

March 5, 1946.

J. M. BLACKHALL
AUTOMATIC TELEPHONE SYSTEM

2,396,077

Filed Sept. 29, 1943

13 Sheets-Sheet 1

Fig. 1.

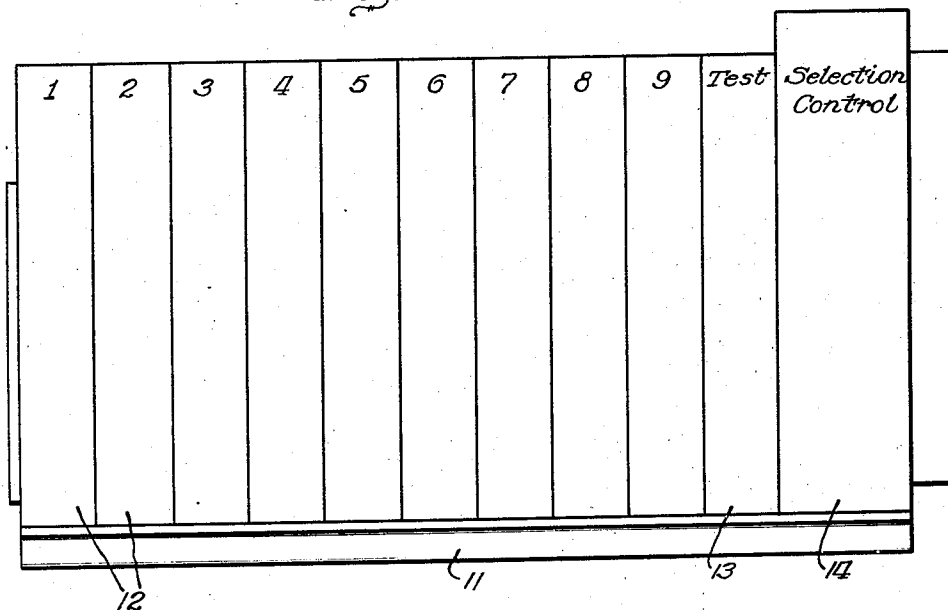


Fig. 16.

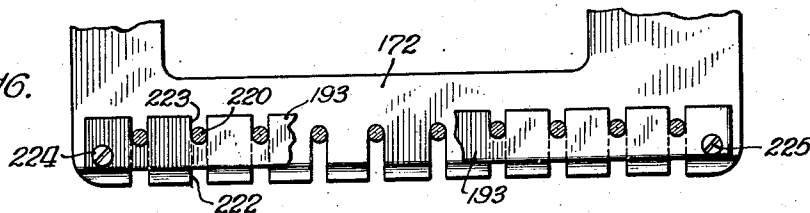
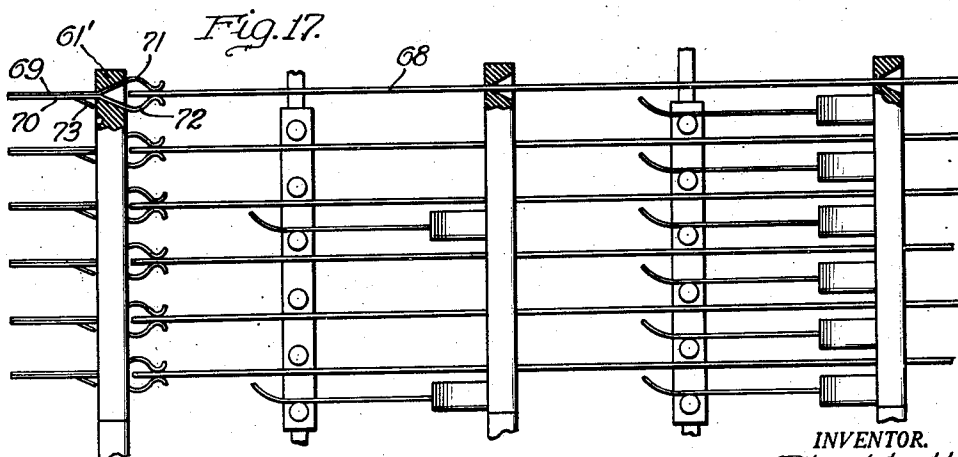


Fig. 17.



INVENTOR.
James M. Blackhall.

BY *Richardson & Quiv*

Attys.

March 5, 1946.

J. M. BLACKHALL

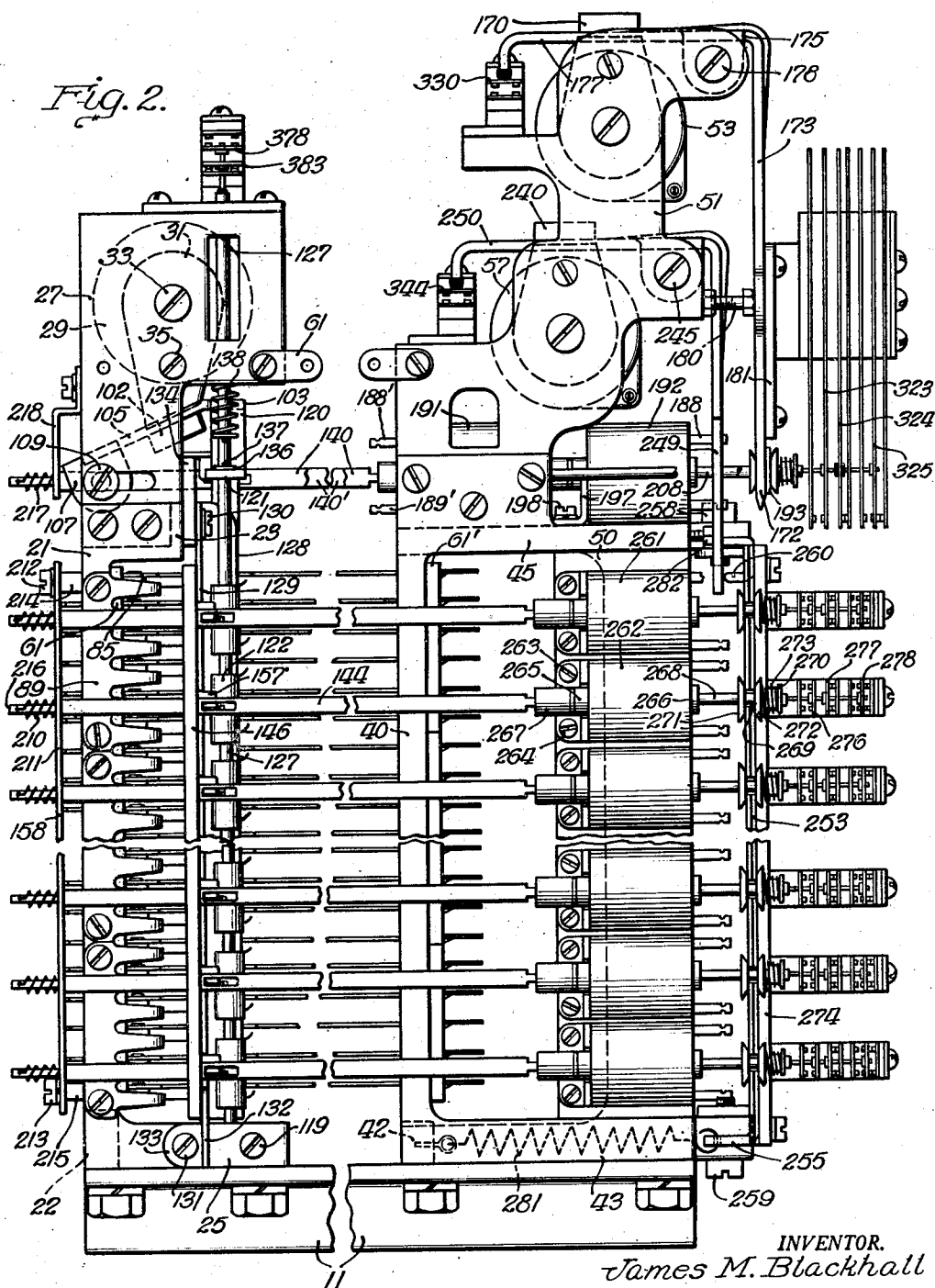
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Fig. 2.



INVENTOR.
James M. Blackhall
BY *Richardson & Quer*
Attys

March 5, 1946.

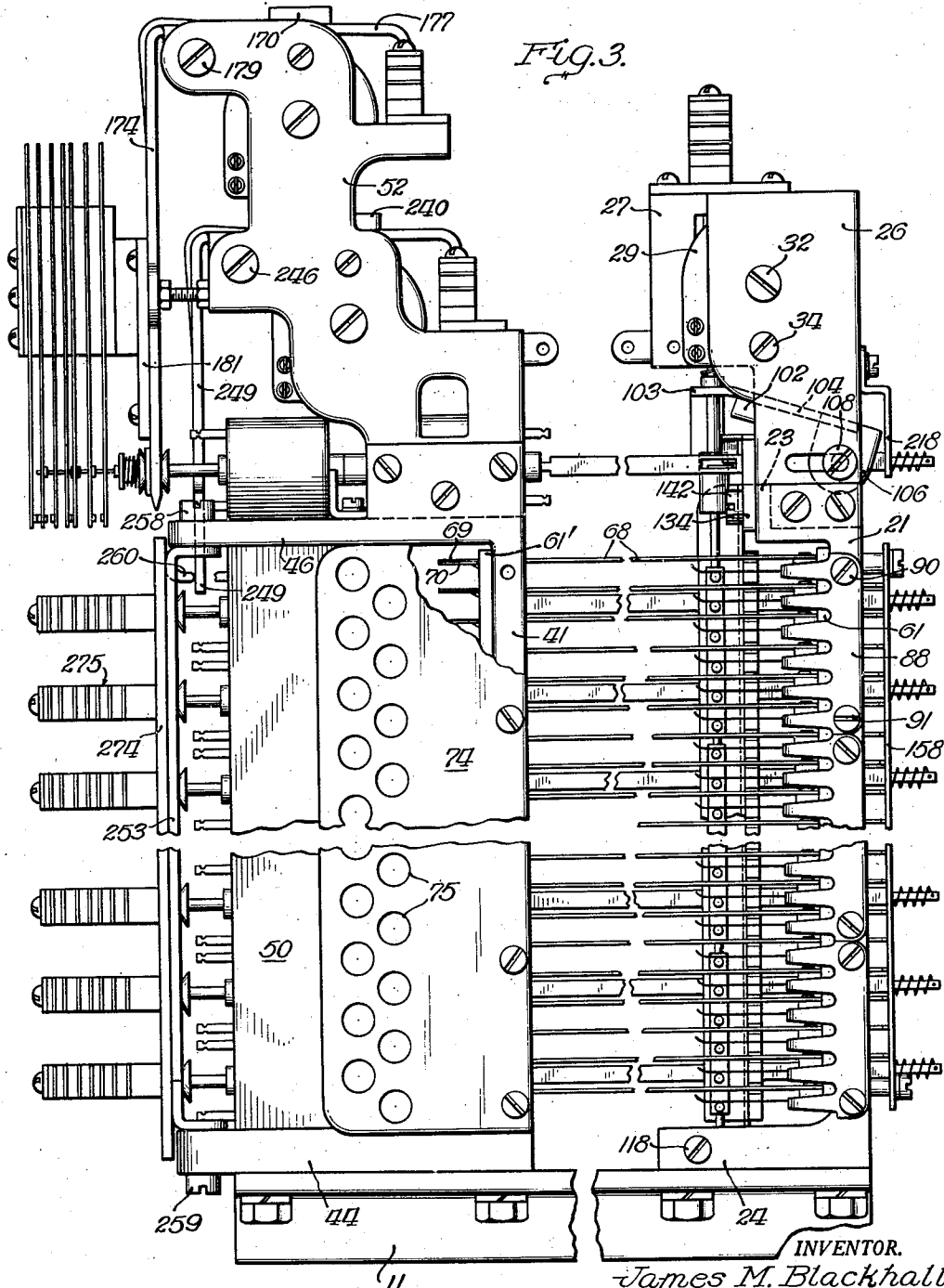
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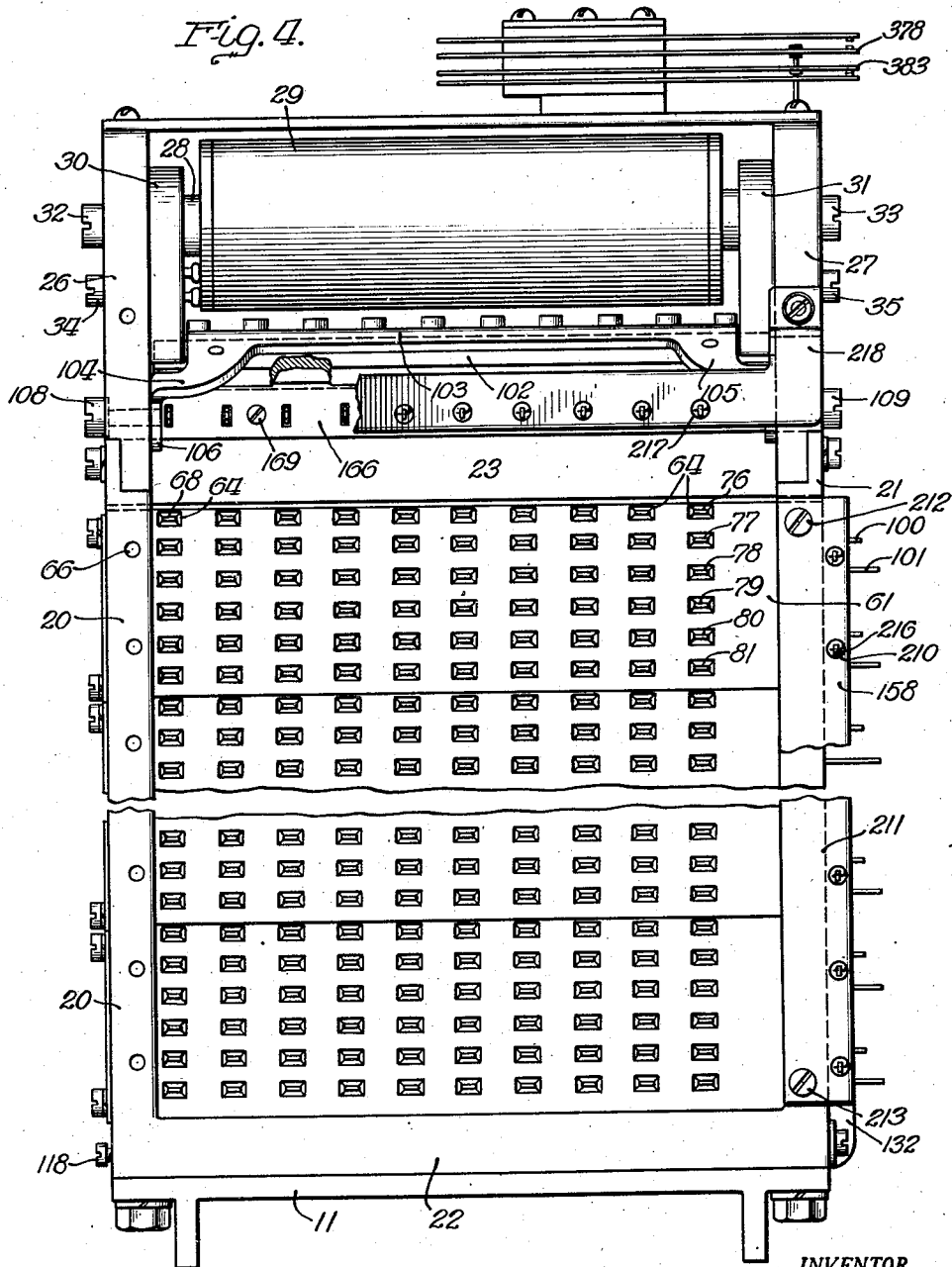
J. M. BLACKHALL

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INVENTOR.
James M. Blackhall
BY
Richardson ^{and} Quer
Attys.

March 5, 1946.

J. M. BLACKHALL

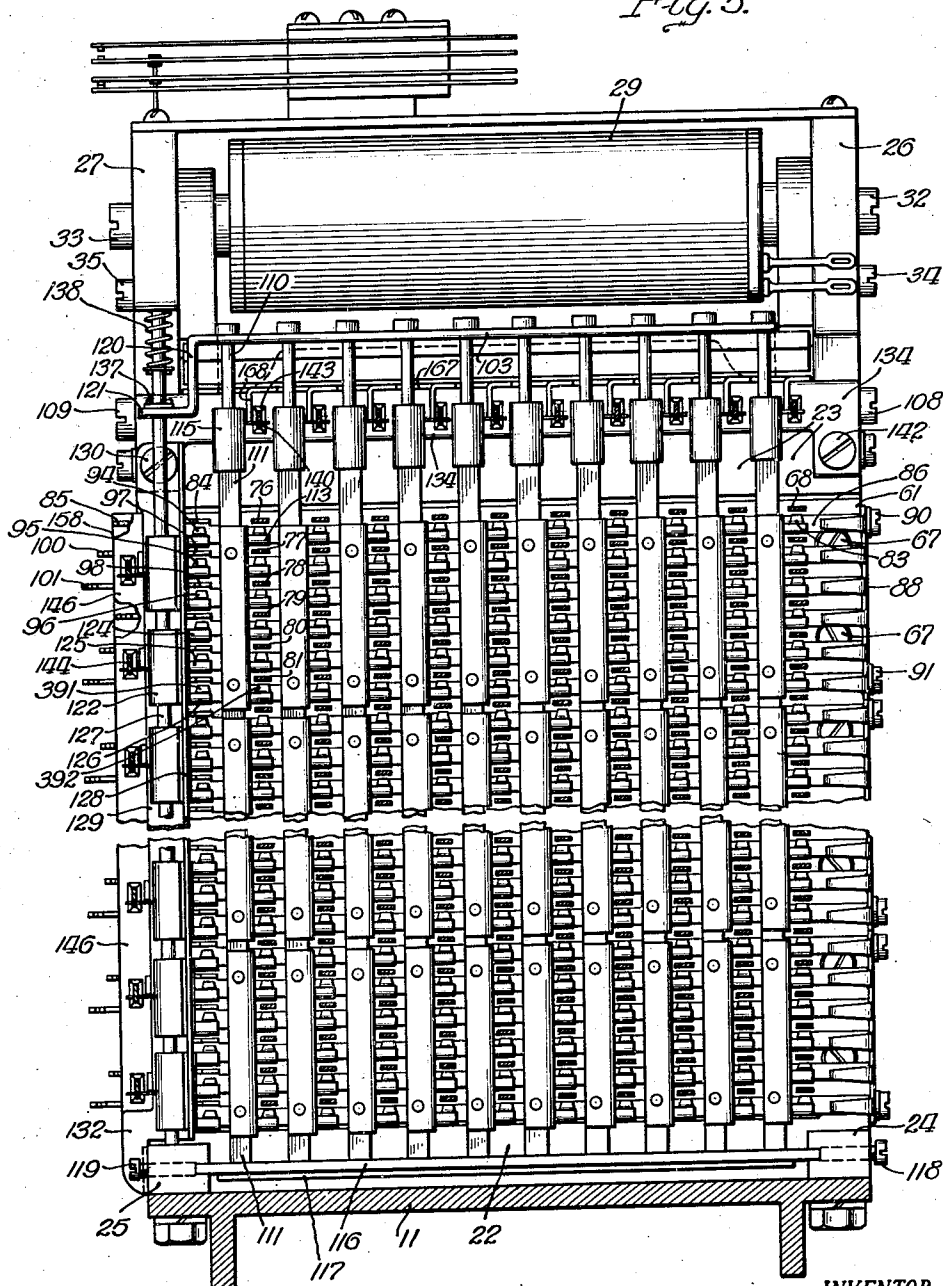
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Fig. 5.



INVENTOR.
James M. Blackhall
BY
Richardson and Quer
Attys.

March 5, 1946.

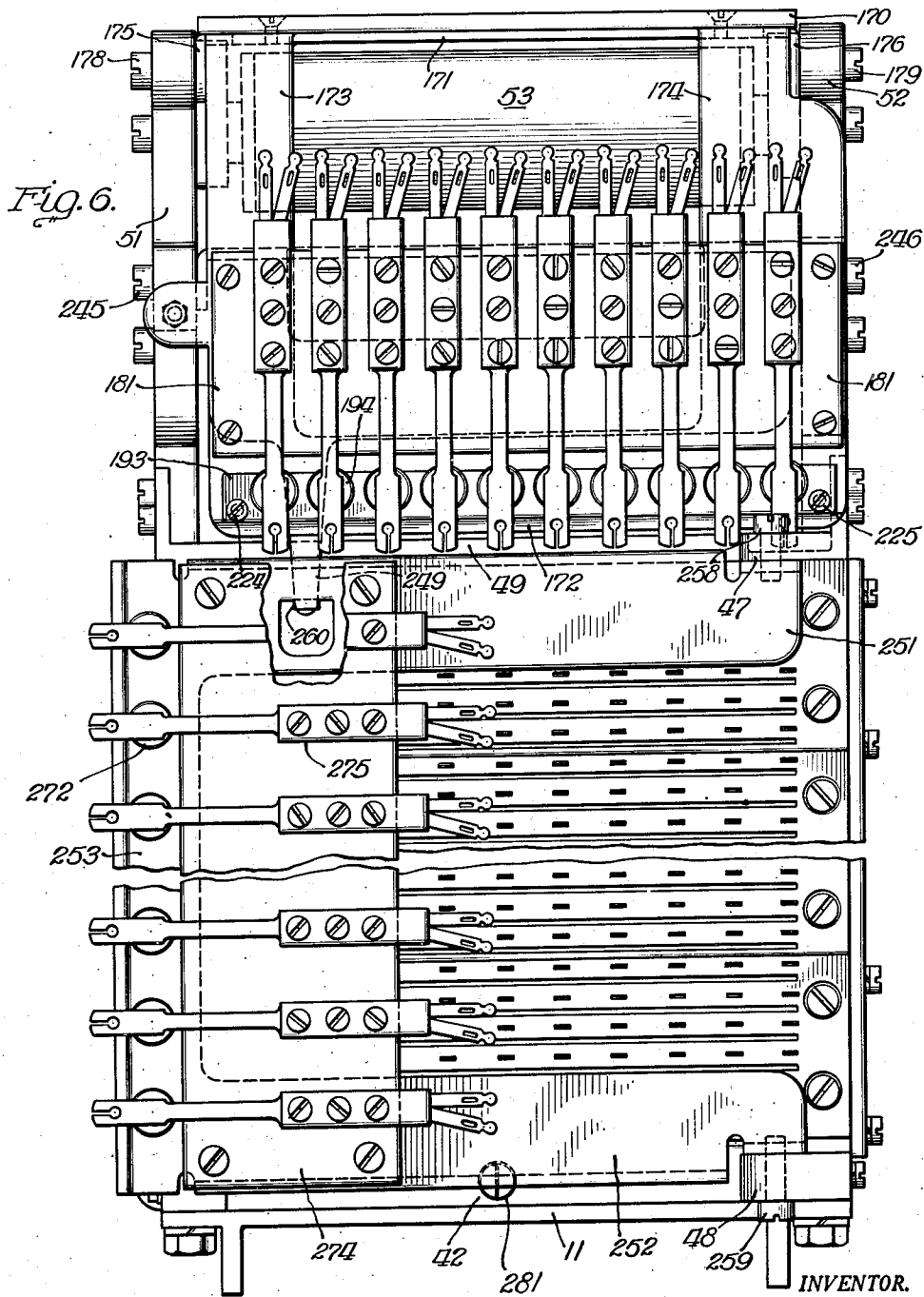
J. M. BLACKHALL

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INVENTOR.
James M. Blackhall
BY
Richardson and Quer
Attys.

March 5, 1946.

J. M. BLACKHALL

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Fig. 8.

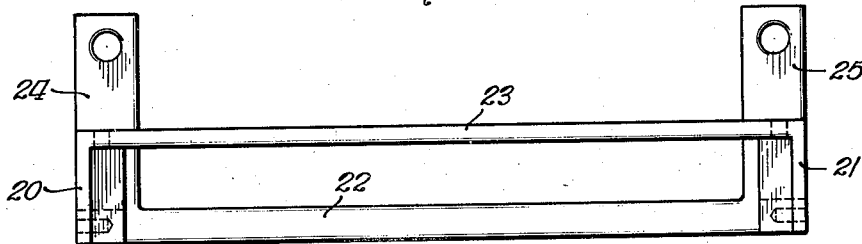
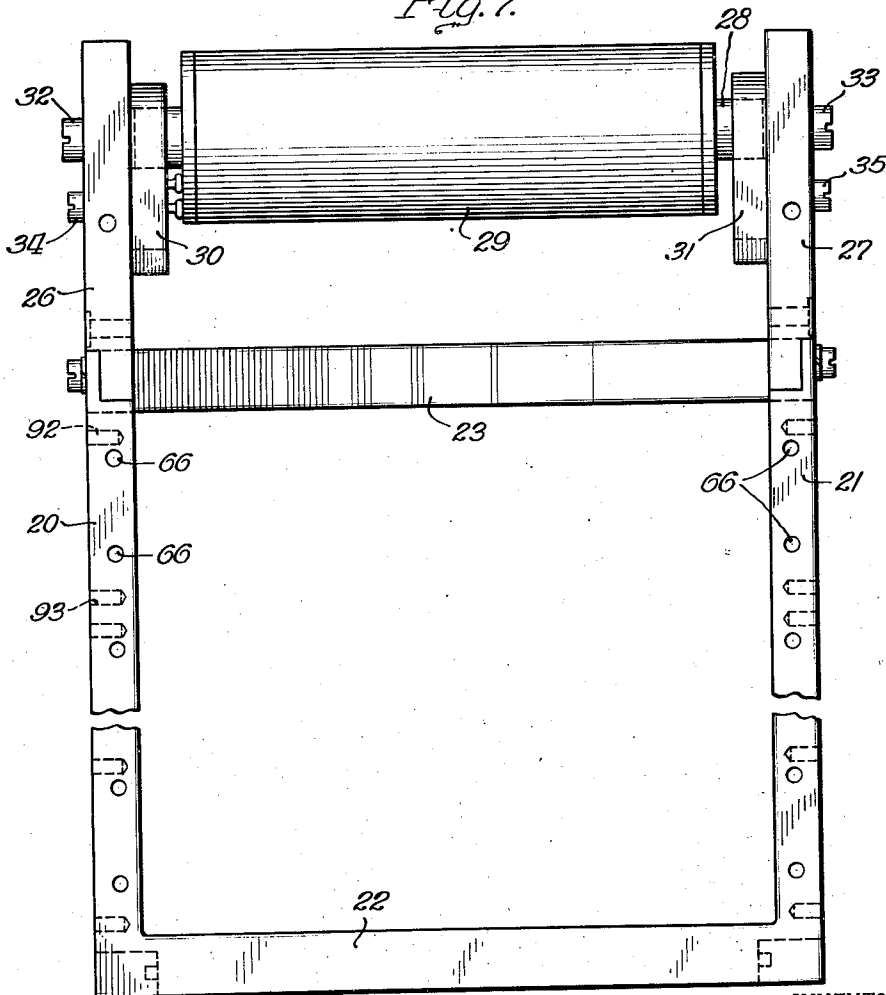


Fig. 7.



INVENTOR.

James M. Blackhall

BY

Richardson and Quer
Attys.

March 5, 1946.

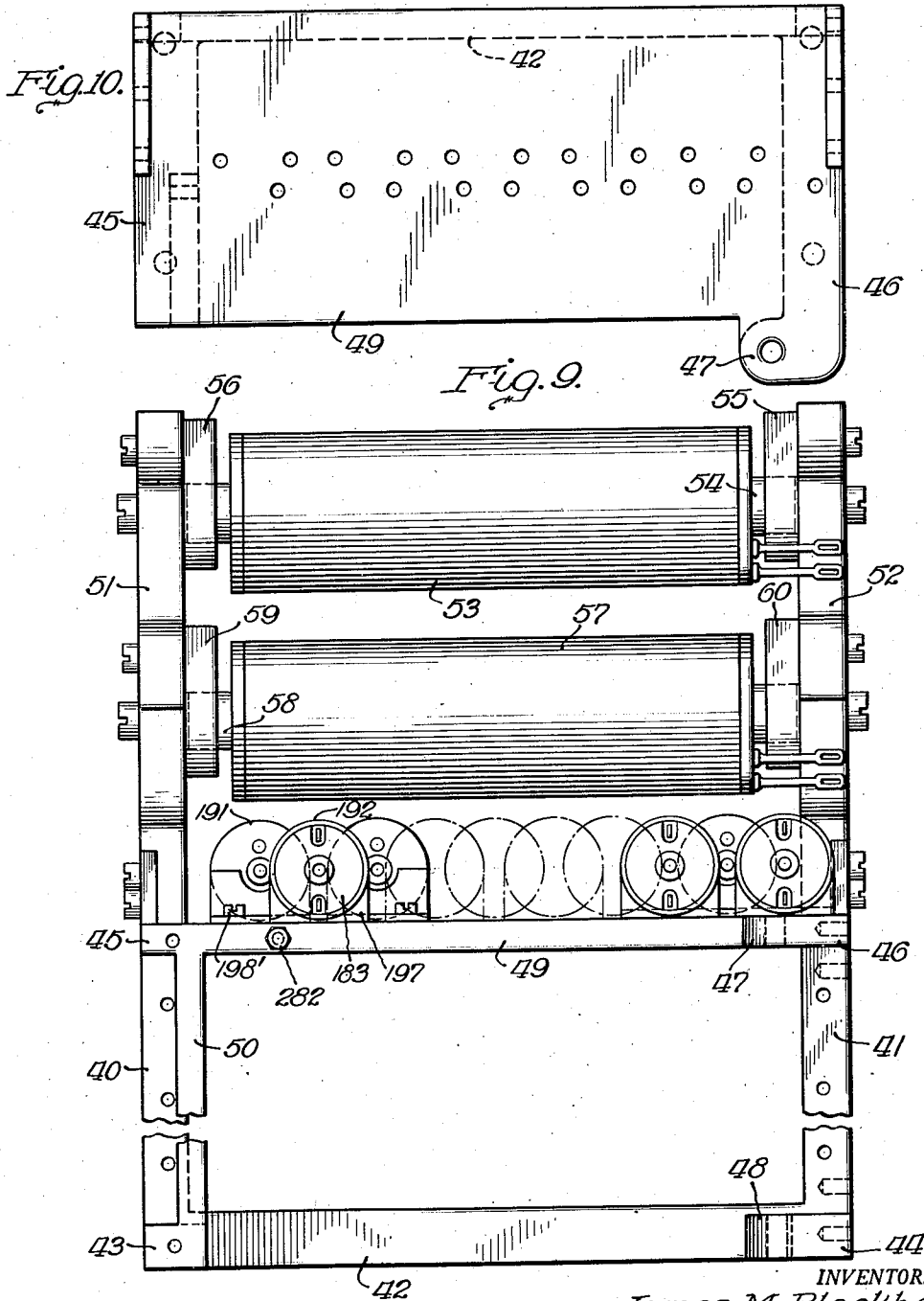
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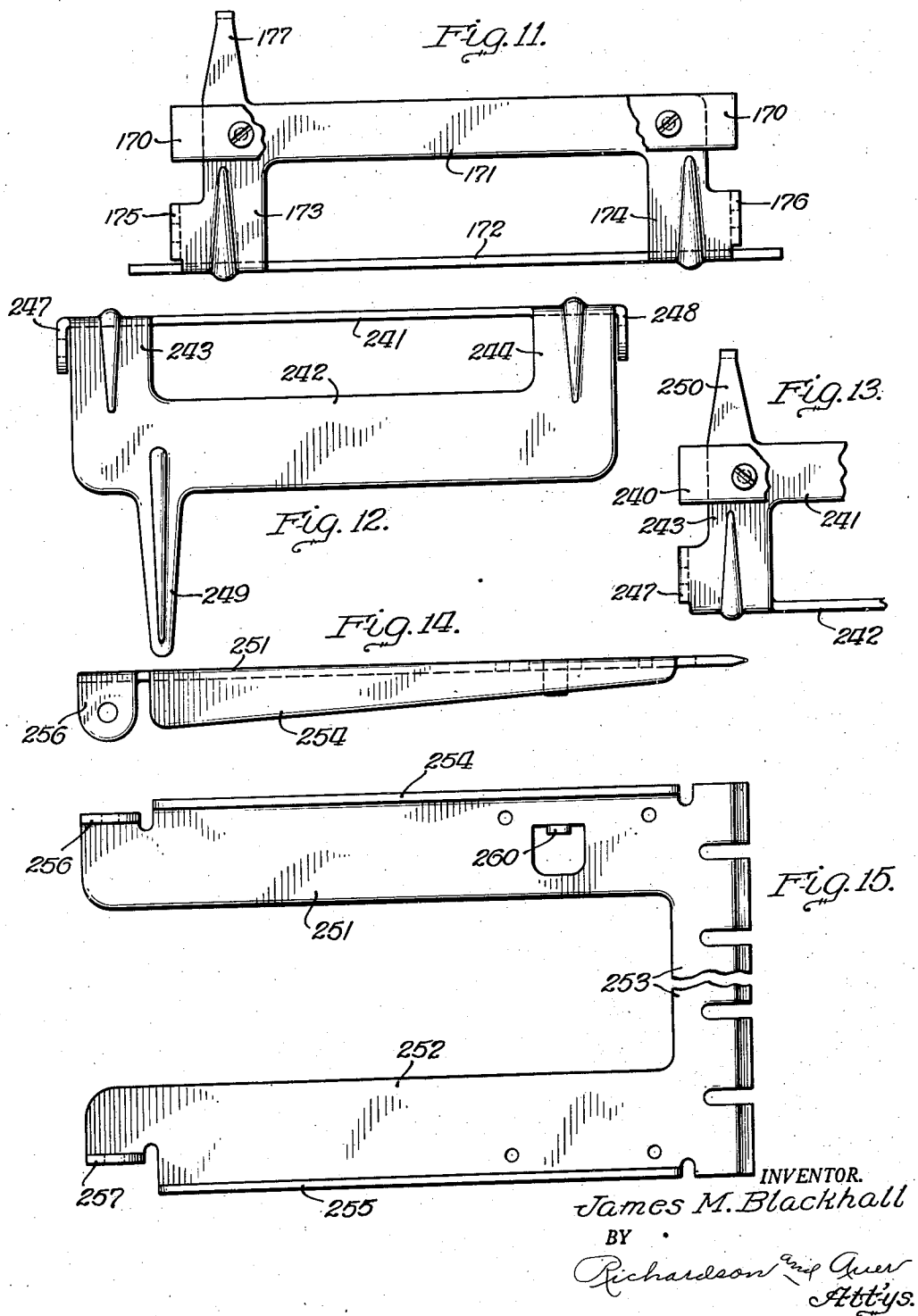
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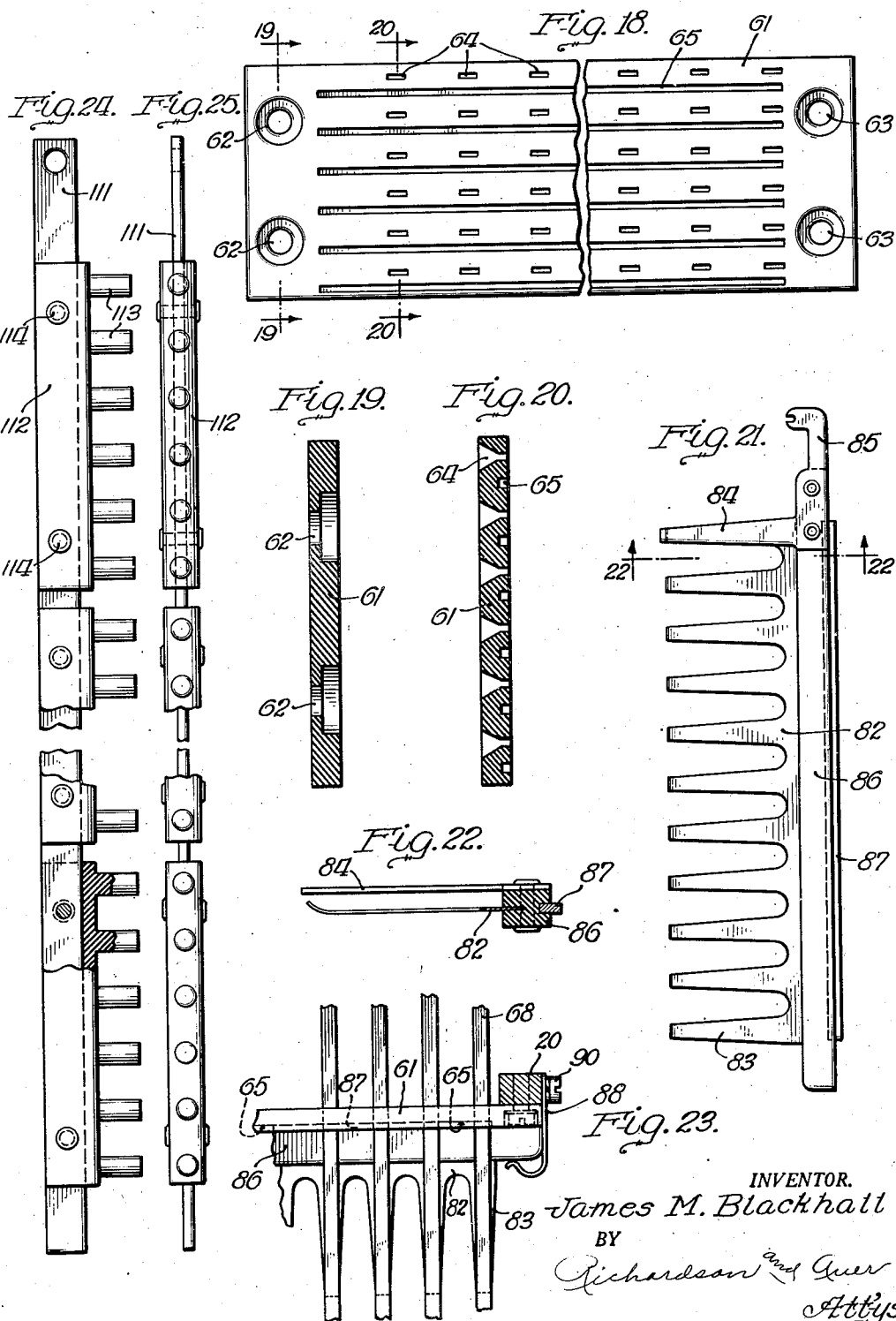
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AUTOMATIC TELEPHONE SYSTEM

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INVENTOR.
James M. Blackhall
BY
Richardson and Quer
Attys.

March 5, 1946.

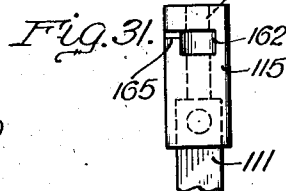
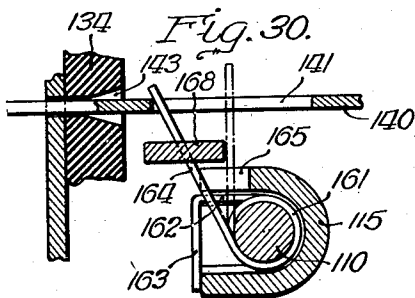
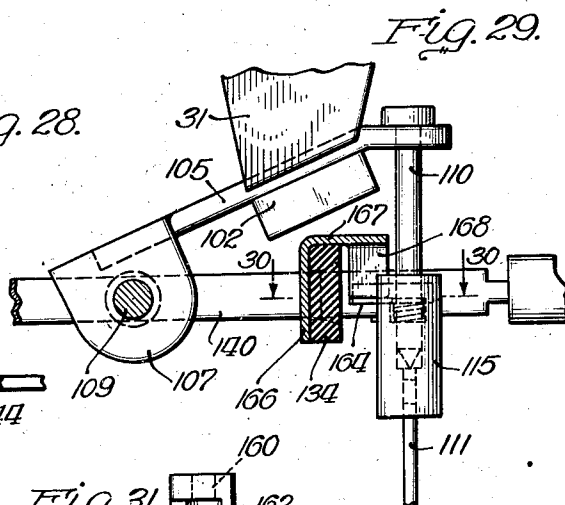
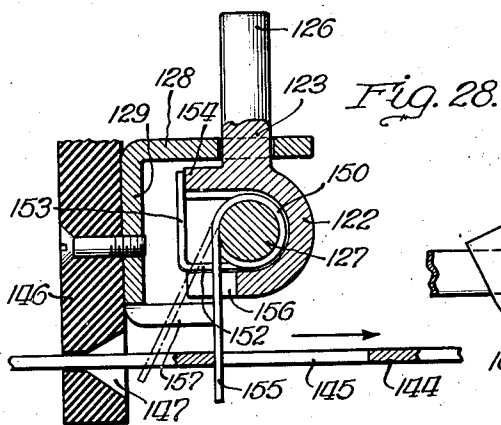
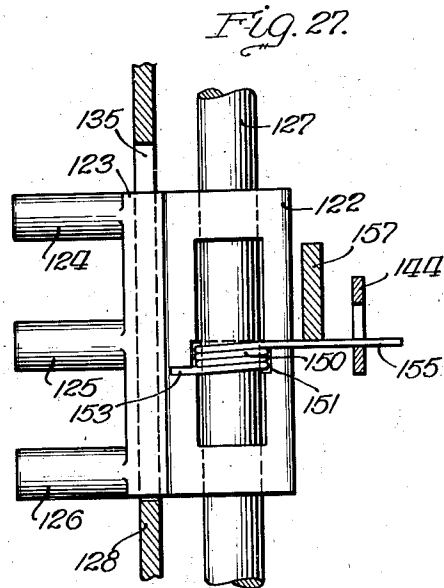
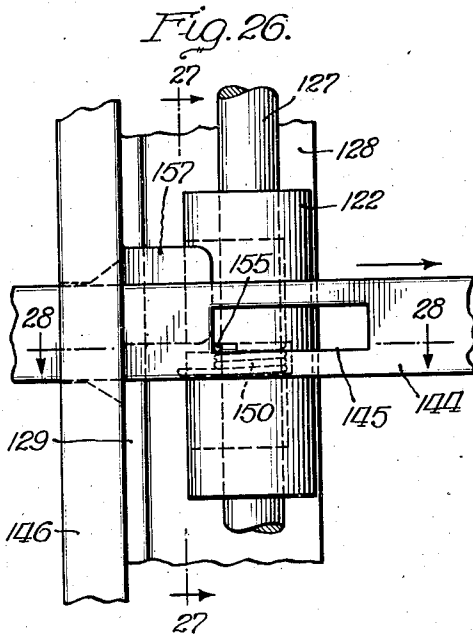
J. M. BLACKHALL

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INVENTOR.
James M. Blackhall
BY
Richardson and Quier
Attys.

March 5, 1946.

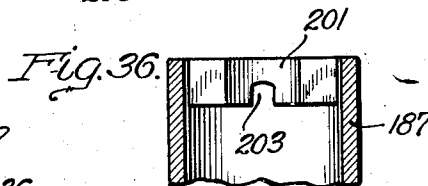
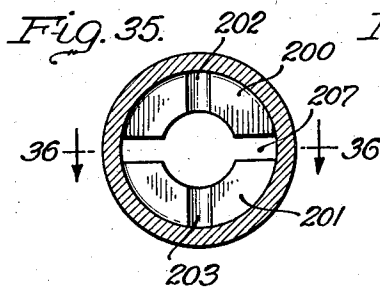
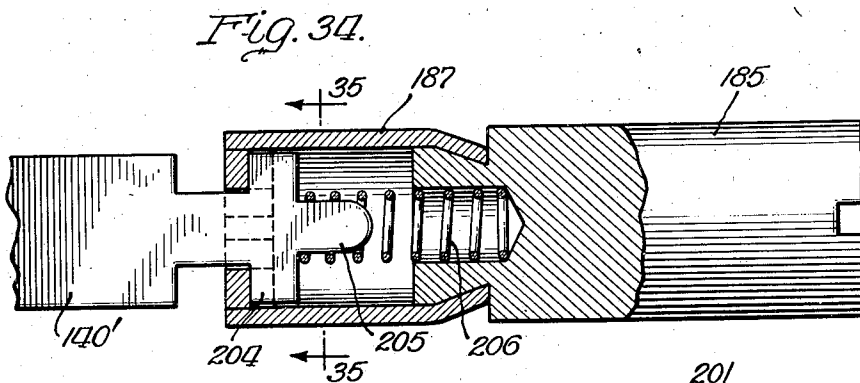
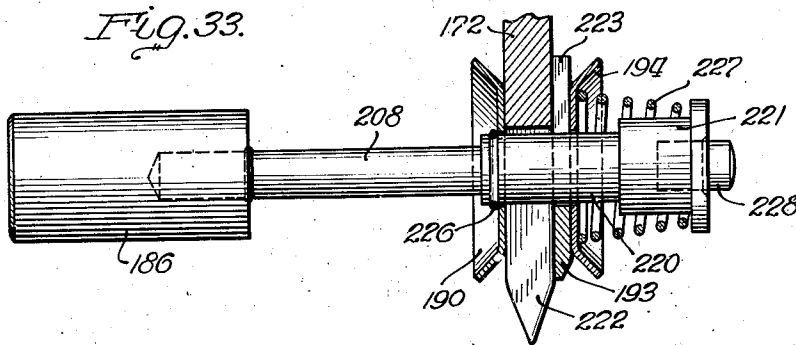
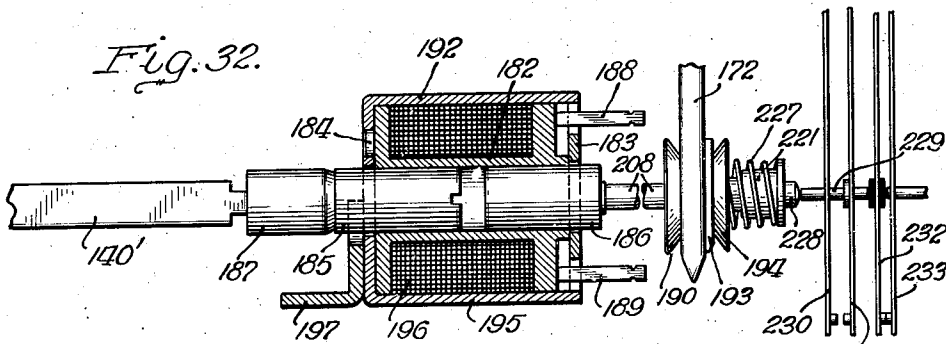
J. M. BLACKHALL

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INVENTOR.
James M. Blackhall
BY
Richardson and Quin
Attys.

March 5, 1946.

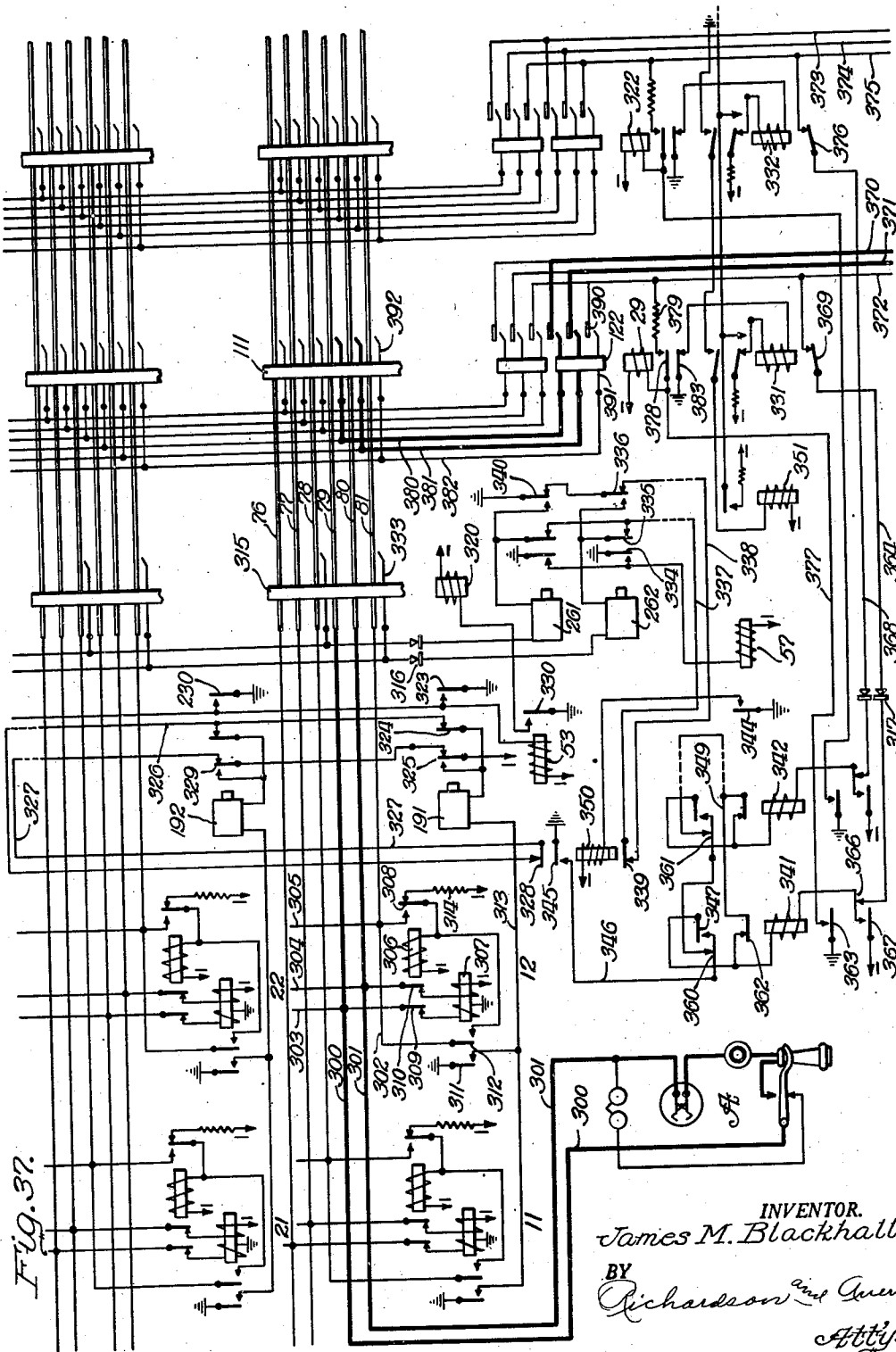
J. M. BLACKHALL

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INVENTOR.
James M. Blackhall
BY
Richardson and Green
Attys.

UNITED STATES PATENT OFFICE

2,396,077

AUTOMATIC TELEPHONE SYSTEM

James M. Blackhall, Genoa, Ill., assignor to Leich Electric Company, Genoa, Ill., a corporation of Illinois

Application September 29, 1943, Serial No. 504,246

70 Claims. (Cl. 179—22)

The present invention relates in general to automatic telephone systems and more in particular to new and improved switching apparatus and circuits for use in such systems.

As indicating generally the type of system and apparatus to which the invention relates, reference may be made to the U. S. patent to Boswau, No. 2,307,757, granted January 12, 1943. The invention may be considered as an improvement on and further development of the system and apparatus disclosed in the Boswau patent.

The switching apparatus disclosed in the Boswau patent is a special type of what is commonly referred to as cross-bar switching apparatus. The principal object of the invention is to produce a new and improved switching apparatus of this character. While retaining the essential advantages of this type of apparatus, a considerable number of improvements are incorporated which are valuable from the standpoint of manufacture and operation, and which increase the flexibility of this type of apparatus and facilitate the maintenance thereof.

The invention and various features thereof will be described more fully hereinafter with reference to the accompanying drawings, in which—

Fig. 1 is a diagrammatic representation of a complete cross-bar switching mechanism constructed in accordance with the invention, showing the principal parts of which the mechanism is composed;

Fig. 2 is a partial front view of the above, showing the No. 1 trunk unit and the selection control unit, the intervening trunk and test units being omitted;

Fig. 3 is a rear view of the same two units shown in Fig. 2;

Fig. 4 is a view of the No. 1 trunk unit, as seen from the left in Figs. 1 and 2;

Fig. 5 is a vertical section between the first and second trunk units, Fig. 1, showing the No. 1 trunk unit as seen from the right in Figs. 1 and 2;

Fig. 6 is a view of the selection control unit, as seen from the right in Fig. 1 or Fig. 2;

Fig. 7 shows a trunk unit frame and trunk operating magnet;

Fig. 8 is a top view of a trunk unit frame, with the operating magnet removed;

Fig. 9 shows the selection control unit frame, with the tens and units selector bar operating magnets and the tens solenoids;

Fig. 10 is a top view of the selection control unit frame, with the operating magnets and solenoids removed;

Fig. 11 is a plan or top view of the tens armature yoke;

Fig. 12 is a side view of the units armature yoke;

Fig. 13 is a partial plan view of the same;

Fig. 14 is a plan or top view of the units auxiliary armature yoke;

Fig. 15 is a side view of the same;

Fig. 16 is a partial side view of the tens armature yoke, with attached supporting plate;

Fig. 17 is a schematic view of a portion of the bank at the test unit and adjacent trunk unit, showing the terminal connections for the line bars;

Fig. 18 is a plan view of one of the line bar supporting plates;

Fig. 19 is a section on the line 19—19, Fig. 18;

Fig. 20 is a section on the line 20—20, Fig. 18;

Fig. 21 is a plan or top view of one of the intermediate trunk elements;

Fig. 22 is a section on the line 22—22, Fig. 21;

Fig. 23 is a section through a portion of the bank showing the arrangement for retaining an intermediate trunk element in assembled position on a line bar supporting plate;

Figs. 24 and 25 are side and edge views, respectively, of one of the tens actuator bars;

Fig. 26 is a front view of one of the units actuators and associated parts, including the spring clutch;

Fig. 27 is a section on the line 27—27, Fig. 26;

Fig. 28 is a section on the line 28—28, Fig. 26;

Fig. 29 shows the spring clutch and associated parts for operating a tens actuator bar;

Fig. 30 is a section on the line 30—30, Fig. 29;

Fig. 31 shows the spring clutch housing as seen from the left in Fig. 29;

Fig. 32 shows the magnetic clutch for operating one of the tens selector bars, being a section through the tens solenoid which is part of the clutch;

Fig. 33 is a section through the lower edge of the tens operating armature yoke, showing on a larger scale certain parts shown in Fig. 32;

Fig. 34 is a partial section showing the arrangement for coupling a tens selector bar to the associated core member of the magnetic clutch;

Figs. 35 and 36 are sectional views showing further details of the coupling arrangement; and

Fig. 37 is a diagrammatic circuit drawing, showing suitable circuits for the switching mechanism when used to perform the functions of finder switches in an automatic telephone system.

55 The switching apparatus or mechanism shown

in Fig. 1 comprises a base 11, on which there are supported a plurality of trunk units such as 12, a test unit 13, and a selection control unit 14. The test unit 13 and the selection control unit 14 are common to all the trunk units, of which there may be any desired number. Nine trunk units are shown in the drawings, numbered from 1 to 9, which is the full capacity of the base shown. The base need not be fully equipped, however, and a smaller number of trunk units could be supplied, say six or seven, the rest to be added as required. On the other hand, a longer base can be provided, having a capacity of fifteen or more trunk units in addition to the test and selection control units. It will be understood from the foregoing that the trunk units are individually removable and replaceable.

As shown in Fig. 1, the test unit 13 is located adjacent the selection control unit 14. The test unit may, however, be located at any point to the left of the selection control unit. It may, for example, be located at the extreme left of the switching mechanism in the position occupied by the No. 1 trunk unit.

The complete switching mechanism shown in Fig. 1 has a capacity of 100 lines and nine trunk lines, although the number of trunk lines in variable, as will be understood from the preceding paragraphs. As described herein the switching mechanism is arranged for use as a group of finder switches, for connecting calling subscribers' lines to idle trunk lines, but it may also be used to perform the functions of selector or connector switches.

There are 300 conductors in the form of bars extending lengthwise of the switching mechanism through the trunk units and the test unit. Since there are three bars per line, two line bars and a test bar, the 300 bars constitute 100 sets of bars and provide terminal facilities for 100 lines, as indicated above. When the switching mechanism is used to perform the functions of finder switches it handles the outgoing calls from a group of 100 subscribers' lines, which are connected to the line bars in the 100 sets of bars, respectively.

Each trunk unit is individual to an outgoing trunk line terminating therein and includes switching means for connecting any subscriber's line to such trunk line. For this purpose the subscribers' lines are divided into ten sub-groups of ten lines each; and each trunk unit is equipped with ten intermediate trunk lines, together with circuit closing means whereby the subscribers' lines of any sub-group may be connected to the intermediate trunk lines and whereby any intermediate trunk line may be connected to the outgoing trunk line terminating in such trunk unit.

For controlling the operation of the circuit closing means in the trunk units two sets of selector bars are provided. There are ten tens selector bars and ten units selector bars, all of which extend lengthwise of the switching mechanism and are common to all the trunk units. These selector bars are controlled and operated from the selection control unit at the end. The test unit cooperates in the control of the units selector bars.

It will be understood, of course, that in the case of a small exchange having less than 100 lines, the switching mechanism need not be fully equipped. In a 60-line exchange, for example, the switching mechanism requires only sixty sets of bars, or 180 bars altogether. The subscribers' lines may be divided into six sub-groups of ten

lines each, or ten sub-groups of six lines each. The physical grouping of the sets of bars corresponds to the grouping of the lines, and the selector bars and associated equipment corresponding to unused tens and units digits may be omitted. Thus, if there are only six sub-groups only six tens selector bars are required, whereas if there are only six lines per sub-group only six units selector bars are required. The latter arrangement is generally to be preferred since it requires only six intermediate trunks instead of ten.

The foregoing will be sufficient to give a general idea of the construction of the switching mechanism and the functions which it is adapted to perform. Further details will be supplied hereinafter.

The first or No. 1 trunk unit shown in Fig. 1 will now be described. The various parts of the trunk unit are mounted on a frame the shape of which will be understood from Figs. 2 to 5, inclusive, with the aid of Figs. 7 and 8, the latter drawings showing two views of the bare frame before any of the parts except the trunk operating magnet have been assembled thereon. The frame is preferably cast from an aluminum alloy, and is in three parts, consisting of the frame proper and two extensions at the top for supporting the trunk operating magnet. The frame proper comprises the two vertical side members 20 and 21 and the horizontal members 23 and 22 which connect the side members together at the top and bottom, respectively. The horizontal member 22 at the bottom is in alignment with the vertical side members 20 and 21, as can be seen in Fig. 8. This figure and Figs. 2 and 3 show the two foot members 24 and 25 which rest on the base 11. The horizontal member 23 is located between the ends of projecting portions of the frame which extend to the right in Fig. 2 and can be seen in Fig. 5.

The frame extensions referred to are indicated by reference numerals 26 and 27, and are received in recesses at the top of the frame proper where they are held by screws as indicated. The trunk operating magnet comprises the core 28, the coil or winding 29 and the two pole pieces 30 and 31, and is supported on the extensions 26 and 27 as shown. The two pole pieces may have holes drilled therein to receive the core, on which they are held by a press fit. The screws 32 and 33 pass through the extensions 26 and 27, respectively, and are threaded into the ends of the core 28. The smaller screws 34 and 35 are threaded into the pole pieces and assist in holding the magnet in position. The magnet assembly, including the two frame extensions, is removable as a unit for repair or to give access to parts beneath.

The frames of all the trunk units are alike. The frame of the test unit is the same as the trunk unit frames.

The selection control unit frame can be seen in Figs. 2, 3 and 6, and also in Figs. 9 and 10. Like the trunk unit frame the control unit frame consists of a frame proper and two extensions on which the operating magnets are mounted. The frame proper includes the two vertical members 40 and 41, which are located at the left as the frame is seen in Fig. 2. At the bottom these vertical members are connected by the horizontal member 42. Projecting to the right from the lower ends of the vertical members 40 and 41 are the foot members 43 and 44, which rest on the base 11. At the top there are corresponding

projecting members 45 and 46. The foot member 44 and the projecting member 46 in vertical alignment therewith, which can be seen clearly in the rear view, Fig. 3, are somewhat longer than the corresponding parts 43 and 45, Fig. 2, and are provided at the ends with rounded offset portions 47 and 48 for receiving the pivot screws for the units auxiliary armature yoke, as will be explained subsequently. The projecting members 45 and 46 are connected by a horizontal shelf 49, on which the tens solenoids are mounted. Extending between the projecting member 45 and the foot member 43 there is a web 50 on which the units solenoids are mounted.

The extensions 51 and 52 are clearly shown in the several figures and will require no detailed description. They are secured to the frame by screws, as indicated, lapped joints being used which are similar to the joints used at the trunk unit frames. At the top the extensions 51 and 52 support the tens operating magnet comprising the core 54, the winding 53 and the two pole pieces 55 and 56. Below the tens operating magnet is the units operating magnet comprising the core 58, the winding 57, and the two pole pieces 59 and 60. These magnets are mounted the same as the trunk operating magnet previously described. It will be clear also that the assembled extensions and magnets constitute a unit which can be removed from the frame for repairs or any other purpose.

The trunk unit frames, test unit frame and the selection control unit frame are supported close together on the base 11, as indicated in Fig. 1, the space allotted to each frame being determined by the length of the foot members such as 24 and 25 of the No. 1 trunk unit. Referring to Fig. 2, for example, it will be understood that in practice the No. 2 trunk unit is mounted just to the right of the No. 1 trunk unit shown, with the back of the frame of the No. 2 unit in contact with the ends of the foot members 24 and 25 of the No. 1 unit frame. The extensions such as 27 of the frames are also in contact and are held together by a link 61, similar links being used between each two adjacent frames. The frames of all the units are attached to the base 11 by means of screws, as shown clearly in the several figures of the drawings 2 to 6, inclusive.

It will be convenient now to explain the construction of the bank comprising the line and test bars, intermediate trunk elements, and outgoing trunk elements, these parts constituting the circuit-closing means for connecting calling subscribers' lines with outgoing trunk lines.

As mentioned previously, there are 100 sets of bars, each set comprising two line bars and a test bar, or 300 bars in all. There could, of course, be four or five conductors per line, but three is the usual number and is sufficient to carry out the ordinary functions of an automatic telephone system.

Each line or test bar is a continuous metallic strip about one-eighth of an inch in width and long enough to extend through all the trunk units and the test unit. The length will accordingly vary with the trunk capacity of the switch mechanism. The bars or strips may be made of any suitable material, but preferably are of stainless steel.

The line and test bars are supported at the No. 1 trunk unit by means of plates of insulating material one of which is shown in Figs. 18, 19 and 20, where it is indicated by the reference numeral 61. The plate 61 is preferably molded of a suit-

able plastic such as polystyrene, and its length is equal to the width of the trunk unit frame. Countersunk holes 62 at one end and 63 at the other end are provided for screws by means of which it is attached to the vertical side members of the frame. The plate 61 is also provided with six rows of tapered rectangular openings such as 64, there being ten such openings in each row. These openings are for receiving the line and test bars. Beneath each row of openings 64 there is a groove 65. The tapered shape of the openings 64 will be clear from Fig. 20, also Figs. 4 and 5.

Five plates such as 61 are required, since there are 300 line and test bars and each plate accommodates 60 bars. The plate 61 is the top plate and is attached to the vertical side members 20 and 21 of the trunk unit frame by means of four screws 67 which pass through the countersunk holes 62 and 63 in the plate and are threaded in tapped holes such as 66 in the said side members. Two of these screws 67 which pass through holes 63 at the right hand end of plate 61 appear in Fig. 5, but the two screws at the other end of the plate are obscured by other parts. It will be noted that plate 61 is assembled to the frame with the grooved side to the right and with the large ends of the tapered openings to the left, as the trunk unit is seen in Fig. 2. This is apparent from Figs. 4 and 5 which show the trunk unit as seen from the left and right, respectively.

The other four plates are assembled on the frame below plate 61, as will be understood from Figs. 4 and 5. Only two complete plates are shown and parts of two other plates, but it will be understood that there are five plates altogether, as is required to take care of the 300 bars.

As seen clearly in Fig. 4, for example, the holes 64 in the five assembled plates such as 61 are arranged in horizontal and vertical rows, there being 10 holes in each horizontal row and 30 holes in each vertical row. The total number of holes in the five plates is 300.

Each of the No. 2, No. 3, etc., trunk units is provided with five line and test bar supporting plates such as plate 61, the same as the No. 1 trunk unit. The same is true of the test unit. The 300 holes in the plates at the several units are in horizontal and vertical alignment.

Five plates such as 61 are also carried on the frame of the selection control unit, as can be seen from Figs. 2 and 3, where the top plate is indicated at 61'. At the selection control unit the plates carry the terminals for the line and test bars. The construction of the terminals is shown clearly in Fig. 17. The upper terminal, for example, comprises two flexible metal strips 69 and 70, having curved jaws 71 and 72 formed as shown. The flat parts of the two strips 69 and 70 may be spot-welded together. The lower strip 70 has a tab 73 struck out from the central part of the strip and bent down as shown. The terminal is inserted in the tapered hole in plate 61' from the right, the tab 73 bending up until it has passed through the hole, when it snaps down and locks the terminal in the hole. The curved jaws 71 and 72 are tensioned towards each other so that they effectively grip the end of the line bar 68.

It will be understood that there are 300 terminals carried on the five plates at the selection control unit. These terminals are in alignment with the 300 holes in the plates at the test unit

and with the corresponding holes in the plates at the trunk units.

The line and test bars are inserted in the switching mechanism from the left as seen in Figs. 1 and 2, or from the right as seen in Figs. 3 and 17. In the case of the line bar 68, for example, the end of the line bar is simply inserted in the upper left hand tapered hole 64 in plate 61, Fig. 4, and is pushed through this hole and the corresponding tapered holes in the plates at the other trunk units and the test unit successively until finally it enters between the curved jaws 71 and 72 of the corresponding terminal, as shown in Fig. 17. The other bars are inserted in the same manner. The bars can be just as readily withdrawn and since they are interchangeable they need not be replaced in the same positions. It will be seen that each bar is supported at each trunk unit and at the test unit.

The subscribers' lines may be connected to the line and test bar terminals by means of a 300-pair cable which is subdivided or formed at the end into 30 groups of conductors of 10 conductors each. The formed end of the cable is secured in a vertical position just outside the fanning strip 74, Fig. 3, and the 30 groups of conductors are passed through the 30 holes such as 75 in the fanning strip. The ten wires of each group are fanned out at the proper intervals for attachment to the ten terminals of the corresponding horizontal row. The arrangement follows the usual practice and will be readily understood.

The order in which the lines are connected to the terminals could logically be explained in connection with Fig. 6, but a considerable part of the terminals are covered up in this figure by other parts and accordingly Fig. 4 will be used for this purpose. Fig. 4 shows the ends of the line and test bars rather than the terminals, but the terminals merely serve to connect the lines to the bars and it is the connections of the lines to the bars that we are interested in.

The 100 lines served by the switching mechanism are divided into 10 sub-groups, the first sub-group comprising lines 11 to 10; the second sub-group comprising lines 21 to 20; the third sub-group comprising lines 31 to 30, etc. The lines of the first sub-group are connected (via the terminals at the selection control unit) to the bars in the first vertical row at the right, Fig. 4; the lines of the second sub-group are connected to the bars of the second vertical row; the lines of the third sub-group are connected to the bars of the third vertical row, etc. In each vertical row the numbering is from top to bottom. Thus line 11 is connected to bars 76, 77 and 78, the two line conductors being connected to bars 76 and 77 and the test conductor to bar 78. Line 12 is connected to bars 79, 80 and 81, bars 79 and 80 being the line bars, while bar 81 is the test bar. The remaining lines in the first sub-group are connected in order to the remaining sets of bars in the first vertical row of bars. The lines in the other sub-groups are connected according to the same plan. The foregoing describes the preferred arrangement, but other arrangements could be used.

The construction and arrangement of the intermediate trunks will next be explained. Each intermediate trunk consists of three separate and individually removable trunk elements, one trunk element for each conductor. One of these trunk elements is shown in Figs. 21 and 22. It comprises a metallic strip 82, preferably of phosphor

bronze, having 11 integrally formed contact fingers such as 83 along one edge. The other edge is embedded in a bar 86 of molded plastic material such as Bakelite or polystyrene. This bar also has partially embedded in it a metallic strip 87 which may be of aluminum or brass or any suitable material. The trunk contact 84 with the integrally formed trunk terminal 85 is secured to one end of bar 86 by means of rivets, as indicated. The trunk contact is directly above the last or eleventh contact finger on strip 82. All the intermediate trunk elements are the same as the one described, except that the trunk terminals are made in three different lengths for convenience in connecting the trunk terminals at each trunk unit in multiple.

The intermediate trunk elements are supported on the plates such as 61 which support the line and test bars. The trunk elements shown in Figs. 21 and 22, for example, assumed to be the upper trunk element in Fig. 5, is assembled to plate 61 with the exposed portion of strip 87 in groove 65, the strip 87 and groove 65 serving to properly locate the trunk element on the plate. The cooperation of these parts will be clear from Fig. 23, which shows the upper trunk element in assembled position on plate 61. There are 5 other trunk elements assembled on plate 61 in the same manner. The 6 trunk elements are held in position against plate 61 by the two spring clips 88 and 89. The spring clips 88 can be seen in Figs. 3, 5 and 23 and is secured to the vertical side member 20 of the trunk unit frame by screws 90 and 91 which are threaded into tapped holes 92 and 93, Fig. 7. The spring clip 88 has 6 rather stiff spring fingers which press the 6 intermediate trunk elements firmly against the plate 61. The spring clip 89 can be seen in Fig. 2 and is similar to spring clip 88.

Each of the other five plates such as 61 on the No. 1 trunk unit also carries six intermediate trunk elements. There are therefore 30 of these intermediate trunk elements on the No. 1 trunk unit, all supported on the plates such as 61 in the manner described.

The strips such as 82 of these trunk elements with their integrally formed contact fingers such as 83 are the conductors of the intermediate trunks. There are 30 such conductors, or 10 intermediate trunks, each having two line conductors and a test conductor. The first and second strips 82, counting from the top down in Fig. 5, are the line conductors of the first intermediate trunk and the third strip 82 is the test conductor. The next three strips are the conductors of the second intermediate trunk, the next three strips constitute the third intermediate trunk, and so on.

It will be observed that the ten intermediate trunks are arranged in intersecting relation to the ten sub-groups of lines. The contact fingers such as 83 on the strips such as 82 of the intermediate trunks are in the same vertical rows as the line and test bars of the sub-groups of lines, and each contact finger 83 is associated with a particular line or test bar. These contact fingers constitute the circuit closing means whereby the ten lines of any sub-group may be connected, respectively, to the ten intermediate trunks.

Each intermediate trunk may be regarded as terminating in the three contact fingers at the left, Fig. 5, which are associated with the trunk contacts. The first intermediate trunk, for instance, terminates in contact fingers 94, 95 and 96 which are associated, respectively, with trunk contacts 84, 87 and 98. These trunk contacts have

integrally formed trunk terminals 85, 100 and 101, respectively, which are connected in multiple with the corresponding trunk terminals of the other nine intermediate trunks. The conductors of the outgoing trunk line which is individual to the No. 1 trunk unit may be connected to the trunk terminals associated with the last intermediate trunk, or at any other point on the multiple. It will be understood from the foregoing that the contact fingers such as 94, 95, 96, etc., in which the intermediate trunks terminate, constitute the circuit-closing means whereby any intermediate trunk may be connected to the outgoing trunk line.

The multiple connections between the trunk terminals are not shown in Fig. 5 but may be made with bare wire in known manner. The connections are shown in the circuit drawing, Fig. 37.

The arrangement of the intermediate trunks and trunk terminals at each of the other trunk units is the same as described for the No. 1 trunk unit.

The arrangement at the test unit is somewhat different, in that only the trunk elements associated with the test bars are furnished, as indicated in Fig. 17. Furthermore, at each trunk element the eleventh contact finger, or the contact finger associated with the trunk contact, is bent up and permanently soldered to the trunk contact. The ten trunk terminals are not multiplied together, but are included in individual test circuits, as will be explained in connection with the circuit drawing, Fig. 37. It will be understood, of course, that in the case of the test unit no trunks are involved but the same parts are used as in the trunk units and the same nomenclature has accordingly been used in referring to these parts.

The operating mechanism at the No. 1 trunk unit will next be described. This mechanism comprises an operating magnet, ten so-called tens actuators, each adapted to connect a sub-group of ten lines to the ten intermediate trunks, and ten units actuators, each adapted to connect an intermediate trunk to the outgoing trunk line. The connections are established by selectively operating the contact fingers of the intermediate trunks.

The trunk operating magnet comprising winding 29, core 28, and pole pieces 30 and 31 has already been described with reference to Fig. 7. The magnet armature is indicated at 102 and is carried on a pivoted yoke which comprises a horizontal member 103 and has two integrally formed downwardly sloping members 104 and 105, having ears 106 and 107, respectively. The pivots for the armature yoke are the shoulder screws 108 and 109 which pass through slots in the frame extensions 26 and 27, respectively, and are threaded into tapped holes in the ears 106 and 107, respectively. The two pivot screws have round heads which rotate in circular recesses in the frame extensions.

The horizontal member 103 of the operating magnet armature yoke carries ten lifting pins such as 110 for operating the tens actuators. The lifting pins are rigidly secured to the armature yoke, having a drive fit in holes in the horizontal member 103. The horizontal member 103 also has an integrally formed extension comprising a downwardly extending member 120 and a slotted horizontal member 121 for operating the lifting rod for the units actuators.

One of the tens actuators is shown in Figs. 24 and 25. It comprises a metallic bar 111 of rec-

tangular cross-section, and five molded members such as 112, each having six projecting pins such as 113. The molded members 112 are slotted along one edge to receive the bar 111 to which they are secured by rivets such as 114. The pins 113 are equally spaced and the spacing is the same as the vertical spacing of the contact fingers of the intermediate trunks. At the top the tens actuator bar 111 carries a molded clutch housing 115, as can be seen in Fig. 5. The clutch housing may be molded on the bar 111, to which it is rigidly attached.

The tens actuator bar 111 is held in position at the top by the lifting pin 110 which passes down into the clutch housing 115. At the bottom the bar is vertically slidable in a rectangular opening in the plate 116 which is closed by a plate 117 secured to plate 116 in suitable manner as by spot welding. The plate 116 is supported in slots which are formed in the foot members 24 and 25 of the trunk unit frame and is retained in the slots by set screws 118 and 119. The bottom of bar 111 rests on plate 117 which supports the weight of the complete tens actuator including the clutch housing 115.

It will be seen from Fig. 5 that the thirty contact fingers which serve to connect the ten intermediate trunks to the ten lines of the first sub-group rest on the thirty pins such as 113 of the tens actuator 111. It will be clear, therefore, that a longitudinal movement of the tens actuator in an upward direction will be effective to connect the ten lines of the sub-group to the ten intermediate trunks, respectively, by moving the contact fingers into engagement with the associated line and test bars.

It will also be seen from Fig. 5 that the No. 1 trunk unit is provided with ten tens actuators altogether, or nine in addition to the one which has been described. These tens actuators are all the same and are associated, respectively, with the ten sub-groups of lines.

The remaining trunk units are equipped with tens actuators like the No. 1 trunk unit. The same is true of the test unit. Although in the test unit connections are made only to the test bars, the same type of tens actuator may be used.

One of the units actuators is indicated at 122 in Figs. 2 and 5 and is shown in detail in Figs. 26, 27 and 28. It may be molded of a suitable plastic material and comprises a clutch housing 122 having an extension 123 which carries three actuator pins 124, 125 and 126. The clutch housing part of the units actuator has a longitudinal bore for receiving the units actuator lifting rod 127, and contains a spring clutch which will be described presently.

The units actuator 122, as well as nine similar units actuators in the No. 1 trunk unit, is supported by means of a units actuator guide of angular cross-section comprising the members 128 and 129 formed from one piece of material and extending vertically from the top to the bottom of the trunk unit frame. The guide is attached to the frame at the top by means of a screw 130, as seen in Figs. 2 and 5. The said screw also supports one end of the tens selector rod guide 134, to be presently described. It passes through a hole in member 129 of the units actuator guide and a hole in the selector rod guide, and is threaded into a tapped hole in the frame. At the bottom the member 129 of the units actuator guide is provided with an offset portion 132 having an ear 133 which rests against the side of foot member

25 of the frame to which it is secured by means of a screw 131.

The member 128 of the units actuator guide is provided with ten slots such as 135, Fig. 27, for receiving the extensions 123 of the ten units actuators. In the case of the units actuator 122, for example, it will be seen that the housing 122 is on one side of the slotted member 128, while the pins such as 124 are on the other side, the extension 123 lying in the slot 135. The actuator is supported by engagement of the extension 123 with the bottom of the slot 135. This slot is somewhat longer than the extension 123 of the actuator, which permits an upward movement of the actuator.

The units actuators are retained in position by means of the lifting rod 127, which passes vertically through all the units actuators, as seen clearly in Figs. 2 and 5. The lifting rod 127 is longitudinally slidable in bearings in the extension 27 of the frame and in the foot member 25 of the frame. In this movement of the lifting rod it slides freely in the units actuators, except for a particular units actuator where the clutch has been operated, as will presently be explained.

The means for raising the lifting rod 127 comprises the extension 120 of the operating magnet armature yoke, already mentioned, together with certain other parts which may now be described. The extension 120 carries a horizontal part 121 which is slotted at the rear to receive the lifting rod 127. The lifting rod is moved longitudinally upward by means of a washer 136 which rests on top of the slotted member 121 and is prevented from sliding upward on the lifting rod by a pin 137. A little higher up on the lifting rod a similar pin and washer are provided. The spring 138, compressed between the last mentioned washer and the extension 27, is the restoring spring for the lifting rod.

The upward movement of lifting rod 127 is effective to operate the contact springs 378 and 383, which with their associated contact springs are suitably mounted at the top of extensions 26 and 27.

It will be understood now that the ten units actuators are individual, respectively, to the ten intermediate trunks and that each units actuator is adapted to connect its associated intermediate trunk to the outgoing trunk for the No. 1 trunk unit. In the case of the units actuator 122, for example, which is the second units actuator from the top, Fig. 5, the pins 124, 125 and 126 support the eleventh or terminal contact fingers of the second intermediate trunk and are adapted to move said contact fingers into engagement with the associated trunk contacts when the units actuator is moved upward by the lifting rod 127.

Each of the other trunk units is provided with ten units actuators, the same as the No. 1 trunk unit being described. The test unit, however, has no units actuators. As previously explained, the eleventh contact finger of each trunk element in the test unit is permanently soldered to the associated trunk contact, so-called, and consequently no units actuators are required.

From the description up to this point it will be understood that the No. 1 trunk unit, which is representative of the other trunk units and of the test unit with the exceptions noted, is provided with an operating magnet 29 the energization of which is effective through the medium of the armature 102 and armature yoke 103 to produce a longitudinal upward movement of the ten lifting pins such as 110 which are associated with

the tens actuators and a similar upward movement of the lifting rod 127 associated with the units actuators. The lifting pins such as 110 move freely in the clutch housings such as 115, leaving the associated tens actuators unoperated, except for one particular tens actuator where the spring clutch in the associated clutch housing has been operated. This particular tens actuator, and it may be any one of the ten, is temporarily coupled to the associated lifting pin by the spring clutch and is moved longitudinally upward by the lifting pin. Likewise the lifting rod 127 moves freely upward through all the units actuators except in the case of one particular units actuator where the spring clutch has been operated.

Thus it will be seen that the operation of the trunk magnet is effective to operate one tens actuator and one units actuator. The actuators are operated by means of the associated spring clutches whereby they are coupled one to a lifting pin such as 110 and the other to the lifting rod 127. These spring clutches will be described, but first it will be desirable to describe the selecting bars by means of which the spring clutches are selectively operated.

There are ten tens selecting bars and ten units selecting bars. The tens selecting bars extend through and are common to all the trunk units and the test unit. The units selecting bars also are common to all the trunk units. They extend through or rather past the test unit but perform no function at the test unit.

One of the tens selecting bars is indicated at 140, Figs. 2 and 5, and is also partially shown in Figs. 29 and 30. It is a metal bar, of rectangular cross-section, the length of which depends on the trunk capacity of the switching mechanism. The bar 140 is provided with a plurality of rectangular openings such as 141, one at each trunk unit and one at the test unit. The other nine tens selecting bars are the same as bar 140. While the ten tens selecting bars are all alike where they pass through the trunk units and the test unit, as stated, there is a difference in the length of the bar sections extending between the test unit and the selection control unit, which makes five of the bars somewhat longer than the other five. This is due to the staggered mounting of the magnetic clutches which couple the tens selector bars to the armature yoke of the common operating magnet, as will appear hereinafter.

The tens selector bars are supported at each trunk unit and at the test unit by means of a tens selector bar guide. In the case of the No. 1 trunk unit the tens selector bar guide is indicated at 134, Figs. 2 and 5. At one end the guide 134 is secured to the trunk unit frame by the same screw 130 that holds the upper end of the units actuator guide, as previously mentioned. At the other end the guide 134 is secured to the trunk unit frame by means of a screw 142. The guide 134 may be made of suitable plastic material molded or cut in the desired shape, as shown, and is provided with ten tapered openings such as 143 for receiving the ten tens selector bars. The selector bars are freely slidable in these openings.

One of the units selector bars is indicated at 144, Figs. 2 and 5, and is also partially shown in Figs. 26, 27 and 28. The selector bar 144 is a metal bar of rectangular cross-section, and is generally similar to the tens selector bars. It has a plurality of rectangular openings such as 145, one at each trunk unit. The other nine units selector bars are the same as selector bar 144.

The units selector bars are supported at each

trunk unit by means of a units selector bar guide. In the case of the No. 1 trunk unit the units selector bar guide is indicated at 146, Figs. 2 and 5. The guide 146 may be of molded plastic material, like the tens selector bar guide 134, and is secured to the member 129 of the units actuator guide by means of countersunk screws, as indicated in Fig. 28. The guide 146 is provided with ten tapered openings such as 147 for receiving the units selector bars. The units selector bars are not necessarily supported at the test unit, but a units actuator guide and selector rod guide may be supplied at this unit if desired.

It will be convenient now to describe the spring clutches hereinbefore referred to as being provided for coupling the units actuators to the lifting rod 127 and for coupling the tens actuators to the associated lifting pins such as 110.

One of the units actuators with its spring clutch is shown complete in Figs. 26, 27 and 28. The units actuator has already been described. The spring clutch comprises a spring having a plurality of coils 150 which are located in a recess 151 in the clutch housing 122 of the units actuator and surround the lifting rod 127. At the lower end the spring has a straight section 152, Fig. 28, bearing against the inside of the clutch housing, and a straight section 153, bent at right angles to section 152, which extends across the opening in the clutch housing and bears against the edge 154 thereof. The straight sections 152 and 153 serve to anchor the spring and prevent rotation of the lower end thereof relative to the clutch housing in either direction. The last coil of the spring at the top terminates in a straight section 155 which extends outside the clutch housing through a slot 156. The section 155 of the spring is long enough so that it extends a short distance through the opening 145 in the units selector bar 144, as shown in Fig. 28. When the selector bar is unoperated or in normal position, the spring section 155 stands in its dotted line position, Fig. 28. When the selector bar is operated, or moved to the right in the direction of the arrow, the spring section 155 is moved to the position in which it is shown in full lines. This operation tightens the coils of the spring around the lifting rod 127. It may be mentioned that the selector bar 144 is shown in operated position in all three of Figs. 26, 27 and 28.

The member 129 of the units actuator guide is provided with a plurality of integrally formed clutch locking cams, one for each of the units actuators. The clutch locking cam associated with the units actuator 122 is indicated at 157, Fig. 2, and is also shown in Figs. 26, 27 and 28. The cam 157 extends to the right from member 129, as seen in Figs. 26 and 28 and its extremity is approximately in line with section 155 of the clutch spring when the latter is in operated position. The location of the cam 157 vertically is such that its lower edge is just above and in light contact with the spring section 155 when the latter is in its normal or unoperated position, as shown by dotted lines in Fig. 28. The described relation between the cam 157 and spring section 155 will be clear from the drawings.

When the spring clutch is not operated, that is, when the spring section 155 is in its dotted line position, the coils 150 fit loosely around the lifting rod 127, which is freely slidable through the said coils. It will be understood, therefore, that if the lifting rod 127 is moved longitudinally upward by the operation of the trunk operating magnet 29 at a time when the selector bar 144

is in normal position the units actuator 122 will not be affected. It should be noted furthermore that since in the normal position of the selector bar 144 the spring section 155 is directly beneath the locking cam 157, the said spring section and cam will positively prevent any upward movement of the units actuator which might otherwise occur due to friction between the lifting rod and the clutch housing or between the lifting rod and the coils 150 of the clutch spring.

If the lifting rod 127 is moved longitudinally upward at a time when the selector bar 144 is in operated position, as shown in Fig. 26, for example, the coils 150 of the clutch spring will have been tightened on the lifting rod, as previously described. The said coils will grip the lifting rod, and the units actuator will move upward therewith. During this movement of the units actuator the spring section 155 slides upward in the rectangular opening 145 in the selector bar 144 to a position near the upper left hand corner of this opening, as seen in Fig. 26. The width of the opening 145 should be somewhat greater than the distance through which the units actuator moves. As regards the adjustment of the selector bar, Fig. 26 shows that when the selector bar is in operated position the rear end of opening 145 is exactly in line with the end of locking cam 157. The adjustment is not critical, however. The selector bar may move somewhat farther to the right, in which case the spring section 155 will merely bend a little after the coils 150 are fully tightened on the lifting rod. Or the selector bar may not fully reach the position in which it is shown in Fig. 26, in which case the spring section 155 will slide upward along the end of cam 157 during the upward movement of the units actuator. The lower corner of the cam is rounded off to facilitate this action. In any event after the upward movement of the units actuator has taken place the spring section 155 will be a substantial distance above the lower edge of cam 157 and when the selector bar 144 is released the spring section 155 is prevented from restoring, due to its engagement with the end of the cam. Thus the cam 157 locks the spring clutch in operated position and holds it operated after the selector bar has restored to normal position.

The units actuator remains operated as long as the lifting rod 127 is held operated by the trunk operating magnet. When the magnet is deenergized the lifting rod is restored by spring 138 and the units actuator moves downward along with the lifting rod. During this movement the spring section 155 slides along the end of the locking cam 157 until, as the units actuator becomes fully restored, the spring section 155 clears the end of the cam and the spring clutch is released.

The remaining nine units actuators on the No. 1 trunk unit with their spring clutches are constructed the same and operate the same as the units actuator 122 just described, except that the spring clutches are operated by different selector bars. There are ten units selector bars, as previously mentioned, which operate the spring clutches in the ten units actuators, respectively, at the No. 1 trunk unit. These selector bars, moreover, are common to all the trunk units and when any selector bar is operated to operate the spring clutch in the associated units actuator at the No. 1 trunk unit it simultaneously operates the spring clutches in the corresponding units actuators at all the other trunk units.

The units selector bars such as 144 are restored partly by the clutch springs in the units actuators at idle trunk units and partly by restoring springs such as spring 210, Fig. 2. The number of idle trunk units is variable and may equal zero, which makes it undesirable to rely entirely on the clutch springs for restoring the selector bars.

The normal position of the units selector bars is determined by a stop plate 211, which is secured to the frame of the No. 1 trunk unit by means of screws 212 and 213, being spaced away from the frame by tubular spacers 214 and 215. The arrangement may be explained in more detail by reference to selector bar 144, which has an end portion 216 of reduced width which extends through a slot in the stop plate 211. The spring 210 has one end secured to the end of 216, the other end bearing against the stop plate, and tends to move the selector bar to the left. Such movement is arrested by the engagement of the shoulders on the selector bar, formed at the junction of the selector bar 144 and its reduced end portion 216, with the side of the stop plate. The arrangement for restoring each of the other units selector bars is the same as described for selector bar 144.

The adjustment of the parts is such that when any units selector bar is in normal position the clutch springs at the associated idle units actuators are under a certain amount of tension. In other words, the clutches are partially operated, not enough to cause them to grip the lifting rod but enough so that most of the lost motion is eliminated. This adjustment provides for a minimum movement of the selector bars in operating the spring clutches.

Figs. 29, 30 and 31 show the details of one of the spring clutches for coupling a tens actuator to its associated lifting pin, being the particular clutch which is associated with the tens actuator 111 and lifting pin 110. The clutch housing 115 secured to the top of the tens actuator has a central bore 160 for receiving the lifting pin 110 which has a loose fit in the bore 160. This is necessary because the lifting pin does not move exactly in a straight line. The clutch spring includes a plurality of coils 161 which surround the lifting pin 110 and are located in the recess 162 in the clutch housing. This recess can be seen in Fig. 31 which shows the clutch housing as seen from the left in Fig. 29. The recess extends through the wall of the housing on one side thereof, as shown in Fig. 30, whereby the spring may be inserted in the housing. The lower coil of the spring is anchored in the housing by the straight sections 162 and 163, as described in connection with the spring clutch in the units actuator 122. The upper coil of the spring terminates in a straight section 164, which extends through the slot 165 to the outside of the housing 115, where it passes through the opening 141 in the tens selector bar 140.

The tens locking plate is a metal stamping of angular cross-section and comprises a member 166 secured to the back of the tens selector bar guide 134 by means of countersunk screws such as 169, Fig. 4, and an integrally formed member 167 which extends forward over the top of guide 134. The member 167 is provided with ten integrally formed locking cams such as 168. The arrangement will be clear from Figs. 5 and 29.

The spring clutches for the tens actuators are operated by the tens selector bars, similar to the manner in which the spring clutches for the units

actuators are operated by the units selector bars. In Figs. 29 and 30 the tens selector bar 140 is shown in normal position. With the selector bar in this position the spring section 164 lies just beneath the locking cam 168 and the coils 161 of the clutch spring are loose on the lifting pin 110. It follows, therefore, that if the lifting pin 110 is raised by energization of the trunk operating magnet while these conditions obtain, the lifting pin will move freely upward through the coils of the spring clutch and the tens actuator will not be moved. It will be noted also that upward movement of the tens actuator is positively prevented by the engagement of spring section 164 with the end of cam 168.

When the tens selector bar 140 is operated it moves to the right as seen in Figs. 29 and 30. This movement of the selector bar moves the spring section 164 to its dotted line position, Fig. 30, where it clears the cam 168. Also the coils 161 are tightened around the lifting pin 110. Under these conditions, if the lifting pin 110 is raised by the energization of the trunk operating magnet the spring clutch will grip the lifting pin and the clutch housing 115 and tens actuator 111 will be carried along. During the upward movement of the clutch housing the spring section 164 moves upward in the opening 141 in the tens selector bar 140 and along the side of the locking cam 168, being in sliding engagement with the rear end of said opening, or the side of the cam, or both, depending on the adjustment of the selector bar. When the selector bar 140 is released and restored to normal position the spring clutch is maintained operated by the locking cam 168 and the tens actuator is maintained in operated position. When the truck-operating magnet is deenergized the lifting pin 110, clutch housing 115 and the tens actuator 111 move downward to normal position, the spring section 164 of the clutch spring sliding along the side of cam 168. In the normal position of the clutch housing the spring section 164 clears the end of cam 168 and it restores to the position in which it is shown in Fig. 30, which releases the spring clutch.

The ten spring clutches associated with the ten tens actuators at the No. 1 trunk unit are operated by the ten tens selector bars, respectively, in the manner described. Each tens selector bar is common to all the trunk units and the test unit, and accordingly when any selector bar operates the spring clutch of the associated tens actuator at the No. 1 trunk unit it simultaneously operates the spring clutches of the corresponding tens actuators at all the other trunk units and at the test unit.

The tens selector bars are restored by the clutch springs of the spring clutches associated with the tens actuators and by restoring springs such as 217. A stop plate 218 determines the normal position of the bars. The arrangement is similar to the arrangement for the units selector bars and need not be further explained.

The selection control unit will now be described. The function of the selector control unit is to selectively operate the tens and units selector bars.

The tens operating magnet 53 has already been described briefly in connection with Fig. 9. This magnet has an armature 170 supported on an armature yoke comprising a member 171 beneath the armature, a member 172 extending parallel thereto, and two integrally formed connecting members 173 and 174, which have a right angle bend formed therein a short distance from the

armature 170, as seen in Figs. 2 and 3. The armature yoke is also seen in Fig. 11, which shows a top view of the same. The armature yoke is supported on the extensions 51 and 52 of the selection control unit frame by means of pivot screws 178 and 179, which are threaded into tapped holes in said extensions and have pivots formed at their ends which enter holes in the ears 175 and 176 with which the armature yoke is provided. The extension 177 of the armature yoke is provided for the purpose of operating the contact spring 330. When the operating magnet 53 is energized the armature and armature yoke assembly rotates on the pivot screws 178 and 179, the armature 170 moving downward into engagement with pole pieces 55 and 56 and the member 172 of the armature moving to the right, as the parts are seen in Fig. 2. The armature and armature yoke assembly restores by gravity, when the magnet is deenergized, to a normal position which is determined by the stop screw 180.

The reference character 181 indicates a plate of any suitable material such as aluminum, which is attached to the members 173 and 174 of the armature yoke by means of four screws, as shown. On the plate 181 there are mounted ten sets of contact springs, as appears clearly in Fig. 6. The first set of contact springs can be seen also in Fig. 2, and the last set in Fig. 3.

The armature yoke of the tens operating magnet selectively operates the ten tens selector bars by means of ten magnetic clutches. These magnetic clutches not only have the function of coupling the selector bars to effect the operation thereof, but also have the function of operating the ten sets of contact springs carried on the armature yoke.

The magnetic clutches referred to above include the solenoids such as 191 and 192, which are the first and second solenoids and are associated with the first and second tens selector bars, respectively. The solenoid 191 is associated with the first selector bar 140, while the solenoid 192 is associated with the second selector bar 140'. The ten solenoids are mounted in two rows of five each on the shelf 49 of the selection control unit frame, as shown in Fig. 9.

The solenoid 192 and associated parts which form the complete magnetic clutch for coupling the tens selector bar 140' to the tens operating magnet armature yoke will now be described. This solenoid comprises a shell 195 of soft iron, Fig. 32, in which there is a spool 182 carrying the winding 196. The ends of the winding are connected to terminals 188 and 189 which are attached to one of the heads of spool 182. The other spool head has a projection 184 which fits in an opening in the bottom of the shell 195. This projection properly locates the spool in the shell and prevents it from rotating therein. The open end of the shell 195 is closed by an iron washer 183 which has notches in its edge for the terminals 188 and 189. This washer should have a press fit in the end of the shell. A bracket 197 is attached to the bottom of shell 195, by spot welding, for example, and is secured to the shelf 49 of the frame by means of two screws such as 198, Fig. 2. By this means the solenoid 192 is firmly secured to the shelf.

It will be understood that the four other solenoids which are in the same row with solenoid 192 are the same and are secured to the shelf 49 in the same manner, with the terminals such as 188 and 189 to the right, as seen in Figs. 2 and 32. The five solenoids such as 191 in the other row

are the same also, but are reversed so that the terminals such as 188' and 189' appear at the left of the selection control unit, as seen in Fig. 2. The mounting holes for the screws such as 198 and 198' of both rows of solenoids are shown in Fig. 10.

The complete clutch including the solenoid 192 also includes the two cores 185 and 186, Fig. 32, which are freely slidable in the bore of spool 182. It will be noted in this connection that the openings in the bottom of the shell 195 and in the washer 183 which are provided for the cores 185 and 186, respectively, are slightly larger than the bore of the spool, so that the cores are maintained out of contact with the shell and washer. These air gaps in the magnetic circuit should be small but are desirable to prevent the cores from sticking to the shell or washer when the solenoid is energized.

The core 185 is detachably secured to the tens selector bar 140' by an arrangement which will now be described, reference being made to Figs. 34, 35 and 36. As shown in these drawings, a tubular member 187 is provided, the end of which is partially closed by two semi-circular members 200 and 201. These members may be held inside the tubular member 187 by soldering or spot welding, for example. They are spaced apart to provide a slot 207, Fig. 35, and are provided with aligned grooves 202 and 203, respectively. The spring 206 projects from a recess in the end of the core 185. After the spring has been placed in position the assembled tubular member 187 is firmly secured to the core in any suitable manner, as by crimping the end of said tubular member into an annular groove near the end of the core. The selector bar 140' is notched near the end to form a T-shaped head 204 and also has an extension 205 for cooperation with the spring 206. To assemble the selector bar to the core the head 204 is passed into the slot 207, the extension 205 entering the coils at one end of spring 206. The selector bar and core are moved toward each other, compressing the spring 206 until the head 204 has passed through slot 207, whereupon the core is rotated 90 degrees and the head 204 is allowed to enter the grooves 202 and 203 where it is held by spring 206, as shown in Fig. 34.

All the selector bars, both tens selector bars and units selector bars, have similar detachable connections to their associated cores. These connections are provided to enable the selector bars to be removed from the switching mechanism, as will appear more fully hereinafter.

Referring now to Fig. 33, it will be seen that the core 186 has attached thereto a rod 208, which includes a section 220 of larger diameter, and a flanged head 221. The section 220 is located in an open slot 222 in the lower edge of the horizontal member 172 which forms part of the tens operating magnet armature yoke. In order to support the rod in slot 222, which is open at the bottom, a slotted plate 193 is provided, having slots such as 223 which are open at the top. The plate 193 is secured to the member 172 of the armature yoke by means of two screws 224 and 225. The details of this arrangement are shown in Fig. 16.

The left side of member 172 of the armature yoke bears against a cup washer 190, which is prevented from sliding on section 220 of rod 208 by means of a split ring 226. Another cup washer 194 bears against the plate 193. A coiled spring 227 is compressed between the washer 194 and the flange on the head 221 and maintains the parts

normally in the position in which they are shown. The rod 208 or rather section 220 thereof is slidable in the slots 222 and 223. The head 221 of rod 208 is provided with a bushing 228 of insulating material.

The above description of the magnetic clutch, including solenoid 192 and associated parts, applies also to the other four magnetic clutches the solenoids of which are located in the same row with solenoid 192. The other five magnetic clutches, including the magnetic clutch of which solenoid 191 forms a part, are the same also, except that since they are in a different row and are farther away from the member 172 on the rods corresponding to rod 208 are somewhat longer.

The ten sets of contact springs which are mounted on plate 181 carried by the tens operating magnet armature yoke are in alignment, respectively, with the ten rods such as 208 of the ten magnetic clutches for the tens selector bars, as will be understood from Fig. 6. More in particular, the parts are so related that the ten operating rods such as 229 for the ten sets of contact springs rest, respectively, against the ten bushings such as 228 in the heads such as 221 of rods 208. See Fig. 32.

As regards the adjustment of these sets of contact springs, this may be explained in connection with Fig. 32, although the set of contact springs associated with rod 208 is only partially shown. The working springs 231 and 232 are tensioned toward the left but are normally held in the position shown by the spring 227, which presses the rod 208 toward the right as far as it can go relative to the armature yoke member 172. The contact springs being mounted on the armature yoke, they are held in the position shown against their own tension, as stated.

The mechanics of the operation of one of the tens selector bars may now be explained. In the case of the selector bar 140', for example, this selector bar is selected for operation by the energization of the tens solenoid 192, as will be explained more in detail in connection with the circuit diagram, Fig. 37. Upon the energization of solenoid 192, the core 185 attached to selector rod 140' remains stationary, or substantially so, because movement of the selector bar 140' is opposed by the associated spring clutches of idle trunk units and by the associated restoring spring corresponding to spring 217. The restoring spring alone is strong enough to substantially prevent movement of the selector bar at this time. The core 186, however, is drawn into the solenoid 192 upon the energization thereof, until it engages core 185, thus closing the magnetic circuit except for the small air gaps at the points where the cores pass through the shell 195 and washer 183. The movement of core 186 and rod 208 attached thereto, which slides in slots 222 and 223, compresses the spring 227 and permits the working contact springs 231 and 232 to shift to their operated position in which contact spring 231 engages contact spring 230 while contact spring 232 separates from contact spring 233. Spring 227, it may be observed, is a somewhat lighter spring than the restoring spring associated with the selector bar and besides this the spring 227 is opposed by the working contact springs. Thus it will be seen that the energization of the solenoid results in the operation of core 186, which is brought into engagement with core 185 and in the operation of the working contact springs in the associated set of contact

springs. The adjustment of the parts is such that at the end of the movement of core 186 the head 221 of rod 208 is in engagement or nearly in engagement with the washer 194.

The contact 230—231 controls the tens operating magnet, which energizes upon the closure of the contact. The armature and armature yoke are accordingly operated as previously described, the member 172 of the armature yoke moving to the right as seen in Figs. 32 and 2. This movement of member 172 has no effect as regards any of the tens selector bars except the selector bar 140'. The magnetic clutches associated with the other selector bars are not energized and consequently the cores corresponding to core 186 are merely drawn to the right, the cores sliding freely in their associated solenoids. In the case of the selector bar 140', however, the associated solenoid 192 is energized and core 186 is magnetically coupled to core 185. When the member 172 moves to the right, therefore, the selector bar 140' is operated. More in detail, the washer 194 engages the head 221 of rod 208 and moves the rod to the right, carrying the attached core 186 along with it. Core 185, being now magnetically coupled to core 186, is moved also and operates the attached selector bar 140'. The movement of the cores 185 and 186 is unopposed magnetically since both cores extend outside the solenoid for a substantial distance and their movement does not alter the value of the flux in the magnetic circuit.

When the selector bar 140' has remained operated as long as required, the circuit of solenoid 192 is opened and the magnetic clutch becomes deenergized, permitting cores 185 and 186 to separate. The selector bar 140' is accordingly moved to the left by the restoring spring to normal position. At the same time the spring 227 moves the rod 208 to the right, restoring the associated set of contact springs to normal position. Contact 230—231 being thus opened, the tens operating magnet 53 is deenergized and the armature and armature yoke restore by gravity, as previously explained.

The units operating magnet, including the winding 57 and core 58, has already been described in connection with Fig. 9. The magnet is provided with an armature 240, carried on an armature yoke the details of which are shown in Figs. 12 and 13. The armature yoke comprises the two parallel members 241 and 242, which are connected by the integrally formed members 243 and 244, the latter members having a right angle bend, so that the yoke has generally the shape of an inverted letter L as viewed from the end. The armature yoke is pivoted on the pivot screws 245 and 246 which are threaded into tapped holes in the frame extensions 51 and 52 and have pivots formed at the ends which enter holes formed in ears 247 and 248 with which the armature yoke members 243 and 244 are provided. The member 242 of the armature yoke has an extension 249, which passes downward between the rod 208 associated with tens solenoid 192 and the adjacent rod to the left which is associated with solenoid 191. The member 241 of the armature yoke has an extension 250 for operating the contact spring 344.

The units auxiliary armature yoke is shown in detail in Figs. 14 and 15 and is a generally U-shaped structure comprising the horizontal members 251 and 252 which are connected at one end by the integrally formed vertical member 253. The members 251 and 252 have stiffening flanges 254 and 255, as shown. At the ends opposite the

member 253 the members 251 and 252 have ears 256 and 257, respectively, by means of which the auxiliary armature yoke is pivotally supported on the frame. To this end the pivot screws 258 and 259 are provided. These two screws are threaded in tapped holes in the offset members 47 and 48 of the frame and have pivots at the ends which pass through holes in the ears 256 and 257. The member 251 has a projection 260, which extends upward in Fig. 15 and to the left in Fig. 2, and which is so located that it is engaged by the depending extension 249, as seen clearly in Fig. 2.

The auxiliary armature yoke is urged to the left, as seen in Fig. 2, by a coil spring 281, shown partly in dotted lines, which extends between the horizontal member 42 of the frame and the flange 255. The normal position of the auxiliary armature yoke is determined by the stop screw 282, which is threaded into a tapped hole in the edge of the shelf 49 on which the solenoids such as 191 and 192 are mounted. The stop screw is in alignment with the extension 249, which is normally held against the head of the stop screw by the projection 260 on the member 251 of the auxiliary armature yoke.

The auxiliary armature yoke carries a plate 274, which is attached to the member 251 and 252 by means of screws, as shown in Fig. 6. On the plate 274 there are mounted ten sets of contact springs such as the set 275.

The units selector bars are selectively operated by means of magnetic clutches through the medium of which any units selector bar may be temporarily coupled to the member 253 of the auxiliary armature yoke. There are ten of these magnetic clutches, one for each of the ten units selector bars, and they include ten units solenoids which are mounted on the web 50 of the frame, as shown in Fig. 2. Only six of these units solenoids are actually shown, but it will be understood that ten are required.

The magnetic clutches associated with the units selector bars are similar to the magnetic clutches associated with the tens selector bars and consequently will need only a brief description. The magnetic clutch associated with units selector bar 144, for example, comprises the solenoid 262, which is mounted on web 50 by means of screws 263 and 264, and the two cores 265 and 266. The selector bar 144 is detachably secured to the core 265 by means of a tubular coupling member 267. To the core 266 there is secured a rod 268 which has a section 269 located in an open slot in the edge of member 253 of the auxiliary armature yoke and a head 270. The section 269 of rod 268 carries the two cup-shaped washers 271 and 272 on opposite sides of member 253, washer 271 being held on said section 269 by means of a split ring, as shown in the case of washer 190, Fig. 33. The spring 273 is compressed between the washer 272 and the head 270 of rod 268 and holds the rod 268 to the right as far as it can go, its movement in this direction being limited by the engagement of washer 271 with member 253.

The spring 273, in maintaining the rod 268 in the above described position, maintains the working contact springs 276, 277 and 278 of the set of contact springs 275 in the position in which they are shown. These working contact springs are tensioned to the left and assume their alternate positions under their own tension when permitted to do so by movement of rod 268 to the left.

The operation of the units selector bar 144 may now be explained briefly. This selector bar

is selected by the energization of solenoid 262, as will be explained more in detail in connection with the circuit diagram, Fig. 37. Upon the energization of solenoid 262, the core 266 is drawn in until it engages core 265, the latter core and the selector bar 144 remaining stationary or substantially so, due to the effect of the spring clutches in the units actuators and the restoring spring 210. The rod 268 attached to core 266 moves to the left with the core and the head 270 is brought into engagement or very nearly into engagement with the washer 272, spring 273 being compressed during this movement. The movement of rod 268 and head 270 permits the working contact spring 276—278 to assume their alternate positions.

Contact spring 276 and the contact engaged thereby in its alternate position control the circuit of the unit operating magnet 57 and this magnet is accordingly energized. The energization of magnet 57 operates the auxiliary armature yoke in the manner already described and the member 253 thereof, moving to the right as seen in Fig. 2, moves the rod 268 and core 266 to the right also. This is accomplished through the engagement of the head 270 of rod 268 by washer 272, the latter being in contact with member 253. The core 266 is moving to the right as described carries along the core 265 to which it is now magnetically coupled and the selector bar 144 is thus operated.

When the solenoid 262 is deenergized the magnetic coupling between cores 265 and 266 is destroyed and the cores no longer cohere. The units selector bar is restored by spring 210. The rod 268 is restored by spring 273 and the working contact springs 276—278 are returned to normal position. The restoration of spring 276 opens the circuit of the units operating magnet 57 and the magnet deenergizes, whereupon the auxiliary armature yoke is restored by spring 281.

The description of the switching mechanism, insofar as the mechanical construction thereof is concerned, is now substantially complete, and the description could continue with the operation of the switching mechanism as connected up in a telephone system. Before going into the circuit operation, however, it will be advantageous to explain briefly how the structural design provides for the removal of certain parts for the purpose of repair or replacement.

As regards those parts which are located on the outside of the switching mechanism, the manner of removal will be sufficiently obvious, so that no detailed explanation will be required. It will be clear enough, for example, that any trunk operating magnet assembly can be removed after taking out the pivot screws for the operating magnet armature yoke and the screws which hold the frame extensions such as 26 and 27 to the frame, also the screws which hold the associated links such as 61. The operating magnet assembly in the selection control unit may also be removed, after taking out the screws which hold the extensions 51 and 52 to the frame. It is understood, of course, that the wiring to the magnets and contact springs may be so arranged, as by flexible cables, as not to interfere with these operations. The spring assemblies may be removed, if necessary.

In connection with the removal and replacement of the tens operating magnet armature yoke it should be pointed out that the slotted member 172 has a tapered lower edge which facilitates its insertion between the cup-shaped washers such as 190 and 194 when the armature yoke is being

replaced. The auxiliary armature yoke for operating the units selector bars is provided with a tapered edge for a similar purpose.

As regards the switch bank, any line or test bar may be readily removed by simply pulling it out at the left hand end of the switching mechanism. To replace a bar it is pushed in until the end is gripped by the terminal at the selection control unit. The removal of an intermediate trunk element, however, is somewhat more complicated and will be explained briefly.

It may be assumed, for example, that it is desired to remove the uppermost trunk element 86 at the No. 1 trunk unit. The multiple conductor of the trunk is first unsoldered at terminal 85. Spring clips 88 and 89 may next be removed. The trunk element may now be disengaged from the slot 65 in plate 61 and could be withdrawn from the switching mechanism at the rear except for the fact that the tens actuators are in the way. This difficulty is provided for by arranging the parts so that the tens actuators may be moved to the right, Fig. 2, far enough to clear the ends of the contact fingers on the trunk element. In order to accomplish this the pivot screws 108 and 109 are turned out far enough so the heads thereof are outside their bearings, and the set screws 118 and 119 are partly unscrewed. This done, the operating magnet armature yoke and the plate 116 may be moved to the right far enough to carry the tens actuators out of the way. In this connection it will be noted that the extensions 26 and 27 have slots in which the pivot screws 108 and 109 can move. It should be noted also that the member 121 of the armature yoke, which operates the lifting rod 127, has an open slot through which the lifting rod extends, whereby the lifting rod does not interfere with the described movement of the armature yoke to the right.

The trunk element may now be removed and the same trunk element or a new one can be put back, after which the other parts which were removed or displaced can be reassembled in their proper positions. In this manner any trunk element can be taken out for repair or adjustment or for replacement by a new trunk element.

A complete trunk unit can also be taken out if it should become necessary for any reason. This operation will now be explained briefly.

It may be assumed, for example, that it is desired to remove the No. 7 trunk unit, Fig. 1. First the trunk conductors are unsoldered from the multiple and the spring assembly at the top of the unit is removed. The line and test bars are now withdrawn far enough so that the right hand ends thereof clear the No. 7 unit. They need not be entirely withdrawn. The operating magnet armature yokes and the auxiliary armature yoke at the selection control unit are now taken off, after which all the rods such as 208 and 268 with their associated cores may be removed. All the cores such as 185 and 265 are then uncoupled from their associated selector bars. In the case of core 185, for example, the core is uncoupled by the insertion of a screwdriver by means of which the core is pressed to the left and then rotated ninety degrees. The other cores are uncoupled in the same way. The restoring springs such as 210 and 217 are now taken off and the stop plates 211 and 218 are removed. The selector bars may now be withdrawn from the switching mechanism at the left, similar to the way in which the line and test bars are withdrawn. The selector bars are,

however, entirely removed from the switching mechanism.

The foregoing operations having been performed, the No. 7 trunk unit may be lifted out, after first removing the screws which attach it to the base 11 and the links such as 61 which secure it to the adjacent trunk units. It may be assumed the trunk unit is being taken out for repairs, in which case it will be replaced after the repairs are made, if they can be made quickly. Otherwise a new trunk unit may be inserted, or if one is not available, the switching mechanism may be reassembled without the No. 7 trunk unit. The procedure is the same if one or more new trunk units are to be added to a switching mechanism which was installed without the full equipment of trunk units; that is, the line and test bars and the selector bars have to be withdrawn to permit the removal or insertion of one or more trunk units, as the case may be.

Before reassembling the switching mechanism the cores such as 185 and 265 have to be removed. This can easily be done in the case of the cores such as 265 associated with the units solenoids. The cores such as 185 associated with the tens solenoids can usually be pulled through the solenoids by means of a screwdriver to which they will stick by residual magnetism. Otherwise a small bar magnet can be used, to avoid the necessity of taking off the operating magnet assembly.

The selector bars can now be inserted from the right, by pushing them through the solenoids and the guides at the trunk units. The spring clutches do not interfere with the movement of the selector bars from right to left, as will be readily understood from Figs. 28 and 30. The cores such as 185 and 265 may now be inserted in the solenoids and coupled to the selector bars. It will be unnecessary to further explain how the parts are reassembled.

The removal or insertion of a trunk unit and the dismantling and reassembling of other parts which are necessary does not take very long, but requires that the switching mechanism be temporarily taken out of service while the operations are being performed. That is, no calls can be handled. It will be understood, therefore, that such operations must be carried out at night, when service can be suspended without inconvenience to the subscribers.

Reference may now be made to Fig. 37, which shows suitable circuits for a switching mechanism such as has been described when the same is used as a group of finder switches for connecting calling subscribers' lines to trunk lines.

As will be understood from the previous description, the switching mechanism is adapted to handle the outgoing calls from a group of 100 subscribers' lines, divided into ten sub-groups of ten lines each. The drawing Fig. 37 shows four subscribers' lines, comprising lines 11 and 12 of the first sub-group and lines 21 and 22 of the second sub-group. The sub-station A on line 12 is also shown.

The line conductors 300 and 301 of line 12 extend from substation A to the exchange, where they are provided with the individual line equipment comprising the line relay 307 and the cut-off relay 306. From the line equipment the line conductors 300 and 301 and the test conductor 302 extend to the finder switching mechanism, where they terminate on the line bars 79 and 80 and the test bar 81, respectively. These connections serve for outgoing calls. Incoming calls to line 12, the line of sub-station A, are completed over the so-

called normal conductors 303, 304, and 305, which come from connector switching mechanism. No connector switching mechanism is shown, but it may be of any suitable type, such as is shown in the patent to Boswau, No. 2,307,757, for example.

The individual line equipment for lines 11, 21 and 22 is also shown and is similar to the individual line equipment of line 12.

Two of the tens solenoids of the finder switching mechanism are indicated at 191 and 192, while two of the units solenoids are indicated at 261 and 262. The tens operating magnet 53 and the units operating magnet 57 are also shown.

The drawings also show diagrammatically two of the intermediate trunks at the No. 1 trunk unit and two intermediate trunks at the No. 2 trunk unit, with the associated tens and units actuators. One of the tens actuators at the No. 1 trunk unit is indicated at 111, and a units actuator at 122. The trunk operating magnets for No. 1 and No. 2 trunk units are shown at 29 and 322, respectively.

Certain equipment at the test unit is also diagrammatically shown in the drawings, including the tens actuator 315 and the operating magnet 320.

Relays 331 and 332 are the trunk distributor relays for the No. 1 and No. 2 trunk units, respectively. There is a similar relay for each of the remaining trunk units. Relay 351 is a common relay for re-setting the trunk distributor relays.

Relays 341 and 342 are the trunk test relays for the No. 1 and No. 2 trunk units, respectively. Each of the other trunk units is provided with a similar test relay. Associated with the trunk test relays there is a start relay 350.

The circuits of the units solenoids such as 262 and the circuits of the trunk test relays such as 341 are provided with rectifiers such as 316 and 317, which have the same functions as the rectifiers shown at corresponding points in the previously mentioned Boswau patent.

The drawings also show the trunk line comprising conductors 370, 371 and 372, and the trunk line comprising conductors 373, 374 and 375. These trunk lines are outgoing from the No. 1 trunk unit and the No. 2 trunk unit, respectively, and extend to the next switching stage, which may be a selector or connector switching stage, depending on the size of the exchange. There is, of course, a similar outgoing trunk line for each of the other trunk units.

The next switching stage is not shown, but it will be understood that the line conductors of each trunk line terminate in a line relay, having an associated slow acting release relay, both of which are energized in known manner when the trunk line is taken into use by a calling subscriber. The test conductor of each trunk line is normally connected to negative battery, which constitutes an idle test potential, but when the release relay is energized responsive to the seizure of the trunk line, the test conductor is disconnected from negative battery and is connected to ground. The grounded test conductor then functions as a holding conductor. Circuit arrangements such as the above are well known and are described, for instance, in the Boswau patent previously referred to.

The outgoing trunk lines are taken into use by calling lines in consecutive order, starting with the trunk line outgoing from the No. 1 trunk unit, as will be made clear in the circuit explanation which follows. It may be mentioned at this point, however, that in order to be selectable for use on an outgoing call a trunk line not only must

be idle, as indicated by a negative potential on the test conductor, but it must be awaiting selection, as indicated by the energized condition of the associated trunk distributor relay such as 331.

The operations which take place in extending an outgoing call from sub-station A will now be explained briefly.

When the receiver is removed at sub-station A, a bridge is closed across the line conductors 300 and 301 and an energizing circuit is completed for the line relay 307 in the usual manner. Upon energizing, the line relay 307 connects the cut-off relay 306 to the test conductor 302 at contact 312. Resistance 314 at this time is in parallel with the cut-off relay. A negative test potential is thus applied to the test conductor through the cut-off relay 306 and resistance 314 in parallel.

The line relay 307 also grounds conductor 313 at contact 311, thereby closing a circuit for the tens solenoid 191, which extends from ground by way of contact 311, conductor 313, winding of solenoid 191, contact 324, conductor 326, contact 328, conductor 327, serially related contacts corresponding to contact 329 on other tens solenoids, contact 329, and contact 325 to negative battery. Upon energizing, solenoid 191 effects the magnetic coupling of its two cores and operates the associated set of contact springs, as previously described in the case of solenoid 192. At front contact 325 negative battery is connected direct to the winding of solenoid 191 and at back contact 325 negative battery is disconnected from conductor 327. Contact 325 should have a make-before-break adjustment. At contact 324 the winding of solenoid 191 is disconnected from conductor 326. The opening of contact 324 and back contact 325 prevents any other tens solenoid from operating at this time.

The energization of the tens solenoid 191 also effects the closure of contact 323, thereby closing a circuit for the tens operating magnet 53. Upon energizing, magnet 53 operates the tens selector bar 140 by means of the associated magnetic clutch including the energized tens solenoid 191, and the selector bar 140 operates the associated spring clutches at the trunk units and at the test unit. The spring clutches couple the tens actuators such as 111 and 315 to their associated lifting pins.

The tens operating magnet also closes contact 330, thereby completing a circuit for the operating magnet 320 at the test unit. Upon energizing, magnet 320 lifts the tens actuator 315, thereby connecting the test conductors of the ten lines in the first sub-group to the tens units solenoids, respectively. A circuit may now be traced for the units solenoid 262, said circuit extending from negative battery by way of the cut-off relay 306 and resistance 314 in parallel, contact 312, test conductor 302, test bar 81, contact finger 333, soldered end contact finger and terminal (not shown), rectifier 316, winding of solenoid 262, contact 335, conductor 337, contact 339, conductor 338, serially related contacts such as 336 on other units solenoids, contact 336, and contact 340 to ground. The cut-off relay is not energized over the above circuit, due to the effect of the shunt connected resistance 314.

The solenoid 262 is energized and effects the magnetic coupling of its cores and the operation of the associated set of contact springs, as previously described. At front contact 336 ground is connected to the winding of solenoid 262 and at back contact 336 ground is disconnected from conductor 338. This operation together with

the opening of contact 335 prevents the energization of another unit's solenoid at this time. Contact 336 should have a make-before-break adjustment. At contact 334 a circuit for the units operating magnet 57 is completed.

Upon energizing, magnet 57 operates the units selector bar 144 by means of the associated magnetic clutch including the energized solenoid 262, and the selector bar operates the associated spring clutches in the trunk units. Magnet 57 also closes contact 344, thereby completing a circuit for the start relay 350.

Upon energizing, the start relay opens conductors 327 and 338 at contacts 328 and 339, respectively, in order to hold the energizing circuits of the tens and units solenoids open until the apparatus is ready to handle another call. The start relay also grounds conductor 346, thereby completing a circuit for the trunk test relay 341 over a path which extends from negative battery on the test conductor 372 of the trunk line 370—372 outgoing from the No. 1 trunk unit, it being assumed that said trunk line is idle, contact 369 of energized trunk distributor relay 331, conductor 364, rectifier 317, contact 366, winding of test relay 341, contact 362, conductor 349, contact 361, contact 360, conductor 346, and contact 345 to ground. The trunk test relay 341 energizes over the above circuit. A similar circuit is closed for the trunk test relay 342 and for other trunk test relays, provided the trunk lines with which such test relays are associated are in selectable condition. The test relay 342 and such other test relays accordingly start to energize at the same time as test relay 341. The test relay 341 is first choice, however, and the other test relays all drop back before any of them can fully energize, as will be understood from the circuit changes produced by the energization of test relay 341. At contacts 347 and 367 relay 341 locks itself to grounded conductor 346 independent of the trunk test conductor 372, the connection to which is broken at contact 366. At contact 360 the grounded conductor 346 is disconnected from conductor 349, and at contact 362 the winding of relay 341, now connected to conductor 346 by way of contact 347, is disconnected from conductor 349. The opening of contacts 360 and 362 prevents the complete energization of test relay 342 and other test relays.

At contact 363 test relay 341 closes a circuit for the trunk operating magnet 29, which extends from ground by way of contact 363, conductor 377, and winding of magnet 29 to negative battery. Upon energizing, the magnet 29 raises the tens actuator 111 and the units actuator 122, as determined by the operated position of selector bars 140 and 144.

The tens actuator 111 connects the ten subscribers' lines in the first sub-group to the ten intermediate trunks at the No. 1 trunk unit and the units actuator 122 connects the second intermediate trunk comprising conductors 380, 381 and 382 to the outgoing trunk comprising conductors 370, 371 and 372. The calling line of sub-station A, line 12, is thus extended over the outgoing trunk line to the next switching stage.

The trunk magnet 29 also prepares a locking circuit for itself at contact 378, and at contact 383 opens the circuit of the trunk distributor relay 331. Relay 331 accordingly deenergizes.

At the next switching stage the line conductors 370 and 371 of the outgoing trunk line terminate in a line relay, as previously explained, which energizes responsive to the connection of the

calling line to the trunk line. The associated release relay energizes also, disconnecting the test conductor 372 from negative battery and connecting it to ground.

The connection of ground to the test conductor 372, as described in the foregoing, completes the locking circuit for the trunk magnet 29, said locking circuit including the resistance 379. This locking circuit is effective to maintain the magnet 29 energized after the test relay 341 has deenergized.

The cut-off relay 306 is now energized over a circuit which extends from the grounded test conductor 372 by way of terminal 390, contact finger 391, test conductor 382 of the second intermediate trunk, contact finger 392, test bar 81, test conductor 302, contact 312, and winding of cut-off relay 306 to negative battery. Relay 306 disconnects the resistance 314 at back contact 308 and at front contact 308 locks itself to the test conductor 302.

The cut-off relay 306 also disconnects the line relay 307 at contacts 309 and 310 and the line relay accordingly deenergizes, disconnecting ground from conductor 313. The latter operation opens the circuit of the solenoid 191, which deenergizes, permitting the operated tens selector bar and the associated set of contacts to restore. The circuit of the tens operating magnet 53 is thus opened at contact 323 and the magnet deenergizes, opening the circuit of operating magnet 320 at the test unit. This magnet therefore deenergizes also, the actuator 315 is restored, and the test conductors of the lines of the first sub-group are disconnected from the units solenoids.

The application of ground to the trunk test conductor 372 not only completes a circuit for the cut-off relay with the above described results but also short-circuits the units solenoid 262, which deenergizes before it is disconnected from test bar 81 by the release of the actuator 315. The deenergization of the units solenoid permits the operated units selector bar to restore, as well as the associated contact set. The circuit of the units operating magnet 57 is therefore broken at contact 334 and the magnet deenergizes, breaking the circuit of the start relay 350. Upon deenergizing, the start relay breaks the circuit of the test relay 341 and this relay deenergizes also. The switching mechanism is now ready to handle another call, since the contacts 328 and 339 on the start relay have been closed. These contacts are included in the energizing circuits of the tens and units solenoids and are not closed until after the solenoids 191 and 262 have deenergized.

In connection with the foregoing, it will be noted that if another line in the first sub-group, line 11, for example, has called before the line relay 307 has deenergized, the tens solenoid 191 will be held operated, as well as magnets 53 and 320. The units solenoid 262 deenergizes, however, when short-circuited by the grounding of test conductor 372, and upon the closure of contact 339 on the start relay another units solenoid will be energized. If line 11 is calling, as above assumed, solenoid 261 is the one which will be energized.

The calling line of sub-station A has now been extended by means of the No. 1 trunk unit to the outgoing trunk 370—372 and a holding circuit has been established over the test conductor 372 of the trunk line for the trunk operating magnet 29 and the cut-off relay 306. The line conductors involved in the connection are shown

by heavy lines so that the complete circuit through the No. 1 trunk unit will be apparent upon inspection. The completion of the connection to the called line takes place in known manner and need not be explained. When the calling subscriber at sub-station A hangs up his receiver, the connection is released in known manner and at the next switching stage ground is disconnected from the test conductor 372, being replaced by negative battery. The cut-off relay 306 and the trunk operating magnet 29 are accordingly deenergized with results which will be obvious so far as the cut-off relay is concerned. The deenergization of the trunk magnet permits the tens and units actuators to restore, thus returning the No. 1 trunk unit to normal.

When the next call is made it is extended over trunk line 373—375 by the No. 2 trunk unit, it being assumed that this trunk line is idle and that the trunk distributor relay 332 is energized, as shown in the drawings. Trunk line 373—375 is employed even though the trunk line 370—372 may now be idle, for the trunk distributor relay 331 associated with the latter trunk line has been deenergized and its contact 369 is open. When the trunk operating magnet 322 of the No. 2 trunk unit is energized, it causes the deenergization of the trunk distributor relay 332, and in like manner the remaining trunk distributor relays become deenergized as their associated trunk lines are taken into use. When the last trunk line is taken into use the last trunk distributor relay will be deenergized and a circuit will be completed in an obvious manner for relay 351. Upon energizing, relay 351 completes parallel energizing circuits for the trunk distributor relays of all idle trunk lines. These relays accordingly energize and lock up, as shown in the case of relays 331 and 332, and open the circuit of relay 351, which deenergizes. The idle trunk lines associated with the energized trunk distributor relays are made available for use again by the closure of the contacts such as 369 and 376.

The invention having been described, that which is believed to be new and for which the protection of letters patent is desired will be pointed out in the appended claims.

I claim:

1. In a cross-bar switching mechanism, a plurality of trunk units, a test unit, a selection control unit, sets of line and test bars extending through said trunk and test units, a set of trunk terminals individual to each trunk unit, means including tens and units actuators in each trunk unit for connecting the associated trunk terminals to any set of line and test bars, ten selector bars common to said units for selecting tens actuators, units selector bars common to said units for selecting units actuators, tens and units magnets in said control unit for selecting said selector bars, tens actuators in said test unit also selectable by said tens selector bars for connecting groups of test bars to said units magnets, means for energizing a tens magnet to select a tens selector bar, a magnet in said control unit common to all tens selector bars for operating the selected tens bar, a magnet in said test unit common to all the tens actuators therein for operating the selected tens actuator in the test unit, means for energizing one of the units magnets connected by operation of the selected tens actuator in the test unit, whereby a units selector bar is selected, a common magnet in the selector control unit for operating the selected units se-

lector bar, a trunk magnet in each trunk unit, and means for energizing the trunk magnet in any trunk unit to operate the tens and units actuators selected by said tens and units selector bars.

2. In a cross-bar switch, a group of longitudinally movable selecting bars, a group of operating members associated with said selecting bars, respectively, means for coupling any selecting bar to the associated operating member, means comprising a pivoted armature for simultaneously actuating all said operating members and a magnet for operating said armature.

3. In a cross-bar switch, a group of selecting bars, a common operating magnet for said bars, a pivoted armature for said magnet, an independently pivoted operating device adapted to be actuated by said armature responsive to energization of said magnet, and selectively controlled means for coupling any said selecting bar to said operating device.

4. A selection control unit for operating a row of selector bars in a cross-bar switching mechanism, comprising a common operating magnet, an armature for said magnet and a pivoted member adapted to be actuated thereby, a plurality of actuating elements carried by said pivoted member and arranged in a row opposite said row of selector bars, and means for coupling any selector bar to the corresponding actuating element.

5. A selection control unit for operating the tens and units selector bars of a cross-bar switching mechanism, comprising a group of tens actuating elements individual to the tens selector bars, respectively, means for coupling any tens selector bar to the corresponding actuating element, a group of units actuating elements individual to the units selector bars, respectively, means for coupling any units selector bar to the corresponding actuating element, a tens operating magnet for simultaneously operating all said tens actuating elements, and a units operating magnet for simultaneously operating all said units actuating elements.

6. In a cross-bar switching mechanism, a plurality of trunk units, tens and units selector bars common to said trunk units, a common operating magnet for the tens selecting bars, a common operating magnet for the units selector bars, means for selecting a tens selector bar, means for energizing the common tens magnet for operating the selected tens bar, means responsive to the energization of said magnet for selecting a units selector bar, and means for energizing the common units magnet to operate the selected units selector bar.

7. In a cross-bar switching mechanism, a plurality of trunk units each having tens and units actuators for completing connections, tens and units selecting bars common to said trunk units for selecting said actuators for operation, means for selecting any tens and any units selecting bar, a tens magnet common to all tens selecting bars for operating the selected tens bar, a units magnet common to all units selecting bars for operating the selected units bar, and a magnet in each trunk unit for operating the actuator selected by the operation of the selected tens and units selecting bars.

8. In a cross-bar switching mechanism, a plurality of trunk units, trunks terminating in said trunk units, respectively, a plurality of lines common to said trunk units, means in each trunk unit for selectively connecting the associated trunk line with any one of said lines, tens and units

selecting bars common to said trunk units for controlling the selective operation of said connecting means, a selection control unit, common operating magnets in said control unit for said tens and units selecting bars, respectively, and means in said control unit for selecting any tens selecting bar and any units selecting bar and for causing the same to be operated by the respective tens and units operating magnets.

9. In a cross-bar switching mechanism, a plurality of trunk units, trunk lines terminating in said trunk units, respectively, a group of intermediate trunks in each trunk unit, means in each trunk unit for connecting the associated trunk line with any of the associated intermediate trunks, a plurality of selecting bars common to said trunk units for controlling said connecting means, a selection control unit, means in said control unit for selecting any one of said selecting bars, and an operating magnet in said control unit common to all said selecting bars for operating the selected selecting bar.

10. In a cross-bar switching mechanism, a plurality of trunk units, a group of lines common to said trunk units, each line comprising a set of bars extending through all said trunk units, said lines being divided into sub-groups, a group of intermediate trunks in each trunk unit, comprising conductors arranged in intersecting relation with the sub-groups of lines, means in each trunk unit for connecting the associated intermediate trunks, respectively, to the lines of any sub-group, a group of selecting bars common to said trunk units for controlling said connecting means, a selection control unit, means in said control unit for selecting any one of said selecting bars, and an operating magnet in said control unit common to all said selecting bars for operating the selected selecting bar.

11. In a cross-bar switching mechanism, a plurality of trunk units, a test unit, a plurality of tens actuators in each trunk unit, a corresponding plurality of tens actuators in said test unit, a plurality of tens selector bars common to said units, means responsive to the operation of any tens bar for selecting the corresponding tens actuator in each unit, a magnet in each unit for operating any selected tens actuator therein, and means operated in timed relation to the operation of any tens bar for energizing the said magnet in the test unit to operate the selected tens actuator in the test unit.

12. In a cross-bar switching mechanism, a plurality of trunk units each having tens and units actuators for completing connections, a test unit common to said trunk units and having tens actuators, tens selecting bars common to said trunk units and said test unit, units selecting bars common to said trunk units, tens magnets individual to said tens selecting bars, respectively, a test unit operating magnet for the tens actuators in said test unit, means for energizing any tens magnet to operate the associated selecting bar, means responsive to the energization of any tens magnet for energizing said test unit operating magnet to operate the tens actuator selected by the operated tens selecting bar, units magnets individual to said units selecting bars, respectively, and means for energizing a units magnet over a circuit completed by the operated tens actuator in said test unit.

13. In a bank unit for a cross-bar switch, a rectangular frame, a sheet of insulating material supported on said frame, a plurality of metallic strips each having a row of integrally formed

contact fingers, and means for supporting said strips in parallel spaced relation on one side of said sheet with corresponding contact fingers of said rows in alignment.

14. In a bank unit for a cross-bar switch, a rectangular frame adapted to be mounted in an upright position, a sheet of insulating material supported on the sides of said frame in a vertical plane, a plurality of metallic strips disposed in spaced horizontal planes on one side of said sheet, each strip being divided along one edge to form a plurality of contact fingers, and means for removably securing the undivided edges of said strips to said sheet.

15. In a bank unit for a cross-bar switch, a rectangular open frame, a sheet of insulating material extending across between the two sides of said frame and secured thereto, a plurality of multiple contact devices each comprising a base and a plurality of conductively connected contact fingers, said contact devices being positioned in parallel spaced relation with their respective bases resting against one side of said sheet, and two retaining devices secured to the two sides of said frame, respectively, said retaining devices having resilient members for pressing the ends of the bases of said contact devices against said sheet.

16. In a bank unit for a cross-bar switch, a rectangular open frame, a sheet of insulating material secured to the sides of said frame, a plurality of bars of insulating material resting against one side of said sheet in parallel spaced relation, each bar having a series of conductively connected contact fingers projecting at right angles to said sheet, said sheet and bars having cooperating means whereby displacement of the bars on the side of said sheet is prevented, and means secured to the sides of the frame for holding said bars against the side of said sheet.

17. A removable multiple contact device for the bank of a cross-bar switch, comprising a bar of molded insulating material, and a metallic strip having one edge embedded in said bar, the other edge of said strip being divided to form a plurality of spaced contact fingers.

18. In a bank unit for a cross-bar switch, a removable multiple contact device comprising a flexible metallic strip, said strip having a plurality of integrally formed contact fingers along one edge thereof, a bar of insulating material in which the other edge of said strip is embedded, and a metallic member secured to one end of said bar and insulated from said strip, said member including a terminal part extending beyond the end of the bar and a contact portion extending at right angles to the bar parallel to the end one of said contact fingers.

19. In a bank unit for a cross-bar switch, a bar of insulating material, said bar having a metallic strip embedded in and projecting from one edge thereof, said strip having a plurality of integrally formed contact fingers, a narrow metallic strip embedded in and projecting from the other edge of said bar, a sheet of insulating material having a groove in which the projecting portion of said narrow strip is received with the associated edge of said bar resting against the face of said sheet, and means for removably securing said bar to said sheet.

20. In a bank unit for a cross-bar switch, a flat sheet of insulating material supported in a vertical plane, a multiple contact device comprising a flexible metallic strip having a row of integrally formed contact fingers disposed in a

horizontal plane, said device including a bar of insulating material secured to the edge of said strip opposite said contact fingers, means for locating said bar in a predetermined position on the face of said sheet, and means for removably securing said bar in said predetermined position.

21. In a cross-bar switch, a sheet of insulating material having a plurality of rows of openings therein, a plurality of rows of metallic conductor bars passing through said openings in planes perpendicular to said sheet, a plurality of metallic strips crossing the bars of said rows, respectively, each strip having integrally formed contact fingers extending parallel to the bars of the associated row, and means for removably securing said strips on one side of said sheet.

22. In a cross-bar switch, a plurality of sheets of insulating material supported in parallel spaced vertical planes, said sheets having horizontal rows of openings therein, a plurality of rows of metallic conductor bars supported by said sheets, each bar passing through corresponding openings in all of said sheets, a plurality of metallic strips at each of said sheets crossing the bars of said rows, respectively, each strip having contact fingers adapted to be individually moved into engagement with the bars of the associated row, respectively, and means for removably securing said strips to said sheets.

23. In a cross-bar switch, a plurality of plates of insulating material supported in parallel spaced vertical planes, said plates having horizontal rows of openings therein, rows of terminals inserted in the openings at the last of said plates, and a plurality of rows of metallic conductor bars supported on said plates, each bar passing through corresponding openings in all said plates except the last and engaging a terminal on the last plate.

24. In a cross-bar switch, a plurality of plates of insulating material supported in parallel spaced vertical planes, a plurality of rows of terminals supported in a plane parallel to the planes of said plates and in alignment therewith, each terminal having means for gripping the end of a metallic conductor bar, and said plates having rows of tapered openings through which such conductor bars may be passed to cause their ends to be gripped by said terminals, said plates being operative to support said bars.

25. In a cross-bar switch, a base, a plurality of trunk units mounted vertically on said base, each trunk unit including a frame, a plurality of metallic conductor bars extending serially through all said trunk units, and means on each trunk unit frame for supporting said bars against lateral displacement while permitting longitudinal sliding movement thereof whereby said bars may be withdrawn to permit the removal of one of said trunk units from said base.

26. In a cross-bar switch, a base, a plurality of trunk units supported side by side on said base, each trunk unit comprising a frame and trunk connecting means supported thereon, a plurality of metallic conductor bars extending serially through all said trunk units, supporting means for said bars on said frames adapted to permit endwise sliding movement of said bars, whereby the said bars may be readily withdrawn by movement in one direction and inserted by movement in the opposite direction, and a terminal unit supported on said base adjacent the last trunk unit and carrying terminals which are engaged by the said bars, respectively, when the same are fully inserted in the switch.

27. In a cross-bar switching mechanism, a base, a plurality of trunk units supported side by side on said base, each unit being individually removable from the base, metallic line bars extending serially through all said trunk units, said bars constituting terminals of lines, trunks terminating in said trunk units, respectively, means in each trunk unit for connecting its associated trunk with any said line, tens and units selecting bars common to said trunk units for controlling said connecting means, said selecting bars extending lengthwise of said switching mechanism parallel to said line bars, and supporting means for said line bars and selecting bars adapted to permit endwise withdrawal of said bars at one end of said switching mechanism to permit removal of one of said trunk units.

28. In a cross-bar switching mechanism, a plurality of trunk units supported side by side on a base, tens and units selecting bars common to said trunk units and extending lengthwise of said switching mechanism, supporting means at said trunk units for said bars permitting longitudinal movement thereof, and trunk connecting means at each trunk unit selectively controlled responsive to longitudinal movement of said bars in one direction and adapted to permit unlimited longitudinal movement of said bars in the other direction, whereby said bars may be withdrawn from the switching mechanism without disturbing said connecting means.

29. In a cross-bar switching mechanism, a plurality of trunk units, each having a plurality of contact actuators and a power device for operating the same, selecting bars common to said trunk units and supported for longitudinal movement thereon, clutches for coupling said actuators to said power device, said clutches being responsive to movement of said selecting bars in one direction while permitting free movement thereof in the other direction, operating means for applying a tractive force to any said bar to move the same in the proper direction to operate the associated clutches, and detachable couplings connecting said bars and said operating means, whereby the said bars may be uncoupled and withdrawn from the switching mechanism by movement in the direction opposite to that required for operation of said clutches.

30. In a cross-bar switching mechanism, a plurality of trunk units supported side by side on a base, each trunk unit including a frame, a selector bar guide mounted on each frame, each guide having a row of openings therein and the openings in each guide being in alignment with the openings in the other guides, and selector bars extending lengthwise of said switching mechanism through the openings in said guides.

31. In a cross-bar switch, an actuator rod, a plurality of contact actuators spaced apart along said rod, a guide for preventing rotation of said contact actuators on said rod, a spring included in each contact actuator having a coil surrounding said rod, selector bars for causing the spring of any selected actuator to grip the said rod, and means to move said rod longitudinally to move the selected contact actuator.

32. In an automatic switch of the cross-bar type, a plurality of sets of contacts arranged in vertical superimposed alignment, a slotted guide extending parallel to said sets of contacts, a plurality of contact actuators positioned in the slots in said guide and having means for actuat-

ing said sets of contacts, a rod extending through all said actuators on the opposite side of said guide from said contact sets, a coil spring in each actuator surrounding said rod, means including selector bars for causing the coil spring in any selected actuator to grip said rod, and means for moving said rod longitudinally to move the selected actuator in its slot in said guide to actuate the associated set of contacts.

33. In a cross-bar switch, a plurality of contact actuators each having a clutch housing, a plurality of rods slidable in said housings, respectively, a spring in each housing having coils surrounding the associated rod, selecting means for tightening the coils of any spring whereby any selected actuator may be coupled to the rod associated therewith, and means for simultaneously moving said rods to operate the selected actuator.

34. In a cross-bar switch, a contact actuator, an operating rod slidable relative to said actuator, a spring for coupling said actuator to said rod having coils surrounding said rod, selective means in said switch for tightening said coils to cause said spring to grip said rod, means for moving said rod to operate said actuator, and a fixed cam adapted to cooperate with said spring while said actuator is in operated position to prevent loosening of said coils if said selecting means is released.

35. In an automatic switch, a row of contact actuators, a movable member common to said actuators, a spring clutch individual to each actuator, whereby the same may be coupled to said member, and means for selectively operating said clutches.

36. In an automatic switch, a plurality of contact actuators arranged in a row, a movable member common to said actuators, a spring clutch individual to each actuator, whereby the same may be coupled to said member, means for operating one of said clutches, means for moving said member to move the actuator associated with the operated clutch, and means for maintaining said last mentioned clutch in operated position after the said clutch operating means is released.

37. In an automatic switch, a contact actuator, a longitudinally movable rod associated therewith, means for coupling said actuator to said rod comprising a spring having coils surrounding said rod, a selecting bar for tightening said coils to cause the spring to grip said rod, means for moving said rod to thereby move said actuator, and means for causing said coils to maintain their grip on said rod after the selecting bar is released.

38. In combination, a contact actuator including a clutch housing, a rod slidable in said housing, a spring in said housing having coils surrounding said rod, said spring having one end anchored on the housing and the other end projecting therefrom, means for moving the said projecting end to tighten said coils on said rod, and means for preventing rotation of said clutch housing responsive to the movement of the said projecting end.

39. In combination, a contact actuator including a clutch housing, a rod slidable in said housing, a guide for preventing rotation of said actuator on said rod, a spring in said housing having coils surrounding said rod, said spring having one end anchored on the housing and the other end projecting therefrom, and means for moving the said projecting end to cause said coils

to grip said rod, whereby subsequent movement of said rod will operate said actuator.

40. In combination, a longitudinally movable rod, a plurality of devices adapted to be selectively operated responsive to movement of said rod, a spring associated with each device for coupling the same to said rod, each spring having coils surrounding said rod, selecting means for tightening the coils of the spring associated with a selected device to cause the said coils to grip said rod, means for moving said rod to operate the selected device, and a fixed cam associated with each device arranged to cooperate with the spring thereof to prevent operation of the device responsive to movement of said rod in case the device has not been selected and to maintain the associated spring in gripping relation to said rod independent of said selecting means in case the device has been selected and operated.

41. In a cross-bar switch, a longitudinally movable selecting bar, operating means for said bar, a magnetic clutch for coupling said bar to said operating means, said clutch including a solenoid and a movable core, and means for detachably securing said bar to said core.

42. In a cross-bar switch, a group of longitudinally movable selecting bars, a common operating magnet having a pivoted armature yoke, and a plurality of magnetic clutches for coupling said selecting bars, respectively, to said yoke, each clutch comprising a solenoid, a core removably attached to one of said selecting bars, and a second core removably attached to said yoke.

43. In a cross-bar switch, a plurality of solenoids arranged in a vertical row, a pivoted armature yoke spanning said row and having a slot opposite each solenoid, rods supported in said slots, respectively, and adapted for longitudinal movement by said yoke, and cores for said solenoids attached to said rods.

44. In a cross-bar switch, a pivoted armature yoke, said yoke having a row of open slots along the edge opposite the pivots, a row of selecting bar operating rods supported in said slots, a pair of washers on each rod, the washers of each pair being on opposite sides of said yoke, and means including a spring on each rod pressing the washers of the associated pair toward each other, the slotted edge of said yoke being tapered to facilitate insertion of the yoke between said washers when the yoke is being replaced after removal for repairs or other purpose.

45. In a cross-bar switch, a movable selecting bar operating member, a selecting bar operating rod associated with said member and having two positions relative to said member, said rod being operable by said member when in the second position, a spring normally holding said rod in the first position, a pair of contact springs of which the working contact spring is normally held in operated condition against its own tension by said rod, and means for supporting said contact springs on said operating member.

46. In a trunk unit for a cross-bar switch, a frame, a plurality of intermediate trunk elements removably supported on said frame, each trunk element including a metallic strip having integrally formed contact fingers projecting horizontally on one side of the frame, the corresponding contact fingers on said trunk elements being aligned in vertical rows, a vertical actuating member located at the side of each of said rows of contact fingers, and means for supporting said actuating members on said frame adapted to permit movement of said members away from the

frame far enough to clear the ends of said contact fingers, whereby said intermediate trunk elements may be withdrawn from the frame through the space between the frame and said actuating members.

47. In a cross-bar switching mechanism, a base, a plurality of trunk units supported side by side on said base, sets of metallic line bars extending serially through said trunk units, a set of trunk terminals in each trunk unit, means in each trunk unit for connecting its set of trunk terminals to any set of line bars, tens and units selecting bars common to said trunk units for controlling said connecting means, said selecting bars extending lengthwise of the switching mechanism parallel to said line bars, a control unit at one end of said base, and means in said control unit for selectively operating all said selecting bars.

48. A cross-bar switching mechanism adapted to establish a plurality of simultaneous connections between trunk lines and other lines, comprising a base, a plurality of trunk units, each having an individual frame removably supported on said base, each trunk unit including trunk and line connecting means supported on the trunk frame, line bars common to said trunk units, selecting bars common to said trunk units for controlling said connecting means, the said line bars and selecting bars being readily removable to permit removal of any trunk unit from said base, and a selection control unit supported on said base and provided with all the apparatus for operating said selecting bars, whereby after a trunk unit has been removed and the line bars and selecting bars have been replaced the remaining trunk units are operative to establish connections as before.

49. In a switching device for use in a signalling system, a switching unit comprising a plurality of vertically extending vertically longitudinally individually movable operating members disposed side by side and each adapted to actuate a plurality of vertically aligned contacts, an actuating member for each of said operating members, a selectively operable clutch for operatively connecting each actuating member with its associated operating member, and a magnet having an armature which is adapted upon energization of said magnet to displace all such actuating members so as to move the operating member which may have been operatively connected thereto by its associated clutch for the purpose of actuating all the vertically aligned contacts which are associated with such operating member.

50. The unitary structure of a switching device for use in a signalling system comprising a vertically positioned rectangular frame, supporting means in said frame for individually removably mounting thereon a plurality of vertically superposed transversely extending rows of contact fingers forming a series of vertically aligned sets of movable contacts which are disposed in transverse direction side by side and in parallel with each other and project from the plane of said supporting means and said frame horizontally substantially at right angles thereto, a vertically disposed vertically longitudinally individually movable operating member for each series of sets of vertically aligned contacts having means effective upon longitudinal displacement thereof for moving all contacts in all of the sets of contacts associated therewith, an actuating member for each of said operating members, a selectively operable clutch for operatively connecting each actuating member with its associated operating member, and a

magnet having an armature which is adapted upon energization of said magnet to displace all such actuating members so as to move the operating member which may be operatively connected by its clutch with its associated actuating member.

51. The structure defined in claim 50, together with separate mounting means for said magnet and said armature, and means for removably attaching said mounting means on said frame to form a unitary structure therewith.

52. The structure defined in claim 50, together with a device for separately mounting said magnet and said armature on said frame, said mounting means being so constructed and arranged as to permit displacement of said armature and said actuating members engaged thereby, in a direction sideways of said frame, for the purpose of moving all of said operating members associated with said actuating members sideways out of their positions relative to said contact fingers when it is desired to gain access to any row of such contact fingers.

53. The structure defined in claim 50, wherein each of the transversely extending rows of contact fingers is conductively interconnected and wherein one such contact finger at the end of each row constitutes a movable terminal contact therefor which is disposed edgewise of said frame, and actuating means for selectively operating said terminal contacts in predetermined groups, each group consisting of a plurality of such contacts corresponding to a like plurality of transverse rows of contact fingers associated therewith, said actuating means comprising a plurality of vertically superposed actuators extending edgewise of said frame, a vertically extending operating member for all of said actuators, a selectively operable clutch for operatively connecting any one of said actuators with said operating member, and means for coupling said operating member with said armature, said last named means being adapted to move said operating member responsive to energization of said magnet for the purpose of moving the actuator which may have been operatively connected therewith by its clutch so as to displace the terminal contacts of the group associated with such actuator.

54. The structure defined in claim 50, wherein each of the transversely extending rows of contact fingers is conductively interconnected and wherein one such contact finger at the end of each row constitutes a movable terminal contact therefor which is disposed edgewise of said frame, together with actuating means for selectively operating said terminal contacts in predetermined groups, each group consisting of a plurality of such contacts corresponding to a like plurality of transverse rows of contact fingers associated therewith, said actuating means comprising a plurality of vertically superposed actuators extending edgewise of said frame, a vertically extending operating member for all of said actuators, a selectively operable clutch for operatively connecting any one of said actuators with said operating member, means for coupling said operating member with said armature, said last named means being adapted to move said operating member responsive to energization of said magnet for the purpose of moving the actuator which may have been operatively connected therewith by its clutch so as to displace the terminal contacts of the group associated with such actuator, and stationary terminal means con-

tacted by said movable terminal contacts upon displacement thereof by such actuator.

55. Switching apparatus for use in a signalling system comprising a plurality of unitary switching devices as defined in claim 50, arranged side by side, together with a control unit arranged in series relationship with said devices and provided with means for selectively operating the clutches of all of said switching devices.

56. Switching apparatus for use in a signalling system comprising a plurality of unitary switching devices as defined in claim 50, arranged side by side, together with a control unit arranged in series relationship with said devices and provided with means for selectively operating the clutches of all of said switching devices, and contact bars extending through all said switching devices, said bars being removably arranged in vertically superposed transverse rows in alignment with the transverse rows of contact fingers in such switching devices for engagement therewith responsive to displacement of said contact fingers by their associated operating members.

57. Switching apparatus for use in a signalling system comprising a plurality of unitary switching devices as defined in claim 50, arranged side by side, together with a control unit arranged in series relationship with said devices and provided with means for selectively operating the clutches of all of said switching devices, a vertically disposed terminal plate in said control unit, a plurality of vertically superposed transverse rows of terminal prongs in said terminal plate, and contact bars removably engaged by said prongs and extending through all said switching devices, said bars being arranged in vertically superposed transverse rows in alignment with the transverse rows of contact fingers in said switching devices for engagement therewith responsive to displacement of said contact fingers by their associated operating members.

58. In a switching device for use in a signalling system, a switching unit comprising a plurality of vertically superposed actuators each adapted to actuate a plurality of contacts forming a group in a row of vertically aligned contacts, an operating shaft common to said actuators, a selectively operable clutch for operatively connecting each actuator with said shaft, and a magnet having an armature which is adapted to move said operating shaft upon energization of said magnet so as to displace the actuator which may have been operatively connected thereto by its associated clutch for the purpose of actuating the group of contacts associated with such actuator.

59. In a switching device for use in a signalling system, a switching unit comprising a plurality of vertically extending vertically longitudinally individually movable operating members disposed side by side and each adapted to actuate all contacts in a vertical row of sets of contacts associated therewith, an actuating member for each of said operating members, a selectively operable clutch for operatively connecting each actuating member with its associated operating member, a plurality of vertically superposed actuators each adapted to actuate a plurality of contacts forming the terminal contacts of a corresponding set in said vertical row of sets of contacts, an operating shaft common to said actuators, a selectively operable clutch for operatively connecting each actuator with said shaft, and a magnet having an armature which is adapted upon energization of said magnet to displace all of said

actuating members and said operating shaft so as to move the operating member which may have been operatively connected by its associated clutch with one of said actuating members and to move simultaneously the actuator which may have been operatively connected by its associated clutch with said operating shaft.

60. In a switching system of the coordinate or crossbar type, a plurality of individual switching units arranged side by side, a plurality of vertically superposed rows of bare conductors extending through said switching units, a control unit disposed at the end of said switching units, a terminal plate in said control unit, and vertically superposed rows of terminal prongs for removably engaging the ends of said bare conductors.

61. Switching apparatus of the crossbar or coordinate type comprising a plurality of individual trunk units arranged side by side, each trunk unit having a trunk line terminating therein, a control unit disposed in serial relation with said trunk units, a plurality of line conductors extending through all of said trunk units in a plurality of superposed rows each conductor terminating in said control unit, movable trunk contacts in each of said trunk units for engagement with said line conductors, tens actuators in each of said trunk units for connecting said movable contacts therein with said line conductors, units actuators in each trunk unit for linking the conductors of a selected line with the trunk line of the corresponding trunk unit, operating means in each of said trunk units for actuating individual tens and units actuators associated therewith, coupling means for operatively interconnecting the individual tens and units actuators in each trunk unit with the operating means therefor, selecting members for actuating said coupling means in all of said trunk units, and actuating means in said control unit for operating said selecting members.

62. The structure defined in claim 61, together with selectively operable coupling means coacting with the actuating means in said control unit for coupling individual selecting members therewith.

63. The structure defined in claim 61, wherein the coupling means for operatively interconnecting individual tens and units actuators with their operating means comprises a movable member adapted to be operated by said operating means, and spring controlled clutch means arranged for coaction with certain of said selecting members for operatively connecting any selected actuator with said movable member.

64. The structure defined in claim 61, together with selectively operable coupling means coacting with the actuating means in said control unit for coupling individual selecting members therewith, said coupling means comprising a solenoid for each selecting member, a core for said solenoid, an operating magnet adapted to move an armature upon energization thereof, and means actuated by said armature to move said core so as to displace the associated selecting member.

65. The structure defined in claim 61, together with selectively operable coupling means coacting with the actuating means in said control unit for coupling individual selecting members therewith, the coupling means for the individual tens and units actuators in each trunk unit comprising a movable member adapted to be operated by said operating means, spring controlled clutch means arranged for coaction with certain of said

selecting members for operatively connecting any selected actuator with said movable member, the coupling means coacting with said actuating means in said control unit comprising a solenoid for each selecting member, a core for said solenoid, an operating magnet adapted to move an armature upon energization thereof, and means operated by said armature to move said core for the purpose of displacing the associated selecting member so as to actuate the coupling means of the actuators in said trunk units which are associated therewith.

66. The structure defined in claim 61, together with selectively operable coupling means for coaction with said actuating means in said control unit for coupling individual selecting members therewith, mechanical clutch means operable by said selecting members constituting the coupling means for the actuators in each individual trunk unit, and magnetically operable clutch means constituting the coupling means for the selecting members in said control unit.

67. The structure defined in claim 61, together with a member in each of said trunk units for holding said line conductors against lateral displacement therein without interfering with displacement of each conductor in longitudinal direction thereof, and a terminal plate in said control unit carrying a prong for removably receiving the end of each line conductor.

68. In a bank unit for a crossbar switch, a rectangular open frame, a sheet of insulating material extending across between the two sides of said frame, a plurality of multiple contact devices each comprising a base and a plurality of con-

ductively connected contact fingers, said contact devices being positioned in parallel spaced relation with their respective bases resting against one side of said sheet, and retaining devices secured to the two sides of said frame, respectively, for holding the bases of said contact devices in engagement with said sheet.

69. In an automatic switch of the crossbar type, a plurality of sets of contacts arranged in vertical superimposed alignment, a guide extending parallel to said sets of contacts, a plurality of contact actuators arranged for coaction with said guide and having means for actuating said sets of contacts, a rod extending through all said actuators, a spring in each actuator associated with said rod, means for causing the spring in any selected actuator to grip said rod, and means for moving said rod longitudinally to move the selected actuator relative to said guide to actuate the associated set of contacts.

70. In an automatic switch of the crossbar type, a plurality of groups of vertically extending contacts, a vertically movable contact actuator for each of said contact groups which is adapted upon vertical displacement thereof to operate all contacts in the associated group, a movable rod associated with each of said actuators, a spring associated with each of said rods, means for causing the spring of any selected actuator to grip its associated rod, and means for simultaneously moving all said rods to move the selected actuator so as to operate the contacts of its associated contact group.

JAMES M. BLACKHALL.