Dec. 18, 1923. 1,478,086

S. B. WILLIAMS, JR

TELEPHONE EXCHANGE SYSTEM

Original Filed April 17, 1918 7 Sheets-Sheet 1

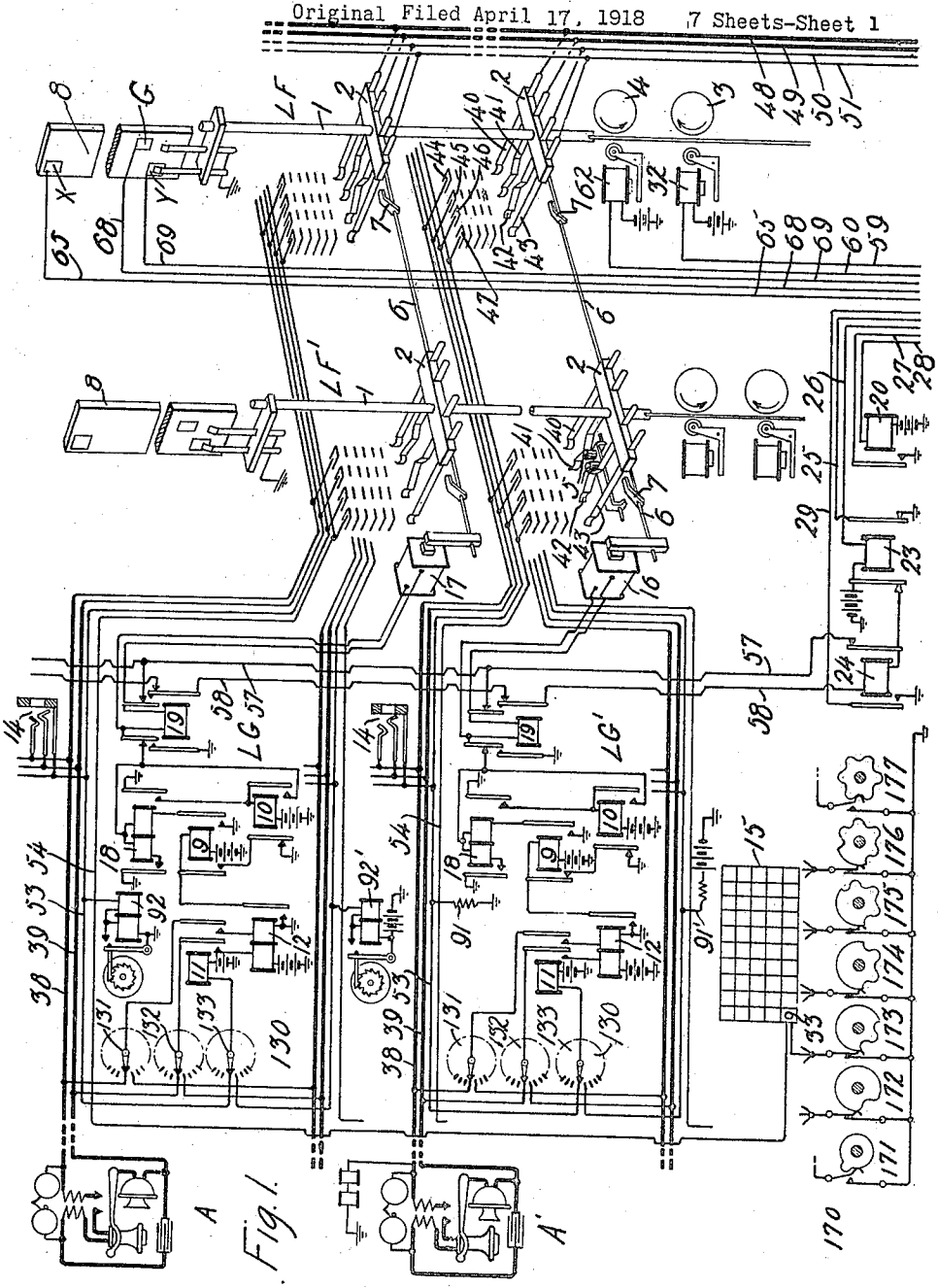

Fig. 1.

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TELEPHONE EXCHANGE SYSTEM

Original Filed April 17, 1918 7 Sheets-Sheet 2

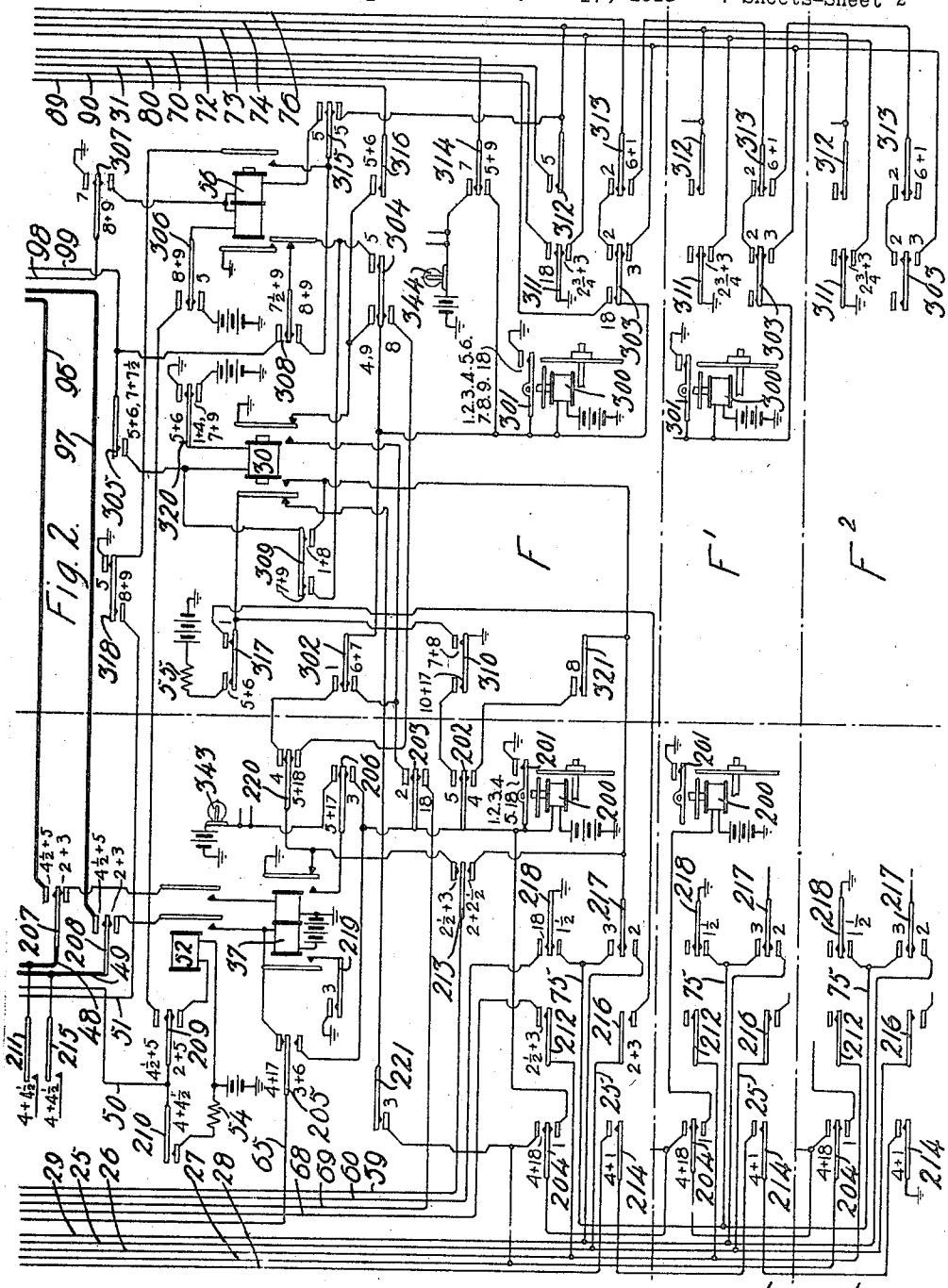

Fig 2.

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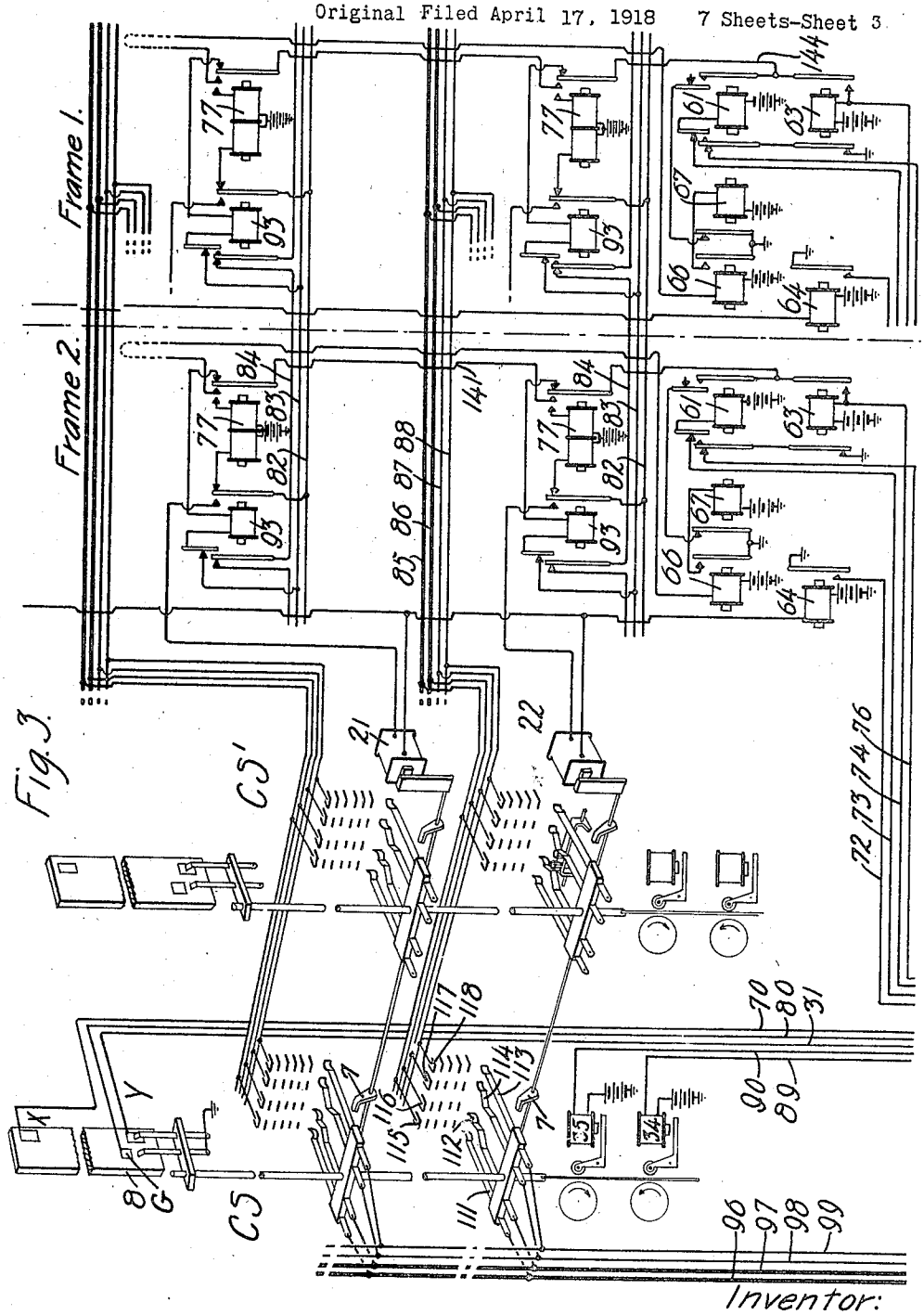
TELEPHONE EXCHANGE SYSTEM

Original Filed April 17, 1918 7 Sheets-Sheet 3



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TELEPHONE EXCHANGE SYSTEM

Original Filed April 17, 1918 7 Sheets-Sheet 4

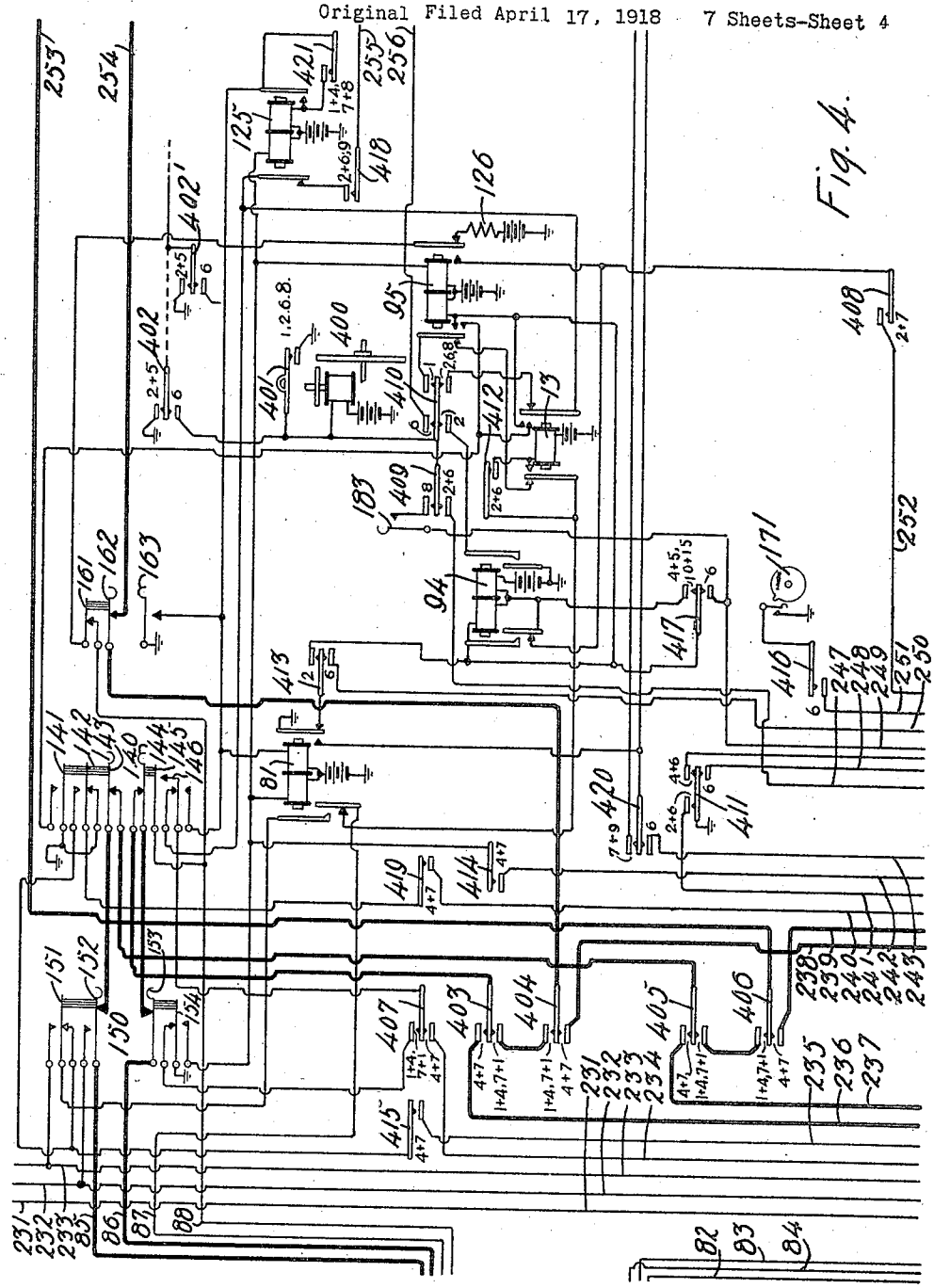

Fig. 4.

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TELEPHONE EXCHANGE SYSTEM

Original Filed April 17, 1918 7 Sheets-Sheet 5

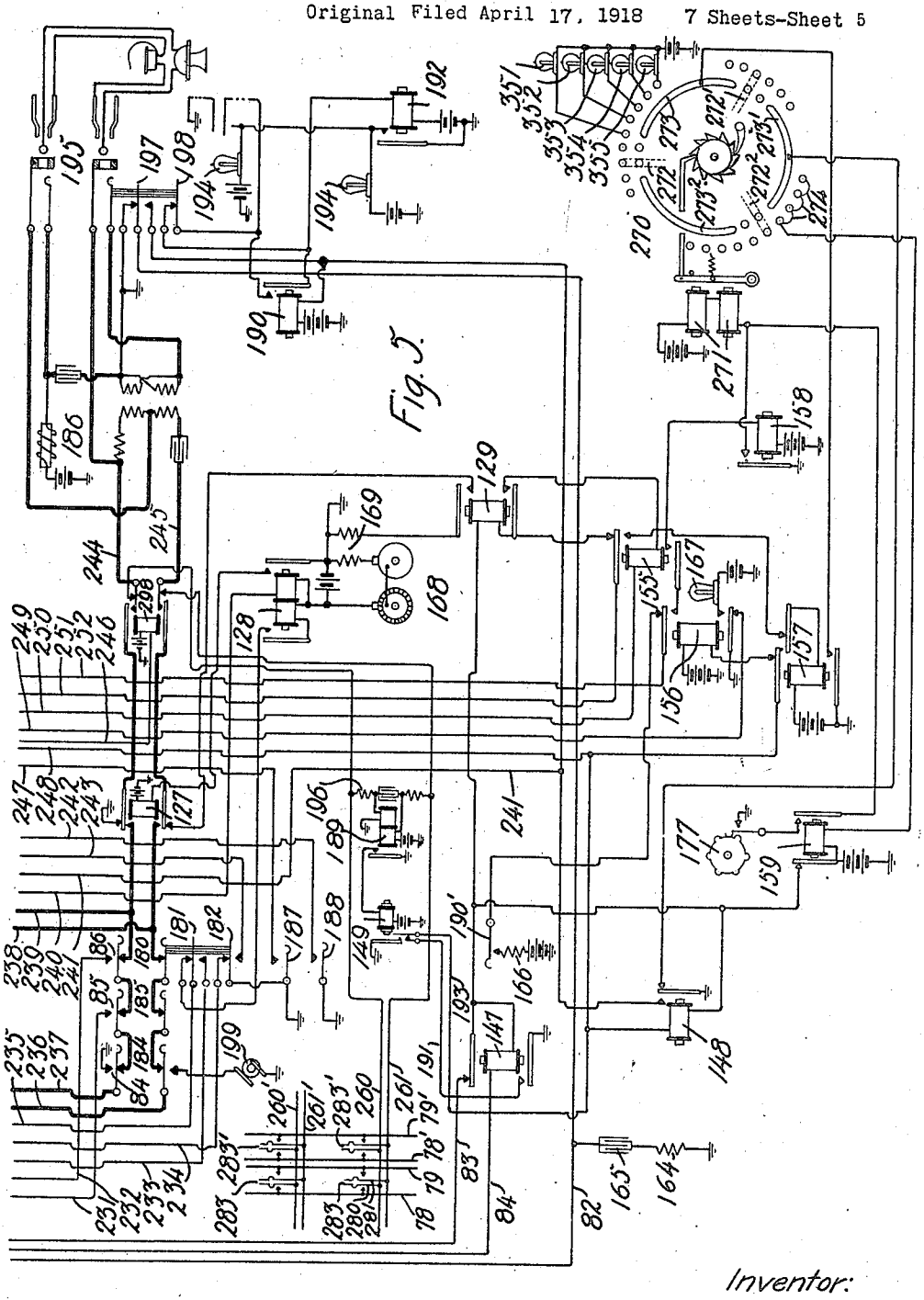

Fig. 5.

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Dec. 18, 1923. 1,478,086

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TELEPHONE EXCHANGE SYSTEM

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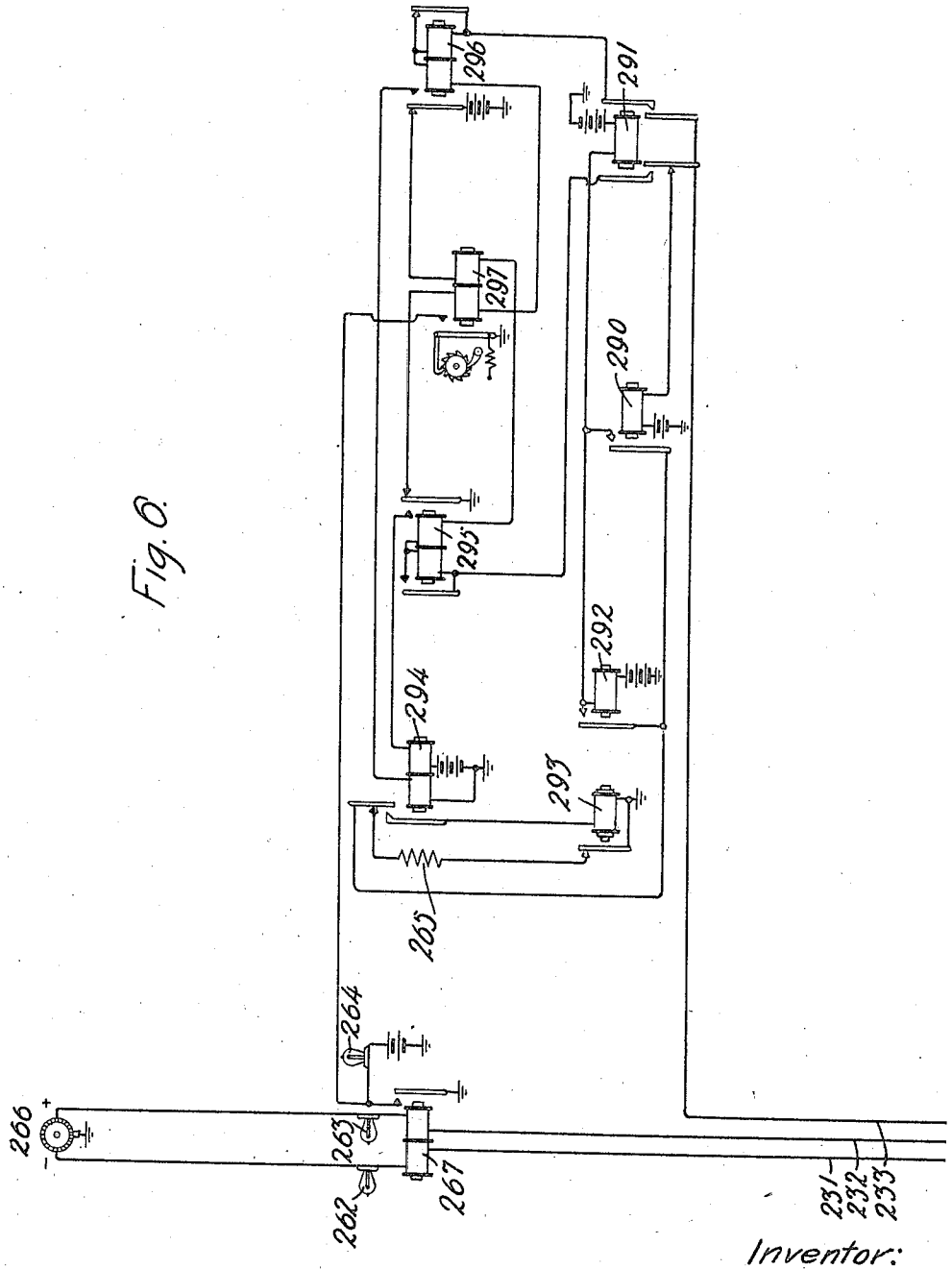
Fig. 6.



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TELEPHONE EXCHANGE SYSTEM

Original Filed April 17, 1918 7 Sheets-Sheet 7

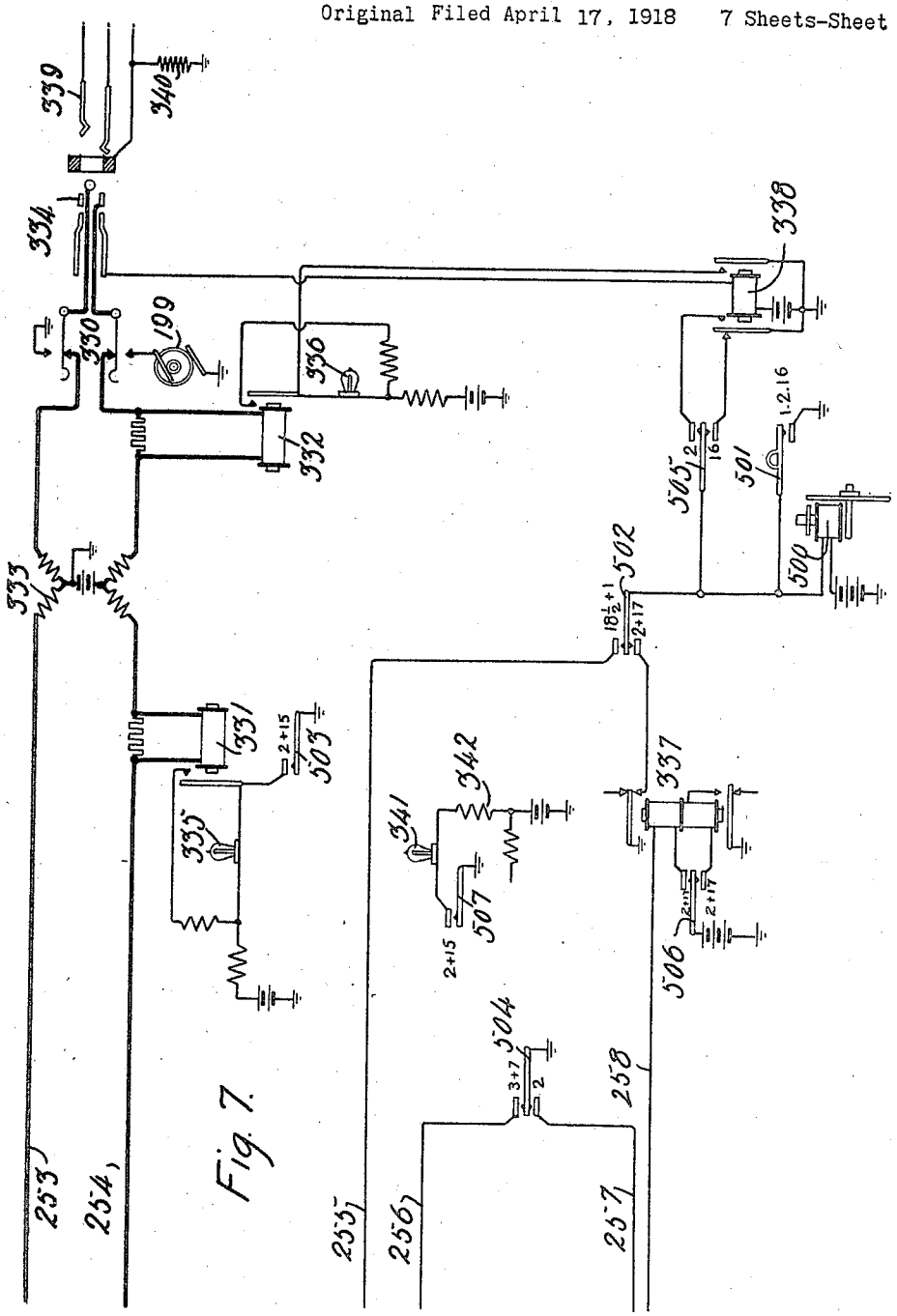

Fig. 7.

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Patented Dec. 18, 1923. 1,478,086

UNITED STATES PATENT OFFICE.

SAMUEL B. WILLIAMS, JR., OF BROOKLYN, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Original application filed April 17, 1918, Serial No. 229,035. Patent No. 1,400,120, dated December 13, 1921. Divided and this application filed May 14, 1921. Serial No. 469,493.

To all whom it may concern:

Be it known that I, SAMUEL B. WILLIAMS, Jr., a citizen of the United States, residing at Brooklyn, in the county of Kings, State of New York, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to improvements in telephone exchange systems and has particular reference to systems of the type employing automatic switches for distributing calls from telephone lines to the connecting circuits of operators' positions.

The invention herein described and claimed is a division of Patent No. 1,400,120, issued December 13, 1921.

An object of the invention is to provide a system wherein an operator has means for applying current to a connecting circuit for operating toll devices associated with calling lines, only when said circuit is connected to said lines and wherein one toll-device-operating key is arranged to effect the actuation of the toll device and then cause disconnection of the calling line, while another key is arranged to operate the toll device and maintain connection with the calling line.

Other objects to which the invention is directed will appear in the course of the following description when taken in connection with the accompanying drawings which illustrate what is now believed to be a preferred embodiment of the inventive idea.

In the drawings, Figs. 1 to 7, inclusive, taken together, and arranged side by side in the manner indicated by the lines that extend to the margins of the drawings illustrate as much of the complete organization of the system as is necessary to enable the construction and mode of operation to be understood.

Two telephone lines are indicated in each of the two groups LG and LG′ shown in Fig. 1, it being understood that each group may comprise a number of such lines. The ordinary practice is to give the finder-switch brushes access to the terminals of 500 lines, these lines being divided into ten groups of 50 lines each. Each of the groups of lines have associated with it a distributor switch 130 to the stationary contact terminals of which the lines of that group extend, the brushes of the distributor switch being connected with group apparatus which is actuated by the passage of the brushes over the terminals of a calling line. For a more complete understanding of the switch 130, reference is made to the above-mentioned pending application. Each of the lines has associated with it at the central office, a connection register 92 or a resistance coil 91. Each line is also provided with one or more spring-jacks 14 by means of which connection may be made with the line when it is called. The lines represented as calling lines in Fig. 1 and the line indicated as a called line in Fig. 7, may be lines of the same sort, similarly equipped and located at the same exchange; or the lines may be located at different offices. Each of the lines of the various groups is connected with a class-of-service interrupter 170, which may be common to the exchange; and each of the lines also has connection with and is represented by a lamp on a common lamp board 15.

The groups of lines have access to groups of connecting circuits through the medium of finder circuits F, F′ and F². These finder circuits terminate upon the brushes of pairs of finder and selector switches, of which two sets, LF and CS and LF′ and CS′, are shown. The starting of the finder switches to find the calling lines is effected by the distributor-switch apparatus through the medium of starting apparatus, including the relays 20, 23 and 24, which is common to all of the line groups and to all of the finder circuits having access to the lines of these groups. Each of the groups of connecting circuits, to which the lines of the various groups have access by way of the finder circuits F, F′ and F², is associated with a particular operator's position. The apparatus of only one position is shown, the others being similarly equipped. Each operator's position is provided with a number of plug-terminated connecting circuits extending to multipled groups of terminals upon the cord selector switches; and the brushes of each cord selector switch are given access to the terminals of a number of such groups of connecting circuits. Only one of the connecting circuits is shown com-

plete, the other connecting circuits in the associated group and in the other groups being similarly organized and connected. The multiple connection of the connecting circuit with the terminals of the cord selector switches are shown in the case of the connecting circuit that is completely illustrated and in the case of a single connecting circuit that is indicated in another group; and in like manner the multiple connections of the telephone line with the terminals of the line-finder switches are shown in the case of the lines that extend from stations A and A'. The multiple connections that exist between corresponding sets of switch terminals in the case of the other connecting circuits and telephone lines are omitted in order to simplify the drawing.

A number of groups of cord-selector switches, like the group illustrated in Fig. 3, may have access to the same groups of connecting circuits and their corresponding operators' positions. This is indicated in Fig. 3. Each of the groups of cord-selector switches has associated with it certain selection-controlling apparatus, that associated with the cord selectors shown in Fig. 3, appearing under the caption "Frame 2," and that associated with another group of cord-selector switches appearing under the caption "Frame 1." The selection-controlling apparatus for each frame or group of cord-selector switches comprises a pair of relays 77 and 93 for each group of connecting circuits or operator's position, to which the cord selector has access, and a group of relays 61, 63, 64, 66 and 67 common to all of the first-mentioned groups.

Each of the operators' positions is provided with apparatus which is common to all of the connecting circuits of that position, and which may be brought into association with any of the connecting circuits either automatically in the extension of a call to one of the connecting circuits, or at the will of the operator in the course of her supervisory operations. The operator's common or position apparatus is illustrated on Fig. 5 and Fig. 6, and each of the connecting circuits with which the operator's position is equipped may have connection with the position apparatus in the same way in which the connecting circuit illustrated in Fig. 4 is shown to have connection with this apparatus.

The line finder switches LF and LF' and the cord selector switches CS and CS' may be substantially like the switch illustrated and described in Patent No. 1,177,044 to James L. McQuarrie, issued March 28, 1916. The line finder and cord selector switches are alike in all substantial respects. Each comprises a longitudinally movable shaft 1, carrying as many sets of brushes 2 as there are groups of stationary terminals to be engaged. To move the shaft up, an extension at the lower end of the shaft is brought into engagement with the constantly rotating power member 3 by means of an idler wheel operated by the up-drive magnet 32; and to move the shaft down, the extension is brought into engagement with the power member 4 by means of an idler wheel operated by the down-drive magnet 62. Normally, the brushes of each of the sets 2 are held apart so as to clear the associated terminals by means of a separating cam 5 located between the innermost brushes of the set. The cam 5 is rotatably mounted, and when rotated in one direction, releases the brushes and permits them to engage the associated terminals. The tripping or releasing of the brushes is controlled by a number of trip magents, as 16 and 17. Each of these when energized, rotates an associated trip rod 6 that extends transversely to the switch shafts 1 and carries as many trip yokes 7 as there are finder switches or selector switches in the group. The trip rod in rotating brings all of its trip yokes 7 into position to operate the brush-controlling cams 5 of the corresponding sets of brushes on all of the switches, so that whichever of the finder switches is caused to move up, has that set of brushes tripped that corresponds with the particular trip magnet 16, 17, that is at the time energized. When the finder switch that has been in use is returned to its normal position, any of the associated controlling cams 5 that has been tripped, is engaged and rotated in a reverse direction to separate its switch springs again and thus render them inactive. Each of the line finder and cord selector switches has associated with it, a commutator 8 which comprises a number of stationary commutator segments and a set of movable brushes carried at the top of the switch shaft 1 and cooperating with the stationary segments. This commutator serves to make and break a number of the controlling circuits in the various stages of the upward movement of the switch shaft.

For controlling the circuits of the organization, there are employed a number of sequence switches which are shown at different points and designated 200, 300, 400 and 500 respectively. These sequence switches may be of the type disclosed in Patent 1,127,808, issued February 9, 1915 to Reynolds and Baldwin. Each consists of an electromagnetically controlled motor or driving mechanism and a number of associated switch cams. The switch cams, associated with each of the sequence switches 200 are designated 201 to 221 inclusive; those associated with each of the sequence switches 300 are designated 301 to 321 inclusive; those associated with each of the sequence switches 400 are designated 401 to

421 inclusive; and those associated with each of the sequence switches 500 are designated 501 to 507 inclusive. To each of the contacts associated with the various sequence switch cams are applied certain numerals. These numerals in the case of the cams 201, 301, 401 and 501 indicate the only positions of the associated sequence switch in which these particular contacts are open; the numerals applied to all of the other contacts of each sequence switch indicate the only positions of the particular sequence switch in which the associated contacts are closed.

The resting positions of the different sequence switches, and the stages of operation with which these positions are associated, are as follows:—

Finder sequence switch 200.

1 Normal.
2 Awaiting starting circuit.
3 Hunting.
4 Awaiting selector sequence switch.
5 Talking.
18 Finder switch return.

Selector sequence switch 300.

1 Normal.
2 Awaiting preceding circuit.
3 Awaiting setting of operator's selecting circuit.
4 Pass by.
5 Awaiting release of operator's selecting circuit.
6 Hunting connecting circuit.
7 Awaiting listening key sequence switch.
8 Awaiting finder sequence switch.
9 Talking.
18 Selector switch return.

Listening key sequence switch 400.

1 Normal.
2 Awaiting finder circuit.
6 Listening in.
8 Listening out.

Calling cord sequence switch 500.

1 Normal.
2 Awaiting connection.
16 Talking.

The class-of-service interrupter comprises a number of sets of switch springs operated by the cams 171 and 177, inclusive. Each of the sets of switch springs associated with cams 172 to 176, inclusive, consists of two springs the contacts of which are normally in engagement. Each of the two sets associated with the cams 171 and 177 consists of two springs the contacts of which are normally open. The cams 172 to 176, inclusive, are so formed as to cause one, two, three, four and five breaks per revolution respectively in the normally closed circuits controlled by the associated sets of switch springs. The cams 171 and 177 are so formed as to cause one closure per revolution and six closures per revolution, respectively, in the circuits controlled by the associated switch springs. The cam 171 and its associated switch springs control the production of the pick-up impulses, the cam 177 and its associated switch springs control the production of the reset impulses, and the cams 172 to 176 and their associated switch springs control the production of the class-of-service impulses, as will be described hereinafter.

For a complete description and understanding of the class-of-service switch shown diagrammatically in the lower right hand corner of Fig. 5, reference is made to the above-mentioned parent application.

In outline, the operation of the system in the embodiment disclosed is as follows:— When a subscriber calls, the passage of the brushes of the distributor switch 130 over the terminals of the calling line records the call in the distributor apparatus of the associated group, and this recorded call causes the closing of the starting circuit common to all of the distributor groups and to all of the line-finder switches that serve these groups, and also causes the energization of the finder switch trip magnet corresponding to the groups of lines in which the calling line is located. If the starting circuit is at the time being used by some other calling line, the recorded call is held until the starting circuit is freed. As soon as the call is discharged into the starting circuit, the distributor apparatus is released and made available for recording another call in the same group.

The finder switches each have as many sets of brushes as there are groups of lines. The closing of the starting circuit causes a preselected one of the finder switches to move its brushes, and the energization of the trip magnet makes active the set of brushes corresponding with the group in which the calling line is located. The apparatus which brings about the energization of the trip magnet operates to prevent temporarily the trip magnets of other groups of lines from being energized by calls that may at the time be initiated in the other groups.

As soon as the brushes of the finder switch are tripped another finder switch is brought into operative relation with the starting circuit, and the starting circuit is released and made available for the use of calling lines in groups other than the group in which the first-mentioned calling line is located. When the new finder switch is connected with the starting circuit, any other finder switch is prevented from being brought into operative relation with the starting circuit, so that the starting circuit

has control over only one finder switch at a time.

When the brushes of the started finder switch complete connection with the terminals of the calling line, the finder circuit operates certain apparatus that determines to which of a number of operators' positions the connection of the calling line is to be extended. The selection of the operator's position is effected through the medium of selection-controlling apparatus that is common to the cord selector switches upon which the finder circuits terminate, and to the operators' positions to which these cord selector switches are designed to extend calls. The selection-controlling apparatus is continuously under the control of the operators' positions, and keeps a path prepared for energizing the trip magnet representing the first available position in the series. The finder circuit that is extending the call sends a tripping impulse over the path thus prepared, and when the tripping magnet operates, the upward movement of the cord selector switch is started. At the outset of this movement the set of brushes is tripped that corresponds with the preselected operator's position, and immediately thereafter the common selection-controlling apparatus is released and made available for controlling the selection of other operators' positions by other cord selector switches and finder circuits. During this selecting operation, the setting of the selection-controlling apparatus is maintained, so that the tripping impulse is prevented from passing to the trip magnet of some other position which in the interval may have become available. If all of the operators' positions should be unavailable at the moment the finder circuit is ready to extend the connection, the finder circuit is held and the availability of the operators' position is periodically tested by the selection-controlling apparatus until one of the positions becomes accessible, when the operation is proceeded with.

After the set of cord selector brushes has been tripped, it continues its upward movement, successively engaging the terminals of the connecting circuits located at the operator's position that has been selected, and steps upon the terminals of the first connecting circuit encountered that is idle and available for use. If for any reason, the brushes should fail to be stopped upon the terminals of a connecting circuit, the cord selector switch is returned to its normal position, and the selecting operation is then repeated.

Prior to the extension of the connection to the connecting circuit, and at the instant that the operator's position is selected and the corresponding trip magnet energized, a signal is displayed at the operator's position which notifies the operator that her position has been selected and that a call is coming. At the same instant, a by-path is closed that puts the operator immediately into telephonic communication with the calling subscriber, and the listening-in keys associated with all of the connecting cords of the position are rendered inoperative so that the operator cannot interfere with the coming call by listening in on a cord circuit after the position has been selected and before the call arrives. The operator's position at the same time is made inaccessible to other incoming calls.

When the cord selector switch stops on the terminals of the selected connecting circuit, it lights a lamp associated with that circuit at the operator's position, and substitutes a direct path to the operator's telephone for the by-path that was closed when the position was selected. At the same time, impulses pass from the subscriber's line to class-of-service signal mechanism at the operator's position, which mechanism is thus operated to inform the operator of the class of service which the calling line is adapted to receive. When the class-of-service signal is displayed, the calling signal, that first notified the operator that her position had been selected, is withdrawn, and means for enabling the operator to inform herself of the identity of the calling line is made operative. The operator's control over the listening keys has in the meanwhile been restored so that she may, if she desires, listen in on any other connection.

When the operator has received the calling subscriber's instructions she tests the line that is called for and, if it is free, inserts the calling plug into the called line spring-jack. This act automatically brings about the disconnection of the operator's telephone apparatus from the circuit and the restoration of the class-of-service signal mechanism, the operator's position being rendered unselectable and the class-of-service mechanism being prevented from being brought into operative relation with any connecting circuit while the restoration is being effected.

When the subscribers have finished their conversation, the operator effects disconnection by pressing the disconnect key and withdrawing the calling plug. If the calling line is a measured service line, the operator presses a key which registers the call on the line register and the position register upon the depression of the key and releases the connection upon the release of the key. This key is effective to apply register operating current to the connecting circuit only when the connecting circuit is extended to a calling line. If the calling subscriber wishes a second connection, the operator presses another key which registers the call on the line and position registers, but does not discon-

nect the calling line from the connecting circuit. Before performing the disconnecting or registering operations referred to above, the operator supervises by pressing her listening-in key, which act connects her telephone with the circuit and at the same time again actuates the class-of-service mechanism to guide her in making the charge or registration.

If the operator is unable for any reason to give the calling subscriber connection with the called line, she presses a holding key which maintains the connecting circuit in connection with the calling line, but withdraws the busy test from the line so that it may call and be called. By listening in on a called line thus held, the operator is given a busy test if the line is in use, the class-of-service signal mechanism under these circumstances not being operated. If the line is free when the operator listens in on the held connection, she may restore the holding key and proceed with the establishment of the connection in the usual way.

The features of the operation that have been set forth in outline in the foregoing, together with other features present in the system, will be fully explained in the detailed description that follows.

It will be assumed that the subscriber at station A takes his receiver from its switchhook. The brushes 131, 132 and 133 of the distributor switch 130 are constantly rotating, and thus are successively bringing the cut-in relay 11 and the test relay 12 into temporary association with the various lines of the line group LG which the distributor switch 130 serves. If a line is in use either as a calling line or as a called line, its sleeve conductor 53 is connected through relatively low resistance with battery of the same potential as that to which the winding of the cut-in relay 11 is connected, as will hereinafter be explained. Consequently, when the distributor brush 133 engages the sleeve terminal of such line, the cut-in relay 11 remains inert. But when the distributor brush 133 engages the sleeve terminal of a line that is not in use, an energizing path is closed for cut-in relay 11 by way of the brush 133 and the sleeve resistance 91, or the message register 92 associated with that line. The test relay 12, therefore, is connected with the two line conductors 38 and 39 of each line that is not in use, and when it is thus connected with the conductors of the line extending to station A, at which the telephone receiver has been removed from its switchhook, the test relay 12 attracts its armature and closes a circuit that extends from battery through the winding of relay 9 to ground by way of the front contact and armature of relay 12. Relay 9, in operating, closes a locking circuit for itself by way of its left-hand front contact and armature and the left-hand back contact and armature of relay 10. The distributor brushes do not stop upon the terminals of the calling line, but continue their rotation, the effect of their engagement with the calling line terminals being in effect to record the call by energizing and locking up the relay 9.

The effect of recording the call upon the relay 9 is to cause the starting of one of the finder switches LF, LF′, etc., which serve the lines of this and the associated line groups. This is accomplished through the medium of a starting circuit, two of the conductors 57 and 58 of which are extended to the relays 19 of the various line groups LG, LG′, etc. Assuming that the starting circuit is not in use at the time the call is recorded on the relay 9 of the line group LG, the operation of this relay closes a circuit that extends from battery through the left-hand armature and back contact of relay 23, right-hand armature and back contact of relay 24, conductor 57, right-hand resting contact and switch spring relay 19 of group LG, the windings of relay 19 and the associated trip magnet 17 in parallel, left-hand switch spring and resting contact of relay 19, right-hand winding of relay 18, and right-hand front contact and armature of relay 9 to ground. The closure of this circuit causes relay 18 to operate; and in operating relay 18 closes at its left-hand front contact and armature a shunt path by way of its left-hand low resistance winding to ground that sufficiently increases the current flow in the circuit to bring about the operation of the relay 19 and its associated trip magnet 17, the relatively high resistance of the right-hand winding of the relay 18 preventing the relay 19 and its associated trip magnet from being operated at the initial closure of the circuit. Relay 19, in operating closes a circuit that extends from battery by way of the left-hand armature and back contact of relay 23, winding of the starting relay 24, conductor 58, the right-hand armatures and resting contacts of other relays 19 in the series, right-hand armature and switch spring of the relay 19 of group LG, the windings of relay 19 and associated trip magnet 17 in parallel, and the left-hand switch spring and armature of relay 19 to ground. The closure of this circuit operates relay 24 and the trip magnet of line group LG to start a line-finder switch and trip the brushes of that switch correspond with the line group in which the calling line is located, as will hereinafter be described. This circuit is maintained and the trip magnet 17, starting relay 24, and group relay 19 held energized until the relay 23 is actuated at a later stage of the operation, as will be described.

When the recorded call has thus brought about the energization of the starting and

brush-tripping circuit, the call recording apparatus including the relays 18, 9 and 10 is disconnected from the starting circuit and the record obliterated by the releasing and return of these relays to their normal condition. When the recording apparatus obtains access to the starting circuit, the operation of the relay 18 not only brings about the energization of the starting and tripping circuit by closing at its left-hand front contact and armature the low resistance path to ground; but it also closes a circuit that extends from battery through the winding of relay 10, and the right-hand front contact and armature of relay 18 to ground. The closure of the circuit causes relay 10 to open, at its left-hand back contact and armature, the locking circuit of the relay 9. Relay 9 in releasing opens at its right-hand front contact and armature, the path to ground by way of the right-hand or high resistance winding of the relay 18. Relay 19, in operating, has opened at its left-hand switch spring and resting contact, the main energizing circuit of the relay 18. Relay 18, therefore, releases, and in doing so, opens at its right-hand front contact and armature, the energizing circuit of the relay 10, which relay thereupon releases. Thus the relay 18, 9 and 10 of the recording apparatus are returned to normal and are in readiness to respond to another calling line.

It will be observed that when the relay 10 operates, it closes a locking circuit for itself that extends by way of its right-hand front contact and armature, right-hand winding of relay 18, and right-hand front contact and armature of relay 9 to ground. This is for the purpose of inserting a continued interruption of the locking path for relay 9, at the left-hand back contact and armature of relay 10, until the relay 9 is released. Otherwise it might happen that if the momentary operation of the relay 18, which operates relay 10, had occurred before the distributor brushes had passed beyond the calling line terminals and thus opened the initial energizing circuit of the recording relay 9, the recording relay would remain locked up and again energize the starting and tripping circuit as soon as that circuit again became available.

As the distributor switch brushes leave the terminals of the calling line, the test relay 12 is released. If in the meanwhile the call has been transferred to the starting circuit, in the manner described, the locking circuit of the recording relay 9 has been opened at the contacts of the relay 10, and the breaking of the initial energizing path of the relay 9 at contacts of the test relay 12 permits the relay 9 to release. The recording apparatus is therefore immediately in condition to respond to another calling line of the group, even though that line be the one whose terminals immediately adjoin the terminals of the line to which the apparatus has just responded. In this case the recording relay 9 is again locked up by the response of the test relay 12 as soon as the terminals of the second calling line are engaged, and remains locked up to bring about the energization of the starting circuit and the starting of another finder switch just as soon as the starting circuit is released and again made available by the operation of the relay 23, as will hereinafter be described. As long as the starting circuit is in use, the call in effect is stored in the recording relay 9, and is made effective to start a finder switch as soon as the availability of the starting circuit is restored.

As has been described, the appropriation of the starting circuit by an incoming call is accompanied by the operation of the relay 24, and the relay 24, in operating, disconnects the conductor 57 from ground. As it is over this path to ground that the initial energization of any of the relays 19 is effected, the calling lines of the other groups are deprived of control over their associated relay 19 and trip magnets until the starting relay 24 is returned to normal. If a line in another group, say group LG′, calls while the starting relay 24 is serving the calling line of group LG, the recording relay 9 of that other group is locked up and holds closed a path to ground from conductor 57 that includes the windings of the associated relay 19 and trip magnet 16 in parallel and the right-hand winding of the associated relay 18. When the starting relay 24 has performed its function in connection with the calling line of group LG and releases its armatures, the path by way of conductor 57 is completed for the energization of the relays 18, 19 and 10 and the trip magnet 16 of group LG′, in the manner that has been described in connection with the operation of these parts in group LG.

If calling lines in several groups are awaiting the starting relay 24, the recording relays 9 of these groups being locked up as a result of the momentary operation of the associated relays 12 as the distributor switch brushes pass over the terminals of the calling lines, the group, which is closest electrically to the starting relay 24, will have its trip magnet operated and will take possession of the starting circuit. The reason for this is that the conductor 58 that includes the winding of the starting relay 24, and over which the continued energization of the relay 19 and associated trip magnet is effected, passes serially through the right-hand armature and resting contact of each of the relays 19, so that the relay 19 that is closest electrically to the relay 24 interrupts the path of the conductor 58 to the more remote relays of the series.

When the relay 19 of a group is energized by its seizure of the starting relay 24, it releases the associated relay 9, as has been described, and thus again renders the relay 9 subject to the momentary operation of the test relay 12 as the brushes of the distributor switch 130 pass over the terminals of the lines of that group. In order to prevent the calling line from starting more than one line finder switch, the time required for the distributor brushes to complete a cycle of their rotation is so regulated that the calling line will have been seized by a finder switch, and thus deprived of its power to control the test relay 12, before the distributor brushes have again moved into position to engage the terminals of that line.

The starting of a line finder switch when the common starting relay 24 is energized is effected by the closure of a circuit that extends from battery by way of the updrive magnet 32 of whichever of the line finder switches LF, LF′, etc., is next in order to be started, conductor 59, line finder sequence switch contact 213 (2 to 2½), line finder sequence switch contact 217 (2), conductor 29, and left-hand armature and front contact of the starting relay 24 to ground. At the same time another circuit is completed from battery by way of the cord selector sequence switch contact 320 (1 to 4) winding of relay 30, selector sequence switch contact 309 (1 to 8), finder sequence switch contact 217 (2), and thence to ground by way of conductor 29 and the left-hand armature and front contact of starting relay 24. Relay 30, in operating, closes a circuit that extends from battery through the motor magnet and contact 203 (2) of the finder sequence switch, and right-hand front contact and armature of relay 30 to ground. The closure of this circuit moves the finder sequence switch 200 out of position 2. Relay 30, in operating, also closes a locking circuit for itself that extends from battery by way of selector sequence switch contact 320 (1 to 4), winding of relay 30, selector sequence switch contact 309 (1 to 8), left-hand front contact and armature of relay 30, selector switch contact 317 (1), finder sequence switch contact 216 (2 to 3), conductor 25 and the right-hand back contact and armature of relay 23 to ground.

When the finder sequence switch moves from position 2 to position 3, it closes a circuit from battery through the winding of updrive magnet 32, conductor 59, finder sequence switch contact 213 (2½ to 3) and the left-hand back contact and armature of test relay 37 to ground, that places the continued energization of the updrive magnet 32 under the control of the test relay 37. The test relay 37 is energized to open the circuit of the updrive magnet 32 and stop the upward movement of the finder switch brushes when the terminals of the calling line are engaged, as will hereinafter be described.

At the outset of the upward movement of the elevator rod 1 of the line-finder switch as a result of the energization of the updrive magnet 32, all of the brush trip levers are moved past the corresponding trip yokes 7. The only trip magnet that is energized in this case is the magnet 17 which corresponds with the group LG in which the calling line is located; and consequently the only trip yoke in position to engage a trip lever on the elevator rod is the one which controls the brushes 40, 41, 42 and 43 that are adapted to engage the terminals of that particular group of lines. This set of brushes, therefore, is released and made operative, and the other sets are held clear of their associated line terminals.

As soon as the set of brushes corresponding with the group in which the calling line is located is tripped, the group apparatus, by means of which the lines control the brush tripping and line finder starting operations, may be returned to its normal position. This is effected by the closure of a circuit which extends from battery by way of the winding of relay 23, conductor 26, finder sequence switch contact 212 (2½ to 3), conductor 68, and segment G of the line-finder commutator and its corresponding brush to ground. As a result the closure of this circuit which is timed to occur an instant after the brushes are tripped, and before they engage the line terminals in the upward movement of the elevator rod, relay 23 is energized to open, at its left-hand armature and back contact, the circuit by way of conductor 58 that up to this time has been holding the starting relay 24 and the trip magnet 17 and associated relay 19 energized. When, an instant later, the relay 23 is deenergized by the ground brush disengaging the commutator segment G, the group or starting circuits are again rendered responsive to a calling line.

When relay 23 operates it also interrupts at its right-hand armature and back contact the previously-traced circuit that has maintained relay 30 of the finder circuit energized. That relay, in releasing its armatures, closes a circuit for moving the finder sequence switch 200 of some other finder circuit from its normal or first position to position 2 where it is in readiness to respond to the next operation of the starting relay 24. Assuming that the finder circuit F′, which may be assumed to be similar to the finder circuit F in its equipment, has its parts in their normal condition, this circuit may be traced from battery through the motor magnet 200 and contact 204 (1) of the finder circuit F′, finder sequence switch contacts 204 (4 to 18) of other finder circuits

similar to the circuits F and F' in their equipment, which may be assumed to be busy, and therefore to have their sequence switches in some position between position 4 and position 18 inclusive, finder sequence switch contact 221 (3) of finder circuit F, left-hand back contact and armature of relay 30, selector sequence switch contact 317 (1), finder sequence switch contact 216 (2 to 3), conductor 25, and right-hand back contact and armature of relay 23 to ground. Thus the passing of the G segment in the upward movement of the started finder switch restores the group and starting circuits, releases relay 30 of the associated finder circuit, and moves sequence switch 200 of another finder circuit into position 2 in readiness to respond to the next actuation of the starting relay 24.

Provision is made for moving the finder sequence switch of one of the finder circuits into position 2, and thus rendering the associated circuit responsive to the starting relay, when all of the finder circuits are idle and have their finder sequence switches standing in position 1, or when all of them are busy and one is released to permit its finder sequence switch to return to position 1 while the sequence switches of all of the others are in some position between 4 and 18 inclusive. This is accomplished through the medium of the relay 20, which has its energizing circuit completed by way of conductor 28 and the series of finder sequence switch contacts 214 (4 to 1) to ground at the end of the series. When this condition of the series of finder sequence switches exists, relay 20 is energized and closes a circuit that extends from the 204 cam series of all of the finder sequence switches to ground by way of conductor 27 and the front contact and armature of relay 20. The closure of this path to ground energizes the motor magnet of one of the finder sequence switches 200 by way of the cam 204 (1) of the associated sequence switch to move that switch to position 2.

The condition that is now assumed to exist is one in which the line finder switch LF is moving up with its set of brushes corresponding with line group LG tripped, in which the trip magnet 17 and relay 19 of that line group and the common starting relay 24 have been returned to their normal condition, and in which the finder sequence switch of another finder circuit F' has been moved to position 2 in readiness to respond to the next operation of the starting relay. As the tripped brushes rise they come into engagement consecutively with the sets of terminals corresponding with the different lines of the group. At the instant of engagement of the brush 42 with the corresponding line terminal 46 of each line, a circuit is closed that extends from low potential battery by way of the relay 52, sequence switch contact 209 (2 to 3), conductor 50, brush 42, line terminal 46, conductor 53, and windings of message register 92 or resistance 91 to ground in the case of certain of the lines or by way of windings of message register 92' or resistance 91' to high potential battery in the case of other of the lines.

In case a line is busy either as a calling line or as a called line, a path to low potential battery exists from conductor 53, as will hereinafter appear, that serves to shunt the relatively high resistance relay 52 and prevent its operation. If a line over the terminals of which the brushes are passing is not busy, the relay 52 is operated and in attracting its armatures closes a circuit that extends from battery through the left-hand winding of the relay 37, inner armature and front contact of relay 52, sequence switch contact 208 (2 to 3), conductor 49, brush 41, line terminal 45, conductor 39 to one limb of the telephone line, thence by way of the path controlled in contacts of the substation switchhook to the other limb of the line, conductor 38, terminal 44, brush 40, conductor 48, sequence switch contact 207 (2 to 3), outer front contact and armature of the relay 52, and right-hand winding of the relay 37 to ground. The circuit traced above is not completed until the finder switch brushes engage the terminals of the calling line, as the calling line is the only line that has its telephone receiver off the hook, and at the same time is not connected with either by some other line finder or by a connecting circuit calling plug. The completion of this circuit energizes the relay 37 and causes that relay to interrupt at its right-hand back contact, the circuit by way of the finder sequence switch contact 213 (2½ to 3) and conductor 59 which up to this time has been keeping the updrive magnet 32 energized and causing the upward movement of the switch brushes. Therefore, the operation of the relay 37 upon the finding of the calling line acts to effect the instant deenergization of the updrive magnet 32 and thus to stop the brushes on the terminals of the calling line.

Relay 37, in operating, also closes a locking circuit for itself by way of its left-hand front contact and armature and finder sequence switch contact 219 (3) to ground. It also completes a circuit that extends from battery through the motor magnet and contact 206 (3) of the finder sequence switch, and left-hand front contact and armature of relay 37 to ground. The closure of this circuit moves the finder sequence switch out of position 3.

Provision is made for preventing the

movement of the sequence switches 200 of more than one finder circuit into the 2 or waiting position in case an intermediate finder circuit returns to its normal position before the started finder circuit has found the calling line and moved its sequence switch 200 out of position 3. As has been described, the passing of the G segment, by energizing and then releasing relay 23, applies ground by way of conductor 25, finder sequence switch contact 216 (2 to 3), selector sequence switch contact 317 (1), left-hand armature and back contact of relay 30, and finder sequence switch contact 221 (3), for moving out of its normal or 1 position the finder sequence switch of the next finder circuit in the series which is standing in that position. Let it be assumed that the finder sequence switch, which is thus moved out of position 1, is that which is associated with finder circuit F^2, the intermediate finder circuit F^1 being in use at the time and its finder sequence switch in some position between 4 and 18. Let it further be assumed that before the line finder switch of finder circuit F has found the calling line, and while its sequence switch 200 is still resting in position 3, the finder circuit F' is freed and its sequence switch 200 returned to normal. If under these circumstances the ground from the back contact of relay 23 should still be applied by way of the back contact of relay 30 and finder sequence switch contact 221 (3) of the finder circuit that is hunting for the calling line, the finder sequence switch of finder circuit F' would also be moved out of position 1 as soon as it was returned thereto, so that the finder sequence switches of circuits F' and F^2 would both be resting in their 2 or waiting positions, and the line finder switches of both circuits would be started in response to the next call. To prevent this, a common conductor 75 is provided, this conductor having a branch which connects with the finder sequence switch contacts 218 (1½) and 217 (3) of each of the finder circuits of the group. As a result, when the sequence switch 200 of finder circuit F^2 is moved out of position 1 in response to the passing of the G segment of finder circuit F as the line finder switch starts up, it closes a circuit that extends from battery through selector sequence switch contact 320 (1 to 4) of finder circuit F, winding of relay 30, selector sequence switch contact 309 (1 to 8), finder sequence switch contact 217 (3), conductor 75, and finder sequence switch contact 218 (1½) of finder circuit F^2 to ground. Relay 30 operates and locks up by way of the path which extends through its left-hand front contact and armature, selector sequence switch contact 317 (1), finder sequence switch contact 216 (2 to 3), conductor 25, and the right-hand back contact and armature of relay 23 to ground. Relay 30, therefore, breaks at its left-hand armature and back contact, the path over which ground from the back contact of relay 23 would otherwise be applied by way of finder sequence switch contact 221 (3) to move the sequence switch 200 of finder circuit F' out of position 1 as soon as the sequence switch of that circuit should return to that position. Relay 30 remains locked up to hold this path open until its locking circuit is broken at finder sequence switch contact 216 (2 to 3) by the movement of the finder switch out of position 3 upon the finding of the calling line. This same movement of the finder sequence switch also interrupts, at sequence switch contact 221 (3), the path for moving the finder sequence switch of any other finder circuit out of position 1. Therefore, the grounding of conductor 75 when any finder sequence switch is moved out of position 1, prevents the movement out of position 1 of any intermediate finder sequence switch whose finder circuit may be released while the finder sequence switch of the started finder circuit is resting in position 3.

In moving to position 4 upon the finder of the calling line, the finder sequence switch closes a circuit that extends from battery, by way of resistance coil 54 and sequence switch contact 210 (4 to 4½), to the sleeve conductor 50 of the finder circuit, and thence by way of the finder switch to the sleeve conductor 53 of the calling subscriber's line. This creates an electrical condition upon the line that prevents it thereafter from affecting the distributor test magnets 11 and 12, and that prevents it from being connected with by any other line. In moving to position 4 the finder sequence switch also closes a circuit that extends from battery through the motor magnet and contact 302 (1) of the selector sequence switch, contact 220 (4) of the finder sequence switch, and right-hand back contact and armature of relay 37 to ground. The closure of this circuit moves the selector sequence switch out of position 1 and into position 2.

The next stages of the operation of the system have to do with the selection by the finder circuit of an available operator's position. The selection of the operator's position is effected through the medium of an operator's selecting circuit that is common to all of the group of finder circuits of which the finder circuit F is one. Before the finder circuit F is given access to the operator's selecting circuit, it is necessary that the circuit shall have been set free by any other one of the group of finder circuits which may have been employing it.

The circuit that controls the movement of the selector sequence switch 300 out of posi-

tion 2 extends from battery, through the motor magnet and contacts 303 (2) and 313 (2) of the selector sequence switch, and thence by way of conductor 76 and the left-hand back contacts and armatures of the relays 61 and 63 of the operator's selecting circuit in series to ground. As will hereinafter be described, one or the other of the relays 61 and 63 is energized from the instant a finder circuit of the group obtains possession of the operator's selecting circuit until the selecting circuit has performed its function and has been released. Therefore, if the operator's selecting circuit is not in use by some other finder circuit of the group, the path traced above is closed, and as a result the selector sequence switch 300 of the finder circuit F moves out of position 2 and comes to rest on position 3.

It will be noted that the path to ground by way of conductor 76 and the resting contacts of relays 61 and 63, for moving the selector sequence switch out of position 2, is continued through the selector sequence switch contacts 303 (6 to 1) of all of the finder circuits in series. As a result, any of the selector sequence switches in moving into position 2 breaks, at its sequence switch contact 313 (6 to 1), the path of the conductor 76 to all of the selector sequence switch contacts beyond it in the series. Consequently, if there should happen to be two finder circuits awaiting access to the operator's selecting circuit, only the one closer electrically to the controlling relays 61 and 63 would be moved out of position 2 when the selecting circuit was released and the armatures of relays 61 and 63 retracted, the more remote finder circuit in the electrical series being obliged to wait until its energizing circuit is closed by the movement to position 6 of the selector sequence switch ahead of it in the series.

When the finder circuit F obtains access to the operator's selecting circuit by the movement of the selector sequence switch 300 into position 3, a circuit is closed that extends from battery through the winding of relay 61, the left-hand switch-spring and resting contact of that relay, conductor 73, and selector sequence switch contact 311 ($2\frac{3}{4}$ to 3) to ground. The relay 61 in operating closes a holding circuit for itself by way of its left-hand switch-spring and armature and the left-hand back contact and armature of relay 63 to ground. The relay 61 at the same time closes, at its right-hand switch-spring and armature, a circuit that brings about the selection of one of the operator's positions which happens at the time to be available, and the energization of the selector-switch trip magnet corresponding to that position.

The availability or unavailability of each of the various operators' positions is determined by the condition of the relay 77 associated with that operator's position in the operator's selecting circuit; and that in turn is determined by the condition of operator's position apparatus that marks whether or not the operator is at her position and in readiness to receive a call. The particular conditions upon which the energization or de-energization of the relay 77 depends will be described hereinafter. For the present, it will be sufficient to say that if the operator is not at her position, a circuit is completed that extends from battery through the left-hand winding of the associated relay 77 of the operator's selecting circuit, the right-hand back contact and armature of the associated relay 93, conductor 82, switch spring 197 and resting contact of the operator's telephone jack 195 to ground. If the operator is at her position, and the selecting apparatus has just operated to assign a call to that position, the path to ground for energizing the associated relay 77 is completed by way of conductor 82, switch spring 197 and alternate contact of the operator's telephone jack 195 and the right-hand front contact and armature of relay 148. If the operator is at her position, and the call assigned to that position has reached one of the connecting cord circuits, then the path to ground for the energization of the associated relay 77 is completed by way of switch spring 197 and alternate contact of the operator's telephone jack 195, conductor 241 and contact 411 (2 to 6) of the listening key sequence switch.

When the relay 61 of the operator's selecting circuit is operated, in the manner hereinbefore described, the attraction of its right-hand armature extends the conductor 141 to ground by way of the resting contact and armature of relay 67. The conductor 141 includes contacts of the entire series of relays 77 associated with the various operators' positions in the operator's selecting circuit. The arrangement is such that each relay 77 when unenergized extends the conductor 141 to the winding of the associated relay 93, and when energized extends the circuit of the conductor to the next relay 77 in the series. Assuming now that the first operator's position in the series is available when the relay 61 is operated, a circuit is completed that extends from battery by way of the left-hand armature and back contact of relay 159 (see Fig. 5), the upper armature and back contact of relay 147, conductor 83, left-hand back contact and switch spring of relay 93, winding of that relay, back contact and armature of associated relay 77, conductor 141, right-hand armature and switch spring of relay 61 and back contact and armature of relay 67 to ground. Relay 93 operates as a result of the closure of this

circuit, and in attracting its left-hand armature substitutes for the energizing path by way of the upper armature and back contact of relay 147 and conductor 83, a branch energizing path that extends by way of the winding of relay 147 and conductor 84 to the left-hand armature and switch spring of relay 93, and thence through the winding of relay 93 and to ground as already traced. Relay 147, in operating, opens at its upper armature and back contact, the path that extends in multiple branches from conductor 83 to the relays 93 associated with this particular operator's position upon the different switch frames, "Frame 1," "Frame 2," etc., that have access to this position. As the initial energization of the relays 93 associated with a particular operator's position on the various frames must be effected through the medium of the common conductor 83, the opening of this conductor at the upper back contact and armature of relay 147 instantly renders the position unselectable at any other cord selector frame. Also, the series relation that exists between the relays 93 of any operator's position with respect to the permanent energizing path 84 of these relays, assures that only one of the relays 93 will be permanently energized in case it is assumed that two calls originating in different frames attempt to gain access to the same operator's position at the same instant. In such a case, the operation of the relay 93 of the frame closer electrically to the relay 147 opens the path of the energizing conductor 84 to the relay 93 of the more remote frame.

When the relay 147 is energized as a result of the selection of the associated operator's position, in the manner described above, it closes a circuit that extends from battery through the winding of relay 156, upper back contact and armature of relay 157, and lower front contact and armature of relay 147 to ground. The relay 156, in operating, closes at its lower front contact and armature, a circuit that causes the lighting of the operator's position lamp 167, and the lighting of this lamp notifies the operator that her position has been selected and that a call is being extended to one of her connecting cord circuits, the particular circuit that has been selected being indicated a few moments later by the lighting of the lamp 341 associated with that particular circuit, as will hereinafter be described. Relay 147, in operating, upon the selection of the operator's position, also closes a circuit that extends from battery through the left-hand armature and back contact of relay 159, winding of relay 148 and lower front contact and armature of relay 147 to ground.

When the relay 148 operates, it closes a circuit that extends from battery through the winding of relay 64 (see Fig. 3), the winding of trip magnet 22 associated with the selected operator's position on the selector switch, right-hand front contact and armature of relay 93, conductor 82, switch spring 197 and alternate contact of the operator's telephone jack 195, and right-hand front contact and armature of relay 148 to ground. The closure of this circuit energizes the trip magnet 22; and also operates relay 64 to close a circuit that extends from battery through the motor magnet and contact 303 (3) of the cord selector sequence switch (see Fig. 2), conductor 72, and the front contact and armature of relay 64 to ground. The closure of this circuit moves the sequence switch 300 out of position 3.

When the selector sequence switch reaches position 4, a circuit is completed that extends from battery through the motor magnet and contact 304 (4) of the selector sequence switch and the right-hand back contact and armature of relay 30 to ground, and as a result of the closure of this circuit the sequence switch is moved to position 5. When the sequence switch reaches position 5, a circuit is closed that extends from battery through the winding of the updrive magnet 34, conductor 89, selector sequence switch contact 516 (5 to 6) and right-hand back contact and armature of relay 30 to ground. The updrive magnet 34 in attracting its armature starts the upward movement of the switch brushes. At the outset of the upward movement of the brushes the tripping levers of all of the sets of brushes move into position to engage the tripping yokes 7 at the various levels corresponding with the various operators' positions. In the present instance, it is assumed that the trip magnet 22 is energized, and as a result the tripping yoke corresponding with that magnet is in position to engage the tripping lever of the corresponding set of brushes and that set of brushes is tripped and made operative.

Immediately after the brush-tripping position is passed in the upward movement of the switch, and before the brushes engage the connecting cord terminals of the corresponding bank, the commutator segment G is engaged by the associated grounded commutator brush. This closes a circuit that extends from battery through contact 306 (5) of the selector sequence switch, the low resistance left-hand winding and high resistance right-hand winding of relay 56 in series, contacts 315 (5) of the selector sequence switch, contact 312 (5) of that switch, conductor 80, and to ground by way of the G segment and corresponding brush of the cord selector commutator. Relay 56, in operating, closes a locking circuit for itself that extends to ground by way of contact 315 (5) of the cord selector sequence

switch, right-hand front contact and armature of relay 56, and selector sequence switch contact 318 (5). Relay 56, in operating, also closes a circuit that extends from battery by way of the motor magnet and contact 304 (5) of the selector sequence switch, and left-hand switch spring and armature of relay 56 to ground. This causes the movement of the selector sequence switch out of position 5 and into position 6.

When the cord selector brushes have been tripped, the operator's selection is completed, and the operator's selecting circuit may be released to become available for performing its function in connection with the extension of another call. Therefore, as the grounded brush engages the G segment of the cord selector commutator a circuit is completed that extends from battery through the winding of relay 63 of the operator's selecting circuit, conductor 74, contact 312 (5) of the selector sequence switch, conductor 80, and G segment and corresponding brush of the cord selector commutator to ground. Relay 63, in operating, closes at its right-hand front contact and armature a locking circuit for itself that extends by way of the right-hand armature and switch spring of relay 61, and the back contact an armature of relay 67 to ground. Relay 63 also opens, at its left-hand armature and back contact, the circuit which, from the moment relay 61 was first operated, has been maintaining that relay energized. Consequently, relay 61 releases its armatures and in doing so, opens the locking circuit for relay 63, which relay in turn is deenergized and released. The restoration of both the relays 61 and 63 again completes the connection of conductor 76 to ground, so that this path is again available for moving out of position 2, the selector sequence switch of any other finder circuit that may be awaiting access to the operator's selecting circuit.

Relay 61, in releasing, also opens at its right-hand armature and switch spring, the path to ground over which the relay 93 of the operator's selecting circuit and relay 147 of the operator's position circuit have been held energized. Relay 93, in releasing, opens the energizing circuit that extends from battery through left-hand winding of the relay 77, right-hand back contact and armature of relay 93, conductor 82, switch spring 197 and alternate contact of the operator's telephone jack 195, and to ground by the divided path one branch of which extends by way of the right-hand front contact and armature of relay 148 and the other of which extends by way of contact 411 (2 to 6) of the listening key sequence switch 400 when that sequence switch is moved out of position 1, as will subsequently be described. Relay 77 therefore becomes energized, and remains energized as long as the operator is at her position and one or the other of the above-mentioned branch paths to ground is closed. Consequently, the selector lead 141 of the operator's selecting circuit is extended by way of the armature and outer right-hand front contact of relay 77 of this position to the relay 77 of the next operator's position in the series, so that when ground is next applied to the selecting lead 141 by the movement of a selector sequence switch of another finder circuit into position 3, the busy operator's position will be passed by and another operator's position selected.

It will be observed that a branch path from battery including the right-hand winding of each of the relays 77 is closed to the selecting conductor 141 by way of the inner right-hand front contact of the relay 77 when that relay is operated. The object of this is to insure that each of the relays 77 that is energized as a result of being associated with an unavailable operator's position will remain energized, and thus prevent any alteration of the series path by way of conductor 141 through the relays 77, while the operator's selecting apparatus is performing its selecting function. If, for instance, the first operator's position in the series is busy and the corresponding relay 77 is energized, while the second operator's position is available and the associated relay 77 deenergized when the relay 61 operates to ground the selecting lead 141, then the ground applied to the conductor 141 is effective to operate relay 93 associated with the second operator's position, and through it to energize the associated trip magnet 21. If at this moment the first operator's position should again become available, the accompanying release of the associated relay 77, if provision were not made for preventing it, would disconnect the selecting conductor 141 from the relays 77 and 93 of the second operator's position and connect that conductor instead to the relay 93 of the first operator's position with the result that both of the trip magnets 21 and 22 might be operated and cause the selection of two operators' positions by a single call. By the provision of the right-hand locking winding of the relay 77, each relay 77 that happens to be energized when relay 61 operates to ground the selecting lead 141 is held energized until the relay 61 releases, regardless of whether the corresponding operator's position becomes available in the meanwhile or not.

Under heavy traffic conditions it is possible that all of the operators' positions may be busy and all of the corresponding relays 77 energized when an incoming call causes the operation of the starting relay 61 of the operator's selecting circuit. Under these circumstances, the grounding of the select-

ing lead 141 by the operation of relay 61 closes the locking path by way of its right-hand winding for each of the operated relays 77, thus maintaining the associated position unselectable until the relay 61 is released, regardless of whether the position becomes available in the meanwhile or not. To prevent such a condition from tying up the operator's selecting circuit by thus indefinitely maintaining all the positions unselectable, the conductor 141 after passing through the armature and upper front contacts of all of the relays 77 in series, is continued to battery by way of the winding of relay 66; and the relay 66, when it operates, closes the energizing circuit of the relay 67, which, in turn, interrupts at its back contact the path to ground of the conductor 141 closed by the operation of relay 61. The alternate energization and deenergization of the reciprocally controlled relays 66 and 67 that results from the completion of this circuit causes an intermittent interruption of the locking path to ground of the relays 77. Consequently, when one of the operators' positions becomes available and opens the energizing path by way of the left-hand winding of the associated relay 77, that relay, at the next interruption of the locking path by way of conductor 141 and the back contact of relay 67, releases its armature and permits the selecting conductor 141 to be extended to the associated relay 93. This brings about the energization of the associated trip magnet and the operation of the common relay 64 for moving the selector sequence switch of the awaiting finder circuit out of position 3, in the manner hereinbefore described.

In the foregoing, the progress of the call has been described up to the point where the selector sequence switch 300 has been moved to position 6, and the cord selector brushes corresponding with the selected operator's position have been tripped and are moving over the terminals of the cord circuits associated with that position. When connecting cord circuit is not in use, battery is connected with the corresponding terminal 118 on the selector switch by way of resistance 126 (see Fig. 4), right-hand back contact and armature of relay 95, switch spring 161 and resting contact of the disconnect key 160, and conductor 88. When the corresponding brush 114 engages the contact terminal 118 of such a connecting circuit, the circuit is completed by way of brush 114, conductor 99, selector sequence switch contact 305 (5 to 6), windings of relay 30, and selector sequence switch contact 320 (4 to 6) to ground. Relay 30, in operating opens the previously traced circuit through updrive magnet 34 of the cord selector switch, conductor 89, contact 316 (5 to 6) of the selector sequence switch and right-hand back contact and armature of relay 30 to ground. The opening of this circuit stops the selector switch with its brushes in engagement with the terminals of the non-busy connecting cord circuit. Relay 30, in operating, closes a circuit that extends from battery through the motor magnet and contact 302 (6) of the selector sequence switch, and right-hand front contact and armature of relay 30 to ground. This moves the selector sequence switch out of position 6. To insure the continued closure of this circuit until the sequence switch is moved out of position 6, the relay 30, in operating, also closes a locking circuit for itself that extends from battery by way of the resistance 55, selector sequence switch contact 317 (5 to 6), left-hand armature and front contact of relay 30, contact 309 (1 to 8) of the selector sequence switch, winding of relay 30, and contact 320 (5 to 6) of the selector sequence switch to ground. This locking path is opened and the relay 30 released as soon as the selector sequence switch moves out of position 6.

When the selector sequence switch reaches position 7, it closes a circuit that extends from battery by way of the motor magnet and contact 410 (1) of the listening key sequence switch 400 (see Fig. 4), left-hand armature and back contact of relay 95, left-hand back contact and armature of relay 13, left-hand back contact and switch spring of relay 81, sleeve conductor 87, selector switch contact 117, brush 113, conductor 98, and contact 307 (7) of the selector sequence switch to ground. This causes the listening key sequence switch to move from position 1 to position 2. In position 2, a circuit is closed that extends from battery through the winding of relay 13, contact 412 (2 to 6) of the listening key sequence switch, left-hand back contact and switch spring of relay 81, sleeve conductor 87, and to ground at contact 307 (7) of the selector sequence switch over the path already traced. Relay 13, in operating, closes a locking circuit by way of its left-hand front contact and armature that maintains the relay energized independently of the initial energizing path through listening key sequence switch contact 412 (2 to 6).

As soon as the listening key sequence switch reaches position 2, a circuit is closed that extends from battery through the motor magnet and contact 502 (18½ to 1) of the calling cord sequence switch (see Fig. 7), conductor 255, contact 418 (2 to 6) of the listening key sequence switch, left-hand back contact and armature of relay 125, resting contact and switch spring 146 of holding key 140, contact 407 (1 to 4) of the listening key sequence switch, and resting contact and switch spring 154 of the register and disconnect key 150 to ground.

As a result of the closure of this circuit, the connecting cord sequence switch 500 is moved out of position 1 and comes to rest in position 2. In position 2, a circuit is closed that extends from battery through resistance 342, lamp 341 and calling cord sequence switch contact 507 (2 to 15) to ground. The lamp 341 lights upon the closure of this circuit, and indicates to the operator the particular connecting cord circuit which the incoming call, of which she has been notified by the lighting of her position lamp 167, has selected.

In position 2 of the listening key sequence switch, a circuit is closed that extends from battery through the left-hand winding of the relay 95, contact 413 (2) of the listening key sequence switch and the right-hand back contact and armature of relay 81 to ground. A branch path also extends from the left-hand winding of the relay 95 by way of the right-hand upper front contact and armature of relay 13, resting contact and switch spring 146 of the holding key 140, listening key sequence switch contact 407 (1 to 4), and resting contact and switch spring 154 of registering key 150 to ground. The two windings of the relay 94 in series are connected in parallel with the left-hand winding of relay 95, and are therefore also included in the above-traced circuits. The relay 95 is energized as a result of the closure of these circuits; but the relay 94 is not energized, because its two windings are differential in their effect.

When relay 95 operates, it closes a circuit that extends from battery by way of contact 320 (7 to 9) of the selector sequence switch (see Fig. 2), the winding of relay 30, selector sequence switch contact 305 (7 to 7½), conductor 99, brush 114 and corresponding contact terminal 118 of the cord selector switch, conductor 88, resting contact and switch spring 161 of the disconnect key 160, right-hand armature and front contact of relay 95, left-hand resting contact and switch spring of relay 94, left-hand winding of relay 94, contact 413 (2) of the listening key sequence switch, and right-hand back contact and armature of relay 81 to ground. The closure of this circuit brings the relay 30 in parallel with the left-hand winding of the relay 94; but the two relays are so related to each other in the matter of their resistances and adjustments that the relay 30 is operated as a result of the closure of this circuit, and the relay 94 is not.

When the relay 30 operates, it closes a locking circuit for itself, this circuit extending from battery by way of the selector sequence switch contact 320 (7 to 9), winding of relay 30, selector sequence switch contact 309 (1 to 8), left-hand front contact and armature of relay 30, and selector sequence switch contact 310 (7 to 8) to ground. The conductor 99, being connected with the path to ground just traced, is itself grounded; and this grounding of the conductor 99, the circuit of which is extended by way of the selector switch and the conductor 88 to the differential relay 94 of the connecting cord circuit, energizes the right-hand winding and short-circuits the left-hand winding of the relay, thus bringing about its operation. Relay 94, in operating, closes a circuit that extends from battery by way of the motor magnet and contact 410 (2) of the listening key sequence switch, and the right-hand armature and switch spring of the relay 94 to ground, the closure of which circuit moves the listening key sequence switch out of position 2. Thus the movement of the listening key sequence switch out of position 2 is made dependent upon the response of the relay 30 of the finder circuit to the movement of the listening key sequence switch into position 2.

The energization of relay 30, as described above, causes the closure of a circuit that extends from battery through the motor magnet and contact 302 (7) of the selector sequence switch, and right-hand front contact and armature of relay 30 to ground. This causes the selector sequence switch to move into position 8. The previously-described locking circuit for the relay 30 is unaffected by the movement of the selector sequence switch into position 8, and the relay 30 therefore continues energized.

When the selector sequence switch moves into position 8, it closes a circuit that extends from battery through the motor magnet and contact 202 (4) of the finder sequence switch, contact 321 (8) of the selector sequence switch, left-hand front contact and armature of relay 30, and contact 310 (7 to 8) of the selector sequence switch to ground. When the finder sequence switch moves into position 5, as a result of the closure of this circuit, it completes a circuit that extends from battery through the motor magnet and contact 304 (8) of the selector sequence switch, contact 220 (5 to 18) of the finder sequence switch, and the left-hand back contact and armature of relay 37 to ground. The selector sequence switch thereupon moves to position 9.

The finder sequence switch 200 and the selector sequence switch 300 are now in their talking positions, and the conversational and signaling circuits through the finder circuit, between the calling subscriber's line and the connecting cord circuit, are established. The circuit of the talking conductors of the finder circuit is closed through at contact 207 (4½ to 5) and contact 208 (4½ to 5) of the finder sequence switch. The sleeve circuit is completed from battery through the winding of relay 13 (see Fig. 4), left-hand

front contact and armature of that relay and contact 412 (2 to 6) of the listening key sequence switch in parallel, left-hand back contact and switch spring of relay 81, conductor 87, contact 117 and corresponding brush 113 of the cord selector switch, conductor 98, selector sequence switch contact 307 (8 to 9), left-hand (low resistance) winding of relay 56, selector sequence switch contact 306 (8 to 9), finder sequence switch contact 209 (4½ to 5), conductor 50, brush 42 and contact 46 of the line finder switch, conductor 53 of the calling line, and winding of the connection register 92 associated with that line to ground. The circuit that is thus closed by way of the sleeve conductor serves the purpose of establishing a test potential upon the line, thus preventing the connection from being intruded upon either by the distributor switch 130 or by the calling plug 334 of a connecting switch. It also serves the purpose of holding the finder sequence switch 200 and the selector sequence switch 300, and maintaining the line finder LF and the cord selector CS in engagement with the terminals of the calling line and the selected connecting cord circuit, respectively.

When the sleeve conductor circuit traced above is closed, the relay 56 of the finder circuit is energized, this energization occurring upon the movement of the finder sequence switch from position 4 to position 5, and while the selector sequence switch 300 is still in position 8. It will be remembered that relay 30 of the finder circuit in position 8 of the selector sequence switch is locked up by way of a circuit that includes contact 309 (1 to 8) of the selector sequence switch, the left-hand front contact and armature of relay 30, and contact 310 (7 to 8) of the selector sequence switch. When the selector sequence switch moves out of position 8, this locking circuit for the relay 30 is broken at the sequence switch contacts; but the energization of the relay 30 is continued by way of a circuit that extends from battery through contact 320 (7 to 9) of the selector sequence switch, winding of relay 30, selector sequence switch contact 309 (7 to 9) and the left-hand switch spring and armature of relay 56 to ground, the relay 56 having been energized, as described above in position 8 of the selector sequence switch. Therefore, when the selector sequence switch reaches position 9, as a result of the movement of the finder sequence switch 200 into its talking position 5, the relay 30 is in an energized condition and consequently prevents the closure, by way of its right-hand armature and back contact and selector sequence switch contact 304 (9), of the circuit which at a later stage of the operation serves to move the selector sequence switch 300 out of its talking position.

The movement of the selector sequence switch 300 into position 9 and the energization of the relay 56 also serve to connect the fourth or lamp conductor 51 of the line finder switch by way of selector switch contact 318 (8 to 9) right-hand armature and front contact of relay 56, and selector sequence switch contacts 308 (8 to 9) and (7½ to 9) to the fourth or lamp conductor of the cord selector switch. This connection of the lamp conductor straight through the finder circuit while the sequence switches of that circuit are in their talking positions, is employed in connection with the transmission of class-of-service and line identifying signalling impulses as will hereinafter be described.

While the sequence switches of the finder circuit are moving into their talking positions, as described above, the listening key sequence switch 400 is moving from position 2 to position 6, its listening-in position. At the time the listening key sequence switch 400 reached position 2, it closed a circuit extending from battery by way of the right-hand winding of relay 128 (see Fig. 5), conductor 240, listening key sequence switch contact 419 (2 to 7), and switch spring 142 and resting contact of the holding key 140 to ground. Relay 128, in operating, as a result of the completion of this circuit, closed a circuit extending from battery by way of the winding of relay 127, and the right-hand front contact and armature of relay 128 to ground. Relay 127, in operating, extended the talking conductors 244 and 245 of the operator's telephone set 186 to the talking loop including conductors 236, 237, 238 and 239, which an instant later, is brought into connection with the connecting cord circuit by way of listening key sequence switch contacts 403 (4 to 7), 404 (4 to 7), 405 (4 to 7) and 406 (4 to 7). Therefore, when the listening key sequence switch reaches its listening-in position, the talking conductors 96 and 97 of the finder circuit are extended through to the talking conductors 253 and 254 of the connecting cord circuit by way of the listening key sequence switch contacts just mentioned, the loop comprising the conductors 236, 237, 238 and 239, and the resting contacts of the operator's position keys 184, 185 and 180, with the operator's telephone set bridged across this loop by way of the front contacts and armatures of the relay 127. The operator is thus in telephonic communication with the calling subscriber, and also with the part of the talking circuit that will be extended to the called subscriber when connection is established by the insertion of the calling plug 334 into the spring jack of the called subscriber's line.

In the operation of the system as described, the selection of the operator's position by the incoming call is accomplished at the outset of the upward movement of the cord

selector elevator when the set of brushes is tripped that corresponds with the operator's position the trip magnet 21 or 22 of which is energized. But the telephone circuit between the operator and the calling subscriber by way of the connecting cord is not completed until the tripped brushes have selected an idle cord and moved the listening key sequence switch of that cord to its listening-in position.

With the object of eliminating this delay, and telephonically extending the calling subscriber to the operator the instant the position is selected, each finder circuit is provided with a by-path having a normally opened switch controlled branch extending directly to the telephone of each operator's position to which the finder circuit has access, and means are provided for causing the closure of the branch corresponding to the operator's position the instant the position is selected.

Referring to Fig. 2, the by-path for the finder circuit F is controlled at the finder sequence switch cams 211 and 215, and extends from the talking conductors 48 and 49 by way of conductors 78 and 79 to the contact points of the series of switches 283, 283', etc., (see Fig. 5) associated with the selector switch elevator upon the brushes of which this particular finder circuit terminates. Assuming that the first operator's position is the one selected, the switch 283 is operated, and the by-path is extended by way of conductor 260 and 261 and resting contacts of the relay 298 to the telephone set of that operator's position. The calling subscriber's line is thus extended to the selected operator's telephone the instant the switch 283 is operated, which is at the outset of the upward movement of the cord selector elevator, and before the finder circuit has been extended to an idle connecting cord circuit.

The construction of the switch shown at the left of Fig. 5 for controlling the by-path circuit is fully illustrated and described in the previously mentioned parent application. Briefly, each elevator shaft 1 is associated with a particular finder circuit, and each trip rod 5 is associated with a particular operator's position of those to which the finder circuit has access. At the point of intersection of each of the elevator shafts 1 with each of the trip rods 6, is located a by-path switch 283. The outer contacts of all of the switches 283 in a vertical row are wired to the by-path conductors 78 and 79 of the corresponding finder circuit; and the switch springs 280 and 281 of each of the switches 283 in a horizontal row are multipled to the conductors 260 and 261 extending to a corresponding operator's position.

The manner in which the system operates when equipped with by-path switches is as follows: The movement of the finder sequence switch 200 to position 4, which occurs when the finder switch finds the calling line, extends the talking conductors 48 and 49 by way of sequence switch contacts 211 (4 to 4½) and 215 (4 to 4½) to conductors 78 and 79. These conductors remain open at the contacts of all of the by-path switches 283, etc., until one of these switches is operated. When the selector switch 300 of the finder circuit in question moves to position 3, the relay 61 of the operator's selecting circuit is operated, as has been hereinbefore described, and brings about the operation of the relay 93 of the first operator's position which is available for receiving the call. The relay 93, in turn, energizes the corresponding trip magnet (which in the present instance will be assumed to be the trip magnet 22) and also energizes the relay 64, which closes a circuit which moves the selector sequence switch 300 out of position 3. The selector sequence switch moves through position 4 and into position 5, in which position it causes the energization of the up-drive magnet 34 and starts the upward movement of the selector switch. At the outset of the upward movement, the set of brushes 111, 112, 113 and 114 corresponding with the selected operator's position are tripped, and at the same time the by-path switch 283 corresponding with that operator's position is operated as fully described in said parent application. As soon as the by-path switch is operated, the by-path conductors 78 and 79 are extended by way of the conductors 260 and 261 and the resting contacts of relay 298 to the operator's telephone, which is thus instantly connected with the calling subscriber's line. Battery is bridged across the by-path circuit by way of the windings of the relay 189 and the windings of the retardation coil 196. The battery thus applied energizes the calling subscriber's transmitter, to enable him to talk with the operator, and also causes the operation of the relay 189. When the relay 189 operates, it closes a circuit that energizes the relay 149. The relay 149, in operating, closes a circuit that extends from battery through the left-hand armature and resting contact of relay 159, winding of relay 148, conductor 193, and switch spring and armature of relay 149 to ground. This maintains the energization of the relay 148, the energizing circuit having previously been closed by way of the lower armature and front contact of relay 147, conductor 191, and the resting contact and switch spring of relay 149, the instant relay 147 operated upon the closure of the selecting circuit in the operator's selecting apparatus.

In the meanwhile the cord selector elevator is moving up and testing the connecting cord circuits of the selected operator's

position. When it finds an idle connecting cord circuit, it seizes that circuit, as has hereinbefore been described, and moves the listening key sequence switch of the seized circuit out of position 1, through position 2, and into the listening-in position 6. When the listening key sequence switch reaches position 4 in its movement a circuit is closed that extends from battery through the winding of relay 298, (see Fig. 5), conductor 246, and listening key sequence switch contact 411 (4 to 6) to ground. The relay 298, in operating, disconnects at its resting contacts and switch springs, the by-path conductors 260 and 261 from the operator's telephone conductors 244 and 245, and connects the conductors 244 and 245 through, by way of the armatures and front contacts of the relay 127, to the operator's loop which is included in the talking conductors of the connecting cord circuit when the listening key sequence switch 400 reaches position 4. Therefore when the listening key sequence switch reaches position 4, the by-path is opened and the operator is placed in communication with the calling subscriber by way of the normal circuit that extends through the connecting cord.

As has hereinbefore been described, the finding of the idle connecting cord circuit and the consequent movement of the selector sequence switch 300 to position 8, moves the finder sequence switch 200 out of its waiting position 4 and into its talking position 5. This occurs as the listening key sequence switch 400 is moving into its listening-in position 6; so that the disconnection of the by-path from the operator's telephone by the movement of the listening key sequence switch to position 4, as described, is accompanied by the disconnection of the by-path from the finder circuit at contacts 211 (4 to 4½) and 215 (4 to 4½) of the finder sequence switch. As the finder sequence switch moves out of position 4 this disconnection of the by-path from the circuit breaks the energizing circuit of the relay 189 bridged across the by-path (see Fig. 5) and the consequent deenergization of the relay 189 causes the deenergization of the relay 149. The relay 149, in retracting its armature, opens the path to ground over which current for energizing relay 148 has been flowing. But another energizing path for the relay 148 is closed by way of conductor 248 and contact 411 of the listening key sequence switch when that switch reaches its listening-in position 6. In order that the relay 148 may not be momentarily deenergized in the interval that may elapse before the last mentioned path by way of contact 411 of the listening key sequence switch is closed, the relay 149 is so constructed, as by placing a copper sleeve about its core, as to be slow in releasing its armature. The relay 148 is thus held energized continually from the moment the operator's position is first selected.

Provision is made for automatically furnishing the operator with information with regard to the class of service which any calling line extended to her position is adapted to receive. The manner in which this information is given to the operator is as follows: When the listening key sequence switch reaches position 6, the listening-in position, a circuit is closed that extends from battery through the left-hand armature and back contact of relay 159 (see Fig. 5), winding of relay 129, upper back contact and armature of relay 155, conductor 251, contact 416 (6) of this listening key sequence switch, and the pick-up switch springs associated with cam 171 of the class-of-service commutator 170 to ground. These switch springs are closed once in each revolution of the class-of-service commutator. As soon, therefore, as this closure occurs after the listening key sequence switch has moved into position 6, the relay 129 included in the circuit traced above is energized. The relay 129, in operating, closes a branch from the above traced circuit that extends by way of the lower armature and front contact of relay 129, winding of relay 155, conductor 250, listening key sequence switch contact 413 (6) and right-hand back contact and armature of relay 81 to ground. As long as the path to ground by way of the pick-up commutator springs 171 is closed, the relay 155 is short-circuited. When the path by way of the pick-up springs opens, the relay 155, being then included in the circuit in series with the relay 129, is energized. When the relay 155 operates, it closes a circuit that extends from battery through the winding of relay 158, lower front contact and armature of relay 155, upper front contact and armature of relay 156 (the relay 156 being energized in parallel with the relay 148 by way of a circuit that extends over conductor 248 and contact 411 (6) of the listening key sequence switch to ground), conductor 252, listening key sequence switch contact 408 (2 to 7), right-hand front contact and armature or relay 95, switch spring 161 and resting contact of disconnect key 160, lamp conductor 88, contact terminal 118 and corresponding switch spring 114 of the cord selector switch, conductor 99, selector sequence switch contacts 308 (7½ to 9) and (8 to 9), right-hand front contact and armature of relay 56, selector sequence switch contact 318 (8 to 9), conductor 51, brush 43 and contact terminal 47 of the line finder switch, conductor 54, line lamp 33, and switch spring and contact associated with cam 173 of the class-of-service commutator 170 to ground.

The cams of the class-of-service commutator are arranged to keep the associated switch contacts closed normally, and to open the contacts momentarily a certain number of times in each revolution of the commutator, the cams being arranged to cause from one to five openings per revolution. In the present instance, it is assumed that the class of service the calling line is adapted to receive is designated by two breaks in the circuit per revolution of the commutator. When the circuit by way of the lamp lead, traced above, is first closed, immediately upon the cessation of the pick-up impulses, the relay 158 (see Fig. 5) is energized, and closes a circuit that extends from battery through the stepping magnet 271 of the class-of-service switch 270, and the front contact and armature of relay 158 to ground. At the first break in the circuit determined by the cam 173 of the class-of-service interrupter with which the calling line is associated, relay 158 is deenergized, stepping magnet 271 releases its armature, and the switch arms of the class-of-service switch 270 are advanced from their N or normal to their O positions. Upon the subsequent closure of the switch springs associated with the cam 173 of the class-of-service interrupter, relay 158 and stepping magnet 271 are again energized; and upon the second break in the circuit, caused by the opening of the associated switch springs by cam 173, the brushes of the class-of-service switch 270 are advanced to their first positions. An instant later the circuit is closed and the relay 158 and stepping magnet 271 again energized. The switch springs associated with cam 173 now remain closed for the rest of the revolution of the commutator; and as the revolution is completed, cam 171 of the class-of-service interrupter again closes its associated switch springs to produce the pick-up impulse. At this instant, a circuit is closed that extends from battery by way of the winding of relay 157, upper front contact and armature of relay 155, conductor 251, listening key sequence switch contact 416 (6), and the closed switch springs associated with pick-up cam 171 to ground. Relay 157, in operating, closes a locking circuit for itself that extends by way of its upper switch spring and armature, conductor 248, and contact 411 (6) of the listening key sequence switch to ground. The relay 157 therefore remains energized until the listening key sequence switch is moved out of its listening-in position. The operation of relay 157 causes the interruption, at its upper back contact and armature, of the circuit that has been maintaining relay 156 energized. Relay 156, in releasing, extinguishes the lamp 167 which was lighted by the operation of the relay 147 to notify the operator of the selection of her position by an incoming call. Relay 156, in releasing, also interrupts, at its upper front contact and armature, the circuit over which the class-of-service impulses have come to the relay 158. Upon the interruption of this circuit, the relay 158 releases its armature, opens the energizing circuit of the stepping magnet 271, and the magnet 271 in retracting its armature advances the brushes of the class-of-service switch to their second position. As the class-of-service switch 270 takes the final step of its movement as the result of the release of relay 156, a circuit is closed that extends from battery through class-of-service lamp 352, contact 2, brush 272 and segment 273 of the class-of-service switch, and the lower front contact and armature of relay 157 to ground. There may be provided a lamp 351, 352, 353, 354, 355 for each of the positions to which the class-of-service switch is advanced by the class-of-service impulses, and each lamp indicates to the operator the particular class of service which the line that has been extended to the connecting cord circuit is adapted to receive. In the present instance, the lighting of the lamp 352 may indicate to the operator that the calling line is a message rate line, requiring a special message charging act on the part of the operator after connection has been successfully established with the called line, and before the connection is released. The manner in which the charge, in this particular instance, is effected will be described hereinafter.

It is sometimes necessary for the operator to determine the number of the line that is calling; and to this end each line has associated with it a line lamp 33, and these lamps are arranged in banks on the lamp board 15 in definite order and in easy sight of the operator, so that the number of any lamp that is flashed, and therefore of the corresponding line, may readily be determined from a distance. If the operator should desire to ascertain the number of the calling line or check up the number of the line as given her by the calling subscriber, she presses the flashing key 190′ (see Fig. 5). When the key is depressed, a circuit is completed that extends from battery through the resistance 166, contacts of the flashing key 190′, upper back contact and armature of the relay 156, conductor 252, listening key sequence switch contact 408 (2 to 7), right-hand front contact and armature of relay 95, switch spring 161 and resting contact of the disconnect key 160, lamp conductor 88, and thence through contacts of the cord selector switch, the fourth or lamp conductor of the finder circuit and contacts of the line finder switch (this circuit already having been traced in detail), to conductor 54, line lamp 33 and

switch springs associated with cam 173 of the class-of-service interrupter to ground. The closure of this circuit causes the lamp to be illuminated; and the operator, noting the position upon the lamp board of the lighted lamp, knows the line number of the calling subscriber. It will be observed that while the flashing key is depressed to complete the circuit of the line lamp, this circuit is intermittently being interrupted at the switch contacts associated with cam 173 by the continuous rotation of the class-of-service interrupter. The relation between the cams and switch springs of the class-of-service interrupter is such, however, that the interruptions are for too brief a period to interfere appreciably with the illumination of the lamp when its circuit is closed.

The operator, having automatically received the class-of-service indication of the calling line, and, if desired, having identified the number of the calling line, proceeds to establish the connection with the called line. This may be assumed to be the line which terminates upon the spring jack 339 (see Fig. 7). It may be assumed that this line, in accordance with the usual practice, is multipled to other connection terminals, and that when the line is in use a test potential exists upon the thimble or sleeve terminal of the associated spring jack 339. The operator tests the condition of the called line in the usual way by touching the sleeve of the spring jack with the tip of the calling plug 334, and if no busy test click is heard in her telephone (the circuit being inductively connected through the windings of the connecting cord repeating coil 333, the talking conductors of the connecting cord, and the loop closed to the operator's telephone in the listening position of the listening key sequence switch), proceeds to complete the connection by inserting the plug 334 into the spring jack 339, and then operating the ringing key 330 to apply calling current from the ringing generator 199 to ring the bell at the called subscriber's station. The insertion of the calling plug 334 closes a circuit that extends from battery, through the winding of relay 338, registering sleeve contacts of the calling plug 334 and called line spring jack 339, and resistance 340 to ground. It will be remembered that the selection of the connecting cord circuit by the cord selector switch caused the movement of sequence switch 500 into position 2 and illuminated the cord circuit identifying lamp 341. When the relay 338 is energized as a result of inserting the calling plug 334, it closes a circuit that extends from battery, through the motor magnet and contact 505 (2) of the calling cord sequence switch to ground. This moves the calling cord sequence switch out of position 2, whereupon it continues to rotate under the control of its cam 501 until it reaches and stops in position 16.

As the calling cord sequence switch moves out of position 2, it closes a circuit that extends from battery, through the motor magnet and contact 410 (6) of the listening key sequence switch, conductor 256 and calling cord sequence switch contact 504 (3 to 7) to ground. The movement of the calling cord sequence switch out of position 2, therefore, causes the listening key sequence switch to move out of its listening-in position 6.

As long as the listening key sequence switch is in its 6 or listening-in position, the relays 128, 129, 155, 157 and 148 of the operator's circuit (see Fig. 5) are energized, their circuits being completed in contacts of the listening key sequence switch closed in position 6. When the listening key sequence switch moves out of position 6, as a result of the extension of the circuit to the called subscriber's line, these relays release their armatures. Relay 127, in releasing, interrupts the connection of the operator's telephone set with the listening key loop. Relays 129 and 155, in releasing, restore their normal paths in readiness to respond to the class-of-service impluses when the listening key sequence switch is next moved to its listening-in position. Relay 157, in releasing, opens at its lower armature and front contact the circuit over which the class-of-service lamp 352 has been kept illuminated. Relay 148, in releasing, closes a circuit that extends from battery through the motor magnet and contact 102 (18) of the timing sequence switch, and the left-hand back contact and armature of relay 148 to ground. This causes the timing sequence switch to move out of position 18 and come to rest in its normal or first position. Relay 148, in releasing, also opens at its right-hand armature and front contact the path to ground which it has kept closed for maintaining the conductor 82 of the operator's position in condition to prevent the position from being selected. As the alternative path to ground from conductor 82 by way of conductor 241 and contact 411 (2 to 6) of the listening key sequence switch is also opened at this time, the relays 77 of the operator's selecting circuit (see Fig. 3) are released, and the position again becomes available for receiving incoming calls.

Furthermore, relay 148 in releasing closes a circuit that extends from battery through the winding of relay 159, contacts 274, brush 272′ and associated segement 273′ of the class-of-service switch 270, and the right-hand back contact and armature of relay 148 to ground. Relay 159 is operated, and closes a circuit that extends from battery through the winding of stepping magnet 271 of the class-of-service switch 270, right-hand

armature and front contact of relay 159, and the switch spring and contact associated with cam 177 of the class-of-service interrupter to ground. As a result of the alternate energizations and deenergizations of the stepping magnet 271 that follow, the switch brushes 272 of the class-of-service switch are stepping ahead until they reach their normal or N positions, at which point the energizing circuit for relay 159 is interrupted by the movement of the brush out of engagement with segment 273′ and contacts 274, and relay 159, in releasing, opens the stepping circuit and stops the movement of the switch.

It will be observed that when relay 159 is energized to cause the restoration of the class-of-service switch to normal, it opens, at its left-hand back contact and armature, the path over which battery is supplied for permitting the energization of the relays 147, 147 and 129. This is in order to prevent either the extension of another calling line to the position or the extension of another connecting cord circuit to the class-of-service switch until the switch has been completely restored and is in condition to receive the new set of class-of-service impulses that accompany the selection of a connecting cord of the position by an incoming call, or the listening in upon an existing connection. It furthermore is in order to prevent the occurrence of either of the events referred to above during the restoration of the switch from interfering with the progress of such restoration.

As long as the battery supply path is interrupted at the left-hand armature and back contact of relay 159, the conductors 83 and 84 extending to the operator's selecting circuit are incapable of supplying current for the operation of the selecting relay 93 (see Fig. 3) of the associated operator's position, and consequently, the selection of the position by a waiting call is prevented until the relay 159 is released. In like manner, as long as the battery supply for the relay 129 is interrupted at the left-hand armature and back contact of relay 159, the relay 129 is unresponsive to the pick-up impulse which would otherwise pass through it by way of conductor 251 and pick-up commutator 171 as soon as any listening key sequence switch of the associated operator's position should be moved into its listening-in or sixth position. If the relay 129 should be permitted to respond before the restoration to normal of the class-of-service switch 270, the new set of class-of-service impulses would be superposed upon the restoring impulses which at the time are passing through the stepping magnet 271, and an incorrect class-of-service indication would result. Furthermore, while the battery supply is interrupted at the left-hand armature and back contact of relay 159, the relay 148 cannot be energized either by the selection of the operator's position or the movement of the listening key sequence switch into position 6; and consequently the restoration of the class-of-service switch, having been started by the deenergization of the relay 148, cannot be stopped by the re-energization of that relay until the restoring operation is completed.

During the existence of the connection between the two subscribers' lines, the calling cord sequence switch 500 is in position 16, the listening key sequence switch 400 is in its listening-out or eighth position, the selector sequence switch 300 is in its ninth or talking position and finder circuit sequence switch 200 is in its fifth or talking position. If, during the existence of this condition, it should be necessary or desirable for the operator to supervise, she may bring her telephone into the circuit by pressing the listening-in key 183. This completes a circuit that extends from battery through the motor magnet and contact 409 (8) at the listening key sequence switch, closed contacts of the listening-in key 183, conductor 249, and lower back contact and armature of relay 156 to ground. In response to the closure of this circuit, the listening key sequence switch moves out of position 8. When it reaches position 1, it is moved through that position by a circuit that extends from battery through motor magnet and contact 410 (1) of the listening key sequence switch, left-hand armature and front contacts of relay 95, upper contacts and right-hand armature of relay 13, resting contact and switch spring 146 of holding key 140, contact 407 (1 to 4) of the listening key sequence switch and resting contact and switch spring 154 of the register and disconnect key 150 to ground. When the listening key sequence switch reaches position 2, it is moved through that position by a circuit that extends from battery through the motor magnet and contact 410 (2) of the listening key sequence switch, and right-hand armature and switch spring of relay 94 to ground, relay 94 having remained in its energized condition from the time when the connecting cord was selected. The listening key sequence switch therefore continues to position 6, in which position the operator's position apparatus is again brought into connection with the circuit. In being extended to the connecting cord circuit, the operator's position apparatus again operates, in the same manner as has hereinbefore been described, to receive and record the class-of-service impulses, thus again indicating to the operator the nature of the calling line with which the position apparatus is connected.

If when the operator has completed supervision of the connection she desires again to

listen out, she may do so by pressing the listening-out key 187, this key being part of the common apparatus of the position. When the key is pressed, a circuit is completed that extends from battery through the motor magnet and contact 409 (2 to 6) of the listening key sequence switch, conductor 247, and closed contacts of the listening-out key 187 to ground. The closure of this circuit causes the listening key sequence switch to move from the listening-in position 6 and come to rest in the listening-out position 8.

It may occasionally happen that the operator is on the point of pressing one of her listening-in keys 183 to supervise a connection at the moment when her position is selected by an incoming call. In order to provide against the complications that would ensue if the operator were enabled to bring her position apparatus into circuit with an existing connection while a finder circuit, having selected the position, was hunting for a connecting cord of that position, the energizing circuit for moving the listening key sequence switch out of position 8 by way of the listening-in key 183 is controlled at the lower armature and resting contact of relay 156. As relay 156, as has been described, is energized through the medium of relay 147 the instant the position is selected by an incoming call, the selection of the position operates to deprive all of the listening-in keys 183 of the position of any control over their associated listening key sequence switches. This control, however is restored to the listening-in keys as soon as the finder circuit has found a connecting cord circuit and extended the calling line to that circuit. This is accomplished through the medium of the branch path that extends from the switch springs of all of the listening-in keys of the position to ground through the medium of the listening key sequence switch contact 417 (6) of the selected connecting cord circuit, right-hand upper front contact and armature of associated relay 13, resting contact and switch spring 146 of the holding key 140 of that circuit, listening key sequence switch contact 407 (4 to 7), conductor 234, and resting contact and switch spring 182 of the position register key 180. The above-described path for restoring the control of the listening-in keys 183 over their associated listening key sequence switches is closed slightly in advance of the path from these keys to ground, by way of the lower resting contact and armature of relay 156, because this last mentioned path is not closed until the relay 156 is restored, which does not occur until relay 157 operates to break the energizing circuit of relay 156 upon the receipt of the pick-up impulse that marks the completed transmission and reception of the class-of-service impulses, as hereinbefore described.

The operator's position apparatus can be brought into connection with only one of the connecting cord circuits of her position at a time. This is accomplished through the medium of the listening key sequence switch cams 402, 402′, etc., associated with the different connecting cord circuits. If any listening key sequence switch of the position is in its listening-in or sixth position at the time when another listening key sequence switch is being moved into position 6 in order to bring its associated cord circuit into connection with the operator's position apparatus, then a circuit is completed that extends from battery through the motor magnet and listening key sequence switch contact 402 (6) of the cord that is in connection with the operator's position apparatus, and to ground by way of listening key sequence switch contact 402′ (2 to 5) of the cord circuit whose sequence switch is being moved into its listening-in position. Thus the movement of the second listening key sequence switch into position 6 moves the first listening key sequence switch out of position 6.

While the conversation between the two subscribers is in progress, the answering supervisory relay 331 and the calling supervisory relay 332 are both energized over their respective circuits extending through the calling and called subscribers' stations, and the associated answering supervisory lamp 335 and calling supervisory lamp 336 are kept extinguished by the shunt paths closed around them at the contacts of their respective controlling relays. When the conversation is finished and the subscribers hang up, these shunt paths about the supervisory lamp 335 and 336 are interrupted and the lamps illuminated, the energizing path for the answering supervisory lamp 335 being closed by way of contact 503 (2 to 18) of the calling cord sequence switch, and the energizing path for the calling supervisory lamp 336 being closed at the right-hand front contact and armature of relay 338, this relay being energized as long as the calling plug 334 is in the spring jack 339.

The lighting of both lamps 335 and 336 is the signal that notifies the operator that the connection is to be taken down. Before disconnecting, however, the operator may gain supervise or listen in upon the conection in order to ascertain whether or not a charge is to be made. The supervision is accomplished, as has already been described, by pressing the listening-in key 183, which causes the listening key sequence switch to move out of its listening-in position 8 and come to rest in its listening-in position 6. In position 6, the operator's telephone apparatus is connected with the circuit, and the class-of-service switch 270 responds to the class-of-service impulses conveyed to it over

the lamp lead of the circuit, as has been described.

In the present instance, it will be assumed that the class-of-service indication received by the operator is such as to inform her that the calling line is a flat rate line. As no message registration is to be made in such a case, the operator effects the disconnection of the two subscribers' lines by pressing the disconnect key 160. When this key is pressed, a circuit is closed that extends from battery through the right-hand winding of relay 81 and contact and switch spring 163 of key 160 to ground. Relay 81, in operating, closes a circuit that extends from battery through contact 506 (2 to 17) of the calling cord sequence switch, upper winding of relay 337, conductor 258, and right-hand front contact and armature of relay 81 to ground. Relay 337, in operating, closes a locking circuit for itself that extends from battery through contact 506 (2 to 17) of the calling cord sequence switch, and lower winding and lower front contact and armature of relay 337 to ground. Relay 337, in operating, also closes a circuit that extends from battery through motor magnet and contact 502 (2 to 17) of the calling cord sequence switch, and upper front contact and armature of relay 337 to ground. The closure of this circuit moves the calling cord sequence switch out of position 16. As the sequence switch moves beyond position 17, the locking circuit of the relay 337 is interrupted at contact 506 (2 to 17) of the calling cord sequence switch, and the energizing path for the sequence switch by way of contact 502 (2 to 17) and the upper front contact and armature of relay 337 is also interrupted. The circuit through cam 407 of the listening key sequence switch just traced, has been holding the relay 95 energized. Relay 95 then releases its armatures and reconnects test battery through the resistance 126 with the extension which will be connected, at switch spring 161 and its resting contact, with the lamp lead 88 as soon as the disconnect key 160 is released.

As has heretofore been explained, relay 56 of the finder circuit is also included in the holding or sleeve circuit which is interrupted at the left-hand switch spring and resting contact of relay 81 when that relay responds to the closure of the disconnect key 160. If the disconnect key is pressed while the listening key sequence switch is in its listening-in position 6, the sleeve conductor 87, extending to the finder circuit, is disconnected from the branch that obtains battery by way of the relay 13 of the listening key circuit, and is connected instead with a branch that extends by way of the left-hand switch spring and armature of relay 81, switch spring 151 and resting contact of key 150, listening key sequence switch contact 415 (4 to 7), conductor 235, switch spring 181 and resting contact of the position register key 180, left-hand front contact and armature of relay 128, and the left-hand winding of that relay to battery, the relay 128 at this time being energized on account of the circuit that extends from battery through its right-hand winding by way of conductor 240, listening key sequence switch contact 419 (2 to 7), and switch spring 142 and resting contact of holding key 140 to ground. But as soon as the listening key sequence switch has moved out of its listening-in position and beyond position 7 as a result of the release of relay 13, as already described, the branch by way of the left-hand winding of relay 128 for supplying the sleeve or holding conductor 87 with battery is opened at listening key sequence switch contact 415 (4 to 7), and current ceases to flow through the left-hand winding of relay 56 included in this path in the finder circuit. During the conversation the energizing circuit of the relay 30 of the finder circuit has been maintained by way of the left-hand switch spring and armature of relay 56 to ground. When relay 56 releases, it opens this circuit and causes the deenergization of relay 30. When relay 30 releases its armatures, it closes a circuit that extends from battery through the motor magnet and contact 304 (9) of the selector sequence switch, and right-hand back contact and armature of relay 30 to ground. The selector sequence switch thereupon moves out of position 9, and continues to move under the control of its cam 301 until it reaches and comes to rest in position 18.

As the selector sequence switch 300 moves out of position 9, it closes a circuit that extends from battery through the motor magnet and contact 202 (5) of the finder sequence switch and contact 310 (10 to 17) of the selector sequence switch to ground. The finder sequence switch thereupon moves out of its talking position 5, and continues to move until it reaches and comes to rest in its position 18. In position 18 of the finder sequence switch, a circuit is closed that extends from battery through the winding of down-drive magnet 62, conductor 60, and finder sequence switch contact 218 (18) to ground. The closure of this circuit energizes the down-drive magnet and causes the restoration of the brushes of the line finder switch LF to normal. As the brushes reach their normal position, a circuit is closed that extends from battery through the motor magnet and contact 203 (18) of the finder sequence switch, conductor 69, and segment Y and corresponding brush of the line finder commutator to ground. In moving out of position 18 as a result of the closure of this circuit, the finder sequence switch breaks, at its contact 218 (18), the energizing circuit

of the down-drive magnet 62, thus causing the brushes of the line finder switch to come to rest. The finder sequence switch continues to move until it reaches and comes to rest in its normal or first position.

In the meanwhile the cord selector switch CS and the selector sequence switch 300 have been restored to their normal positions as follows: When the selector sequence switch reaches position 18, it closes a circuit that extends from battery through the down-drive magnet 35 of the cord selector switch, conductor 90, and selector sequence switch contact 311 (18) to ground. As the brushes of the cord selector reach their normal position, in response to the energization of the down-drive magnet, a circuit is closed that extends from battery through the motor magnet and contact 303 (18) of the selector sequence switch, conductor 31, and Y segment and corresponding brush of the cord selector commutator to ground. The closure of this circuit causes the selector sequence switch to move out of position 18 and come to rest in its normal or first position, and in doing so, to open at contact 311 (18) the circuit of the down-drive magnet 35, thus stopping the downward movement of the cord selector brushes. Thus the line finder and cord selector switches and the finder and selector sequence switches are returned to their normal positions when the disconnect key 160 is pressed.

In the present embodiment of the system it has been found desirable to make the battery which furnishes current for the talking circuit of lower potential than the battery which is used in connection with the test relay 12 associated with the distributor 130. Specifically, it has been found convenient to connect a twenty-four volt battery between the windings of the repeating coil 335 of the connecting cord circuit and to employ a forty-eight volt battery for energizing the test relay 12 of the distributor circuit (see Fig. 1). Obviously after the calling subscriber has hung up and before the connection of his line with the cord circuit has been broken, if the brushes 131 and 132 of the distributor switch connect the test relay 12 with the circuit of this particular line, then the test relay 12 will be energized by the current which flows through its windings from its higher potential battery in opposition to the lower potential battery of the connection which still exists by way of the repeating coil 333 of the connecting cord circuit. Under such circumstances, the test relay 12 of the distributor circuit would be energized to start a finder switch unnecessarily. In order to prevent this, the switch spring 162 of the disconnect key 160 is so arranged as to open the ring conductor of the talking circuit between the calling line and the repeating coil of the cord circuit the instant the disconnect key is pressed. Thus the connection is prevented from originating a false call in the interval that elapses between the breaking of the sleeve or holding conductor, which permits the cut-in relay 11 of the distributor circuit to associate the test relay 12 with the brushes, and the definite interruption of the talking strands of the circuit which takes place at contacts 207 ($4\frac{1}{2}$ to 5) and 208 ($4\frac{1}{2}$ to 5) of the finder sequence switch when that switch responds to the interruption of the holding circuit.

As has hereinbefore been described, the relay 95 (see Fig. 4) is released, through the medium of the relays 13 and 81, the instant the disconnect key 160 is pressed; and the release of the relay 95 is adapted to reconnect high potential test battery with the lamp lead 88 through the medium of the resistance 126 and the right-hand back contact and armature of relay 95. Each of the class-of-service interrupters 172 to 176 inclusive (see Fig. 1) is common to the lamp leads of all of the lines having that class of service. If the high potential test battery should be extended back to the common interrupter by way of the lamp lead of the connection that is being disestablished, it would serve to shunt out and interfere with the operation of the class-of-service relay 158 (see Fig. 5) that might at the time be in process of receiving the impulses from another calling line of the same class. Therefore, the disconnect key 160 is so arranged as to interrupt, at its resting contact and switch spring 161, the extension of the high potential battery to the lamp lead 88 while the disconnect key is pressed, and until the lamp lead of the connection in process of disestablishment is definitely interrupted at the selector sequence switch contacts by the movement of the sequence switch out of its talking position as a result of the pressing of the disconnect key.

The disconnecting operation described above was upon the assumption that the calling line was a flat rate line in connection with which no charge was to be made. It will now be assumed that the calling line is a line in connection with which toll is to be charged or collected for each completed call. In this case, the operator presses her register and disconnect key 150, it being assumed that the listening key sequence switch 400 is in its listening-in position 6, to which position the switch was moved when the operator supervised the connection. When the key 150 is pressed, a circuit is closed that extends from battery through the left-hand winding of relay 81, the right-hand winding of relay 95 and the left-hand winding of relay 125 in parallel, and to ground by way of the contact and

switch spring 154 of the register and disconnect key 150. Relay 81, in operating closes, at its right-hand front contact and armature, the circuit for energizing relay 337 (see Fig. 7) and bringing about the restoration to normal of the calling cord sequence switch 500, as hereinbefore described. Relay 81 in operating also disconnects the holding or sleeve conductor 87 from its connection with battery by way of the winding of relay 13, and connects it instead with a branch that extends to battery by way of the left-hand switch spring and armature of relay 81, switch spring 151 and alternate contact of key 150, conductor 233, left-hand switch spring and resting contact of relay 291 (see Fig. 6) and the winding of relay 290. The interruption of the branch to battery by way of the winding of relay 13 causes that relay to release its armatures. Relay 13, in releasing, closes a circuit that extends from battery through the motor magnet and contact 410 (6) of the listening key sequence switch, right-hand back contact and armature of relay 13, resting contact and switch spring 146 of holding key 140, listening key sequence switch contact 407 (4 to 7), conductor 234, and resting contact and switch spring 182 of the position register key 180 to ground. As a result of the closure of this circuit the listening key sequence switch is moved out of its listening-in position 6, and comes to rest in position 8.

The extension of the sleeve or holding conductor 87 to the winding of relay 290 (see Fig. 6) by way of the left-hand switch spring and armature of relay 81, causes relay 290 to operate and close a circuit that extends from battery by way of the windings of relays 291 and 292 in parallel, front contact and armature of relay 290, switch spring and resting contact of relay 294, resistance 265, and back contact and armature of relay 293 to ground. Relay 292, in operating, closes a path for maintaining its own energization and that of relay 291 independent of the initial energizing path. Relay 291, in operating, disconnects conductor 233 from the winding of relay 290, and connects it with two paths, one of which extends to high potential battery by way of the windings of relay 295 in series, right-hand winding of position register 297, and left-hand back contact and armature of relay 296; and the other of which extends to ground by way of the two windings of relay 296 in series, left-hand winding of the position register 297, and right-hand armature and back contact of relay 295. The object of thus connecting the sleeve conductor of the connection, by way of conductor 233, with two paths, one of which extends to high potential battery and the other of which extends to ground, is to provide for the proper operation of the metering or connection registering apparatus, whether the sleeve conductor of the calling line is connected to ground, as it may be in the case of ordinary lines, or whether it is connected to high potential battery, as it may be in the case of private branch exchange or PBX lines, it being customary to provide different connections for different classes of lines for the purpose of controlling the busy test in a manner that need not here be described.

In the present instance it will be assumed that the calling line is the line extending from station A, and that the sleeve conductor 53 of this line has connection with ground by way of the windings of the line register 92. When relay 291 operates, therefore, a circuit is completed that extends from high potential battery by way of the left-hand armature and back contact of relay 296, right-hand winding of position register 297, the two windings of relays 295 in series, and the left-hand armature and switch spring of relay 291 to conductor 233; from which point the connection to ground is by way of two parallel paths, one of which extends through the right-hand switch spring and armature of relay 291, the two windings of relay 296 in series, left-hand winding of position register 297, and the right-hand back contact and armature of relay 295; and the other of which extends by way of conductor 233, alternate contact and switch spring 151 of key 150, left-hand armature and switch spring of relay 81 to the sleeve conductor 87, and thence through the cord selector switch, the finder circuit, and the line finder switch, over a path that has already been traced, to conductor 53 of the calling line, and thence to ground by way of two windings of the line register 92 in series. As the entire current flow passes through relay 295, while the relay 296 is shunted by the path to ground by way of the line register 92, the relay 295 is operated and the relay 296 is not. Relay 295, in operating, opens at its right-hand armature and back contact the shunt path which was traced as extending through the windings of relays 296, and therefore the relay 296 is excluded from the circuit. The relay 295, in operating, also closes at its left-hand armature and front contact, a short circuit about its left-hand winding. The left-hand winding of the relay 295 and the right-hand winding of relay 296 are of relatively high resistance, and the right-hand winding of relay 295 and the left-hand winding of relay 296 are of relatively low resistance. Therefore, in short-circuiting its left-hand winding the relay 295 causes a considerable increase in the current flow over the circuit. The left-hand winding of the line register 92 of the calling line is of relatively high resistance, and the right-hand winding of relatively low resistance,

and the adjustment of the register is such that it is not responsive to the ordinary current flow in the circuit, but responds to such increase of current flow as results when the relay 295 operates, as described, to short-circuit its left-hand or high resistance winding. When the line register operates in response to this increased current flow, it short-circuits its left-hand or high resistance winding, and in doing so further increases the flow of current in the circuit. The adjustment of the position register 297, both of whose windings are of low resistance, is such that it is unresponsive to the increased current flow that operates the line register 92 but responds to the further increase caused by the operation of the line register in short-circuiting its left-hand winding. Therefore, the operation of the line register 92 causes the operation of the position register 297. The position register in operating closes a circuit that extends from battery through the pilot lamp 264 and by way of the front contact and armature of the position register to ground. The illumination of this lamp indicates to the operator that the registration has been properly effected. Relay 295, in operating, closes a circuit that extends from battery through the right-hand winding of relay 294 and the right-hand front contact and armature of relay 295 to ground. Relay 294, in operating, closes at its switch spring and armature a path to ground through the winding of the relay 293, and at the same time opens the path to ground by way of resistance 265 and back contact and armature of relay 293. Relays 291 and 292 included in this circuit are thus maintained energized, and the relay 293 is also energized.

When the operator is informed by the lighting of the pilot lamp 264 that the line register 92 and the position register 297 have responded, she releases the register and disconnect key 150. This opens, at contact and switch spring 151 of the key, the circuit by way of the left-hand switch spring and armature of relay 291, right-hand winding of relay 295, right-hand winding of position register 297, and back contact and armature of relay 296, and as a result the relay 295 and position register 297 are released. The relay 295, in releasing, opens the energizing circuit of the relay 294, and that relay in releasing opens the energizing circuit of the relay 293 and again connects the energizing circuit of the relays 291 and 292 to the branch path that extends by way of the resistance 265 and back contact of relay 293. But the relay 293 is so constructed, as by placing a copper sleeve around its core, as to be slow in releasing. Consequently, the path by way of the resistance 265 is held open for an instant before it is closed at the back contact and armature of relay 293; and during this instant the relays 291 and 292 are released. Relay 292 in releasing opens the locking circuit by way of its front contact and armature so that thereafter the relays 291 and 292 remain deenergized. The position register apparatus is thus restored to its normal condition.

If it had been assumed that the calling line was of a character that, for its proper identification in the operation of the system, requiring the connection of its line register 92 to the free pole of the high potential battery instead of to ground, then the operation would have been the same as has been described, excepting that the relay 296 of the position register apparatus would have operated and the relay 295 would have remained inert, the path for the energization of the relay 296 being by way of the right-hand switch spring and armature of relay 291, the windings of relay 296 in series, the left-hand winding of position register 297, and right-hand back contact and armature of relay 295 to ground. In this case, the operation of the position register 297 lights the pilot lamp 264 and the operation of the relay 296 energizes the relay 294 by way of its left-hand winding, in a manner similar to that described under the first assumption.

It will be observed that the pressing of the register and disconnect key 150 brings about the connection of the relays 295 and 296 and the position register 297 with the sleeve conductor 87 only when the sleeve conductor has connection with a calling line. If the key 150 should be pressed at a time when no calling line is extended to the corresponding connecting circuit, the relay 290, having no energizing path by way of the sleeve conductor 87, is not operated, and consequently, the relay 291, which controls the connection of the devices 295, 296 and 297 with the circuit, is not operated. The object of this is to prevent the relays 295 and 296 from being brought together in a local circuit without any outlet to a calling subscriber's line, the result of which would be the setting up of a vibratory action in which the relays would interrupt their own energizing circuits and would cause an improper operation of the position register 297.

If the calling line is assumed to be a coin collector line with a coin box connected with the line at the subscriber's station, in a manner that is well known in the art, and therefore does not need to be described, then the connection of the sleeve conductor of the line with ground is by way of a resistance 91 instead of by way of the windings of a line register 92. In this case when the operator presses her register and disconnect key 150, the relay 290 operates and causes the operation and locking up of the relays 291 and 292, and relay 291 in operating ex-

tends the conductor 233 to the windings of the relays 295 and 296, and the relay 295 is operated, just as previously described. But the position register 297 is not operated, by reason of the fact that the relay 295 in operating and in increasing the current flow in the sleeve circuit does not bring about the further increase, such as is caused when the line register 92 operates, that is necessary to operate the position register 297. The relay 294, however, is energized by the operation of relay 295 to unlock the relays 291 and 292 when the operator releases the register and disconnect key 150. But in the case of a coin collector line, the pressing of the key 150 closes a circuit that extends from the positive pole of the source of current 266, which may be a generator that delivers current at a potential of 110 volts, through the lamp 263, right-hand winding of relay 267, conductor 232, alternate contact and switch spring 152 of the key 150, conductor 85, and thence through the corresponding conductors of the cord selector switch, finder circuit, and line finder switch to the talking conductor 38 of the calling line, and to ground by way of the magnet of the coin collector box at the calling subscriber's station. The current which is thus caused to flow causes the deposit of the coin, the lighting of the lamp 263 and the lighting of the pilot lamp 264, the energizing circuit of the last mentioned lamp being completed by the operation of the relay 267.

As long as the register and disconnect key 150 is held depressed, the current which flows from the position register apparatus by way of conductor 233, alternate contact and switch spring 151 of the key 150, and left-hand armature and switch spring of relay 81 to sleeve conductor 87, maintains the energization of the holding relay 56 of the finder circuit. When the key 150 is released, the energizing circuit of the relay 81 is broken at the switch spring 154 and alternate contact of key 150, and the relay 81, in releasing, disconnects the sleeve conductor 87 from the path extending to the position register apparatus and reconnects it with the path which extends to the left-hand armature of relay 13. But the relay 13 has been released and the listening key sequence switch is standing in position 8, as has been described, therefore, this path is open, and current ceases to flow through the winding of the holding relay 56 included in the sleeve conductor of the finder circuit. The relay 56, therefore, releases its armatures and opens the energizing circuit of the relay 30, and that relay in releasing moves the selector sequence switch out of position 9 and brings about the return of the finder circuit sequence switches and the line finder and cord selector switches to normal in the manner hereinbefore described. It will be observed that the arrangement is such that the connection through the finder circuit with the calling subscriber's line is maintained until after the register and disconnect key 150 is released, thus preventing the disestablishment of the connection until the registration of the call or the collecting of the coin at the calling subscriber's station is effected.

The listening key sequence switch has been resting in position 8 pending the restoration of the register and disconnect key 150. When that key is released, a circuit is closed that extends from battery through the motor magnet and contact 410 (8) of the listening key sequence switch, right-hand back contact and armature of relay 13, resting contact and switch spring 146 of the holding key 140, listening key switch cam 407 (7 to 1), and resting contact and switch spring 154 of the key 80 to ground. The closure of this circuit moves the listening key sequence switch out of position 8, and the switch thereafter continues to move under the control of its cam 401, until it reaches and comes to rest in its normal or first position.

As hereinbefore stated, as long as the register and disconnect key 150 is depressed, the relay 95 is held energized. This is for the purpose of preventing the lamp lead 88 from being extended during this interval to the high potential battery by way of the resistance 126, in order that the connecting cord circuit upon which the registration is being effected may be maintained unselectable while the registration is being made.

In case the operator is unable to complete the desired connection, and is informed by her class-of-service signal that the calling line is a call box line, the coin which the calling subscriber has deposited must be returned to him. This the operator accomplishes by pressing the refund key 185, which closes a circuit that extends from the negative pole of the generator 266 (see Fig. 6) lamp 262, left-hand winding of relay 267, conductor 231, upper contact and switch spring of the refund key 185, resting contact and switch spring of the ring back key 184, conductor 237, listening key sequence switch contact 405 (4 to 7), resting contact and switch spring 143 of the holding key 140, resting contact and switch spring 152 of the register and disconnect key 150, and to the tip conductor 85, from which point the circuit is by way of the tip conductor of the finder circuit and of the calling line and through the refund magnet of the coin box at the calling subscriber's station to ground. The closure of this circuit returns the coin and also operates the relay 267 to light the pilot lamp 264 which indicates to the operator that the refund current has passed over the circuit.

It sometimes happens that the calling subscriber wishes to call a number of lines one

after the other. In this case, it is desirable that the operator be provided with means for making the registration or collecting the coin at the end of each successful connection of the succession without disconnecting the calling subscriber's line from the connecting cord circuit to which it has been extended. To attain this end in the present system, the key 180 (see Fig. 5) is provided. It will be assumed that at the end of a conversation the called subscriber hangs up and the calling subscriber flashes his supervisory lamp 335; that the operator in response to this signal presses the listening-in key 183, thus bringing her telephone apparatus into connection with the corresponding connecting cord circuit and also automatically obtaining the class-of-service indication of the calling line; and that the calling subscriber, whose line is a message rate line, requests the operator to connect him with a different line from that with which he has been talking. In this case, the operator, before establishing the new connection, presses register key 180, which key is part of the operator's common or position apparatus. When the key 180 is pressed, the talking conductors of the circuit are opened, and a circuit is closed that extends from battery through the left-hand winding of relay 81, right-hand winding of relay 95 and the left-hand winding of relay 125 in parallel, listening key sequence switch contact 414 (4 to 7), conductor 242, and alternate contact and switch spring 182 of key 180 to ground. Relay 81, in operating, disconnects the sleeve conductor 87 from the path that extends to battery by way of the left-hand armature and front contact and the winding of relay 13, and connects it instead with a branch that extends by way of switch spring 151 and resting contact of key 150, listening key sequence switch contact 415 (4 to 7), conductor 235, switch spring 181 and alternate contact of key 180, conductor 233, left-hand switch spring and resting contact of relay 291 (see Fig. 6) and winding of relay 290 to battery. Upon the closure of the above-traced circuit through the sleeve conductor, the position registering apparatus (shown in Fig. 6) and the line register 92 of the calling subscriber's line are operated to effect their registrations in the manner hereinbefore described. Relay 81, in operating, also closes at its right-hand armature and front contact the energizing circuit of the relay 337 (see Fig. 7) and that relay operates, in the manner hereinbefore described, to bring about the restoration of the connecting cord sequence switch 500 to its normal position. The action of the relay 81 in disconnecting, at its left-hand switch spring and resting contact, the sleeve conductor from battery by way of the winding of relay 13, permits relay 13 to release its armatures. But in closing its right-hand armature and back contact, the relay 13 does not close the circuit by way of cam 410 (6) for moving the listening key sequence switch out of its listening-in or sixth position, for the reason that the continuation of this circuit by way of switch spring 146 and resting contact of holding key 140, listening key sequence switch contact 407 (4 to 7), and conductor 234 is broken at the resting contact and switch spring 182 of the position register key 180. This path is closed when the register key 180 is released; but the release of the register key effects the release of the relay 81, which in turn immediately causes the reenergization of the relay 13, the energizing path being closed at listening key sequence switch contact 412 (2 to 6), and the opening of the energizing circuit of the listening key sequence switch motor magnet at the right-hand back contact and armature of relay 13. As a result the depression and release of the position register key 180 does not cause the movement of the listening key sequence switch out of its listening-in position.

As soon as the position register key 180 is restored, which act causes the deenergization of relay 125, the circuit for energizing the motor magnet of the connecting cord sequence switch 500 is closed by way of contact 502 (18½ to 1) of that sequence switch, conductor 255, listening key sequence switch contact 418 (2 to 6), left-hand back contact and armature of relay 125, resting contact and switch spring 146 of holding key 140, listening key sequence switch contact 407 (4 to 7), conductor 234, and resting contact and switch spring 182 of position register key 180 to ground. The closure of this circuit moves the connecting cord sequence switch 500 out of position 1 and into position 2 where the connecting cord circuit is in position to proceed with the establishing of the new connection when the calling plug 334 is inserted into the called line spring-jack.

During the time that the relay 13 is released as a result of the depression of the position register key 180, relay 94 continues energized by way of the circuit that extends from battery through the right-hand winding and the switch spring and left-hand armature of relay 94, listening key sequence switch contact 417 (6), conductor 249, and lower back contact and armature of relay 156 to ground. Thus the lamp lead 88, which is extended back by way of the finder circuit to conductor 54 of the calling subscriber's line and the common class-of-service interrupting apparatus, is kept clear during the interval while the position register key 180 is pressed, the relay 95 being also energized at this time to prevent the lamp lead from being reconnected with the high potential battery by way of the resistance

126 and the right-hand back contact and armature of relay 95.

In operating a telephone system of the character of that disclosed herein, it sometimes happens that, when the called line is found busy or does not answer, the calling subscriber requests the operator to call him as soon as she is able to get connection with the line that is being called. In the present system, the operator is enabled to meet this condition through the provision of the holding key 140 and its associated circuits and apparatus. When, under the above mentioned circumstances, the operator presses the holding key 140, the extensions of the talking conductors of the calling line to the connecting cord circuit are interrupted at the holding key switch springs 143 and 144 and their resting contacts, and a circuit is closed that extends from battery by way of the right-hand winding of relay 81, alternate contact and switch spring 146 of key 140, listening key sequence switch contact 407 (4 to 7) (it being assumed that the operator's telephone apparatus is connected with the circuit and that the listening key sequence switch is in its listening-in position), conductor 234, and resting contact and switch spring 182 of position register key 180 to ground. Relay 81, in operating, disconnects the sleeve conductor 87 from battery by way of the winding of relay 13, and connects it with a branch path that extends by way of switch spring 151 and resting contact of the register and disconnect key 150, alternate contact and switch spring 142 of holding key 140, listening key sequence switch contact 419 (2 to 7), conductor 240, and right-hand winding of relay 128 to battery.

Prior to the pressing of the holding key, the relay 128 has been in an operated condition by reason of the current that flows through its right-hand winding, conductor 240, listening key sequence switch contact 419 (2 to 7), and switch spring 142 and resting contact of the holding key 140 to ground. The relay 128 therefore remains energized, and at the same time, a parallel energizing path is closed from battery by way of the left-hand winding of relay 128, left-hand armature and contact of that relay, resting contact and switch spring 181 of the position register key 180, conductor 235, listening key sequence switch contact 415 (4 to 7), resting contact and switch spring 151 of key 150, and left-hand armature and switch spring of relay 81 to the sleeve conductor.

Relay 81, in operating, also closes at its right-hand armature and front contact the previously described energizing circuit for relay 337 by way of conductor 258; and relay 337 in operating effects the return of the calling cord sequence switch 500 to normal in the manner hereinbefore described. As the calling cord sequence switch reaches position 18½, a circuit is closed that extends from battery through the motor magnet and contact 410 (6) of the listening key sequence switch, right-hand back contact and armature of relay 13 (that relay having been released by the opening of its energizing circuit at the left-hand switch spring and resting contact of relay 81), left-hand armature and back contact of relay 125, contact 418 (2 to 6) of the listening key sequence switch, conductor 255, calling cord sequence switch contact 502 (18½ to 1), and cam 501 of the calling cord sequence switch to ground, the path to ground by way of this sequence switch contact not being opened until the switch reaches position 1. The closure of this circuit moves the listening key sequence switch from its listening-in position 6 to its listening-out position 8.

In moving into position 8, the listening key sequence switch closes a circuit that extends from battery through the right-hand winding of relay 125, listening key sequence switch contact 421 (7 to 8), alternate contact and switch spring 146 of holding key 140, listening key sequence switch contact 407 (7 to 1), and resting contact and switch spring 154 of the register and disconnect key 150 to ground. Relay 125, in operating, closes at its right-hand front contact and armature a locking circuit that thereafter maintains the energization of the relay as long as the holding key is in its operated position. The object of thus locking up the relay 125 after the listening key sequence switch has moved out of its listening-in position 6, is to prevent the movement of the connecting cord sequence switch out of position 1 at a later stage in the operation by the movement of the listening key sequence switch 400 from its listening-out position 8 to its listening-in position 6. The circuit which would thus be closed may be traced from battery through the motor magnet and contact 502 (18½ to 1) of the calling cord sequence switch, conductor 255, listening key sequence switch contact 418 (2 to 6), left-hand back contact and armature of relay 125 (assuming that the circuit were not broken at this point as a result of the operation of the relay 125), right-hand armature and back contact of relay 13, listening key sequence switch contact 410 (2 or 6), and cam 401 (2 or 6) of the listening key sequence switch to ground, the ground connection at cam 401 not being opened until a moment after the circuit at cam 410 is closed. The current which would thus momentarily flow would cause the calling cord sequence switch to move out of position 1.

When the listening key sequence switch moves into position 8 as a result of the return of the calling cord sequence switch

500 to position 1, it opens, at listening key sequence switch contacts 415 (4 to 7) and 419 (2 to 7), the previously traced connection of the sleeve conductor 87 with battery by way of the windings of relay 128. As a result of the opening of the sleeve conductor, the relay 56 of the finder circuit releases its armatures and, at its right-hand armature and front contact, opens the path over which the lamp lead of the calling line is extended to the connecting cord circuit. But the release of the relay 56 does not release the finder circuit and disconnect it from the calling line, for the reason that a circuit is now completed from battery by way of selector sequence switch contact 320 (7 to 9), winding of relay 30 of the finder circuit, selector sequence switch contact 309 (7 to 9), left-hand switch spring and resting contact of relay 56, selector sequence switch contact 308 (7½ to 9), conductor 99, brush 114, and terminal 118 of the cord selector switch, conductor 88, switch springs 145 and 146 of holding key 140, listening key sequence switch contact 407 (7 to 1), and resting contact and switch spring 154 of key 150 to ground. This path to ground, closed by the operation of the holding key, maintains the relay 30 of the finder circuit energized, and thus prevents the closure of the circuit for moving the selector sequence switch out of position 9 by way of selector sequence switch contact 304 (9) and the right-hand back contact and armature of relay 30.

The condition of the circuit at this time, therefore, is that the calling line is maintained in connection with the connecting cord circuit by way of the finder circuit, but has its talking conductors open at switch springs 143 and 144 of the holding key, its lamp lead open at the right-hand armature of relay 56, and its sleeve conductor open at contacts 415 (4 to 7) and 419 (2 to 7) of the listening key sequence switch. As a result the calling line, although still held in connection with the connecting circuit that it originally selected, is free to originate calls that will be extended to other finder circuits and connecting cord circuits, and to receive calls from other lines just as though the connection with the original finder circuit and connecting circuit did not exist.

When the operator is ready to attempt again to complete connection with the called line, she first listens in upon the connecting cord circuit on which the calling line is being held. This closes a circuit that extends from battery through the motor magnet and contact 409 (8) of the listening key sequence switch, contact of the listening-in key 183, conductor 249, and lower back contact and armature of relay 156 to ground. The closure of this circuit causes the listening key sequence switch to move out of its listening out or eighth position, and to continue to move under the control of its 401 cam, until it reaches its normal or first position. But instead of stopping here, as it does ordinarily, the listening key sequence switch is moved through its first position by an energizing circuit that extends from battery through the motor magnet and contact 410 (1) of the listening key sequence switch, left-hand armature and lower front contact of relay 95, and alternate contact and switch spring 141 of holding key 140 to ground. This path to ground at the same time serves to keep relay 95 energized by way of its left-hand winding and left-hand front contacts and armature, the path being closed by the depression of the holding key before the normal energizing path for the relay 95 by ways of its left-hand winding and the right-hand front contact and armature of relay 13 is opened by the release of relay 13 when the holding key is pressed. The energizing path for the motor magnet of the listening key sequence switch, by way of the contact 410 (1) and contact and switch spring 141 of the holding key, is normally open at the left-hand armature and front contact of the relay 95 in order that pressing the holding key when no call has been extended to the associated connecting cord circuit may not cause the movement of the associated listening key sequence switch out of position 1.

After passing position 1, the listening key sequence switch is moved through position 2 by a circuit that extends through its motor magnet and by way of its contact 410 (2) and the right-hand armature and switch spring of relay 94 to ground, this relay being maintained energized while the holding key is depressed by the path that extends to ground by way of the left-hand front contacts and armature of relay 95, and contact and switch spring 141 of the holding key. The listening key sequence switch therefore continues to move until it reaches its listening-in position 6, where it comes to rest.

When the listening key sequence switch reaches position 2 in its movement to position 6, it connects the right-hand winding of relay 128 with the sleeve conductor 87 of the circuit by way of conductor 240, listening key sequence switch contact 419 (2 to 7), switch spring 142 and alternate contact of holding key 140, resting contact and switch spring 151 of register and disconnect key 150, and the left-hand armature and switch spring of relay 81. If the calling line has in the meanwhile initiated another call, or has been called, and is therefore busy, the sleeve conductor of the line is connected with battery by way of the relatively low resistance winding of relay 13 if the calling line has originated a call, or is connected with battery by

way of the relatively low resistance of relay 338 (see Fig. 7), if the line has been called by another line. In either case this low resistance path from battery shunts the path by way of the relatively high resistance right-hand winding of the relay 128 (see Fig. 5), and hence the relay 128 is not energized. Therefore, at the first closure of the pick-up circuit that occurs after the listening key sequence switch reaches its listening-in position 6, a circuit is completed that extends from battery through the left-hand armature and resting contact of relay 159 (see Fig. 5), winding of relay 129, upper back contact and armature of relay 155, conductor 251, listening key sequence switch contact 416 (6), and contacts of the pick-up commutator 171 to ground. As the relay 128 has remained shunted and inert, and has not operated relay 127, the operation of relay 129 causes the closure of a circuit that extends from one of the windings of the induction coil 169 associated with the tone-test apparatus 168, by way of upper armature and front contact of relay 129 and lower back contact and armature of relay 127 to the operator's telephone set. Therefore, if the calling line which is being held is in use, the operator, when she listens in on the corresponding circuit, hears a tone in her telephone receiver that informs her of this fact. She may then listen out by pressing the listening-out key 187, or by listening in on some other connecting cord circuit, as hereinbefore described.

If, however, the calling line is not in use when the operator listens in upon the circuit the holding key of which is depressed, then the relay 128, not being shunted, operates and closes at its right-hand front contact and armature the energizing circuit of the relay 127. This relay, in operating, brings the operator's telephone apparatus into circuit, and also opens at its lower armature and resting contact the path that otherwise will be closed for the transmission of the busy tone when the relay 129 operates as a result of the passage of the first pick-up impulse a few moments later. When relay 128 operates it closes a path from battery to the sleeve conductor 87 of the circuit by way of the low resistance left-hand winding of relay, 128, the left-hand armature and front contact of that relay, resting contact and switch spring 181 of the position register key, conductor 235, listening key sequence switch contact 415 (4 to 7), resting contact and switch spring 151 of the register and disconnect key 150, and left-hand armature and switch spring of relay 81. The closure of this relatively low resistance path from battery establishes the electrical condition upon the sleeve conductor of the calling line which marks the line as busy, and again causes the energization of the relay 56 included in the sleeve conductor of the finder circuit.

If, therefore, the operator listens in upon a cord circuit the holding key of which is depressed, and hears no busy tone in her telephone receiver, she knows that the calling line is free and in readiness for connection with the called line. To establish the connection, the operator first restores the holding key 140 to its normal position. This breaks the energizing circuit for the relay 81 which has existed by way of its right-hand winding, and the relay releases its armatures. In releasing its left-hand armature the relay 81, without interrupting the flow of current in the sleeve conductor 87, disconnects that conductor from the parallel branches that extend to battery by way of the two windings of the relay 128, as described, and connects it instead with the branch that extends to battery by way of listening key sequence switch contact 412 (2 to 6) and the winding of relay 13. The last mentioned relay, in operating, locks up by way of its left-hand front contact and armature, and at its right-hand armature and front contacts reapplies ground, by way of resting contact and switch spring 146 of holding key 140 and listening key sequence switch contact 407 (4 to 7), for maintaining the energization of the relay 95 when the energizing path for that relay is interrupted at contact and switch spring 141 of the holding key. When the extension of the sleeve conductor 87 to battery by way of the windings of the relay 128 is interrupted by the release of the relay 81, the relay 128 is not released, but is maintained energized, to maintain the relay 127 energized, by way of the path that extends from battery through the right-hand winding of relay 128, conductor 240, listening key sequence switch contact 419 (2 to 7), and switch spring 142 and resting contact of the restored holding key 140 to ground.

The restoration of the holding key 140 to normal as a result of finding the calling line available, also closes a circuit by way of motor magnet and contact 502 (18½ to 1) of the calling cord sequence switch, conductor 255, listening key sequence switch contact 418 (2 to 6), left-hand back contact and armature of relay 125, resting contact and switch spring 146 of holding key 140, listening key sequence switch contact 407 (4 to 7), conductor 234, and resting contact and switch spring 182 of the position register key 180 to ground. The calling cord sequence switch is therefore moved to position 2.

When the relay 81 is released upon the restoration of the holding key, it also, at its right-hand armature and resting contact, reapplies ground to the relay 155 for bringing

about, in the manner previously described, the energerization of that relay at the termination of the first pick-up impulse; and the relay 155, in operating, connects the operator's class-of-service apparatus with the calling line to give the operator the class-of-service indication in the manner hereinbefore described. The operator in listening in on a connection, the holding key of which is depressed, does not receive the class-of-service indication, on account of the energizing circuit of the relay 155 being broken at the right-hand armature and back contact of relay 81, the indication being received only after the holding key is restored to normal.

As a result of the above described circuit changes brought about by the restoration of the holding key 140, the operator again has control over the calling subscriber's line, and may proceed to establish the connection. If upon resting the called subscriber's line in the usual way the operator finds it in use, she may again depress the holding key and reestablish the holding condition on the circuit and at the same time automatically listen out, in the manner hereinbefore described. If the called line is not in use, the operator inserts the calling plug 334 to hold the called subscriber's line and to advance the calling cord sequence switch to its talking position 16. She then signals the calling subscriber by depressing the ring-back key 184, and signals the called subscriber by pressing the connecting cord ringing key 330.

At each operator's position there is a relay 190 which is energized when the corresponding position is selected by an incoming call, and which is kept energized as long as the operator is engaged in attending to incoming calls or in supervising existing connections. The energizing circuit of this relay extends from battery through the winding of the relay, and by way of two branches, one of which is closed to ground at the right-hand front contact and armature of relay 148, and the other of which extends to ground by way of conductor 241 and contact 411 (2 to 6) of any of the listening key sequence switches which may be at or approaching its listening-in position. The contacts of all of the relays 190 of the various operators' position are connected in a series circuit that includes the winding of a common relay 192. The contacts 198 of the telephone spring jack 195 at each operator's position are also connected in parallel with the contacts of the relay 190 in that position, the contacts 198 being open when the operator is at her position and closed when the operator leaves her position and withdraws the telephone plug from its spring-jack. As a result of this arrangement, the energizing circuit of the relay 192 is closed and the relay is energized when all of the operators are either engaged in receiving calls, supervising connections or are absent from their positions. When the relay 192 operates it closes a circuit that causes the illumination of a number of lamps 194, one lamp being located at each operator's position. The illumination of these lamps notifies the operators that no position is available for receiving incoming calls, with the result that the operators make an effort to speed up in order that their positions may become available. One of the lamps may also be placed upon the chief operator's desk, in order that the chief operator may be made aware of this condition when it arises, and may send operators to vacant positions when all of the occupied positions become busy.

The organization of the system is such that if for any reason the line-finder brushes are not stopped upon the terminals of the calling line, and the switch goes to the top of its movement, the line finder switch is automatically returned and the finder sequence switch is restored to its normal position. When the line finder elevator goes to the top of its movement, a circuit is completed that extends from battery through the motor magnet contact 205 (3 to 6) of the finder sequence switch, conductor 65, and line finder commutator segment X and corresponding brush to ground. The closure of this circuit moves the finder sequence switch out of position 3, its line hunting position, and causes it to continue to move until it reaches position 18, the movement of the sequence switch after it passes position 5 being under the control of sequence switch cam 201. The finder sequence switch comes to rest in position 18, in which position the energizing circuit of the down-drive magnet 62 is closed at sequence switch cam 218. At the end of the downward movement of the line finder switch, an energizing circuit for the finder sequence switch is closed by way of contact 203 (18), conductor 69, and Y segment and corresponding brush of the line finder commutator. The closure of this circuit causes the finder sequence switch to move out of position 18 and to come to rest in its normal or first position.

As the finder sequence switch reaches position 4 as a result of the action described above, a circuit is closed from battery through the left-hand winding of relay 37, finder sequence switch contact 205 (4 to 7), conductor 65, line finder commutator X, and corresponding brush to ground. The relay 37 is thereupon energized and closes at its left-hand armature and front contact a circuit for causing the illumination of the tell-tale lamp 343 common to a number of the finder circuits. Relay 37, in operating also opens, at its left-hand armature and back

contact, the circuit that extends by way of finder sequence switch contact 220 (4) and selector sequence switch contact 302 (1) for energizing the selector sequence switch motor magnet. The result is that when the finder sequence switch moves into position 4 as a result of the line finder switch going to the top of its movement, the selector sequence switch is not moved, but remains in position 1.

In the case of the cord selector, when the switch does not stop upon the terminals of an idle connecting circuit it goes to the top of its movement and a circuit is closed that extends from battery through the motor magnet and contact 314 (5 to 9) of the selector sequence switch conductor 70 and cord selector commutator segment X, and corresponding brush to ground. The closure of this circuit causes the selector sequence switch to move out of position 6, its cord hunting position, through position 9; and after passing position 9, to continue to move under the control of selector sequence switch cam 301 until it reaches and comes to rest in position 18. In position 18, a circuit is closed that extends from battery through the down-drive magnet 35 of the cord selector, conductor 90, and contact 311 (18) of the selector sequence switch to ground. When the cord selector switch has been returned to its normal position as a result of the closure of this circuit, a circuit is completed that extends from battery through the motor magnet and contact 303 (18) of the selector sequence switch, conductor 31 and Y segment and corresponding brush of the cord selector commutator to ground. The closure of this circuit moves the selector sequence switch out of position 18 and into position 1. The selector sequence switch, however, does not stop in position 1, but is moved through that position by means of a circuit that is closed from battery through the motor magnet and contact 302 (1) of the selector sequence switch, contact 220 (4) of the finder sequence switch, and the left-hand back contact and armature of relay 37 to ground. The finder sequence switch is resting in position 4 at this time because the circuit by way of finder sequence switch contact 202 (4) and selector sequence switch contact 321 (8) has remained open at the left-hand front contact and armature of relay 30 on account of that relay not having been energized by the finding of a connecting cord circuit, it being assumed that the cord selector brushes went to the top of their movement without being stopped upon the terminals of a cord circuit. Consequently, the selector sequence switch is moved through its normal or first position into its second position, and thereafter repeats its regular cycle of operations and again starts the cord selector in search of an idle cord circuit in a selected operator's position, as has hereinbefore been described. In this way, if all of the cord circuits of the operator's position are in use, or if for any other reason the cord selector fails to extend the finder circuit to a connecting cord, the cord selector is returned to normal and another trial made.

In the particular embodiment of the invention illustrated, the extension of the connecting circuit to the called subscriber's line is accomplished through the medium of a plug which may be inserted in the called line spring-jack. The organization of the system is such that the connecting circuit may be extended to the called line through the medium of automatic switches controlled by keys at the operator's position in the manner illustrated and described in Patent No. 1,168,319, issued January 18, 1916, to Alben E. Lundell. This circuit-extending organization of the Lundell patent is all of the organization shown in the Lundell drawings excepting substantially that part of Fig. 1 which is enclosed in the dotted line area in the upper left-hand quarter of the figure. If it is desired to utilize the Lundell switch-controlled method of effecting connection with the called line in practising the present invention, conductors 253, 254, 255, 256, 257 and 258 which extend to the margin of Fig. 4 of the drawing in the present case, may be joined to the part of the organization lying beyond the dotted line area of Figure 1 of the Lundell drawing as follows: Conductors 253 and 254 may be continued to the left-hand windings of the repeating coil of the Lundell drawing in substitution of the conductors which extend from the sequence switch contacts 260 and 259, respectively; conductor 255 may be continued to selector sequence switch contact 205 (1) of the Lundell drawing in substitution of the conductor that extends from the listening key sequence switch contact 103 (2 to 5) of that drawing; conductor 256 may be continued to conductor 112 in substitution of the connection with conductor 112 that extends from listening key sequence switch contact 111 and key 114 of the Lundell drawing; conductor 257 may be continued to selector sequence switch contact 208 (2) in substitution of the connection that extends from listening key sequence switch contact 118 (6 to 9) of the Lundell drawing; and conductor 258 may be continued to the left-hand winding of relay 210 in substitution of the conductor that extends to this winding from listening key sequence switch cam 118 of the Lundell drawing.

In order to disclose more fully the features to which this invention is directed, they have been shown and described in connection with other features that are the

subject of patents granted to S. B. Williams, jr., and assigned to the same assignee as follows:

No. 1247770 dated Nov. 27, 1917.
No. 1247771 " Nov. 27, 1917.
No. 1294587 " Feb. 18, 1919.

Such other features are the subject of claims in the patents mentioned above, and are not claimed in the present application.

What is claimed is:

1. In a telephone system, the combination with two telephone lines, a source of current, a service meter for one line connected with one pole of said source, a service meter for the other line connected with the other pole of said source, a connecting circuit, means for extending either of said lines to said connecting circuit, a switch for simultaneously applying both poles of said source of current to said connecting circuit, electromagnetic apparatus associated with said connecting circuit for automatically continuing the connection with the connecting circuit of that pole of the source of current adapted to effect the operation of the service meter of the extended line, and disconnecting the other pole of said source of current, and means for preventing the operation of the aforesaid switch when no line is extended to said connecting circuit.

2. In a telephone system, a connecting circuit, a source of current, a pair of branch circuits extending to opposite poles of said source, a relay in each branch, a pair of normally closed contacts for each relay controlling the branch circuit through the other relay, a telephone line, a service meter associated therewith and connected with one pole of said source of current, a connection switch for connecting said telephone line with said connecting circuit, electromagnetic means for connecting said branch circuits with each other and with the connecting circuit, one of said relays being actuated in the closure of said means to open the branch through the other of said relays, the branch that is opened being that which extends to the same pole of said source of current as that to which said service meter is connected, and means for preventing the operation of said electromagnetic means when said connection switch is open.

3. In a telephone system, the combination with two lines, of a source of current, an electric responsive device associated with one of said lines and connected with one pole of said source, an electric responsive device associated with the other line and connected with the other pole of said source, a connecting circuit, a connection switch for connecting either of said lines with said connecting circuit, electromagetic apparatus associated with said connecting circuit and including a pair of branch circuits extending to opposite poles of said source, a relay in each branch, a pair of normally closed contacts for each relay controlling the branch circuit through the other relay, switching mechanism for connecting the branch circuits of said electromagnetic apparatus with each other and with said connecting circuit, said relays acting upon the completion of said connection to continue the connection with the connecting circuit of that branch which is adapted to effect the operation of said electric responsive device of the connected line and to disconnect the other branch, and means actuated by the closure of said connection switch for rendering said switching mechanism operable.

4. The combination with a connecting circuit, of a telephone line, an automatic switch operated to extend said line to said connecting circuit, a toll device associated with said line, a switch associated with said connecting circuit, means actuated upon the operation of said switch for operating said connection register, and means actuated by the operation and release of said switch for restoring said automatic switch.

5. The combination with a connecting circuit, of a telephone line, automatic switching mechanism for extending said line to said connecting circuit, a holding circuit for said automatic switching mechanism operating to hold said telephone line in connection with said connecting circuit as long as current flows through said holding circuit, a connection register associated with said line and having its operating magnet included in said holding circuit, a register key associated with said connecting circuit, means actuated upon the operation of said key for changing the current flow in said holding circuit to operate said connection register and hold said connection while said key is operated, and means actuated by the operation and release of said key for interrupting said holding circuit to release said connection.

6. The combination with a connecting circuit, of a telephone line, an automatic switch for extending said telephone line to said connecting circuit, a holding circuit for holding the connection between said telephone line and said connecting circuit while current flows in said holding circuit, a connection register associated with said telephone line, a switch associated with said connecting circuit and adapted upon its operation to actuate said connection register and upon its release to interrupt the current flow in said holding circuit to release the connection, and another switch associated with said connecting circuit and adapted upon its operation to actuate said connection register and upon its release to maintain current flow in said holding circuit to hold said connection.

7. The combination with a connecting cir-

cuit, of a telephone line, an automatic switch for extending said line to said connecting circuit, toll apparatus associated with said line, two controlling switches associated with said connecting circuit, means actuated in the operation of one of said switches for operating said toll apparatus and releasing said automatic switch to disconnect said line from said connecting circuit, and means actuated in the operation of the other of said switches for operating said toll apparatus and maintaining the connection of said line with said connecting circuit.

In witness whereof, I hereunto subscribe my name this 12th day of May, A. D. 1921.

SAMUEL B. WILLIAMS, JR.