F. R. McBERTY.

TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED NOV. 3, 1911.

1,127,467.

Patented Feb. 9, 1915.

7 SHEETS—SHEET 1.

Fig. 1.

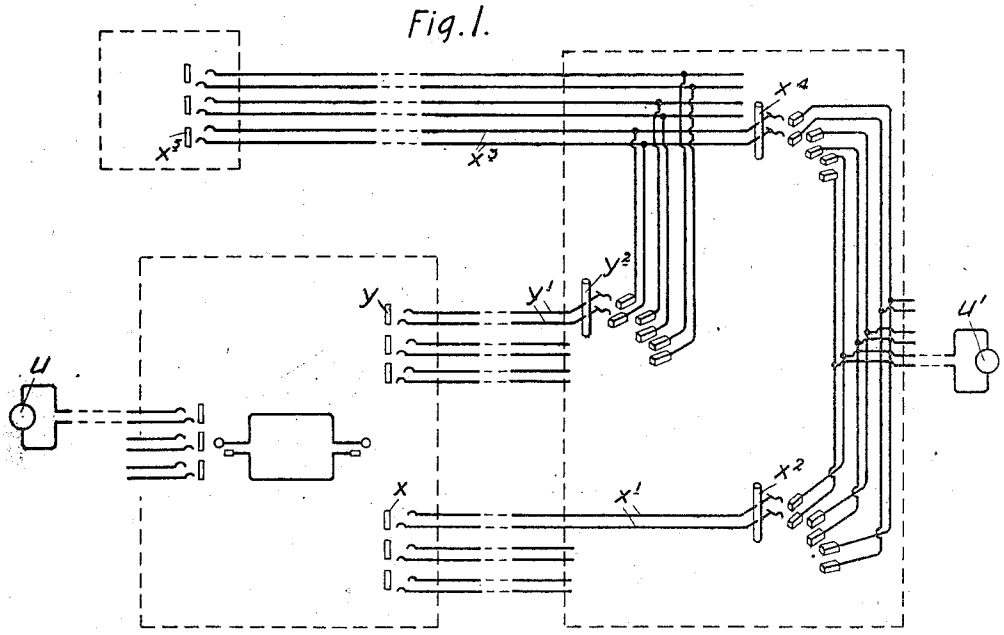
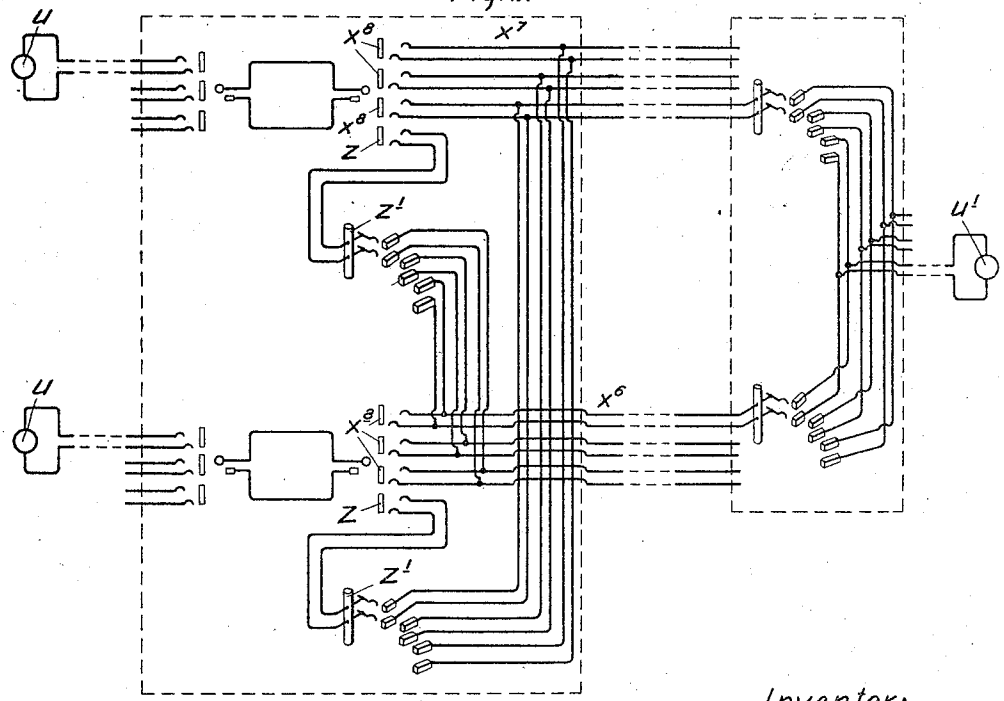


Fig. 2.



Witnesses:

J. P. McIntosh.

C. F. Hoffman

Inventor:

Frank R. McBerty.

by A. C. Hanner, Atty.

F. R. McBERTY.

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7 SHEETS—SHEET 2.

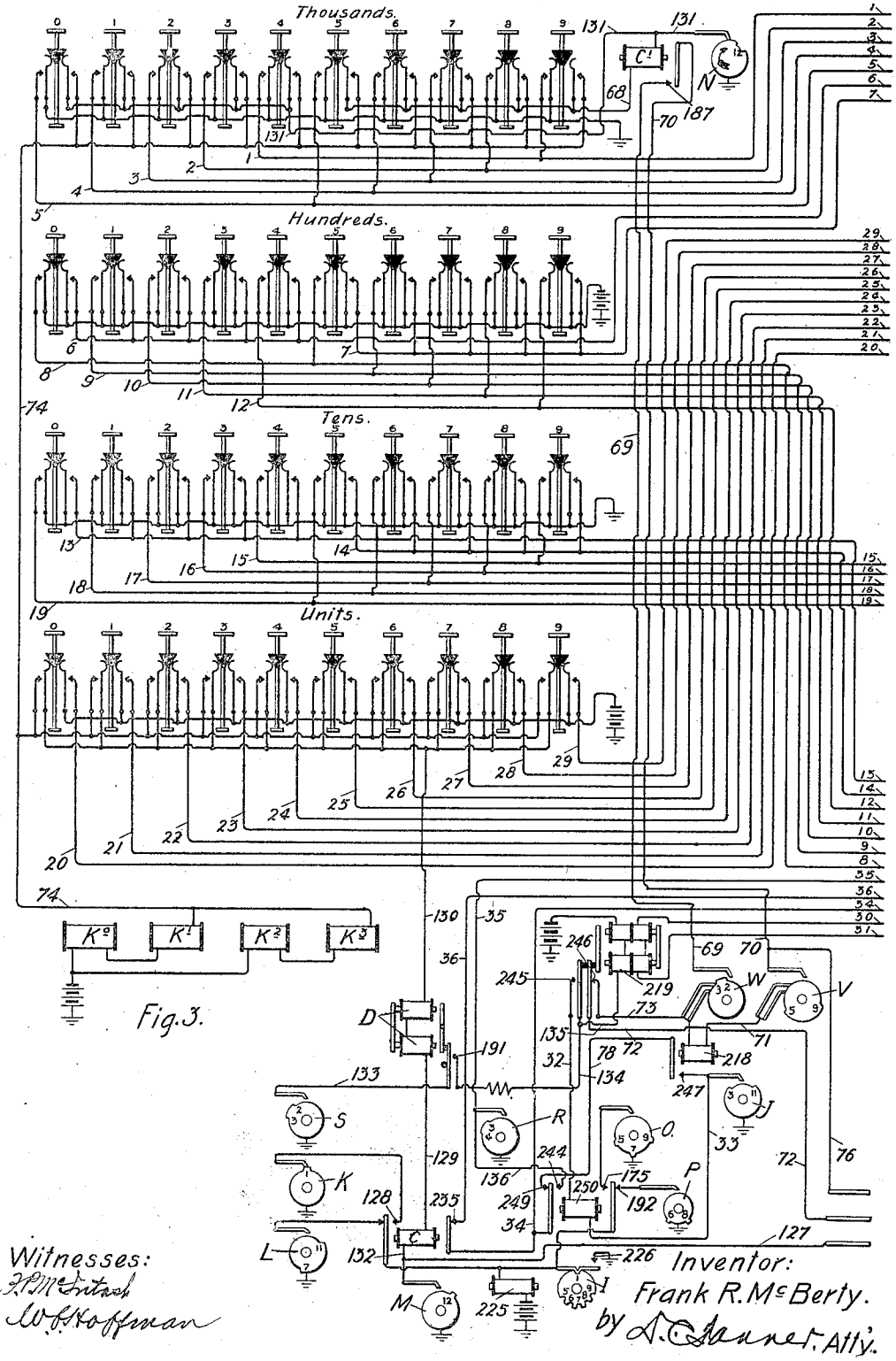

Fig. 3.

Witnesses:
F. M. Entwistle
W. F. Hoffman

Inventor:
Frank R. McBerty.
by A. G. Mauer Atty.

F. R. McBERTY.

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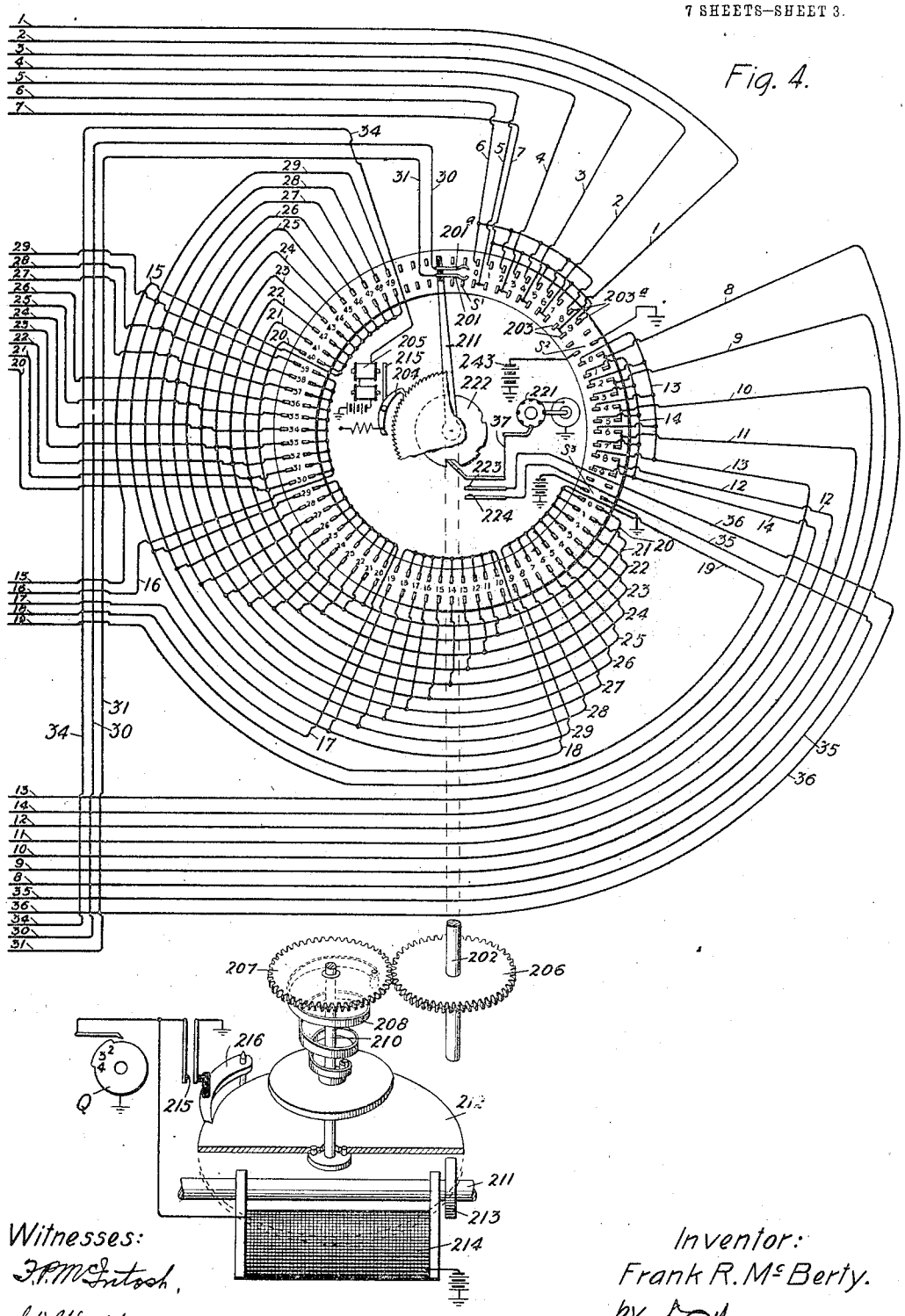
7 SHEETS—SHEET 3.

Fig. 4.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S3
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Witnesses:

J. P. McIntosh,

C. P. Hoffman

Inventor:

Frank R. McBerty.

by S. C. Tanner Atty.

F. R. McBERTY.

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7 SHEETS—SHEET 4.

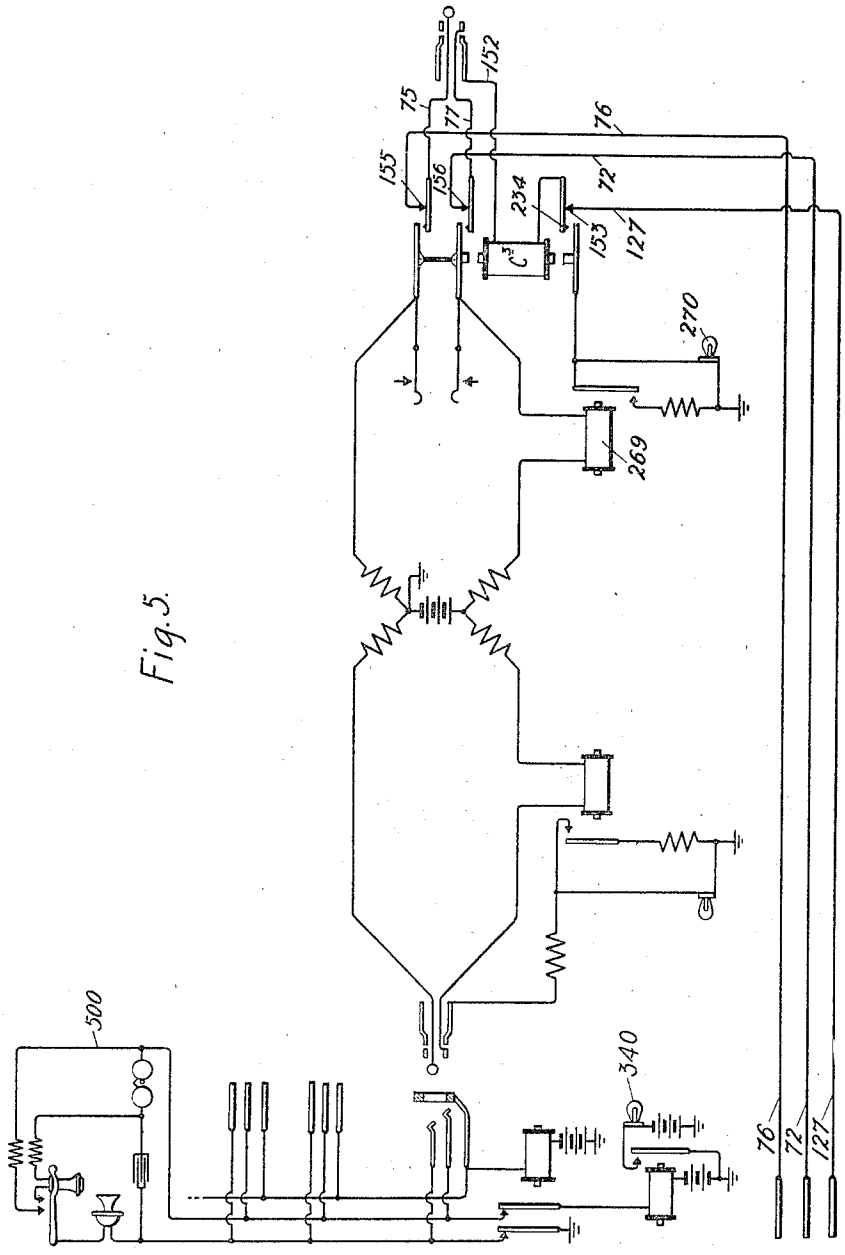

Fig. 5.

Witnesses:
H. McIntosh.
W. S. Hoffman

Inventor:
Frank R. McBerty
by L. C. Stewart, Atty.

F. R. McBERTY.

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7 SHEETS—SHEET 5.

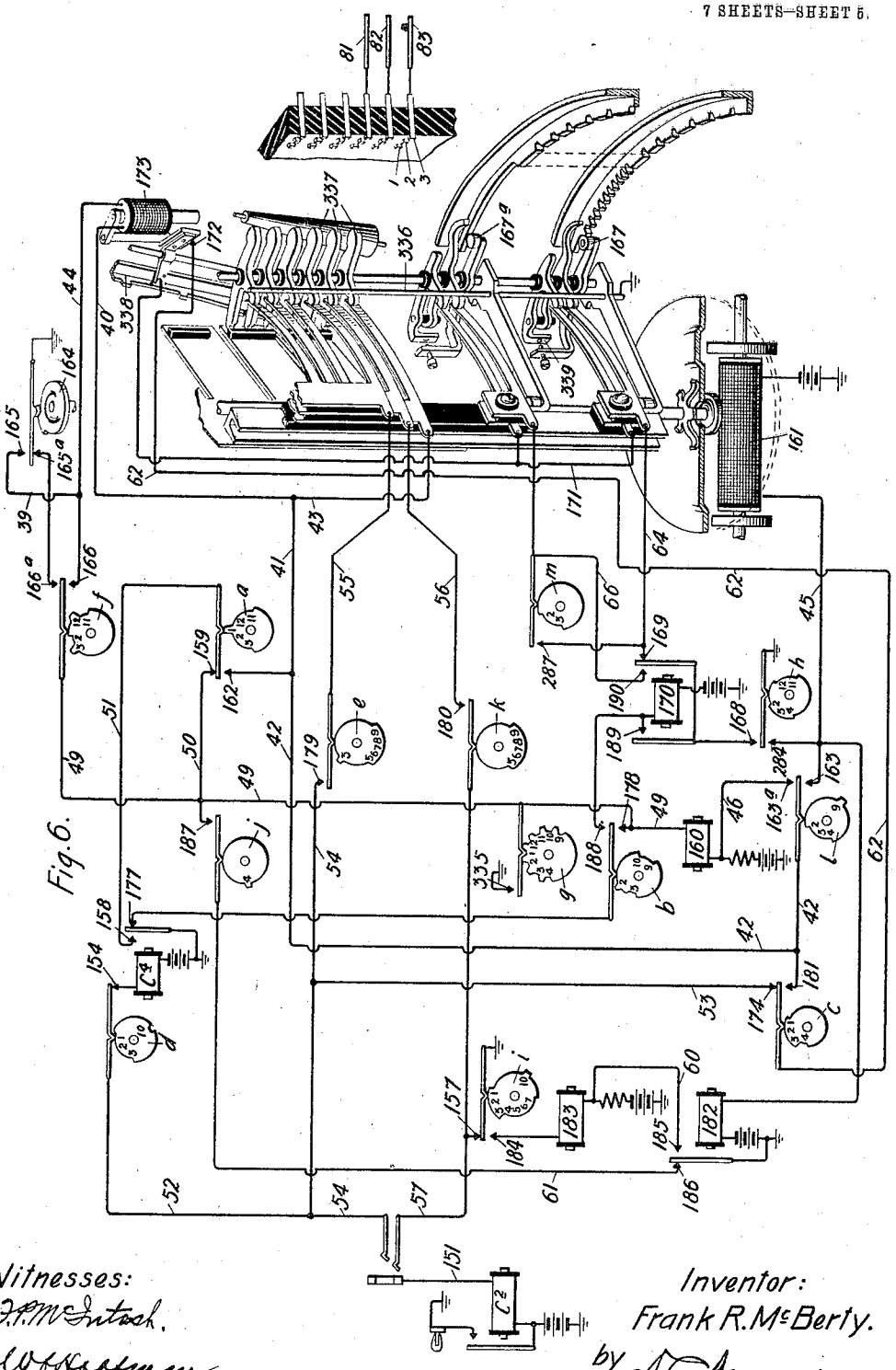

Fig. 6.

Witnesses:
J. P. McIntosh.
W. F. Hoffman

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

F. R. McBERTY.

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7 SHEETS—SHEET 6.

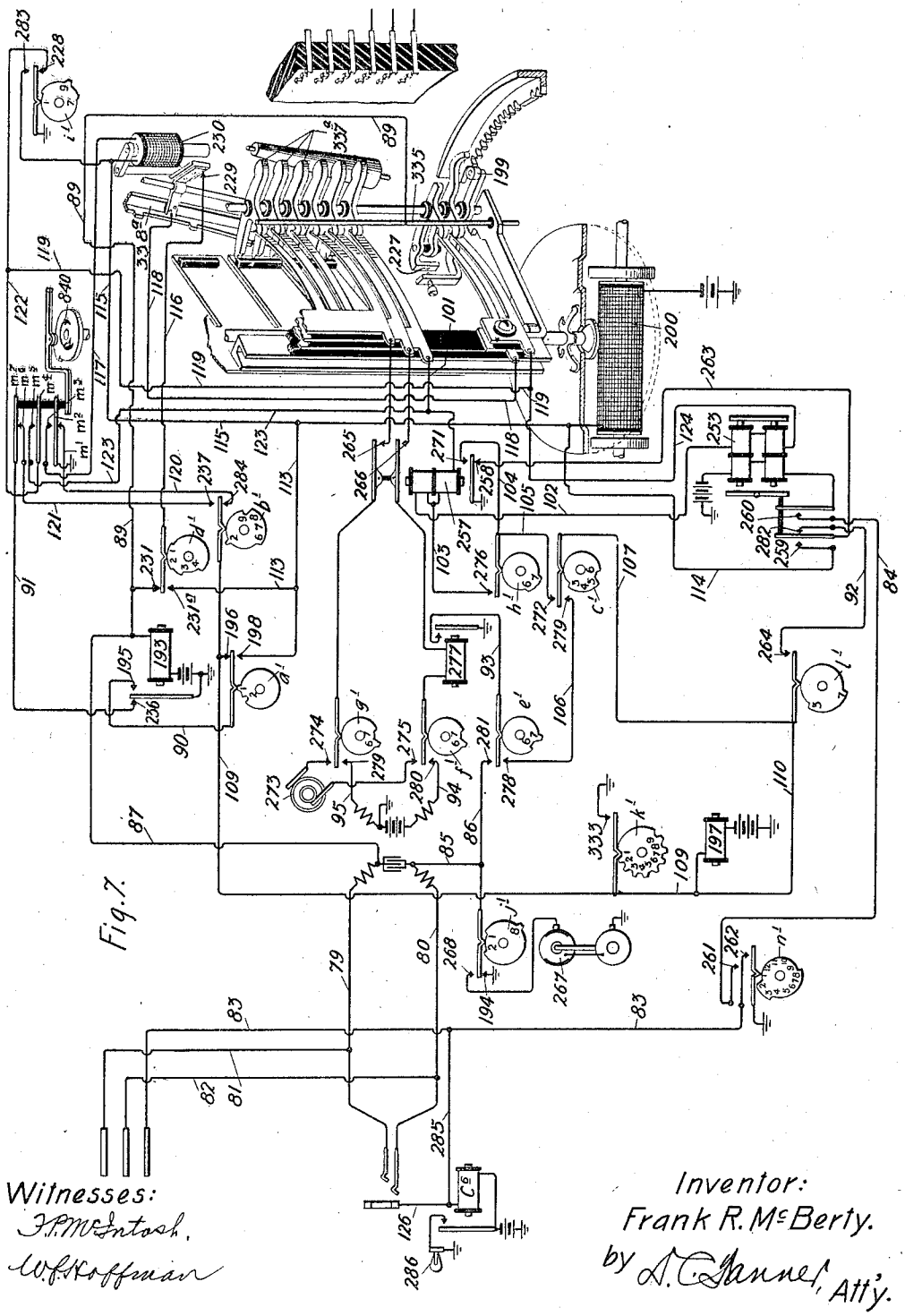

Fig. 7.

Witnesses:
J. P. McIntosh.
W. F. Hoffman

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

F. R. McBERTY.

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7 SHEETS—SHEET 7.

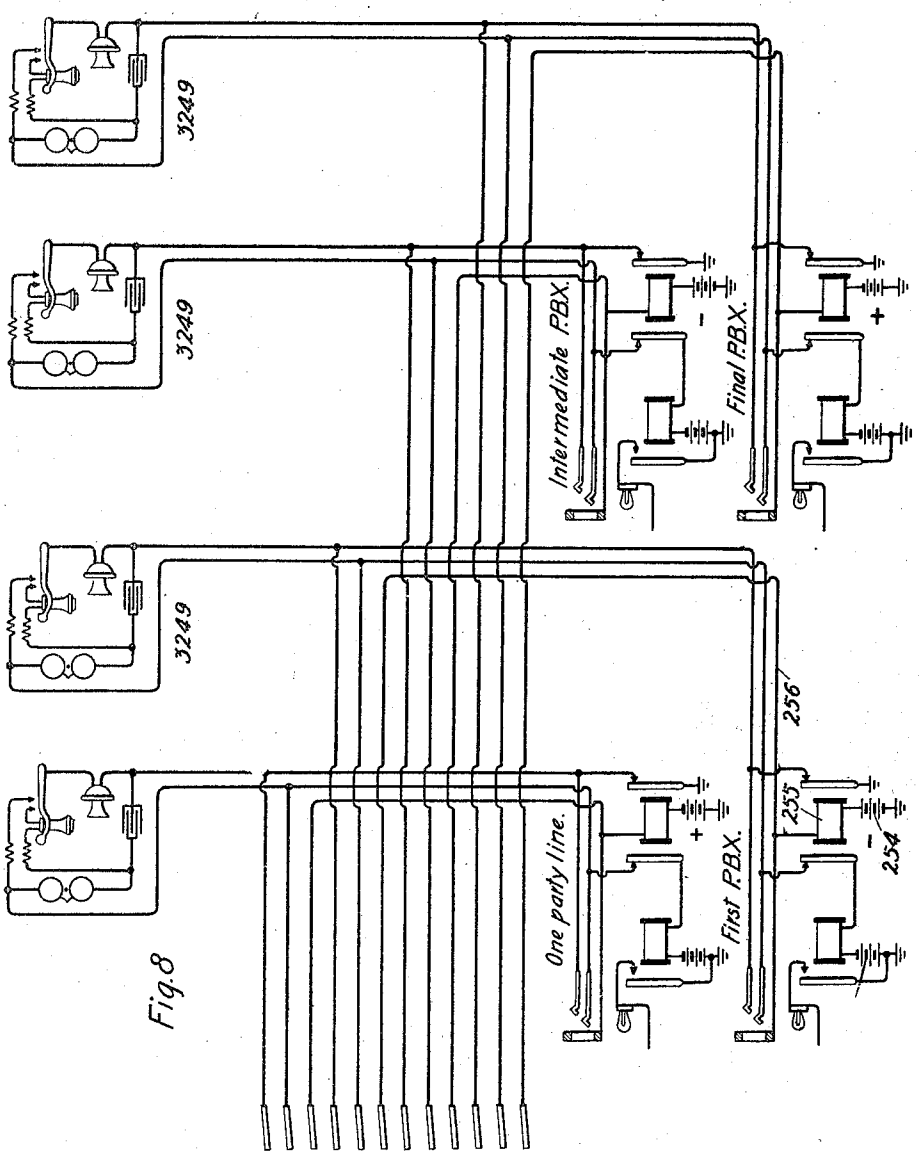

Fig. 8

Witnesses:
J. P. McIntosh.
W. F. Hoffman

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

UNITED STATES PATENT OFFICE.

FRANK R. McBERTY, OF NEW ROCHELLE, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY OF NEW YORK, N. Y., A CORPORATION OF ILLINOIS.

TELEPHONE-EXCHANGE SYSTEM.

1,127,467. Specification of Letters Patent. Patented Feb. 9, 1915.

Application filed November 3, 1911. Serial No. 658,291.

To all whom it may concern:

Be it known that I, FRANK R. McBERTY, citizen of the United States, residing at New Rochelle, in the county of Westchester and State of New York, have invented a certain new and useful Improvement in Telephone-Exchange Systems, of which the following is in full, clear, concise, and exact description.

This invention relates to a telephone exchange system, and its object is in general to provide an improved organization of automatic switching apparatus and controlling means therefor, whereby connections between subscribers' lines may be made with rapidity and precision.

Another object is to promote trunk economy by reducing the number of trunks required to handle the traffic.

The invention of my present application represents a further development of the invention disclosed in my application Serial No. 418,123, filed February 27, 1908, and contains many features in common therewith, the present application being filed as a continuation of and a substitute for my aforementioned application with respect to several of these common features.

In accordance with the embodiment of my invention which I have herein illustrated, and which I shall describe, the substation equipment is of the usual character, and does not involve any special calling apparatus. The subscribers' lines extend to a central office, where they are terminated in such a manner that a call for connection operates a signal that attracts the attention of the operator. The operator is provided with switching means for putting herself into communication with the calling subscriber and ascertaining his wants; and also with connecting means through which the line of the calling subscriber may be extended to a circuit over which his line, without any further effort on his part, and without requiring the services of another operator, may be brought into connection with the particular line for which he is calling.

The circuit over which connection with the called line is established, in accordance with my invention, is provided with an automatic switch or selector which has access to connection terminals of the line with which connection is desired and which is under the control of a calling or sending device adapted to be manipulated by the operator who answers the subscriber's call. Upon receiving the call of the calling subscriber the operator sets the calling device with which she is provided, and when she has completed connection with the trunk line extending to the group in which the called line is included, the automatic switch at the other end of the trunk operates under the control of the calling device to select and establish connection with the particular line with which connection is desired.

In the system of this invention as preferably organized, each subscriber's line has multiple terminals upon each of a group of automatic switches or "final selectors" by which connection is made to the line from other lines; and connection switches are provided at the central office whereby any line when calling may be united with one of a number of operators' connecting circuits by which the call may be answered. Each operator will have a number of such connecting circuits, any one of which may be united with any calling line of the group assigned to that operator.

So far as many of the features of the present invention are concerned, any desired means may be employed for bringing a calling line into connection with an operator's connecting circuit, in order that the operator may answer the call. In the particular system to be described, each subscriber's line has an answering springjack and line signal as in the manual system, appearing before one of the central office operators; and the operators' connecting circuits comprise flexible cord conductors terminating each in an answering plug of the usual type, adapted for insertion in the springjacks of calling lines. Likewise, there are preferably located at each of the operators' positions springjacks forming the terminals of trunks to other offices, the flexible cord conductors being each also provided with a calling or trunk plug of the usual type adapted for insertion in any of the springjacks to extend the connecting circuit. Each trunk springjack at an operator's position constitutes the terminal either; (1) of a "direct trunk" extending to a "direct trunk switch" which is a final selector; or (2) of an "overflow trunk" extending to an "overflow

switch" which is an intermediate selector adapted to select an idle direct trunk of a group of direct trunks other than the ones terminating in a springjack before the particular operator's position.

The sequence of selections required to reach any wanted line is brought about and controlled by an automatic "sending apparatus" upon which the number of such wanted line is registered by the operator, preferably a set of number keys, which may be similar in arrangement to the keys of an adding machine and which may be set in the combinations required to represent any line number of the system. Thus the operator plugs into the jack of the calling subscriber and throws the listening key as in standard practice. Obtaining the number of the party wanted, she presses the keys of the number as received. She then takes the calling plug of the cord circuit which she has used for answering and inserts it in the jack of the direct trunk which represents the group of selectors to which the line of the party wanted is multiplied in case such jack is not already in use. If she cannot thus directly connect to the final selector, she will plug into the springjack of an overflow trunk. The sending apparatus will in either case proceed automatically with a series of controlling operations, which will bring about the successive selections required to extend the circuit to the line represented by the keys depressed.

In an exchange of ten thousand lines capacity, the lines may be divided into, for example, twenty groups of five hundred lines each; so that the final selectors would be 500-line machines, each line being multiplied to a number of final selectors sufficient to handle the incoming calls for the group to which it belongs. Connection may thus be made to the line by any one of the group of final selectors upon which the line is multiplied, each final selector of a given group having direct access to the same five hundred lines.

Referring to the accompanying drawings—Figure 1 is a schematic view illustrating my invention as particularly adapted for use in large cities where each exchange may comprise, for example, ten thousand lines, a large number of such exchanges being connected by interoffice trunk lines. Fig. 2 shows my invention as applied to direct trunks connecting two exchanges only, the overflow selector in this case being shown as located at the exchange at which the line of the calling subscriber terminates. Figs. 3 and 4 placed side by side form a complete diagram of the keys and sending or calling mechanism, Fig. 3 showing a bank of keys arranged in four sets representing thousands, hundreds, tens and units digits respectively, and Fig. 4, together with a portion of Fig. 3, representing one form of sending or calling apparatus adapted to govern the various selecting operations under the control of the keys shown in Fig. 3. Fig. 5 represents the calling subscriber's line and the operator's cord circuit. Fig. 6 represents the overflow trunk and selector. Fig. 7 represents a direct trunk and its final selector to which the circuit may be extended by the overflow selector. Fig. 8 represents a number of subscribers' lines to which the final selector may make direct connection. Figs. 5 to 8 when placed together edge to edge form a complete diagram, the lines which continue to the edge of one sheet being continued on the next sheet, the lines from the cord circuit of Fig. 5 leading to the sender circuit of Fig. 3. Figs. 3 to 8 inclusive illustrate the circuits and apparatus involved in extending a connection from the calling line to a line called for.

The same reference letters indicate corresponding parts wherever shown.

General plan of system.—When any one of the operator's connecting circuits is put into service to answer a call, the sending apparatus is automatically appropriated to the use of that connecting circuit; and a controlling or "stepping" circuit is established between a controlling relay at the selector and a magnet at the sender which is adapted to operate a step-by-step mechanism. Means are provided for transmitting electrical impulses over this stepping circuit, and for operating the selector and the stepping mechanism at the sender in unison therewith. The advance of the stepping mechanism at the sender in unison with the impulses transmitted over the stepping circuit furnishes a means for measuring off at the sender the exact extent of operation of the distant selector; and when a predetermined number of impulses have been transmitted, as indicated by the advance of the sender stepping mechanism to a predetermined point, the stepping circuit may be automatically opened, bringing that particular selecting operation to an end, after which another selection may be made in the same way. In case the operator plugs into a direct trunk jack, the connection to the called line is effected through a single or final selector. In case she plugs into an overflow trunk, the connection is established through both an overflow switch, which is a first selector, and then through a final selector. In the former case, the final selector, and the latter case each selector in the train through which the circuit is successively extended, is, as it is reached, brought under control of the sending apparatus by the establishment of the selecting circuit, which includes a controlling relay or magnet at the selector and a relay or magnet at the

sender adapted to operate the stepping mechanism thereof.

The extent of advance of the sender stepping mechanism is determined by the selection of a pair of a series of pairs of sender terminals over which a "point-finder" or sender arm is advanced by the stepping machanism, the particular pair of terminals required for determining the successive selecting operations being chosen by keys which are depressed by the operator. In the particular system shown, there are four rows of ten keys each, numbered from 0 to 9 inclusive, the first row representing "thousands," the second row "hundreds," the third "tens" and the fourth "units" digits. A thousands key in combination with a hundreds key determines the level selection of an overflow switch; a hundreds key in combination with a tens key determines the level selection of a final switch; and a tens key in combination with a units key determines the line range selection of a final switch.

The sender or calling device comprises an arm having two brushes, an inner and an outer brush, arranged to be advanced over a series of inner and outer terminals by the stepping mechanism or escapement operated by the stepping magnet which responds in unison with the stepping impulses. The terminals are in three divisions. Those in the first division determine the level selection of an overflow selector; those in the second division, the level selection of a final switch; and those in the third division the line range selection of a final switch. Each combination of keys, above set forth, is adapted when depressed to select a corresponding pair of terminals—in the present case by connecting one terminal of the pair to ground and the other to battery—and the finder brush upon reaching the pair of terminals so selected will complete a circuit for a stop relay. This relay in its response breaks the circuit over which the stepping impulses are transmitted, so bringing the selecting operation to an end. The response of the stop relay also brings switching mechanism into action to prepare the sender for the next selection, and so on until the last selection has been made, whereupon the stop relay in its response causes switching mechanism to be actuated which will disconnect the sending apparatus from the circuit which has been established, leaving the calling line united through the operator's connecting circuit and the selector or selectors, as the case may be, to the line which has been selected. In the system shown, the impulses for measuring each selection are derived from a battery associated with the selector under control, and are produced by the action of interrupter contacts closed periodically in the advance of such selector, which intermittently short-circuit the line. Power is applied to the movable element of the selector under control of a line relay, which is in a portion of the stepping circuit not shunted by the interrupter, and which is released when the circuit is opened by the stop relay at the sender.

The local controlling circuits at each selector and at the sending apparatus, which must be established in definite order at successive stages of the operation to bring into service different devices or parts as required, are in the present system established by automatic switching appliances which I term sequence-switches. There is a sequence-switch for each selector, and one for the sending or calling apparatus. The sequence-switch consists in its elements of a movable switch-operating member, a number of circuit-changers or switches actuated in sequence as said member is moved from one position to another, an electromagnet, and motor mechanism operated or controlled by said magnet for advancing said movable member.

The sequence-switch may control any desired sequence of operations, whether of the same or of different devices. In each position to which its movable member is advanced a circuit is established whereby a given operation of the device under control is made possible, and at the same time another circuit is established, whereby the motor magnet of the sequence-switch may be actuated automatically when such operation of the device under control has been completed; so that as each operation takes place, the sequence-switch will be automatically advanced to a succeeding position, in which a new operation or another stage of the same operation will be brought about, and so on. Finally, the sequence-switch establishes a condition whereby the apparatus under control is returned to its normal condition, and also establishes a circuit whereby the sequence-switch itself will be returned to normal.

Referring to Fig. 1 attention is directed to the fact that in the particular system shown, the operations performed in transmitting a call received from the subscriber U may be: first, the operator plugs into the jack x of a direct trunk x^1 leading to a final selector x^2 at the distant office; and, second, the selection by the chosen final selector of the subscriber's line U′ wanted. Or as an alternative, the operations required in transmitting a call may be: first, the operator plugs into the jack y of an overflow trunk y^1 leading to an overflow selector y^2; second, the selection by the overflow selector of an idle trunk of a group of direct trunks x^3 each terminating at one end in a final switch x^4 at the distant office and at the other end in a springjack x^5 at still another distant office, said trunks x^3 being also multiplied

to terminals of the overflow selector; and third, the selection, by the final selector x^4 of the direct trunk chosen, of the subscriber's line U′ wanted.

In Fig. 2, an embodiment of the invention is schematically shown in which two exchanges are connected by a number of interoffice trunks x^6, x^7 terminating in springjacks x^8 before two different operators in one exchange and in final selectors at the other exchange, the called for subscriber's line U′ at the latter exchange being multipled to final selectors which are represented before both operators at the former exchange. Each operator's position is also equipped with an overflow jack z leading to an overflow selector z^1 which is adapted to select an idle trunk which leads to the other operator's position. Thus if an operator finds all her direct trunks leading to the final switch representing the called for subscriber to be busy, she will plug into an overflow jack in order to take for use some other trunk leading to a final switch representing the same subscriber.

While I have thus shown interoffice trunks terminating at one office in a springjack and at the other office in a final selector or switch, it is not to be understood that my invention is so limited with respect to certain of its features, the overflow trunk feature being applicable to trunks of telephone systems in general with a view to trunk economy. Thus, to handle the maximum traffic, ordinarily several times the number of trunks are provided that would suffice to handle the average traffic. According to my present invention it is necessary to provide only the number of regular trunks required to handle the average traffic, and in addition thereto a few extra or overflow trunks to take care of the excess traffic, such arrangement obviously reducing the total number of trunks required to handle the maximum traffic.

Mechanism of selectors or connector switches.—The mechanism of the overflow switch or selector, shown diagrammatically in Fig. 6 and of the final selector shown diagrammatically in Fig. 7, may be, for example, in general substantially that of the selectors shown and described and shown in my British Patent No. 20,839 of September 11, 1908; and hence a detailed description of the construction and mode of operation of the selector mechanism is deemed unnecessary. Moreover, the power transmitting device of the selector forms the subject matter of my United States Letters Patent No. 922,802, granted May 25, 1909. Certain other features of the mechanism of the selector forms the subject matter of my copending application for Letters Patent of the United States, Serial No. 418,126, filed February 27, 1908. It should be noted, however, that the overflow selector shown in Fig. 6 is provided with two interrupter levers or contact devices, 167 and 167^a, the latter for subscribers' numbers above 4999, in the case of a ten thousand line exchange, and the other for subscribers' numbers below 5000. Which of these two interrupters is active is determined by a "level" relay 170, which relay in turn is ultimately controlled by the depression of a thousands key, the level relay being energized when a thousands key above No. 4 is depressed and not being energized when a thousands key below No. 5 is depressed, as will be more fully set forth hereinafter in connection with the description of the circuit arrangements employed.

An overflow selector in the system shown and described can select one of twenty different groups of final selectors, each of the final selectors having a capacity of 500 lines. Each final selector can thus select any one of 500 subscribers' lines and each overflow selector can assist in the selection of any one of the ten thousand subscribers' lines which terminate in said twenty different groups of final selectors.

In the final selector each level represents fifty subscribers. Level No. 0, for example, of the first group of selectors represents subscribers No. 0 to 49, level No. 9 of the same selectors subscribers No. 450 to 499, level No. 0 of the second group of selectors representing subscribers No. 500 to 549, level No. 9 of these latter selectors representing subscribers No. 950 to 999, and so forth, there being, as before stated, twenty different groups of final switches for a 10,000 line exchange.

In the overflow selector each level represents 1000 subscribers, level No. 0 representing subscribers No. 0 to 499, and subscribers No. 5000 to 5499; level No. 2 subscribers No. 500 to 999 and No. 5500 to 5999; and so forth, level No. 9 representing subscribers No. 4500 to 4999 and No. 9500 to 9999.

In the overflow switch or selector the terminals of each level are connected to final switches as follows: Terminals No. 1, 3, 5, 7 and 9 of a given level are connected to final switches serving the same 500 subscribers, and terminals No. 2, 4, 6, 8 and 10 of the same level are connected to other final selectors serving another group of 500 subscribers, each level thus, as before stated, representing a thousand subscribers. For example, in level No. 9 of the overflow switch, terminals 1, 3, 5, etc., are connected to final switches serving subscribers No. 4500 to 4999, and terminals No. 2, 4, etc., are connected to switches serving subscribers No. 9500 to 9999.

As before stated, the overflow switch has two interrupters, one of which is used when a subscriber is wanted above No. 4999, and

the other for subscribers below No. 5000. The operation of these two interrupters may be understood by reference to Fig. 6. The lower toothed segment over which the lower interrupter lever 167 travels has as usual ten teeth which transmit impulses for the level selection of the final switch, the lever 167 being used for this purpose irrespective of whether or not the number of the line wanted is below or above 5000. Then comes the usual long tooth, followed by teeth which are in staggered relation with corresponding teeth on the segment over which the upper interrupter lever 167ª travels. In short, every other tooth for trunk hunting, all of which would ordinarily be in the path of the lever 167, is placed upon an upper segment in the path of the upper lever 167ª. As before stated, which of these two levers is active for trunk hunting is determined by the level relay 170, for while a tripped brush contacts with all the terminals of the level over which it passes, every other one only of said terminals has at the time of contact a circuit therefor closed through the contacts of an active interrupter, the circuit through the contacts of the other interrupter being opened at the contacts of the level relay. Thus in hunting for a final switch representing a subscriber's number below 5000, the brushes will test only terminals No. 1, 3, 5, 7 and 9 and will pass over without testing or interfering with terminals No. 2, 4, 6, 8 and 10 which represent a different group of final selectors.

In the particular system shown in the drawings, each selector is intended thus to select any one of 500 sets of terminals, there being three terminals in each set, for the two lines and the test conductor, respectively, of a telephone circuit. Each selector will therefore be considered to have thirty brushes, ten sets of three each, and five hundred sets of three stationary terminals each arranged in ten levels corresponding to the ten sets of brushes. For simplicity in the diagram, there are shown only two sets of brushes and a few of the contact terminals in the two corresponding levels.

Mechanism of sender or calling device.—The mechanism of the sending or calling apparatus may be as shown diagrammatically in Figs. 3 and 4. A pair of contact brushes 201, 201ª are mounted at the extremity of an arm 211 carried by a rotary shaft or spindle 202, said brushes being arranged to wipe over two concentric circular ranges of stationary contact terminals 203, 203ª, which are mounted one above the other, (shown diagrammatically in Fig. 4, and hereinafter referred to as one outside the other), in a suitable insulating support surrounding the shaft 202. The brushes 201, 201ª, are electrically united, so that they will serve to connect a terminal 203ª of the outer range to the corresponding terminal 203 of the inner range, at any point around the circle. In other words, whenever the brush 201ª is in contact with a terminal 203ª at any point in the outer range of terminals, the corresponding terminal 203 in the inner range will be electrically connected to such outer terminal through the brushes 201, 201ª. The normal position of the rotary arm is indicated diagrammatically in Fig. 4—that is at s^1, one step back of the first pair of terminals in the division which is used for controlling selections of the trunk selector.

The electrical connections of the stationary terminals in the outer and inner ranges 203, 203ª, are indicated diagrammatically in Figs. 3 and 4. Said terminals are arranged in three divisions which are traversed successively by the finder brushes 201, 201ª, as the arm 211 makes a complete revolution. That is to say, beginning with the normal position of the brushes, there is first a division which may be called the overflow division, comprising ten pairs of terminals which are used in controlling the brush-choosing action of the overflow selector; then a pair of dead terminals; then a pair of terminals representing a secondary starting position s^2 for the brushes, preliminary to the direct trunk division; then the direct trunk division comprising ten pairs of terminals used for controlling the brush-choosing action of the final selector; then a pair of dead terminals; then a pair of terminals representing the starting position s^3 for the brushes preliminary to the line range selection, that is the rotary selective action of the final selector. Thus at the end of each division there are dead terminals; and at the beginning of each division there is an extra pair of inner and outer terminals s^1, s^2, s^3, respectively, representing a starting position for the brushes, preliminary to their entry upon such division. In the normal starting position s^1, of the finder brushes 201, 201ª, and in the second and third starting positions s^2, s^3 thereof the finder brushes lie one step back of the first or zero terminal of the corresponding division.

The brush-carrier arm 211 is adapted to be rotated step-by-step around the annular bank of stationary terminals, by the action of an escapement which controls a train of gears, the brushes being caused to step from terminal to terminal at each complete vibration of the pallet 204. The motive power for rotating the brush-carrier shaft 202 may be furnished by a coiled spring 208 acting upon a gear wheel 207 which meshes with another gear wheel 206 fixed upon said shaft 202. The pallet 204 of the escapement is mounted upon an arbor which also carries the armature 215 of an electromagnet 205. This "step magnet" 205 is in a local circuit controlled by a "stepping relay" 218, which

responds to the selecting impulses transmitted over the controlling circuit by the action of the interrupter of the distant selector under control.

The rotary brush-carrier shaft 202 of the sender carries a cam 222 which is adapted to close contacts 223, 224 while the brushes 201, 201ª are traversing the terminals of each division; said contact being open when the brushes rest in the starting positions preliminary to the respective divisions.

The coiled spring 208 which drives the gear train to rotate the brush carrier under control of the escapement may be automatically wound up after each complete revolution of the brush carrier. The winding mechanism is shown at the bottom of Fig. 4. One end of the spring 208 is fixed to a shaft 210 upon which the gear wheel 207 is journaled to rotate; and said shaft 210 carries an iron disk 212 which is adapted to be engaged by an iron friction-driving roller 213 and rotated thereby in a direction to wind up said spring 208. The driving roller 213 is continuously rotated by a power shaft 211; and a clutch magnet 214 is adapted when excited to magnetize said roller 213 to attract the iron plate 212 into engagement with said roller. A pawl 216 is adapted to engage a notch in the edge of the plate 212 to hold the latter against reverse rotation, when the clutch magnet 214 is deënergized. Said pawl 216 is arranged to close a contact 215 whenever the disk 212 has been rotated away from its normal position; said contact 215 being employed to close a local circuit for the clutch magnet 214 to maintain said magnet excited (when it has once been energized) until the disk 212 has made a complete rotation. The spring 208 thus starts when the cam O of the sequence switch, in positions 2, 3 and 4, closes the circuit of clutch magnet 214, and it continues to wind for one revolution under the power of the clutch magnet 214, the circuit of which is continued by the pawl 216 riding on the circumference of the power driven plate 212. Upon this plate completing the revolution the pawl 216 drops into a notch in the periphery of the plate and the circuit of the magnet 214 is opened.

The electrical connections of the sending apparatus may be as shown in Figs. 3 and 4 of the circuit diagram. The stepping magnet 205 is included in a circuit which is controlled at a back contact 249 of a relay 250, the circuit of which is controlled by the stop relay 219, and at a front contact 247 of the stepping relay 218. Said stepping relay 218 is adapted to be included in a stepping circuit which also includes the line relay of the distant selector to be controlled; and said stepping circuit is controlled by a contact 246 of the stop relay 219 at the sender. Said stop relay 219 is included in a circuit which is arranged to be completed by the finder brushes 201, 201ª, when said brushes contact with the pair of terminals 203, 203ª, which the operator has selected in each division by means of her keys. The stop relay 219 is also adapted in its response to close a local circuit for the relay 250 which controls a local circuit for the stepping magnet 205, including an interrupter 221, whereby the point finder may be independently advanced from the point at which it found the terminal grounded by the corresponding key, to the starting point s^2 or s^3, as the case may be, at the beginning of the next division of terminals; and after the last selecting operation the local circuit from the interrupter 221 is completed until the brush finder has traveled clear around to its original starting point s^1.

A cam 222 carried by the point finder shaft 202 is adapted to operate the contacts 223 and 224. Contact 223, as is clearly indicated on the drawings, is closed in all positions except when the shaft is resting in the normal or starting position in which the brushes are in contact with the contact point s'. In all other positions of the point finder shaft 202, even when the contact lever rests in one of the other notches shown upon the cam, which notches correspond to the sub-normal or starting points s^2, s^3, the contact 223 is closed through the wire 37 and interrupter 221 to ground. On the other hand, contact 224 is so arranged that it will only be closed when the contact lever rests upon the periphery of the cam 222 and will be open whenever the contact lever rests in any one of the notches cut in the periphery of such cam. The contact 224 controls a local circuit for the stepping magnet 205 through the interrupter 221, and by opening, when the finder brush reaches the starting points s^1, s^2 or s^3 respectively, causes the finder brush to be arrested in such starting positions in the ordinary or usual operation of the apparatus. The contact 223 also controls a local circuit for the stepping magnet 205 when, in an intermediate stage of the operation of the apparatus, an abnormal or knock-down operation takes place, and its utility is to assure the entire return of the apparatus to its normal position in case of any such abnormal or knock-down operation.

There is a sequence switch associated with the sender, by which the stop relay 219 is brought successively under control of the finder brushes and the selected pairs of terminals in the different divisions of the sender; said sequence switch also performing other necessary circuit changes from time to time, as will hereafter be described in detail.

The connections of the keys with the sender terminals.—By reference to Fig. 3, it

will be seen that the numeral keys are arranged in four rows of ten keys each, the keys in each row being numbered 0 to 9 inclusive. The keys are intended to lock electromagnetically in their depressed positions, in a well-known manner.

Each key of the several rows of keys is adapted when depressed to close two contacts. The right-hand contact of each of the thousands keys controls the circuit of the key magnets K^0, K^1, K^2, K^3. The right-hand contact of each of the thousands keys Nos. 5, 6, 7, 8 and 9 also controls the circuit of a relay C^1, which in turn determines, as will hereinafter be more fully described, which of the two interrupters of the overflow selector becomes active. The left-hand contacts of thousands keys No. 0 and 5 controls the application of a ground connection to the first two inner terminals of the first division of the sender apparatus; the left-hand contacts of the keys No. 1 and 6 controls the application of a ground connection to the next two successive terminals of the sender; and so forth with respect to the remaining keys.

The right-hand contact of each of the hundreds keys No. 0 to 4 inclusive controls the application of battery to outer terminals Nos. 0, 2, 4, 6 and 8 of the first division of the sender terminals; and the right-hand contact of each of the hundreds keys No. 5 to 9 inclusive controls the application of battery to the remaining outer terminals of the first division of the sender terminals. The left-hand contact of hundreds keys No. 0 and 5 control the application of battery to the first two outer terminals of the second division of the sender terminals; the left-hand contacts of the hundreds keys 1 and 6 control the application of battery to the next two outer terminals; and so forth.

The right-hand contacts of each of the tens keys 0 to 4 inclusive control the application of a ground connection to inner terminals 0, 2, 4, 6 and 8 of the second division of the sender terminals; and the right-hand contacts of the remaining tens keys control the application of a ground connection to the remaining inner terminals of the second division of sender terminals. The left-hand contacts of the tens keys No. 0 and 5 control the application of a ground connection to the inner terminals No. 0 to 9 inclusive of the third division of sender terminals; the left-hand contacts of the tens keys 1 and 6 control the application of a ground connection to the inner terminals No. 10 to 19 inclusive of the sender terminals; and so forth with respect to the left-hand contacts of the other tens keys.

The right-hand contact of the units keys No. 0 controls the application of battery to the outer terminals Nos. 0, 10, 20, 30 and 40 of the third division of the sender terminals; the right-hand contact of the units key No. 1 controls the application of battery to the outer terminals Nos. 1, 11, 21, 31 and 41 of the same division; and so forth. The left-hand contact of each of the units keys controls a local circuit which includes the key magnets K^0, K^1, K^2, K^3, and the magnets D and C, the function of which latter magnets will hereinafter be set forth.

For the purpose of conveniently tracing the connections between the key contacts and the terminals of the sender, the various wires connecting the same have each been numbered at two or more places, the numbers employed being 1 to 29 inclusive, the same number referring to the same wire.

Mechanism of sequence switches.—The mechanism of the sequence switches of the sender, the overflow selector and the final selector, respectively, may be for example, in general substantially that of the sequence switch described and shown in my British Patent No. 20,839 of September 11, 1908; and hence a detailed description of the construction and mode of operation of the mechanism is deemed unnecessary, similar mechanism forming, moreover, the subject-matter of my copending application for Letters Patent of the United States, Serial No. 451,868, filed September 5, 1908.

In the circuit diagram herein, Figs. 3 to 7 inclusive, the switch springs of the sequence switches and the operating cams therefor are not shown in their actual arrangement, but are so located as to give the clearest arrangement of circuits. The various positions of the cams of each sequence switch are indicated by numbers placed on the periphery of said cams. It will be understood, however, that the mechanism of each of these sequence switches is substantially that disclosed in my aforementioned British patent. Referring, for example, to Figs. 3 and 4, it will be understood that the cams lettered J, K, L, M, N, O, P, Q, R, S, V and W are the switch operating cams and are mounted on the vertical rotary shaft of the sender sequence switch, said shaft being arranged to be driven by power applied through the agency of a motor magnet 225, the rotation of the shaft and the cams carried thereby continuing as long as the motor magnet remains excited. The said cams J, K, etc., are arranged to control circuits through the medium of switch springs, according to the positions of said cams. Certain of the switch springs may control circuits for the motor magnet 225. A special cam I is also provided to control a local circuit for said motor magnet, whereby after the initial energizing circuit is broken by one of the other switches, the motor magnet may still be exicted by current in the local

circuit until the next intended stopping position of rotary element of the sequence switch is reached.

In the present instance the cams of the sequence switches are preferably of metal to form part of an electric circuit. Certain of these cams are insulated and certain others not insulated from the rotary shaft, as is indicated by the absence or the presence, respectively, of a ground connection at the cam.

In the operation of the sender sequence switch, the circuit for the motor magnet 225 will first be closed through the cam K. Then as the motor magnet is excited and the shaft of the sequence switch begins to rotate, the circuit through the cam K is broken, but a local circuit will be continued for the motor magnet through the contact 226 closed by the special cam I, and the rotary element will thus continue to advance to a position determined by said special cam.

Further and detailed description of the operation of the several sequence switches will be given hereinafter in connection with the description of the operation of the system.

Brief statement of the operation of the system.—Briefly stated, the system in which the embodiment of my invention illustrated and described herein is particularly designed to be employed operates as follows: The act of the calling subscriber in taking his telephone for use displays at a central station switchboard a signal which leads the answering operator to complete connection with the calling line by inserting one of the plugs of a pair of connecting cords into a springjack associated with said signal. Upon this act of the operator, as in standard construction, the cut-off relay of the calling line is energized and the signal device (the line lamp) individual to this subscriber's line is rendered inoperative. As will be hereinafter pointed out, this same operation of the cut-off relay and the consequent rendering inoperative of the signal device individual to such line takes place when a line selector selects and seizes the desired line. When the operator, having made connection with the calling line as described, has learned the number of the line with which the calling subscriber desired connection, she sets her calling device to correspond to the number of the desired line, inserts the other plug of the pair of connecting cords into the springjack of a direct trunk line extending to the group of lines of which the called line is one, or else she inserts the plug in the springjack of an overflow trunk, thereby in either case bringing the calling device into operative relation with the automatic switch at the other end of the trunk line. As soon as the calling device and automatic switch are brought into operative relation a local source of power associated with the automatic switch is made operative to drive it, and the movement of the switch produces impulses that in turn serve to drive the calling device.

The automatic switch has a number of rows of stationary terminals wired to the lines that terminate on the springjacks in the switchboard, and a number of movable terminals or brushes that are caused to pass over the stationary terminals in the movement of the switch, each movable terminal being arranged to pass over a particular row of stationary terminals. While all of the movable terminals are connected with the trunk line, none of them is normally in condition to engage the terminals of the row over which it moves, but the selector or switch is provided with mechanism that acts under the control of the calling device to select a particular one—or group—of the movable terminals, and bring it into position to engage the stationary terminals of its associated row. The particular movable terminal selected depends upon the degree to which the movable terminals—which all move together—have been displaced from their normal or resting position when the selecting mechanism operates; so, inasmuch as the automatic switch controls the movement of the calling device so that they both move together, the operator, by setting the calling device, to produce, after a predetermined movement, a current change that actuates the selecting mechanism, is able to bring about the operation of the selecting mechanism of the automatic switch at any predetermined point in its movement, and is thus able to select and make active any desired one or group of the movable terminals. The movement of the automatic switch is stopped by the operation of mechanism associated with the switch and actuated by another current change controlled by the calling device; and, as the extent of movement of the selected movable terminal of the switch at the moment it is stopped determines the particular stationary terminal with which the movable terminal of the trunk switch completes connection, the operator, by setting the calling device to produce this other current change after a predetermined movement of the calling device, is able to stop the correspondingly moving automatic switch with its selected movable terminal in engagement with any desired one of the stationary terminals. When the called line is thus selected, either over a direct trunk only or over first an overflow and then a direct trunk, a testing relay is brought into action to prevent the trunk line from being extended to the selected line in case the latter is busy, and to transmit a busy signal to the other end

of the trunk. If the line is not busy, connection with it is completed and ringing current is applied by means of a circuit which is automatically disconnected when the called subscriber answers the call. The talking circuit of the trunk is at the same time completed at this end, and, as the devices at the other end of the trunk line have operated in the meanwhile to disconnect the calling device and complete the trunk circuit at that point, the calling subscriber and the called subscriber are now brought into communication. During the use of their telephone, both subscribers have control of the the usual supervisory signals before the operator. When they replace their telephones the operator disconnects, and the resultant change of current flow in the circuit causes the return of the automatic switch to its normal position.

In the system in which I have illustrated the switching apparatus of my invention as being employed, the reciprocal control over each other of the calling device and the automatic switch, the control of the called subscriber's supervisory signal, the transmission of the busy signal if the line is engaged, and the telephonic communication between the subscribers are all effected over the usual single pair of conductors. The control of the calling device over the automatic switch to cause it to perform its various operations of starting, selecting a particular movable terminal, selecting and connecting with a particular stationary terminal and returning to normal position is effected through the medium of switching apparatus at the automatic switch end of the trunk, which operates at each change of current flow produced by the calling device to shift the control of the calling device from one to the other of the various operating circuits and mechanisms of the automatic switch.

Detailed description of operation of system.—The apparatus and circuits not already described will sufficiently appear from consideration of the diagram, Figs. 3 to 8 inclusive, and the description of the mode of operation hereafter to be given. In the diagram, devices of known types are designated by the usual conventional symbols. Certain of the ordinary appliances required in an actual telephone system, such for example as the operator's telephone set, are not shown because their characteristics, electrical connections and manner of use are well understood by those skilled in the art, and to show them in detail would unnecessarily complicate the diagram. For convenience in tracing the circuits, separate batteries are shown at various points; but it will be understood that where batteries of the same polarity and potential are indicated at the same exchange, these would in practice be replaced by a central battery common to the exchange, which would be connected as indicated by the separate symbols shown on the diagram.

The organization and mode of operation of the system can best be understood by tracing the sucessive steps involved in extending the connection of a calling line through to the line called for, performing the requisite incidental operations, finally disconnecting the lines and restoring the circuits and apparatus to normal condition.

Let it be assumed that the subscriber at station 500 (Fig. 5) wishes to talk to the subscriber No. 3249 (Fig. 8). The calling subscriber signals the central office operator in the usual way by removing his telephone receiver from its hook, thereby causing the line circuit to be closed, exciting the line relay at the central office in the usual way, and causing the signal lamp 340 to be lighted. The operator responds to the call in the usual way by inserting her answering plug into the answering jack of the calling line, and then by depressing her listening key brings her telephone set (not shown) into circuit, and inquires the number of the subscriber wanted. While obtaining the number wanted she presses the keys of the number as received, which number, as assumed, is 3249. A case will be assumed in which all of the springjacks of the direct trunk corresponding to such number are in use, and in which the operator, therefore, inserts the calling plug in the jack on an overflow trunk, thereby closing a circuit which includes the relay C (Fig. 3), which relay, upon being energized, results in the starting of the sequence switch. This circuit is as follows: from battery, winding of relay C^2 (Fig. 6), wire 151, sleeve of the jack, sleeve of the plug, wire 152, winding of the relay C^3, contact 153 of said relay, wire 127, winding of relay C, wire 129, winding of polarized relay D, wire 130, left-hand contact of No. 9 units key, wire 74, right-hand contact of No. 3 thousands key, wire 131, and cam N to earth. Relay C^2 energizes and lights the trunk busy light. Relay C^3 does not energize, it being marginal. Relay D does not energize, it being polarized, and the current in this case being in the wrong direction. Relay C energizes and closes ground through cam K of the sequence switch in its first position, front contact 128 of the relay C, winding of the motor magnet 225 of the sequence switch to battery. The sequence switch then starts from normal, whereupon contact 226 is closed by special cam I between the first and fifth position, thereby closing the local circuit for the motor magnet 225, and the sequence switch advances to the fifth position without stopping.

With the sender sequence switch in the fifth position a circuit is closed for the step-

ping relay 218 and for the line relay C^4 as follows: from battery, winding of line relay C^4, contact 154 closed by cam *d* of the overflow sequence switch in the first position, wires 52, 54, tip of the overflow trunk jack, tip of the plug, wire 75, contact 155 of relay C^3, wire 76, cam V of the sender sequence switch in the fifth position, wire 71, winding of the stepping relay 218, wire 73, normally closed contact 246 of relay 219, wire 72, contact 156 of the relay C^3, wire 77, ring of the plug and jack, wire 57, contact 157 closed by cam *i* in the first position of the overflow sequence switch to earth. The stepping relay 218 energizes and closes a circuit from earth through cam J of the sender sequence switch in the fifth position, from contact 247 of relay 218, wire 78, back contact 249 of the relay 250, wire 34, winding of the sender stepping magnet 205 to battery. The magnet 205 thus energized, attracts its armature 215, thereby operating the escapement mechanism of the sender so that the arm 211 advances one-half of a step and the brushes 201 and 201^a are between the terminals. Upon the close of the circuit just traced, line relay C^4 also energizes and closing its front contact 158 closes the following circuit for the overflow sequence switch: from ground, through contact 158, wire 51, contact 159, closed by cam *a* in the first position of the overflow sequence switch, wires 50, 49, winding of the clutch magnet 160 of the sequence switch to battery. The overflow sequence switch is carried to the second position under the control of the special cam *g*. In the second position of said overflow sequence switch, the motor magnet 161 of the overflow selector is energized by the following circuit: from ground, through front contact 158 of line relay C^4, wire 51, contact 162 closed in the second position of cam *a*, wire 42, contact 163 closed in the second position of cam 1, wire 45, winding of the motor magnet 161 to battery. The brush frame of the overflow selector now starts to rotate and upon the machine cam 164 closing contact 165, the circuit is closed from earth, through contact 165, wire 39, contact 166 closed by cam *f* in the second position, wire 49, winding of clutch magnet 160 of the sequence switch to battery. The sequence switch is thereupon carried to the third position.

When the interrupter lever 167 of the overflow selector reaches the first tooth, it closes a circuit from earth, contact 168 closed by the cam *h*, back contact 169 of the level relay 170, wire 64, contact 339 closed by the interrupter lever 167, wire 171, back contact 172 of the trip relay 173, wire 62, contact 174 closed by the cam *c*, wire 53, to the tip of the trunk. This circuit shunts battery from the stepping relay 218, which thereupon deënergizes, thereby opening its front contact 247. This opens the circuit of the sender stepping magnet 205, which thereupon releases its armature 215 and the escapement controlled thereby. The arm 211 of the sender is thus advanced the other half of the step, and brings the brushes 201 and 201^a onto the pair of No. 0 terminals of the sender. When the interrupter lever 167 opens contact 339 upon leaving the first tooth, the shunt is removed from the stepping relay 218 which thereupon again energizes and closes the circuit of the magnet 205, thereupon allowing the sender arm 211 to take another half step. The contact 339 of the interrupter thus opens and closes in succession, energizing and deënergizing the stepping relay and thereby causing the sender arm 211 to advance by steps until the sender brushes find the earth terminal from the thousands key and battery terminal from the hundreds key. This according to the number assumed will be the No. 6 pair of terminals in the first division of the sender terminals.

Upon the brushes 201, 201^a reaching the selected sender terminals No. 6, the polarized stop relay 219 is energized by a circuit from earth, left-hand contact of No. 3 thousands key, wire 2, inside terminal 6 of the sender, contact brush 201, wire 31, winding of the relay 219, wire 30, outside brush 201^a of the sender arm, outside terminal 6, wire 6, right-hand contact of No. 2 hundreds key, to battery. Relay 219, thus energized, closes a locking circuit for itself as follows: from battery, through the left-hand winding wire 135 and front contact 245 of relay 219, wire 32, winding of relay 250, wire 33, and cam J, now in the fifth position, to earth. The resultant energization of the relay 250 closes a circuit for the clutch magnet 225 of the sender sequence switch as follows: from ground, through the cam O in its fifth position, front contact 175 of the relay 250, winding of the clutch magnet 225 to battery. The sender sequence switch is thereupon advanced from the fifth to the sixth position.

The relay 219 when energized, as described in the paragraph just preceding, opens the line circuit of the stepping relay 218. The relay 250 now closes a circuit which results in the advance of the sender arm to its second normal position s^2, which circuit is as follows:—from ground, sender interrupter 221, wire 37, contacts 223, 224, wire 35, wire 136, front contact 244 of relay 250, wire 34, winding of the sender stepping magnet 205 to battery. Thereupon the magnet 205, acting under the influence of the interrupter 221, operates the sender escapement and the sender arm 211 is advanced until the cam 222 is in position so that the interrupter spring falls into the notch corresponding to position s^2 of the sender brushes 201, 201^a.

The interrupter circuit is thereupon opened at contacts 223, 224, and the sender arm comes to rest with the contact brushes in their normal position s^2 just preceding the division of the sender terminals of the level selection of the direct trunk.

When the sender brushes 201, 201ª reach position s^2, the polarized relay 219 is reset, a circuit therefor being closed from ground, through outside terminal of position s^2, wire 30, right-hand winding of the relay 219, wire 31, brush 201, inside terminal of position s^2, to battery 243. The battery 243, it will be observed, is so grounded that the current flowing in this circuit is opposing the polarized relay 219, which is thus caused to reset to its normal condition. The relay 219 upon being thus reset opens its front contact 245, thus opening the circuit of the relay 250, which latter relay is thereupon deënergized and closes its back contact 192. This closes a circuit from ground through cam P, now in the sixth position, contact 192, clutch magnet 225 of the sequence switch to battery, and thereupon the sender sequence switch advances to the seventh position. The relay 219 upon being reset also closes its back contact 246 and thereby closes the circuit of the stepping relay 218. The sender is now in condition to receive pulsations of current for the level selection of the final switch.

When the energization of the polarized relay 219 opened the line circuit which included the stepping relay 218, as hereinbefore described, it caused the overflow selector to become a local device, so far as its own advancement was concerned. This selector was left with its motor magnet 161 energized and the brush frame revolving and transmitting pulsations of current for the level selection. The last closure of the contact 339 of interrupter caused, as described above, the sender arm to reach the selected sender terminals, thus energizing the stop relay 219, which thereupon opened the line circuit; but the line relay C^4 continued to be energized so long as the contact 339 of interrupter was closed. Upon the interrupter contact opening, the line relay C^4 is deënergized. The circuit of the motor magnet 161 continues to be closed even after the relay C^4 opens its front contact 158, the circuit for the motor magnet then being from earth, contact 165 of machine cam 164, wires 39, 44, winding of the brush frame trip magnet 173, wires 40, 41 and 42, contact 163, closed in the third position of cam *l*, wire 45, winding of the magnet 161, to battery. This circuit causes the trip magnet 173 to be energized, whereupon it opens its back contact 172 and prevents the closure of the contact 339 of the interrupter lever 167 from reënergizing relay C^4, which would otherwise shunt out the winding of the magnet 173 when the contact of the interrupter lever again closes. The trip magnet 173 thus energized also places the brush tripper 338 in the path of the brush frame which is moving, and a set of brushes 337 is tripped. The sleeve brush thereupon contacts with the grounded rod 336 and closes a circuit, in shunt of the trip magnet 173, from ground over wires 43, 41, 42, contact 163, now closed in the third position of cam *l*, wire 45, winding of the magnet 161 to battery. The motor magnet 161 is thus continued to be energized. The shunting of battery from the trip magnet 173 causes the trip magnet to become deenergized, thus resetting the brush tripper 338 and thereby preventing a second set of brushes from being tripped.

When the relay C^4 was deënergized as above set forth, it closed a circuit for the clutch magnet 160 of the overflow sequence switch as follows: from ground, through the back contact 177 of the relay C^4, contact 178 closed by the cam *b* in the third position, winding of the clutch magnet 160, to battery. This causes the overflow sequence switch to advance to the fourth position, which position is the one for hunting an idle trunk. It will be noted that the tip and ring selector brushes 337 are now open at the contacts 179 and 180, respectively, controlled by the cams *e* and *k*, and also that the battery circuit to the tip is open at contact 154 opened in the fourth position of the cam *d*.

The circuit last described for the motor magnet 161 gives battery to said magnet until the sleeve brush contacts with the first terminal, which if busy will have earth circuit, as will hereinafter be set forth, and this being substituted for the earth rod can be traced over the same path. Contact 339 of the interrupter closes before the sleeve brush leaves this first terminal and thereby substitutes the following circuit for the energization of the clutch magnet 161:—from earth, contact 168, closed by the cam *h* in the fourth position, back contact 169 of the level relay 170, wire 64, contact 339 of the lower interrupter lever 167, wire 171, contact 172, wire 62, contact 181, closed in the fourth position of cam *c*, contact 163, now closed by the cam *l*, wire 45, winding of the clutch magnet 161 to battery. The hunting continues until the sleeve brush finds the terminal of an idle trunk, that is one having no earth circuit. When this happens, the clutch magnet 161 will be deënergized and the rotation of the brush frame will stop. Upon the overflow switch thus selecting a direct trunk, the operator before whom such direct trunk terminates in a springjack is notified that the trunk is busy by the lighting of the lamp 286. As will presently be described, as soon as a direct trunk is selected, the sequence switch thereof moves out of the first position. Thereupon a circuit is closed from

ground through contact 262, controlled by the cam n', wires 83, 285, winding of relay C^6 to battery, causing the relay C^6 to become energized and to close the circuit of the lamp 286.

During the time that the clutch magnet 161 was energized, the relay 182 was energized in parallel, and in the fourth position of the selector sequence switch it keeps a shunt, (through the wire 60 and front contact 185 of the magnet 182 to ground) against the holding magnet 183, thereby preventing it from becoming energized, although said holding magnet 183 has a circuit from ground through contact 184, closed by the cam i in the fourth position, winding of magnet 183 to battery. The relay 182 becoming deënergized at the time the circuit of the motor magnet 161 is opened by finding an idle line, as just described, and opening its front contact 185 removes the shunt from the holding magnet 183, which magnet thereupon becomes energized and acts as a brake to prevent the brush frame from stepping off of the terminal found idle. The deënergization of relay 182 closes its back contact 186, thereby closing a circuit from ground over the wire 61, contact 187 closed by the cam j in its fourth position, wire 49, winding of the clutch magnet 160 of the sequence switch, to battery. The sequence switch is thus moved out of the fourth position. By reference to the numerals on the special cam g, it will be seen that the local circuit for the motor magnet 160 of the sequence switch remains closed at contact 335 of the cam g between the fourth and ninth positions, so that the sequence switch advances to the ninth or talking position. The sequence switch is held in the ninth position by reason of a shunt of the magnet 160 closed over wire 46, contact 163^a closed in the ninth position of cam l, wires 42, 41 and 43, sleeve brush 337, wire 83, contact 262 closed in the second and third positions of cam n' of the final sequence switch to ground.

With the sender sequence switch in the seventh position, the line circuit is closed as follows: from battery, line relay 193, (see Fig. 7), wire 87, repeating coil, wires 79, 81, overflow selector brush 337, wire 55, contact 179 closed in the ninth position of cam e, wire 54, tip of the overflow trunk jack and of the plug, wire 75, contact 155 of relay C^3, wire 76, springs and cam V of the sender sequence switch, wire 71, stepping relay 218, wire 73, back contact 246 of relay 219, wire 72, contact 156 of relay C^3, wire 77, ring of plug, overflow jack and trunk, wires 57, 56, contact 180 closed in the ninth position of cam k, overflow selector brush 337, wire 82, wire 80, repeating coil, wire 85, contact 194, closed in the first position of the cam j' of the sequence switch of the final selector, to earth. The stepping relay 218 is thus energized and closes a circuit for the magnet 205, as hereinbefore described, and causes the sender arm to advance one half of a step. The line relay 193 being energized, causes the sequence switch of the direct trunk selector to leave the first position and advance to the second position by reason of the closure of the following circuit: from ground, through front contact 195 of the line relay 193, wire 90, contact 196, closed by the cam a' in the first position, wire 109, winding of the sequence switch clutch magnet 197 to battery.

In the second position of the direct trunk sequence switch, the brush frame power magnet 200 has its circuit closed as follows: from ground, through front contact 195 of the line relay 193, wire 90, contact 198 closed by the cam a' in the second position, wire 113, winding of the magnet 200 to battery. The brush frame now starts to revolve, and upon the interrupter lever 199 reaching the first tooth and closing its contact 227, a circuit is closed as follows: from ground, through contact 228, now closed by the cam i' of the sequence switch, wire 119, interrupter lever 199, contact 227, wire 118, contact 229 of the brush frame trip magnet 230, wire 116, contact 231, closed in the second position of the cam d' of the sequence switch, winding of the line relay 193 to battery. This shunts the battery from the stepping relay 218, and causes it to be deënergized and thereby to open the circuit to the magnet 205. This magnet thereupon releases the sender escapement, and the brush arm takes another half step, which places its brushes 201, 201^a on the pair of sender terminals No. 0 of the second division. The selector interrupter closing and opening its contact 227 removes and places the shunt against the stepping relay 218, thereby operating the magnet 205 and advancing the sender arm 211 until sufficient pulsations have been transmitted to bring the sender brushes 201, 201^a in contact with the inner and outer sender terminals No. 4, representing, in the case assumed, the combination of the No. 2 hundreds key and the No. 4 tens key. Thereupon the following circuit will be established: from battery, left-hand contact of No. 2 hundreds key, wire 10, outside terminal No. 4 of the second division of sender terminals, brush 201^a, wire 30, winding of relay 219, wire 31, inside brush 201, inside terminal No. 4, wire 13, right-hand contact of No. 4 tens key, to earth. This causes the relay 219 to become energized and upon opening its back contact 246 it opens the line circuit above described. The energization of the relay 219 closes its front contact 245, thereby closing a locking circuit for itself through the relay 250.

Upon the opening of the line circuit and

upon the interrupter lever 199 of the final selector opening contact 227, the line relay 193 is deënergized and opens the last described circuit of the brush frame power magnet 200. This magnet is continued to be energized, however, by the following circuit: from ground, machine springs m^2 and m^3, wire 117, winding of the brush trip magnet 230, wire 115, winding of the magnet 200 to battery. The trip magnet 230 energized by this circuit places the trip lever 338^a in the path of the rotating brush frame and a set of brushes is tripped. The magnet 230 also opens at its back contact 229 the interrupter circuit, thereby preventing the line relay 193 from again being energized by the operation of the interrupter. The sleeve brush when tripped closes the following circuit: from ground, contact 228, then closed in the second position of cam i', wire 122, machine springs m^4 and m^5, wire 123, sleeve brush, insulated rod 335, wire 89, winding of the line relay 193 to battery. The line relay is thus energized and in closing its front contact 195 recloses the earth circuit to the power magnet 200. The closure of this circuit continues the energization of the magnet 200, and also shunts battery from the trip magnet 230. The consequent deënergization of magnet 230 prevents another set of selector brushes from being tripped. When the interrupter is closed on the long tooth, the earth circuit is closed to the tip side of the line, and during this time the earth circuit is opened from the sleeve brush at the machine springs m^4 and m^5. It will therefore be seen that the interrupter has substituted earth circuit for the one that the sleeve brush has been supplying.

The locking circuit of the said relay 219 includes, as above set forth, the winding of the relay 250, which relay becoming energized closes its front contact 175 and causes the sender sequence switch to advance from the seventh to the eighth position, the circuit of the clutch magnet 225 thereof being closed in the seventh position of cam O. The energization of the relay 250 also closes the circuit for the sender stepping magnet 205 through the interrupter contacts 223, 224, thus causing the sender brushes to advance to the position s^3, where the said contacts 223, 224 will be open, and the brushes will be in contact with the sender terminals of position s^3. The inner terminal of position s^3 has the same battery connection as the inside terminal of position s^2 and hence the relay 219 is reset to its normal condition as heretofore described with respect to position s^2. Thereupon the relay 250 is deenergized and upon closing its back contact 192, a circuit closed for the clutch magnet 225 through the cam P, in the eighth position, contact 192, winding of magnet 225, to battery. This causes the sequence switch to advance from the eighth to the ninth position, which latter position is the one for receiving the line range pulsations. The relay 219 upon taking its normal position reclosed the line circuit.

Upon the interrupter lever 199 of the final selector passing from the long tooth and thereby opening contact 227, it removes the shunt it has had against the stepping relay 218 and the said relay is energized. Upon the interrupter rising on the next tooth, it again places the short circuit against the stepping relay, which is thereupon deënergized. This action of the stepping relay is repeated under the influence of the interrupter lever 199 and the stepping relay opens and closes the circuit of the magnet 205 as hereinbefore described, and thereby causes the sender brush arm 211 to advance until a sufficient number of pulsations of current have been received to advance the brush arm to the position where its brushes contact with the sender terminals No. 49, in the case assumed, whereupon the following circuit will be established: from ground, left-hand contact of the No. 4 tens key, wire 15, inside sender terminal No. 49, inside brush 201, wire 31, winding of relay 219, wire 30, brush 201^a, outside terminal No. 49, wire 29, right-hand contact of No. 9 units key to battery. This energizes the relay 219 and it opens the line circuit and again closes its own locking circuit through the relay 250. The energization of relay 250 closes a circuit from ground, through cam O, in the ninth position, front contact 175 of relay 250, winding of magnet 225 to battery. This starts the sequence switch and it advances from position 9 to position 1, under control of the special cam I, which closes the contact 226 between the ninth and first positions of the sender sequence switch.

While the sender sequence switch is passing the twelfth position, it shunts the relays C and D, a circuit to earth from the wire 132 being closed through the cam M of the sequence switch in the twelfth position. This elimination of the resistance of the relays C and D causes the relay C^3 of the cord to become energized, which thereupon closes a locking circuit for itself from ground through the supervisory lamp 270, contacts 234 of relay C^3, to the winding of said relay C^3. The relay C^3 when energized opens, at its back contacts 155 and 156, the tip and ring of the trunk from the sender and closes said tip and ring to the repeating coil. This end of the circuit is now in talking position.

The sender starts to reset to its normal position under the influence of the sender interrupter 221 when the relay 250 is energized as hereinbefore described, but as the relay 250 is deënergized when the sequence switch leaves the eleventh position, another

circuit is provided for resetting the sender, such circuit being from ground, through the interrupter 221, wire 37, contact 223, wire 36, back contact 235 of relay C, wire 34, winding of the magnet 205 to battery. The opening of the interrupter contact 223, when sender brushes reach position s', stops the brush arm at its normal position.

Returning now to the operation of the final selector, it will be noted that the terminals of the first and intermediate private branch exchange lines have negative battery and that the terminals of the final private branch exchange line and the one-party line have positive battery. The voltage on these terminals is high provided the corresponding line is not busy, but is low in the case of a busy line. The energization of the polarized test relay 253 indicates a private branch exchange line. The test relay 257 is marginal and is energized only when the line selected is not busy, the voltage on the selected terminal being otherwise not sufficiently high to energize said relay.

When the stop relay 219 opened the line circuit as above described and when the interrupter lever 199 of the final selector opened its contact 227, the line relay 193 was deënergized and, upon the line relay opening its front contact 195, the circuit of the motor magnet 200 is thereby opened. In case the terminals upon which the selector brushes rest happen to be those of an idle line, the motor magnet 200 will become deenergized and the selector brushes will remain on the line selected. If, however, the line happens to be a busy one-party line, circuits are successively closed which will advance the sequence switch of the final selector to the eighth or busy position. This operation will now be described. The deenergization of line relay 193 closes its back contact 236 and a circuit is closed for the magnet 197 as follows: from ground, through back contact 236, wire 91, machine springs m^7, m^8, wire 121, contact 237, closed in the second position of cam b', wire 109, winding of magnet 197 to battery. The sequence switch is then advanced to the third position, in which position a circuit is closed for the magnet 197 as follows: from ground, back contact 258 of test relay 257, wire 263, back contact 282 of relay 253, wire 92, contact 264 closed from the third to the seventh positions of cam l', wire 110, winding of magnet 197 to battery. The sequence switch is thus advanced, under the control of cam l', to the eighth or busy-back position, whereupon a busy signal will be given to the operator as will presently be described.

Let it be assumed next that the line called for happens to be a private branch exchange line. The polarized test relay 253 will be energized by a circuit from negative battery 254, winding of the cutoff relay 255, wire 256 of the sleeve terminal, sleeve brush, wire 101, both windings of the test relay 257, wire 102, right-hand winding of the polarized test relay 253, wires 124 and 119, contact 228 closed in the second position of the cam i', to ground. The relay 253, thus energized, closes a locking circuit for itself from battery through left-hand winding of relay 253, front contact 260 of said relay, wire 84, contacts 261 and 262, closed in the second position of the cam n', to ground.

Since the sleeve brush contacts with the selected terminal before the interrupter lever 199 for the line range opens the circuit of the line relay 193 and allows the latter, at its front contact 195, to open the circuit to the motor magnet 200, and since the voltage on the sleeve terminal over the above described circuit is too low, in case the private branch exchange line which the brushes test is busy, to energize the marginal test relay 257, then a circuit will be continued for the motor magnet 200 as follows: from ground, back contact 258 of the test relay 257, wire 263, front contact 259 of the relay 253, wire 114, winding of the magnet 200 to battery. With the test relay 257 thus deënergized and the test relay 253 energized, the brush frame continues to revolve. The deënergization of the line relay 193 and the resulting closure of its back contact 236 closes a circuit for the sequence switch clutch magnet 197, as hereinbefore described. The sequence switch of the final selector is thereby advanced to the third position.

It will be assumed first that the final selector brushes find the entire group of private branch exchange lines busy. In this case the brush frame will stop rotating with the brushes on the last terminal in the private branch exchange group, and the polarized relay 253 will become deënergized thereby opening the circuit of the power magnet 200 by reason of the reversed polarity of current now supplied to the brushes and also causing the relay 257 to remain deënergized due to the low voltage of this last busy terminal. With the relays in the condition just stated the following circuit can be traced: from ground through back contact 258 of the relay 257, wire 263, back contact 282 of the relay 253, wire 92, contact 264 closed by the cam l' in the third position, wire 110, winding of the magnet 197 to battery. This circuit remains closed at the contact 264, controlled by the cam l', until the sequence switch has advanced to the eighth position.

While the sequence switch is passing the sixth or ringing position and the seventh or talking position, the tip and ring of the line will be opened at the back contacts 265

would be used instead of the lower one. Assume that the subscriber wanted is number 8249. In this case the overflow level is the same as in the case of number 3249, and the final level is the same but is in a different group, since the call is above instead of below 5000. The operator pressing No. 8 thousands key causes the relay C^1 (see top of Fig. 3) to be energized by circuit which may be traced as follows: from the grounded cam N of the sequence switch, winding of relay C^1, wire 68, right-hand contact of No. 8 thousands key, wire 74, windings of key magnets K, K^1, etc., to battery. After the operator has pressed all the keys representing the number of the called subscriber, she will insert the trunk plug into an overflow jack. Thereupon, as before described in connection with the call for subscriber No. 3249, a circuit is closed which causes the relay C to be energized. This relay when energized causes the sequence switch to advance to the fifth position. In the first instance assumed, it was found that the line circuit was not closed until the sequence switch reached the fifth position under the control of the special cam I, as heretofore described. In the case now assumed when the sequence switch is passing the second and third position the line circuit is closed as follows: from battery, winding of line relay C^4, contact 154, closed in the first position of the cam *d*, wires 52, 54, tip of the trunk, jack and plug, wire 75, contact 155, wires 76 and 70, front contact 187 of relay C^1, wire 69, cam W of the sequence switch (in the second and third positions of the sequence switch), wire 73, back contact 246 of the relay 219, wire 72, back contact 156 of relay C^3, wire 77, ring of plug, jack and trunk, wire 57, contact 157, closed in the first position of the cam *i* of the overflow sequence switch, to earth. This energizes the line relay C^4 which thereupon closes its front contact 158 and closes a circuit for the magnet 160 of the sequence switch as follows: from ground, through contact 158, wire 51, contact 159, closed in the first position of cam *a*, wires 50 and 49, winding of magnet 160 to battery. Thereupon the sequence switch of the overflow selector moves from the first to the second position. The line circuit by this time is open at the cam W of the sender sequence switch, and this causes the relay C^4 to be deënergized thereby closing its back contact 177. This closes the circuit from earth through contact 177, contact 188, closed in the second position of cam *b*, winding of the level relay 170 to battery. The level relay when energized closes a locking circuit for itself as follows: from ground through contact 168 closed in the second position of the cam *h*, left-hand front contact 189 of relay 170, winding of said relay to battery. It will be noted that the condition of the right-hand contacts 169 and 190 of the level relay 170 determines which of the two interrupters is active, the top interrupter lever 167^a getting earth circuit from the front contact 190 and the lower interrupter lever 167 getting earth circuit from the rear contact 169 of the relay.

Since the level relay 170 is energized before the brush frame starts to rotate, and hence opens the circuit of the interrupter lever 167, at the back contact 169 of the level relay, before it can transmit impulses for the level selection, means are provided for elsewhere closing a circuit for the interrupter lever 167, such means being the cam *m* of the overflow sequence switch, which cam in its second and third position closes contact 287, thus providing a circuit for the lower interrupter 167 through contact 287, over the wire 66 and through front contact 190 of the level relay in lieu of through the back contact 169 of said level relay.

The sender sequence switch can now be assumed to have reached the fifth position, and to have closed the line circuit as hereinbefore described. This causes the relay C^4 to again be energized, which closing its front contact 158 causes the motor magnet 161 to be energized by the following circuit: from ground, through front contact 158 of relay C^4, wire 51, contact 162, closed in the second position of cam *a*, wire 42, contact 163, closed in the second position of cam *l*, wire 45, winding of magnet 161, to battery. Thereupon the brush frame starts to revolve. From this point the operation is the same as that hereinbefore described except that the upper interrupter lever 167^a is used for transmitting the impulses for trunk hunting instead of the lower lever 167, which will of course cause the switch to pick up the final selector in a different group. The final selector thus chosen will be moved in the seventh or talking position as hereinbefore described.

It will now be assumed that the operator after pressing the keys representing the number 3249, plugged into the jack of a direct trunk instead of into the jack of an overflow trunk. This establishes the following circuit: from battery, through winding of relay C^6, (see Fig. 7), wire 126, sleeve of jack and plug, wire 152, winding and contact 153 of relay C^3, wires 127, 132, winding of relay C, wire 129, winding of the polarized relay D, wire 130, left-hand contact of No. 9 units key, wire 74, right-hand contact of No. 3 thousands key, wire 131, cam N of the sequence switch, to ground. Relay C^6 energizes and lights the busy lamp. Relay C^3 of the cord circuit being marginal is not energized. Relay C is energized and causes the sequence switch of the sender to move from the

and 266 respectively of the relay 257 in order to prevent any noise on the busy line on the terminals of which the selector brushes are now resting.

In the eighth position of the sequence switch thus reached, either in case the line called for is either a busy one-party line or a busy private branch exchange line, a busy signal is given to the operator by an interrupted circuit from ground through the busy-back interrupter 267, contact 268 closed in the eighth position of the cam j', wire 85, the ring side of the line and cord through the winding of the supervisory relay 269 of the cord to battery. This interrupted circuit causes the supervisory relay 269 to alternately light and extinguish the supervisory lamp 270 before the operator, thus indicating that the line called for is busy. On the other hand if the selector brushes advance to the terminal of the subscriber wanted and if said terminal is not busy, a high voltage therefor existing on that terminal, the test relay 257 becomes energized and the test relay 253 will not perform any functions even though the selected terminal should be that of a private branch exchange line.

Assume now either that the selector brushes are hunting in a private branch exchange group and find a high voltage on a sleeve terminal, or secondly that the line wanted is a one-party line and that the sleeve terminal thereof has a high voltage, due in both cases to the line called for being idle. The marginal test relay 257 will in either case be energized and will open at its back contact 258 the circuit of the motor magnet 200, thereby causing the brushes to stop on the terminals of the selected idle line. However, in the case of private branch exchange hunting, during the time the roller is on top of a tooth of the segment over which it travels it closes a momentary circuit for the motor magnet 200 as follows: from ground through contact 228, closed by cam i', wire 119, contact 227, closed by interrupter lever 199, wire 118, back contact 229 of relay 230, wire 116, contact 231^a, closed by the cam d' in the third or private branch exchange hunting position of the sequence switch, wire 113, winding of magnet 200 to battery. The brush frame, therefore, continues in the case of private branch exchange hunting, to rotate until the lever rides off the tooth, and such momentary closure of the circuit of the motor 200 causes the selector brushes to properly center on the selected idle terminals. The energization of the test relay 257 will also cause the sequence switch to leave the third and advance to the sixth or ringing position by the closing of the following circuit: from ground through front contact 271 of the relay 257, wires 104, 105, contact 272, closed in the third position of the cam c', wires 107, 110, winding of magnet 197 to battery. This circuit for the magnet 197 remains closed at contact 272, controlled by the cam c', until the sequence switch reaches the sixth or ringing position. A ringing generator 273 is thereupon closed to the tip side of the line at contact 274 closed by the cam g' in the sixth position, and to the ring side of the line at contact 275 closed by the cam f' in the sixth position.

Upon the sequence switch reaching the sixth position a circuit is closed from ground through the front contact 271 of the test relay 257, wire 104, contact 276 closed by the cam h' in the sixth position, wire 103, lower winding of relay 257, wire 101 to the sleeve brush. This being a low resistance path reduces the voltage on the sleeve terminal of this line and hence makes it busy against other selectors, while at the same time allowing sufficient current to pass through the marginal test relay 257 to maintain it energized and also to maintain the cut-off relay individual to the seized line energized so that when the called subscriber removes his receiver from the hook in answering, the line lamp individual to his line cannot be operated.

The act of the called subscriber removing the telephone from the hook causes the supervisory relay 277 to be energized, and on said relay closing its front contact a circuit is closed from ground over the wire 93, contact 278 closed by the cam e' in the sixth position, wire 106, contact 279, closed by the cam c' in the sixth position, wires 107 and 110, winding of magnet 197 to battery. This causes the sequence switch to advance from the sixth to the seventh position. In this latter position earth circuit is closed through the repeating coil, wire 95, contact 279, closed by the cam g' in the seventh position, to the tip side of the line; and battery is closed to the ring side of the line through the repeating coil, wire 94, contact 280, closed by the cam f' in the seventh position.

The seventh position of the sequence switch is the talking position, and a circuit is closed from ground through the front contact of the supervisory relay 277, wire 93, contact 281 closed by the cam e' in the seventh position, wires 86, 85 over the ring side of the trunk and from thence through the supervisory relay 269 of the cord to battery. This circuit energizes supervisory relay 269 and causes it to shunt out the supervisory light 270. During the use of their telephones, both subscribers have control over the supervisory signal before the operator.

A case will now be assumed in which the upper interrupter of the overflow switch

first to the fifth position, as hereinbefore described, in the case first assumed. The polarized relay D energizes, since the polarity of the battery is in the proper direction, and closes a circuit for stop relay 219 as follows: from ground, through cam S of the sender sequence switch (while passing the second and third positions), wire 133, front contact 191 of relay D, wire 134, wire 135, left-hand winding of relay 219 to battery. The relay 219 thus energized closes a locking circuit for itself, including the winding of relay 250, as follows: from ground, through cam J of the sequence switch, wire 33, winding of relay 250, wire 32, front contact 245 of the relay 219, wire 135, winding of relay 219 to battery. The resultant energization of the relay 250, which is included in the locking circuit just described, closes a circuit for the clutch magnet 225 of the sequence switch, as follows: from ground, through cam O in the fifth position, front contact 175 of relay 250, winding of magnet 225 to battery. The sequence switch is thus advanced to the sixth position. The energization of relay 250 also causes a circuit to be closed for the sender stepping magnet 205 as follows: from ground, through cam R while passing positions 3 and 4 of the sequence switch, wire 136, front contact 244 of relay 250, wire 34, winding of magnet 205 to battery. Magnet 205 acts on the escapement and causes the sender brush to advance one half a step. Magnet 205 is deënergized when the cam R opens after the sequence switch has passed the fourth position, and the sender arm takes another half step. This closes the interrupter contacts 223, 224 of the sender, and the following circuit is thereupon closed for the magnet 205: from ground through the interrupter 221, wire 37, interrupter contacts 223, 224, wire 35, wire 136, front contact 244 of relay 250, wire 34, winding of magnet 205 to battery. The magnet 205 acting under the influence of the interrupter 221, operates the sender escapement and the sender arm is advanced until the brushes 201 and 201ª contact with the sender terminals of positions s^2 of the sender brushes. The cam 222 of the sender has now advanced so that the interrupter springs fall into the notch of said cam corresponding to said position s^2, and the circuit of the magnet 205 is opened at the interrupter contacts 223, 224. The sender terminals of position s^2, preceding the direct trunk level selection, have battery and earth, respectively, on them, and hence a circuit is closed from ground, through brush 201ª, wire 30, winding of relay 219, wire 31, brush 201 to battery. This current flow is in a direction to oppose the polarized relay 219 and hence said relay is reset to normal.

Upon the relay 219 resetting to normal, it opens its front contact 245. The relay 250 is thereupon deënergized, thereby closing its back contact 192 and closing the following circuit: from ground, cam P of the sequence switch in the sixth position, back contact 192 of relay 250, winding of the clutch magnet 225 of the sequence switch, to battery. The sequence switch thereupon advances from the sixth to the seventh position, which is the position for receiving pulsations from the final selector for the level selection, and which is also the position the sender sequence switch was left in at the end of the overflow selections hereinbefore described.

It will be noted that the line circuit is controlled at the back contact 246 of the relay 219, and hence while said relay was energized the line circuit was open. It follows, therefore, that the operations up to this point have not affected the final selector or its sequence switch. In short, the sender brushes have merely been advanced to position s^2, which is the position immediately preceding the level selection of the final selector, and the sender sequence switch has been advanced to the seventh position which, as stated, is the position for receiving pulsations from the final selection for the level selection. From this point the operation is the same as that hereinbefore described.

Restoration of apparatus to normal.—It may happen that after an operator has plugged into a trunk jack to transmit a call, and at any time before the connection has been finally established, the calling plug may be withdrawn; or there may be a temporary break in some of the main circuits, from one cause or another. One of the features of this system is that in case the normal orderly progress of establishing a connection is thus interfered with, the apparatus and circuits of the system will in general be automatically restored to normal under the control of circuits which are purely local.

Each automatic selector cooperates with its sequence switch or controlling device to govern the local operating circuits of these devices in such a manner that when the rotary element of either device is off normal, due to the partially completed operation, circuits are progressively established for the motor magnets of said devices to return them both to normal each device at different stages in its movement closing circuits for the motor magnet of the other, until both have returned. In the regular operation of the system this progressive travel of the two devices which would finally result in returning them both to normal, is only checked, so to speak, at certain stages of the operation by controlling apparatus which is

dependent upon a flow of current in one of the principal circuits, extending, for example, to a distant point. If such flow of current is permanently interfered with, either accidentally or otherwise, when the selector or sequence switch is off normal, the progressive operation of the two devices can no longer be checked, and they proceed automatically with the requisite series of operations which result in both being returned to normal condition. A similar provision is made respecting the sending apparatus and its sequence switch.

The possibility of the restoration of the apparatus of the entire system to normal is essential when the final sequence switch is in the sixth or ringing position, the seventh or talking position, or the eighth or busy-back position, and hence the restoration of the apparatus upon the withdrawal of the calling plug by the operator when the called party fails to answer or when the operator receives the usual disconnect signal or when she gets the busy signal will first be considered. This restoration is accomplished upon the operator removing the trunk plug, whereby earth circuit is disconnected from the tip side of the trunk. This causes the line relay 193 in the direct trunk to be deenergized and to close earth circuit at its back contact 236 over wire 91, through machine springs m^7, m^6, wire 121, contact 237, closed by the cam b', in the sixth, seventh and eighth positions, wire 109, winding of motor magnet 197 to battery. This causes the final sequence switch to move under the control of the cam b' from the sixth, seventh or eighth position, as the case may be, and stop in the ninth position. In this latter position the tip and ring brushes are on open circuit under the control of the cams g' and f' respectively, thereby preventing any possibility of clicks to lines that may be busy, over the terminals of which the switch may travel in its return to normal.

In the ninth position of the final sequence switch, earth circuit is closed through contact 283, closed in the ninth position of the cam i', over the wire 115, through winding of power magnet 200 to battery. This causes the brush frame to rotate reversely to its normal position, and upon reaching that position earth circuit is closed at machine springs m^1 and m^2 (springs m^1 and m^2 are closed only in the normal position of the machine cam 840) over wire 120, through contact 284, closed in the ninth position of the cam b', wire 109, winding of clutch magnet 197 to battery. This causes the sequence switch to leave the ninth position whereupon contact 333 is closed by the special cam k' and is held closed until the sequence switch returns to normal. Upon the sequence switch leaving the ninth position, earth circuit to the motor magnet 200 is opened at contact 283, under the control of the cam i'. The brush frame therefore ceases to rotate upon its reaching, as just described, the normal position. The various mechanisms associated with the final selector have thus been returned to their normal positions.

The sequence of operations whereby the various mechanisms associated with the overflow trunk are returned to their normal positions will now be considered. Upon the sequence switch of the final selector leaving the eighth position, the following circuit is opened at contact 262, controlled by the cam n' of said sequence switch: from ground, contact 262, wire 83, the sleeve terminal 337 of the overflow switch, wires 43, 41, 42, contact 163^a, closed in the ninth position of the cam l, wire 46 to battery. This circuit has heretofore been closed and has been acting as a shunt to the clutch magnet 160 of the overflow sequence switch, thereby holding the overflow switch in the ninth position as hereinbefore described. This removal of the shunt to the motor magnet 160 by the above described opening of the contact 262 causes the sequence switch of the overflow selector to advance from the ninth to the tenth position and in this position the line relay C^4 is connected to the tip side of the trunk through contact 154, closed in the tenth position of the cam d. The trunk, however, being open at this time, the operator having disconnected, the line relay C^4 will not become energized and hence will continue the circuit for the clutch magnet 160 from ground through back contact 177 of relay C^4, contact 178, closed by the cam b in the tenth position, wire 49, winding of the clutch magnet 160 to battery. The sequence switch will thereupon advance from the tenth to the eleventh position, as determined by the cam b.

In the eleventh position a circuit is closed for the brush frame motor magnet 161 as follows: from ground through contact 284, closed by the cam h in the eleventh position, wire 45, winding of magnet 161 to battery. This causes the brush frame of the overflow selector to rotate reversely to normal, and when it has rotated to a position where the machine cam 164 closes its contact 165 a circuit for the clutch magnet 160 is closed as follows: from ground through contact 165, wire 39, contact 166, closed in the eleventh position of the cam f, wire 49, winding of the magnet 160 to battery. This causes the overflow sequence switch to advance to the twelfth position. The circuit for the brush frame magnet 161, however, is not interfered with. Upon the overflow selector reaching normal, a circuit is closed from earth through the contact 165^a, closed by the machine cam 164, contact 166^a, closed by the cam f in the twelfth position, wire 49, wind-

ing of magnet 160 to battery. This causes the overflow sequence switch to advance to normal, and upon its leaving the twelfth position the circuit of the brush frame magnet 161 is opened at contact 284 controlled by the cam *h*. The restoration of the sender and of the sequence switch associated therewith has heretofore been set forth in connection with the description of the operation of the system. All the apparatus of the system is now in the normal condition.

Other conditions under which the apparatus will be restored to normal by the withdrawal of the calling plug will now be set forth. As hereinbefore described, upon plugging into either the jack of a direct or of an overflow switch the sender sequence switch is thereupon advanced to the fifth position and the sender arm will step from normal. If the answering plug be then withdrawn, a circuit is closed for the stepping magnet 205 as follows: from ground, through interrupter 221, wire 37, contact 223, wire 36, back contact 235 of relay C (deënergized by reason of the withdrawal of the answering plug), wire 34, winding of magnet 205 to battery. The sender brushes are thus advanced to normal and as they pass over the pair of sender terminals selected, relays 219 and 250 are energized as hereinbefore described. The sender sequence switch is thereupon advanced from the fifth to the sixth position under the control of the cam O. When the sender brushes step off of the selected terminals, thus deënergizing relay 250, the sender sequence switch is advanced to the seventh position under the control of cam P, and from the latter position is advanced to normal under the joint control of cam L and special cam I. Thus it is apparent that whatever may be the position of the sender and its sequence switch, the apparatus thereof is restored to normal upon the withdrawal of the answering plug.

If the answering plug is withdrawn while the overflow sequence switch is in the third position, a circuit for the motor magnet 160 is closed from ground through back contact 177 of relay C', contact 178 closed in the third position of cam *b*, winding of magnet 160 to battery, and the sequence switch is advanced to the fourth or hunting position. In the fourth position of the sequence switch an earth circuit is closed for the motor magnet through contact controlled by cam *h* as hereinbefore described. The hunting continues until an idle trunk is found, and thereupon the restoration to normal of the apparatus associated with the overflow switch is the same as that hereinbefore described. If the answering plug is withdrawn while the sequence switch of the final selector is in the second position it does not interfere with the operations hereinbefore described and both the final switch and sequence switch are advanced, restoration taking place, in the manner hereinbefore described, when the sequence switch reaches the sixth position.

I claim:

1. In a telephone system, the combination with telephone lines of a number of inter-office trunks terminating at a common office in selectors individual to the same group of said lines and terminating at the other end in far apart individual terminals, of overflow trunks each having a terminal adjacent to the individual terminal of one of said inter-office trunks and terminating at the other end in an overflow selector having terminals multipled to another of said inter-office trunks.

2. In a telephone system, the combination with telephone lines, of a number of trunks terminating at a common office in selectors individual to the same group of lines and at the other end at separate exchanges, of an overflow trunk having a terminal at one of said latter exchanges and terminating at its other end in an overflow selector having a terminal multipled to one of said trunks terminating at another of said separate exchanges.

3. In a telephone exchange system, the combination with telephone lines, of a group of trunks terminating in an office in selectors individual to the same group of lines, and each trunk of the group also terminating at another office, of overflow trunks having terminals at still another office, said overflow trunks also terminating in an overflow selector having terminals multipled to said first mentioned group of trunks.

4. In a telephone exchange system, the combination with a plurality of groups of trunks terminating at a common office in selectors individual to the same group of lines, each group of trunks terminating at the other end in an individual office, of overflow trunks each having a terminal at one of said individual offices and terminating at its other end in an overflow selector having terminals multipled to one of said groups of trunks terminating at another of said individual offices.

5. In a telephone exchange system, the combination with a plurality of groups of direct trunks terminating at a common office in selectors individual to the same group of lines, each group of trunks terminating at the other end in springjacks at an individual office, of overflow trunks each having springjacks at one of said individual offices and terminating at its other end in an overflow selector having terminals multipled to one of said groups of trunks terminating at another of said individual offices, an operator's connecting circuit, an operator's sender apparatus, and automatic means actuated in extending said connecting circuit, over either

a direct trunk or over an overflow trunk, to bring said sender apparatus into operative relation to the selector at the terminal of the trunk.

6. In a telephone exchange system, the combination with subscribers' lines, terminating at an office, of a plurality of groups of direct trunks extending from said office and terminating at a common distant office in selectors individual to the same group of lines, an overflow selector upon which the trunks of the groups have terminals, an overflow trunk extending from said overflow selector to still another distant office, operators' connecting circuits at said first mentioned office and at the office to which the trunks from said overflow selector extend adapted to extend the circuit of a calling line to said final selector or to said overflow selector, respectively, an operator's sender apparatus associated with each of said connecting circuits and adapted to control the selector at the end of the trunk, automatic switching mechanisms adapted to bring said selectors into operative relation to the sending apparatus, and an operating circuit for said automatic switching mechanism controlled by said connection switch.

7. In a telephone exchange system, the combination with a trunk line and substation lines, of an operator's connecting circuit by which the trunk line may be joined to a substation line, a selector associated with said trunk line and adapted to connect said trunk line with other lines, said last mentioned lines having terminals on the selector, the terminals of each level being arranged in two distinct groups, each group representing subscribers' lines having the same number but different from the number represented by the other group, electrically controlled sending apparatus adapted to be set to control the operation of said selector, two contact devices associated with the selector and adapted to control the movement of the sending apparatus and also to control the selection of the particular group of lines of a given level corresponding to the setting of the sending apparatus, and means made operative upon the setting of said sending apparatus and completing connection with the trunk line to cause the operation of said selector.

8. In a telephone exchange system, the combination with a trunk line and subscribers' lines, of an operator's connecting circuit by which the trunk line may be joined to a substation line, a selector associated with said trunk line and adapted to connect the same with other trunks, said latter trunks having terminals on the selector, the terminals of each level being connected to two groups, each group terminating in selectors individual to the same group of subscribers' lines but different from the subscribers' lines individual to the selectors of the other group, electrically controlled sending apparatus adapted to be set to control the operation of said selectors, two contact devices associated with the first mentioned selector adapted to control the movement of the sending device and also to confine the hunting of said first mentioned selector over the particular group of lines of a given level corresponding to the setting of the sending apparatus, and means, made operative upon setting said sending apparatus and completing connection with the trunk line, adapted to cause the operation of said selectors.

9. In a telephone exchange system, the combination with a trunk line and subscribers' lines, of an operator's connecting circuit by which the trunk line may be joined to a substation line, a selector associated with said trunk line and adapted to connect the same with other trunks, said latter trunks having terminals on the selector, the terminals of each level being connected to two groups, each group terminating in selectors individual to the same group of subscribers' lines but different from the subscribers' lines individual to the selectors of the other group, electrically controlled sending apparatus adapted to be set to control the operation of said selectors, two contact devices associated with the first mentioned selector adapted to control the movement of the sending device and also to confine the hunting of said first mentioned selector over the particular group of lines of a given level corresponding to the setting of the sending apparatus, a level relay adapted to render one or the other of said contact devices operative, and means adapted upon setting said sending apparatus and completing connection with the trunk line to control said level relay and to cause the operation of said selectors.

10. In a telephone exchange system, the combination with a plurality of groups of inter-office trunks, each group extending from a different office to a common distant office and there terminating in selectors individual to the same group of lines, of overflow trunks extending from each of said first mentioned different offices to overflow selectors each having terminals multipled to one of said groups of inter-office trunks, and means whereby, upon a connection being extended to an inter-office trunk over either an overflow trunk or over the terminals at the office from which such office trunk extends, said inter-office trunk is made busy against other connections.

11. In a telephone exchange system, the combination with a plurality of groups of direct trunks terminating at a common

office in selectors individual to the same group of lines, each group of trunks terminating at the other end in springjacks at an individual office, of overflow trunks each having springjacks at one of said individual offices and terminating at its other end in an overflow selector having terminals multipled to one of said groups of trunks terminating at another of said individual offices, an operator's connecting circuit, an operator's sender apparatus having three divisions of terminals, the first adapted to control the level selection and hunting of an overflow selector, the second adapted to control the level selection of a final selector, and the third adapted to control the line range selection of the final switch, and automatic means actuated in extending said connecting circuit over an overflow switch to bring said sender apparatus into operative relation successively with an overflow selector and a final selector and actuated in extending a connection direct to a direct trunk to cause said sender apparatus to pass over its first division of terminals without affecting the direct trunk selector and then to bring said sender apparatus into operative relation to said final selector.

12. In a telephone exchange system, an automatic line selector, an automatic trunk selector, manual switches at an operator's position, a trunk line connected to said line selector terminating at one of said manual switches and in said trunk selector, and a trunk line from said trunk selector terminating in another of said manual switches.

13. In an automatic telephone system in combination a calling subscriber's line, an operator's cord circuit, trunk lines and a called subscriber's line, said called subscriber's line being connected in multiple to the contact banks of a plurality of line selectors, said line selectors being connected in multiple to jacks terminating at an operator's position and to trunk selectors which are connected to jacks at an operator's position.

14. In a telephone exchange system, groups of incoming lines, groups of trunks, one for each group of lines, an overflow circuit associated with the first one of said groups of trunks and extending to a second of said groups of trunks, means for connecting the lines of a group to the trunks of the first group or to said overflow circuit, and means actuated upon the connection of a line to said overflow circuit whereby said circuit will be united to an idle trunk of said second group.

15. In a telephone exchange system, groups of incoming lines, groups of trunks, one for each group of lines, an overflow circuit associated with one of said groups of trunks, means for connecting a line to said trunks or to said overflow circuit, an overflow selector at which said overflow circuit terminates, contact terminals of another of said groups of trunks at said overflow selector, and means whereby said overflow selector will automatically select an idle trunk of said second group upon the connection of a line to said overflow circuit.

16. In a telephone exchange system, groups of incoming lines, groups of trunks, one for each group of lines, an overflow circuit associated with each of said groups of trunks and extending to another of said groups of trunks, means for connecting a line to a trunk or to an overflow circuit, and means actuated upon the connection of a line to an overflow circuit associated with one group of trunks whereby said line will be automatically united to a trunk of another of said groups.

17. In a telephone exchange system, two groups of incoming lines, groups of trunks, one for each of said groups of lines, an overflow circuit associated with each of said groups of trunks and extending to the other of said groups of trunks, means for uniting a line to a trunk or to an overflow circuit, and means actuated upon uniting a line to an overflow circuit associated with one group of trunks for automatically connecting said line through said overflow circuit to an idle trunk of the other group.

18. In a telephone system, two groups of incoming lines, groups of trunks, one for each group of lines, overflow selectors, an overflow circuit associated with each group of trunks and terminating in an overflow selector, terminals of the other group of trunks at said selector, and means whereby an overflow selector will be actuated to select an idle trunk upon uniting a line thereto.

In witness whereof, I hereunto subscribe my name this 16 day of October A. D., 1911.

FRANK R. McBERTY.

Witnesses:
WOLDEMAR HAUPT,
HENRY HASPER.