F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 1.

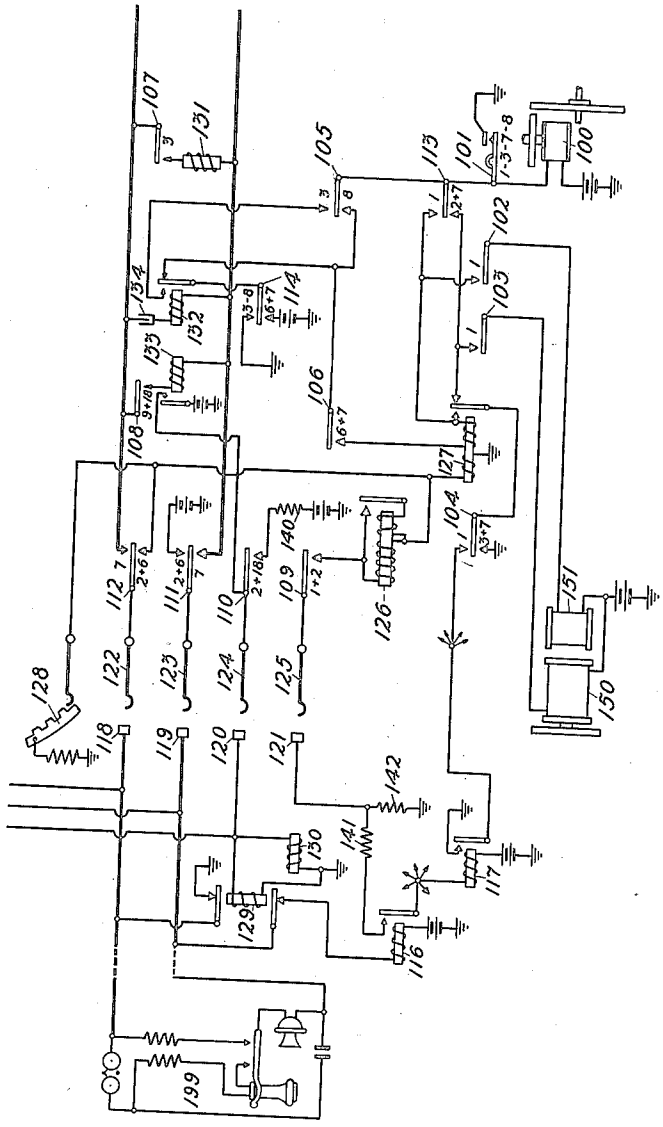


Fig. 1.

Witnesses:
O. B. M. Guthe.
Ph. R. Rossi.

Inventor:
Frank R. McBerty.
by L. C. Garner. Att'y.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

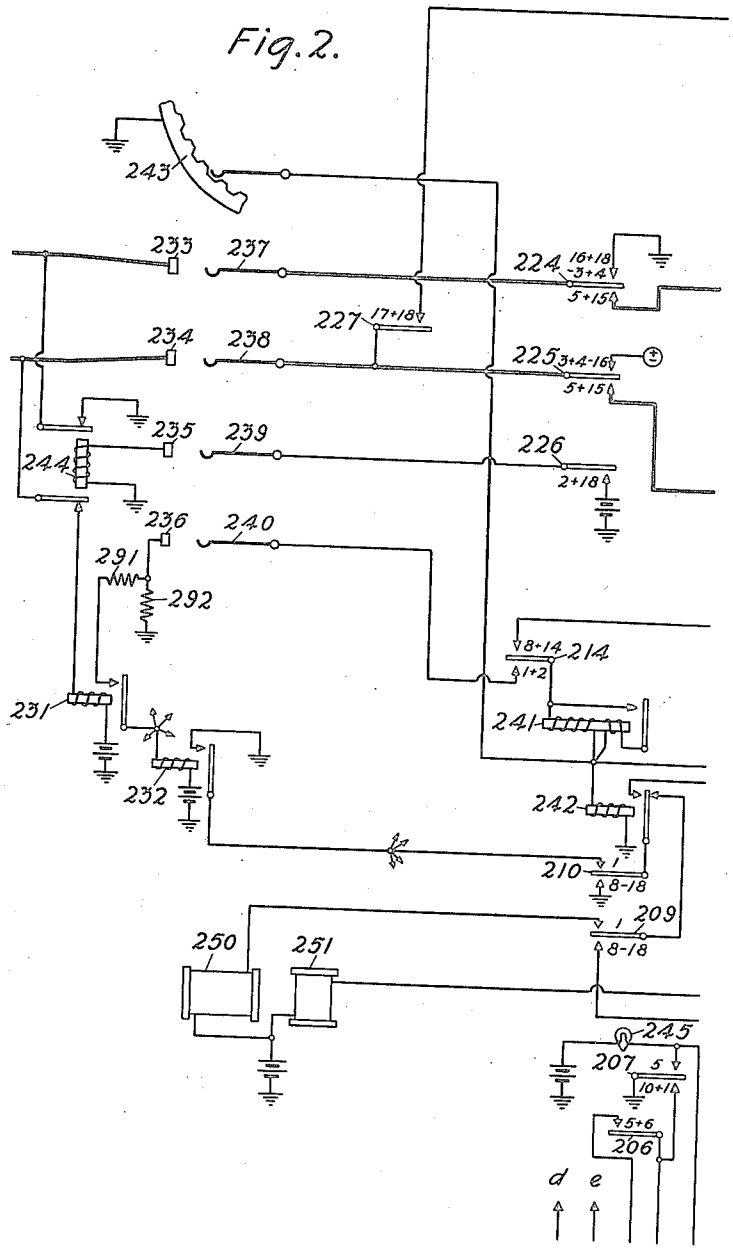
APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 2.

Fig. 2.



Witnesses:
O.B.m. Luthe.
Ph. R. Rossi.

Inventor:
Frank R. McBerty.
by A. C. Gannett Att'y.

F. R. McBERTY.

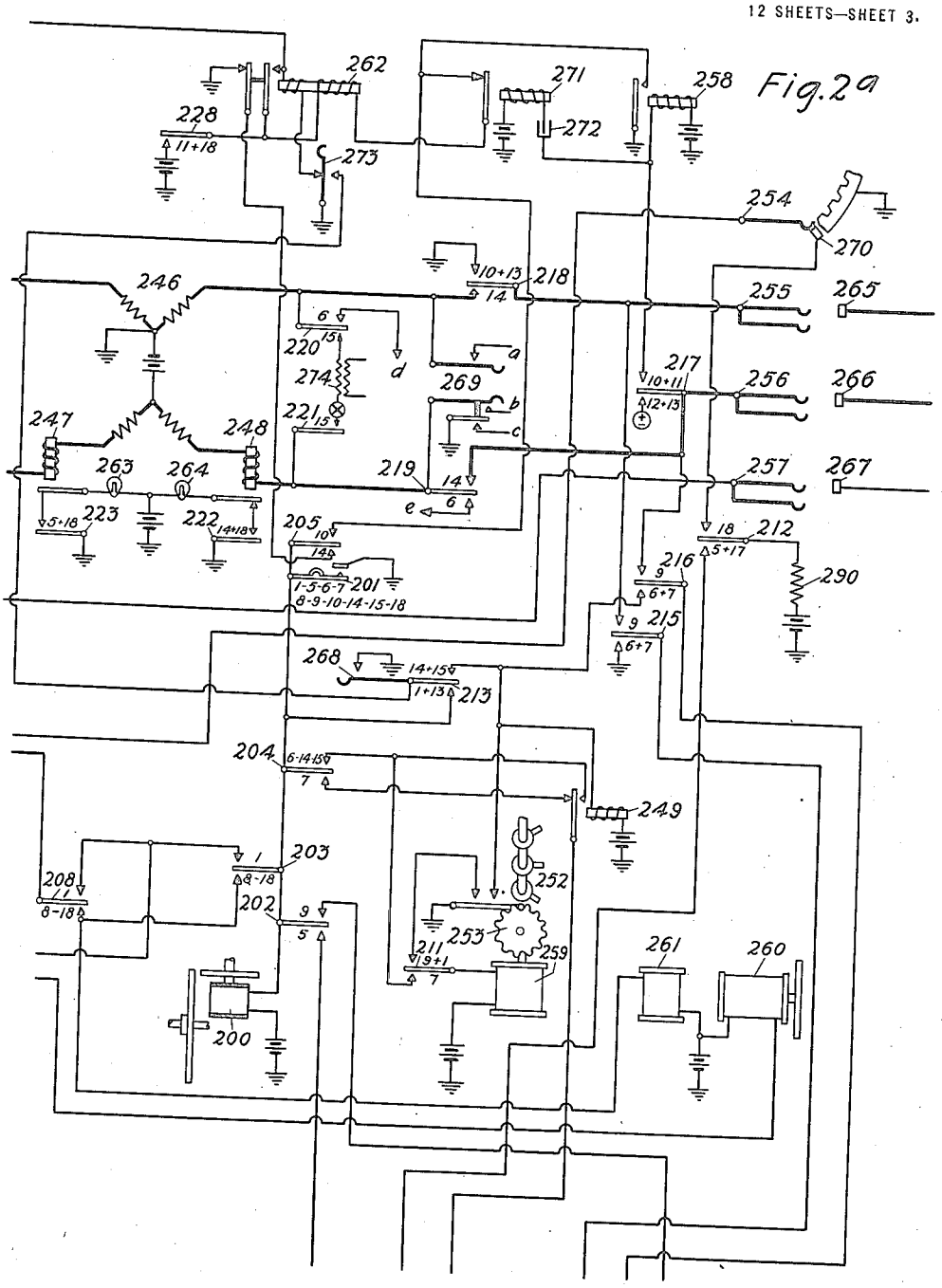
MACHINE TELEPHONE SWITCHING SYSTEM.

APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 3.



Witnesses:
O. D. M. Guthe.
Ph. P. Rossi.

Inventor:
Frank R. McBerty.
by A. Manuel Att'y.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 4.

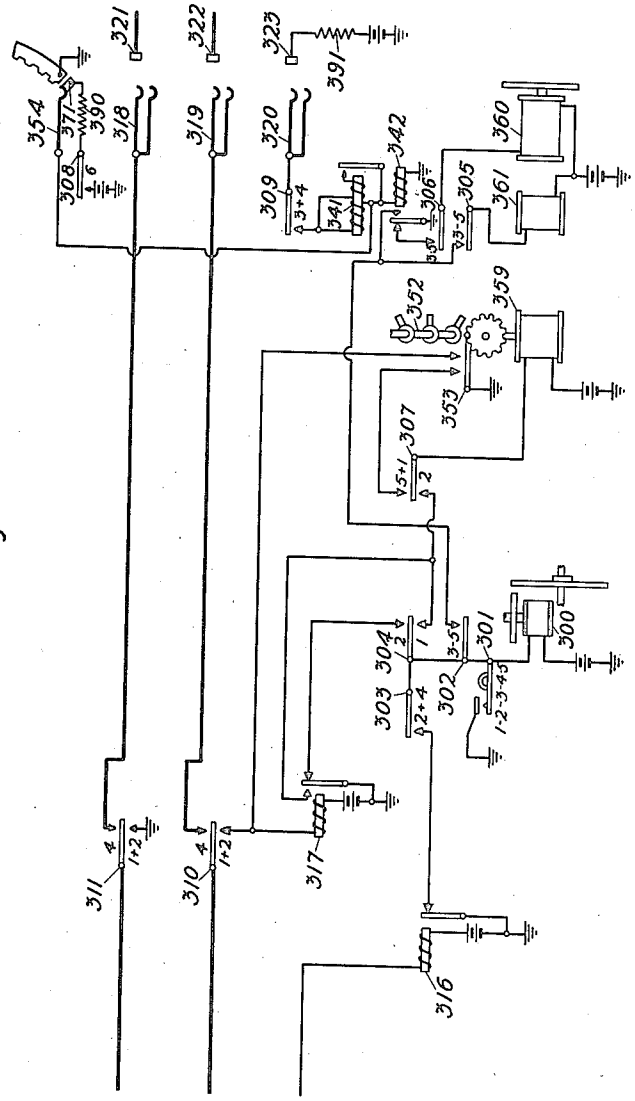


Fig. 3.

Witnesses:
O. D. M. Luthe.
Ph. R. Rossi.

Inventor:
Frank R. McBerty.
by D. C. Skinner, Atty.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 5.

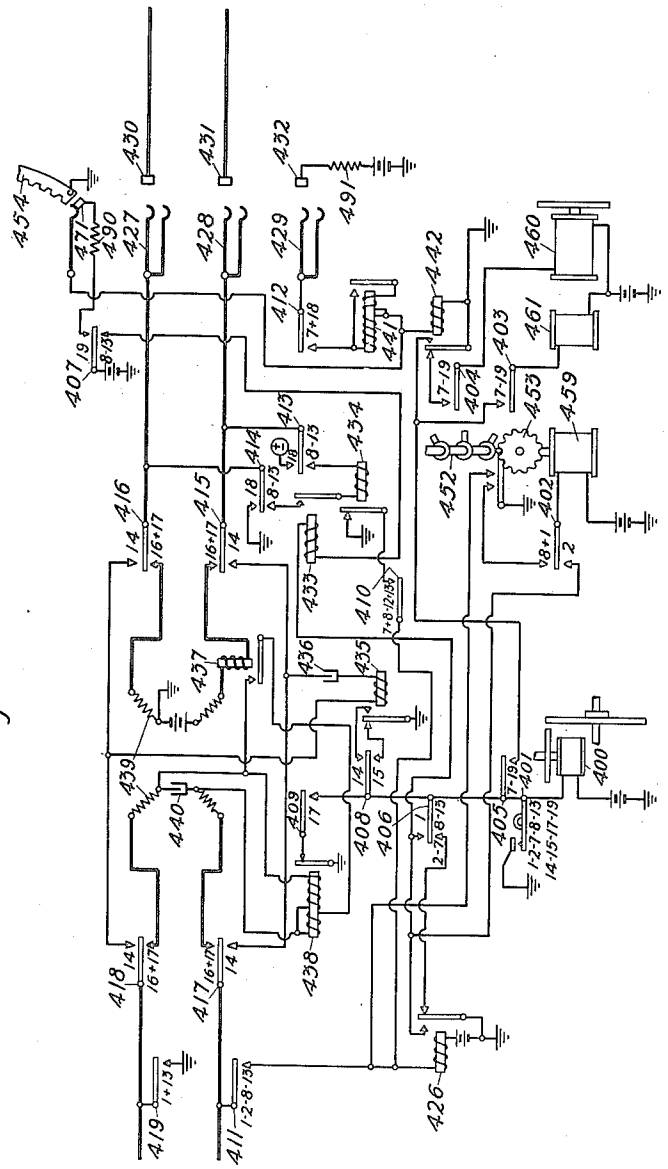


Fig. 4.

Witnesses:
O. D. M. Guthe.
Ch. R. Rossi.

Inventor:
Frank R. McBerty.
by A. Gannett, Att'y.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

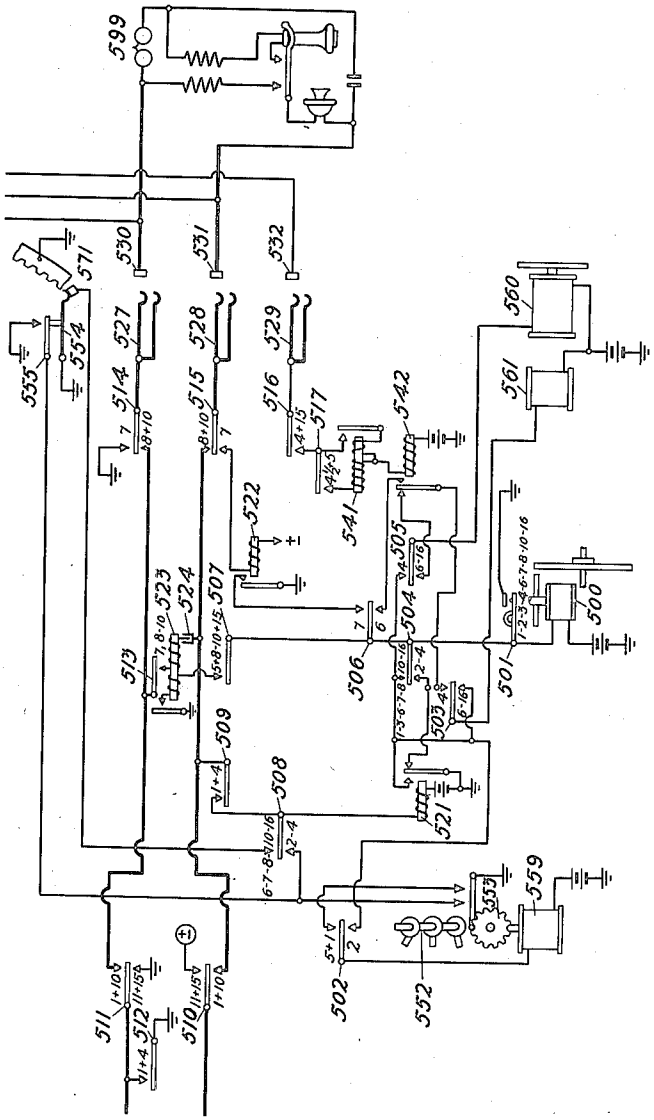
APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 6.

Fig. 5.



Witnesses:
C. D. M. Guthrie.
Ph. R. Rossi

Inventor:
Frank R. McBerty.
by A. C. Tanner. Atty.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 7.

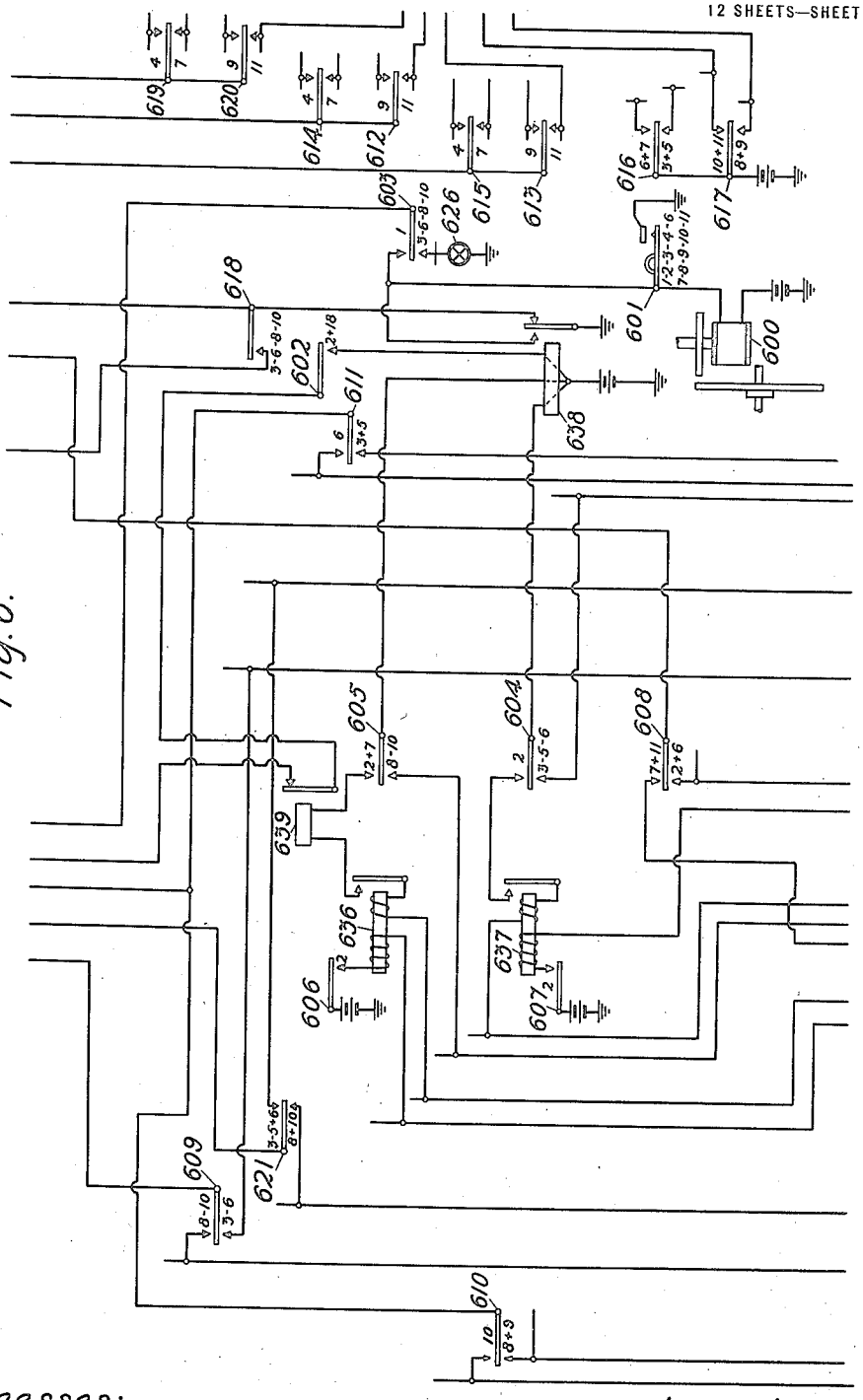


Fig. 6.

Witnesses:
O. D. M. Griffiths.
Ch. R. Rossi.

Inventor:
Frank R. McBerty.
by A. C. Manuel, Atty.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

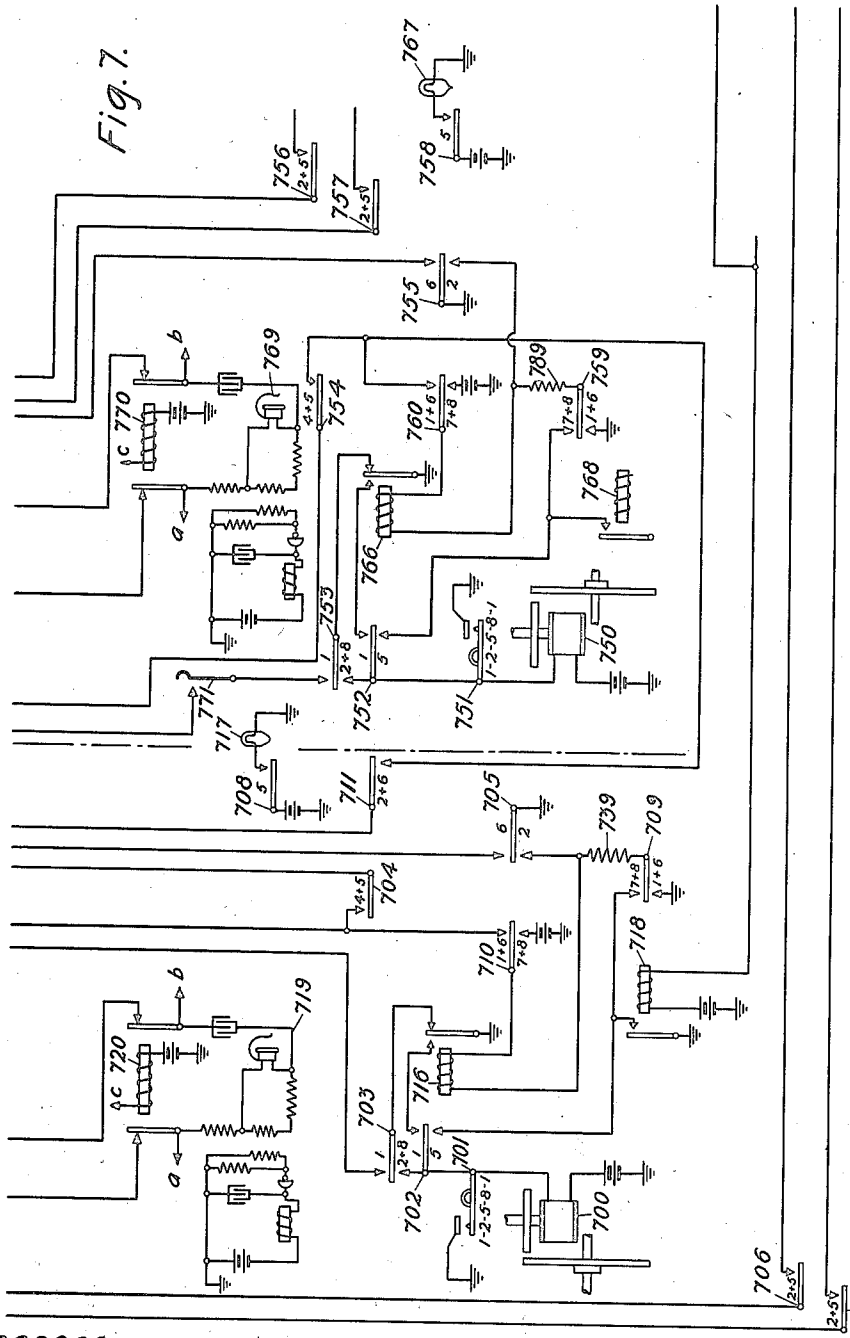
APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 8.

Fig. 7.



Witnesses:
O. L. M. Luthe
Ph. R. Rossi.

Inventor:
Frank R. McBerty.
by A. C. Tanner, Att'y.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

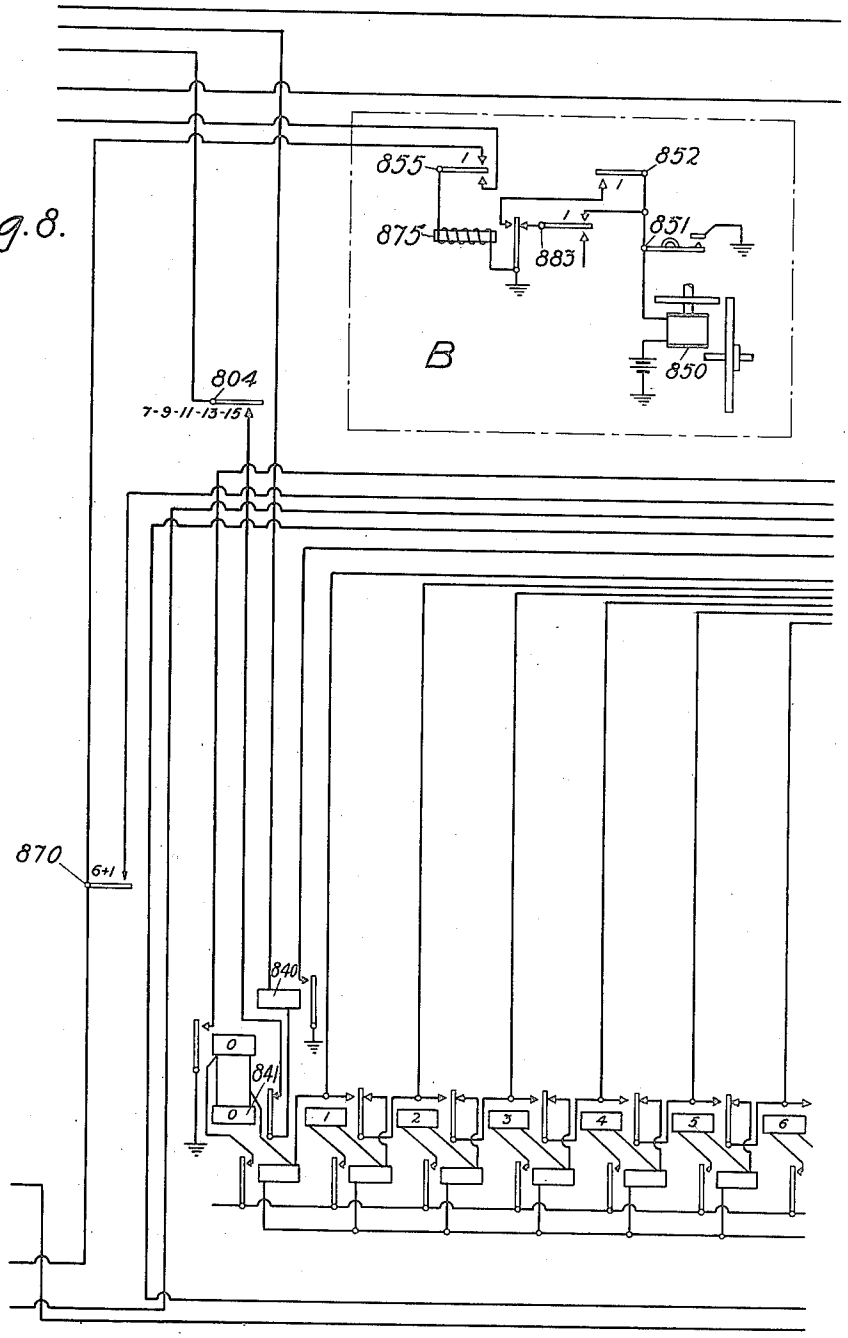
APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 9.

Fig. 8.



Witnesses:

O. B. McCuthe.

Ph. R. Rossi.

Inventor:

Frank R. McBerty.

by A. C. Gannett Atty.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 10.

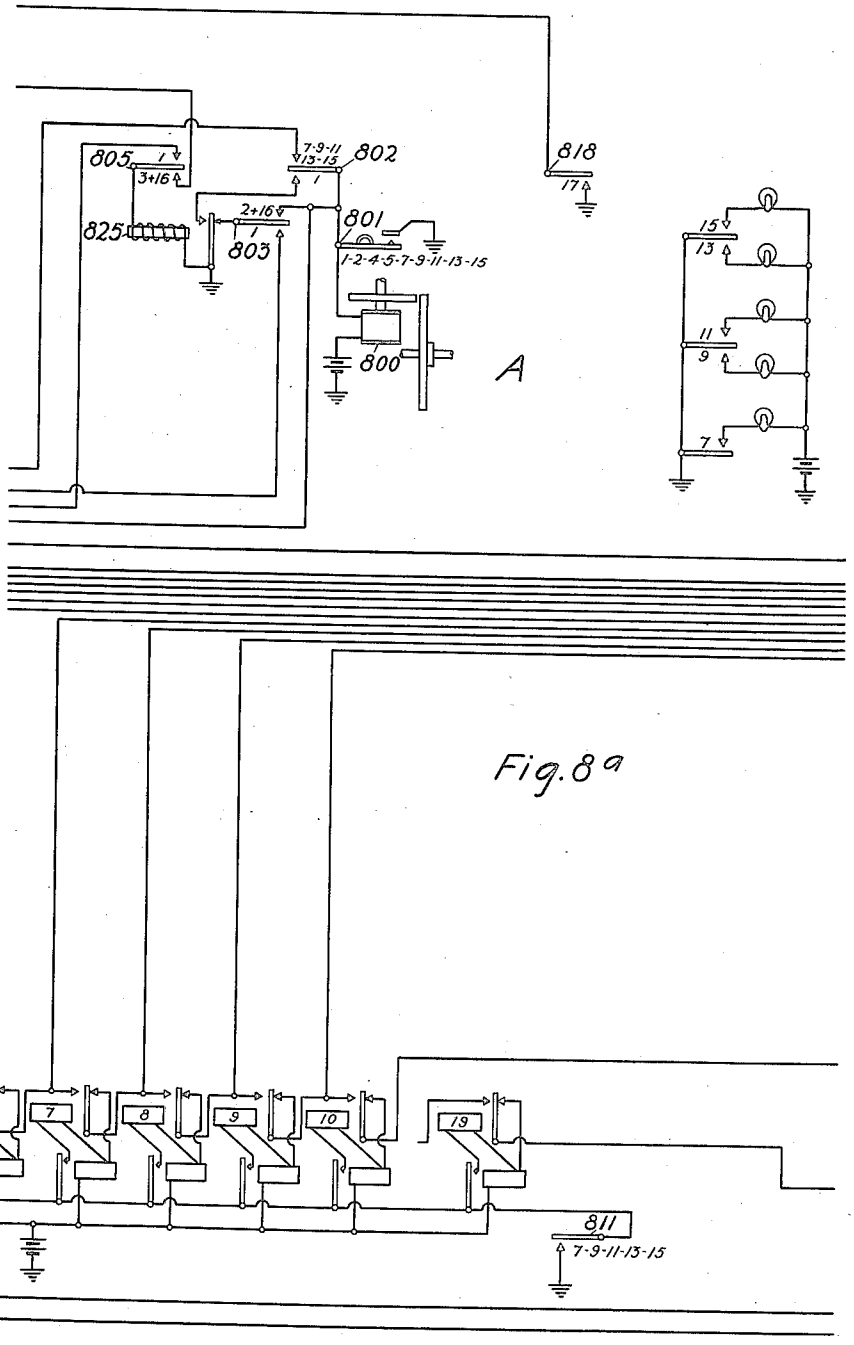


Fig. 8a

Witnesses:
O. D. M. Cutter.
Ph. R. Rossi.

Inventor:
Frank R. McBerty.
by D. C. Dane Atty.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

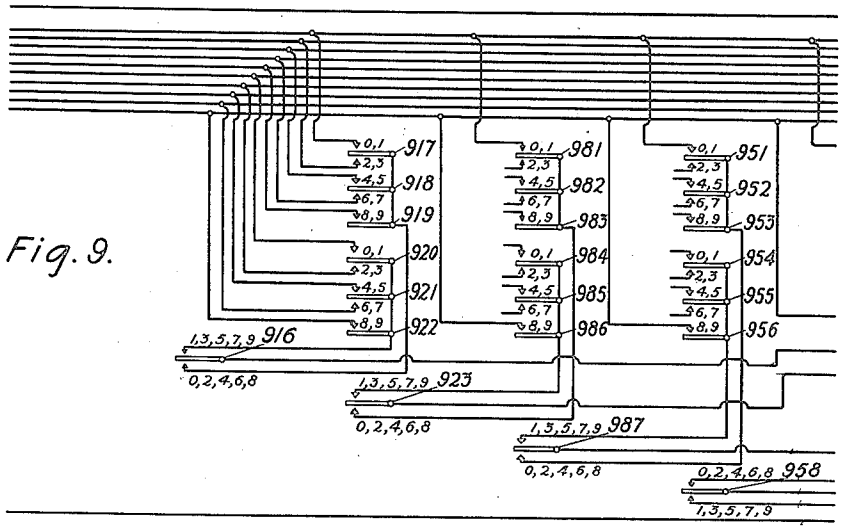
APPLICATION FILED JUNE 25, 1913.

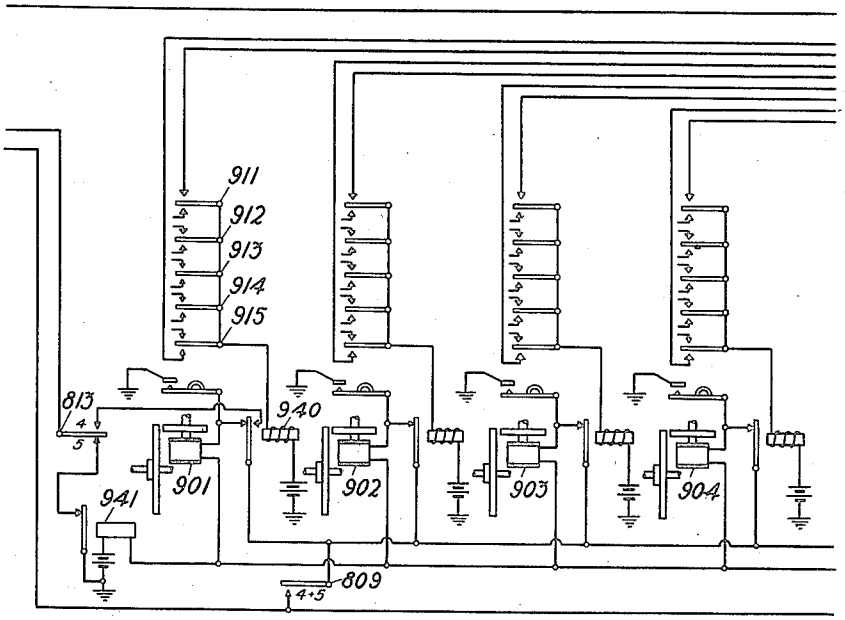
1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 11.

Fig. 9.





Witnesses:
O. M. Smith.
Ph. R. Rossi.

Inventor:
Frank R. McBerty.
by N. C. Bennet. Atty.

F. R. McBERTY.

MACHINE TELEPHONE SWITCHING SYSTEM.

APPLICATION FILED JUNE 25, 1913.

1,167,646.

Patented Jan. 11, 1916.

12 SHEETS—SHEET 12.

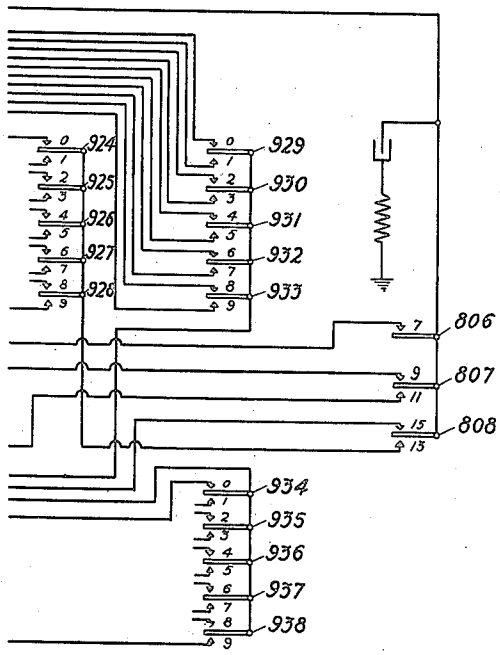
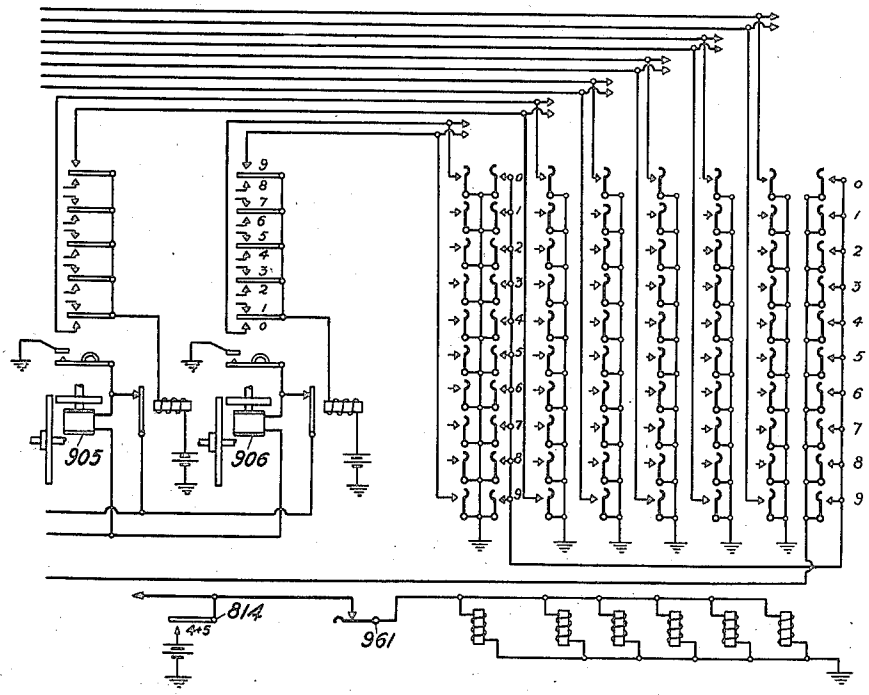


Fig. 9.a



Witnesses:
O. E. M. Cuttle.
H. P. Rossi.

Inventor:
Frank R. McBerty
by A. C. Gannett Atty.

UNITED STATES PATENT OFFICE.

FRANK ROBERT McBERTY, OF ANTWERP, BELGIUM, ASSIGNOR, BY MESNE ASSIGNMENTS, TO WESTERN ELECTRIC COMPANY, INCORPORATED, A CORPORATION OF NEW YORK.

MACHINE TELEPHONE SWITCHING SYSTEM.

1,167,646. Specification of Letters Patent. Patented Jan. 11, 1916.

Application filed June 25, 1913. Serial No. 775,645.

To all whom it may concern:

Be it known that I, FRANK ROBERT McBERTY, a citizen of the United States, residing at 49 Boulevard Leopold, Antwerp, Belgium, have invented new and useful Improvements in Machine Telephone Switching Systems, of which the following is a specification.

This invention relates to improvements in telephone exchange systems for the interconnection of telephone lines, and has to do more particularly with systems in which the extension of the desired connection from a calling line to a called line is accomplished by automatic selector switches under the control of an operator at the central or switching station. Many of the features to be described, however, are not restricted to systems of this character, being also applicable, as will be apparent to those skilled in the art, to systems of widely varying character, as, for example, to full automatic or machine telephone exchange systems and, particularly those features relating to the connection of a calling line with an operator, to manual telephone exchange systems.

One of the principal features of the invention relates to the use in a telephone exchange system of alternating current, as well as direct current, for both controlling the establishment of connection and the restoration to normal of the automatic selector switches over which the desired connection is established.

A further feature involves the use in such control of both relays responding only to alternating current, and relays responding to direct current; such relays being used where necessary side by side throughout the system, each performing its proper function in the control of the connection established or being established.

Another important feature of the invention relates particularly to that construction of the system herein disclosed, wherein a connection may be established over a plurality of two-conductor trunk circuits. A further development of this feature involves the establishment of a connection over a plurality of such two-conductor trunk circuits in series and in succession.

A still further feature of the invention relating to two-conductor trunk circuits involves the establishment of a connection over two-conductor trunk circuits in both directions from the office or central station at which the control and, if desirable, supervision of the connection is exercised. That is to say, that the connection established from an office or sub-office to the central or switching station at which the control of the selector-switches operating to select, test, ring and seize a desired line is exercised may be over two-conductor trunk circuits, and also the trunk circuits leading from such office at which the control is exercised to a second office, or even to a third office, may be of the two-conductor type.

A still further feature of the invention relates to improved and novel methods and means whereby a successful call may be charged or registered against the calling subscriber and involves in part the location of the apparatus whereby the charging circuit is prepared and controlled in association with the first group selector.

A further feature relating to the registering or charging of a call has to do with such an arrangement of the system that no apparatus at the final selector or line switch or any of the group selectors subsequent to the first group selector is necessary to insure the charging of a call to the calling subscriber if such call has been successful.

A still further feature of this portion of the invention involves the location of the subscriber's register or toll device by which successful calls are registered or charged at any office or sub-office to which the calling line is directly connected, which office may, if preferred, be distant from the office at which the control of the selector switches is exercised and at which the relays hereinbefore referred to as controlling the charging of a successful call, may be located.

Still another feature of the invention relates to an improved, novel and efficient arrangement and construction of "satellites" in a telephone exchange system. According to this feature each central station may have associated therewith one or more sub-central stations or satellites located at a distance therefrom, such satellites being of an improved and novel construction and arrangement of such character that incoming calls may be promptly and efficiently received and outgoing calls accurately and properly completed.

A further feature of the invention relates more particularly to the satellite in which a

called line is selected and involves the immediate restoration of the apparatus at such satellite and the freeing of the trunk line leading thereto in case the called line is busy.

Another feature of the invention relates more particularly to systems in which the establishment of a connection is controlled by what is known as the "revertive impulse system of control," that is, in which the selecting operations are controlled and accompanied by impulses established in the selecting or fundamental circuit by the movement of a part of the selector, which impulses affect the sending or controlling apparatus under the control of a subscriber or operator until the proper number of impulses have been sent and the proper selection has been accomplished, when the controlling apparatus will in turn so affect the selector under control that it will stop with the proper selection made. In systems of this character, of which, for example, one is shown in the British patent specification No. 21260 of 1911 the impulses, instead of passing from the controlling apparatus to the selector under control, pass from the selector under control to the controlling apparatus.

A feature of the invention, therefore, relates to circuits and arrangements of apparatus whereby in a selecting or fundamental circuit these revertive impulses produced in one portion of the circuit will be reproduced in another and separate portion of the circuit to affect the sending or controlling apparatus.

A still further feature of the invention involves the use of a clear, unobstructed registering control circuit from the first group selector to the called subscriber's sub-station, such circuit having associated therewith no bridges conductive to direct current, and such bridges as are associated therewith being without function with regard to the registering operation.

A further feature of the invention relates to the provision of positive means whereby, in case the line called and selected is busy, the charging or registering of a call to the calling subscriber will be prevented, such means being located at the first group selector, and being responsive to means located at the final or line selector operating under the control of the testing means at such final selector.

An additional feature of the invention involves the arrangement of circuits and apparatus whereby, upon the attempted establishment of the call and the finding of the line desired busy, all the selectors involved in such attempted connection will, except the first group selector, be immediately restored to their normal condition and prepared for use in connection with some other call. This feature of the invention also involves the simultaneous restoration of such selectors after an attempted connection to a busy line, and, further, the simultaneous restoration of all the selectors upon disconnection after a successful call, whereby the time in which any selector is necessarily out of actual service is reduced to a minimum.

A still further feature of the invention relates to the location of the busy back apparatus, that is, the apparatus whereby the subscriber, or the operator supervising the connection, or both such subscriber and operator, will be informed that the desired line is busy at the apparatus associated with the first group selector. This feature involves, in addition, the construction wherein the busy back apparatus, although initially controlled by the testing apparatus at the final selector, operates thereafter independently of such apparatus and the connection, in so far as all apparatus subsequent to the first group selector is concerned, may be immediately restored to its normal condition.

Another feature of the invention relating particularly to systems in which each calling line is immediately made manifest before an operator by a visual signal and such calling lines are automatically connectible one at a time to an operator when idle, involves means whereby such signal will indicate not only the existence of the call, but also whether or not the calling line to which it is individual is connected to an operator. This result is obtained in the invention herein disclosed by having a calling lamp burn steadily upon the receipt of the call until the line with which it is individual is connected to an operator, from which time, until the operator is disconnected from such line, the lamp will intermittently flash to indicate such connection.

A still further feature of the invention relates to a new and simplified arrangement associated with a non-numerical switch over which a calling line is connected to a connecting circuit at a central office, whereby a single means exercises various and different controls in the different stages of the operation.

Another feature of the invention also consists in an improved circuit arrangement between a supervising office and a distant office at which the call as extended includes automatic switching apparatus and relates to such an arrangement of the trunk circuit between such offices that the control of the automatic switching apparatus may be exercised thereover in one direction, while the control of a signal at the supervising office may be exercised thereover in another direction.

Other novel and improved features, particularly such as relate to the controlling apparatus, the control of the finding operation at the second line finder, that is, the line finder at the controlling station, the connec-

tion of an incoming call to an operator's telephone set, the connection of a cord circuit taken for use to an idle controlling equipment of a selected operator, and other features, will sufficiently appear from the detailed description hereinafter given.

There is shown one form of the invention, but it will be understood that the invention is not limited to the particular form or system shown, and is so shown merely for convenience, and is applicable to systems widely varying in character.

The drawings which comprise 9 figures set forth diagrammatically a system embodying the invention.

Figure 1 shows that apparatus involved in the connection located at the first or incoming satellite or sub-central station. Figs. 2 and 2ª show the connecting circuit and associated apparatus, including a line finder and a first group selector, situated at the controlling central office or station. Fig. 3 shows a second group selector and the apparatus associated therewith which is also situated at the controlling central office or station. Fig. 4 shows a third group selector and its associated apparatus including the relays whereby the controlling impulses involved in tens and units selection at the final selector are repeated back to the controlling apparatus at the controlling central office or station, all of which apparatus is located at a second central office or station. Fig. 5 shows the apparatus involved in the connection including a connecting or line selector and its associated apparatus located at a second satellite. Fig. 6 shows further means associated with the connecting circuits at the controlling central office or station whereby the selection and seizing of an operator's equipment is controlled. Fig. 7 shows apparatus also at the controlling central office or station associated with the different operators' positions to which the calls coming in on the connecting circuit shown in Fig. 2 are connectible. Figs. 8 and 8ª illustrate the two register-controlling equipments of one of the operators, that is, the home operator, showing the A register of such operator in full and indicating sufficient of the B register of such operator to make clear the operation thereof. These figures also show the counting relay apparatus of such A register. Figs. 9 and 9ª illustrate the registers themselves of the A register apparatus and the set of manually operable keys by which the controlling operation is controlled by the operator.

The figures should be placed as follows:—Figs. 1, 2, 2ª, 3, 4 and 5 in order from left to right; Fig. 6 under Figs. 2 and 2ª; Fig. 7 under Fig. 6; and Figs. 8, 8ª, 9, 9ª to the left of Figs. 6 and 7 and in order from left to right.

A connecting or final selector switch such as is diagrammatically shown in Fig. 5 is illustrated in British Patent No. 16,867 of 1911. The apparatus associated with this switch as shown in Fig. 5 is somewhat different, but the structure of the switch will sufficiently appear from such patent and need not be herein described. The group selectors shown in Figs. 2, 3 and 4 are in structure substantially the same as that shown in Fig. 5 and in the British patent referred to. The only substantial difference in the structure of the switches from that shown in the patent is in the brush carriage interrupter devices indicated above the brushes in the several figures. That is to say, instead of the brush carriage interrupter involving two switch devices as in the British patent and Fig. 5 herein, it involves a single switch device which is closed each time the brush carriage moves from one stage to the next, and is open only when the brush carriage rests with its released brushes centered upon a set of contacts. Of course, in the normal position the interrupter brush rests upon the insulated segments 270, 371, and 471 of the several selector switches and as it moves from normal position into position in which the released brushes will make contact and be centered upon the first set of contacts of the row to which they are individual, the brushes 254, 354, 454 will be connected to earth over the toothed segment and then opened as the brushes are centered. In every successive movement from one set of terminals to the next this circuit to earth will be again closed and opened as the brushes are centered upon the terminals.

The line finder switches shown in Fig. 1, and to the left in Fig. 2, are of a somewhat similar construction to that of the selector switches above referred to and shown in British Patent No. 16867 of 1911 hereinbefore mentioned. They are fully described in British patent application No. 16151 of 1912, and will not be herein further described.

The sequence switches which are used throughout the system shown to control the circuits of the various portions of the apparatus, and which are indicated at 100, 200, 300, 400, 500, 600, 700, 750, 800, and 850, are of the type shown in British Patent No. 20840 of 1909, and since they are sufficiently shown and described therein will not be further described.

Throughout the drawings the sequence switch springs are not indicated in their structural relation to the moving parts of the switch, but are so located as to make most clear the circuits of the system disclosed herein. The positions in which such sequence springs are closed to the contacts shown associated therewith are indicated by the numbers shown adjacent to such springs,

such springs being closed to the contact, shown on the same side of the spring with any given number or numbers, in the position indicated by such numbers. The controlling springs of the respective sequence switches indicated at 101, 201, 301, 401, 501, 601, 701, 751, 801, 851 are the springs which insure that the sequence switch when started from any position will be positively driven into its next stopping position. The numbers placed adjacent to these springs indicate the positions in which the springs are open, these springs being closed at all other times and positions. Where these numbers are separated by a minus sign (—) it indicates that the circuit is at all times open between the position indicated by the numbers and is closed only in such positions, whereas where such numbers are separated by the plus sign (+) it indicates that the circuit is closed continuously between and in the positions indicated,—for example, the sequence switch spring 114 top is closed in position 3 and in position 8, but is not closed in any other position nor between positions 3 and 8, whereas sequence switch contact 110 bottom is closed in positions 2 and 18 and continuously while the sequence switch is passing from position 2 to position 18.

The set of counting relays shown in Fig. 8 is of somewhat similar arrangement to that shown in British Patent No. 23508 of 1911. Although the circuits are somewhat different from the circuits shown in the patent application referred to, the operation of the set of counting relays is directly analogous to the operation of the set of counting relays in such specification. In detail the arrangement of the circuit of the set of counting relays shown herein will sufficiently appear from the detailed description of the operation of the system.

The registers shown in Fig. 9 are structurally precisely like the sequence switches above referred to and shown in the British Patent No. 20840 of 1909. The only difference in their operation is that they have no normal position, and having been used in connection with one call, remain in such set position until used in connection with some other call.

The manually operable keys shown in Fig. 9 are arranged in a somewhat similar manner to the keys of the ordinary adding machine; when a key is depressed it is held in such position by the energization of a locking magnet individual to the row of which such key forms a part. A key device of this character is disclosed in British patent application No. 23508 of 1911.

Description of operation.—The system is best described by the description of the establishment of a call, and the subsequent restoration to normal of the apparatus involved therein. Assuming therefore that a subscriber at the substation 199 desires connection with the subscriber at the substation 599, the number of which latter substation we will assume to be 170492, he removes his receiver from its switch-hook, thereby closing in the usual manner the circuit through his substation and energizing the line relay 116; the attraction of the armature of the line relay closes a circuit and energizes the pilot relay 117 for the group of line finder switches having access to the calling line, and at the same time, by the arrangement of such circuit, including the resistances 141 and 142, places a selectable potential upon the terminal 121 individual to such calling line. The energization of the relay 117 has closed a circuit through the springs 103 and 104 for the power magnet for each of the idle finders of the group controlled by such relay. The brush carriages of such idle line finders thereupon start in motion and the brushes 122, 123, 124, 125 sweep over the contacts 118, 119, 120, 121 of the various lines connected thereto, which contacts appear in multiple upon each of this group of line finder switches. So long as the brushes 125 of the line finders pass over contacts 121 of any non-calling lines, that is to say, over contacts on which there exists no selectable potential as above referred to, the line finders continue in motion. As soon, however, as the brush 125 of the line finder reaches the contact 121 upon which such selectable potential exists, the test relay 126 is energized, and by closing the parallel circuit through its armature and low resistance winding so reduces the potential upon the terminal 121 that no test relay 126 of some other line finder subsequently coming in contact with the terminal 121 will be energized. The line finder, however, which has seized the calling line does not immediately stop, coming to rest only when it brushes are centered upon the terminals of the calling line at which time the interrupter 128 will be open and the test relay 127 will become energized through its left-hand winding. Immediately upon the energization of this relay the circuit of the power magnet 150 is opened at its back contact, the circuit of the holding magnet 151 is closed at its front contact; the brush carriage of the finder switch will therefore come positively to rest with its brushes centered upon the terminals of the calling line. The same operation of the test relay 127 has closed a circuit over spring 113 top to drive the sequence switch 100 out of its first or normal position into its third position. On coming into its second position the sequence switch closes the spring 110, and the circuit is therefore established to energize the cut-off relay 129 of the calling line. This in

the usual manner cuts off the line relay, and ground and battery from such line, and causes the consequent deënergization of such line relay 116 and of the pilot relay 117. In consequence of the deënergization of the pilot relay 117, all of the line finders which are in motion will be brought to a stop. Of course, if some other call had meanwhile been initiated the deënergization of the line relay 116 would not have caused the deënergization of the pilot relay 117, and the idle line finders would have continued in motion so long as a line remained unseized upon which a call had been initiated. The circuit for the cut-off relay over the spring 110 is maintained until the restoration of all the apparatus at this satellite. Therefore, as the sequence switch leaves its second position the spring 109 may be opened and the test-guard heretofore established on the terminal 121 may be removed. This line, however, will not be selected by any other line finder as its selectable potential has also been removed by the deënergization of the line relay 116 individual to the line. Before, however, the spring 109 is opened the control of the relay 127 is transferred to the calling subscriber by the closure of the springs 111 top and 112 bottom. The circuit for this relay will be maintained through the sixth position of the sequence switch so long as the subscriber's loop-circuit is closed at his substation. This is for the purpose that should the subscriber hang up his receiver before the call has been extended to the controlling central office, the deënergization of the relay 127 will, by driving the sequence switch through its seventh position over the spring 113, produce the restoration of the apparatus at the satellite.

On coming into position 3 the sequence switch 100 closes the spring 107. This initiates the operation of the line finder apparatus at the central station to which the trunk line terminating in the terminals 233, 234 is connected precisely as did the removal of the subscriber's receiver from his switch-hook hereinbefore described initiate the operation of the line finders at the satellite. The line relay 231 is energized, energizing the pilot relay 232 and placing a selectable potential upon the terminal 236, such selectable potential being produced and adjusted by the resistances 291 and 292. In response to the energization of the pilot relay 232 all the idle line finders of the group having access to the trunk line upon which the call exists will be started in motion over circuits including the springs 209 top, 210 top individual to them respectively. As the line finders move the brushes 237, 238, 239 and 240 thereof will sweep over the terminals 233, 234, 235 and 236 individual to the respective trunks appearing in such line finders. When a line finder reaches the trunk upon which the call exists its test relay 241 will be energized and, in the well-known manner, place the test guard upon the terminal 236 of the trunk line. The brush carriage, however, will continue to move until the circuit through the interrupter 243 is opened, when the test relay 242 will be energized, opening the circuit to the power magnet 250, closed over the spring 209 top, and closing the circuit to the holding magnet 251 over the spring 208 top. The finder therefore stops with its brushes accurately centered upon the terminals of the trunk line upon which the call exists. The same operation of the relay 242 drives the sequence switch 200 out of its first and normal position into its fifth position by means of a circuit over springs 208 top and 203 top. As the sequence switch comes into its second position the circuit is closed over the spring 226 for the cut-off relay 244 and the line relay 231 and the pilot relay 232 will be deenergized precisely as the line relay and pilot relay at the satellite hereinbefore described. As the sequence switch moves through its third and fourth position, alternating current, the source of which is indicated here and elsewhere on the drawings by a circle including plus and minus signs, is applied to the trunk line by the closure of the spring 225 top and a corresponding ground connection is connected to the trunk line to complete the circuit for said alternating current over spring 224 top. This energizes the alternating current relay 132 at the satellite, the current passing through the condenser 134. This alternating current, while it is capable of passing through the condenser 134 as shown, is of sufficiently low frequency and has such other electrical characteristics that it will be inaudible and unobjectionable to the calling subscriber if by chance it should be impressed upon the circuit leading to his receiver. The energization of the relay 132 at the satellite, by means of a circuit including the springs 114 top and 105 top drives the sequence switch 100 into its 7th position. As this sequence switch comes into its 6th position, the alternating current circuit being by this time open at the springs 224 and 225 at the central office, it closes a substitute circuit for the relay 127 through the spring 114 bottom, armature and back contact of the relay 132, spring 106, front contact and armature of the relay 127 and spring 104 bottom so that the restoration of the apparatus at the satellite still controlled by the relay 127 now awaits the energization of the relay 132. Position 7 in which the sequence switch 100 comes to rest is the through or talking position of such sequence switch, and in such position the calling subscriber's line is connected through to terminals 233, 234 of the

second line finder switch located at the central or controlling station.

When the connecting circuit sequence switch 200 comes into its 5th position the circuit of the calling subscriber is connected through to the repeating coil 246 and current is supplied to such subscriber's circuit from the battery included between the windings thereof. The supervisory lamp 263 will not be lighted at this time, although the spring 223 is closed, because the supervisory relay 247 is energized. However, the calling lamp 245 will be lighted due to the closure in this position of the spring 207 top. This will indicate to the operator that a call is waiting upon the connecting circuit to which such calling lamp 245 is individual. If the operator in whose position the connecting circuit shown in Fig. 2 is situated is idle at this time such connecting circuit will be immediately and automatically connected to such operator's telephone equipment and to an idle controlling equipment of such operator. Similarly, if such operator is busy, but the alternate operator is idle and her helping-out key is closed, the connecting circuit shown in Fig. 2 will be connected to such alternate operator's telephone equipment and to an idle controlling equipment of such alternate operator. This is accomplished as follows: The spring 207 not only closes the circuit for the calling line lamp, but also closes a circuit for the distributing sequence switch 600 over the spring 603 top of such sequence switch. The sequence switch 600 therefore moves into its second position. This is the testing position of this distributing sequence switch. In this position battery is connected to the high resistance winding of the relay 636 individual to the home operator of the position in which the connecting circuit shown on Fig. 2 appears, such relay being also individual to this particular connecting circuit. At the same time the battery is connected to the corresponding winding of the relay 637 appropriated to that connecting circuit but which is individual to an alternate or helping-out operator, such operator being, for example, the operator whose position is immediately to the left of the home operator. It will be understood, of course, that an additional helping-out or alternate operator may be provided in the person of the operator to the right of the home operator, but for clearness and simplicity the apparatus of but a single helping-out operator is shown. Battery connections referred to are provided by the springs 606, 607. If the home operator is busy, her sequence switch 700 will be out of its normal position and no circuit will be established for the relay 636. If the alternate operator is busy, her sequence switch 750 will be out of its normal position, or if, even though she is idle, her helping-out key 771 is not thrown, no circuit will be provided for the relay 637. So long as neither of these relays 636 and 637 is energized the distributing sequence switch 600 will remain in its second position. Immediately, however, that the home operator becomes idle, or the alternate operator is idle and her helping-out key 771 is closed, the relay 636 or 637 appropriated to such operator will be energized and the operation of selecting an operator and an equipment of such operator will begin.

It will be understood that for each connecting circuit of a position there will be a relay 636 of the home operator, the high resistance winding of which is connected to the conductor leading to the top contact of the spring 703, all of such high resistance windings being connected in parallel to such conductor. Similarly for each connecting circuit of a position there will be a relay 637 of the alternate operator, the high resistance windings of which are connected in parallel to the conductor leading to the contact of the helping-out key 771. It may be, therefore, that a plurality of connecting circuits are simultaneously attempting to select and seize an idle operator and an idle equipment of such operator. Immediately that the circuit through the high resistance winding of the relay 636 is closed at the spring 703, such relay and any other similar relay of other connecting circuits on the same position, the distributing sequence switches 600 of which are in second position, will be energized, and close, by the attraction of their armatures, circuits through their low resistance windings in parallel and through the relay 716 and the high resistance 739. Current in the common circuit will be sufficient to energize the relay 716 but the current in the parallel branches through the low resistance windings of the relays 636 will not be sufficient to energize two of such relays simultaneously. Therefore, when the circuit through the high resistance windings is open at the back contact of relay 716, as it is energized to drive the home operator's sequence switch 700 into second position, the relays 636 connected in parallel will allow their armatures to retract until circuit is closed through but one of them, which will be the one the armature of which would be the last to open the circuit at its front contact. This relay 636 alone will remain energized. Therefore, when the sequence switch 700 comes into its second position but one of the relays 636 is or remains energized. In this position a shunt is closed around the high resistance 739 through the spring 705 bottom, so that sufficient current will pass through the relay 638 to energize it and the sequence switch 600 will move out of its second position and under the control of

the relay 636 and the spring 605 move into its eighth position. This operation by which the home operator is selected rather than the alternate operator will take place if the home operator is idle, whether or not the alternate operator is busy or idle. If the alternate operator is busy obviously no circuit will be provided for the relay 637. If the alternate operator is idle and her helping-out key 771 is closed, the relay 637 will be energized and the alternate operator's sequence switch will have moved, but as the distributing sequence switch 600 will be driven through its positions individual to the alternate operator, no circuit will be established to hold the alternate operator's sequence switch 750 in its fifth position, and such sequence switch will immediately return to its normal position. If, however, the home operator is busy, the alternate operator observing the calling lamp 245 to be lighted may close her helping-out key 771 (unless it is already closed) and if such operator is idle the same selecting operation will take place with regard to the alternate operator as has been described with regard to the home operator. In this case, however, the distributing sequence switch 600 will only be driven into its third position by the energization of the relay 637 and the closure of the spring 604, top. From position 3 when the alternate operator has been seized, the operation of seizing an idle register of the alternate operator will take place precisely as will the seizure of an idle registering equipment of the home operator with the distributing sequence switch 600 in the eighth position. For the purpose of illustration, therefore, it will be assumed that the home operator is idle and the distributing sequence switch 600 has moved into its eighth position. As the sequence switch 600 comes into its eighth or tenth position, the relay 638 being deënergized, it establishes a circuit over the springs 618 and 202 bottom, to drive the sequence switch 200 into its sixth position. In the sixth position of the sequence switch 200 and the third, sixth, eighth or tenth positions of the sequence switch 600, the calling lamp 245 depends for current on the circuit through the interrupter 626 and the spring 603 bottom. This will cause the lamp to flash, indicating that the connecting circuit to which it is individual is the one which is now connected to an operator's equipment.

Upon the opening of the circuit of the relay 716 at the spring 605 top, this relay is deënergized and the home operator's sequence switch 700 driven from its second position. As this sequence switch comes into its fourth position, the circuit is again established for this relay over springs 710 top, 704, 608 top and 212 bottom. This will energize the relay 716 again before the sequence switch 700 reaches its fifth position, and this sequence switch will therefore stop in such position. If when the sequence switch 600 comes into its eighth position the A register of the home operator is idle, the relay 638 will be energized over springs 602, back contact of relay 639, springs 206, 610 bottom, 706, 870, 803 bottom and back contact and armature of the relay 825 of the A register equipment. This circuit will energize the relay 638 in the eighth and ninth positions of the sequence switch 600 and such sequence switch will therefore be driven into its tenth position which with the eleventh position are the positions individual to the A register equipment of the home operator on such sequence switch. It will be observed that this circuit depends on the closure of the spring 206, indicating thereby that the connecting circuit is ready to have the connection extended, that it depends on the spring 706 indicating that the home operator's telephone set is connected to the seizing connecting circuit, that it depends on the spring 870 which is open in the second, third, fourth and fifth positions of the sequence switch 850 of the B register equipment, and its closure therefore indicates that the B register equipment is no longer using the set of manually operable keys shown in Fig. 9, which are common to the A and B register equipments of the home operator; and finally that it depends upon the spring 803 and the armature of the relay 825, which together indicate that the A register equipment is idle. If the A register equipment had been busy the circuit traced would have been open at the spring 803. On the other hand, a circuit would have been established over the major portion of such circuit and through the spring 855 top and the high resistance relay 875 of the B register equipment.

In the event that the A register equipment is idle the relay 875 would have been shunted and could not have been energized. If the A register equipment is busy the relay 875 would have been energized, but insufficient current would have passed therethrough to energize the relay 638, and therefore although the B register equipment would have been seized and its apparatus started in operation, the sequence switch 600 would have remained in the eighth position. On the other hand, assuming the A register equipment to be idle, immediately that the sequence switch 600 comes into its tenth position a circuit will be established for the high resistance relay 825 over the circuit as traced before to the spring 610, but now over the top contact of such spring, spring 707, spring 805 top and relay 825. When this circuit is established, the relay 825 is energized, but insufficient current passes there-

through to energize the relay 638, the sequence switch 600 will remain in its tenth position. Since the energization of the relay 875 of the B register equipment in the eighth position of the sequence switch 600 is followed by the same operations as the energization of the relay 825 of the A register equipment in the tenth position of the sequence switch 600, a description of such subsequent operations in connection with one of the register equipments will suffice. It will therefore be assumed that the A register of the home operator is idle, and that therefore the sequence switch 600 is in its tenth position and the relay 825 is energized. The energization of this relay 825 drives the A register equipment sequence switch 800 out of its first position and into its second position. This movement immediately opens the circuit of such relay 825, and by its deënergization it drives the sequence switch 800 out of its second position, and such sequence switch under control of its spring 801 will move into its fourth position. As this sequence switch, however, comes into its third position, a circuit is closed for the relay 825 over the spring 617 top and 805 bottom, so that before the sequence switch 800 comes into its fourth position this relay is energized and the sequence switch will stop in its fourth position.

When the sequence switch 600 comes to rest in either its tenth position as described or in its eighth position if the A register is busy (and similarly in positions 3 and 6 if the alternate operator has been seized) a circuit is established over the springs 618 and 202 bottom to drive the sequence switch 200 into its sixth position. At this time the springs 609 top and 621 bottom are closed and also in the sixth position of the sequence switch 200 the springs 220 top and 219 bottom are closed. A circuit is therefore established for the home operator's telephone set 719 to the connecting circuit over the conductors *d*, *e* (broken in Fig. 2 for clearness) so that the operator may converse with the calling subscriber and inquire and learn the number of the desired line. When the operator has thus learned the number of the line wanted, she will depress the manually operable keys shown in Fig. 9ª to indicate such number thereon in a well understood manner.

In the fourth position of the register sequence switch 800, the apparatus is ready for the operator to indicate the number of the desired line upon the manually operable keys, shown in Fig. 9ª, by depressing the appropriate key of each of the groups of digit keys. The preparation of these circuits and apparatus for such act by the operator has, of course, taken place while the operator has been learning from the subscriber the number of the desired line. We have assumed that the number of such line is 170492. The operator will therefore depress the number 1 or second key of the row to the extreme right of the set of manually operable keys; the number 7 or eighth key of the next row of keys; the number 0 or first key of the next or 1000's row of keys; the number 4 or fifth key of the next or 100's rows of keys; the number 9 or tenth key of the next or 10's row of keys, and the number 2 or third key of the last or units row of keys. Each key as it is depressed will be locked and held in such position by the locking magnets indicated for the several rows of keys, the energizing circuit for which is closed by the spring 814 in the fourth and fifth positions of the sequence switch 800. It is assumed that the keys will be depressed in order either from the highest digit to the lowest or from the lowest digit to the highest. When, therefore, all the keys are depressed a circuit will be closed through the depressed units key and the depressed 100,000's key, to start the various registers 901, 902, 903, 904, 905, 906 in motion over the spring 809 and also a circuit for the relay 718 to drive the operator's sequence switch out of its fifth position. The operator having learned the number desired, and indicated such number upon the manually operable keys, her attention is no longer required, and her telephone therefore need no longer be connected to the connecting circuit in question during the normal course of the establishment of the connection desired. As the home operator's sequence switch moves through position 6 the spring 705 will be closed to drive the distributing sequence switch 600 into its eleventh position in which the connecting circuit will still be connected to the A register apparatus but will no longer be connected to the operator's telephone, the springs 609, 610 and 621 being open. The movement of the sequence switch 700 on leaving its fifth position will continue into its eighth position, in which position it will find a circuit closed for the relay 716 over the front contact of the relay 718, spring 709 and spring 710, bottom. This will be maintained until the release of the keys when the number indicated thereon has been registered upon the registers hereinbefore noted when the circuit for the relay 718 will be opened and in consequence the circuit for the relay 716 will be opened and the home operator's sequence switch will return to its first and normal position ready to be selected and seized by some other connecting circuit for use in the establishment of some other connection. The registers 901—906 are now in motion. Each register has contacts coöperating with its springs such as 911, 912, 913, 914, 915 connected to

contacts with keys of the manually operable keys shown. Each register will therefore move until it comes into the position corresponding to the key depressed in the row of keys to which the register is individual—that is to say, the 100,000's register will move until it is in its No. 1 or second position where it will stop: the 10,000's register will move until it comes into its No. 7 or eighth position where it will stop: the 1000's register will move into its No. 0 or first position where it will stop: the 100's register will move into its No. 4 or fifth position where it will stop: the 10's register will move into its No. 9 or tenth position where it will stop: and the units register will move into its No. 2 or third position where it will stop.

It will be observed that in addition to the springs 911—915 each of the registers has thereon certain other springs—for example, the 100,000's register has a spring 916 closed at its top contact when the register is in the positions noted adjacent thereto and closed at its bottom contact when the register is in positions adjacently noted to such bottom contact. The 10,000's register has the springs 917, 918, 919, 920, 921, 922 and in addition the spring 923. Correspondingly 1000's and 100's registers have similar sets of springs, all of which are closed in the positions of the registers as indicated by the numbers adjacent to such springs. The 10's register has the springs 924, 925, 926, 927, 928, and the units register the springs 929—938. Each register as it comes into the position in which it is necessary that it should stop will find a circuit closed for its stop relay, such as the relay 940 of the 100,000's register over the appropriate contact spring and the depressed key of the row of keys to which this register is individual. The energization of such relay will open the circuit for the register motor magnet, and the register will stop. When all the registers have been brought into their set position the circuit for the relay 941 will be opened and such relay will retract its armature. Before this occurs, however, the energization of the stop relay 940 of the 100,000's register has closed a circuit for the register sequence switch 800, which circuit includes the spring 813 top and the spring 809. The sequence switch 800 is therefore moved into its fifth position. When the relay 941 is deënergized as described, a circuit will be closed through spring 813 bottom for the sequence switch 800, and it will move out of its fifth position and into its seventh position. As the sequence switch 800 moves out of its fifth position, the spring 814 being opened the depressed keys are released ready for use in establishing some other connection, and are, until the A register equipment is again idle, associated with the B register equipment in a well known manner. The release of the keys has opened the circuit for the relay 718 controlling the home operator's sequence switch 700, and such sequence switch moves into its normal position for the purposes hereinbefore described. The movement of the register sequence switch 800 into its seventh position has established the fundamental or selecting circuit whereby the selection controlling operations which control the movement of the various selector switches to be used in the establishment of the desired connection may be exercised. This fundamental circuit may be traced from the first group line relay 249 over spring 216 bottom, spring 612 bottom, stepping relay 840, back contact and armature of the cut-off relays 841, spring 804, spring 613 bottom and spring 215 bottom. The closure of this circuit causes the energization of the group line relay 249 and the stepping relay 840. The energization of the stepping relay 840 has closed the circuit through one of the lower counting relays, in the case assumed the ninth or No. 8 pair of such counting relays since the 100,000's register is in its No. 1 or second position, and the 10,000's register is in its No. 7 or eighth position, over the back contact of the armature of the upper counting relay of the same pair over the spring 921 bottom of the 10,000's register (the circuits to the contacts of the various springs of the 1000's, 100's, and 10's registers are for clearness not shown as it is obvious from the showing of the units and ten-thousands registers how these connections are made) through the spring 916 top of the 100,000's register, spring 806 of the register sequence switch 800 and front contact and armature of the relay 840. This will cause the energization of the lower counting relay of the No. 8 pair of such relays, which closes a locking circuit for itself through its front contact and armature and includes the top counting relay of the same pair. This top counting relay will not, however, be energized as long as the relay 840 remains energized as it is shunted by the ground connection at its front contact. When, however, the relay 840 retracts its armature the top counting relay is energized, and, by attracting its armature opens the original energizing circuit for the lower counting relay of the same pair, and prepares a circuit for the lower counting relay of the next pair to the left (the No. 7 pair) so that when the stepping relay 840 again energizes and attracts its armature, such lower relay will be energized over a circuit substantially the same as the one heretofore traced, except that instead of including the back contact and armature of the upper relay of the pair first referred to it includes the front contact and armature of such relay. Meanwhile, the lower and upper re-

lays of the pair initially energized remain locked up.

Upon the energization of the last lower relay to the left, in the case assumed due to the ninth energization, and the subsequent deënergization of the stepping relay 840, the cut-off relays 841, which operate in this instance as the upper relay of the last pair of counting relays shown in the left, will be energized. The energization of these cut-off relays on the one hand opens the fundamental circuit at the right-hand armature thereof to cause the cessation of selection, and on the other hand closes a circuit at the left-hand armature thereof to drive the sequence switch 800 out of its 7th position and into its 9th position. In the meanwhile, however, in causing and producing this operation the apparatus at the first group selector has been in operation. When the relay 249 is energized simultaneously with the relay 840 it closed the circuit over the spring 204 top to drive the sequence switch 200 into its 7th position. In this position the circuit is closed for the power magnet 259 of the tripping spindle 252 and the tripping spindle therefore commenced to rotate; in such rotation the movement of the interrupter 253 thereon causes an intermittent shunting of the stepping relay 840, and the consequent deënergization of such relay, by connecting a circuit to earth to the fundamental circuit between such stepping relay and the line relay 249. This earth connection, however, will maintain the relay 249 energized while it is applied. For each movement of the tripping spindle from one position to the next, that is, in each of its movements to select and afterward release a different set of brushes on the brush carriage, this earth connection will be closed once and, therefore, for each movement of a step or stage by the tripping spindle the stepping relay 840 will be deënergized and again energized as the earth connection is opened until the fundamental circuit has been opened by the cut-off relays 841. When this occurs, which in the case assumed will be after the tripping spindle has taken nine steps and is in position to select the ninth set of brushes in the group selector shown on Fig. 2ª, the line relay 249 will find itself without current, both the fundamental circuit and the earth connection through the interrupter of the tripping spindle being open. The relay 249 will therefore be deenergized and will close a circuit over the spring 204 bottom for the sequence switch 200, which will thereupon move into its 8th position, which is the trunk-hunting position of the first group selector apparatus.

Before considering the further operation of the group selector it will be necessary to call attention to the fact that, to select in this group selector the particular group of second group selectors over which the desired line may be connected to, the ninth set of brushes must be released, and that the trunk to be selected should correspondingly be in the ninth set or level of trunks in such first group selector. The reason why this is necessary depends upon the fact that the switches, both group and final selectors, which it is preferred to use in the system herein shown, are 200 point switches. That is to say, the final selectors for example—one of which is indicated Fig. 5 at the second satellite—each accommodate terminals of lines leading to 200 subscribers' stations. The terminals in this switch are arranged in ten banks of 20 sets of contacts each; 200 lines in numerical order upon the decimal system being apportioned to each such final selector. For example, in any thousand lines, lines from zero to 199 will be connected and multiplied to one set of final selectors. Lines from 200 to 399 will be connected and multiplied to the next set of final selectors. Lines from 400 to 599 to the third set of final selectors, and so on. On each set of switches the lines of the 100 apportioned thereto having the lower hundreds digit will be connected to the first ten sets of contacts on each of the banks or levels of contacts; whereas, the lines of the second 100—that is, the 100 having the higher hundreds digit—will be connected to the second set of ten sets of contacts upon each of the 10 banks or levels of contacts of such switches. It will therefore be obvious that to select a line in the group of 100 lines whose hundreds digit is odd will require precisely the same selection as to select the corresponding line in the group of 100 lines whose hundreds digit is even, except that, having selected the proper final selector and the proper bank or level in such selector, it will be necessary that ten more steps be taken by the brushes of such final selector to select the number in the group of 100 lines whose hundreds digit is odd than to select the corresponding line in the group of 100 lines whose hundreds digit is even. Systems using switches of this character and capacity therefore require what is known as "translation."

The group-selectors are also 200 line switches but they select only one out of 10 groups of trunk lines, there being capacity in such switches for 20 trunk lines to each group. However, since the final selectors are 200 line switches it will be necessary that the group selector having direct access to 10 groups of final selectors shall select one out of 10 groups of 200 lines. This means that the first bank or level of trunk terminals in the last group selector have connected thereto trunks over which connection may be made (in any group of 2,000 lines) to lines from zero to 199. In the

second bank or level, to lines from 200 to 399. In the third bank or level, to lines from 400 to 599. In the fourth bank or level, to lines from 600 to 799. In the fifth bank or level, to lines from 800 to 999. In the sixth bank or level, to lines from 1,000 to 1,199. In the seventh bank or level, to lines from 1,200 to 1,399. In the eighth bank or level, to lines from 1,400 to 1,599. In the ninth bank or level, to lines from 1,600 to 1,799, and, finally, in the tenth bank or level, to lines from 1,800 to 1,999. Correspondingly in the group selector shown in Fig. 3 selection must take place to choose the particular group of 2,000 lines in which the line wanted is located. Here analogously the brushes must be selected to select a trunk in the first level if the line wanted, in any particular group of 20,000 lines, is in that group of lines zero to 1,999; in the second group or level if the line wanted is in the group 2,000 to 3,999, and so on. Correspondingly, in the group selector shown in Fig. 2 selection is made of one of ten groups of trunk lines, each group having access to 20,000 lines. Here similarly the brushes must be made to select a trunk connected to sets of contacts in the first bank or level if the line desired is in the group containing lines from zero to 19,999. In the second bank or level, if the line desired is in the group of lines from 20,000 to 39,999. In the sixth group or level if the line desired is in the group of lines from 100,000 to 119,999. In the seventh group or level if the line desired is in the group of lines from 120,000 to 139,999, and so on. Since therefore we have assumed that the line wanted is numbered 170,492, it will be necessary that the trunk selected in the various group selectors be in the ninth bank or level in the first group selector,—that is, that the tripping spindle at the first group selector should take 9 steps; that the selected trunk in the second group selector should be in the sixth level—that is, that the tripping spindle thereat should take six steps; that the trunk selected in the third group selector should be in the third level—that is, that the tripping spindle thereat should take 3 steps; that the line desired will be found in the final selector in the tenth level—that is, that the tripping spindle thereat should take 10 steps; and, finally, that the terminals of the particular desired line in the selected final selector will be found as the 3rd set of contacts in such selected tenth level of the final selector. Consequently, it will be observed that the circuit by which the control of the tripping spindle at the first group selector is governed leads through the springs 921 bottom of the 10,000's register and the spring 916 top of the 100,000's register, such circuit leading to the No. 8 or 9th pair of counting relays; that the circuit which will hereafter control in the 9th position of the register sequence switch 800 the movement of the tripping spindle at the second group selector will be closed over the spring 984 top of the 1,000's register and the spring 923 top of the 10,000's register, and will initially energize the 6th or No. 5 pair of counting relays. Again, in the 11th position of the register sequence switch 800 when the movement of the tripping spindle at the third group selector is under control, the circuit for the counting relays will extend over the spring 952 top of the 100's register and the spring 987 bottom of the 1,000's register, and will initially energize the No. 2 or 3rd pair of counting relays. Again, in the 13th position of the register sequence switch 800 when the movement of the tripping spindle of the final selector is under control the circuit for the counting relays will be over the spring 928 bottom of the tens register, and will initially energize the 10th or No. 9 pair of counting relays. Finally, in the 15th position of the register sequence switch 800, when the selection of the particular line in the chosen bank of the final selector is under control, the circuit for the counting relays will be over spring 930 top of the units register and 958 top of the 100's register and the Number 2 or third set of counting relays will be the counting relays initially energized at this time.

The energization of the cut-off relays 841 not only caused the cessation of the selecting operation due to movement of the tripping spindle at the first group selector shown on Fig. 2, but also closed a circuit over spring 802 top to drive the register sequence switch 800 from its seventh into its ninth position. In this motion of the sequence switch the spring 811 is opened and again closed, the opening of this spring unlocking and causing the restoration to normal of all the locked up counting relays. In this movement of the sequence switch 800 the spring 804, which is included in the fundamental circuit is also opened to prevent premature closing of such fundamental circuit at the group selector. When the sequence switch 800 reaches its ninth position the registering apparatus is ready to control selection at the second group selector and now awaits the finding of an idle trunk to such selector when such circuit will be closed again at the first group selector apparatus. As the sequence switch 200 comes into its eighth position a circuit is closed over springs 209 bottom and 210 bottom for the brush carriage power magnet 260 of the first group selector. The brush carriage therefore begins to move, in the first portion of its movement passing the brushes by the tripping spindle and thereby causing the release of the selected set of brushes, and in the further movement

thereof causing the operation of the interrupter 254 in the manner fully described in the British patent referred to. As the brushes 255, 256, 257 come in contact with the terminals of trunk lines of the group individual thereto represented in the drawings by the one trunk line terminating in the terminals 265, 266, 267 a test circuit is established over the brush 257 and the relays 241, 242. If there is present on the test terminal 267 full potential of the battery shown connected to the relay 316 (Fig. 3), that is, if this trunk line is idle and no other test circuit is connected thereto, the relay 241 will be energized. On the other hand, if some other group selector has already seized this trunk line the potential on the terminal 267 will be so reduced by the test circuit connected thereto that the relay 241 will not be energized and the brush carriage will continue in motion to bring the brushes in contact with the set of terminals of the next trunk line of the group. Assuming therefore that the brushes have reached a set of terminals connected to an idle trunk line the test relay 241 will be energized, closing a circuit through its low resistance winding in parallel to that of its high resistance winding, thereby reducing the potential on the test terminal 267 and rendering this trunk line busy in all of the other first group selectors in which it appeared. This test circuit at first includes the interrupter 254, but when the brushes are properly centered upon the terminals the interrupter will be opened and the circuit will now include the test relay 242. It being energized will stop the brush carriage by opening the circuit of the power magnet 260 and closing the circuit of the holding magnet 261 over the spring 208 bottom. An idle trunk in the proper group of trunk lines—that is the group of trunk lines leading to the second selectors having access to the desired group of 20,000 lines has now been seized. The same operation of the test relay 242 has closed a circuit for the sequence switch over the springs 208 bottom and 203 bottom to drive such sequence switch into its ninth position.

In the ninth position of the sequence switch 200 the springs 215 top and 216 top being closed, the fundamental or selecting circuit from the controlling apparatus is now closed through to the selected second group selector and includes and energizes the line relay 317 (Fig. 3) and stepping relay 840 (Fig. 8). Substantially the same operation now takes place in the second group selector (Fig. 3) as has already been described as taking place in the first group selector (Fig. 2). The energization of the line relay 317 has caused the second group selector sequence switch 300 to move into its second position. In this position the circuit to the power magnet 359 of the tripping spindle 352 is closed and the tripping spindle is started in motion, in such motion intermittently shunting the stepping relay 840 at the controlling apparatus while maintaining energized the line relay 317 at the second group selector in a manner already well understood and hereinbefore described. When the tripping spindle has moved the proper number of steps and has sent back the proper number of impulses (has shunted the stepping relay 840 a proper number of times) the cut-off relay 841 will be energized at the controlling apparatus. In this case since the number 5 or sixth set of counting relays is the set initially energized in this operation, the opening of the fundamental circuit by the energization of the cut-off relays 841 will take place on the sixth shunting of the stepping relay 840—that is, as the tripping spindle takes its sixth progressive step or stage of movement. The line relay 317 will therefore be deënergized as the tripping spindle comes into position to trip the sixth set of brushes on the second group selector, and it will therefore stop in such position when the circuit over the spring 307 bottom is opened at the line relay. The same operation now takes place at the controlling apparatus to release the locked-up counting relays and change the controlling circuits for the next selection, which will take place in the third group selector at the second office (Fig. 4), by the movement of the register sequence switch 800 out of its ninth and into its eleventh position. The deënergization of the line relay 317 of the second group selector has driven the sequence switch 300 into its third position by the closure of a circuit over the spring 304 top. This is the trunk hunting position. The brush carriage moves, due to the energization of its power magnet 360, over the spring 306. The proper set of brushes are released by the tripping spindle and the several lines of the selected group are tested until an idle line—that is, one having unshunted potential on its test terminal 323—is found. The test relay 341 is then energized, placing the usual busy guard upon the test terminal of the seized line by the closure of the circuit through its low resistance winding. As before, when the brushes 318, 319, 320 are centered upon the terminals of the seized line the brush carriage will be stopped and the sequence switch advanced by the energization of the relay 342. The sequence switch 300 will stop in position 4. The fundamental circuit is now, by the closure of the springs 310 top and 311 top, completed from the controlling apparatus to the third group selector at the second office over the two-conductor trunk line terminating in the terminals 321, 322. It will be observed that the circuit connected to the test terminals 328

which includes the resistance 391, is local in the first office. The fundamental circuit, which now includes the springs 411 and 419 also includes and energizes the line relay 426 and the stepping relay 840. The selection of an idle trunk in a selected group of trunk lines now takes place in the third group selector precisely as has already been described in connection with the operation of the first and second group selectors. The control at the group selector is exercised by the line relay 426. The tripping spindle 452 is driven by the power magnet thereof 459, and in such motion the interrupter 453 closes the usual intermittent earth connection to the fundamental circuit to shunt the stepping relay 840. When after the proper number of steps of the tripping spindle the cut-off relays 841 are energized, the line relay 426 will be deënergized, opening the circuit which has existed for the power magnet 459 over the spring 402 bottom and closing a circuit over the spring 406 bottom for the sequence switch 400 which moves into its 7th position. This is the trunk-hunting position, and in this position the circuit is closed over the contact 404 for the brush carriage power magnet 460.

The testing and seizing of the wanted line is accomplished as will be now well understood by the test relays 441 and 442 coöperating with the interrupter 454. The brushes 427, 428, 429 will be brought and properly centered upon the terminals 430, 431, 432 of an idle trunk line in the selected group, the proper set of brushes having been tripped in the first part of motion of the brush carriage by the tripping spindle 452. At the close of this operation the holding magnet 461, energized by a circuit including the spring 403, will insure the stoppage of the brush carriage in its proper position, and at the same time a circuit will be closed over the spring 405 to move the sequence switch 400 into its 8th position. The 8th position of the third group selector sequence switch 400 is the position in which tens selection in the final selector located at the second satellite takes place. In this position the fundamental circuit is again closed to include the line relay 426 and the stepping relay 840. At the same time, a sub-fundamental circuit is closed by the spring 413, 414 bottom, Fig. 4, and 509, 510 bottom and 512, Fig. 5, which circuit includes the line relay 521 of the final selector and the repeating stepping relay 434 at the third group selector. This circuit is controlled by a repeating cut-off relay 433 at the third group selector which is energized in the 8th position of the sequence switch 400 over a circuit including the spring 407 bottom and the front contact and armature of the line relay 426. The repeating stepping relay 434 is intermittently shunted, as will be well understood from the analogous and well-known operation of the stepping relay in the fundamental circuit hereinbefore described, by a ground connection connected to the sub-fundamental circuit over the spring 508 bottom by the interrupter 553. This repeating stepping relay 434 in turn controls a ground connection for the fundamental circuit over the spring 410 which will cause the stepping relay 840 at the controlling apparatus to be deënergized in exact correspondence with the deënergization of the repeating stepping relay 434 under the control of the interrupter 553. Therefore, upon the establishment of the sub-fundamental circuit, which takes place at the same time that the fundamental circuit is closed for the control of tens selection, the line relay 521, the repeating stepping relay 434, the repeating cut-off relay 433, the line relay 426 and the stepping relay 840 are all simultaneously energized. As the tripping spindle 552 moves to be brought into position to trip the proper set of brushes in the final selector, the repeating stepping relay 434 will be intermittently deënergized and the ground connection applied to the fundamental circuit to cause the deënergization of the stepping relay 840, which in turn controls the operation of the counting relays in the well-known manner.

When the tripping spindle 552 has taken the proper number of steps, the stepping relay 840 has been operated the proper number of times (in the case assumed ten times), and causes the cut-off relays 841 to open the fundamental circuit, deënergizing the line relay 426 which in turn, by deënergizing the repeating cut-off relay 433, opens the sub-fundamental circuit, thereby deënergizing the line relay 521 and causing the tripping spindle 552 to stop in proper position to trip the 10th set of brushes on the final selector, since the line desired will be found in the 10th bank or level of contacts in such final selector. The deënergization of the line relays 426 and 521 has caused the movement respectively of the sequence switch 400 into the 13th position and the sequence switch 500 into the 3rd position. Immediately upon the coming into its 15th position of the register sequence switch 800 the line relay 426 will be energized, and in consequence thereof, as before, the line relay 521 will be energized. The line relay 521 will immediately move the sequence switch 500 into its 4th position. Units selection will now take place and the brush carriage of the final selector moved to bring its brushes 527, 528, 529 into contact with the terminals 530, 531, 532 of the particular line desired. In this movement of the brush carriage the selected set of brushes, that is, the 10th set, will be released due to the set position of the tripping spindle, and after such release the move-

ment of the brush carriage will cause intermittent shuntings of the repeating stepping relay 434 due to connection to earth through the interrupter device 555 over the branch circuit connected to the sub-fundamental circuit by the spring 508 bottom; impulses will be sent and repeated to the controlling apparatus operating the stepping relay 840 precisely as has been hereinbefore described with relation to tens selection. After the proper number of shuntings have been produced—in this case 3 since the line desired is connected to the No. 2 or 3rd set of contacts in the first half of the 10th level of the final selector, the cut-off relays 841 will be energized, opening the fundamental circuit and causing the deënergization of the line relay 426, the repeating cut-off relay 433 and the line relay 521, which last in its retraction opens the circuit of the power magnet 560 which has existed over the spring 505 top and closing the circuit of the holding magnet 561 over the spring 503 top, which actions bring the brush carriage positively to rest with its selected brushes squarely upon the terminals of the desired line, and drives the sequence switch 500 out of its 4th position. Before considering what eventuates at the final selector as the result of this movement of the sequence switch 500, the operations taking place at the controlling apparatus of the first group selector as the result of the completion of the final or units selecting operation will be considered. The energization the last time of the cut-off relays 841 has driven the register sequence switch 800 out of its 15th position, and it returns immediately to its first or normal position. The first result of this movement is the restoration of the counting relays to their normal un-energized condition. As the sequence switch 800 passes through its 17th position it closes the spring 818 and a circuit is thereby established over the spring 620 bottom and 202 top to drive the sequence switch 200 into its 10th position, in which position this sequence switch, associated with the first group selector, will await the completion of certain operations at the final selector. However, as this sequence switch moves into its 10th position, a circuit is closed over the springs 207 bottom and 602 to energize the relay 638 which by its energization, which will be maintained through the 18th position of the distributing switch 600, will move such sequence switch directly into its first or normal position. It will be observed that at this time the entire apparatus associated with the distributing sequence switch, and the apparatus at the controlling device (A register), is restored to its normal condition and is ready for use in connection with the establishment of some other call.

It will be re-called that when upon the completion of the registration of the designation of the desired line upon the several registers shown in Fig. 9 the sequence switch 600 moves from its 10th position into its 11th position, the operator's telephone apparatus, which up to that time has been associated with the connecting circuit shown on Fig. 2, had been disconnected for use with some other call. From that time the home operator's telephone apparatus in connection with the B register apparatus associated with the same position could have been used in connection with the manually operable keys in association with some other connecting circuit to control the establishment of the desired connection over such connecting circuit.

From the time that the distributing sequence switch 600 moves out of its 11th position until the initiation of the establishment of some other call over the connecting circuit shown in Fig. 2, the apparatus shown in Figs. 6, 7, 8, 8[a] and 9 will have no active coöperative relation to such connecting circuit, the leads thereto being effectively opened.

The sequence switch 100 at the first satellite being in its 7th position, the sequence switch 200 at the first group selector being in its 10th position, the sequence switch 300 at the second group selector being in its 4th position, the sequence switch 400 at the third group selector at the second office being in its 14th position (having been driven into this position from its 13th position upon the deënergization of the line relay 426 in such position), and the sequence switch 500 at the final selector at the second satellite having left its 4th position, the testing of the desired line now takes place. The testing of the desired line takes place between the 4th and 5th positions, and in the 5th position of the final selector sequence switch 500.

The busy or idle condition of the desired line is indicated respectively by the presence of reduced or full potential upon the test terminal 532 thereof. If the line is in use either as a calling line or a called line the normal potential upon such terminal due to the connection of such terminal to ground through a cut-off relay such as the one 129, Fig. 1, will have been modified or reduced by the connection thereto of a circuit to energize such cut-off relay, such circuit being, in case the line is busy as a calling line, a circuit similar to that one hereinbefore described over the brush 124 and the spring 110; or, if the line is busy as a called line, due to the connection thereto, of a circuit over a brush 529, spring 516, relays 541, 542 of some other final selector. Assuming first that the desired line is idle in this case, sufficient current will pass through the high resistance (left-hand winding of

the relay 541) to energize such relay, and it will immediately attract its armature closing a low resistance path in parallel to the high resistance winding through its right-hand winding, such closure producing the test guard upon the test terminal of the connected line to prevent its seizure by any other final selector and, at the same time, permitting sufficient current to pass to energize the test relay 542. This latter relay drives the sequence switch 500 through its sixth position and into its 7th position by means of a circuit including the spring 506 bottom. The test relays 541 and 542 will be maintained energized until the breaking down of the connection, and therefore when the sequence switch is passing through its 6th position the restoring circuit over the spring 505 bottom will be held open. The 7th position of the sequence switch 500 is the ringing position in which ringing current is projected over the circuit of the desired line through the ringing cut-off relay 522 and the springs 515 bottom and 514 top. So long as the circuit for direct current at the subscriber's substation is open insufficient current will pass through the ringing cut-off relay 522 to energize it. When, however, the subscriber responds by removing his receiver from its switch-hook, thereby closing the circuit for direct current, sufficient of the ringing current will flow through this lowered resistance to energize the relay 522 which, on its energization, closes over the spring 506 top a circuit for the sequence switch 500 and such sequence switch will be driven into its 8th position. Immediately that the sequence switch 500 comes into its 8th position, a circuit is closed for the relay 258 associated with the first group selector at the first office which includes the springs 217 top and 218 top thereat, the several trunk lines and group selectors forming the connection as established, and the springs 514 bottom and 515 top at the final selector and the called line. This causes the energization of the relay 258 which, by the attraction of its armature, closes a circuit through spring 205 to drive the sequence switch 200 out of its 10th and into its 14th position. As the sequence switch 200 comes into its 11th position the locking registration control relay 262 is energized over a circuit including the spring 228, the right-hand winding of such relay, the armature and back contact of the relay 271 and the front contact and armature of the relay 258. This relay 262 closes a locking circuit for itself over its left-hand winding and will be maintained locked until, upon the sequence switch leaving its 18th position, the spring 228 is opened. As the sequence switch 200 passes through its 12th and 13th positions alternating current is applied to the trunk line leading to the second and third group selectors, and the final selector, by the closure of the spring 217 bottom, earth being maintained connected to the other side of the trunk line through spring 218 top.

The application of alternating current to the trunk line is for the purpose of energizing relay 435 at the third group selector at the second office and the relay 523 at the final selector at the second satellite. The energization of the relay 435 which, it should be noted, is energized only by current capable of passing through the condenser 436, drives the sequence switch 400 out of its 14th position (spring 408 top being closed), and into its 15th position. The energization of the relay 523, which is, similarly, energized only by current capable of passing from the condenser 524 drives the sequence switch 500 out of its eighth position by means of a circuit through the spring 507 and the armature of such relay 523. The sequence switch 500 comes to rest in its tenth position. As soon as the sequence switch 200 leaves its 13th position the energizing circuit for the relay 435 is open and the spring 408 bottom being closed the deënergization of this relay causes the sequence switch 400 to move into its 17th position. As the sequence switch 400 reaches its 16th position the circuit from the called subscriber's substation is completed through the right-hand portion of the repeating coil 439 and the supervisory relay 437, and also includes, of course, the battery included between the two right-hand branches of the repeating coil. This battery supplies talking current to the called subscriber's substation and also serves to maintain energized the relay 437 so long as the circuit is closed at such substation. The energization of the relay 437 has closed a circuit for the low resistance winding of the restoring relay 438. The closure of this circuit through the winding of the relay 438 causes the energization of the supervisory relay 248 at the controlling office or station which would otherwise, by remaining unenergized, permit the lighting of the supervisory lamp 264. The sequence switch 100 at the first satellite is in its 7th position. The sequence switch 200 of the first group selector at the first central office or station is in its 14th position. The sequence switch 300 at the second group selector at the first office is in its 4th position. The sequence switch 400 at the third group selector located at the second central office or station is in its 17th position and the sequence switch 500 of the final selector at the second satellite is in its 10 position. The talking circuit between the calling and the called subscribers is now complete, the current being supplied to the called subscriber by the battery located between the right-hand branches of the repeating coil 439 and to the

calling subscriber by the battery located between the windings of the repeating coil 246. Conversation may now take place.

Disconnection.—Upon the completion of conversation the respective subscribers replace their receivers upon their switch-hooks, thereby opening the path for direct current through their respective substations. The result of this act by the calling subscriber causes the deënergization of the supervisory relay 247, which by the retraction of its armature lights a supervisory lamp 263. Similarly this act by the called subscriber deënergizes the supervisory relay 437. The retraction of the armature of the supervisory relay 437 will open the low resistance winding of the disconnecting relay 438. This relay will maintain its armature attracted, but insufficient current will pass through such winding to maintain the supervisory relay 248 energized at the first or controlling office, and such relay 248 by retracting its armature will cause the supervisory lamp 264 to be lighted. The operator seeing these lamps lighted knows that disconnection is desired. Of course, if preferable she may depress her listening key 269, thereby connecting this connecting circuit to which the key is individual to her telephone set 719, by means of the leads *a*, *b* indicated at the listening key 269, and at the home operator's telephone set 719. These leads are not shown continuously for the sake of clearness. A third lead *c* is also shown connected between the additional or grounded spring of the listening key 269, and connected to the telephone cut-off relay 720, so that this operator's telephone set, if connected to any other connecting circuit through the distributing sequence switch 600 of such circuit when the listening key 269 of the connecting circuit herein shown is depressed will open this connection so long as this key is depressed.

Disconnection being desired, the operator depresses the disconnect key 268, by which a circuit is established over the spring 213 top to energize the relay 249, which drives the sequence switch 200 out of its fourteenth and fifteenth positions, and it will come to rest in its eighteenth position, where the restoration of the brush carriage of the first group selector will take place. However, when the sequence switch 200 leaves its fourteenth position the circuit for the disconnecting relay 438 at the second office will be opened and such relay will allow its armature to retract. This causes the movement of the sequence switch 400 into its nineteenth position, in which the circuit from the battery included between the right-hand branches of the repeating coil 439 is opened to the second satellite and the brush carriage of the third group selector is restored to normal. This restoration of the third group selector is produced by the closure in the nineteenth position of the sequence switch 400 of the circuit of the brush carriage power magnet through the spring 404, the relay 442 having been deënergized by the opening of the spring 412. The brush carriage power magnet moves therefore until the brush of the interrupter 454 comes in contact with the normal segment 471, which is connected in the nineteenth position through the resistance 490 and the spring 407 to battery. At this time the relay 442 will be energized, opening the circuit for the magnet 460 and closing the circuit for the holding magnet and the sequence switch. The brush carriage will be stopped positively in normal position and the sequence switch 400 will be moved from its nineteenth to its normal position. It will be observed that the tripping spindle may have been restored in the eighth position of the sequence switch 400, its function having been performed or in any subsequent position to and through the first or normal position of such sequence switch. The first group selector (Fig. 2), the sequence switch 200 having been driven out of its fourteenth and fifteenth positions by the depression of the disconnect key 268 will be restored in the eighteenth position of the sequence switch in which position this sequence switch will come to rest. In this position circuit for the brush carriage power magnet will be closed as before, and the brush carriage will move until the brush of the interrupter 254 comes in contact with the normal segment 270. The brush carriage being in normal position a circuit will be established for the relay 242 including the spring 212 top, and such relay will be energized to open the circuit for the power magnet 260, close the circuit for the holding magnet 261, and drive the sequence switch 200 out of its eighteenth into its normal position. The tripping spindle of this group selector also may have been restored in any of the positions of the sequence switch 200 including and subsequent to the eighth position. The apparatus of the first group selector, including the selector itself and the sequence switch 200 associated therewith is now all in normal condition. The line finder has no normal position. As the sequence switch 200 left its fifteenth position it opened the circuit heretofore existing to the first satellite at springs 224 bottom, 225 bottom. In its sixteenth position it applied alternating current to such circuit at the spring 225 top and connected ground in such circuit at the spring 224 top. This caused the energization of the relay 132. The energization of this relay opens the circuit of the relay 127, which by its deenergization drives the sequence switch 100 from its seventh into its eighth position, in which movement it opens the circuit to the

subscriber, who has heretofore been considered the calling subscriber, at the springs 111 bottom and 112 top.

As the sequence switch 200 leaves its position 16 alternating current is removed from the trunk line leading to the first satellite, and the relay 132 is consequently deënergized, closing a circuit over its back contact and through the springs 105 bottom and 114 top, to cause the sequence switch 100 to be driven out of its eighth through its ninth to eighteenth positions and into its first or normal position. As the sequence switch 100 passes through its ninth and tenth positions, a circuit will be closed, (since the sequence switch 200 is now passing through its seventeenth and eighteenth positions) for the relay 133. This circuit, which includes the springs 228, 227, 108 and 224 top depends upon the locked up condition of the relay 262. If this relay is not locked up no energization of the relay 133 will take place. Such will be the case if the call has not been a successful one. On the other hand, if the call has been successful, as in the case assumed, the relay 262 has been energized and locked up as in the manner hereinbefore described. In this case, therefore, the relay 133 will be energized and by attracting its armature closes a circuit including the high potential battery shown adjacent to such relay 133 to the circuit of the register magnet 130. This will cause the energization of the register magnet to charge the call to the calling subscriber. It will be observed that while the battery shown connected to the spring 110 through the resistance 140 has maintained the cut-off relay 129 energized, it has been insufficient to energize the register magnet 130. As the sequence switch 100 reaches its normal position all of the apparatus associated at the first line finder at the first satellite will be again in normal condition. The line finder itself, of course, has no normal position. It will be furthermore observed that as the sequence switch 200 left its eighteenth position the energizing circuit for the relay 262 is opened at the spring 228, and such relay returns to its normal unenergized condition. As the sequence switch 200 left its fourteenth position it initiated the restoration of the second group selector (Fig. 3) by opening the spring 214 top. This caused the relay 316 to be deënergized, which by the retraction of its armature drives the sequence switch 300 into its fifth position. In this position of the sequence switch 300 both the brush carriage and the tripping spindle return to their normal positions, the tripping spindle stopping when the off normal contact of its interrupter is opened, the tripping spindle being in normal position and the brush carriage stopping when the brush of the interrupter 354 comes in contact with the normal segment 371 and closes a circuit including the spring 308 for the relay 342. The energization of this relay 342, as is well understood, opens a circuit for the power magnet 360, closes a circuit for the holding magnet 361, thereby stopping its brush carriage, and also drives the sequence switch 300 into its first and normal position. The entire apparatus of the second group selector is again in normal condition. When the sequence switch 400 at the third group selector upon disconnection left its seventeenth or talking position, and opened the springs 415 top and 416 bottom it connected on coming into its eighteenth position alternating current to the trunk line leading to the second satellite over the spring 413 top, and a corresponding connection to ground over the spring 414 top. This causes the energization of the relay 523 through the condenser 524, which when it attracts its armature not only closes for itself a locking circuit, but such locking circuit includes the sequence switch 500 and such sequence switch will be moved into its sixteenth position where it will be stopped, the spring 507 being opened in such position. In the sixteenth position of the sequence switch 500 the final selector will be restored to normal, the brush carriage moving due to the circuit closed over spring 505 bottom, back contact of relay 542 and back contact of relay 521, until the brush of the interrupter 554 comes into contact with the normal segment 571, when the relay 521 being immediately energized, the circuit for the power magnet will be opened, the circuit for the holding magnet 561 closed and the sequence switch will be driven out of its sixteenth position and returned to its normal position. The entire apparatus at the second satellite is now in normal condition, the tripping spindle 552 having been returned to normal as early as the fifth position of the sequence switch 500. All of the apparatus used in the establishment of the connection described has now been returned to its normal condition, and may be used in the establishment of any other call in which it may be needed. It will be observed, however, that the restoration of the various selector switches has been taking place substantially simultaneously so that although four of such switches are used in the connection the time of restoration of the entire apparatus is little if any more than the time of restoration of one of such switches. It will be further observed that each of the trunk lines is guarded from interference until the switch to which it is connected is in such position or condition that it may be seized without danger of its remaining in an off normal position and without detriment to the call being established over the seizing selector switch.

Attempted connection to a busy line.—If

when the sequence switch 500 at the final selector is testing the desired line in its fourth-and-a-half and fifth positions, such line was found busy—that is, with a reduced potential upon its test terminal 532, neither of the relays 541 nor 542 would have been energized. When the sequence switch then came into its sixth position, it would have stopped, the circuit through the spring 506 bottom not being closed. In this position the brush carriage will return to its normal position, the power magnet 560 being energized over the spring 505 bottom and the back contacts and armatures of the relays 542 and 521. When the brush carriage reaches its normal position, the brush of the interrupter 554 makes contact with the normal segment 571, and a circuit is closed for the relay 521 which upon energizing drives the sequence switch 500 out of its sixth position and the circuit being maintained in the seventh, eighth and tenth positions causes the sequence switch to move without stopping into its sixteenth position. The energization of the relay 521 in the sixth position has by opening the circuit of the power magnet 560 and the closing of the circuit of the holding magnet 561 stopped the brush carriage in the manner well understood. On coming into its sixteenth position, the same circuit being closed through the normal segment 571, the relay 521 will be again energized and the sequence switch 500 will move into its first or normal position. The tripping spindle 552 having been restored to normal as hereinbefore described, the entire apparatus of the second satellite is again in normal condition. It will be observed that the restoration of this apparatus has taken place immediately when the called line having been tested it was found busy. As the sequence switch 500 passed through its seventh position, which in the normal operation of the establishment of a call is the ringing position, no disturbance of the line with which connection was desired took place although the springs 514 top and 515 bottom are closed, as the brush carriage has been restored to its normal position and the brushes 527, 528 and 529 are not in contact with the terminals of any line. As the sequence switch 500 passes through its eleventh to fifteenth positions alternating current is applied to the trunk circuit leading to the third group selector at the second office by the closure of the springs 510 top and 511 bottom. It will be recalled that as no circuit has been established up to the fifth position of the sequence switch 500 to energize the relay 258 (Fig. 2) the sequence switch 400 at the third group selector is still in its fourteenth position. The application therefore of alternating current at the second satellite to the trunk line leading to the third group selector will energize the relay 435 (Fig. 4) and the relays 258 and 271 (Fig. 2). The energization of the relay 435 will cause the sequence switch 400 to move into its fifteenth position. The deenergization of this relay by the opening of the springs 416 top, 415 bottom will cause the sequence switch 400 to move into its seventeenth position, where since the relay 438 is not energized a circuit will be closed to drive the sequence switch 400 into its nineteenth or restoring position, in which position the brush carriage will return to its normal position and the sequence switch 400 into its first or normal position, as has been hereinbefore described. The energization of the relay 258 has driven the sequence switch 200 out of its tenth position, as has been hereinbefore described. The energization of this relay has not, however, caused the energization and locking-up of the relay 262, as the circuit for the right-hand winding of such relay has been opened at the back contact of the relay 271 energized through the condenser 272, simultaneously with the closure of its circuit at the relay 258. No charging of the call, therefore, can take place upon the restoration of the apparatus, the relay 271 having positively prevented the energization of the relay 262, and as the relay 262 cannot be energized at any other time, no energization of the relay 133 will take place, and consequently no call will be charged by the magnet 130.

As the sequence switch 200 comes into its fourteenth position it will find a circuit closed over the spring 205 bottom, and the second armature and back contact of the relay 262, which, as has just been mentioned, is not locked up. The sequence switch will therefore move into its fifteenth position. In this position the springs 220 bottom and 221 top being closed, the busy back apparatus and interrupter 274 will be connected across the trunk line on the outgoing side thereof of the repeating coil. The calling subscriber will hear the busy back through such repeating coil and know that the line desired is busy, and the operator will observe the flashing of the supervisory lamp 264 due to the intermittent energization of the supervisory relay 248 responding to the operation of the interrupter. When now the supervisory lamp 263 is lighted, indicating that the calling subscriber has replaced his receiver upon its hook, the operator will depress the key 268 and the sequence switch 200 will be driven from its fifteenth position, the brush carriage restored to its normal position and the entire apparatus of the first group selector restored to its normal condition, precisely as has been hereinbefore described. Also the apparatus at and including the second group selector will have been restored as has been hereinbefore described, such restoration be-

ing initiated by the movement of the sequence switch 200 from its fourteenth position. Also, the apparatus at the first line finder located at the first satellite will be restored to normal, as has been hereinbefore described, after the sequence switch 200 has left its fifteenth position, with the exception that since the relay 133 will not be energized, the register magnet 130 will not be energized and no charge will be registered for this unsuccessful call. It will be observed that all the selectors except the first group selector have been restored to normal immediately that the test showed the called line to be busy.

Disconnection before called subscriber responds.—If the called subscriber, although his line is idle, does not respond, the sequence switch 500 remains in the seventh position. It will be recalled that at this time the sequence switch 400 is in fourteenth position, the sequence switch 300 is in fourth position and the sequence switch 200 is in tenth position. When now it is desired to restore the apparatus to normal, the calling subscriber being informed that the called party "does not respond," the operator depresses the disconnect key 268, causing the sequence switch 200 to move directly into its eighteenth position. As it moves through its eleventh position no circuit will be established for the relay 258 and therefore the call will not be charged to the calling subscriber, such call not having been successful. As the sequence switch 200 passes through its twelfth and thirteenth positions alternating current will be supplied to the trunk line leading to the second group selector, as has been hereinbefore described. In consequence the relays 435 and 523 will be energized. The energization of the relay 435 and its subsequent deënergization when such alternating current is removed causes the third group selector apparatus to restore to normal, as has been hereinbefore described. The energization of the relay 523 causes such relay to close its locking winding and the circuit through such winding, which would be maintained continuously through the sequence switch 500, will drive such sequence switch into its tenth position where it will stop due to the opening of the spring 507 and will therefore await the application of alternating current to the trunk line in the eighteenth position of the sequence switch 400. The relay 523 will then again be energized and locked up and will drive the sequence switch out of its tenth position and directly into its sixteenth position, where the apparatus of the second satellite will be restored to normal, as has been hereinbefore described.

Disconnection without charging call.—If after a connection has been established the operator should be informed by the calling subscriber that connection was made with a wrong line it will sometimes be necessary that disconnection be brought about without charging the call to the calling subscriber. Of course, it will be understood that the calling subscriber attracts the attention of the operator by moving his receiver hook up and down, thereby opening and closing the direct current path through his substation and causing the flashing of his supervisory lamp 263. The operator will have listened in by depressing the listening key 269. If, therefore, the operator should find it necessary to bring about disconnection without charging the call to the calling subscriber, she will depress the special disconnect key 273, which will initiate disconnection precisely as the disconnect key 268 hereinbefore described; but in addition, the operation of this key will open the locking circuit of the locking register control relay 262 and such relay being deënergized the circuit over the spring 227 to the relay 133 will not be closed when the sequence switch 200 passes through its seventeenth and eighteenth positions and therefore no charging of the call can take place.

On Fig. 7 associated with the home operator's sequence switch is a pilot lamp 717 controlled by the spring 708 of such sequence switch, which will be lighted whenever the operator's apparatus is in position to converse with a calling subscriber. This is known as the home operator's pilot lamp and will indicate in the usual manner to any monitor that such home operator is busy. Correspondingly on the same figure is shown a pilot lamp 767 controlled by the spring 758 750 which serves in precisely the same manner for a corresponding purpose.

On Fig. 9[a] is shown a wipe-out key 961 by which the operator, when the A register sequence switch 500 is in its 4th position, may, before she has completed indicating the designation of the desired line upon the manually operable keys, wipe out such designation so far as it has been accomplished if she discovers that she has made an error. Immediately that the wipe-out key is again closed, the operation will proceed in the normal manner.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In a telephone exchange system, the combination with a plurality of lines, automatic power-driven selector switches adapted to interconnect the same, a sender adapted severally to control said switches by means of revertive impulses transmitted over a selection-controlling circuit from the switch under control back to the sender and which measure the advance of such switch, and electromagnetic impulse-repeating

means located at one of said switches adapted to reproduce in a selection-controlling circuit terminating thereat impulses produced by the movement of a succeeding switch, whereby the movement of such succeeding switch may be controlled by said sender.

2. In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in different offices, trunk lines, automatic power-driven selector switches adapted to interconnect said subscribers' lines by means of said trunk lines, a sender adapted severally to control said switches by means of revertive impulses transmitted over a selection-controlling circuit from the switch under control back to the sender and which measure the advance of such switch, an established connection leading through a plurality of such offices, a repeating coil and battery for supplying current to the called party being located at a switch in one of the offices through which the connection extends, and electromagnetic impulse-repeating means located at said switch adapted to reproduce in the selection controlling circuit terminating thereat impulses produced by the movement of a switch located beyond said repeating coil, such repeating means being rendered operative upon the completion of operation of the selector with which it is associated, and subsequently rendered inoperative before the completion of the talking connection.

3. In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in different offices, trunk lines, automatic power-driven selector switches adapted to interconnect said subscribers' lines by means of said trunk lines, a sender adapted severally to control said switches by means of revertive impulses transmitted over a selection-controlling circuit from the switch under control back to the sender and which measure the advance of such switch, an established connection leading through a plurality of said offices, a repeating coil and battery for supplying current to the called party being located at a switch in one of the intermediate offices over which the connection extends, and electromagnetic impulse repeating means located at said switch adapted to reproduce in the selection controlling circuit terminating thereat impulses produced by the movement of a switch located in a distant office beyond said repeating coil, a sequence switch, such repeating means being rendered operative by said sequence switch upon the completion of operation of the selector with which it is associated, and subsequently rendered inoperative thereby before the completion of the talking connection.

4. In a telephone exchange system, the combination with a plurality of lines, automatic power-driven selector switches adapted to interconnect the same, a sender adapted severally to control said switches by means of revertive impulses transmitted over a selection-controlling circuit from the switch under control back to the sender and which measure the advance of such switch, and electromagnetic impulse-repeating means located at one of said switches adapted to reproduce in the selection controlling circuit terminating thereat impulses produced by the movement of a succeeding switch, said repeating means comprising a relay 434 included in the circuit leading to the other selector adapted to control the circuit leading to the sender, and a relay 433 controlled by the circuit leading to such sender adapted to control the circuit leading to the subsequent selector.

5. In a telephone exchange system, the combination with a plurality of subscribers' lines, trunk lines, automatic power-driven selector switches adapted to interconnect said subscribers' lines by means of said trunk lines, a relay for each switch controlling the motor circuit thereof, a sender adapted severally to control such switches by means of revertive impulses transmitted over a selection-controlling circuit from the switch under control back to the sender, such circuit including the power control relay of the switch under control, a repeating coil and battery for supplying current to the called party located at one of the switches of the connecting circuit over which the connection extends, impulse repeating means located at said switch adapted to be operated by the advance of a selector located beyond the repeating coil and intermittently to deënergize the sender magnet without affecting the motor control relay of the switch with which the impulse repeating means is associated and which controls the circuit of said impulse repeating means which in turn controls the motor-control relay of the succeeding switch, the impulses from which are being repeated in the selection controlling circuit, until upon the completion of operation of the sender the motor control relay circuit of the switch with which the repeating means is associated is opened which causes the opening of the circuit of the impulse repeating means which in turn opens the motor-control relay circuit of the succeeding switch and thus terminates selection.

6. In a telephone exchange system, the combination with a plurality of lines, automatic selector switches adapted to interconnect the same, relays governing said switches, sources of alternating and direct current, certain of said relays being included in circuits adapted to carry both

kinds of current but being responsive only to one, while one of said relays included in said circuits responds to both.

7. In a telephone exchange system, the combination with a plurality of lines, automatic selector switches adapted to interconnect the same, electro-mechanisms controlling the same, a relay responding to both direct and alternating current, a second relay in circuit with said first relay but responding only to alternating current, said first relay when energized by direct current causing a certain operation of one of said electromechanisms and when operated by alternating current in conjunction with the second relay causing a different operation of said electromechanism.

8. In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in different central offices, trunk lines of the two and three conductor type, automatic selector switches, sending mechanism at one of said offices adapted to direct said switches to interconnect said subscribers' lines by means of said trunk lines, an established connection including both two-conductor and three-conductor trunk lines, and signals before the operator at said controlling office for supervising connection so established.

9. In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in different central offices, trunk lines of the two and three conductor type, automatic selector switches, sending mechanism at one of said offices adapted to direct said switches to interconnect said subscribers' lines by means of said trunk lines, an established connection including both two-conductor and three-conductor trunk lines and leading through a plurality of offices, the trunk lines extending to the controlling office and from the controlling office to another office through which the calling line is extended being of the two-conductor type, and signals at said controlling office for supervising connections.

10 In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in different main offices and in satellites, trunk lines of the two-conductor type extending between said main offices and between the satellites and their main offices, automatic selector switches, sending mechanism at one of said main offices manipulated by the operator thereat for directing said switches to interconnect the lines terminating in different satellite offices by means of said two-conductor trunk lines, and signals before the operator thereat for supervising the connection.

11. In a telephone exchange system, the combination with a plurality of subscribers' lines, connecting circuits for interconnecting the same, a plurality of non-numerical switches adapted to extend a calling line to a connecting circuit, the circuit leading from one of said switches to the next, and over which the control of such switches takes place, being of the two-conductor type.

12. In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in main offices and in satellites, connecting circuits at the main offices, and trunk lines of the two-conductor type extending between said satellites and their main offices and terminating at each end in non-numerical switches adapted to extend calling lines from the satellites to said connecting circuits at the main offices.

13. In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in main offices and in satellites, connecting circuits at the main offices and trunk lines of the two-conductor type extending between said satellites and their main offices, and terminating at each end in non-numerical switches adapted to extend calling lines from the satellites to said connecting circuits at the main offices, a sequence switch for controlling the non-numerical switch at the satellite and adapted to initiate the operation of the non-numerical switch at the main office.

14. In a telephone exchange system, the combination with a plurality of subscribers' lines terminating in main offices and in satellites, connecting circuits at the main offices and trunk lines of the two-conductor type extending between said satellites and their main offices, and terminating at each end in non-numerical switches adapted to extend calling lines from the satellites to said connecting circuits at the main offices, each of said trunk lines being provided at the main office with a line and a cut-off relay, the former being adapted to be energized under the control of the non-numerical switch at the satellite which has responded to the call to start the switch in motion and the latter being energized under control of the associated non-numerical switch at the central office to cut off the line relay from the line and thus to stop such switch.

15. In a telephone exchange system, the combination with a plurality of subscribers' lines, connecting circuits for interconnecting the same, a plurality of line finders adapted to extend a calling line to a connecting circuit, the circuit leading from one of said switches to the next, and over which the control of such switches takes place, being of the two-conductor type.

16. In a telephone exchange system, the combination with a plurality of lines, connecting circuits, means for automatically extending a calling line to an idle connecting circuit, a visual signal actuated by such

connection of the calling line thereto, operators' positions, means for automatically extending such connecting circuit to an idle position and for thereupon changing the character of the visual signal to indicate such connection to the operator at such position.

17. In a telephone exchange system, a plurality of lines, selector switches for interconnecting the same, an impulse receiving mechanism for controlling the adjustment of said switches, an electromagnetic impulse repeating means located at one of said switches operable in accordance with the adjustment of a succeeding switch.

18. In a telephone exchange system, a plurality of lines terminating in different offices, trunk lines, selector switches for interconnecting calling and called lines by means of said trunk lines through a plurality of offices, a sender adapted severally to control said switches by means of revertive impulses transmitted over a selection controlling circuit from the switch under control back to the sender, a current source for the called line located at a switch in one of the offices through which the connection extends, and electromagnetic impulse repeating means located at said switch adapted to reproduce in the selection controlling circuit terminating thereat impulses produced by the movement of a switch located beyond said current source.

19. In a telephone exchange system, a plurality of lines terminating in different offices, trunk lines, selector switches for interconnecting calling and called lines by means of said trunk lines through a plurality of offices, a sender adapted severally to control said switches by means of revertive impulses transmitted over a selection controlling circuit from the switch under control back to the sender, a repeating coil and a battery for supplying current for the called line located at a switch in one of the offices through which the connection extends, and electromagnetic impulse repeating means located at said switch adapted to reproduce in the selection controlling circuit terminating thereat impulses produced by the movement of a selector located beyond the repeating coil.

20. In a telephone exchange system, a plurality of lines, trunk lines, selector switches for interconnecting said lines by means of said trunk lines, a sender for controlling the operation of said switches, a repeating coil and a battery for supplying current to the called line located at one of said switches, impulse repeating means located at said switch adapted to control the operation of said sender, means controlled by a selector located beyond said repeating coil for operating said impulse repeating means, a relay provided at said switch for coöperating in the control of said switches and impulse repeating means, and means operable upon the completion of the connection for actuating said relay.

In witness whereof, I hereunto subscribe my name this 9th day of June A. D., 1913.

FRANK ROBERT McBERTY.

Witnesses:
PAUL KOLISCH,
HARRY TUCK SHERMAN.