuating plate 40 lies within the cut-away front portion of the switch frame, reducing the required vertical height to this extent. Plate 40 carries upturned pivot ears 41 and 42, and fixed ears 38 and 39 are provided on the switch frame. Pivot pin 43 passes through all these ears to retain plate 40 pivotally in place. The one end of pin 43 may be provided with a retaining head as indicated, while the other end may be bifurcated and bent outwardly, as at 44, to retain the pin removably in place.

Plate 40 has an actuating extension 46 which overlies the rear end of the generally L-shaped armature 35. The cooperating portion of armature 35 may be offset downwardly, as indicated, by an amount about equal to the thickness of plate 40 and extension 46, while extension 46 may be offset upwardly, as indicated, by an amount substantially equal to the thickness of the armature material. Armature 35 has an opening through which stud 27 extends. Retaining nut 36, threaded on stud 37, retains armature 35 pivotally in place.

When magnet 34 is energized, it attracts the downwardly extending portion of armature 35 (seen in profile view in Fig. 8) drawing this armature portion inwardly, and raising the horizontal portion of the armature to thereby rotate the plate 40 about pivot pin 43. The springs in the common stackup SC, and the springs in any selected one of stackups S1 to S10 are thereby actuated. When magnet 46 is deenergized, plate 40 falls of its own weight and restores armature 35.

Fig. 7 is a right-side view taken along the line 7—7 of Fig. 6 to show the common stackup SC of Fig. 6. The vertical frame member 2 and a portion of the frame of the switch 14 are sufficiently broken away to give an unobstructed side view of the stackup SC and of actuating plate 40. Portions of the switch 14 are omitted in this view for clarity.

Stackup SC includes a pair of "make" contact springs 75 and 76 and a pair of "break" contact springs 73 and 74, all actuatable by plate 40. Stackup SC includes also a pair of normally closed cut-out springs 71 and 72 which are not actuatable by the plate 40, but are adapted to be opened manually, as by the insertion of a piece of insulating material of suitable thickness between the front and ends of the contact springs 71 and 72 to separate the contacts thereof.

Contact springs 73 to 76 are controlled by a bushing 77. The lower end of this bushing rests on the top surface of actuating plate 40, while the upper end of this bushing is normally just below the lower surface of the upper contact spring 73. Contact springs 73 and 74 are thus normally in contact with each other, and contact springs 75 and 76 are normally out of contact with each other. Bushing 77 is secured to spring 76, as indicated, but passes freely through springs 74 and 75, each of which is bifurcated as shown in Fig. 6 for the top springs of the stackups S1 to S10.

Whenever plate 40 is raised about the pivot pin 43, bushing 77 is thereby moved upwardly. The contact carried on the front of spring 76 is thereby brought into engagement with the contact carried by spring 75. At the same time the upper end of bushing 77 engages spring 73 and brings it out of contact with spring 74. These springs assume their normal position when armature plate 70 is released and allowed to return to its illustrated normal position. It will be understood, of course, that the number and arrangement of actuatable contact springs in stackup SC may be varied according to individ-

ual circuit requirements, depending upon the function to be performed by the switch with which the stackup is associated.

Fig. 8, taken along the line 8—8 of Fig. 6, illustrates stackup S10 of the switch 14 in profile view. The selective stackups S1 to S10 of Fig. 6 are each so arranged that it is not normally actuated by the upward movement of plate 40. The lower spring of each of these stackups is a support spring, normally resting on the upwardly turned support ledge 45, which extends across the frame below the stackups S1 to S10, but stops short of extending below the common stackup SC. In Fig. 8, the lower spring 48 of stackup S10 can be seen to be resting on the upstanding ledge 45, maintaining the stackup sufficiently above the level of actuating plate 40 that the stackup is out of the direct reach of the actuating plate, and is thus not directly actuated by an upward movement of such plate.

The lower spring 48 in stackup S10 is merely a supporting and actuating spring. Stackup S10 includes four springs 55 to 58 which may be termed "armature" springs, in that they are to be directly moved when the stackup is actuated. Springs 59 to 62 are termed "make" springs, being paired respectively with armature springs 55 to 58.

Each of the armature springs 58, 57, and 56 carries a bushing as illustrated, whereby armature springs 55 to 58 and support spring 49 can be moved upwardly as one. These bushings do not touch the "make" springs 60, 61, and 62, but pass freely between the branches thereof, the latter springs having a bifurcate shape as shown in Fig. 6 for the top springs of the selective stackups.

When support spring 48 is raised upwardly by an action to be subsequently described, armature springs 55 to 58 are raised into engagement with their respective make springs 59 to 62. The four pairs of contacts thus closed may correspond respectively to those leads in a telephone system which are commonly referred to as tip, ring, sleeve, and hold (T, R, S, and H).

For the purpose of enabling any one of the stackups S1 to S10 of switch 14 to be selected and operated, five selecting fingers 30 are provided as seen in Fig. 6, one such finger for each of the common operating shafts, these fingers may be formed of thin strip material, and they lie directly on actuating plate 40, being held pivotally in place by shoulder screws 29. Each of the selecting fingers 30 is adapted to be rotated a small angular distance to the left or to the right to select and render operable one stackup or the other of the associated pair. Each of the fingers 30 carries a pair of upstanding actuating blades 31, one such blade for each associated stackup. As shown, fingers 30 are normally so positioned that, when plate 40 is actuated, the blades 31 pass upwardly alongside the associated stackups without causing operation thereof, unless one of the fingers 30 has been rotated either to the right or to the left. Considering finger 30 associated with stackups S5 and S6, when this finger 30 is moved in a clockwise direction, the left-hand upstanding blade 31 thereof comes below stackup S5 to thereby select and render this stackup operable by plate 40. When this finger 30 is rotated in a counterclockwise direction from its normal position, the right-hand upstanding portion 31 thereof is brought beneath stackup S6 to thereby select this stackup and render it operable by plate 40. The desired turning of any one of the fingers 30 to the right or to the left is controlled by the common shafts 1—2 to 9—10, shown in section in Fig. 6.

Each of the selecting fingers 30 has a pair of control levers 26 assembled therewith to serve as a yielding coupling between such finger and the blade 23 of the associated shaft. The levers 26 are yieldably assembled with the fingers 30 to enable the common shaft to return to its normal position after an operation of a stackup in any one of the switches, while leaving the selecting finger 30 in an off-normal position for so long a time as the selected stackup of a switch is to remain in operated position. This yielding arrangement is provided by loosely assembling the two similar control levers 26, one above the other on top of the selecting finger 30 and around the same pivot screw 28. The finger 30 and the two assembled levers 26 are thus each independently rotatable around the pivot screw 28.

Each of the fingers 30 has an upstanding positioning blade 28 at the front portion thereof adjacent the shaft blade 23. This upstanding blade 28 lies between the levers 26. It is through this blade 28 that the associated finger 30 is moved either to the right or to the left to select one of the associated stackups and is later returned to its normal position. Each of the pairs of levers 26 is provided with a generally hairpin-shaped tension spring 27, seen in front view in Fig. 1, and in profile view in Fig. 8. Each such spring 27 normally urges the associated levers 26 toward each other to grasp the upstanding blade portion 28 of the selecting finger 30 between them. By this arrangement, when any one of the shafts is turned in either direction, the corresponding one of the levers 26 is thereby directly rotated around the associated pivot screw 29. The tension spring 27 causes the other lever 26 to follow, thereby rotating the associated selecting finger 30, through the consequent movement of the upstanding blade 28. When any one of the selecting fingers 30 is held from returning to its normal position when the associated shaft restores, the concerned levers 26 are merely forced apart against the tension of the light hairpin spring 27. The return movement of the common shaft is thus not materially interfered with, and the consequent tensioning of hairpin spring 27 insures that the off-normal selecting finger 30 will return to normal position when subsequently released.

Referring to Fig. 6, when shaft 9—10 associated with stackup S10 is rotated in a clockwise direction (as seen in Fig. 6, by an energization of magnet M10, Fig. 1), blade 23 directly moves the right-hand one of the levers 26 of switch 14 (along with the corresponding parts of all the other switches), whereby the other lever 26 is caused to follow by the tension of the hairpin spring 27. The selecting finger 30 is thereby rotated through the consequent movement of the upstanding front blade portion 28 thereof. The upstanding selecting blade 31 (shown also in Fig. 8) is thereby brought underneath the end of support spring 48 (Fig. 8) of stackup S10. Under this condition, switch magnet 34 may be energized to attract its armature 35, thereby raising actuating plate 40 through the medium of extension 46. Selecting finger 30 is moved upwardly along with its effective selecting blade 31. Such blade 31 engages the lower side of support spring 49, raising spring 49 upwardly sufficiently to bring armature springs 55 to 58 into contact re-

spectively with their associated make contact springs 59 to 62.

In the intended operation of the device, magnet 34 remains energized, but the common shaft-operating magnet is promptly restored to permit the shaft to restore to normal position.

The restoration of the shaft to normal position causes the associated fingers 30 in all unoperated switches to restore to normal position. In the operated switch 14 of Figs. 6 and 8, however, the selecting finger 30 associated with the shaft under discussion is not restored to normal position when the shaft 9—10 restores, for the selecting blade 31 shown in Fig. 8 is retained by the illustrated downwardly extending catch portion 49 of support spring 48. The concerned selecting finger 30 is thereby prevented temporarily from rotating around its pivot screw 29 to normal position under the tension of spring 27. The selected stackup S10 is thus held actuated so long as magnet 34 remains operated.

When magnet 34 is subsequently deenergized to allow armature 35 and plate 40 to restore, the contact springs in stackup S10 are thereby restored to their illustrated normal condition, whereupon the concerned selecting blade 31 of the off-normal finger 30 is disengaged from catch 49 of spring 48 and is allowed to return immediately to its normal position illustrated in Fig. 6, under the control of its restoring spring 27.

As shown in Fig. 6, each selecting finger 30 has a downwardly extending stop blade 32, which lies within a limit hole 33 in plate 40. Each such hole 33 is of suitable size to permit the left and right selecting movement of its finger 30 to occur unopposed, but when a shaft is removed for any purpose, the stops 32 cooperate with the walls defining holes 33 to limit the rotation of the fingers 30 from normal position, whereby such fingers remain close to normal position, and the removed shaft may be readily inserted, the forward ends of fingers 26 being beveled outwardly as shown to facilitate reentry of shaft blade 23 between them. The arrangement of the selective stackups in pairs, with ample spacing between pairs, enables inspection and adjustment of the contact springs of the several stackups to be made readily.

The spacing apart of the pairs of stackups also facilitates attaching and soldering of vertical bare-wire multiples extending between corresponding stackups of the concerned switches. For this purpose, the rearwardly extending terminal portions of the "make" contacts in the selective stackups are provided with laterally projecting terminal lugs as seen best in Fig. 6. These laterally projecting lugs for the tenth stackup S10 are shown at 63 to 66 in Fig. 8. Each such lug is provided with an indentation or notch into which the vertically extending multpling wire may be laid and soldered. Additionally, a rear attachment notch is provided on each terminal portion to which a conductor can be connected to extend the multiple to the desired point. The four make springs in any stackup are specifically different. The lug on each is at a different horizontal distance from the end thereof, to bring each stackup group of bare multipling conductors in a vertical plane at right angles to the face of the switchboard. Additionally, such contact springs are made in lefts and rights; that is, the side lugs on each odd-numbered stackup extend to the left, while the lugs on each even-numbered stackup extend to the right, as shown.

The make springs in the stackups S1 to S10 of any switch comprise ten separate outlets. The armature springs of stackups S1 to S10 of any switch are multipled together horizontally, and provided with common terminals 67 to 70 constituting the inlet of the switch. The horizontal multipling is accomplished by forming the armature springs of the selective stackups as forward integral extensions of strips extending laterally through the clamping portions of stackups S1 to S10. Such strips are 51 to 54, having inlet terminals 67 to 70, respectively. The inlet terminals 67 to 70 are offset laterally to the rear of the common stackup SC to clear the adjacent field in which the vertical bare-wire multipling of stackup S10 is accomplished.

Fig. 9 shows a switchboard comprising switches as disclosed in Figs. 1 to 8 arranged in the specific groups required in the telephone exchange whose circuit arrangements are herein disclosed. This switchboard includes switch frames F1 to F18, each constructed as shown in Fig. 1. These frames are attached to floor bar 902 and to top bar 901.

Various sized groups of individual switches are mounted on these frames to meet the requirements to appear hereinafter. The frames are all of the same length, sufficient to accommodate seventy-two individual switches and the common selecting mechanism, as is required for groups 2SP and 3SP, mounted on frames F11 and F12.

Frames F1 and F2 accommodate groups 2LP and 3LP, each of which has sixty switches.

Frame F3 accommodates two separate groups 2LS and 3LS, each of which contains 32 switches. Each of the groups 2LS and 3LS has its own separate set of shafts supported on upper and lower brackets such as 9 and 15 in Fig. 1. Similarly, frames F4 to F8 and F13 to F18 accommodate two groups each, while frame F9 accommodates the four nine-switch groups 4D to 7D.

It will be clear that two physically separate groups of switches, each with its own separate set of control shafts and common actuating magnets, can be made to operate as a single group by suitably interconnecting the operating magnets of the two groups whereby corresponding magnets in the two groups may be energized at the same time. The necessity for such provision, however, is avoided in the layout shown in Fig. 9 where the mounting frames are each long enough to accommodate the maximum number of switches required in any one group.

B. The System

As shown in Fig. 10, the automatic telephone system to which the invention is applied herein includes two automatic exchanges. One automatic exchange is termed the local automatic exchange, while the other is termed automatic exchange #9 in that it is reached from the local automatic exchange responsive to the dialing of the initial digit 9.

As is indicated in Fig. 10, there are twenty-five trunk lines incoming from automatic exchange #9 to the local exchange, and twenty-seven trunk lines outgoing from the local exchange to automatic exchange #9.

Additionally, a toll switchboard is shown in Fig. 10 which is reached from the local automatic exchange responsive to the dialing of the digit 0. As indicated, this toll switchboard is interconnected with the local automatic exchange by six trunk lines incoming to the local

automatic exchange and by six other trunk lines outgoing therefrom to the toll switchboard.

The local automatic exchange of Fig. 10 is one having a nominal capacity of one thousand lines. Only 600 lines, however, are at present provided for, being served by the hundreds groups of switching equipment 2 to 7.

The selector stage required in a one-thousand line exchange is indicated within the local automatic exchange of Fig. 10 by the rectangle labeled "Selector stage." Fig. 10 shows that there are sixteen link paths leading to the selector stage from each of the hundreds groups 2 and 3, nine from each of the hundreds groups 4 to 7, twenty-five from automatic exchange #9, and six from toll switchboard #0. This drawing indicates also that the groups of link paths leading from the selector stage and corresponding respectively to the initial dialed digits 2 to 7, 9, and 0 comprise sixteen link paths leading to each of the hundreds groups 2 and 3, nine link paths leading to each of the hundreds groups 4 to 7, twenty-seven link paths leading to automatic exchange #9, and six link paths leading to toll switchboard #0.

Hundreds groups 2 and 3 of the local exchange are similar in that each contains individual lines and P. B. X lines, while hundreds groups 4 to 7 of the local exchange are required to serve individual lines and four-party lines.

The present requirements of hundreds groups 2 and 3 is that each shall contain sufficient links and switching equipment that fifteen originated connections and fifteen terminated connections may be established contemporaneously in each.

The present requirements with respect to each of the hundreds groups 4 to 7 is that it contain sufficient links and switching equipment that eight originated connections and eight terminated connections may be established contemporaneously in each.

C. The Switching Diagram

The switching diagram shown in Fig. 10A, parts 1 to 8, will now be explained.

C1. The Line-Finder and Connector Switching Stage

The switching equipment for the line-finder and connector stage of hundreds group 2 comprises the primary line-finder switch group 2LP of Fig. 10A, part 1, and secondary line-finder switch group 2LS of Fig. 10A, part 2. These are the switch groups shown at 2LP and 2LS of Fig. 9 on the frames F1 and F3.

Connections originated in hundreds group 2 may be extended over the sixteen selector links in the associated branch of selector cable CA—1200, being selector links SL1 to SL16. The number of these links has been increased by one from the required fifteen to give a latitude in the event of abnormal traffic peaks, as well as to provide for those cases when one of the selector links assigned to the hundreds group for outgoing service cannot be used because of the inability to match such link with an idle primary switch in the calling ten-line group.

The connections terminating in hundreds group 2 come into the group over the sixteen incoming links represented by cable CA—1950 incoming to secondary switch group 2LS. Here again, the required group number of fifteen is increased by one for reasons above stated.

The switching arrangement within hundreds group 3 is only partially shown in Fig. 10A, but is similar to that for hundreds group 2. The switch groups for hundreds group 3 are shown at 3LP and 3LS on frames F2 and F3, Fig. 9. The calls outgoing from hundreds group 3 are handled over the sixteen selector links SL17 to SL32.

The primary and secondary switching apparatus for hundreds group 4, as shown in parts 1 and 2 of Fig. 10A, comprises primary group 4LP and secondary group 4LS. These switch groups are shown on the switchboard drawing, Fig. 9, at 4LP and 4LS on switch frame F4.

The required outgoing connections from hundreds group 4 may be established through switch group 4LS by way of the sixteen links in the associated branch of cable CA—1200 comprising selector links SL33 to SL41. The required number (8) has been increased by one as a safety margin for reasons above discussed.

Connections incoming to hundreds group 4 may be established through switch group 4LS by way of the nine links in the associated cable CA—3250, the required number having been increased from eight to nine to provide a margin of safety as hereinbefore discussed.

The switching arrangement for connections outgoing from and incoming to each of the hundreds groups 5 to 7 is similar to that provided for hundreds group 4, hundreds groups 5 to 7 being only partially indicated. The primary switching groups for hundreds groups 5 to 7 are shown at 5LP to 7LP on frames F5 to F7 (Fig. 9), on which frames are also shown the secondary groups 5LS to 7LS for the same hundreds groups.

The calls outgoing from hundreds group 5 are handled over the selector links SL42 to SL58 in cable CA—1200; those from hundreds group 6 are handled over selector links SL51 to SL59; and those from hundreds group 7 are handled over selector links SL60 to SL68.

The twenty-five trunk lines incoming from automatic exchange #9, Fig. 10A, part 3, comprise selector links SL69 to SL93 in cable CA—1200, and those incoming from toll switchboard #0 comprise selector links SL94 to SL99 in cable CA—1200. The total present selector-link requirements of the exchange is thus ninety-nine selector links SL1 to SL99. These selector links extend respectively to selectors S1 to S99 (Fig. 10A, part 6), shown in groups of ten selectors each. Future requirements of the system with respect to selector links and selectors are provided for by installing selector links SL100 to SL120 associated respectively with selectors S100 to S120, which may be used for future growth, as when an additional hundreds group is installed (hundreds group 8, for example) and also to take care of increased traffic requirements from any of the present hundreds groups.

The selectors above referred to are each similar to selector S1, shown in detail in Fig. 11. It is to be observed that such a selector consists merely of a group of link-control and digit-impulse counting relays.

Referring again to switch groups 2LP and 2LS (parts 1 and 2 of Fig. 10A) which serve hundreds group 2, it is to be observed that switch group 2LP is divided into ten primary sections numbered 1 to 0 respectively. Each such section includes six primary switches all having access to the same tens group of lines. For example, group 1 comprises switches 1A to 1F which have access in common to lines 11 to 10 of the hundreds group; section 2 of switch group 2LP comprises

the six primary switches 2A to 2F which have access to lines 21 to 20 of the group; and, finally, the tenth or 0 section comprises the six primary switches 0A to 0F which have access to the tens group of lines 01 to 00.

Any one of the switches in any section of the primary switch group 2LP may be used to complete either an originating or a terminating connection. The number of switches in a section depends, therefore, upon the total peak requirements of the tens group of lines, for calls both outgoing and incoming. Six switches have been provided in each primary section in the 2 and 3 hundreds groups on the basis of a peak requirement of six connections in a tens group, whether originated, terminating, or both.

The switches in secondary group 2LS are divided into as many sections (six in this case) as there are primary switches in a section of group 2LP. The sections in group 2LS are designated A to F respectively. As indicated, the switches in section A of 2LS have common access, through the ten links (1 to 0) of cable 2LA, to the A primary switches 1A to 0A in group 2LP. Similarly, the switches in secondary section B have access (through the ten links of cable 2LB) to the ten B primary switches in group 2LP; link cables 2LC, 2LD, and 2LE are associated respectively with secondary sections C, D, and E of group 2LS and contain the links extending to the correspondingly lettered switches in primary sections 1 to 0; and cable 2LF contains the ten primary links rendering primary switches 1F to 0F accessible in common to the switches in section F of secondary group 2LS.

By the above arrangement, each secondary section of switches has access in common to one primary switch in each primary section. Any secondary switch in group 2LS can thus complete connection, through a primary switch, to any subscriber line in the hundreds group.

Since secondary group 2LS must accommodate sixteen outgoing paths (represented by selector links SL1 to SL16), and must also accommodate sixteen incoming paths (represented by the sixteen links in cable CA—1950), the total switches required in secondary group SL2 is thirty-two. These thirty-two switches are provided by six switches in section A, five switches in each of the groups B to E, and six switches in group F.

The first four switches in section A of group 2LS are assigned to outgoing service, being choices 1 to 4. The remaining twelve of the sixteen outgoing choices are switches B1 to B3, C1 to C3, D1 and D2, E1 and E2, F1 and F2.

The remaining switches in sections A to F of group 2LS are assigned to incoming service, the choice being in reverse order.

The first four choices for incoming service are the sixth to second switches in section F. The remaining twelve of the sixteen incoming choices are switches E5 to E3, D5 to D3, C5 and C4, B5 and B4, A6 and A5.

In group 4LP assigned to the 4 hundreds group of lines, the lighter traffic requirements permit each tens group of subscriber lines to be served by a primary section of four switches, the switches in group 4LP being those numbered 1A to 1D, 2A to 2D, and so forth, to 0A to 0D.

There being only four primary switches to a section in group 4LP, the switches in group 4LS are divided into only four corresponding sections, sections A to D. The eighteen switches required in group 4LS are made up of five switches in section A, four in each of the sections B and C, and five switches in section D. The outgoing choices 1 to 9 in group 4LS are respectively the first three switches in section A, and the first two in each of the sections B, C, and D. The nine incoming choices in sections D to A of group 4LS are respectively switches 5 to 3 in section D, 4 and 3 in each of sections C and B, and switches 5 and 4 in section A.

C2. The Selector Stage

The switch groups at the selector switching stage of Fig. 10 are the selector-primary groups 2SP to 7SP (Fig. 10A, part 7), 9SP, and 0SP (Fig. 10A, part 8), shown in Fig. 9 at 2SP to 7SP, 9SP, and 0SP, on frames F11 to F18; and selector-secondary groups 2SS to 7SS (Fig. 10A, part 4), 9SS, and 0SS (Fig. 10A, part 5), shown in Fig. 9 at 2SS to 7SS, 9SS, and 0SS on frames F10, F13 to F16, F18, and F17.

As shown in Figs. 11 and 12 for the selectors S1, S33, S69, and S94, the selector links SL1 to SL120 hereinbefore referred to are paired respectively with selector multiples SM1 to SM120, as indicated in Fig. 10A, part 6. Each of the selector multiples comprises three conductors referred to respectively as tip, ring, and sleeve conductors (T, R, and S). As shown in Fig. 10A, the selector multiples are divided into groups of ten multiples each, corresponding to the capacity of the ten-point primary switches used at the selector switching stage. These groups are SM1 to SM10, SM11 to SM20, and so forth, to SM111 to SM120. The twelve groups of selector multiples extend horizontally from the twelve groups of selectors into multiple connection with the respective twelve sections into which the primary switches in groups 2SP to 7SP are divided.

Multiples SM69 to SM93 (representing the selector links SL69 to SL93, which carry traffic incoming from automatic exchange #9) are not required to be multipled into primary group 9SP through which outgoing calls to exchange #9 are made, leaving only ninety-five selector multiples to be provided for in group 9SP. The selector multiples connected to group 9SP are the six groups comprising multiples SM1 to SM60, a partially filled seventh group comprising multiples SM61 to SM68, a partially filled eighth group comprising multiples SM94 to SM100, and the ninth and tenth groups comprising multiples SM101 to SM120.

Likewise, the selector multiples SM69 to SM93 are not required to be multipled into switch group 0SP, which handles calls to toll switchboard #0. Additionally, selector multiples SM94 to SM99 (which handle calls incoming from the toll switchboard) do not have to be multipled into switch group 0SP. Therefore, only nine groups of the selector multiples need to be extended to the switch group 0SP. The first six of these groups comprise selector multiples SM1 to SM60; the incompletely filled seventh group comprises multiples SM61 to SM68 and SM100; and the eighth and ninth groups comprise selector multiples SM101 to SM120.

Referring particularly to switch group 2SP (through which connections destined for the seconds hundreds group in the local exchange are made with selector multiples SM1 to SM120), the switches in this group are divided into twelve sections. The switches 1A to 1F in section 1 of group 2SP have common access to selector multiples SM1 to SM10; the switches 2A to 2F in section 2 have common access to selector multiples SM11 to SM20; and so forth, to the switches

in section 12 of group 2SP, which have common access to selector multiples SM111 to SM120.

The number of switches in any of the twelve sections of group 2SP is required to be at least sufficient to handle the peak number of connections which may be required from the associated group of ten selector multiples into the associated 2 hundreds group. The number of switches illustrated herein in each section of group 2SP is six. This number is believed to be more than ample. The sixteen link paths leading to the associated hundreds group 2 (from secondary switch group 2SS) are approximately sixteen percent of the total number of link paths leading from the switching stage. Yet, the arrangement shown enables sixty percent of the calls made over any single group of ten selector multiples to be extended to such hundreds group. The allowance for variation is thus about four to one.

The sixteen switches A1 to F2 in the corresponding secondary group 2SS are divided into as many sections (six) as there are switches in a single section in the selector primary group 2SP. Sections A to D have three switches each, while sections E and F have two each.

The switches in section A of group 2SS have common access to twelve links in cable 2SA, leading respectively to the A switches (1A to 12A) in sections 1 to 12 of group 2SP; and the switches in sections B to F have access through the links in cables 2SB to 2SF to the switches B to F in the twelve sections of group 2SP.

Switch groups 3SP and 3SS are arranged and interconnected in the same way as switch groups 2SP and 2SS.

The switches in primary group 4SP are divided into twelve sections, with the switches in each section having common access to a separate one of the twelve groups of selector multiples. Since there are only nine link paths (less than ten percent of the total) leading from the selector switching stage into the associated 4 hundreds group, the switches in a section in group 4SP have been reduced from six (as in 2SP and 3SP) to four. It is extremely unlikely that any group of ten selector multiples will receive more than four calls destined for the hundreds group 4, as the average for a full loaded group of ten selector multiples is less than one call for the concerned hundreds group.

The nine switches in selector-secondary group 4SS are divided into as many sections (four) as there are switches in a section in group 4SP. Section A of group 4SS contains three switches and sections B to D contain two switches each.

Sections A to D of selector-secondary group 4SS have access through cables 4SA to 4SD to the switches in selector-primary group 4SP.

The arrangement of the switches in selector-secondary groups 5SS to 7SS and in the selector-primary groups 5SP to 7SP is similar to the arrangement groups 4SS and 4SP.

The switches in the selector primary group 9SP are divided into ten sections corresponding respectively to the ten groups of selector multiples through which calls may be received for the associated automatic exchange #9. Since the twenty-seven link paths outgoing from the local automatic exchange to automatic exchange #9 comprise less than thirty percent of the total link paths outgoing from the selector switching stage, the average number of calls outgoing to automatic exchange #9 from any full-loaded group of ten selector multiples is less than three. It is, therefore, considered that not more than six calls outgoing through switch group 9SP will be offered by any single group of ten selector multiples. The group 9SP, therefore, is accordingly provided with six switches for each of the ten sections. These switches are identified as switches A to F in any section, being switches 1A to 1F in section 1, and 10A to 10F in section 10.

The twenty-seven switches in secondary group 9SS, corresponding respectively to the twenty-seven link paths outgoing to automatic exchange #9, are divided into six sections A to F, corresponding to the number of switches in a section in the associated selector primary group 9SP. There are five switches in each of the sections A to C of group 9SS, and four switches in each of the sections D to F.

The switches in section A of group 9SS have common access, through the ten links in cable 9SA to the ten A switches (1A to 10A) in selector-primary group 9SP, while the switches in sections B to F of group 9SS have access, through the links in cables 9SB to 9SF, to the B to F switches in group 9SP.

Calls for the toll switchboard #0 are handled through the switches in selector primary group 0SP, divided into nine sections corresponding respectively to the nine groups of selector multiples over which calls for the toll switchboard may arrive. Each of the nine sections of group 4SP comprises four primary switches.

The six switches in selector-secondary group 0SS, corresponding respectively to the six link paths outgoing to the toll switchboard, are divided into four sections A to D corresponding to the number of switches to a section in the associated selector primary group 0SP. There are two switches in each of sections A and B of group 4SS, and one switch in each of the sections C and D. The sections of group 0SS have access over the links in cables 0SA to 0SD to the switches A to D in the respective sections of group 0SP.

C3. The Outgoing Repeaters

The repeaters 9R1 to 9R27 are inserted respectively in the twenty-seven trunk lines outgoing from the switches in selector secondary group 9SS to the associated automatic exchange #9, and repeaters 0R1 to 0R6 are inserted respectively in the six trunk lines outgoing from the switches in secondary group 0SS to the associated toll switchboard. All of these repeaters may be similar, repeaters 9R1 and 0R1 being shown in the circuit drawings, Figs. 40 and 46.

C4. The Selectors

As previously noted, selectors S1 to S120 are indicated (in part 6 of Fig. 10A) in groups of ten each, there being one selector for each selector link and associated selector multiple. As shown in Fig. 11, each of these selectors comprises essentially a group of control relays and a group of digit-impulse counting relays. The counting relays count the received impulses constituting the initial digit in a called number. The counting relays of any operated selector energize a start conductor and a mark conductor associated with the called group of selector-primary and selector-secondary switches to cause the necessary apparatus of the called group to be started into operation to select the associated selector multiple by selector-primary and selector-secondary action as will be hereinafter described.

C5. The Selector Common Equipments

Each of the selector groups 2 to 7, 9, and 0 is provided with a selector common equipment for controlling the associated groups of selector-primary and selector-secondary switches, according to the starting and marking information imparted thereto from time to time by the selectors S1 to S120. This information is imparted over the conductors in cable CA—1300, which includes a separate mark conductor and a separate start conductor for each of the selectors, extending to each of the selector groups of primary and secondary switches.

The selector common equipment for selector group 2 is 2SCE, while common equipments 4SCE, 9SCE, and 0SCE are shown for selector groups 4, 9, and 0 respectively. It will be understood, of course, that selector group 3 (comprising switch groups 3SS and 3SP) is provided with a common equipment similar to 2SCE, while selector groups 5 to 7 are each provided with a common equipment similar to 4SCE.

C6. The Connectors

Each of the links extending from an individual switch of Fig. 10A in the selector secondary groups 2SS to 7SS extends to a connector associated with the concerned hundreds group of lines. The sixteen connectors associated respectively with the switches in group 2SS are indicated at 2C1 to 2C16, while the nine connectors associated respectively with the switches in group 4SS are shown at 4C1 to 4C9. The circuit arrangements of connector 2C1 are shown in detail in Figs. 20 and 21, while the circuit arrangements of the party-line connector 4C1 are shown in detail in Figs. 33 and 34. Each of these connectors includes essentially a group of control relays and a sufficient number of groups of counting relays to count the series of digit impulses necessary to identify the called substation in the concerned hundreds group. Only tens and units groups of counting relays are required in the connectors such as C1 assigned to the P. B. X, and straight-line hundreds groups 2 and 3, while tens, units, and party groups of counting relays are required in each of the connectors such as 4C1 assigned to the four-party-line and individual-line hundreds groups 4 to 7.

C7. The Line Common Equipments

Each of the hundreds groups of lines in the local exchange is provided with a line common equipment for controlling primary and secondary line-finder action on originated calls, and for controlling secondary and primary connector action and distributor action on terminating calls. The line common equipments for hundreds groups 2 and 4 are shown at 2LCE and 4LCE in Fig. 10A, part 2. Cable CA—1900 carries tens and units conductors associated with the group-2 connectors 2C1 to 2C16 to common equipment 2LCE, while cable CA—3200 carries tens and units conductors associated with the group-4 connectors 4C1 to 4C9 to the common equipment 4LCE. Other conductors in cable CA—1900 connect common equipment 2LCE with each of the switch groups 2LP and 2LS, as well as with the distributor group 2D. Similarly, common equipment 4LCE is connected with each of the associated switch groups 4LP, 4LS, and 4D.

C8. Distributors

Distributor groups 2D to 7D are associated respectively with hundreds groups 2 to 7. They contain switches operative to interconnect the connectors in calling condition with matched paths through the associated line-secondary and line-primary groups to the respective called lines. In connection with the distributors 2D and 3D, the so-called graded trunking principle is employed because the number of link paths (sixteen) leading from the connectors into the respective line-secondary groups are in excess of the number of selective positions (ten) of the distributors. In the case of the distributor 2D, the sixteen link paths are those contained in cable CA—1950 leading to line-secondary switches in group 2LS. As indicated in part 4 of Fig. 10A, stackups 1 to 6 of distributor switches 2D1 to 2D8 provide link paths to six of the sixteen connector-action secondary switches in group 2LS; stackups 1 to 6 of distributor switches 2D9 to 2D16 provide access to six other of the associated connector-action secondary switches; and stackups 4 to 10 of all the distributors 2D1 to 2D16 provide link paths to the final four connector-action secondary switches in group 2LS.

As indicated in Fig. 19, wherein the stackups of switches 2D1 and 2D9 are shown in detail, the six odd-numbered connector-action choices 1 to 11 are through stackups 1 to 6 of distributors 2D1 to 2D8; the even-numbered connector-action choices 2 to 12 are through stackups 1 to 6 of distributors 2D9 to 2D16; while the final four choices 13 to 16 are through stackups 6 to 10 of all of the distributors 2D1 to 2D16.

D. The Circuit Drawings

The relation of the equipment shown on the circuit drawings, Figs. 11 to 50, to the switching diagram shown in Fig. 10A, is as follows:

Figs. 11 to 13 show the selectors S1, S33, S69, and S94 together with the terminal blocks in Fig. 13 to which the associated start and mark conductors are connected;

Figs. 14 to 17 show the line common equipment 2LCE for hundreds group 2;

Figs. 18, 19, 20 and 21, and 22 show respectively certain switches of the line-primary group 2LP of Fig. 10A, part 1, and certain associated subscriber lines and line equipment; certain switches of line-secondary group 2LS and distributor group 2D; connector 2C1; and certain switches of the #2 selector groups 2SS and 2SP;

Figs. 23 to 26 show the selector common equipment 2SCE for the digit-2 selector group;

Figs. 27 to 30 show the line common equipment 4LCE of hundreds group 4;

Figs. 31, 32, 33 and 34, and 35, show respectively certain switches of the line-primary group 4LP and associated subscriber lines and line equipment; certain switches of the line-secondary group 4LS and of the distributor group 4D, the connector 4C1; and certain switches of the selector-secondary and selector-primary groups 4SS and 4SP;

Figs. 36 to 39 show the selector common equipment 4SCE for the digit-4 selector group;

Figs. 40 and 41 show respectively one of the trunk lines incoming from, and one of the trunk lines outgoing to, the associated automatic exchange #9, with the repeater 9R1 interposed in the illustrated outgoing trunk line; and certain switches of the selector-secondary and selector-primary groups 9SS and 9SP;

Figs. 42 to 45 show the selector common equipment 9SCE for the digit-9 selector group;

Figs. 46 and 47 show respectively one of the trunk lines incoming from, and one of the trunk lines outgoing to, the toll switchboard, with the repeater 0R1 interposed in the illustrated outgoing trunk line; and certain switches of the selector-secondary and selector-primary groups 0SS and 0SP; and

Figs. 48 to 50 show the selector common equipment OSCE for the digit-0 selector group.

E. Call from Substation #211 to Substation #4111

Operations involved in a call from individual-line substation #211 (Fig. 18) in hundreds group 2 to individual-line substation #4111 on line #411 (Fig. 31) in hundreds group 4 will now be described.

E1. Marking the Calling Line

When the receiver (not shown) is removed at substation #211, the usual direct-current bridge is closed across the conductors thereof, operating line relay 1802, through contacts of cutoff relay 1803. At its outer contacts, line relay 1802 grounds start conductor S1, common to the ten line circuits associated respectively with lines 11 to 10 in hundreds group 2. Cable CA—1850 has ten branches B1 to B0, each associated with a separate group of ten line circuits.

Line relay 1802 also places ground potential on the associated mark conductor M11 to identify the calling line in the calling tens group.

E2. Tens Selection

Assuming that the chained group relays 1621 to 1630, associated respectively with the ten tens groups, are all in restored condition at this time, the grounding of conductor S1 in branch B1 of cable CA—1800 closes a circuit for group-1 relay 1621, as follows: from ground on conductor S1, through contacts of group-lockout relay 1601, the winding of group relay 1611, the left-hand winding of group relay 1621, contacts controlled by the second right armature of relay 1621, chain-end conductor 1652, contacts of hold relay 1507, conductor 1651, series-chain contacts of relays 1630 to 1621, corresponding contacts of transfer-control relay 1501, chain-supply conductor 1544, contacts of clear-out relay 1506, and through resistor 1526 to battery. Relays 1611 and 1621 operate in series over this circuit. Upon operating, relay 1621, at its second right armature, locks itself to the operating chain and disconnects its winding from chain-end conductor 1652. At its first right armature, relay 1621 opens the chain circuit to deprive chain-end conductor 1633 of energizing potential, whereby operation of any of the other pairs of group relays is prevented for the time being.

At its fourth right armature, relay 1621 applies ground potential to conductor 1 in secondary-magnet branch BSM of cable CA—1900, thereby energizing selecting magnet M1 of line-secondary group 2LS (Fig. 19). This magnet corresponds to magnet M1 (Figs. 1, 3, and 4). The operation of magnet M1 of group 2LS causes its associated shaft (1—2, Fig. 1) to rotate in such a direction as to move the upstanding left-hand actuating plates 31 of all its fingers 30 (Figs. 6 and 8) under the stackups S1 of all the switches in the secondary group. This selection is maintained in group 2LS of Fig. 19 until a secondary switch and a primary switch have operated to extend the calling line to an idle selector.

E3. Units Selection

When group relay 1611 operates (in series with 1621), it connects the associated units-mark conductors M11 to M10 in branch B1 of cable CA—1800 respectively to the units conductors 1 to 0 in cable CA—1800, leading to units-preference relays 1721 to 1730. With conductor M11 having been grounded by the calling line relay 1802, ground potential is extended over conductor 1 of cable CA—1600 to relay 1721, operating relay 1721 through contacts controlled by the second armature thereof, chain-end conductor 1752, contacts of hold relay 1507, conductor 1751, chain contacts of relays 1730 to 1721, chain-supply conductor 1544, contacts of clear-out relay 1506, to battery through resistor 1526. Upon operating, relay 1721 locks itself to the contact chain and disconnects its winding from chain-end conductor 1752. At its inner armature, it opens the chain circuit to prevent operation of any other ones of the relays 1722 to 1730, in the event that two or more lines in the same tens group are calling at the same time. The lowest numbered line has the operating preference in the arrangement indicated, which is similar to the arrangement associated with tens group relay 1621 to 1630, where the lowest numbered tens group has the operating preference.

At its third armature, relay 1721 applies ground potential to conductor 1 of the primary-magnet branch BPM of cable CA—1900, thereby operating magnet M1 of group 2LP, Fig. 18. The #1 stackups of all the primary switches in group 2LP are thereby selected.

E4. Starting the Cycle Timer

The cycle timer comprising relays 1503 to 1505 is used to time a cycle of operations of the common equipment 2LCE, and to clear out the common equipment in the event that the matching operation to be hereinafter described is unsuccessful. The starting of the cycle timer is initiated by start relay 1502, operated through the third left armature of any of the relays 1621 to 1630, and over conductors 1634 and 1634'. At its right armature, relay 1501 operates each of the relays 1504 and 1505 through the associated resistor. At its first left armature, relay 1502 closes an operating circuit for the right-hand winding of relay 1503. The operation of relay 1503 is delayed for a short interval by the normally short-circuited left-hand winding thereof, preferably on the armature end of the relay. Upon operating, at the end of an interval sufficient to allow relays 1503 and 1504 to operate, relay 1503 opens its delaying winding to render it fast restoring, and it short-circuits relay 1504 to cause this relay to restore after an interval.

When the short-circuited relay 1504 restores, it in turn short-circuits the winding of relay 1505 to cause the latter relay to restore at the end of a further interval.

The matching operation to be described, unless prevented from occurring by an all-links-busy condition, is able to take place and cause the normal clearing-out action of the common equipment to occur before the operation of the cycle timer (relays 1503 to 1505) has progressed sufficiently far that relay 1505 thereof has been restored.

E5. Primary Matching

The six left armatures of relay 1621 connect individual test conductors 1A to 1F of primary

branch BP of cable CA—1900 respectively to the conductors A to F of cable CA—1400, leading to the six primary-match relays 1403 to 1408.

Test conductors 1A to 1F in branch BP of cable CA—1900 are associated respectively with switches 1A to 1F (Fig. 10A, part 1), comprising section 1 of group 2LP, these being the six primary switches having access to the tens group of lines containing the currently calling line #211. Switches 1A and 1F of this group are shown at 2LP in Fig. 18.

If switch 1A is idle at this time, there is an idle-indicating battery potential on the associated hold conductor H, which is consequently extended through make-busy contacts 1897 (corresponding to contact springs 71 and 72, Fig. 7, mounted for convenience in the upper portion of stackup SC of the switch), to conductor 1A. This idle-indicating battery potential is applied through the low-resistance upper winding of operating magnet 1806 (magnet 34 in the apparatus drawings) by way of the normally closed c stackup (stackup SC in the apparatus drawings) of contacts. Similarly, for each idle one of the associated switches 1A to 1F in the same primary section, there is an idle-indicating battery potential on the associated one of the cable conductors 1A to 1F in branch BP. For each of these switches which is in use, there is a ground potential on the associated one of the conductors 1A to 1F.

The test conductors 1A to 1F in branch BP of cable CA—1900 having been extended respectively (by contacts of relay 1621) to conductors A to F of cable CA—1400, the potentials on conductors A to F are extended respectively to the left terminals of the left-hand windings of primary-match relays 1403 to 1408. Accordingly, each of the relays 1403 to 1408 associated with an idle primary switch in the connected section of group 2LP (Fig. 18) is operated by battery potential supplied over the corresponding one of the conductors A to F of cable CA—1400, provided the right terminal of the left-hand winding of such relay is supplied with a return ground potential, as all such terminals normally are. The right terminals of the left-hand windings of relays 1403 to 1408 are connected respectively to section conductors A to F in the secondary-finder-action branch BSF of cable CA—1900, by way of the conductors of cable CA—1450, contacts of cutoff relay 1402, and the back contacts of transfer relay 1401.

Section conductors A to F of branch BSF extend respectively to sections A to F of line-secondary group 2LS (Fig. 10A, part 2) whereat they connect multiply to the outgoing or finder-action ones of these switches. That is, section conductor A of branch BSF connects to switches A1 to A4; section conductor B connects to switches B1 to B3; conductor C connects to switches C1 to C3; conductor D connects to switches D1 and D2; and so forth, to section conductor F which connects to switches F1 and F2. Of these switches, switch A1 is shown at 2LS in Fig. 19, from which it will be seen that section conductor A of branch BSF of cable CA—1900 is maintained grounded through the normally closed upper pair of contacts in the associated stackup c as long as switch A1 is idle. Such conductor is grounded when any of the finder-action secondary switches in the same section is idle. Similarly, each of the other conductors B to F in cable branch BSF of cable CA—1900 is maintained grounded as long as there is an idle secondary finder-action switch in the associated section.

It may be assumed at this time that all of the section conductors A to F in branch BSF of cable CA—1900 are grounded, because there is at least one finder-action secondary switch idle in each of the sections of group 2LS. Under this condition, the right terminal of the left-hand winding of each of the primary-match relays 1403 to 1408 is supplied with ground potential.

If it be assumed further that all of the switches A to F in the calling first section of primary 2LP (Fig. 10A, part 1, and Fig. 18) are idle, all of the relays 1403 to 1408 start to operate simultaneously. None of the stackup operating magnets, such as 1806 and 1808, of primary device 2LP are operated at this time because of the comparatively low-resistance (small number of turns) of the upper windings of the operating magnets such as 1806 and 1808, and because of the high-resistance (large number of turns) of the left-hand windings of relays 1403 to 1408.

Each of the relays 1403 to 1408 is preferably so arranged that the locking armatures thereof (the third left armature for finder action, now under consideration, and the second left armature for connector action, to be later described) are completely operated when the relay as a whole is only partially operated, and while the front contacts of the right armatures of the relay are still unclosed. This may be accomplished as by placing the locking armature springs in the preferred position in the respective stackups, with a suitable gap in the operating bushing to permit sufficient movement of the armature proper to effect the complete break-make operation of the said locking armature springs before the remaining armature springs of the stackup are encountered.

Upon partially operating, each of the primary matching relays 1403 to 1408 attempts to close a locking circuit for itself at its third left armature. The locking circuit of these relays, however, is claimed, with the preference leading from A to F. As a result, only the A relay 1403 is able to close a locking circuit for itself. This locking circuit is from ground on locking conductor 1532 (applied by start relay 1502), through contacts of transfer relay 1410, third left armature of relay 1403 and its front contact, and the right-hand winding of relay 1403, to battery, through the winding of cutoff relay 1402. Cutoff relay 1402 now operates to disconnect conductors A to F of cable CA—1450 thereby open-circuiting the high-resistance matching windings of all of the relays 1403 to 1408. When this occurs, the partially operated unsuccessful matching relays 1404 to 1408 restore, but relay 1403 completes its operation by the energization of its right-hand winding in its locking circuit in series with cutoff relay 1402. Relays 1403 and 1402 remain locked operated until locking conductor 1532 is subsequently ungrounded.

The successful locking and the completion of the operation of the A primary matching relay 1403 signifies that the A primary switch in the calling section of the primary group is idle and that there is at least one idle finder-action secondary switch in the corresponding A section of the secondary group, and it predetermines that the matching will occur in the A secondary section.

E6. Secondary Matching

The primary matching operation having occurred by the described operation of the A primary-matching relay 1403, the secondary-match-

ing operation next occurs. This secondary-matching operation is a preference selection among any idle ones of the finder-action secondaries in the section of the secondary group predetermined by the primary-matching operation.

With the A primary-matching relay 1403 in fully operated condition, the high-resistance left-hand windings of secondary-matching relays 1411 to 1414 are under the control respectively of test conductors A1 to A4 in the secondary branch BS of cable CA—1900, through contacts of relay 1403.

Conductors A1 to A4 in branch BS extend respectively to secondary switches A1 to A4 of secondary group 2LS (Fig. 10A, part 2), of which secondary switch A1 is shown at 2LS in Fig. 19. Idle-indicating battery potential is maintained on each of the test conductors such as A1 associated with idle finder-action secondary switches of group 2LS. For example, if switch A1 of group 2LS is idle, idle-indicating battery potential is maintained on the associated test conductor A1 in secondary branch BS over the following circuit path: from battery, through resistor 1114 associated with the selector S1 (Fig. 11), through the normally closed make-busy contacts 1115, contacts of release and cut off relays 1103 and 1101, hold conductor H of selector link SL1 in cable CA—1200, the low-resistance lower winding of the operating magnet 1901 of switch A1, and thence through the normally closed make-busy contacts 1902 of switch A1 to the associated test conductor A1 in branch BS of cable CA—1900.

It may be assumed that all of the finder-action secondary switches (1 to A4 of section A of group 2LS) are adle at this time. In this event, each of the associated test conductors A1 to A4 in branch BS of cable CA—1900 has an idle-indicating battery potential thereon. Operating circuits are, therefore, closed for the high-resistance matching windings of each of the secondary-matching relays 1411 to 1414: from battery on each of the test conductors A1 to A4 in branch BS of cable CA—1900, the second to sixth right armatures of primary-matching relay 1403, back contacts of transfer relay 1410, the left-hand windings of relays 1411 to 1414, to ground through contacts of cutoff relay 1415. All of the secondary-matching relays 1411 to 1414 (representing secondary choices 1 to 4 respectively in the matched secondary section) now start to operate. None of the secondary operating magnets (such as 1901) operates at this time, because of the low resistance (small number of turns) of its lower winding, coupled with the high resistance of the matching windings of relays 1411 to 1412.

Upon partially operating, each of the secondary relays closes a point in a locking circuit for its right-hand winding, but under this condition only the first choice relay 1411 is able to lock. Its locking circuit is from ground on conductor 1532, through the first right armature of relay 1411, the right-hand winding of relay 1411, and through the winding of cutoff relay 1415, to battery. Cutoff relay 1415 operates in this circuit to disconnect the matching windings of relays 1411 to 1414, whereupon the partially operated relays 1412 to 1414 restore, but relay 1411 operates fully and remains operated in the above-traced locking circuit including its right-hand winding.

The secondary-matching operation is now complete, and the fully operated condition of secondary-matching relay 1411, coupled with the restored condition of secondary-matching relays 1412 to 1414 predetermines that the first-choice secondary switch in the matched A secondary section will be operated, along with the matched A primary switch 1A in the calling first section of the primary group.

E7. Operating the Matched Primary and Secondary Switches

At its lower armature, cutoff relay 1415 closes a circuit from the grounded locking conductor 1532, through contacts of clear-out relay 1506, for slow-acting hold relay 1507. Hold relay 1507 operates after a slight interval. At its second and third right armatures, relay 1507 disconnects chain-end conductors 1652 and 1752 to preclude any new operations of relays 1621 to 1630 and 1721 to 1730 for the time being following the clearing out of relays 1621 and 1721, which is to follow. At its first right armature, relay 1507 shunts the associated contacts of clear-out relay 1506, while at its first left armature it operates clear-out relay 1506.

At its second left armature, clear-out relay 1506 locks itself to contacts of start relay 1502, and at its first right armature it disconnects hold relay 1507, but slow-acting hold relay 1507 remains operated for a substantial interval thereafter.

A further result of the operation of hold relay 1507 is the grounding of operating conductor 1533 at the first left armature thereof. Responsive to this operation, the operating magnets of the matched-primary and secondary switches are energized to bring about the operation of the selected #1 set of stackups in each switch to extend connection from the calling line to selector S1, Fig. 11, associated with the matched secondary switch.

The operating circuit for the matched primary switch is from ground on operating conductor 1533, through the first left armature of the operated primary-matching relay 1403, conductor A in cable CA—1400, contacts of the operated group relay 1421, test conductor 1A in branch BP of cable CA—1900, make-busy contacts 1897 of primary switch 1A, c-stackup contacts of switch 1A, to battery through the low-resistance upper winding of operating magnet 1806. Magnet 1806 (corresponding to magnet 34, with its armature 35, of the switch shown in plan view in Fig. 6) now operates, to close the selected #1 stackup of contacts of switch 1A of group 2LP. The operation of magnet 1806 occurs promptly as a result of the energization of the powerful low-resistance upper winding thereof. This upper winding is disconnected when the associated c stackup of contacts opens, leaving the comparatively high-resistance lower winding of the relay energized as a holding winding which consumes but little holding current.

The operating circuit for the matched secondary switch is as follows: from ground on operating conductor 1533, through the second right armature of the operated secondary-matching relay 1411, contacts of transfer relay 1410, and of the operated primary-matching relay 1403, test conductor A1 in secondary branch BS of cable CA—1900, make-busy contacts 1902, and low-resistance lower winding of operating magnet 1901, conductor H of selector link SL1, contacts of relays 1101 and 1103, make-busy contacts 1115, and thence to battery, through resistor 1114.

Magnet 1901 is quickly energized over the above circuit for its powerful lower winding. Thereupon the selected #1 stackup of contacts of secondary switch A1 of group 2LS is closed to complete the extension of the connection of the calling line to the selector S1. Additionally, the c stackup of contacts of switch A1 is operated. At the normally closed upper pair of the c stackup, section conductor A of branch BSF is ungrounded at one point, while at the normally open lower contact pair of the c stackup, the comparatively high-resistance upper winding of magnet 1901 is connected up as a low-current holding winding.

E8. Preparing the Selector S1 for Operation

The tip, ring, and sleeve conductors of line multiple L. M. #211 (Fig. 18) associated with calling line #211 have been extended by the above operations through the #1 stackup of switch 1A of primary group 2LP, through link L1A in cable 2LA, the #1 stackup of switch A1 of secondary group 2LS, and selector link SL1 in cable CA—1200, to the tip, ring, and sleeve conductors incoming to the selector S1, Fig. 11.

Line relay 1102 of the selector S1 now operates over the calling line, followed by the operation of slow-acting release relay 1103, to prepare the selector for operation in response to the initial digit in the desired number. At its first right-hand armature, release relay 1103 applies ground potential to the associated incoming hold conductor H, closing a holding circuit for the operated primary and secondary switches to maintain magnets 1806 and 1901 operated after the common equipment 2LCE of Figs. 14 and 17 has cleared out. Additionally, release relay 1103, at its third right armature, applies ground potential to the associated incoming sleeve conductor S thereby closing a circuit over the sleeve conductor S of link SL1, and through the sleeve contacts in the operated #1 stackups of the secondary and primary switches A1 of Fig. 19 and 1A of Fig. 18, for cutoff relay 1803 associated with the calling line.

Line relay 1802 is now disconnected and restored by cutoff relay 1803. Upon restoring, line relay 1802 disconnects ground potential from conductor M1 and disconnects ground potential at one point from start conductor S1, common to the ten lines served by the first section of switches in primary group 2LP.

In order to explain one feature of operation of the common equipment, it will be assumed that another line in the same ten-line group has made a call in the meantime, in which case conductor S1 remains grounded after line relay 1802 has restored. The restoration of line relay 1802 and the consequent ungrounding of conductor M1 results in the immediate removal of ground potential from conductor 1 in cable CA—1600, whereupon the #1 units-preference relay 1721 restores and removes ground potential from the associated conductor 1 in primary magnet branch BPM of cable CA—1900, permitting selecting magnet M1 of group 2LP (Fig. 18) to restore. The associated shaft (1—2 of Fig. 1) is thus permitted to restore to normal position. This, however, causes no harm to result as the matched primary switch has already been operated as described.

With another line calling in the same ten-line group, one or another of the marking conductors M2 to M10 in branch B1 of cable CA—1800 is in grounded condition, but none of the units-preference relays 1722 to 1730 can operate for the time being, for chain-end conductor 1752 is being maintained disconnected by slow-acting hold relay 1507.

E9. Clearing Out the Common Equipment 2LCE

After a sufficient time has elapsed for the described operation of the primary and secondary switches (1A of 2LP, Fig. 18, and A1 of 2LS, Fig. 19) to occur, followed by the described operation of line and release relays 1102 and 1103 to close a holding circuit for the operated primary and secondary switches. Slow-acting hold relay 1507 in the common equipment 2LCE restores responsive to having been disconnected by clear-out relay 1506 as described. Upon restoring, relay 1507 removes ground potential from operate conductor 1533, but this causes no harm to result because a holding circuit has been closed, as described, for the operated primary and secondary switches.

Relay 1507 also reconnects chain-end conductors 1652 and 1752, at the same time disconnecting resistor 1526 from chain-supply conductor 1544. Any operated ones (1611 and 1621) of the tens-group relays 1621 to 1630 and 1611 to 1620, are thereby restored, as is any operated one of the units-preference relays 1721 to 1730, for they all depend for operating current on the now-disconnected chain-supply conductor 1544.

One result of the restoration of relay 1621 is the ungrounding of conductor 1 in branch BSM of cable CA—1900, thereby deenergizing selecting magnet M1 of group 2LS, Fig. 19.

A further result of the restoration of relay 1621 is the removal of ground potential from start conductor 1634, permitting start relay 1502 to restore. The restoration of start relay 1502 is followed immediately by the restoration of cycle-timer relay 1503 and the restoration of any operated ones of the associated cycle-timer relays 1504 and 1505, whereby the cycle-timer is immediately cleared out.

Start relay 1502 also ungrounds lock conductor 1532, thereby unlocking and restoring primary match relay 1403 and cutoff relay 1402, as well as secondary-match relay 1411 and cutoff relay 1415.

Clear-out relay 1506 restores responsive to the removal of ground from lock conductor 1532 by start relay 1502. It reconnects battery-supply resistor 1526 to the chain-supply conductor 1544 whereupon relays 1621 and 1611 immediately re-operate over start conductor S1 (still grounded by another call in the tens group of lines, as assumed), to cause the common equipment to be taken for use for another cycle of operations, resulting in an idle primary switch and an idle secondary switch being matched with the second calling line to extend such line to an idle selector by operations substantially as hereinbefore described.

When there is no other line calling in the same tens group, the start conductor such as S1 in cable CA—1800 is ungrounded immediately upon the restoration of the concerned line relay such as 1802 when the associated cutoff relay such as 1803 operates as hereinbefore described. In this case, the operated group relays such as 1611 and 1621 immediately clear out along with units-preference relays 1721 and 1730, when the calling line relay (1802) is disconnected and restored, as described. The described clearing-out operation is immediately initiated by start relay 1502, but no new cycle of operations can be initiated

until slow-acting hold relay 1507 falls back to reconnect chain-end conductors 1652 and 1752.

E10. Holding the Switches Operated

The selected #1 stackup of contacts of secondary switch A1 of group 2LS is maintained operated by magnet 1901 whose high-resistance upper winding is maintained energized through the lower pair of contacts in the operated *c* (common) stackup thereof, from ground potential maintained on the associated hold conductor H of selector link SL1 by release relay 1103 of selector S1. The temporary operating energization of the low-resistance lower winding has been terminated by the substitution of ground potential for battery potential on hold lead H of link SL1. Additionally, the associated test lead A1 in branch BS of cable CA—1900 has now been disconnected by the described clearing-out operation of the common equipment 2LCE of Figs. 14 to 17.

The ground potential on hold lead H of link SL1 is extended, through the lower contact pair in the operated #1 stackup of switch A1, to the hold lead H in link L1A extending to the operated primary switch 1A of group 2LP. The ground potential on this lead maintains the high-resistance lower winding of operating magnet 1806 energized to maintain the switch 1A operated. The powerful low-resistance operating winding of magnet 1806 is maintained disconnected from the holding circuit at the operated *c* stackup of contacts.

E11. Setting the Selector S1

The selector S1 of Fig. 11 has been prepared for operation by the previously described operation of line relay 1102 over the calling line and the consequent operation of release relay 1103. A dial-tone signal is now transmitted back to the calling line from the common dial-tone lead DT, through contacts of busy relay 1104, small-capacity condenser 1116, contacts of the operated release relay 1103, and contacts of cutoff relay 1101, to the tip conductor of the extended connection. The calling subscriber is thereby informed that he may now dial the digits in the desired number (4111).

When the hundreds digit 4 is dialed, by the usual calling device (not shown), a series of four momentary, closely spaced, interruption impulses is produced in the direct-current bridge across the conductors of the calling line, whereby line relay 1102 of the selector S1 is momentarily restored four times. Release relay 1103, being rendered slow-restoring as by the indicated conducting sleeve surrounding its core inside its winding, remains operated throughout the series of restorations of line relay 1102.

Each time it restores, line relay 1102 transmits an impulse through contacts of the operated release relay 1103, and through contacts of busy relay 1104, to impulse conductor 1117. Series relay 1105 operates responsive to the first impulse delivered to conductor 1117. Being slow-restoring as indicated, series relay 1105 remains operated throughout the series of impulses to maintain the two sets of contacts of counting relays 1107 to 1112, associated with cables SC1 and MC1, disconnected.

E11*a*. Counting the Digit Impulses

The first impulse delivered to conductor 1117 results in the closure of a circuit from ground thereon, through the back contact of the armature of driver relay 1106, through the winding of the 1, 7 counting relay 1107, and thence through the contact chain controlled by relays 1108 to 1111, to battery through resistor 1113. Counting relay 1107 is thereby operated. At its first left armature, it prepares an operating circuit for the 2, 8 counting relay 1108. At its right armature, it closes a locking circuit for itself to ground through the right-hand winding of driver relay 1106, and locking conductor 1118, grounded through contacts controlled by the first right armature of busy relay 1104, the front contact of the second right armature of release relay 1103, back contact of the first right armature of cutoff relay 1101, and front contact of the first right armature of release relay 1103. Driver relay 1106, however, does not operate for the time being, for its right-hand winding is short-circuited by ground potential on impulse conductor 1117 until the first impulse subsides.

At the end of the first impulse delivered to conductor 1117, driver relay 1106 operates in the locking circuit of relay 1107. Upon so doing, it disconnects impulse conductor 1117 from odd-impulse conductor 1119 and transfers it to even-impulse conductor 1120.

When the second impulse is delivered to conductor 1117, such impulse passes through contacts of the operated driver relay 1106, to even-impulse conductor 1120, and thence through contacts of the operated counting relay 1107, the winding of the 2, 8 counting relay 1108, to battery through chain contacts of relays 1109 to 1111 and resistor 1113. Relay 1108 thereupon operates. At its first left armature, it prepares an operating circuit for the next succeeding counting relay 1109 by connecting it to odd-impulse conductor 1119 (now disconnected by the operated driver relay 1106). At its second right armature, relay 1108 locks itself directly to ground on conductor 1118, while at its first right armature, it disconnects and restores the first counting relay 1107, thereby open-circuiting the right-hand winding of driver relay 1106. Driver relay 1106 is maintained energized thereafter by its left-hand winding until the instant even-numbered impulse (the second impulse) is terminated.

At the end of the second impulse, counting relay 1108 having been operated and locked as described and counting relay 1107 having been restored, driver relay 1106 restores as a result of the consequent deenergization of its left-hand winding, transferring impulse conductor 1117 back from even-impulse conductor 1120 to odd-impulse conductor 1119.

When the third impulse is delivered to conductor 1117, by the third momentary restoration of line relay 1102, odd-impulse conductor 1119 is again energized through contacts of the restored driver relay 1106. The 1, 7 counting relay 1107 does not now respond as it has been disconnected at the first right contacts of the operated 2, 8 counting relay 1108. The 3,9 counting relay 1109 now operates in a circuit from ground on conductor 1119, through contacts of operated relay 1108, the winding of relay 1109, and thence to battery, through the chain contacts of relays 1110 and 1111, and resistor 1113. Upon operating, relay 1109, at its second right armature, locks itself to branch locking conductor 1121, connected to the grounded locking conductor 1118 through the right-hand winding of driver relay 1106, driver relay 1106 not responding for the time being as hereinbefore described. At its second left arma-

ture, relay 1109 shunts the first left armature and front contact of relay 1108 so as to maintain relay 1109 connected to odd-impulse conductor 1119 after relay 1108 restores, as it now does responsive to the opening of the back contact of the first right armature of relay 1109. Relay 1109 is thus maintained connected to conductor 1119 for the duration of the currently received impulse, whereby the right-hand winding of driver relay 1106 is maintained short-circuited until the impulse is terminated.

When the third impulse is terminated, driver relay 1106 is again operated, this time by the energization of its right-hand winding in the locking circuit of counting relay 1109. It again transfers impulse conductor 1117 from odd conductor 1119 to even conductor 1120.

When the fourth impulse is received on conductor 1117, it is delivered, through the front contact of the operated driver relay 1106, to even conductor 1120. The 4, 0 counting relay 1110 is thereupon operated in a circuit from ground on conductor 1120, through the front contact of the first left armature of relay 1109, the winding of relay 1110, and thence to battery, through contacts of relay 1111 and resistor 1113. Upon operating, relay 1110 locks itself directly to conductor 1118 at its second right armature; it connects the fifth counting relay 1111 to odd conductor 1119 at its first left armature; and, at its first right armature, it disconnects and restores counting relay 1109, leaving driver relay 1106 energized only by its left-hand holding winding.

At the end of the fourth received impulse, driver relay 1106 is again restored to transfer impulse conductor 1117 from even conductor 1120 back to odd conductor 1119 in preparation for the operation of the fifth counting relay 1111 in response to the fifth impulse of the series provided the series contains a fifth impulse.

In the present example, the impulse series comprises four impulses, as a result of which no further counting-relay operations occur after counting relay 1110 operates as described and restores counting relay 1109.

At this point, it may be well to describe the further counting-relay operations that occur in impulse series containing up to the full number of ten, as when the digit 0 is dialed. Driver relay 1106 continues to be operated by its right-hand winding, as previously described, responsive to the termination of each odd impulse, and to be held by its left-hand holding winding until the end of the next succeeding even impulse, after the circuit through its right-hand winding is opened at the beginning of such even impulse.

Counting relay 1111 has operated over odd conductor 1119 when the fifth impulse arrives, locking itself to branch locking conductor 1121 and to odd conductor 1119, and restoring counting relay 1110.

When the sixth impulse arrives, counting relay 1112 is operated, through contacts of counting relay 1111, from ground on even conductor 1120. It locks itself directly to conductor 1118 and remains operated thereafter until conductor 1118 is subsequently ungrounded. Relay 1111 is consequently maintained disconnected at the contacts of relay 1112 and cannot therefore be reoperated.

The chain circuit is again completed to the 1, 7 counting relay 1107, through contacts of restored relays 1108 to 1111. As a result, when the seventh impulse is delivered, relay 1107 is reoperated over odd conductor 1119.

The remaining counting-relay operation is that relay 1108 is reoperated over even conductor 1120 when the eighth impulse is received, restoring relay 1107; relay 1109 is operated over odd conductor 1119 when the ninth impulse is received, restoring relay 1108; and the 4, 0 counting relay 1110 is operated over even conductor 1120 when the tenth impulse is received, restoring relay 1109.

By referring to the contacts of relays 1107 to 1112 associated with conductors 1 to 0 in cables MC1 and SC1, it will be observed that, for any number of impulses from one to five, the corresponding ones of conductors 1 to 5 in these cables are connected up, through contacts of operated counting relays 1107 to 1111 respectively.

When the received series contains six impulses, and relay 1112 operates, conductor 6 in each of the cables SC1 and MC1 is rendered effective through front contacts of the operated relay 1112, and through back contacts of the restored relays 1110 to 1107.

When the received impulse series contains any number from seven to ten, the corresponding ones of the conductors 7 to 10 in cables SC1 and MC1 are connected up, through front contacts of the sixth counting relay 1112, and through front contacts of the corresponding one of the reoperated relays 1107 to 1110.

In the present example, the received impulse series contains 4 impulses, corresponding to the called hundreds digit 4, and the only counting relay in operated condition in the selector S1 at the end of the impulse series is the fourth counting relay 1110, as hereinbefore described.

E12. The Selector Arrangement of Start and Mark Conductors

Each of the 120 selectors has two cables referred to respectively as a start cable and as a mark cable. As shown in Figs. 11 and 12, the start and mark cables of selector S1 are SC1 and MC1; those of selector S33 are SC33 and MC33; selector S69 has corresponding cables SC69 and MC69, and selector S94 has corresponding cables SC94 and MC94.

As shown in Fig. 13, the start and mark cables of the selectors extend respectively to start and mark terminal blocks, such as SB1 and MB1 for selector S1; SB33 and MB33 for selector S33; blocks SB69 and MB69 for selector S69; and blocks SB94 and MB94 for selector S94. These terminal blocks are preferably arranged in regular order, with the first pair being SB1 and MB1 of selector S1, the last pair being the corresponding blocks of the last selector S120 (not shown).

Terminals 2 to 7, 9, and 0 in each of the 120 pairs of blocks of Fig. 13, are connected to separate conductors in cable CA—1300. The #2 terminals in all of the SB blocks are connected respectively to conductors S1 to S120 in branch B2 of cable CA—1300, and the #2 terminals of the MB blocks are connected respectively to other conductors M1 to M120 in the same branch B2 of the cable. Each of the illustrated branches B2 to B7, B9, and B0 contains 120 start conductors corresponding respectively to the 120 selectors, and 120 mark conductors corresponding respectively to the 120 selectors, there being 240 conductors in each branch of cable CA—1300.

Special connections are made to the #1 and#8 terminals in the MB blocks to cause a busy tone signal to be returned when the digit 1, or the digit 8, is dialed as an initial digit as will be hereinafter described.

As shown along the top of Figs. 23, 36, 42, and 48, the branches B2 to B0 of cable CA—1300 extend respectively to the selector common equipments for the various groups of paths outgoing from the selector switching stage.

The call now under consideration is for hundreds group 4. The corresponding branch of cable CA—1300 is branch B4 extending to the common equipment 4SCE shown in Figs. 36 to 39.

Branch B4 is divided into two sub-branches B4M and B4S, Fig. 36. Sub-branch B4M contains the mark conductors M1 to M120 corresponding to the digit-4 mark conductors of the respective selectors S1 to S120, while branch B4S contains start conductors S1 to S120 corresponding to the digit-4 start conductors of the respective selectors S1 to S120.

Terminal blocks 3611 and 3612 are provided to enable the 120 mark conductors in cable branch B4M to be cross-connected as desired to conductors 1 to 120 in cable CA—3700. The cross-section on blocks 3611 and 3612 is straight, as indicated, because the selector multiples SM1 to SM120 extend straight across from the selectors to the primary sections of group 4SP (Figs. 10A and 35).

Blocks 3613 and 3614 are provided to permit start conductors S1 to S12 in cable CA—3700 corresponding respectively to the twelve primary section relays 3701 to 3712, Fig. 37, to be cross-connected with the 120 start conductors in sub-branches B4S in cable CA—1300 as desired.

In conformance with the illustrated straight-across connection of the selector multiples to the concerned primary group 4SP of Figs. 10A and 35, individual start conductors S1 to S10 in branch B4S are multiply connected to section-1 start conductor S1; the next ten individual start conductors are connected to section-2 start conductor S2; and so on, to the final ten individual start conductors S111 to S120 in B4S, which are multiply connected to section-12 start conductor S12.

E13. Marking the Calling Selector S1 in Equipment 4SCE

When slow-restoring series relay 1105 falls back at the end of the series of impulses constituting the dialed hundreds digit 4, it applies ground potential at its first and second armatures respectively to the fourth conductor in cable MC1 and to the fourth conductor in cable SC1. Ground potential is applied to the fourth conductor in cable MC1 through the back contact of the second left armature of relay 1101, the low-resistance left-hand winding of the marginal busy relay 1104, back contact of the first armature of series relay 1105, back contacts of armatures of relays 1112 and 1111, and the front contact of the third left armature of the operated counting relay 1110, to conductor 4 in cable MC1. The ground potential applied directly at the back contact of the second armature of series relay 1105 is extended over a similar path to the fourth conductor in cable SC1.

Ground potential is now extended from conductors 4 in cables SC1 and MC1, through terminals 4 in blocks SB1 and MB1 of Fig. 13, conductors S1 and M1 in branch B4 of cable CA—1300, through terminals of blocks 3614 and 3613 to section-1 start conductor S1 in cable CA—3700, as well as through terminals in blocks 3612 and 3611 to individual mark conductor 1 in cable CA—3700.

The section and individual identity of the calling selector S1 are thus marked in the common equipment 2SCE.

E14. Secondary Selection

Assuming that section relays 3701 to 3712 are all in restored condition at this time, the above grounding of section-1 start conductor S1 in cable CA—3700 results in the closure of a circuit for section-1 relay 3701; from ground on conductor S1, relay 3701, contacts controlled by the second right armature of relay 3701, chain-end conductor 3752, the chain contacts (back contacts of the first right armatures) of relays 3712 to 3701 in series, chain supply conductor 3851, contacts of relays 3809 and 3807, and hence to battery, through the winding of start relay 3805. Section relay 3701 and start relay 3805 operate in series over the above-traced circuit. At its third right armature, section-1 relay 3701 applies ground potential to conductor 1 in branch BSM of cable CA—3500, thereby energizing selecting magnet M1 of group 2SS (Fig. 22) to cause selection of the #1 stackup of contacts in the associated secondary switch A1 and in all of the other secondary switches in this group.

Relay 3701 also locks itself to the chain circuit at its second right armature, disconnecting its winding from chain-end conductor 3752, while at its first right armature it opens the operating chain to the ungrounded chain-end conductor 3752, thereby precluding operation for the time being of any of the other group relays 3702 to 3712. The locking circuit of relay 3701 obviously includes conductor 3851 and energized start relay 3805.

E15. Primary Selection

Group relay 3701 also connects the individual mark conductors 1 to 10 in cable CA—3700 (corresponding respectively to the selectors S1 to S10) respectively to conductors 1 to 10 in cable CA—3750 extending to selector-preference relays 3601 to 3610. The selector-preference relays are arranged to prevent plural selection in the primary group when more than one selector associated with the same primary section is making a call at the same time, to the same link group at the selector stage.

The individual-marking ground potential on conductor 1 in cable CA—3700 is now extended, through contacts of relay 3701, and over conductor 1 in cable CA—3750, to the left-hand winding terminal of the first selector-preference relay 3601. A circuit is thereby closed for relay 3601, in series with selecting magnet M1 of group 4SP (Fig. 35) as follows: from ground on conductor 1 of cable CA—3750, through the winding of relay 3601, conductor 1′ in primary-magnet branch BPM of cable CA—3500, magnet M1 of primary group 4SP (Fig. 35), conductor 1 in branch BPM of cable CA—3500, contacts controlled by the second right armature of relay 3601, chain-end conductor 3652, contacts of relay 3809, conductor 3651, the chain contacts of relays 3610 to 3601, and thence to battery through chain-supply resistor 3651. Magnet M1 of group 4SP of Fig. 35 is operated over the above circuit to select the #1 set of stackups of all the primary switches in the group, which operation occurs directly responsive to the operation of primary-section relay 3712, simultaneously with the described operation of magnet M1 of secondary group 4SS (Fig. 35).

Units-preference relay 3601 operates in series

with the operating magnet over the above-traced circuit. At its second right armature, it locks itself and the operating magnet to resistor **3651** independent of chain-end conductor **3652**, and disconnects the circuit from the latter conductor. At its first right armature, it opens the chain circuit to chain-end conductor **3652** to preclude operation of any other ones of the selecting magnets of the associated primary group **4SP** (Fig. 35), as well as the operation of any further ones of the selector-preference relays **3602** to **3610**.

E16. Starting the Cycle Timer

As described, the operation of section-1 relay **1301** is accompanied by the simultaneous operation of start relay **3805** in series therewith. Start relay **3805** initiates the secondary-matching operation to be hereinafter described. It also closes an operating circuit for relay **3806** of the cycle timer comprising relays **3806** and **3807**. The action of relay **3806** is retarded for an interval by the left-hand winding thereof, short-circuited through its own back contacts, and through the upper front contact of relay **3805**. As will subsequently appear, relay **3807** responds to the operation of relay **3806** to clear out the common equipment at the end of a short interval in the event that the normal cycle of operations (leading to the normal clearing-out operation to be hereinafter described) fails at some point.

E17. Primary Matching

A further result of the operation of section-1 relay **3701** is that it connects up conductors 1A to 1D in the primary branch BP of CA—**3500**, these being the test conductors of the switches 1A to 1D comprising the first section of primary group **4SP** (Figs. 10A and 35). These conductors (1A to 1D) are connected to conductors A to D in cable CA—**3800**, extending respectively to primary-matching relays **3901** to **3904**. Each of the relays **3901** to **3904** is accordingly supplied with an operating battery potential over its associated conductors A to D in cable **3800**, depending upon the corresponding primary switch being idle in the connected primary section of switches. If primary switch 1A in group **4SP** (Fig. 35) is idle, there is no ground potential on the associated sleeve conductor S and on the associated test lead 1A in branch BP of cable CA—**3500**, with the result that idle-indicating battery potential is extended to the said test conductor 1A, by way of the low-resistance upper winding of operating magnet **3503**, the associated *c*-stackup contacts, and make-busy contacts **3504**, and thence over conductor 1A in branch BP of cable CA—**3500**, contacts of relay **3701**, and conductor A in cable CA—**3901**, to the left terminal of relay **3901**.

Ground potential normally reaches the right winding terminal of the A primary matching relay **3901** over conductor A in branch BSG of cable CA—**3500**, through the normally closed lower pair of *c*-stackup contacts (Fig. 35) of any of the section-A switches (including switch A1) in secondary group **2SS**, conductor A' in branch BSG, and thence to the right winding terminal of relay **3901**.

Ground potential reaches the right winding terminal of the B primary-matching relay **3902** by way of the back contact of the second right armature of relay **3901**, section conductor B in branch BSG of cable CA—**3500**, *c*-stackup contacts of any idle section-B secondary switch in group **2SS**, and over the associated conductor B' to the right winding terminal of relay **3902**.

Similarly, ground potential normally reaches the right terminal of the C primary-matching relay **3903** through the series back contacts of the second right armatures of relays **3901** and **3902**, the associated section conductors C and C' of the associated cable branch BSG in series, while ground potential normally reaches the right terminal of the D primary-matching relay **3904**, through the series back contacts of the second right armatures of relays **3901** to **3903**, and the associated section conductors D and D' in series.

Assuming that all the switches in the concerned section 1 of primary group **4SP** are idle and that there is at least one switch idle in each of the sections A to D of the associated secondary group **4SS**, the described extension of the first-section primary test leads to conductors A to D of cable CA—**3800** results in an energization of the windings of each of the primary-matching relays **3901** to **3904**. Accordingly, all four of these primary-matching relays **3901** to **3904** start to operate at the same time. Each of the relays **3901** to **3903** opens the ground connection to the next succeeding one of the relays under this condition, with the result that only relay **3901** is able to operate fully. Relays **3902** to **3904** are accordingly deenergized and restored by the opening of the back contact of the second right armature of relay **3901**, which occurs before any of the relays **3902** to **3904** has fully operated.

As a further result of its operation, at the front contact of its second right armature, relay **3901** applies ground potential directly to its right winding terminal, independent of the continued joined condition of secondary-section conductors A and A'. At its first right armature, relay **3901** disconnects the associated secondary-off-normal conductor SON from the corresponding armatures of relays **3902** to **3904** and transfers it to the operating chain circuit of the A group of secondary-matching relays **3905** to **3907** corresponding respectively to switches A1 to A3 constituting section A of group **4SS** (Figs. 10A and 35). At its left armature, relay **3901** prepares an operating circuit for the A primary switch A1 in the connected section of primary group **4SP** (Figs. 10A and 35).

The primary-matching operation has now been accomplished by a single relay operation, the described operation of relay **3901**.

E18. Secondary Matching

Instead of succeeding the primary-matching operation, as in the line common equipment **2LCE**, the secondary-matching operation in the selector common equipment **4SCE** occurs simultaneously with the primary-matching operation, which result is accomplished in the selector common equipments by providing the full number of secondary-matching relays **3905** to **3909** and **3801** to **3804**, corresponding respectively to the switches in the associated secondary group **4SS** of Figs. 10A and 35, rather than by providing a group of secondary-preference relays common to all sections of the secondary group as in the line common equipments.

When start relay **3805** operates in series with section relay **3701** as hereinbefore described, it applies ground potential to the left-winding terminal of each of the secondary-matching relays **3905** to **3909** and **3801** to **3804**. Each of these relays thereupon operates, depending upon the associated secondary switch being idle. For example, if secondary switch A1 of Fig. 35 is idle at this time, there is an idle-indicating battery

potential present on the associated test conductor A1 in branch BS of cable CA—3500, applied thereto over the following circuit path: from battery, through resistor 3431 associated with connector 4C1, make-busy contacts 3430 of the connector 4C1, back contact of the fourth left armature of busy relay 3409, normally closed contacts controlled by the second left armature of release relay 3403, sleeve conductor S of link 4LA1, the low-resistance operating winding of magnet 3501, and the associated make-busy contacts 3502, to the said test conductor A1. Secondary-matching relay 3905, individual to secondary switch A1 of Fig. 35, is operated by this battery potential responsive to being connected up by start relay 3805.

It may be assumed, for example, that all the switches in secondary group 4SS are idle at this time, in which case all of the relays 3905 to 3909, and 3901 to 3904 operate. The operation of none of these relays, except the section-A group 3905 to 3907, have any effect at this time because only operate conductor 3951 of the group comprising conductors 3951 to 3954 are connected up by the primary-matching group, wherein only relay 3901 is operated, as before described. It is also clear that, with relays 3905 to 3907 operated, the operation of relay 3905 is alone effective, because conductor 3951 is disconnected from the contact chain and is transferred into connection with the associated conductor A1.

With ordinary adjustments, primary and secondary matching relays (3901 and 3905) operate before the selecting-shaft rotation is completed, because of the light weight of an ordinary relay structure, as compared to the weight of a selecting shaft. Arrangements are, therefore, provided to prevent the closing of the circuit for the matched primary and secondary operating magnets prior to completion of the stackup-selecting operations. These arrangements include the off-normal contacts shown in association with the operating magnets of groups 4SS and 4SP (Fig. 35). The off-normal contacts of the secondary group control conductor SON in cable CA—3500, while the off-normal contacts in the primary group control conductor PON in the said cable. These off-normal contacts are shown structurally at 21 in Fig. 3. A pair of them is provided for each shaft of the mechanism, and each such pair is arranged to close just as the shaft reaches its selective position in either direction.

E19. Operating the Matched Primary Switch

When, responsive to the energization of magnet M1, the shaft controlled by the magnets M1 and M2 of group 4SP (Fig. 35) is rotated into selective position to select the #1 contact stackup of all of the associated primary switches, the associated off-normal contacts apply ground potential to conductor PON in cable CA—3500, thereby closing a circuit through contacts of the operated start relay 3805, through contacts of the operated primary-matching relay 3901, conductor A in cable CA—3800, front contact of the fourth left armature of section-1 relay 3701, individual test conductor 1A in branch BP of cable CA—3500, make-busy contacts 3504, the associated normally closed c-stackup contacts, and thence through the low-resistance operating winding of magnet 3503, to battery. Magnet 3503 thereupon operates to close the selected #1 stackup of contacts of the associated primary switch 1A and to open the c-stackup contacts to disconnect the powerful low-resistance operating winding, leaving the high-resistance holding winding energized to hold the switch operated.

E20. Operating the Matched Secondary Switch

When the shaft controlled by the energized magnet M1 of secondary group 4SS (Fig. 35) reaches the selective position, in which it selects the #1 stackup of contacts in each of the associated secondary switches, the associated off-normal contacts apply ground potential to conductor SON in cable CA—3500, thereby closing a circuit, through contacts of the operated primary-matching relay 3901, section-A secondary operating conductor 3951, front contact of the operated secondary-matching relay 3905, conductor A1 in branch BS of cable CA—3500, make-busy contacts 3502, the low-resistance operating winding of magnet 3501, conductor S in link 4LA1, and thence to battery through contacts of relays 3403 and 3409, contacts 3430, and resistor 3431. Magnet 3501 now operates and closes the selected #1 stackup of contacts of the associated switch A1, and it shifts the contacts of the associated c stackup. The lower contacts of this stackup separate the associated conductors A and A' at one point, while the upper contacts of this stackup connect up the high-resistance holding winding of magnet 3501.

It is to be noted that the closing of the above operating circuits for magnets 3503 and 3501 results in a short-circuiting of the primary and secondary-matching relays 3901 and 3905, but relays do not immediately restore as a result of being short-circuited, as is well known.

E21. Preparing the Connector 4C1 for Operation

With the primary and secondary switches 1A and A1 of Fig. 35 now in operated condition, the tip and ring conductors of the selector link SL1 incoming to the selector S1 (Fig. 11) are now extended, by way of the tip and ring conductors of selector multiple SM1 in cable CA—1250, the operated #1 selective stackup of switch 1A of group 4SP (Fig. 35), the tip and ring conductors in link 1 of cable 4SA, and tip and ring conductors in the operated #1 stackup of switch A1 of group 4SS, to the tip and ring conductors incoming to connector 4C1 (Fig. 34).

Line relay 3401 of the connector 4C1 now operates over the calling line, in multiple with the line relay 1102 of the selector S1. Upon so doing, it operates release relay 3403 to prepare the connector for operation. This preparation includes the disconnection of the associated incoming sleeve conductor, at its second left armature, from the battery-supply resistor 3421 and the substitution of ground to provide a holding circuit for the operated primary and secondary selector-action switches and for the selector S1, after the cutoff operation has occurred in the selector S1.

E22. Cutoff Operation at Selector S1

Since the incoming tip and ring conductors of the selector S1 (Fig. 11) in the selector link SL1 are permanently joined to the corresponding tip and ring conductors in the selector multiple SM1, no switching-through operation is required at the selector S1 to permit the connector 4C1 to be prepared for operation as above described. A cutoff operation, however, is required to disconnect line relay 1102, and for other purposes.

When the #1-selective stackup of switch 1A of Fig. 35 is closed by the described operation of

magnet 3503 (responsive to the grounding of the associated conductor 1A in cable CA—3500), the ground potential on this conductor 1A is thereby extended to the sleeve conductor S of selector multiple SM1, and thereover to the winding of cutoff relay 1101 of the selector S1. Cutoff relay 1101 thereupon operates. At its second right armature, it joints the sleeve conductor S of selector link SL1 to the grounded sleeve conductor S of the selector multiple SM1. Additionally, relay 1101, at the back contact of its first right armature, disconnects ground potential from locking conductor 1118, thereby clearing out driver relay 1106 and any operated ones of the counting relays 1107 to 1112, thereby terminating the application of ground potential to the #4 conductors in cables SC1 and MC1.

At its first left armature, relay 1101 removes ground from the armature of line relay 1102; at the front contact of its first right armature, it makes a ground connection to the incoming hold conductor H in link SL1 to maintain this conductor grounded after release relay 1103 has restored; and at the back contacts of its third and fourth right armatures, it disconnects the windings of line relay 1102 from the associated tip and ring conductors. Line relay 1102 accordingly restores immediately, followed a short time later by the restoration of release relay 1103.

With release relay 1103 restored, the clearing-out operation of 4SCE (to be subsequently described) having previously occurred, the connection is held as follows:

Release relay 3403 in the connector 4C1, held over the calling line by line relay 3401, maintains the associated incoming sleeve conductor S of link 4LA1 grounded at the front contact of its second left armature. The ground potential on conductor S of link 4LA1 passes through the upper contacts in the operated *c* stackup of secondary switch A1 of group 4SS to the high resistance holding winding thereof.

The ground potential on the sleeve lead of link 4LA1 is extended, through the sleeve contacts of the operated #1 stackup of switch A1, to the sleeve lead of primary switch 1A of group 4SP, to which lead the high-resistance holding winding of magnet 3503 is connected.

The ground potential on the sleeve conductor of the said switch 1A is extended, through the sleeve contacts of the operated #1 stackup thereof, to the sleeve conductor of selector multiple SM1, to hold cutoff relay 1101 of the selector S1 operated, which cutoff relay maintains the hold conductor H in link SL1 grounded at the front contact of its first right armature to maintain the line primary and secondary switches operated.

The ground potential on the sleeve conductor of multiple SM1 passes through the front contact of the second right armature of cutoff relay 1101 to sleeve conductor S in link SL1 to maintain the cutoff relay 1803 of the calling line operated.

E23. Clearing Out the Common Equipment 4SCE

The way in which the selector common equipment 4SCE is cleared out at the end of its previously described operation will now be described.

The normal clearing-out operation is controlled by clear-out relays 3808 and 3809. Clear-out relay 3808 is operated over conductor 3650 by the operation of any one of the selector-preference relays 3601 to 3610 (relay 3601 in this case). Upon operating, relay 3808, at the front contact of its second right armature, shunts the associated contacts of relay 3809. At the back contact of its first armature, relay 3808 removes the short-circuit previously existing around the winding of the low-resistance clear-out relay 3809. When this occurs, relay 3809 operates over conductor 3852 and through contacts of any operated one of the section relays 3701 to 3712 (relay 3701 in this case) in series with the actuated secondary selecting magnet.

Upon operating, relay 3809, at its first armature, opens a further point in the shunt circuit previously existing around its winding; at its second armature, it renders the circuit of start relay 3805 and the operated one of the relays 3701 to 3712 dependent on the closed outer contacts of relay 3808; and at its third right armature, it disconnects chain-end conductor 3652 of relays 3601 to 3610 to preclude operation of any further one of these relays until relay 3809 again restores.

The above operation of relays 3808 and 3809 takes place in rapid succession following the described operation of selector-preference relay 3601, and is concluded before the previously described operation of the matched selector-stage primary and secondary switches.

Upon the described operation of cutoff relay 1101 of selector S1, ground potential is removed at the back contact of the second left armature thereof from the previously marked conductor 4 in cable MC1 thereby terminating the marked condition of this conductor immediately, without waiting for the associated counting relays to clear out as previously described. This operation results directly in the removal of ground potential from the left winding terminal of the operated selector-preference relay 3601, whereupon relay 3601 restores and again completes the operating chain to chain-end conductor 3652, except for the open point at the third armature of the energized clear-out relay 3809.

The restoration of relay 3801 also results in the removal of ground potential from conductor 3650, open-circuiting and restoring clear-out relay 3808. With relay 3809 operated, the restoration of relay 3808 opens the series circuit previously existing through start relay 3805 and section relay 3701. Relays 3701 and 3805 thereupon immediately restore. Any operated ones of the matching relays 3901 to 3909 and 3801 to 3806 are thereby immediately restored.

The above restoration of start relay 3805 normally occurs before the retarded cycle-timer relay 3806 has had time to operate. The circuit of the operating winding of relay 3806 is opened by start relay 3805, and the retarding winding of relay 3806 is also opened, to terminate the flow of circulating current therein to avoid a partially saturated condition thereof at the outset in the event that the next cycle of operations of the common equipment immediately follows the clear-out operation now being described.

Clear-out relay 3809 restores responsive to the described restoration of relay 3701, rejoining the winding of start relay 3805 to chain-supply conductor 3851 and rejoining chain-end conductor 3652 to conductor 3651, completing the clearing out of the common equipment 4SCE.

E24. Résumé of Operations at the Selector Stage

In résumé of the described operations at the selector stage, it may be pointed out that such

operations occur in three successive short intervals which may be tabulated as follows:

Table 1

INTERVALS OF OPERATION AT THE SELECTOR STAGE

1 Seizure of 4SCE (25 m. s.)	2 Matching and selecting (50 m. s.)	3 Switch operation (25 m. s.)
3701	3601 M1 of 2SP 3901 M1 of 2SS	3503 3501
3805	3905	

As shown in the above table, the hereinbefore described operations at the selector switching stage resulting in the completion of the connection to the connector 4C1 of Fig. 4, following the hereinbefore described restoration of series relay 1105 of the selector S1, occur in three successive intervals represented respectively by the three columns of the table.

Seizure of the selector common equipment 4SCE occurs during the first interval, relays 3701 and 3805 operating in series; during the second interval, five operations are started simultaneously, that of selector-preference relay 3601, matching relays 3901 and 3905, and the operation of the two selecting magnets M1; and, in the third interval, switch-operating magnets 3503 and 3501 occur responsive to the completion of the operation of the respective selecting magnets M1.

As is indicated within parentheses in the table, the first and third intervals are rated at twenty-five milliseconds each, and the second interval is rated at fifty milliseconds. These ratings are given by way of example only, for the intervals may be made considerably shorter than the times given, provided the concerned magnet windings are specially chosen to this end.

With the respective interval durations as indicated, the total time consumed by the three intervals at the switching stage is only one hundred milliseconds (one-tenth of a second) which is only a fraction of the average pause between successive dial operations at the calling substation.

E25. Résumé of Clearing-Out Operations at 4SCE

Since it is important that the common equipment 4SCE clear out promptly following the handling of a call to permit another call (if one has arrived or is waiting) to be handled immediately thereafter, a résumé is given of the previously described clearing-out operations at the selector common equipment 4SCE of Figs. 36 to 39, with reference to the following table:

Table 2

CLEARING-OUT INTERVALS AT 4SCE

1 (25 m. s.)	2 (15 m. s.)	3 (15 m. s.)	4 (15 m. s.)	5 (15 m. s.)
1101	3601	3808	3701 3805	3809 3901 3905

As shown in the above table the above described clearing out of the common equipment 4SCE, following the described completion of the connection through the switching stage occurs in five successive intervals, represented respectively by the columns of the table.

As shown by the above Table 2, cutoff relay 1101 of the selector S1 operates during the first clear-out interval (responsive to the operation of primary switch 1A, Fig. 35); selector-preference relay 3601 releases in the second interval responsive to the operation of relay 1101; clear-out relay 3808 releases in the third interval responsive to the restoration of relay 3601; section relay 3701 and start relay 3805 release in the fourth interval responsive to the restoration of relay 3808; and, in the fifth and final clear-out interval, clear-out relay 3809, primary-matching relay 3901, and secondary-matching relay 3905, release responsive to the restoration of relays 3701 and 3805.

The hereinbefore described reclosing of the chain-supply conductor 3851 at the back contact of the second armature of relay 3809 renders the selector common equipment immediately capable of starting the next cycle of operations.

As is indicated by the notations in parentheses under the respective column headings in Table 2, the relay-operating time of twenty-five milliseconds is assigned to the first interval, and the relay-releasing time of fifteen milliseconds is assigned to each of the remaining intervals, a total time of eighty-five milliseconds. This is substantially less than one-tenth of a second.

E26. Simultaneous Selector-Stage Calls

With the timing as given in the Tables 1 and 2, when two calls at the selector switching stage are directed simultaneously to the same group of selector links, the call which does not have preference in the chains of Figs. 36 and 37 waits through the selector-stage operating period of the preferred call (one hundred milliseconds), and through the clearing-out period of the common equipment (eighty-five milliseconds), following which the second call is put through during its selector-stage operating period, of one hundred milliseconds. The total inter-digit switching time required at the selector stage for the second of the two simultaneously presented calls under discussion is 285 milliseconds, substantially less than three-tenths of a second. This period of time is also well within the average interval occurring between successive series of digit impulses.

E27. Setting the Connector 4C1

Following its seizure by the hereinbefore described selector-switching action of the switches A1 and 1A of Fig. 35 and the consequent operation of its line and release relays 3804 and 3403 to prepare it for operation, the connector 4C1 is set in accordance with the tens, units, and party digits 1, 1, and 1 in the called number, as will now be described.

E27*a*. Operating the Sequence Relays

Sequence relays 3411 to 3413, and their common driver relay 3410, are provided to distribute the impulse series, received thereat over impulse conductor 3435, to the tens register of Fig. 34, and the units and party registers of Fig. 35.

Each time a digit is dialed into the connector 4C1, and line relay 3401 restores momentarily a number of times corresponding to the value thereof, series relay 3404 is operated, through the back contact of the armature of line relay 3401, and through the front contact of the right armature of release relay 3403. Being slow-restoring, as indicated, series relay 3404 remains

operated throughout the series of impulses constituting a dialed digit.

Each time it operates, series relay 3404 applies ground potential to conductor 3444, by way of the following circuit path: from ground on conductor 3450, grounded at the front contact of the first left armature of release relay 3403, back contact of the second left armature of busy relay 3409, conductor 3440, and the front contact of the right armature of series relay 3404, to conductor 3444.

The first grounding of conductor 3444, at the beginning of the ten series of impulses, results in the closure of a circuit, through the back contact of the first right armature of driver relay 3410, and through the back contact of the first right armature of sequence relay 3412, for the winding of the #1 sequence relay 3411. Relay 3411 thereupon operates and closes a self-locking circuit, as follows: from ground on conductor 3440, left-hand winding of driver relay 3410, front contact of the left armature of relay 3411, back contact of the first right armature of relay 3412, and thence to battery through the winding of relay 3411. The left-hand winding of driver relay 3410 remains unaffected in this locking circuit (being short-circuited) so long as the initial circuit for relay 3411 exists.

When series relay 3404 falls back at the end of the first digit, relay 3411 remains operated, and driver relay 3410 operates in the above-traced locking circuit of relay 3411. Upon operating, driver relay 3410 disconnects conductor 3444 from the winding of counting relay 3411 and transfers it to the winding of relay 3412, through contacts of the operated relay 3411.

Upon the next succeeding operation of series relay 3404 (during the units digit), the resulting grounding of conductor 3444 closes a circuit through contacts of the operated relays 3410 and 3411 for counting relay 3412. Relay 3412 thereupon locks itself to conductor 3440 at its first left armature. At its first right armature, relay 3412 opens the above-traced locking circuit and prepares an operating circuit for relay 3413. Counting relay 3411 thereupon restores, but driver relay 3410 is maintained operated over conductor 3444 by its right-hand winding until series relay 3404 restores at the end of the digit. When this occurs, driver relay 3410 restores, leaving relay 3412 locked operated over grounded conductor 3440.

When series relay 3404 operates pursuant to the party digit (the final digit in the number), it closes a circuit over conductor 3444, through the back contact of the first right armature of driver relay 3410, front contact of the first right armature of relay 3412, to battery through the winding of relay 3413. Relay 3413 thereupon operates. Upon so doing, it locks its winding in series with the left-hand winding of driver relay 3410, at the front contact of its left armature.

When series relay 3404 restores at the end of the party digit, counting relay 3413 remains locked in series with the left-hand winding of driver relay 3410 and the driver relay thereupon reoperates in the locking circuit of relay 3413.

E27b. Registering the Tens Digit

Each time line relay 3401 restores momentarily during the dialing of the tens digit in the desired number, it extends ground potential through the front contact of the right armature of release relay 3403, and the back contact of the left armature of busy relay 3409, to impulse conductor 3435. Impulse conductor 3435 normally extends, through back contacts of sequence relays 3410 and 3413, to the tens-register impulse conductor 3436, leading to the tens register comprising driver relay 3414 and counting relays 3415 to 3420. The operation of relays 3414 to 3420 is as described for the corresponding relays 1106 to 1112 of selector S1. It will suffice to say that counting relays 3415 to 3420 operate in accordance with the value of the received digit series of impulses to prepare a circuit over the corresponding one of the conductors 1 to 0 in branch BTM of cable CA—3200.

E27c. Registering the Units Digit

When the units digit is dialed, the impulse series delivered to impulse conductor 3435 by line relay 3401 is transmitted through the front contact of the second right armature of driver relay 3410 (which has operated as described at the end of the tens digit), and through the back contact of the right armature of sequence relay 3413, to the units-register impulse conductor 3437, extending to the relays 3301 to 3307, comprising the units register. The counting relays 3302 to 3307 are thereby set in accordance with the value of this digit to prepare a circuit over the corresponding one of the conductors 1 to 0 in units-mark cable 33UM.

E27d. Registering the Party Digit

When the party digit is dialed, the resulting series of impulses delivered to impulse conductor 3435 by line relay 3401 is transmitted through the back contact of the second right armature of driver relay 3410 (restored as described at the end of the units digit), through the front contact of the second armature of relay 3412 (operated at the beginning of the units digit), and thence over the party-register conductor 3438 to relays 3308 to 3313, constituting the party register. Counting relays 3309 to 3313 of this register operate in accordance with any value of from 1 to 5 of the called party digit to prepare a ringing circuit over the corresponding one of the common ringing conductors F1 to F5.

In the present example, the tens, units, and party digits (of the called number 4111) are each a 1. Accordingly, the #1 counting relays are operated in each of the registers; relay 3415 in the tens register, relay 3302 in the units register, and relay 3309 in the party register. The first conductor 1 is accordingly selected in branch BTM of cable CA—3300 and in cable 33 UM, while the first ringing conductor F1 is selected at the party register.

E28. Seizing the Common Equipment 4LCE Through the Connector Chain

When driver relay 3410 reoperates as described at the end of the party digit (sequence relay 3413 having operated during the party digit), ground potential is applied to start conductor ST in branch BC1 of cable CA—3200, through contacts of the operated relays 3413 and 3410.

Assuming that the line common equipment 4LCE of Figs. 27 to 30 is idle at this time, the above grounding of start conductor ST in branch BC1 of cable CA—3200 closes a circuit for connector-chain relay 3001, individual to the calling connector 4C1, as follows: from ground on the associated start conductor ST, through the winding of relay 3001, normally closed contacts controlled by the second right armature thereof, the associated chain-end conductor, the

chained path through back contacts of the first right armatures of relays 3009 to 3001, chain-supply conductor 30CH, transfer-control relay 2801, normally closed contacts controlled by the second right armature thereof, chain-end conductor 2952, back contact of the second right armature of hold relay 2807, conductor 2951, the chained path through the back contacts of relays 2930 to 2921, conductor 2932, back contact of the first right armature of transfer-control relay 2801, chain-supply conductor 2844, back contact of the second right armature of clear-out relay 2806, to battery through chain-supply resistor 2826.

Transfer-control relay 2801 and connector-chain relay 3001 operate in series over the above-traced circuit. At its second right armature, relay 3001 locks itself directly to the operating chain over conductor 30CH, at the same time disconnecting its winding from the associated chain-end conductor. At its first right armature it opens the operating chain to the associated common chain-end conductor to preclude operation at this time of any of the associated connector-chain relays 3002 to 3009. At its left armatures, relay 3001 connects up the associated conductors TR, UR, H, BU, SW, and S in the associated branch BC1 of cable 3200, all of these conductors being individual to the calling connector 4C1 of Figs. 33 and 34.

E29. Changing Over Common Equipment 4LCE From Line-Finder Operation to Connector Operation

When transfer-control relay 2801 operates in series with connector-chain relay 3001 as described, at its second right armature, it locks itself to chain-supply conductor 2844, at the same time disconnecting its winding from the associated chain-end conductor 2952. At its first right armature, it disconnects chain-supply conductor 2844 from conductor 2932, thereby depriving chain-end conductor 2952 of current, and precluding operation of any one of the relays 2921 to 2930 and 2911 to 2920 thereover for finder action.

At its first left armature, transfer-control relay 2801 joins operate conductor 2833 to conductor 30H for a purpose to appear hereinafter; and, at its second left armature, it applies ground potential to transfer conductor 2831, thereby operating transfer relays 2710 and 2701, to complete the changeover of the common equipment from its normal condition for controlling line-finder action, to the condition in which it controls what is termed connector action.

E30. Section Selection in the Line Primary Group

The #1 section of the primary group 4LP of Figs. 10A and 31 (containing the terminals of the called line #4111) is now selected by the operation of section-1 relay 2921 over the following circuit: from ground, through the front contact of the sixth left armature of the operated connector-chain relay 3001, conductor TR in branch BC1 of cable CA—3200, back contacts of relays 3420 to 3416 of the tens register, front contact of the third right armature of the operated counting relay 3415, conductor 1 in branch BTM of cable CA—3200, to battery through the right-hand winding of section-1 relay 2921. Upon operating, relay 2921, at its left armatures, connects the conductors 1A to 1D in branch BP of cable CA—3200 respectively to the conductors A to D in cable CA—2700, pursuant to primary matching to be subsequently described. Additionally, relay 2921 grounds start conductor 2934 at its third right armature; while, at its fourth right armature, it grounds conductor 1 in branch BSM of cable CA—3200.

E31. Tens Selection

Responsive to the grounding of conductor 1 in branch BSM of cable CA—3200, by section-1 relay 2921, selecting magnet M1 of secondary group 4LS (Figs. 10A and 32) operates to select the #1 stackup of contacts in all the associated secondary switches.

E32. Units Selection

Contemporaneously with the described operation of section-1 relay 2921, units selection in primary group 4LP (Figs. 10A and 31) is accomplished by the energization of selecting magnet M1 thereof over the following circuit path: from ground, through the front contact of the fifth left armature of connector-chain relay 3001, conductor UR in branch BC1 of cable CA—3200, back contacts of counting relays 3307 to 3303 of the units register of connector 4C1, front contact of the third right armature of the operated counting relay 3302, conductor 1 in cable 33UM, to battery through magnet M1 (Fig. 31) of primary group 4LP. The #1 stackup of contacts is thereby selected in each of the associated primary switches.

E33. Starting the Cycle Timer

The cycle timer of equipment 4LCE, comprising relays 2803 to 2805, is started into operation responsive to the energization of start relay 2802 over conductor 2934, grounded at the front contact of the third right armature of section-1 relay 2921. The operation and function of this cycle timer is similar to that hereinbefore discussed in connection with the cycle timer shown in Fig. 15.

Start relay 2802 also grounds lock conductor 2833 as a preparatory operation.

E34. Primary Matching

Primary matching at relays 2703 to 2706 now occurs, with the left-hand windings of these relays being connected, through conductors in cable CA—2700, and through contacts of section-1 relay 2921, respectively to test conductors 1A to 1D in cable CA—3200, which test conductors are connected respectively to the primary switches 1A to 1D comprising section 1 of primary group 4LP (Figs. 10A and 31).

The right terminals of the left-hand windings of primary-match relays 2703 to 2706 are now connected, through conductors in cable CA—2750, contacts of cutoff relay 2702, and the front contacts of the operated transfer relay 2701, to conductors A to D respectively in branch BSC of cable CA—3200. Conductors A to D in the said branch BSC are connected multiply to the connector-action switches in sections A to D respectively of secondary group 4LS (Figs. 10A and 32). Any one of such conductors is maintained grounded, as indicated in Fig. 32, so long as any one of the connector-action switches in the associated section is idle. For example, conductor D of this cable branch is normally maintained grounded at the upper contact pair of the *c* stackup of the connector-action secondary switch D5 of Fig. 32, as well as at the corresponding contacts in each of the other associated connector-action switches in section D.

It may be assumed, for the purpose of illustration, that all four of the primary switches in the called #1 primary section are idle, and that there is at least one idle connector-action secondary switch in each of the sections A to D of the concerned secondary group, 4LS. In this event, the high-resistance left-hand winding of each of the primary-matching relays 2703 to 2706 is energized, resulting in all four of these relays starting to operate.

The matching circuit for primary-matching relay 2706 may be traced from ground on conductor D in branch BSC of cable CA—3200, through the front contact of the fourth armature of transfer relay 2701, back contact of the fourth right armature of cutoff relay 2702, conductor D in cable CA—2750, left-hand winding of relay 2706, conductor D in cable CA—2700, front contacts of the first left armature of section-1 relay 2721, conductor 1D in branch BP of cable CA—3200, make-busy contacts 3109, c-stackup contacts of switch 1D of group 4LP, to battery, through the low-resistance operating winding of magnet 3108. Magnet 3108 is not operated at this time because of the high-resistance of the left-hand winding of relay 2706.

Each of the relays 2703 to 2706 attempts to close a locking circuit for itself upon partially operating, but in this example only relay 2706 is able to close a locking circuit for itself.

By the operation of the second left armature of transfer relay 2710, locking conductor 2722 has been substituted for locking conductor 2721, thus shifting the primary preference from the finder-action order of preference (section A to section D) to the connector-action order (from section D to section A).

At its second left armature, the section-D primary-matching relay 2706 disconnects the connector-action locking conductor 2722 from the locking armatures of each of the relays 2705 to 2703, and closes a locking circuit through its right-hand winding, to battery through the winding of cutoff relay 2702. Cutoff relay 2702 thereupon operates to open-circuit the left-hand winding of each of the relays 2703 to 2706. When this occurs, each of the partially operated matching relays 2703 to 2705 restores. Relay 2706 is fully operated by its right-hand winding, in series with cutoff relay 2702.

With relay 2706 locked operated, and relays 2703 to 2705 in restored condition, primary matching has taken place between the D primary switch (1D) in the called #1 section of primary group 4LP (Fig. 31) and section D of the associated secondary group 4LS (Fig. 32).

E35. Secondary Matching

The described primary-matching operation is followed by a secondary-matching operation.

With primary-matching relay 2706 operated and relays 2703 to 2705 in restored condition, secondary-matching relays 2711 to 2713 are under the control of test leads D5 to D3 respectively, in branch BS of cable CA—3200, keeping in mind that transfer relay 2710 is now in operated condition. Each of these secondary-matching relays, therefore, starts to operate, depending upon the associated one of the connector-action secondary switches D5 to D3 in group 4LS of Figs. 10A and 32 being in idle condition. It may be assumed that all three of these switches are in idle condition at this time, in which case all three of the secondary-matching relays 2711 to 2713 start to operate.

The matching circuit of relay 2711 is from ground, through contacts of cutoff relay 2715, through the high-resistance left-hand winding of relay 2711, front contact of the first right armature of transfer relay 2710, front contact of the first right armature of primary-matching relay 2706, conductor D5 in branch BS of cable CA—3200, make-busy contacts 3204, lower contact pair in the associated c stackup, to battery through the low-resistance operating winding of magnet 3203. Magnet 3203 is not operated at this time because of the high-resistance of the left-hand winding of secondary-matching relay 2711.

Upon operating partially, relay 2711 closes a self-locking circuit through the front contact of its first right armature, its own right-hand winding to battery through cutoff relay 2715. Cutoff relay 2715 thereupon disconnects the left-hand winding of each of the relays 2711 to 2713, whereupon partially operated relays 2712 and 2713 restore. Relay 2711 operates fully and remains operated in its locking circuit through its right-hand winding in series with the cutoff relay.

E36. Distributor Selection

Selection now occurs in the distributor group 4D (Figs. 10A and 32) according to which of the the nine connector-action secondary switches in group 4LS (Figs. 10A and 32) has been predetermined by the described primary and secondary matching operations. In the present example, the first-choice connector-action secondary switch D5 in group 4LS (Fig. 32) is the one predetermined by the matching operation. Accordingly, ground potential is extended from the front contact of the outer armature of transfer relay 2710, over conductor 2724, the front contact of the outer right armature of the operated primary-matching relay 2706, over the associated A distributor control conductor, and the front contact of the third right armature of secondary-matching relay 2711, to conductor 1 in branch BDM of cable CA—3200. The grounding of this conductor results in the energization of the #1 selecting magnet M1 in the distributor group 4D (Figs. 10A and 32) to cause the #1 stackup of contacts to be selected in each of the nine distributor switches of the group.

E37. Operating the Matched Primary, Secondary, and Distributor Switches

At its lower armature, cutoff relay 2715 applies ground potential, from the grounded lock conductor 2832, to conductor 2834, closing a circuit through contacts of clear-out relay 2806 for the slow-acting hold relay 2807. Hold relay 2807 being both slow-operating and slow-releasing as described hereinbefore in connection with the similar hold relay 1507, operates after a sufficient interval has elapsed following the operation of cutoff relay 2715 to permit the previously described stackup selection to occur in distributor group 4D, Fig. 32.

Upon operating, hold relay 2807 disconnects the associated chain-end conductors 3052 and 2952 at its third and second right armatures to preclude operation for the time being of any of the associated chained relays; at its first right armature and front contact, it shunts the associated contacts of clear-out relay 2806; at the front contact of its second left armature, it closes an operating circuit for the delayed-action clear-out relay 2806; and, at its first left armature, it applies ground potential to operate con-

ductor 2833, closing a circuit for the operating magnet of each of the switches 4D1 and A1 of Fig. 32, and 1D of Fig. 31.

The operating circuit for magnet 3203 of the secondary switch D5 is as follows: from ground on operate conductor 2833, through the front contact of the second right armature of secondary match relay 2711, front contact of the first right armature of transfer relay 2710, front contact of the first right armature of primary-match relay 2706, test conductor D5 in branch BS of cable CA—3200, make-busy contacts 3204, the lower pair of associated *c*-stackup contacts, and to battery through the low-resistance operating winding of magnet 3203. Magnet 3203 thereupon operates, closing the associated #1 stackup of contacts and shifting the contacts of stackup *c*. The upper contacts of the associated *c* stackup disconnect ground potential at one point from the associated section conductor D for the connector-action secondary switches, while the lower pair of contacts in the *c* stackup disconnect the low-resistance operating winding of magnet 3203, leaving the high-resistance lower winding connected as a holding winding.

The operating circuit for magnet 3108 of primary switch 1D is as follows: from ground, on operate conductor 2833, through the front contact of the first left-armature of primary-matching relay 2706, conductor D in cable CA—2700, front contact of the first left armature of section-1 relay 2921, conductor 1D in branch BP of cable CA—3200, make-busy contacts 3109, the associated *c*-stackup contacts, and thence to battery through the low-resistance operating winding of magnet 3108. Magnet 3108 thereupon operates to close the associated #1 stackup of contacts and to shift the contacts of stackup *c*. The *c*-stackup contacts disconnect the operating winding of magnet 3108, leaving the high-resistance lower winding of this magnet connected as a holding winding.

The operating circuit for the distributor switch (4D1, Fig. 32) associated with the calling connector 4C1 of Fig. 33 is as follows: from ground on operate conductor 2833, through the front contact of the first right armature of transfer control relay 2801, conductor 30H, front contact of the fourth left armature of connector-chain relay 3001, conductor H of link L4C1 in cable CA—3400, *c*-stackup contacts of switch 4D1 (Fig. 32), and thence to battery through the low-resistance operating winding of magnet 3205. Magnet 3205 now operates to close the associated #1 stackup of contacts and to shift the associated *c* stackup, thereby disconnecting the low-resistance operating winding of magnet 3205, leaving the high-resistance lower winding thereof connected as a holding winding.

The outgoing tip, ring, and sleeve conductors of the connector 4C1 (conductors T, R, and S in link L4C1) have now been extended through the tip, ring, and sleeve contacts in the operated #1 selective stackup of switch 4D1 (Fig. 32), tip, ring, and sleeve conductors of link 1 in cable CA—3250, tip, ring, and sleeve contacts of the operated stackup #1 of secondary switch D5, primary link L1D, and thence through the tip, ring, and sleeve contacts of the operated #1 stackup of contacts of primary switch 1D (Fig. 31) to the conductors T, R, and S respectively of line multiple L. M. #411, being the switchboard multiple of the called line.

E38. Testing the Called Line

The operations now occurring depend upon whether the called line is busy or is idle. If the called line is busy, cutoff relay 3103 thereof is being held operated by ground potential on sleeve conductor S of line multiple L. M. #411, applied thereto through the #1 selective stackup of contacts of another one of the associated primary switches. On the other hand, if the called line is idle, there is no ground potential on the sleeve conductor thereof and the cutoff relay 3103 is in a restored condition.

In the present example, it may be assumed that the desired line is idle when called. Under this condition, test relay 3018 operates in series with cutoff relay 3103 of the called line over the following circuit path, responsive to the completion of the described connection between the calling connector and the called line: from ground, through the winding of test relay 3018, through the front contact of the first left armature of connector-chain relay 3001, sleeve conductor S in branch BC1 of cable CA—3200, and thence over the sleeve conductor of the established connection, to battery through cutoff relay 3103.

Cutoff relay 3103 operates in series with test relay 3018, clearing the called line for ringing and talking purposes. Test relay 3018 prepares a circuit for switching relay 3408 of the connector 4C1.

E39. Seizing the Called Line

The connector 4C1 is now operated to seize the called line and to free the common equipment 4LCE, as follows:

A further result of the grounding of operate conductor 2833 by the described operation of hold relay 2807, and the consequent grounding of conductor 30H, through contacts of transfer-control relay 2801, is the closing of a circuit for the right-hand winding of delay relay 3017.

Upon operating (after sufficient time has elapsed for the connection to be completed and for test relay 3018 to operate if the called line is idle), delay relay 3017 operates. It removes the short-circuit from around its left-hand, delaying winding to render it fast releasing. Relay 3017 applies ground potential to the associated conductor common to relays 3001 to 3009. A circuit is thereby closed through the front contact of the third left armature of relay 3001 for busy relay 3409, whether the called line is busy or is idle. At the same time, with test relay 3018 operated, a circuit is closed through the front contact of the armature of this relay, through the front contact of the second left armature of relay 3001, and over switching conductor SW in branch BC1 of cable CA—3200, for relay 3408 of the connector 4C1. Switching relay 3408 and busy relay 3409 both operate. Each of these relays locks itself operated to the local locking conductor 3450, grounded at the front contact of the first left armature of release relay 3403.

At the front contact of the first left armature of busy relay 3409, ground potential is applied locally to the hold conductor H in link L4C1, to hold the operating magnets of the concerned distributor, secondary, and primary switches between the connector and the called line after the common equipment is cleared out.

Ground potential is applied through the front contact of the second left armature of switching relay 3408 and the front contact of the third left armature of busy relay 3409 to the sleeve con-

ductor S in link L4C1 to maintain cutoff relay 3103 operated after the common equipment has cleared out.

E39a. Closing the Ringing Circuit

At the front contacts of the third and fourth left armatures of switching relay 3408, the ringing circuit is completed to the called line, and a ringing-tone signal is applied to the calling line from the common lead RT, through the front contact of the outer left armature of switching relay 3408, condenser 3423, and the back contact of the outer armature of ring-cutoff relay 3406.

E39b. Clearing Out the Tens and Units Registers and the Sequence Relays

At the back contact of the second left armature of busy relay 3409, ground potential is disconnected from conductor 3440, thereby restoring and clearing out any operated ones of sequence relays 3410 to 3413 and clearing out any operated ones of the tens register relays 3414 to 3420, as well as any operated ones of the units-register relays 3301 to 3307. The marked conductors 1 in branch BTM of cable CA—3200 and in cable 33UM are thereby ungrounded.

Selecting magnet M1 of group 4LP (Fig. 31) restores responsive to the clearing out of the units register, while section-1 relay 2921 restores responsive to the clearing out of the tens register.

E40. Freeing and Clearing Out Common Equipment 4LCE

Responsive to the restoration of sequence relays 3410 and 3413, start conductor ST in branch BC1 of cable CA—3200 is ungrounded, open-circuiting and restoring connector-chain relay 3001 and transfer-control relay 2801. Transfer relays 2701 and 2710 restore responsive to the restoration of relay 2801.

Start relay 2803 restores responsive to the described restoration of relay 2921, open-circuiting and restoring any operated ones of the associated cycle-timer relays 2803 to 2805. Start relay 2802 also removes ground potential from lock conductor 2832, permitting the operated relays 2702, 2706, 2711, and 2715 to restore. Additionally, the removal of ground potential from locking conductor 2832 permits clear-out relay 2806 to restore.

A short interval later, slow-operating hold relay 2807, whose circuit was initially opened at the back contact of the first right armature of clear-out relay 2806, restores and reconnects chain-end conductors 2952 and 3052, completing the clearing out of the common equipment 4LCE for further operation, either for finder action or connector action.

The circuits of the operated selecting magnets M1 in groups 4D, 4LS, and 4LP (Figs. 32 and 31) are opened incident to the above clearing-out operations, as are the circuits over which the operating magnets of the switches in this group were initially controlled.

E41. Holding the Connection to the Called Line

After the clearing-out operation has taken place, the operating magnets of the switches between the connector and the called line are held operated as follows: the ground potential applied to the hold conductor H of link L4C1 at the front contact of the first left armature or busy relay 3409 maintains the lower winding of magnet 3205 of the switch 4D1 energized as a holding winding; ground potential on the conductor H of link L4C1 is further extended, through the lower pair of contacts in the operated stackup #1 of switch 4D1, and over the hold conductor of link 1 of cable CA—3256, to the lower winding of magnet 3203 of switch D5; and ground potential on the hold conductor H of secondary switch D5 is extended, through the lower pair of contacts in the operated #1 stackup of the switch to the hold conductor H of primary link L1D, to provide a holding circuit for the lower winding of operating magnet 3108 of the primary switch 1D.

E42. Signaling the Called Substation

Following the described operation of switching relay 3408, ringing current is transmitted to the called line from the selected 20-cycle ringing lead F1, Fig. 33, through the front contact of the second right armature of counting relay 3309, back contacts of relays 3310 to 3313, conductor 3432, back contact of the third left armature of ring-cutoff relay 3406, front contact of the fourth left armature of switching relay 3408, and thence to the called substation by way of the tip conductor of the established connection. The return path for the ringing current is over the ring conductor of the established connection, through the front contact of the third left armature of switching relay 3408, back contact of the second left armature of ring cutoff relay 3406, the winding of ring-trip relay 3407, the exchange battery (not shown), and the common ground connection.

The ringing current is preferably intermittently applied in accordance with the usual practice, as by ringing relay 3333 which alternately connects the leads F1 to F5 to ground and to its respective source of ringing current.

Ring-trip relay 3407 is of the usual slow-responding construction, whereby it does not respond to alternating current during the ringing operation, the flow of direct current being precluded at this time by the usual condenser (not shown) in the ringing circuit at the called substation.

E43. Answering

When the called subscriber responds, by removing his receiver, the resulting closure of the usual direct-current bridge across the conductors of his line permits trip relay 3407 to operate over the ringing circuit. Upon operating, trip relay 3407 closes a circuit for ring-cutoff relay 3406. Ring-cutoff relay 3406 now operates and locks itself to the grounded conductor 3450, at the front contact of its first left armature. At the back contact of its first left armature, relay 3406 disconnects ground potential from conductor 3439, thereby permitting the party register comprising relays 3308 to 3313 to clear out.

At its outer armature, ring-cutoff relay 3406 disconnects the ringing-tone lead RT from the calling line, while at its second and third left armatures, it opens the ringing circuit and completes the talking circuit. Back-bridge relay 3402 thereupon operates over the called line and makes a multiple application of ground potential to locking conductor 3450.

The two subscribers may now converse as desired.

E44. Clearing Out the Established Connection

When the conversation is terminated and the subscribers have replaced their receivers, the established connection is cleared out, as will now be described. It will be assumed that the called subscriber does not replace his receiver for an

interval after the receiver is replaced on the calling line.

E44a. Clearing Out the Connection From the Calling Line

When the receiver is replaced on the calling line under the above assumption, line relay 3401 restores, but back-bridge relay 3402 remains operated for the time being. Upon restoring, line relay 3401 open-circuits the slow-restoring release relay 3402 and momentarily reoperates series relay 3404 through contacts of release relay 3403. The reoperation of series relay 3404 is for no particular purpose except during a reverting call, to be hereinafter described.

When release relay 3403 restores, after a slight interval, it open-circuits series relay 3404 permitting the latter relay to restore after a further slight interval. With relays 3403 and 3404 restored, conductor 3450 is maintained grounded at the contacts of back-bridge relay 3402 to maintain the connection established between the connector and the called line by maintaining relays 3406, 3408, and 3409 locked operated.

The second left armature of release relay 3403 disconnects the incoming sleeve conductor of the connector (conductor S in link 4LA1) from ground, opening the holding circuit of the upper winding of magnet 3501 of the selector secondary switch A1 (Fig. 35) and the holding circuit of the lower winding of magnet 3503 of the selector primary switch 1A, whereupon these magnets restore returning these switches to their illustrated normal condition.

Additionally, the removal of ground potential from the incoming sleeve conductor of the connector 4C1 open-circuits and restores cutoff relay 1101 of the selector S1 (returning this selector to its illustrated normal condition), and it open-circuits and restores cutoff relay 1803 associated with the calling line.

A result of the above described restoration of cutoff relay 1101 is the removal of ground potential from the associated hold conductor H of the selector link SL1, thereby opening the holding circuit through the upper winding of magnet 1901 of the finder-action secondary switch A1 (Fig. 19), as well as the holding circuit through the lower winding of magnet 1806 of primary switch 1A (Fig. 18). These operating magnets thereupon restore returning the switch A1 of Fig. 19 and the switch 1A of Fig. 18 to their illustrated normal condition.

The connection between the calling line and the connector 4C1 of Figs. 33 and 34 has been cleared out by the above described operations.

E44b. Clearing Out the Connection to the Called Line

When the called subscriber replaces his receiver, back-bridge relay 3402 restores, finally removing ground potential from conductor 3450. When this occurs, relays 3406, 3408, and 3409 restore, completing the clearing out of the connector 4C1 and reconnecting the incoming sleeve conductor of the connector to idle-indicating battery potential through resistor 3431 to render the associated secondary switch A1 of Fig. 35 again selectable.

The removal of ground potential from the outgoing sleeve lead S in link L4C1 by relay 3409 permits cutoff relay 3103 of the called line to restore. The removal of ground potential from the outgoing hold lead H in link L4C1 by relay 3409 open-circuits the holding windings of magnets 3205, 3203, and 3108, whereupon these magnets restore, clearing out the distributor switch 4D1 and the connector-action secondary switch D6 of Fig. 32, and the primary switch 1D of Fig. 31.

The connection between the calling and called lines has now been completely cleared out and the apparatus involved therein has been returned to normal condition.

When the called subscriber replaces his receiver first, back-bridge relay 3402 restores, but without any immediate effect. Under this condition, when the calling subscriber replaces his receiver, ground potential is removed from conductor 3450 responsive to the restoration of release relay 3403 (as soon as the momentarily operated series relay 3404 restores), resulting immediately in the described clearing out of the connection to the called line, along with the clearing out of the connection from the calling line.

E45. Alternative Operations in Line Common Equipment 2LCE

Certain alternative operations in the line common equipment 2LCE (Figs. 14 to 17) will now be described, including other matching possibilities, and the temporary locking out of a section of lines from finder action when all link paths outgoing therefrom are unavailable.

E45a. Matching in Other Primary Sections

When the calling line is one associated with a section of primary 2LP (Figs. 10A and 18) other than the first section thereof, one or another of the start conductors S2 to S0 (Fig. 16), contained in one or another of the branches B2 to B0 of cable CA—1800, is grounded by the line relay (similar to 1802) associated with the calling line, causing the operation of one or another of the pairs of section relays 1612 and 1622 to 1620 and 1630. From this point, the operation proceeds as previously described, with the ten individual mark conductors of the tens group of lines under consideration being connected respectively to conductors 1 to 0 in cable CA—1600, and with the conductors A to F in cable CA—1400 being connected respectively to the test conductors of the switches A to F in the concerned section of the primary group 2LP. The primary-matching relays 1403 to 1408 are thereby rendered temporarily individual respectively to the six primary switches in the calling section.

E45b. Matching in Other Secondary Sections

It was described hereinbefore that primary-matching relay 1403 is effectively operated and locked, and that the associated partially operated relays 1404 to 1408 are restored by cutoff relay 1402, to predetermine matching in the preferred section A of the secondary with the preferred A-primary switch, in the event that all six of the concerned primary switches are idle and that there is at least one idle finder-action secondary switch in each of the sections A to F thereof.

When the A primary-matching relay 1403 fails to respond and the other associated relays respond, then the B matching relay 1404 is the one which is locked operated through the cutoff relay 1402 and the remaining relays 1405 to 1408 are restored.

Finally, if relays 1403 to 1407 fail to respond and relay 1408 responds alone, it locks in series with cutoff relay 1402 from ground on conductor 1421, through the back contacts of the outer left armatures of relays 1403 to 1407 and through the front contact of its own outer left armature.

In any case, whichever one of the primary-matching relays 1403 to 1408 operates fully connects the test conductors of the matched section of finder-action secondary switches (comprising A1 to A4; B1 to B3; C1 to C3; D1 and D2; E1 and E2; and F1 and F2; in branch BS of cable CA—1900) to the corresponding ones of the secondary match relays 1411 to 1414 to enable the latter relays to select an idle one of the switches in the matched secondary section, as previously described.

E45c. Other Secondary Matching

In the previous example, the secondary matching described was that involving the first-choice secondary switch in the matched secondary section, the secondary-matching relay operating fully being relay 1411.

When relay 1411 fails to respond, because the first-choice finder-action secondary switch in the matched secondary section is in use, locking conductor 1423 remains extended to the first right armature of the second-choice secondary match relay 1412, enabling this relay to lock if it responds. Similarly, any succeeding one of the relays 1413 and 1414 can lock and thereby operate fully if all the preceding secondary match relays fail to operate.

In any case, when operate conductor 1533 becomes grounded (by hold relay 1507 as hereinbefore described), the matched primary switch is operated through the front contact of the first left armature of the operated one of the primary match relays 1403 to 1408, and the matched secondary switch is operated through the front contact of the second right armature of the operated one of the secondary match relays 1411 to 1414.

E45d. All Finder-Action Links Busy

As described, the operation of one of the primary-matching relays 1403 to 1408 for finder action requires that the associated primary switch in the calling section be idle, and that at least one of the finder-action secondary switches in the corresponding secondary section be idle. Therefore, when no finder-action link path is available on a call originated in hundreds group 2, none of the primary matching relays 1403 to 1408 can operate. Under this condition, no secondary matching can occur. As a consequence, relay 1415 fails to operate, whereby hold relay 1507 cannot be operated over conductor 1534. The normal cycle of operations begun by the equipment 2LCE cannot then be completed. This equipment, however, is cleared out by cycle timer comprising relays 1503 to 1505, previously discussed.

It was described hereinbefore that the cycle timer is so arranged that it does not complete its cycle of operations under normal conditions. Under the conditions now assumed, however, the operation of the cycle timer proceeds to a completion. Briefly, this operation includes the operation first of relays 1504 and 1505 by start relay 1502, followed a short time later by the operation of the delayed-action relay 1503. Relay 1504 is short-circuited by relay 1503, with the result that it restores a short interval thereafter. With relay 1503 operated, and relay 1504 restored, relay 1505 is short-circuited, with the result that it restores a short interval thereafter.

Upon the restoration of relay 1505, a circuit is closed for the right-hand winding of the delayed-action clear-out relay 1506 through contacts of the operated relays 1502 and 1503 and through the back contact of the first left armature of relay 1505. At the same time, ground potential is applied to busy conductor 1635 through the back contact of the second left armature of relay 1505 and the front left armature of relay 1503, thereby closing a circuit through the front contact of the first left armature of the operated one of the relays 1611 to 1620 for the associated one of the section-lockout relays 1601 to 1610, to battery, through contacts of the ten-second timer 1600. Such section-lockout relay thereupon operates to disconnect the associated one of the start conductors S1 to S0 from the winding of its associated one of the relays 1611 to 1620, and to close a locking circuit for itself thereover. The operated one of the lockout relays 1601 to 1610 remains operated over its associated one of the start conductors as long as such conductor remains grounded from the calling line, or until the ten-second timer 1600 next opens its contacts momentarily to permit such relay to restore, terminating the temporary locked-out condition.

When delayed-action clear-out relay 1506 responds to the above-mentioned closure of its circuit by the restoration of cycle-timer relay 1505, it removes battery potential from chain-supply conductor 1544 at the back contact of its second right armature, thus forcing the clearing-out of any operated ones of the section relays 1621 to 1630 (along with its companion one of the relays 1611 to 1620) by an operation independent of lockout relays 1601 to 1610.

The removal of ground potential from start conductor 1634 by the restoration of the operated one of the relays 1621 to 1630, results in the restoration of start relay 1502 to immediately clear out the cycle timer comprising relays 1503 to 1505, permitting clear-out relay 1506 to restore, and returning the common equipment 2LCE to normal condition.

E46. Alternative Operations in the Selector Common Equipment 4SCE

From what has been already stated in connection with certain alternative operations in the line common equipment 2LCE of Figs. 14 to 17, corresponding alternative operations in the selector common equipment 4SCE will be clear. The operations occurring, however, when no matching is possible are somewhat different and will now be described.

E46a. All Links Busy

Let it be assumed now that, when the common equipment 4SCE is taken for use as hereinbefore described by the selector S1 of Fig. 11, all of the concerned links through which primary and secondary matching can be accomplished are in use. Under this condition, none of the primary-matching relays 3904 to 3901 can operate. As a direct result, none of the conductors A to D of cable CA—3800 is connected to the associated off-normal conductor PON, and none of the concerned primary switches is operated. At the same time, none of the concerned secondary switches is operated because secondary-operate conductors 3951 to 3954 are all left disconnected.

When the connection is not completed through the selector switching stage, clear-out relays 3808 and 3809 remain operated for sufficient time to permit the retarded cycle-timer relay 3806 to operate. When it does so, it closes a circuit for the associated relay 3807, but this relay does not operate for a substantial interval, being provided with a comparatively inductive winding and having a comparatively stiff adjustment.

At the front contact of its right armature, cycle-timer relay 3806 operates the marginally adjusted busy relay 1104 of the calling selector S1 over the following circuit path: from battery through resistor 3849, front contact of the right armature of cycle-timer relay 3806, busy conductor 3850, front contact of the left armature of selector-preference relay 3601, conductor 1 in cable CA—3750, front contact of the outer left armature of section-1 relay 3701, conductor 1 in cable CA—3700, terminal blocks 3611 and 3612, conductor M1 in branch B4 of cable CA—1300, conductor 4 in cable MC1, front contact of the third left armature of counting relay 1110, back contacts of relays 1111, 1112, and 1105, the low-resistance left-hand winding of marginal busy relay 1104, to ground through the back contact of the second left armature of cutoff relay 1101.

Busy relay 1104, which is unresponsive to the normal flow of current through its left-hand winding, now operates responsive to the increased current flow over the above-traced circuit.

Upon operating, busy relay 1104 closes a locking circuit for its right-hand winding; from ground, through the front contact of the first right armature of release relay 1103, back contact of the first right armature of relay 1101, front contact of the second right armature of release relay 1103, front contact of the first right armature of relay 1104, to battery through the right-hand winding of busy relay 1104.

In the common equipment 4SCE of Figs. 36 to 39, when clear-out relay 3807 responds a sufficient interval after the response of relay 3806 to enable the busy relay of the selector to operate and lock as described, it open-circuits and restores start relay 3805 and the operated section-1 relay 3701. The restoration of relay 3701 disconnects the conductors in cable CA—3750, permitting any operated one of the selector-preference relays 3601 to 3610 to clear out.

Cycle-timer relay 3806 restores responsive to the restoration of start relay 3805, followed by the restoration of relay 3807, completing the clearing-out operation.

In the selector S1 (Fig. 11), busy relay 1104, at contacts controlled by its first right armature, removes ground potential from conductor 1118, permitting relays 1106 to 1112 to clear out; at the back contact of its left armature, relay 1104 disconnects conductor 1117 to prevent further response of series relay 1105 and of the counting relays; and at its second right armature, it disconnects the common dial-tone lead DT and substitutes the common busy-tone lead BT, thereby transmitting a busy signal back to the calling line to inform the calling subscriber that the desired connection cannot be completed for the time being.

When the calling subscriber replaces his receiver, line relay 1102 restores, followed shortly by the restoration of release relay 1103. By the restoration of release relay 1103, the locking circuit of busy relay 1104 is opened, whereupon relay 1104 restores.

The connection between the calling line and the selector S1 clears out responsive to the removal of ground potential from the hold conductor H in the selector link SL1 by release relay 1103.

E47. The Called Line is Busy

Let it be assumed now that, in the call previously considered, the called line is busy. In this event, the ground potential on the sleeve conductor S of line multiple L. M. #411 (Fig. 31) of the called line prevents test relay 3818 of the common equipment 4LCE from operating in series with the cutoff relay when the previously described test of the called line is made. Under this condition, the operation of delay relay 3817 results in the previously described operation of busy relay 3409 of the connector 4C1, but the circuit over lead SW in branch BC1 of cable CA—3200 for switching relay 3408 remains open at the contacts of test relay 3818. Switching relay 3408, therefore, remains unoperated. The previously described clearing out of the sequence relays and the tens and units registers occurs responsive to the described ungrounding of conductor 3440 by busy relay 3409, resulting in start conductor ST in the associated cable branch BC1 being ungrounded to permit the common equipment 4LCE to clear out.

With busy relay 3409 operated, and with switching relay 3408 not operated, a busy-tone signal is transmitted back to the calling line from the common busy-tone lead BT, through the front contact of the outer left armature of busy relay 3409, back contact of the outer left armature of switching relay 3408, condenser 3423, and the back contact of the outer left armature of ring-cutoff relay 3406. The calling subscriber is thereby informed of the busy condition of the called line.

When the calling subscriber replaces his receiver following the receipt of the busy-tone signal, the removal of ground potential from conductor 3450 consequent upon the restoration of release relay 3403, following the restoration of busy relay 3440. At the front contact of its first left armature, busy relay 3440 disconnects ground potential from conductor H in link L4C1 permitting the connection established with the busy called line to be cleared out. The clearing out of the connection from the calling line to the connector results directly from the removal of ground potential from the incoming sleeve conductor of the connector at the front contact of the second left armature of release relay 3403.

F. Reverting Call on Party Line #410

The way in which reverting calls are made on the party lines will now be described. For this purpose, it will be assumed that the subscriber at substation #4102 (Fig. 31) on party line #410 desires to converse with the subscriber at substation #4105 on the same party line. For this purpose, the calling party-line subscriber removes his receiver; waits for dial tone; dials the desired number, 4105; waits for busy tone; replaces his receiver for a sufficient length of time to enable the called substation to be signalled; and then removes his receiver to converse with the called subscriber when he answers.

F1. Marking the Calling Line

When the receiver is removed at the calling party-line substation #4102 (Fig. 31), line relay 3104 operates through contacts of cutoff relay 3105. It grounds the associated start conductor S1 and the associated mark conductor M10.

Assuming that the common equipment 4LCE of Figs. 27 to 30 is idle, the grounding of start conductor S1 closes a circuit through branch B1 of cable CA—3100, the back contact of group cutoff relay 2901, section-1 relay 2911, the left-hand winding of section #1 relay 2921, contacts controlled by the second right armature of relay 2921, chain-end conductor 2952, contacts of hold relay 2807, conductor 2951, chain contacts of relays

2930 to 2921, and 2801, and thence to battery over chain-supply conductor 2844 and resistor 2826.

Relays 2911 and 2921 operate over the above-traced circuit. Relay 2911 connects the associated mark conductors M11 to M10 respectively to units-preference relays 3021 to 3030, whereupon units-preference relay 3030 operates over the grounded mark conductor M10 to ground the associated conductor 0 in branch BPM of cable CA—3200 thereby operating selecting magnet M0 in line primary group 4LP (Figs. 10A and 31) to cause selection of the #0 stackups of contacts in all the switches thereof.

Section-1 relay 2921 grounds start conductor 2934 to start the cycle-timer comprising relays 2803 to 2805 into operation by the operation of start relay 2802, at the same time grounding conductor 1 in branch BSM of cable CA—3200 to operate selecting magnet M1 of group 4LS (Fig. 32), whereby the #1 set of stackups is selected therein.

F2. Finder-Action Matching

Primary and secondary matching operations now take place substantially as hereinbefore described.

It may be assumed that primary switch 1A of group 4LP (Fig. 31) and secondary switch A1 of group 4LS (Fig. 32) are idle, in which case primary-matching relay 2703 operates and locks in series with cutoff relay 2702 and secondary-matching relay 2711 operates and locks in series with cutoff relay 2715. At its lower contacts, cutoff relay 2715 connects the grounded lock conductor 2832 to conductor 2834 thereby operating hold relay 2807 through contacts of clear-out relay 2806. Hold relay 2807 closes an operating circuit for clear-out relay 2806 at its outer left-hand contacts with the result that relay 2806 operates a short time later and locks itself to conductor 2832 at its left-hand contacts.

F3. Operating the Matched Primary and Secondary Switches

The operating magnets of the matched switches 1A and A1 of Figs. 31 and 32 are operated responsive to the grounding of operate conductor 2833 at the inner left-hand contacts of hold relay 2807. The operating circuit for the matched primary switch is from ground on operate conductor 2833, through the front contact of the first left armature of the operated primary-match relay 2703, conductor A in cable CA—2700, front contact of the fourth left armature of section-1 relay 2921, conductor 1A in branch BP of cable CA—3200, make-busy contacts 3107, c-stackup contacts of switch 1A, and through the low-resistance operating winding of magnet 3106, to battery. Magnet 3106 thereupon operates to close its selected #0 stackup of contacts and to shift its c stackup of contacts, whereby the operating winding of the magnet is disconnected, and the lower winding thereof is left connected as a holding winding.

The operating circuit of the matched secondary switch is from ground on operate conductor 2833, through the front contact of the second right armature of the operated secondary-match relay 2711, back contact of the first right armature of transfer relay 2710, front contact of the third right armature of relay 2703, conductor A1 in branch BS of cable CA—3200, make-busy contacts 3202, low-resistance lower winding of operating magnet 3201 of switch A1, hold conductor H in selector link SL33 (in cable CA—1200), and thence to battery over the incoming hold conductor H of the selector S33 (Fig. 12), similar to the selector S1 of Fig. 11. Magnet 3201 operates over the above-traced circuit, closing the selected #1 stackup of the switch A1 and shifting the c stackup thereof. The upper contacts of the c stackup remove ground potential at one point from the finder-action, section-A conductor in branch BSF of cable CA—3200, while the lower contact pair of the c stackup connects up the high-resistance upper winding of magnet 3201 as a holding winding.

The calling line has now been extended to the selector S33 (Fig. 12), through the #0 stackup of contacts of primary switch 1A (Fig. 31), link L1A in cable 4LA, the #1 stackup of contacts of secondary switch A1 (Fig. 32), and selector link SL33.

The selector SL33 is now prepared for operation as hereinbefore described for the selector S1. It applies ground potential to the sleeve conductor of the established connection to operate cutoff relay 3105 to restore line relay 3104; it applies a holding ground potential to the hold conductor of the established connection to hold primary and secondary switches operated; and it returns a dial-tone signal to the calling line to inform the calling subscriber that he may now proceed to dial the digits in the desired number.

F4. Clearing Out the Common Equipment 4LCE

In the common equipment 4LCE, relays 3030, 2911, and 2921 restore responsive to the restoration of line relay 3104, partially clearing out the common equipment and restoring start relay 2802 to clear out the associated cycle timer and to restore clear-out relay 2806. The clearing out is complete when slow-restoring hold relay 2807 restores to reconnect chain-end conductors 2952 and 3052.

F5. Setting the Selector S33

When the calling subscriber at substation 4012 (Fig. 31) dials the hundreds digit 4 in the desired number, the selector S33 is set as hereinbefore described in connection with the selector S1 of Fig. 11 to prepare circuits over the conductors 4 in the cables SC33 and MC33.

F6. Marking the Calling Selector

When the setting of the selector S33 is complete and the relay therein corresponding to series relay 1105 restores, ground potential is extended over the prepared circuit paths to conductors 4 in cable SC33 and MC33, extending ground potential through terminals of blocks SB33 and MB33, conductors S33 and M33 in branch B4 of cable CA—1300, to start conductor S4 and mark conductor 33 in cable CA—3700.

Assuming the common equipment 4SCE to be idle at the moment, the grounding of conductor S4 in cable CA—3700 results in the closure of a circuit for section-4 relay 3704, through contacts controlled by the second right armature of relay 3704, chain-end conductor 3752, chain contacts of relays 2712 to 3701, chain-supply conductor 3851, contacts of relays 3809 and 3807, to battery through the winding of start relay 3805, relays 3704 and 3805 operating.

Start relay 3805 prepares for secondary matching as hereinbefore described and starts the associated cycle timer into operation.

Section-4 relay 3704 grounds conductor 4 in branch BSM of cable CA—3500, thereby closing a circuit for selecting magnet M4 of secondary group 4SS (Fig. 35), to cause the #4 stackup to be selected in each of the associated secondary switches.

The ground potential on mark conductor 33 in cable CA—3700 is extended through the front contact of the corresponding armature of section-4 relay 3704 to conductor 3 in cable CA—3750, thereby operating selector-preference relay 3603, over conductor 3' in branch BPM of cable CA—3300, selecting magnet M3 of selector-primary group 4SP, conductor 3 in branch BPM of cable CA—3200, contacts controlled by the second right armature of relay 3603, chain-end conductor 3652, contacts of clear-out relay 3609, conductor 3651, chained contacts of relays 3610 to 3601, to battery through chain-supply resistor 3651.

Selecting magnet M3 of group 4SP (Fig. 35) operates to select the #3 stackup of contacts in all the associated switches, while selector-preference relay 3603 locks itself and the selecting magnet to the associated conductor 3 in cable CA—3500 and disconnects its winding and that of the selecting magnet from chain-end conductor 3652, at the same time opening the operating chain to the chain-end conductor to preclude operation for the time being of any other one of the selector-preference relays.

F7. Selector-Action Matching

Primary and secondary selector-action matching occurs substantially as hereinbefore described, the primary matching being accomplished by relays 3901 to 3904 and the secondary matching being accomplished by relays 3905 to 3909 and 3801 to 3804.

It may be assumed that all of the switches of section 4 (Fig. 10A, part 7) of device 4SP, having access to the concerned selector multiple SM33, are idle. One of these switches is 4A, Fig. 35. In this event, all four of the primary-matching relays 3901 to 3904 attempt to operate; complete operation of relays 3902 to 3903 is prevented by relay 3901; and the A primary switch 4A of the section is matched with the switches in section A, Fig. 10A, part 4, of group 4SS, of which secondary switch A1 (Fig. 35) is one. Assuming that switch A1 is idle, secondary matching relay 3905 operates.

F8. Operating the Matched Primary and Secondary Switches

When conductors PON and SON in cable CA—3500 become grounded as hereinbefore described, the matched primary and secondary switches are operated. The operating circuit for the matched primary switch is from ground on conductor PON of cable CA—3500, through contacts of the operated start relay 3805, front contact of the operated primary-matching relay 3901 (relays 3902 to 3904 being in restored condition), conductor A in cable CA—3800, front contact of the fourth left armature of section-4 relay 3704, conductor 4A in branch BP of cable CA—3500, make-busy contacts 3906, *c*-stackup contacts of primary switch 4A, to battery through the low-resistance operating winding of magnet 3505. Magnet 3505 closes the selected #3 stackup of contacts of switch 4A, associated with multiple SM33, and it shifts the *c* stackup of contacts to disconnect its operating winding, leaving the lower winding of magnet 3505 connected as a holding winding.

The operating circuit of the matched secondary switch is from ground on conductor SON of cable CA—3500, through the front contact of the first right armature of primary-matching relay 3901, conductor 3951, front contact of the armature of secondary match relay 3905, conductor A1 in branch BS of cable CA—3500, make-busy contacts 3902, lower winding of operating magnet 3501, sleeve conductor S in link 4LA1, and thence to battery over the previously traced path through resistor 3431. Magnet 3501 now operates to close its selected #4 stackup of contacts, associated (through link 4 in cable 4SA) with secondary switch 4A in group 4SP. Magnet 3501 also shifts its *c* stackup of contacts with results as hereinbefore described.

The seized connector 4C1 of Figs. 33 and 34 is seized and prepared for operation as hereinbefore described. The connection between the tip, ring, and sleeve conductors of selector link SL33 and the incoming conductors of the connector 4C1 is by way of the multiple SM33, the #3 stackup of contacts of the operated primary switch 4A (Fig. 35), link 4 in cable 4SA, the operated #4 stackup of secondary switch A1, and link 4LA1.

F9. Clearing Out Common Equipment 4SCE

The selector common equipment 4SCE clears out as hereinbefore described (responsive to the operation of the cutoff relay of the calling selector S33), whereafter the connection between the calling line and connector 4C1 is held by ground potential on the incoming sleeve lead of link 4LA1, applied at the front contact of the second left armature of the operated release relay 3403.

F10. Completing the Connection to the Called Line

When the tens, units, and party digits (1, 0, and 5) in the desired number are dialed, these digits are recorded respectively in the tens register of Fig. 34 and in the units and party registers of Fig. 33, the sequence group comprising relays 3410 to 3413 operating as hereinbefore described.

The line common equipment 4LCE of Figs. 27 to 30 is now taken for use for connector action, whereupon it operates to cause the connection to be completed to the called line by operations similar to those hereinbefore described. Selecting magnet M1 of group 4LS (Fig. 32) is operated over the associated conductor 1 in branch BSM of cable CA—3200, responsive to the operation of section-1 relay 2921, responsive in turn to ground potential received over conductor 1 in branch BTM of cable CA—1300, under the control of the tens register (Fig. 34).

The selecting magnet M0 of primary group 4LP (Fig. 31) is energized over conductor 0 in cable 33UM responsive to the marking in the units register of Fig. 33.

It may be assumed that the matched primary and secondary switches are the switches 1A of Fig. 31 and connector-action secondary switch D5 of Fig. 32. These two switches are operated along with the distributor switch 4D1 of Fig. 32 to complete the connection to the called party line, #410.

Since the called line is also the calling line, the sleeve conductor (conductor S of line multiple L. M. #410) of the called line is grounded, whereby test relay 3018 fails to operate. Switching relay 3408 is accordingly not operated, busy relay 3409 operating alone.

The clearing out of the line common equipment 4LCE, along with the sequence relays and the tens and units register relays of the connector, occurs as hereinbefore described, responsive to the operation of busy relay 3409.

With switching relay 3408 not operated, the connector 4C1 does not place ground potential on the outgoing sleeve conductor S in link L4C1,

leaving the sleeve conductor of the concerned line multiple L. M. #410 grounded only by virtue of the finder-action connection made as hereinbefore described to the selector S33 of Fig. 12, and thence through the selector switching stage to the incoming conductors of the connector 4C1.

F11. The Reverting-Call Test

When the calling subscriber at substation 4102 hears the busy-tone signal in the reverting call, he is expected to follow instructions by replacing his receiver for a time interval sufficient to enable signaling of the called party-line substation to occur.

When the receiver is replaced on the calling line under the present assumed conditions, line relay 3401 restores and operates series relay 3404 through contacts of the slow-releasing release relay 3403. Series relay 3404 prepares certain circuits to be hereinafter traced, and at the front contact of its first left armature it makes a multiple ground connection to conductor 3450 to maintain this conductor grounded after release relay 3403 has restored.

When release relay 3403 restores, responsive to the restoration of line relay 3401, it removes ground potential from its incoming sleeve conductor, but it first applies ground potential to its outgoing sleeve conductor (conductor S of link L4C1) over the following circuit path: from ground through the front contact of the first left armature of the operated series relay 3404, normally closed contacts controlled by the first left armature of release relay 3403, front contact of the second left armature of series relay 3404, normally closed contacts controlled by the fourth left armature of reverting-call relay 3405, and the front contact of the third left armature of busy relay 3409, to the said outgoing sleeve conductor. Ground potential is therefore supplied over the sleeve conductor of the established connection to the sleeve conductor S of the line multiple L. M. #410. The ground potential thus placed on the sleeve conductor S of line multiple L. M. #410 extends forward over the connection set up by finder action from the line as a calling line to and through the selector S33 of Fig. 12, and thence through the connection set up through the selector switching stage to the incoming sleeve conductor of the connector. The cutoff relay (similar to 1101) of the selector S33 is thereby held operated temporarily to enable the reverting call test to be made. Such test is now made during the interval required for slow-restoring series relay 3404 to fall back, following the restoration of release relay 3403.

The incoming sleeve conductor of the connector 4C1 is now extended, through the normally closed contacts controlled by the second left armature of release relay 3403, the front contact of the fourth left armature of busy relay 3409, and the front contact of the outer left armature of series relay 3404, to the right-hand winding of reverting-call relay 3405. Ordinarily, there is no ground potential on the incoming sleeve conductor of the connector in the interval required for series relay 3404 to restore after release relay 3403 has restored. Now, however, the incoming sleeve conductor is grounded over the circuit path above pointed out, because the connection (a reverting-call connection) has been made to the same line from which the call originated. The right-hand winding of reverting-call relay 3405 is accordingly energized by the ground potential it receives over the above-traced circuit path. Reverting-call relay 3405 now operates to close a locking circuit for its left-hand winding, at the front contact of its third left armature, to conductor 3439, connected to the grounded conductor 3450 through the back contact of the first left armature of relay 3406; relay 3405 also makes a multiple ground connection to conductor 3450 at the front contact of its first left armature to lock the connector in its reverting-call condition; it prepares a circuit for switching relay 3408 at its second left armature; and at the normally closed contacts controlled by its outer left armature, it opens the previously traced ground connection to the outgoing sleeve conductor of the connector, thereby depriving the sleeve conductor of all portions of the connection made to and from the concerned subscriber line of ground potential. When this occurs, cutoff relay 3105 restores, along with the cutoff relay (similar to 1101) of the selector S33. The cutoff relay of such selector thereupon restores to permit the connection established thereto by finder action to clear out responsive to the consequent ungrounding of the associated incoming hold conductor of the selector. Additionally, the removal of ground potential from the sleeve conductor causes the portion of the connection set up through the selector switching stage to clear out directly, for the selector-stage switches (A1 and 4A, Fig. 33) are held directly over the sleeve conductor.

The only portion of the entire connection made to and from the concerned subscriber line (line #410, Fig. 31) which is now held is the portion between the connector 4C1 and the concerned line as a called line, which portion is held by ground potential maintained on the hold conductor H of link L4C1 at the front contact of the first left armature of busy relay 3409.

When series relay 3404 restores, a moment after the described operation of reverting-call relay 3405, it makes a new application of ground potential to the outgoing sleeve conductor of the connector to immediately reoperate cutoff relay 3105 to clear the called line for the application of ringing current. This connection is from ground, through the front contact of the first left armature of reverting-call relay 3405, conductor 3450, normally closed contacts controlled by the first left armature of release relay 3403, back contact of the second left armature of the restored series relay 3404, front contact of the outer left armature of reverting-call relay 3405, and the front contact of the third left armature of busy relay 3409.

Switching relay 3408 now operates from ground on conductor 3450, through the back contact of the first left armature of series relay 3404 and the front contact of the second left armature of reverting-call relay 3405. Upon operating, switching relay 3408 locks itself to conductor 3450 at its first left armature; at its second left armature, it makes the usual ground connection to the already grounded outgoing sleeve conductor, through contacts of the busy relay 3409; and at the front contacts of its third and fourth left armatures, it completes the ringing circuit to the called line over the tip and ring conductors of the connection established thereto.

F12. Signaling the Called Substation

Since the called party-line digit is the digit 5, the #5 counting relay 3313 in the party register is in operated condition, and ringing current is intermittently sent out to the called line from the fifth-frequency lead F5, through the front

contact of the second right armature of relay 3313, over ringing conductor 3432, and the tip conductor of the connection, to the called line. The tuned ringer (not shown) at called substation #4105 is thereby intermittently operated in the usual manner.

It will now be observed that the ringing of the called substation on the line from which and to which the reverting call has been made is occurring with the connector 4C1 locked in operated condition with no holding control being exercised thereover from either a calling line or a called line. Such locked condition is terminated either when the call is answered or when the subscriber at the calling substation again removes his receiver after having waited for an interval to allow the ringing operation to proceed.

F13. Unlocking the Connector 4C1

When the receiver is removed at either of the concerned substations (#4102 and 4105) on line #410, trip relay 3407 operates as hereinbefore described, followed by the operation of ring-cutoff relay 3406, to open the ringing circuit and to connect up back-bridge relay 3402. When ground potential is removed from locking conductor 3439 at the back contact of the first left armature of ring-cutoff relay 3406, to permit the party register of Fig. 33 to clear out, the locking circuit of the left-hand winding of reverting-call relay 3405 is thereby opened, permitting relay 3405 to restore. At the front contact of its first left armature, relay 3405 opens the connection which it previously made to conductor 3450, thereby terminating the locked-up condition of the connector. The connector is henceforth held in operated condition by ground potential applied to conductor 3450 by back-bridge relay 3402 which operates over the called line before the slow-restoring reverting-call relay has had time to fall back.

The subscribers at the calling and called substations #4102 and #4105 may converse with each other as desired when they have both removed their receivers.

F14. Clearing Out the Reverting-Call Connection

When the ensuing conversation is terminated, and both the subscribers replace their receivers, back-bridge relay 3402 restores, removing ground potential from conductor 3450, whereupon relays 3406, 3408, and 3409 restore. The connection to the called line is cleared out as hereinbefore described responsive to the removal of ground potential from the outgoing hold conductor by relay 3409. Idle-indicating potential, which was withheld from the incoming sleeve conductor of the connector 4C1 at the back contact of the fourth left armature of busy relay 3409 during the reverting-call connection, is now replaced to again mark the associated secondary switch A1 (Fig. 35) as idle to the associated selector-action common equipment 4SCE.

G. Call From Substation #211 to P. B. X #210

The way in which calls to a P. B. X are handled will now be described. As above noted, hundreds groups 2 and 3 are both arranged to handle calls to P. B. X's (private branch exchanges). One such P. B. X (#210) is indicated in part 1 of Fig. 10A, and at 1801 in Fig. 18.

By way of example, this P. B. X is illustrated as being served by ten lines, although a smaller or larger number may be provided, as required.

It is to be noted that each of the lines of this P. B. X (#210) bears a different tens designation. This is in accordance with the arrangement hereinbefore disclosed which enables the P. B. X lines to be scattered to distribute the calls substantially uniformly throughout the ten sections of the associated primary group of switches. The listed number of a P. B. X is the regular directory number of the first-choice line assigned thereto. The connection is always completed to this line if it is idle, being completed to one or another of the other lines of the group in regular-choice order according to their busy or idle condition, when the first line is busy.

As indicated in part 1 of Fig. 10A, the lines of P. B. X #210 succeeding the first-choice one thereof have call numbers 220, 239, 243, 254, 265, 277, 286, 298, and 202. These numbers are given merely by way of example, as any line whatever in the hundreds group may be assigned to occupy any selected position in a P. B. X group.

Let it be assumed now that the subscriber at substation #211 (Fig. 18) desires to converse with someone at P. B. X #210.

G1. Seizing an Idle Selector

When the receiver is removed at substation #211, line relay 1802 responds as hereinbefore described to cause connection to be extended to an idle selector. It may be assumed that connection is extended as hereinbefore described (under the finder-action control of line common equipment 2LCE) to the selector S1 of Fig. 11, whereupon this selector is prepared for operation by the consequent operation of its line and release relays 1101 and 1102. This connection includes primary switch 1A of Fig. 18, secondary switch A1 of Fig. 19, and selector link SL1.

G2. Setting the Selector S1

When the hundreds digit 2 in the desired number is dialed, the selector S1 responds as hereinbefore described to record the resulting series of impulses. Counting relays 1107 and 1108 operate successively as previously described, relay 1107 restoring and relay 1108 remaining operated. Then, when series relay 1105 restores, ground potential is extended through the front contacts of the fifth and third left armatures of relay 1108, over conductors 2 in cables SC1 and MC1, terminals of blocks SB1 and MB1, Fig. 13, to the conductors S1 and M1 in branch B2 of cable CA—1300, marking the selector S1 as calling from the standpoint of the common equipment 2SCE (Figs. 23 to 26). The ground potential on conductor M1 in branch B2 of cable CA—1300 is extended, through terminals of blocks 2812 and 2811, to conductor 1 in cable CA—2400, while the ground potential on conductor S1 in branch B2 of cable CA—1300 is extended, through terminals of blocks 2314 and 2313, to start conductor S1 in cable CA—2400.

G3. Seizing the Selector Common Equipment 2SCE

Assuming that the common equipment 2SCE is idle at this time, the placing of ground potential on start conductor S1 of cable CA—2400 results in the operation of section-1 relay 2401 in series with start relay 2511, the circuit being similar to that described for relays 3701 and 3805.

Primary and secondary selector-action matching now occurs in the relays 2601 to 2612 and 2501 to 2510 similar to that hereinbefore described in connection with the corresponding relays of Figs. 38 and 39.

At the same time, circuits are closed for the concerned #1 selecting magnets of selector-primary and selector-secondary groups 2SP and 2SS of Figs. 10A and 22.

The primary selecting circuit is as follows: from ground on mark conductor 1 in cable CA—2400, through the outer left contacts of the operated section-1 relay 2401, conductor 1 in cable CA—2450, selector-preference relay 2301, conductor 1' in branch BPM of cable CA—2200, magnet M1 of group 2SP, Fig. 22, conductor 1 in the said branch BPM, contacts controlled by the second right armature of selector-preference relay 2301, chain-end conductor 2352, back contact of the third left armature of clear-out relay 2515, conductor 3651, chained contacts of relays 2310 to 2301, to battery through resistor 2351. Relay 2301 locks itself and the associated selecting magnet M1 to resistor 2351 and disconnects the operating circuit from chain-end conductor 2352, while at the back contact of its inner right armature, it opens the chain circuit to conductor 2352 to preclude operation of any further ones of the associated selector-preference relays and their associated selecting magnets.

The operating circuit for magnet M1 of secondary group 2SS (Fig. 22) is from ground on conductor 2552, through the front contact of section-1 relay 2401, and over conductor 1 in branch BSM of cable CA—2200.

G4. The Selector-Stage Matching Operation

It may be assumed that primary matching relay 2601 operates, because the associated primary switch 1A (Fig. 22) in the calling section 1 of the primary is idle, and because at least one secondary switch is idle in the associated A section of secondary group 2SS (Figs. 10A and 22). Under this condition, the associated primary matching relays 2602 to 2606 are prevented from operating by the removal of their ground supply connection at the back contact of the second right armature of relay 2601, as pointed out in connection with the corresponding relays shown in Fig. 39.

It may be assumed further that secondary matching relay 2607 operates, because the associated secondary switch A1 (Fig. 22) is idle.

G5. Operating the Matched Selector-Stage Switches

When the selecting magnets M1 of groups 2SS and 2SP (Fig. 22) have operated over their above described circuits and grounded the associated conductors SON and PON in cable CA—2200, the matched primary and secondary switches are thereby operated.

The operating circuit for the matched primary switch is as follows: from ground on conductor PON in cable CA—2200, through contacts of the operated start relay 2511, front contact of the operated primary matching relay 2601, conductor A in cable CA—2500, contacts of relay 2401, conductor 1A in branch BP in cable CA—2200, make-busy, contacts 2204, the associated c-stackup contacts, the low-resistance upper winding of magnet 2203, to battery. By the operation of magnet 2203, the selected #1 stackup of contacts of switch 1A are closed and the c stackup thereof is shifted.

The operating circuit for the matched secondary switch is as follows: from ground on conductor SON of cable CA—2200, through the front contact of the first right armature of relay 2601, front contact of the armature of the operated secondary-matching relay 2607, conductor A1 in branch BS of cable CA—2200, make-busy contacts 2202, low-resistance operating winding of magnet 2201, sleeve conductor S of link 2LA1, contacts of relays 2103 and 2108, make-busy contacts 2130, to battery through resistor 2131. Magnet 2103 thereupon closes the selected #1 stackup of contacts of switch A1 and shifts the associated c stackup. The upper contacts of the c stackup connect up the upper winding of the operating magnet as a holding winding, while the lower contacts thereof separate the associated secondary section conductors A and A' at one point, leaving them connected together through any idle one of the secondary switches in the A group.

G6. Preparing the Connector 2C1 for Operation

Line relay 2101 of connector 2C1 now operates over the calling line in parallel with the windings of line relay 1102 of the selector S1, through the tip and ring contacts of the operated switches 1A and A1 of Fig. 22. Release relay 2103 responds to the operation of line relay 2101 by grounding conductor 2150, and by transferring the associated incoming sleeve conductor from its idle-indicating battery connection to ground, to provide a holding circuit for the operated switches after the selector common equipment has cleared out and after the release relay of the selector S1 has restored.

Cutoff relay 1101 in the selector S1 operates over the sleeve conductor in multiple SM1 responsive to the closing of the #1 stackup of contacts at switch 1A (the sleeve conductor S of this switch being maintained grounded for the moment by the selector common equipment). Cutoff relay 1101, as hereinbefore described, makes a multiple ground connection to the associated incoming hold conductor; extends the incoming sleeve lead to the outgoing sleeve lead; and disconnects line relay 1102. The line and release relays 1102 and 1103 are restored successively following the operation of cutoff relay 1101.

G7. Clearing Out the Selector Common Equipment 2SCE

The clearing-out operation of the selector common equipment 2SCE is initiated by the opening of the back contact of the second left armature of cutoff relay 1101, immediately depriving the operated selector-preference relay 2301 of current, resulting in the clearing out of the common equipment 2SCE substantially as hereinbefore described for the common equipment 4SCE. Clear-out relays 2514 and 2515 correspond respectively to the previously described clear-out relays 3808 and 3809. Additionally, cycle-timer relays 2512 and 2513 correspond respectively to the relays 3806 and 3807.

G8. Setting the Connector 2C1

The connector 2C1 of Figs. 20 and 21 correspond generally to the connector 4C1 of Figs. 33 and 34, except that it does not have a party register, as no party digits are included in the numbers assigned to the lines served thereby; the sequence group comprising relays 2109 to 2111 contains one less relay than the corresponding group of connector 4C1; and no reverting-call relay is required in the connector 2C1.

When the tens digit 1 in the desired number is dialed, line relay 2101 restores once momentarily, thereby transmitting an impulse through

contacts of the operated release relay 2103 and through contacts of busy relay 2108 to impulse conductor 2135. This impulse proceeds further, through contacts of relays 2109 and 2111, to tens conductor 2136 associated with the tens register comprising relays 2112 to 2118. These relays correspond respectively to relays 3414 to 3420 of the connector 4C1. They are set in accordance with the dialed digit 1 to prepare a circuit over conductor 1 in branch BTM in cable CA—1900.

Series relay 2104 responds during the dialing of each of the tens and units digits. At the beginning of the tens digit, it closes a circuit, from ground on conductor 2140 (grounded by virtue of its connection with conductor 2150), through the front contact of the right armature of series relay 2104, conductor 2144, back contact of the first right armature of driver relay 2109, back contact of the first left armature of relay 2111, to battery through the winding of sequence relay 2110. Relay 2110 thereupon operates and locks itself through the left-hand winding of driver relay 2109, the last-named winding remaining short-circuited as long as series relay 2104 remains operated.

At the end of the tens digit, series relay 2104 falls back and removes the short-circuit from around the left-hand winding of relay 2109, whereupon relay 2109 operates. At its second left armature, it disconnects impulse conductor 2135 from the tens impulse conductor 2136 and transfers it to the units impulse conductor 2137.

When the units digit 0 is dialed, the ten resulting impulses are delivered over units conductor 2137 to the units register comprising relays 2001 to 2007. The relays of this register respond as hereinbefore described to record the value of the digit, relays 2007 and 2005 being in operated condition at the end of the digit to prepare a circuit over the 0 conductor in cable 20UM.

When series relay 2104 responds at the beginning of the units digit, it again grounds conductor 2144, extending ground potential through the front contact of the first right armature of the operated driver relay 2109 to the holding winding of the driver relay, which ground potential further extends, through the front contact of the right armature of the operated relay 2110 to the winding of sequence relay 2111. Relay 2111 thereupon operates and locks itself to conductor 2140 at its second left armature. At its first left armature, relay 2111 open-circuits and restores relay 2110, whereby the circuit through the left-hand winding of driver relay 2109 is opened, but the driver relay remains operated for the time being by its right-hand winding.

When series relay 2104 falls back at the end of the units digit, driver relay 2109 restores.

G9. Seizing the Common Equipment 2LCE Through the Connector Chain

Start conductor ST in branch BC1 of the cable CA—1900 is now grounded through the front contact of the third left armature of relay 2111 and the back contact of the left armature of driver relay 2109 to cause the line common equipment 2LCE of Figs. 14 to 17 to be seized through the connector chain comprising relays 1701 to 1716, individual respectively to the sixteen connectors of hundreds group 2.

Assuming that equipment 2LCE is idle at this time, the grounding of start conductor ST in branch BC1 of cable CA—1900 closes a circuit for connector-chain relay 1701 as follows: from ground on conductor ST in the said branch BC1, through relay 1701, contacts controlled by the second right armature of relay 1701, the associated chain-end conductor, chained contacts of relays 1716 to 1701, chain conductor CH in cable CA—1650, transfer control relay 1501, contacts controlled by the second right armature of relay 1501, chain-end conductor 1652, back contact of the second right armature of hold relay 1507, conductor 1651, chained contacts of relays 1630 to 1621, conductor 1632, back contact of the first right armature of transfer-control relay 1501, chain-supply conductor 1544, contacts of clear-out relay 1506, and the chain-supply resistor 1526, to battery.

Relays 1501 and 1701 operate in series over the above traced circuit. Relay 1701 locks itself to conductor CH at its second right armature, at the same time disconnecting its winding from the associated chain-end conductor, while at its first right armature, it deprives the said chain-end conductor of current to preclude operation of any one of the relays 1702 to 1716 for the time being.

At the front contacts of its left armature, relay 1701 connects up conductors TR, UR, H, BU, SW, and S in the associated branch BC1 to their respective associated common conductors.

G10. Preparing for Matching in Group 1 of the Associated Connector-Action Secondary Switches

Relay 1701 also grounds the associated group-1 conductor G1 at the front contact of its third right armature, operating group-1 relays 1719 and 1419 to prepare for matching an idle one of the connector-action secondary switches in group 1 of secondary group 2LS of Figs. 10A and 19. This grouping of the connector-action secondary switches is made necessary because there are more of these switches than are selective stackups in the distributor switches of group 2D (Figs. 10A and 19). More particularly, these distributor switches are illustrated as having only ten selective stackups each, while there are sixteen connector-action secondaries in group 2LS.

As is shown in part 4 of Fig. 10A, the distributor switches 2D1 to 2D16 in distributor group 2D are assigned respectively to connectors 2C1 to 2C16. The connectors and distributors are divided into two groups. The first group comprises the first eight of the connectors and distributor switches, while the second group comprises the ninth to the sixteenth connectors and distributor switches.

As is indicated in part 4 of Fig. 10A, six of the sixteen connector-action secondary links in cable CA—1950 are multipled to the first six stackups in the group-1 distributors; six other of the secondary links are multipled to the first six stackups in the group-2 distributors; and the final four links in cable CA—1950 are multipled to the last four stackups in all the distributor switches. This arrangement is further shown in Fig. 19 which shows the distributor switch 2D1 (of the first group of distributor switches) and distributor switch 2D9 (of the second group of distributor switches). The six links in cable CA—1950 representing the odd-numbered connector-action choices 1, 3, 5, 7, 9, and 11 (extending respectively to connector-action secondary switches F6, F4, E5, E3, D4, and C5) are connected respectively to stackups 1 to 6 of the first group of distributors; the six even-numbered links representing choices 2, 4, 6, 8, 10, and 12 (extending respectively to the secondary switches F5, F3, E4, D5, D3, and C4) are connected respectively to the

first six stackups in the second group of distributor switches; and the thirteenth to sixteenth choice links in cable CA—1950 (extending respectively to secondary switches B5, B4, A6 and A5) are connected respectively to the seventh to tenth stackups in all distributor switches in groups 1 and 2 in distributor group 2D. The above arrangement is similar to the usual graded-trunking arrangement employed generally in telephone systems when a selective switch has a capacity less than the number of link paths in the group to which it has access.

For the purpose of evening the demand on the two groups of connectors (2C1 to 2C8 and 2C9 to 2C16) to the end that advantageous use shall be made of the four last choice connector-action links accessible in common to the distributor switches of both groups, the connectors 2C1 to 2C16 are interconnected to the links contained in cable 2L (Figs. 22 and 10A, part 4) as indicated in part 4 of Fig. 10A.

The links in connector cable 2L are numbered at the lower end of the cable in accordance with the order of preference in which these links are taken for use through the switches in group 2SS. As is indicated in association with the connectors 2C1 to 2C16 in part 4, Fig. 10A, the links in cable 2L representing the odd-number connector choices 1, 3, 5, and so forth, to 15 are connected respectively to connectors 2C1 to 2C8 comprising the first connector group, while the links in cable 2L representing the even-numbered connector choices 2, 4, 6, and so forth, to 16 are connected respectively to the connectors 2C9 to 2C16 comprising the second connector group. By this arrangement, substantially equal numbers of calls are directed to the two groups of connectors.

Any operated one of the connector-chain relays 1701 to 1708, associated respectively with the connectors 2C1 to 2C8 comprising the first connector group, grounds group-1 conductor G1; while group-2 conductor G2 is grounded upon the operation of any one of the connector-chain relays 1709 to 1716 associated respectively with the connectors 2C9 to 2C16.

In the call now under consideration, connector-chain relay 1701 is the one operated and it grounds conductor G1 as above noted, operating group-1 relays 1719 and 1419 in parallel. Group-1 relay 1719 connects each of the connector-action secondary section conductors C, D, E, and F in branch BSC of cable CA—1900 respectively to its individual group-1 section conductors in branch BSC' of cable CA—1900 preparatory to the primary-matching operation. Group-1 relay 1419 connects up the test leads in branch BS of cable CA—1900 of the respective connector-action secondary switches individual to group 1 of the connectors and distributors. These are test leads F3, F4, E5, E3, D4, and C5.

G11. Preparing Common Equipment 2LCE for Connector Action

When transfer-control relay 1501 operates in series with relay 1701 as above noted, it locks itself to the associated chain-supply conductor 1544 at its second right armature, at the same time disconnecting its winding from chain-end conductor 1652. At the back contact of its first right armature, relay 1501 disconnects conductor 1632, thereby depriving chain-end conductor 1652 of current to preclude operation at this time of any further relays thereover. At its first left armature, relay 1501 prepares a circuit over conductor H of cable CA—1650; at its second left armature it prepares a circuit for P. B. X reset relay 1508; and at its third left armature, it applies ground potential to locking conductor 1541 and to transfer conductor 1531.

Transfer relays 1401 and 1410 now operate over conductor 1531 in preparation for connector-action primary and secondary matching, and connecting relay 1525 operates to initiate the P. B. X test to be described subsequently.

G12. Section Selection in the Line Primary Group

The #1 section in line primary group 2LP of Figs. 10A and 18 is now selected by the energization of section-1 relay 1621 over the following circuit: from ground, through the back contact of the second left armature of P. B. X reset relay 1508, conductor TR in cable CA—1650, front contact of the outer left armature of connector-chain relay 1701, conductor TR in branch BC1 of cable CA—1900, back contacts of relays 2118 to 2114, front contact of the third right armature of relay 2113, conductor 1 in branch BTM of cable CA—1900, and through the right-hand winding of relay 1621, to battery.

Relay 1621 connects conductors A to F in primary-match cable CA—1400 respectively to test conductors 1A to 1F in branch BP of cable CA—1900, being the test conductors of the respective primary switches 1A to 1F comprising section 1 of group 2LP (Figs. 10A and 18).

G13. Tens Selection

At the front contact of its outer right armature, relay 1621 applies ground potential to conductor 1 in branch BSM of cable CA—1900, thereby energizing selecting magnet M1 of secondary group 2LS (Fig. 19). The associated #1 stackups are thereby selected.

G14. Units Selection

Along with the described operation of section-1 relay 1621, units selection in primary group 2LP (Figs. 10A and 18) is accomplished by the energization of selecting magnet MO thereof over the following circuit path: from ground by way of the back contact of the first left armature of P. B. X reset relay 1508, conductor UR in cable CA—1650, contacts of relay 1701, conductor UR in branch BC1 of cable CA—1900, front contact of the right armature of relay 2007, front contact of the second right armature of relay 2005, conductor 0 in cable 20UM, and through the winding of selecting magnet MO of Fig. 18, to battery. The #0 stackups of all the primary switches in group 2LP are thereby selected.

G15. The P. B. X Test

Concurrently with the above-described primary and secondary selecting operations, a P. B. X test is made to determine whether or not the connector-action call being handled is for one of the P. B. X's served by the group. This P. B. X test is made over the conductors controlled by the tens and units registers of the currently calling connector 2C1.

When connecting relay 1525 operates over transfer conductor 1531, in parallel with transfer relays 1401 and 1410, it connects the units conductors 1 to 0 in the primary selecting-magnet branch BPM of cable CA—1900 to the terminals 1 to 0 respectively in the units test block 1522. The conductors 1 to 0 of the tens-mark branch BTM of cable CA—1900 are normally connected to the terminals of the tens block 1523.

Test relay 1510 is the P. B. X test relay for P. B. X #210. Relay 1510 is a marginal relay, unresponsive to current flow through either winding alone but operable responsive to current flow through both windings at the same time.

In the call under consideration, conductor 1 in tens-mark branch BTM of cable CA—1900 is grounded over the traced circuit for the right-hand winding of section-1 relay 1621, closing a circuit through terminal 1 in tens block 1523, over the illustrated jumper to block 1520, through the contacts controlled by the first right armature of relay 1510, to battery through the right-hand winding of relay 1510.

At the same time, ground potential is present on units conductor 0 of cable branch BPM by virtue of its connection in Fig. 18 with the grounded units conductor 0 in cable 20UM, closing a circuit through contacts of the operated connecting relay 1525, conductor 0, units test block 1522, the illustrated jumper, a terminal of block 1520, and thence to battery through the left-hand winding of test relay 1510. Relay 1510 now operates responsive to the energization of both windings thereof. At its first right armature, relay 1510 locks its right-hand winding to conductor 1541 (grounded at the outer left contacts of transfer-control relay 1501), at the same time disconnecting such winding from terminal 1 of block 1523. Relay 1510, once operated, is able to remain operated with only one winding energized.

At the front contacts of its second and third armatures, P. B. X test relay 1510 extends the grounded re-mark conductors 1542 and 1543, depending upon relay 1511 being in operated condition.

The results now occurring depend upon whether the first line of the called P. B. X is busy or is idle. If this line is busy, there is a ground potential on the sleeve conductor S of line multiple L. M. #210 thereof. As a result, the left-hand winding of relay 511 is energized over conductor 10 in cable CA—1850. Relay 1511 is therefore operated, and is locked, at the front contact of its first right armature, to conductor 1541 to prevent restoration thereof during the P. B. X testing operation if the associated line then becomes idle.

With relays 1510 and 1511 operated, it is thereby determined that the call cannot be completed responsive to the tens and units marking imparted by the calling connector 2C1 (Figs. 20 and 21). This marking is thereupon terminated and a new marking is applied in accordance with the busy or idle condition of the remaining lines of the P. B. X group in a manner which will be pointed out hereinafter.

G16. The First P. B. X Line Is Idle

In the present example, it will be assumed that the first line of the P. B. X group is idle at the moment, in which case its associated relay 1511 is not in operated condition, and the tens and units re-mark conductors 1542 and 1543 are open at the contacts of relay 1511.

G17. Primary Matching

Primary matching now occurs responsive to the described operation of section-1 relay 1621. If the first-choice primary switch 1F in the called section-1 of primary group 2LP (Fig. 18) is idle, there is battery potential on the associated conductor 1F in branch BP of cable CA—1900, which is extended, through the front contact of the first left armature of relay 1621, and over conductor F of cable CA—1400, to the left terminal of the left-hand winding of primary-matching relay 1408, which is the first-choice relay for connector action. If there is at least one idle group-1 connector-action secondary switch in section F of secondary group 2LS (Figs. 10A and 19), ground potential is present on the right terminal of the left-hand winding of primary-matching relay 1408.

If secondary switch F6 of Fig. 19 is idle, the associated individual conductor F6 in branch BSC' is grounded through the upper contact pair of the c stackup of the switch F6. Similarly, there is ground on conductor F4 in the said branch BSC' if switch F4 of group 2LS, Figs. 10A and 19, is idle.

With ground on either of the said conductors F6 and F4 in branch BSC' of cable CA—1900, such ground potential is extended, through contacts of the operated group-1 relay 1719, conductor F in branch BSC of cable CA—1900, front contact of the outer armature of transfer relay 1401, back contact of the outer armature of cutoff relay 1402, and thence by way of conductor F in cable CA—1450, right terminal of the left-hand winding of primary-matching relay 1408. The left-hand, matching, winding of relay 1408 is energized by the above noted opposite potentials on its terminals.

Similarly, the left-hand winding of each of the other primary-matching relays 1407 to 1403 is energized dependent upon the associated primary switch being idle, and upon there being at least one idle connector-action secondary switch in the associated section, assigned to group 1, containing the calling connector 2C1 of Figs. 10A and 20, 21.

In the present example, it may be assumed that all of the primary-matching relays 1403 to 1408 start to operate.

With transfer relay 1410 in operated condition, the ground potential which has been placed on lock conductor 1532 by start relay 1502 is transferred from the finder-action lock conductor 1421 to the connector-action lock conductor 1422 connected to relays 1408 to 1403 in the reverse order employed for connector-action primary matching.

Upon operating partially, relay 1408, at its second left armature, deprives relays 1407 to 1403 of locking potential and closes a locking circuit for its own right-hand winding in circuit with cutoff relay 1402. Cutoff relay 1402 thereupon operates to open-circuit the left-hand windings of all of the partially operated relays 1403 to 1408, whereupon such relays restore. Relay 1408 operates fully in its locking circuit.

G18. Secondary Matching

With primary-matching relay 1408 operated fully and with relays 1403 to 1407 in restored condition, the first-choice and third-choice secondary-matching relays 1411 and 1413 are connected respectively to test conductors F6 and F4 in branch BS of cable CA—1900, through contacts of the operated group-1 relay 1419, front contacts of the first and third right armatures of relay 1408, and front contacts of the first and third right armatures of transfer relay 1410, to the left-hand windings of relays 1411 and 1413.

If both of the switches F6 and F4 in secondary group 2LS of Fig. 19 are idle, there is battery potential on both of the leads F6 and F4 in branch BS of cable CA—1900. The first-choice and third-choice secondary-matching relays 1411 and 1413 start to operate.

Relay 1411 opens a point in the locking circuit of relay 1413, and locks its right-hand winding in series with cutoff relay 1415. Cutoff relay 1415 thereupon operates to disconnect the left-hand windings of relays 1411 to 1414 whereupon the partially operated relay 1413 restores, but relay 1411 operates fully in its locking circuit in series with the cutoff relay.

G19. Distributor Selection

Upon operating fully, secondary-match relay 1414 closes the following distributor-selection circuit: from ground, through the front contact of the outer armature of transfer relay 1410, conductor 1424, front contact of the outer right armature of primary-matching relay 1408, the front contact of the third right armature of relay 1411, conductor 1 in branch BDM of cable CA—1900, and thence to battery through selecting magnet M1 of the distributor group 2D (Fig. 19). The resulting energization of this magnet brings about the selection of the #1 stackup of contacts in all the distributor switches of this group.

G20. Operating the Matched Primary, Secondary, and Distributor Switches

The operation of cutoff relay 1415 is followed by the hereinbefore described operation of the slow-acting hold relay 1507, followed in turn by the operation of clear-out relay 1506, to disconnect hold relay 1507. Relay 1507 holds operated for a sufficient interval to permit operation of the matched primary, secondary, and distributor switches to occur.

When operate conductor 1533 is grounded, at the first right armature of hold relay 1507, a circuit is thereby closed through the front contact of the first left armature of primary-matching relay 1508, conductor F of cable CA—1400, contacts of relay 1621, conductor 1F in branch BP of cable CA—1900, make-busy contacts 1809, the associated c-stackup contacts, to battery through the low-resistance upper winding of magnet 1808. Magnet 1808 thereupon operates to close the selected #0 stackup of contacts of the switch 1F to make connection with the called line.

A further result of the grounding of conductor 1533 is the closing of a circuit through the front contact of the second right armature of secondary-matching relay 1411, front contact of the first right armature of transfer relay 1410, front contact of the first right armature of relay 1408, front contact of the lower armature of group-1 relay 1419, conductor F6 in branch BS of cable CA—1900, make-busy contacts 1904, the lower contact pair in the associated c stackup, to battery through the low-resistance upper winding of magnet 1903. By the operation of magnet 1903, the selected #1 stackup of contacts of secondary switch F6 is closed to make connection with primary switch 1F of Fig. 18, by way of primary link L1F in cable 2LF.

A further result of the placing of ground potential on operate conductor 1533, is the closing of a circuit, through the front contact of the first left armature of transfer-control relay 1501, conductor H in cable CA—1650, contacts of relay 1701, conductor H in branch BC1 of cable CA—1900, conductor H in link L2C1 in cable CA—2100, c-stackup contacts of switch 2D1, to battery through the low-resistance upper winding of magnet 1905. By the operation of magnet 1905, the selected #1 stackup of distributor switch 2D1 is closed to select secondary switch F6 of Fig. 19 by way of link 1 in cable CA—1950.

By the above switch operations, the connection has been linked between the outgoing conductors of the connector 2C1 of Figs. 20 and 21 and the first line #210 of the called P. B. X #210.

G21. Testing the Called Line

Upon the completion of the connection with the called line, a testing operation as hereinbefore described occurs under the control of test relay 1718 (Fig. 17). Since the line is idle, as indicated by the P. B. X test previously made, test relay 1718 now energizes over the established connection in series with cutoff relay 1805 of the called line, and the cutoff relay operates to clear the called line for ringing and talking purposes.

The left-hand winding of the P. B. X relay 1511 is at the same time partially energized in parallel with the winding of cutoff relay 1805 over conductor 10 in cable CA—1850. The left-hand windings of P. B. X relays 1511 to 1518 are preferably of comparatively high-resistance, whereby such a relay does not operate in parallel with its associated cutoff relay when test relay 1718 is in the common ground-supply path for both relays. The current cycle of operations of device 2LCE is therefore completed before relay 1511 can operate.

G22. Seizing the Called Line

The connector 2C1 is now operated to seize the called line and to free the common equipment 2LCE as follows:

Delay relay 1717 operates from the ground potential on conductor H in cable 1650 at the end of the short interval allowed for the above described testing of the called line by relay 1718. When it operates under the present assumed conditions, relay 1717 grounds conductors BU and SW in branch BC1 of cable CA—1900. The said conductor BU is grounded through the front contact of the third left armature of relay 1701, and conductor SW is grounded through contacts of test relay 1718 and the front contact of the second left armature of relay 1701.

In the connector 2C1, Figs. 20 and 21, busy and switching relays 2108 and 2107 operate responsive to the grounding of the associated conductors BU and SW, and each locks itself to the associated conductor 2150, grounded at contacts of release relay 2103.

Busy relay 2106, at the front contact of its first left armature, grounds hold conductor H in link L2C1 to maintain the connection established with the called line; and at the back contact of its second left armature, it ungrounds conductor 2140 to clear out any operated ones of the sequence relays 2108 to 2111, and the operated relays of the tens and units registers.

At the front contact of the second left armature of relay 2107 and the front contact of the third left armature of busy relay 2108, ground potential is applied directly to the associated sleeve conductor to place a full guarding potential on sleeve conductor S of line multiple L. M. #210, whereupon relay 1511 operates promptly over conductor 10 in cable CA—1850, and remains operated so long as the associated P. B. X line is in use.

G23. Clearing Out Common Equipment 2LCE

When the sequence relays are cleared out as described, conductor ST in branch BC1 of cable CA—1900 is ungrounded by relay 2111 to cause the common equipment 2LCE to clear out sub-

stantially as hereinbefore described, particularly in connection with the connector-action operation of common equipment 4LCE of Figs. 27 to 30.

G24. The Ringing Operation

At the front contacts of the third and fourth left armatures of switching relay 2107, the ringing circuit is closed. The ringing current intermittently applied by ringing relay 2133 to the common ringing lead 2132 now passes out over the tip conductor of the established connection to the terminating equipment of line #210 of the called P. B. X #210, a return path being provided over the ring conductor of the connection, to battery through trip relay 2106.

Each time conductor 2132 receives ringing current, a portion thereof passes back to the calling line through small-capacity condenser 2123 to give the calling subscriber a ringing-tone signal.

G25. Answering the P. B. X Call

When the operator at the called P. B. X responds, a direct-current bridge is thereby closed over the called P. B. X line #210 permitting trip relay 2106 to operate. Ring-cutoff relay 2105 is thereby operated, and it locks itself at its first left armature, at the same time opening the ringing circuit and completing the talking circuit. Back-bridge relay 2102 now responds to make a multiple application of ground potential to conductor 2150.

G26. Clearing Out the Established Connection

When the ensuing conversation is terminated, the established connection is cleared out as hereinbefore described in connection with a call through the connector 4C1 of Figs. 33 and 34, the apparatus involved therein being returned to the illustrated normal condition. P. B. X relay 1511 is restored along with cutoff relay 1805 when the connection is cleared out.

G27. P. B. X Reset Operations

The preceding description having been made under the assumption that the first line of the called P. B. X is idle, in which case no P. B. X reset operations are involved, a description will now be given of the alternative operations involved in the same P. B. X call under the assumption that the first line of the P. B. X is busy. Relay 1511 is, therefore, in operated condition when P. B. X test relay 1510 operates as previously described.

It may be further assumed, for example, that all of the P. B. X lines are in use except the last one thereof, which is line #202. In this case, all of the P. B. X relays 1511 to 1519 (associated respectively with the lines 1 to 9 of the P. B. X) are in operated condition. Each of these relays is now locked operated by its right-hand winding to conductor 1541, grounded upon the described operation of transfer-control relay 1501.

G28. Clearing Out the Original Marking

The original tens and units marking is now cleared out responsive to the closing of the following circuit by P. B. X test relay 1510: from ground, through the winding of P. B. X reset relay 1508, front contact of the second left armature of relay 1501, units-reset conductor 1542, the front contact of the second right armature of each of the relays 1510 to 1519, the upper illustrated terminal of block 1521, the associated units-reset jumper, digit-2 terminal of units-reset block 1524, conductor 2 of cable CA—1600, units relay 1722, contacts thereof, chain conductor 1752, contacts of relay 1507, conductor 1751, chained contacts of relays 1730 to 1721, chain-supply conductor 1544, and thence to battery through contacts of clear-out relay 1506, and resistor 1526.

P. B. X reset relay 1508 operates over the above-traced circuit in series with units relay 1722. Reset relay 1508 recycles the common equipment for operating in accordance with reset tens and units marking; clears out the original marking; and applies the reset tens marking, as will be described.

At its right armature, relay 1508 disconnects conductor 1634' from the grounded start conductor 1634, thereby restoring start relay 1502 and clearing out the associated cycle-timer comprising relays 1503 to 1505 for a new cycle of operations. At the front contact of its first left armature, relay 1508 closes a circuit for the operating winding of delay relay 1509 to cause such relay to reoperate after a slight interval to reclose the start circuit.

At the back contacts of its left armatures, relay 1508 removes ground potential from conductors TR and UR of cable 1650, thereby opening the previously traced tens and units marking circuits.

Responsive to the above opening of the original tens marking circuit, section-1 relay 1621 restores because of the consequent removal of ground potential from conductor 1 in branch BTM of cable CA—1900. Upon restoring, relay 1621 terminates the selection of section 1 in the associated group 2LP (Figs. 10A and 19). At its outer right armature, relay 1621 removes ground potential from conductor 1 in branch BSM of cable CA—1900, thereby deenergizing selecting magnet M1 of group 2LS (Fig. 19) and terminating the selection of the #1 stackup of contacts of the associated secondary switches.

As a result of the ungrounding of the units-register conductor UR in the cable CA—1650 by reset relay 1508, conductor 0 in units-mark cable 20UM becomes ungrounded, thereby deenergizing selecting magnet M0 in primary group 2LP (Fig. 18) to terminate the selected condition of the #0 stackup of the associated primary switches.

G29. Reset Units Selection

When units relay 1722 operates over its above traced units-reset circuit in series with P. B. X reset relay 1508, it grounds conductor 2 in branch BPM of cable CA—1900 to thereby cause the #2 stackups of all of the switches in primary group 2LP of Figs. 10A and 18 to be selected by the consequent energization of selecting magnet M2 (Fig. 18) thereof. The units-reset selection is thereby made, in accordance with the units digit 2 in the number of the first idle P. B. X line, which in the present example is the last line #202 of the called P. B. X #210.

G30. Reset Tens Selection

At the front contact of its second left armature, P. B. X reset relay 1508 grounds tens-reset conductor 1543 thereby closing a circuit through the front contacts of the third left armatures of relays 1510 to 1519, the associated tens-reset jumper between terminal blocks 1521 and 1523, conductor 0 in tens-mark branch BTM of cable CA—1900, to battery through the right-hand winding of section-0 relay 1630. Relay 1630 thereupon operates to connect the associated section-0 test conductors 0A to 0F respectively to

conductors A to F in primary-match cable CA—1400.

Relay 1630, at its outer right armature, grounds conductor 0 in branch BSM of cable CA—1900, thereby operating selecting magnet M0 of secondary group 2LS (Fig. 19) to select the #0 stackups of the associated secondary switches preparatory to completing the connection to the final P. B. X line #202 in accordance with the reset markings, corresponding to the tens and units digits 0 and 2.

G31. The Reset Cycle of Operations.

Section-0 relay 1630 regrounds start conductor 1634. As a consequence, when delay relay 1509 responds, a short interval following the described operation of P. B. X reset relay 1508, the ground potential on conductor 1634 is thereby extended over start conductor 1634' to start relay 1502, reoperating such start relay to reground lock conductor 1532 and to restart the associated cycle timer comprising relays 1503 to 1505.

From this point, the newly started cycle of operations of the common equipment 2LCE proceeds substantially as hereinbefore described, including a primary-matching operation involving relays 1403 to 1408, followed by secondary-matching operation involving relays 1411 to 1414, followed in turn by the operation of hold and clear-out relays 1507 and 1506.

Operating circuits similar to those hereinbefore traced are closed for the matched primary switch in section 0 of group 2LP in Figs. 10A and 18 (none of the section-0 primary switches is shown in Fig. 18), for the matched secondary switch in group 2LS (Fig. 19) and for the distributor switch 2D1 of Fig. 19 to complete the connection from the calling connector 2C1 of Figs. 20 and 21 to the final line #202 of the called P. B. X #210.

Test and delay relays 1718 and 1717 operate as previously described to bring about the operation of busy and switching relays 2108 and 2107 of the connector 2C1.

G32. Clearing Out the Common Equipment 2LCE

The clearing out of the common equipment 2LCE is initiated as previously described responsive to the ungrounding of start conductor ST in branch BC1 of cable CA—1900, as a result of the operation of relay 2106, to release relay 2011. When this occurs, relays 1701 and 1501 immediately restore.

P. B. X reset relay 1508 and units relay 1722 restore responsive to the opening of the front contact of the second left armature of transfer-control relay 1501; P. B. X test relay 1510 is unlocked and restored responsive to the removal of ground potential from conductor 1541 by transfer-control relay 1501; and delay relay 1509 restores responsive to the restoration of relay 1508.

The clearing out of the remaining portion of the common equipment is as previously described.

H. Calls Outgoing to Automatic Exchange #9

The way in which calls outgoing from the local automatic exchange #9 (shown at 4000 in Fig. 10A, part 3, and Fig. 40) are handled will now be described. For this purpose, it will be assumed that the subscriber at substation #211 (Figs. 10A and 18) desires to converse with a subscriber of automatic exchange 4000. The subscriber at substation #211 accordingly removes his receiver; waits for dial tone; and then dials the listed directory number of the subscriber in automatic exchange 4000, preceded by the digit 9 required to cause extension of the connection to the called exchange.

H1. Seizing an Idle Selector

It may be assumed that, when the receiver is removed at substation #211, connection is extended, through primary switch 1A of group 2LP (Fig. 18), link L1A, secondary switch A1 of group 2LS (Fig. 19), and selector link SL1, to the selector S1 of Fig. 11, by operations as hereinbefore described. The selector S1 is thereupon prepared for operation, its line and release relays 1102 and 1103 operating. A dial-tone signal is returned responsive to the closure of the outer right contact pair of release relay 1103.

H2. Dialing Exchange Digit 9

When the calling subscriber dials the exchange digit 9, the selector S1 responds as hereinbefore described to record the nine impulses in the resulting series. Series relay 1105 operates as previously described. At the end of this series of impulses, register relays 1112 and 1109 are in operated condition.

H3. Marking Selector S1 as Calling Selector Group 9

When series relay 1105 restores at the end of the dialing of the digit 9, it extends ground potential to conductor 9 in each of the cables SC1 and MC1, through the front contacts of the second and first left armatures of relay 1112, back contacts of the fourth and second left armatures of relay 1110 and the front contacts of the fifth and third left armatures of relay 1109.

The ground potential on conductors 9 in cables SC1 and MC1 is further extended, through terminals 9 in blocks SB1 and MB1 (Fig. 13), conductors S1 and M1 in branch B9 of cable CA—1300, jumper terminals on blocks 4214, 4213 and 4212, 4211, to start conductor S1 and mark conductor 1 in cable CA—4300.

Responsive to the grounding of start conductor S1 and mark conductor 1 in cable CA—4300, the common equipment 9SCE of Figs. 42 to 45 is operated substantially as described hereinbefore for the similar common equipments 2SCE and 4SCE. Briefly, this operation is as follows:

H4. Seizing Selector Common Equipment 9SCE

If the common equipment 9SCE is idle (or, as soon as it is cleared out, if it is busy), section-1 relay 4301 operates over the grounded conductor S1 in cable CA—4300 in series with start relay 4415. Start relay 4415 starts the associated cycle timer comprising relays 4416 and 4417, and connects up secondary-matching relays 4507 to 4518 and 4401 to 4414 corresponding respectively to the twenty-seven outgoing secondary switches in group 9SS (Figs. 10A and 41).

Section-1 relay 4301 operates selecting magnet M1 of secondary group 9SS (Fig. 41); initiates the primary-matching operation by connecting conductors A and F in primary matching cable CA—4400 respectively to conductors 1A to 1F in branch BP in cable CA—4100, corresponding respectively to the section-1 primary devices 1A to 1F of group 9SP (Figs. 10A and 41); and it connects mark conductors 1 to 10 in cable CA—4300, through the conductors in cable CA—4350, respectively to selector-preference relays 4201 to 4210.

The marking ground potential on conductor 1 of cable CA—4300 is thereby extended, over con-

ductor 1 of cable CA—4350, to selector-preference relay 4201, operating this relay in series with selecting magnet M1 of primary group 9SP (Fig. 41).

Relay 4201 also grounds conductor 4250, thereby operating clear-out relay 4418, following which clear-out relay 4419 (being unshorted by relay 4418) operates over conductor 4452 in circuit with the operated secondary selecting magnet.

H5. The Matching Operation

It may be assumed that primary switch 1A of group 9SP (Fig. 41) and secondary switch A1 of group 9SS are idle, in which event idle-indicating battery potential is applied to conductors 1A and A1 in branches BP and BS of cable CA—4100 resulting in the operation of primary-matching relay 4501 and secondary-matching relay 4507, preparing for the completion of the connection over the first-choice outgoing link path.

H6. Operating the Matched Switches

When the energized selecting magnets M1 of groups 9SP and 9SS (Fig. 41 complete their operation and close the associated off-normal contacts, conductors PON and SON in cable CA—4100 are thereby grounded, closing operating circuits for the matched primary and secondary switches.

The operating circuit for the matched primary switch is as follows: from ground on conductor PON in cable CA—4100, through the lower contact pair of the operated start relay 4515, front contact of the left armature of primary-matching relay 4501, conductor A of primary-match cable CA—4400, contacts of the operated section-1 relay 4301, conductor 1A in branch BP of cable CA—4100, make-busy contacts 4104, the associated *c*-stackup contacts, to battery through the operating winding of magnet 4103. Magnet 4103 thereupon operates to close the selected #1 stackup of switch 1A of group 9SP. The associated *c* stackup of contacts is also shifted, thereby disconnecting the operating winding of magnet 4103, leaving the lower winding of this magnet connected as a holding winding.

The operating circuit for the matched secondary switch is as follows: from ground on conductor SON in cable CA—4100, from contact of the first right armature of primary-matching relay 4501, front contact of the armature of secondary-matching relay 4507, conductor A1 in branch BS of cable CA—4100, make-busy contacts 4102, the operating winding of magnet 4101, conductor S in link 9LA1, back contact of the armature of release relay 4002 of repeater 9R1, make-busy contacts 4003, and through resistor 4004, to battery. Magnet 4101 thereupon operates to close the selected #1 stackup of contacts of switch A1 of group 9SS, and to shift the associated *c* stackup of contacts. The lower contact pair of the *c* stackup separates conductors A and A' in branch BSG of cable CA—4100 at one point, while the upper contact pair connects up the upper winding of the magnet as a holding winding.

H7. Seizure of Repeater 9R1

The repeater 9R1 is seized by the above described operations of switches 1A and A1 of Fig. 41. The calling line, which has been extended as previously described to the incoming tip and ring conductors of the selector S1 (Fig. 11) is thereby further extended over the tip and ring conductors of selector multiple SM1, through the closed #1 stackup of primary switch 1A of group 9SP (Fig. 41), the tip and ring conductors of link 1 in cable 9SA, the closed #1 stackup of secondary switch A1 of group 9SS, tip and ring conductors of link 9LA1, and through the lower windings of repeating coil 4005, to the winding of line relay 4001 of the repeater 9R1. Line relay 4001 thereupon operates, operating the associated release relay 4002 through the front contact of its right armature to disconnect the incoming sleeve conductor S in link 9LA1 from its source of idle-indicating potential and to transfer it to ground, to provide a holding circuit for the established connection.

At the same time, line relay 4001 places a bridge across the tip and ring conductors of the associated trunk line 4010, outgoing to the called automatic exchange. This bridge includes the upper windings of repeating coil 4005 and the left contact pair of line relay 4001. Responsive to the closure of this bridge, incoming switching equipment (not shown) in the called automatic exchange 4000 is prepared for operation in response to the next digit to be dialed in the called number.

H8. Clearing Out Common Equipment 9SCE

Responsive to the described closure of the #1 stackup of contacts of primary switch 1A (Fig. 41), the ground potential applied over conductor 1A of cable CA—4100 to the associated sleeve conductor is thereby applied to the sleeve conductor S of selector multiple SM1, thereby operating cutoff relay 1101 of the selector S1 with results as hereinbefore described. One result is that the grounded conductor (conductor 9 in this case) in the associated mark cable MC1 is immediately ungrounded at the back contact of the second left armature of cutoff relay 1101 to initiate the clearing-out operation of the selector common equipment 9SCE.

Briefly, the clearing-out operation of equipment 9SCE of Figs. 42 to 45 is as follows:

Selector-preference relay 4201 restores responsive to the described operation of the cutoff relay of the calling selector, thereby ungrounding conductor 4250. Clear-out relay 4418 thereupon restores, open-circuiting and restoring section-1 relay 4301 and start relay 4415. Any operated one of the secondary-matching relays is restored responsive to the restoration of the start relay, and any operated one of the primary-matching relays is restored responsive to the restoration of the section relay.

Clear-out relay 4419 restores responsive to the restoration of section relay 4301, completing the clearing out of the common equipment.

H9. Repeating the Remaining Digits

As the remaining digits in the desired number are dialed, they are repeated to the called automatic exchange 4000, over the outgoing trunk line 4010, at the left contacts of line relay 4001. Release relay 4002 being slow-restoring, remains operated while the impulses are being repeated.

The automatic switching equipment (not shown) of exchange 4000 responds to the repeated digit impulses to set up connection to the desired line in any well-known or desired manner.

H10. Clearing Out the Established Connection

When the calling subscriber at substation #211 (Fig. 18) replaces his receiver, line relay 4001 restores to open the bridge across the outgoing trunk line 4010, permitting the portion of the connection in the called exchange 4000 to be cleared out. Release relay 4002 restores after a slight interval to remove the holding ground

potential from the associated sleeve conductor S in link 9LA1, whereupon the operated switches in the local exchange are cleared out, as hereinbefore described, along with the selector S1 of Fig. 11.

I. Calls Outgoing to Toll Switchboard #0

The way in which calls outgoing to toll switchboard #0 (shown at 4600 in Figs. 10A and 46) are handled will now be explained. For this purpose, it may be assumed that the subscriber at substation #211 (Fig. 18) desires to set up a connection to the toll switchboard.

It may be assumed that, when the receiver is removed at the calling substation, connection is extended therefrom as hereinbefore described to the selector S1 (Fig. 11), the selector S1 being thereupon prepared for operation.

When the calling subscriber dials the digit 0 assigned to the toll switchboard, this digit is recorded in the selector S1 by operations hereinbefore described. Counting relays 1112 and 1110 are in operated condition at the end of the counting operation. As a result, when slow-acting series relay 1105 restores at the end of the dialed digit, it applies ground potential to conductors 0 in the associated cables SC1 and MC1, through contacts of the operated relays 1112 and 1110, extending ground potential through terminals 0 of blocks SB1 and MB1 (Fig. 13), and over conductors S1 and M1 in branch B0 of cable CA—1300, through jumper blocks 4814, 4813 and 4812, 4811 to start conductor S1 and mark conductor 1 in cable CA—4900 of selector common equipment 0SCE, Figs. 48 to 50.

The equipment 0SCE now operates substantially as hereinbefore described to control extension of the connection through the 0 group of the selector-switching stage to an idle trunk line outgoing to the called toll switchboard. Briefly, these operations are as follows:

Section-1 relay 4901 operates responsive to the ground potential on conductor S1 of cable CA—4900, in series with start relay 5011. Start relay 5011 starts the associated cycle timer comprising relays 5012 and 5013, and it connects up secondary-matching relays 5005 to 5010, corresponding respectively to the link paths outgoing to the called toll switchboard.

Section-1 relay 4901 operates selecting magnet M1 of secondary group 0SS, Fig. 47; connects conductors A to D in primary match cable CA—5000 to conductors 1A to 1D in branch BP of cable CA—4700, corresponding respectively to the section-1 switches of group 0SP (Figs. 10A and 47); and it connects mark conductors 1 to 10 in cable CA—4900, through the conductors of cable CA—4950, respectively to selector-preference relays 4801 to 4810.

Selector-preference relay 4801 now operates over the said mark conductor 1, in series with selecting magnet M1 of primary group 0SP (Fig. 47). Relay 4801 grounds conductor 4850, whereupon clear-out relays 5014 and 5015 operate successively.

I1. The Matching Operation

The matching operation, involving primary-matching relays 5001 to 5004 and secondary-matching relays 5005 to 5010, occurs responsive to the described simultaneous operation of relays 4901 and 5011. It may be assumed that primary-matching relay 5001 and secondary-matching relay 5005 operate. Under this condition, when the selecting magnets M1 of the primary and secondary groups shown in Fig. 47 have operated responsive to the closure of their circuits as noted above, and grounded the associated conductors PON and SON in cable CA—4700, primary and secondary switches 1A and A1 of Fig. 47 operate to extend connection over the first-choice link outgoing through repeater 0R1 (Fig. 46).

The circuit for the matched primary switch is as follows: from ground on conductor PON in cable CA—4700, through the lower contact pair of start relay 5011, front contact of the left armature of primary-matching relay 5001, conductor A in cable CA—5000, conductor 1A in branch BP of cable CA—4700, make-busy contacts 4704, the associated *c*-stackup contacts, to battery through the operating winding of magnet 4703. Magnet 4703 thereupon operates to close its selected #1 stackup of contacts and to shift the *c* stackup of contacts.

The operating circuit for the matched secondary switch is as follows: from ground on conductor SON in cable CA—4700, through the front contact of the first right armature of relay 5001, front contact of the armature of relay 5005, conductor A1 in cable CA—4700, make-busy contacts 4702, the operating winding of magnet 4701, sleeve conductor S of link 0LA1, back contact of the armature of release relay 4602, make-busy contacts 4603, and through resistor 4604, to battery. Magnet 4701 thereupon operates, thereby closing its selected #1 set of contacts and shifting the associated *c* stackup.

I2. Seizure of the Repeater 0R1

The repeater 0R1 is seized over selector multiple SM1 by the described operation of switches 1A and A1 of Fig. 47, through link 1 in cable 0SA, and through link 0LA1. Line relay 4601 now operates over the calling line, followed by the operation of the associated release relay 4602. The operator at toll switchboard 4600 is signalled in the usual manner responsive to the bridging of the outgoing trunk line 4610 at the left contact pair of line relay 4601.

The switching-through operation at the selector S1 is performed responsive to the operation of primary switch 1A of Fig. 47, followed by the clearing out of the selector common equipment 0SCE of Figs. 48 to 50 in the manner hereinbefore described in connection with the other selector common equipments.

The calling subscriber at substation #211 (Fig. 18) may converse with the operator at the called switchboard, when the operator responds.

The established connection is cleared out in the manner hereinbefore described responsive to the restoration of line and release relays 4601 and 4602 of the repeater 0R1 when the calling subscriber replaces his receiver. The opening of the left contacts of line relay 4601 may be utilized at the toll switchboard to give the operator a disconnect signal.

J. Calls Incoming From Automatic Exchange 4000

As previously noted, and as indicated in part 3 of Fig. 10A, there are twenty-five trunk lines incoming to the local automatic exchange from automatic exchange 4000, which incoming trunk lines extend respectively to the selectors S69 to S93 by way of the correspondingly numbered selector links. One of these selectors, the selector S69, is indicated generally in Fig. 12 together with its incoming selector link SL69 and its outgoing selector multiple SM69.

When the incoming trunk line 4020 is bridged at the distant automatic exchange 4000 responsive to being seized therein, the line and release relays in selector S69, corresponding to relays 1102 and 1103, are operated to prepare the selector S69 for operation. It is to be observed that the sleeve and hold leads incoming to selector S69 are left open at the terminals thereof, for sleeve and hold leads are not required for the selector link of an incoming selector.

The selector S69 responds to the subsequently dialed hundreds digit to cause the desired connection to be extended through the selector switching stage as hereinbefore described, following which the connection may be completed through the connector stage of the called hundreds group in the manner hereinbefore described.

K. Calls Incoming From the Toll Switchboard

As is indicated in part 3 of Fig. 10A, there are six trunk lines incoming from the toll switchboard 4000, which extend respectively, through selector links SL94 to SL99, to selectors S1 to S99. In Fig. 46, incoming trunk line 4020 is shown extended by way of selector link SL94 in cable CA—1200 to selector S94 indicated generally in Fig. 12. The selectors, such as S94, assigned to the trunk lines incoming from toll switchboard operate as hereinbefore described to cause extension of the incoming calls through their respective selector multiples, such as SM94.

L. Calling Unassigned Hundreds Digits

Arrangements illustrated in Fig. 13 are provided for causing a busy-tone signal to be returned to the calling line when an unassigned hundreds digit is dialed. As previously noted, the unassigned hundreds digits are 1 and 8. The conductors 1 in all the selector mark cables, such as MC1, MC33, MC69, and MC94, are all multipled together on the mark terminal blocks of Fig. 13, through conductor 1302, and are connected to battery through resistor 1301. When the digit 1 is dialed at any of the selectors, a battery potential through resistor 1301 and conductor 1302 is returned over the mark conductor 1 in the MC cable associated with the calling selector to cause the busy relay thereof to be operated.

Suppose, for example, that the digit 1 is dialed into the selector S1. Under this condition, counting relay 1107 operates, and is in operated condition when series relay 1105 restores. The marking ground potential thus applied through the left-hand winding of busy relay 1104 is extended through back contacts of relays 1112 to 1108, through the front contact of the third left armature of relay 1107, and over conductor 1 in cable MC1 to the common conductor 1302. The heavy current thereupon drawn through the comparatively low-resistance resistor 1301 causes the marginally adjusted busy relay 1104 to operate. Upon operating, relay 1104 closes a self-locking circuit for its right-hand winding at the front contact of its first right armature, at the same time ungrounding conductor 1118 to clear out the counting relays and thereby open the circuit through its left-hand winding. The operating circuit for the counting relays is opened at the back contact of the left armature of relay 1104, whereby these relays do not respond to any further digits which may be dialed. A busy-tone signal is returned to the calling line from the common lead BT, through the front contact of the second right armature of relay 1104, and condenser 1116.

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

Similarly, if the unassigned hundreds digit 8 is dialed, the busy relay of the calling connector is operated over the common conductor 1304 and resistor 1303.

M. Calling Digits Unassigned at Certain Selectors

As previously noted and described in connection with Fig. 10A, selector multiples SM00 to SM03 over which calls incoming from automatic exchange 4000 are handled at the selector stage do not appear in primary groups 0SP and 0SP over which calls outgoing through the 0 and 0 link groups at the selector stage are handled. The calling subscriber (in distant automatic exchange 4000) using one of the incoming selectors S00 to S03 has no occasion to dial either the digit 9 or the digit 0 into such selector. Accordingly, arrangements, as disclosed in Figs. 42 and 48, are provided for causing a busy signal to be returned by the calling selector if either the digit 9 or the digit 0 is dialed into any one of the said incoming selectors S00 to S03.

In Fig. 42, the mark conductors M00 to M03 in sub-branch B0M of cable CA—1300 (being the digit-0 mark conductors of selectors S00 to S03, respectively) are not jumpered across blocks 4212 and 4211 to mark conductors in the associated cables CA—4300 for the selector multiples of these selectors do not appear in the associated primary switch group 0SP of Figs. 10A and 41. Instead, these mark conductors M00 to M03 are connected together in common and extended to battery through the low-resistance resistor 4215, whereby a sufficiently heavy current is drawn over any one of these conductors to operate the busy relay of the calling one of any of the selectors S00 to S03 when set in accordance with the digit 9.

For a similar reason, the corresponding conductors M00 to M03 in branch B0 of cable CA—1300 are connected to battery through resistor 4015.

Additionally, the digit-0 mark conductors of the selectors S94 to S99 (associated with trunk lines incoming from the toll switchboard) are connected to battery through said resistor 4015, to cause the busy relay of any one of these selectors to operate if the hundreds digit 0 is transmitted to such selector.

N. Withdrawing Switches From Service

Any of the switches herein disclosed may be individually withdrawn from service by separating the concerned ones of the make-busy contacts hereinbefore referred to. For example, if the line primary switch 1A of group 2LP (Fig. 18) is to be withdrawn temporarily from service, as for inspection or repair, this may be accomplished by separating the make-busy contacts 1897, thereby disconnecting the associated conductor 1A in branch BP of cable CA—1900. With this conductor disconnected, no idle-indicating battery potential can be impressed thereon; consequently, the associated line common equipment 2LCE of Figs. 14 to 17 cannot include the said switch 1A of Fig. 18 in a matched link path, and the primary-matching operation takes some other idle primary switch in the section.

It is to be noted that separation of the make-busy contacts such as 1897 does not disturb any connection that may be currently established

through the switch, but merely prevents the switch from being taken for use after such connection is cleared out. Similarly, separation of make-busy contacts 1902 or 1904 withdraws the concerned secondary switch A1 or F6 of group 2LS from service.

Additionally, the opening of make-busy contacts 1902, withdraws also the selector S1 of Fig. 11 from service, along with switch A1 of Fig. 19, for the selector S1 can be taken for use only through the last-named switch. Similarly, opening the make-busy contacts 1115 of the selector S1 withdraws both the selector S1 and the finder-action secondary switch A1 of Fig. 19 from service, because the circuit path through which idle-indicating battery potential is placed on test conductor A1 in branch BS of cable CA—1900 includes make-busy contacts 1115 and the associated resistor 1114.

Selector primary switch 1A (Fig. 22), for example, is withdrawn from service by the opening of make-busy contacts 2204 thereof, thereby disconnecting, from the associated conductor 1A in cable CA—2200, the idle-indicating battery potential normally applied thereto through contacts 2206.

Selector-secondary switch A1 of Fig. 22, for example, is withdrawn from service, along with the associated connector 2C1 of Figs. 20 and 21 by the opening of make-busy contacts 2202. Similarly, the last-named switch and connector are withdrawn from service by the opening of make-busy contacts 2130 of the connector.

Additionally, the opening of make-busy contacts 2202 or 2130 withdraws the distributor switch 2D1 of Fig. 19 from service, for such distributor switch can be used only when the associated connector 2C1 of Figs. 20 and 21 is taken for use, which can be done only through the secondary switch A1 of Fig. 22.

The advantage of providing two sets of make-busy contacts (such as 2202 and 2130, or 1115 and 1902) for withdrawing the same link from service is that such link and associated equipment may be withdrawn from service at either of two points by the switchroom attendant, depending upon with which part of the apparatus he is currently concerned.

I claim:

1. In combination, a group of switches mounted in a row extending in a first direction, each switch having a plurality of stackups of contacts arranged thereon in a row extending in a second direction, the contact sets on the several switches being in rows extending in the first direction, each of said switches having selecting fingers movably mounted thereon respectively adjacent the stackups of such switch, selecting shafts, each stub shaft extending along a row of said fingers in the first direction, means for selectively actuating said shafts, means responsive to the actuation of any shaft for moving all of the fingers in the row along which such shaft extends, each of said switches having a magnet, and means responsive to the energization of the magnet of any switch for operating any stackup thereof, depending upon the adjacent one of said fingers having been moved.

2. In combination, a group of switches mounted in a row extending in a first direction, each switch having a plurality of stackups of contacts arranged thereon in a row extending in a second direction, the contact sets on the several switches being in rows extending in the first direction, each switch having an actuating member underlying the stackups thereof, each of said members having selecting fingers movably mounted thereon respectively adjacent the stackups of the associated switch, each such finger having an actuating portion lying to one side of the adjacent stackup, selecting shafts, each such shaft extending along a row of said fingers in the first direction, means for selectively actuating said shafts, means responsive to the actuation of any shaft for moving all the fingers in a row along which such shaft extends to bring the actuating portion of each such finger between the adjacent stackup and the associated actuating member, and means for moving the actuating member of any switch toward the stackups thereof, any one of the stackups of such switch being operated responsive to such movement, depending upon the adjacent one of said fingers having been moved to bring its actuating portion between the member and such stackup.

3. In combination, a group of switches mounted in a row extending in a first direction, each switch having a plurality of stackups of contacts arranged thereon in a row extending in a second direction, the contact sets on the several switches being in rows extending in the first direction, each switch having an actuating member underlying the stackups thereof, each of said members having selecting fingers movably mounted thereon respectively adjacent the stackups of the associated switch, each such finger having an actuating portion lying to one side of the adjacent stackup, selecting shafts, each such shaft extending along a row of said fingers in the first direction, means for selectively actuating said shafts, means responsive to the actuation of any shaft for moving all the fingers in a row along which such shaft extends to bring the actuating portion of each such finger between the adjacent stackup and the associated actuating member, means for moving the actuating member of any switch toward the stackups thereof, any one of the stackups of such switch being operated responsive to such movement, depending upon the adjacent one of said fingers having been moved to bring its actuating portion between the member and such stackup, and yielding means interposed between each of said fingers and the associated shaft for permitting completion of the selecting movement of such shaft when such finger is unable to complete its movement, on account of encountering the side of the adjacent stackup when the associated actuating member is actuated but the last-named stackup is not actuated.

4. In combination, a group of switches, each switch having a plurality of stackups of contacts thereon, each switch having an actuating member underlying the stackups thereof, each of said members having selecting fingers movably mounted thereon respectively adjacent the stackups of the associated switch, each such finger having an actuating portion lying to one side of the adjacent stackup, means selectively operable for moving any desired finger in each of said switches to bring the actuating portion thereof between the adjacent stackup and the associated actuating member, means for moving the actuating member of any switch toward the stackups thereof, any one of the stackups of said switch being operated responsive to such movement, depending upon the adjacent one of said fingers having been moved to bring its actuating portion between the member and such stackup, and yielding means interposed between each of said fingers

and said finger-moving means for permitting completion of the movement of such means when such finger is unable to complete its movement, on account of encountering the side of the adjacent stackup when the associated actuating member is actuated but the last-named stackup is not actuated.

5. In combination, a mounting frame including a pair of parallel mounting rails having opposed mounting openings therein enabling selectively operable automatic switches to be mounted in superposed relationship on said frame, said switches being provided in groups, the number of switches in a group depending upon traffic requirements, selecting shafts extending across all the switches of a group and having a length depending upon the number of switches therein, shaft-mounting brackets at the two ends of a group of switches, said shafts being journaled for rotation in said brackets, said brackets being detachably mounted on said rails, enabling any such bracket to be mounted at any desired point along the frame according to the shaft length required for the concerned group of switches, whereby the said frame can accommodate either one large group of switches served by selecting shafts extending substantially the entire length of the frame where the traffic requirements demand it, or two or more smaller groups of switches and associated selecting shafts, each such smaller group and associated selecting shafts extending over only a part of the frame.

6. A switchboard comprising a row of frames of uniform length, selectively operable automatic switches mounted on each of said frames in superposed relationship, said switches being provided in groups, the number of switches in a group varying from group to group depending on traffic requirements, the number of such groups of switches on a frame varying from frame to frame depending on the number of switches in the concerned groups in relation to the frame capacity, groups of selecting shafts associated respectively with said groups of switches, each such group of shafts extending across all the switches of the associated group and having a length depending on the number of switches therein, and means associated with each group of switches for operatively mounting the selecting shafts thereof on the concerned frame.

7. In a telephone system, a telephone exchange terminating subscriber lines, switching equipment in said telephone exchange for interconnecting any calling one of said lines with any desired called one thereof, said switching equipment comprising serially related switching stages interconnected by links, said switching stages including a first stage effective to extend connections from calling lines, an intermediate stage, and a final stage; each of said stages, except the final one, including a plurality of groups of links extending therefrom to the next stage, each said group of links having a separate group of switches assigned thereto in the stage from which it extends, including primary and secondary switches effective to extend connections through the concerned stage to the associated group of links outgoing therefrom, common control equipments associated respectively with said groups of switches, and means included in each of said equipments for controlling the operation of the associated switches to complete connections therethrough to the associated outgoing links.

8. A selector switching stage for a switching system, including links incoming thereto, separately designated groups of links outgoing therefrom, a separate group of primary and secondary switches assigned to each group of outgoing links and effective to connect any one of said incoming links with any associated outgoing link, selectors associated respectively with said incoming links, means controlled over any incoming link for setting the associated selector to designate any desired group of outgoing links, and means responsive thereto for operating an idle primary switch and an idle secondary switch of the switch group assigned to the designated link group to connect the concerned incoming link with an idle link of the designated outgoing group.

9. In a switching stage as set forth in claim 8, common equipments associated respectively with the separately designated outgoing groups, each such common equipment being responsive to the designation of the associated link group by any selector to control the operation of the associated primary and secondary switches to interconnect the concerned incoming link with an idle link of the designated outgoing group.

10. In a selector switching stage as set forth in claim 8, common equipments associated respectively with the separately designated outgoing groups, means responsive to the designation of any outgoing group by a selector for rendering the concerned common equipment temporarily individual to such selector, such common equipment being thereupon effective to operate an associated primary switch and an associated secondary switch to interconnect the incoming link with which the last-named selector is associated with an idle outgoing link in the designated group, each of said selectors having a cutoff relay operable responsive to the extension of the connection through the switching stage, and means responsive to the operation of the cutoff relay of any selector to which a common equipment has been rendered temporarily individual for terminating the said designation and for returning the last-named common equipment to common use.

11. A selector switching stage for a switching system including links incoming thereto, separately designated groups of links outgoing therefrom, a separate group of primary and secondary switches assigned to each group of outgoing links and effective to connect any one of said incoming links with any associated outgoing link, selectors associated respectively with said incoming links, groups of mark conductors individual respectively to said selectors, the mark conductors in any of said groups being individual respectively to said groups of outgoing links, means controlled over any incoming link for setting the associated selector to mark any desired one of the associated group of mark conductors to thereby designate the group of outgoing links to which such conductor is individual, and means associated with the designated outgoing group of links, and including means controlled over the last-named mark conductor, for operating an idle primary switch and an idle secondary switch of the switch group assigned to the designated link group to connect the last-named incoming link with an idle link of the designated outgoing group.

12. In a selector switching stage as set forth in claim 11, each selector having a busy relay, and means controlled over the marked one of said conductors responsive to all of the outgoing

links in the designated group being unavailable for actuating the busy relay of the concerned selector.

13. A selector switching stage for a switching system, including links incoming thereto, and separately designated groups of links outgoing therefrom, groups of primary switches corresponding respectively to said groups of outgoing links, groups of secondary switches corresponding respectively to said groups of outgoing links, each of said groups of primary switches being divided into sections, the primary switches in each section of any group having access in multiple to a separate plurality of said incoming links, the number of primary sections in a group being determined by the number of said incoming links, divided by the capacity of a primary switch, the number of primary switches in a section varying from group to group according to the traffic offered therethrough to the respective associated groups of outgoing links, the secondary switches in any group being divided into sections, corresponding respectively to the primary switches in any section of the associated primary group, the secondary switches in any section having access in common to the corresponding primary switches of the several sections in the associated primary group, the secondary switches in any group being individual respectively to the links of the corresponding outgoing group.

14. A selector switching stage for a switching system including links incoming thereto and separately designated groups of links outgoing therefrom, groups of primary switches corresponding respectively to said groups of outgoing links, groups of secondary switches corresponding respectively to said groups of outgoing links, each of said groups of primary switches being divided into sections, the primary switches in each section of any group having access in multiple to a separate plurality of said incoming links, the number of primary sections in a group being determined by the number of said incoming links divided by the capacity of a primary switch, the secondary switches in any group being divided into sections corresponding respectively to the primary switches in any section of the associated primary group, the secondary switches in any section having access in common to the corresponding primary switches of the several sections in the associated primary group, the secondary switches in any group being individual respectively to the links of the corresponding outgoing group.

15. In a selector switching stage as set forth in claim 14, selectors individual respectively to said incoming links, means controlled over any incoming link for setting its individual selector to designate any one of said groups of outgoing links, and means responsive thereto for causing an idle primary switch in the concerned section of the primary group associated with the designated group of outgoing links to make connection with the concerned incoming link, and for causing an idle secondary switch in the secondary section having access to the last-named primary switch to connect the associated individual outgoing link, through the last-named primary switch, to the concerned incoming link.

16. In a switching system, a group of selectors divided into sections, a group of primary switches divided into corresponding sections, the primary switches of each section having access in multiple to the selectors of the corresponding section, primary selecting magnets common to all said primary switches and corresponding respectively to the selectors in any section, secondary switches divided into as many sections as there are primary switches in a primary section, each secondary section corresponding to a separate primary switch in any primary section, the secondary switches in each secondary section having access in multiple to the corresponding primary switches, secondary selecting magnets common to all said secondary switches and corresponding respectively to said primary sections.

17. In a switching system as set forth in claim 16, a selector common equipment for controlling the operation of all said primary and secondary switches, said selector common equipment including section relays corresponding respectively to said primary sections, a start relay, selector-preference relays corresponding respectively to the selectors of any section, primary-matching relays corresponding respectively to the primary switches of any section, means for taking any selector for use and for imparting any one of a number of calling conditions thereto, one of said conditions being specific to said primary and secondary switches, any selector to which said specific calling condition has been imparted being effective to operate said start relay and the section relay corresponding to the concerned selector section, any operated section relay being effective to disable the other section relays; to operate the corresponding secondary selecting magnet; to connect the selectors of the corresponding section respectively to the selector-preference relays; and to connect the primary switches in the corresponding section respectively to said primary-matching relays, the one of said selector-preference relays which corresponds to the last-named selector thereupon operating to disable the other selector-preference relays, said primary selecting magnets being connected in circuit respectively with said selector-preference relays, the corresponding primary magnet operating along with the operated selector-preference relay, means controlled by said start relay for performing a secondary-matching operation, means controlled by said primary-matching relays and by the said secondary-matching operation for matching an idle primary switch in the primary section corresponding to the operated section relay with an idle secondary switch having access to the matched primary switch, and means responsive to the completion of the operation of the primary and secondary selecting magnets for operating the matched primary and secondary switches to extend connection therethrough from the last-named selector.

18. In a switching system, a group of selectors divided into sections, a group of primary switches divided into corresponding sections, the primary switches of each section having access in multiple to the selectors of the corresponding section, secondary switches having access in multiple to the primary switches, means for taking any selector for use and for imparting any one of a group of settings thereto, only one of which corresponds to said group of primary switches, a selector common equipment interconnected with all said primary and secondary switches, means in said common equipment responsive to said one setting being imparted to any one of said selectors for selecting and operating an idle primary switch of the section corresponding to the set selector to make connection with such selector, and for selecting and operating an idle secondary switch to make connection with the last-named primary switch.

19. In a common equipment for controlling the operation of primary and secondary switches, said primary switches being divided into sections, the switches in each primary section having access in multiple to a separate section of lines, said secondary switches being divided into sections corresponding respectively to the primary switches in any primary section, the switches in any secondary section having access in multiple to the corresponding primary switches in the several primary sections, primary-matching relays corresponding respectively to the primary switches in any section, means in said common equipment responsive to a calling condition on a line in any section for associating said matching relays respectively with the primary switches in the corresponding section, operating circuits for said matching relays respectively, each such circuit being effective depending on the associated primary switch being idle, and depending upon at least one section in the corresponding secondary switch being idle, said matching relays being arranged in an order of preference, and contacts on each of said matching relays, except the last, effective on operation thereof, to prevent operation of each succeeding relay in the order of preference.

20. In a selector common equipment arranged to be taken for use to extend connections from calling selectors through primary and secondary switches having access thereto, section relays, selector-preference relays, means effective when said common equipment is taken for use for operating any one of said section relays to connect up said selector-preference relays one of said selector-preference relays thereupon operating, a clearout relay operable responsive to the operation of any of said selector-preference relays, means responsive to the extension of the connection with respect to which the common equipment was taken for use for restoring the operated selector-preference relay, said clearout relay thereupon restoring, and means for clearing out said common equipment responsive to the restoration of said clearout relay.

21. In a common equipment for controlling the operation of primary and secondary switches, said primary switches being divided into sections, the switches in each primary section having access in multiple to a separate section of lines, said secondary switches being divided into sections corresponding respectively to the primary switches in any primary section, the switches in any secondary section having access in multiple to the corresponding primary switches in the several primary sections, primary-matching relays corresponding respectively to the primary switches in any section, means in said common equipment responsive to a calling condition on a line in any section for associating said matching relays respectively with the primary switches in the corresponding section, secondary-matching relays corresponding respectively to the switches in any secondary section, and means controlled by said primary-matching relays for associating said secondary-matching relays with one or another of said secondary sections, said secondary-matching relays being thereupon operable to select an idle secondary switch in the associated secondary section.

22. In a switching system, a group of primary switches and a group of secondary switches, said primary and secondary switches being serially related and effective when operated to extend calling lines, and common equipment for controlling the operation of all said primary and secondary switches, means controlled over any calling line accessible to said primary switches for taking said common equipment for use, said common equipment being thereupon effective to select and operate an idle one of said primary switches and to select and operate an idle one of said secondary switches to extend said calling line, means in the said common equipment normally effective for clearing it out and returning it to normal condition following the said operation thereof, and means including a cycle timer in said common equipment for independently clearing out said common equipment and returning it to normal condition in case the first-named clearing-out means fails.

23. In a switching system as set forth in claim 22, means responsive to the clearing out of the common equipment by said cycle timer when the first-named clearing-out means fails to operate for imposing a busy condition on the calling line.

24. In a switching system, a group of lines divided into sections, a group of primary switches divided into sections assigned respectively to said line sections, a group of secondary switches divided into sections, the switches in each secondary section having access to a primary switch in each of the primary sections, a group of connectors, links incoming respectively to said connectors, a group of distributor switches, said distributor switches corresponding respectively to said connectors and having common access to said secondary switches, selecting magnets common to all said distributor switches and corresponding respectively to said secondary switches, means for extending a connection from a calling line to any one of said connectors over its said incoming link, means in the last-named connector controlled over the calling line for indicating the line section containing the desired called line and for indicating which line therein is the desired called line, means responsive thereto for setting an idle primary switch in the called section on the called line and for setting an idle secondary switch on the last-named primary switch, means for operating the one of said selecting magnets which corresponds to the last-named secondary switch to select such secondary switch in all said distributor switches, and means for operating the distributor switch associated with the last-named connector in accordance with which selecting magnet is operated, to extend connection from such connector through the associated distributor switch to the called line by way of the operated secondary and primary switches.

25. In a switching system, a group of lines divided into sections, a group of primary switches divided into sections assigned respectively to said line sections, a group of secondary switches divided into sections corresponding respectively to the switch in any primary section, the switches in each secondary section having common access to the corresponding switches in the several primary sections, a group of connectors, links incoming respectively to said connectors, said group of secondary switches being divided into two subgroups, said group of connectors being divided into corresponding subgroups, a group of distributor switches divided into corresponding subgroups, means for extending a connection from a calling line to any one of said connectors over its said incoming link, means in the last-named connector controlled over the calling line for indicating the line section containing the desired called line and for indicating which line therein

is the desired called line, subgroup relays selectively operable according to the subgroup in which the last-named connector is located, means controlled by said subgroup relays for setting an idle primary switch in the called section on the called line and for setting an idle secondary switch in the last-named subgroup on such primary switch, and means for operating a distributor switch in the last-named subgroup to extend connection from the last-named connector to the called line by way of the operated secondary and primary switches.

26. In a telephone system, a local automatic exchange terminating lines divided into groups, a selector switching stage in said local automatic exchange, groups of selector links incoming respectively from said groups of lines to said selector stage, local groups of links outgoing from said selector stage respectively to said groups of lines, a second automatic exchange, a group of links incoming from said second automatic exchange to said selector stage, a group of links outgoing from said selector stage to said second automatic exchange, designations assigned to said outgoing groups respectively, said selector stage including groups of primary and secondary switches corresponding respectively to said outgoing groups of links, selectors assigned respectively to said incoming links, each of said selectors being operable over its associated incoming link to designate any one of said groups of outgoing links, means responsive to the designation of any of said groups of outgoing links by a selector associated with any of said links incoming from a local group of lines for causing an idle primary switch and an idle secondary switch in the corresponding group to extend the concerned incoming link to an idle outgoing link in the designated group, means responsive to the designation of any one of said local groups of outgoing links by a selector associated with a link incoming from said second automatic exchange for causing an idle primary switch and an idle secondary switch in the corresponding group to extend the concerned incoming link to an idle link in the designated group, the primary and secondary switch in the said group corresponding to the outgoing interexchange links being ineffective to make connection with the group of links incoming from said second automatic exchange, and means responsive to the designation of the outgoing interexchange group of links by any selector associated with any one of the incoming interexchange links for placing such selector in a busy-signaling condition.

27. In a telephone system, a group of telephone-line terminals, a group of P. B. X. lines connected respectively to certain of said terminals, a group of connectors serving said terminals when called, switching means for extending a calling line to any one of said connectors and for extending such connector to any called terminal of the group, each connector having mechanism for recording telephone numbers assigned to said terminals, switch-control equipment common to all said connectors, means effective when a telephone number has been set up in the recording mechanism of a connector for rendering said common equipment temporarily individual to such connector and for setting up the called number in the common equipment, said common equipment being normally effective to operate said switching means to extend the currently associated connector to the line terminals whose telephone number is set up therein, a P. B. X. relay included in said common equipment, means for operating said P. B. X. relay subject to a specific telephone number being set up in said common equipment, and means controlled by said relay for resetting said common equipment to respond to a different telephone number, said different telephone number varying according to the busy or idle condition of the P. B. X. lines.

28. In a telephone system, a group of telephone-line terminals having a block of telephone numbers assigned thereto, each line terminal bearing a separate telephone number, a group of P. B. X. lines connected respectively to certain of said line terminals, a group of connectors serving said line terminals when called, switching means for extending a calling line to any one of said connectors and for extending such connector to any called terminal of the group, each connector having mechanism for recording telephone numbers in said block, switch-control equipment common to all said connectors, means effective when a telephone number has been set up in the recording mechanism of a connector for rendering said common equipment temporarily individual to such connector, said common equipment being normally effective to operate said switching means to extend the currently associated connector to the line terminal whose telephone number is recorded, a P. B. X. relay included in said common equipment and having assigned thereto the telephone number of one of said P. B. X. line terminals, means controlled by the recording mechanism of the currently associated connector for operating said P. B. X. relay when its said assigned telephone number is recorded, and means controlled by said relay, when operated, and depending upon the associated P. B. X. line being busy, for causing said common equipment to operate the switching means to extend the connector to one or another of the other P. B. X. line terminals instead of to the line terminal to which the recorded telephone number is assigned.

29. In a selector switching stage having a group of trunk lines incoming thereto, selector links thereat, and groups of trunk lines outgoing therefrom; primary switching devices for interconnecting said incoming trunk lines with selector links, secondary switching devices for interconnecting said selector links with said outgoing trunk lines; said incoming trunk lines, said primary switching devices, and the primary end of said selector links, being divided into primary subgroups; the secondary end of said selector links, said secondary switching devices, and each of said groups of outgoing trunk lines, being divided into secondary subgroups; means controlled over any calling one of said incoming trunk lines for selecting any desired one of said groups of outgoing trunk lines, means responsive to such selection for rendering the primary subgroup containing the calling trunk line, and the selected group of outgoing trunk lines, temporarily individual to each other, while leaving the remaining groups of outgoing trunk lines and the remaining subgroups of incoming trunk lines free to become similarly individualized, whereby a number of switching operations may be proceeding through the seelctor stage at the same time, means for selecting an idle trunk line in the selected outgoing group, which is in a secondary subgroup containing an idle selector link extending thereto from the primary subgroup individualized therewith, and means for operating a primary

switching device in the last-named primary subgroup and a secondary switching device in the last-named secondary subgroup, to interconnect the calling incoming trunk line with the selected outgoing trunk line by way of said idle selector link.

30. A switching system according to claim 29, wherein there are a number of groups of lines accessible to the selector stage, the groups of trunk lines outgoing from the selector stage extending respectively to said groups of lines, switching mechanism at each group of lines for interconnecting the said trunk lines incoming thereto with desired called lines, each of said lines having a number assigned thereto including a digit designating the one of said groups in which the line is located, followed by digits designating the line in the group, means responsive to the calling of any one of said numbers over any said trunk line incoming to the selector stage for recording the group-designating digit thereof at the selector stage, means controlled by the recorded digit and effective in the interval between the recording thereof and the calling of the next digit in the number for extending the concerned incoming trunk line to an idle trunk line outgoing from the selector stage to the designated called group of lines, means controlled over the last-named trunk line responsive to the subsequent calling of the line-designating digits in the desired number for recording such digits, and means for operating switching mechanism at the called group of lines in accordance with the recorded line-designating digits to extend connection from the last-named trunk line to the desired called line.

31. A switching system according to claim 29, wherein selectors are associated respectively with said incoming trunk lines, means controlled over any incoming trunk line for setting the associated selector to designate any desired group of outgoing trunk lines, such designation constituting the said selection of the desired outgoing group.

32. A switching system according to claim 29, wherein selectors are associated respectively with said incoming trunk lines, means controlled over any incoming trunk line for setting the associated selector to designate any desired group of outgoing trunk lines, such designation constituting the said selection of the desired outgoing group, groups of mark conductors associated with said selectors, the mark conductors in any of said groups being individual respectively to said groups of outgoing trunk lines, each selector being adapted, on being set, to mark any desired one of the associated group of mark conductors to thereby designate the group of outgoing trunk lines to which such conductor is individual.

33. A switching system according to claim 29, wherein selectors are associated respectively with said incoming trunk lines, means controlled over any incoming trunk line for setting the associated selector to designate any desired group of outgoing trunk lines, such designation constituting the said selection of the desired outgoing group, groups of mark conductors associated with said selectors, the mark conductors in any of said groups being individual respectively to said groups of outgoing trunk lines, each selector being adapted, on being set, to mark any desired one of the associated group of mark conductors to thereby designate the group of outgoing trunk lines to which such conductor is individual, each selector having a busy relay, and means controlled over the marked one of said conductors, responsive to all of the outgoing trunk lines in the designated group being unavailable, for actuating the busy relay of the concerned selector.

34. A switching system according to claim 29, wherein selectors are associated respectively with said incoming trunk lines, means controlled over any incoming trunk line for setting the associated selector to designate any desired group of outgoing trunk lines, such designation constituting the said selection of the desired outgoing group, common equipments associated respectively with the separately designated outgoing groups, each such common equipment being responsive to the designation of the associated trunk-line group by any selector to control the operation of the concerned primary and secondary switches to interconnect the concerned incoming trunk line with an idle trunk line of the designated outgoing group.

35. A switching system according to claim 29, wherein selectors are associated respectively with said incoming trunk lines, means controlled over any incoming trunk line for setting the associated selector to designate any desired group of outgoing trunk lines, such designation constituting the said selection of the desired outgoing group, common equipments associated respectively with the separately designated outgoing groups, each such common equipment being responsive to the designation of the associated trunk-line group by any selector to control the operation of the concerned primary and secondary switches to interconnect the concerned incoming trunk line with an idle trunk line of the designated outgoing group, each of said selectors having a cutoff relay operable responsive to the extension of the connection through the switching stage, and means responsive to the operation of the cutoff relay of the calling selector in any primary subgroup to which an outgoing group of trunk lines has been rendered temporarily individual for terminating the said designation and for returning the associated common equipment to common use.

36. Switching apparatus including a group of switches mounted in a row extending in a first direction, each switch having a number of stackups of contacts arranged thereon in a row extending in a second direction, the stackups on the several switches being in rows extending in the first direction, each of said switches having selecting fingers movably mounted thereon respectively adjacent the stackups of such switch, selecting shafts, each extending along a row of said fingers in the first direction, means for selectively actuating said shafts, means responsive to the actuation of any shaft for moving all of the fingers in the row along which such shaft extends, each switch having means for operating any stackup thereof depending upon the adjacent one of said fingers having been moved.

37. A switching apparatus according to claim 36, the stackups of each switch being arranged in pairs, the selecting fingers of any switch corresponding respectively to said pairs of stackups, each of said fingers having a pair of arms extending toward the associated shaft, each shaft having an eccentric portion extending between the arms of each of the associated fingers, rotation of any shaft in one direction serving to act upon one arm of each of the associated fingers to move each such finger into selective association with one stackup of its pair, rotation of the said shaft in the other direction serving to act upon the other arm of each of the associated fingers to

move each such finger into selective association with the other stackup of its pair.

38. In combination, a group of selective switches arranged to be controlled by a selecting shaft, selecting fingers interconnecting the shaft with the switches, each finger including a relatively rigid portion associated with its switch and a relatively rigid portion associated with the shaft, the two said portions of any finger being flexibly connected together to permit movement of both portions as a unit, responsive to movement of the shaft, unless the switch portion is prevented from moving, in which case the flexible connection between the portions permits the shaft portion to move alone.

39. In a switching system, a group of call-extending links divided into subgroups, lines, means for extending calling ones of said lines to idle ones of said links, a group of primary link finders divided into subgroups corresponding respectively to the subgroups of links, the primary link finders of any subgroup having access to all of the links of the corresponding link subgroup, a group of secondary finders divided into subgroups corresponding respectively to the individual finders of any primary subgroup, trunk lines extending respectively from said secondary finders, digit-responsive devices associated with said call-extending links for recording the digit value of a train of impulses transmitted to any link from a calling line, and means responsive to the recording of a specific digit value at any one of said call-extending links for causing an idle primary finder in the subgroup having access thereto to make connection with such link and for causing an idle secondary finder in the corresponding secondary subgroup to connect the trunk line associated therewith, through the said idle finder, to the found call-extending link.

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