F. R. McBERTY.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED SEPT. 13, 1912.

1,146,583.

Patented July 13, 1915.

6 SHEETS—SHEET 1.

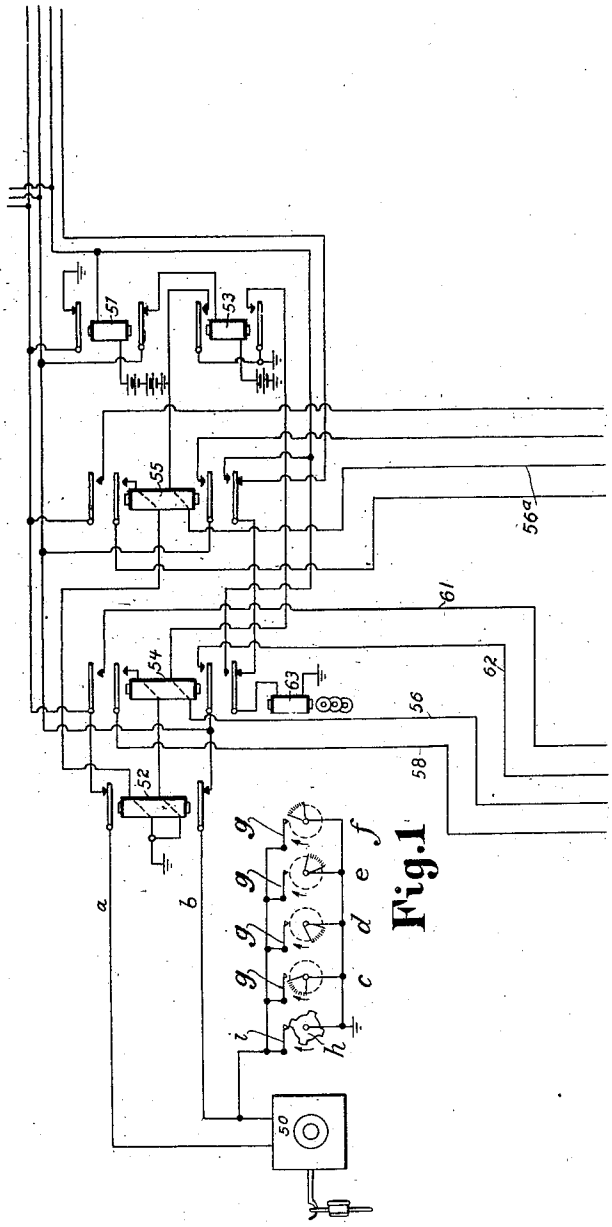


Fig. 1

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

Inventor:
Frank R. McBerty.
by John B. Roberts
Atty.

F. R. McBERTY.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED SEPT. 13, 1912.

1,146,583. Patented July 13, 1915.

6 SHEETS—SHEET 2.

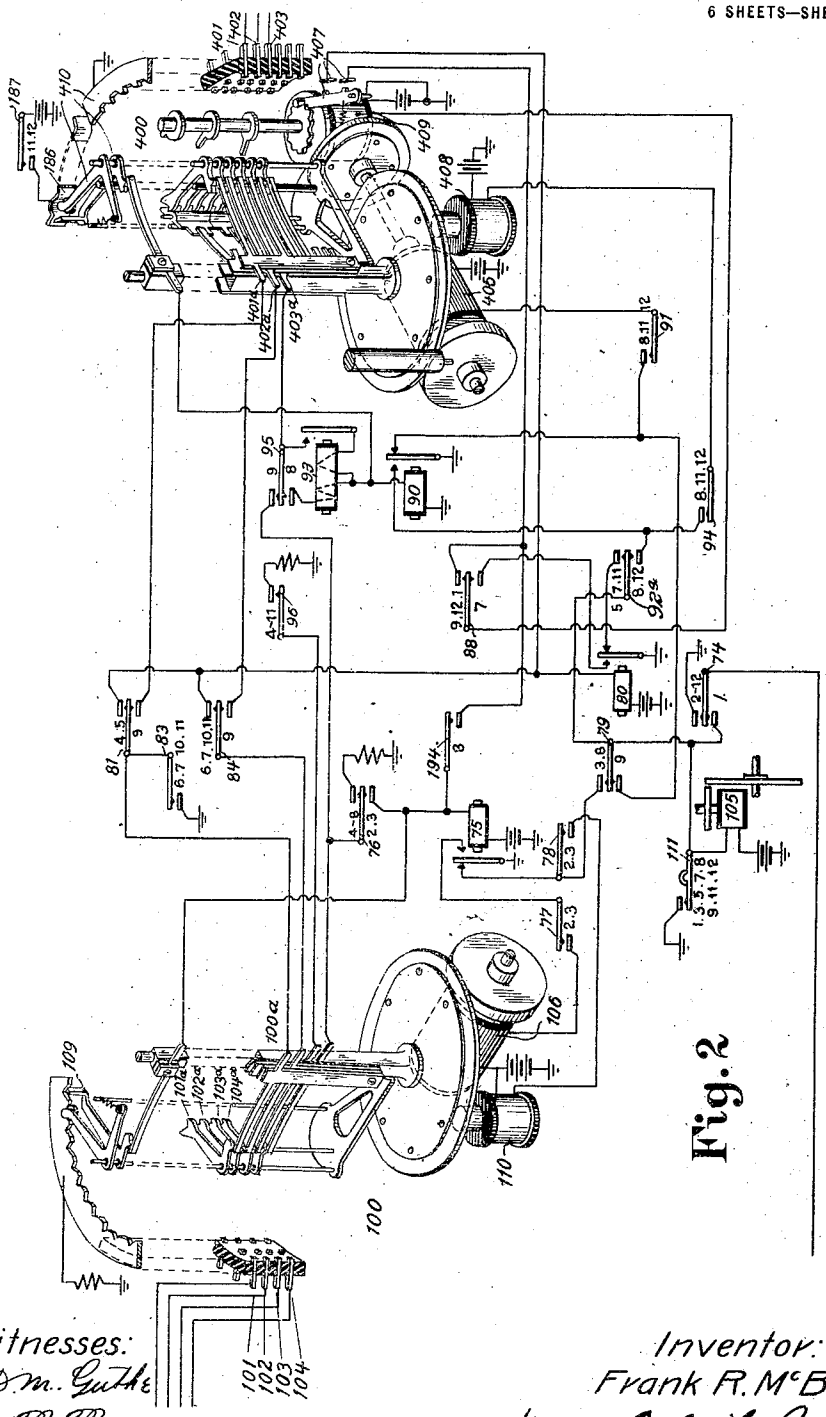


Fig. 2

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

Inventor:
Frank R. McBerty.
by John G. Roberts
Att'y

F. R. McBERTY.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED SEPT. 13, 1912.

1,146,583.

Patented July 13, 1915.

6 SHEETS—SHEET 3.

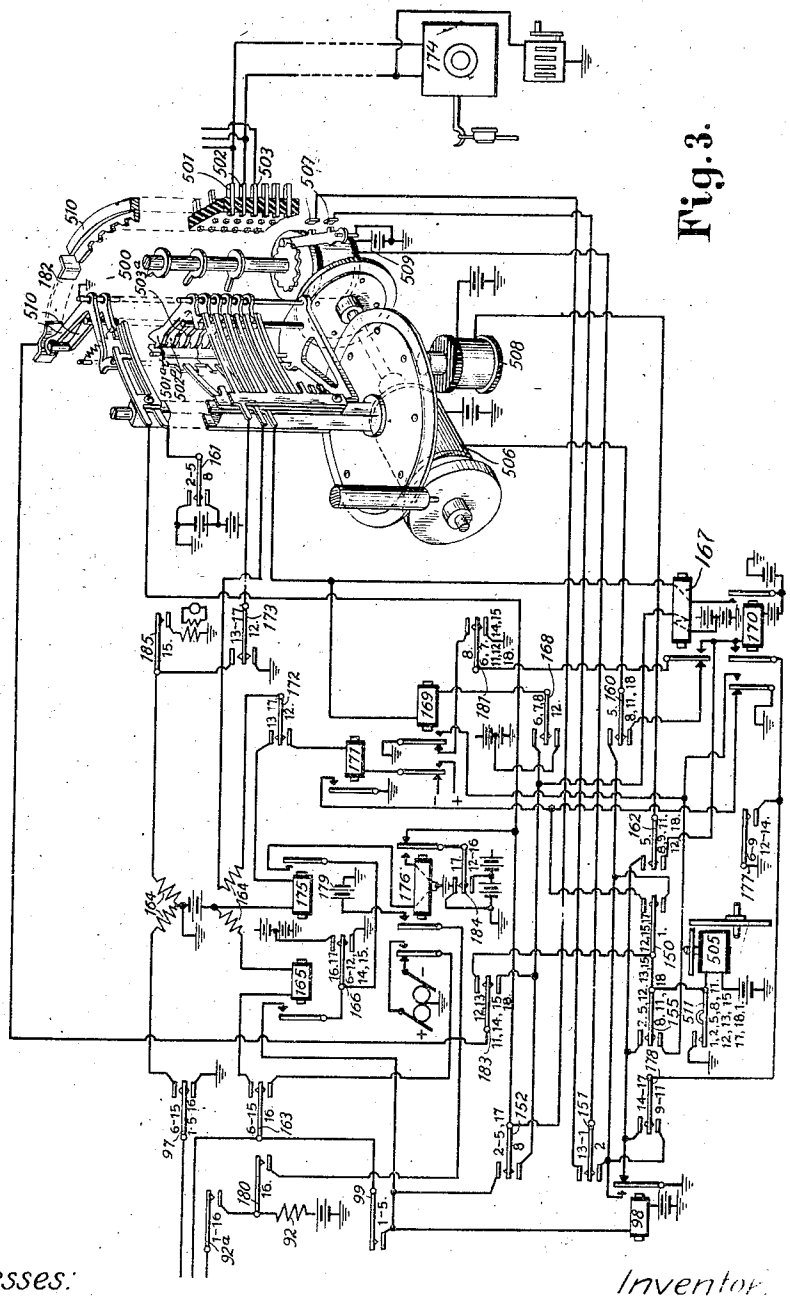


Fig. 3.

Witnesses:

O. E. M. Buttle

H. P. Rossi

Inventor.

Frank R. McBerty

by Johnson Robertson

Atty

F. R. McBERTY.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED SEPT. 13, 1912.

1,146,583.

Patented July 13, 1915.

6 SHEETS—SHEET 4.

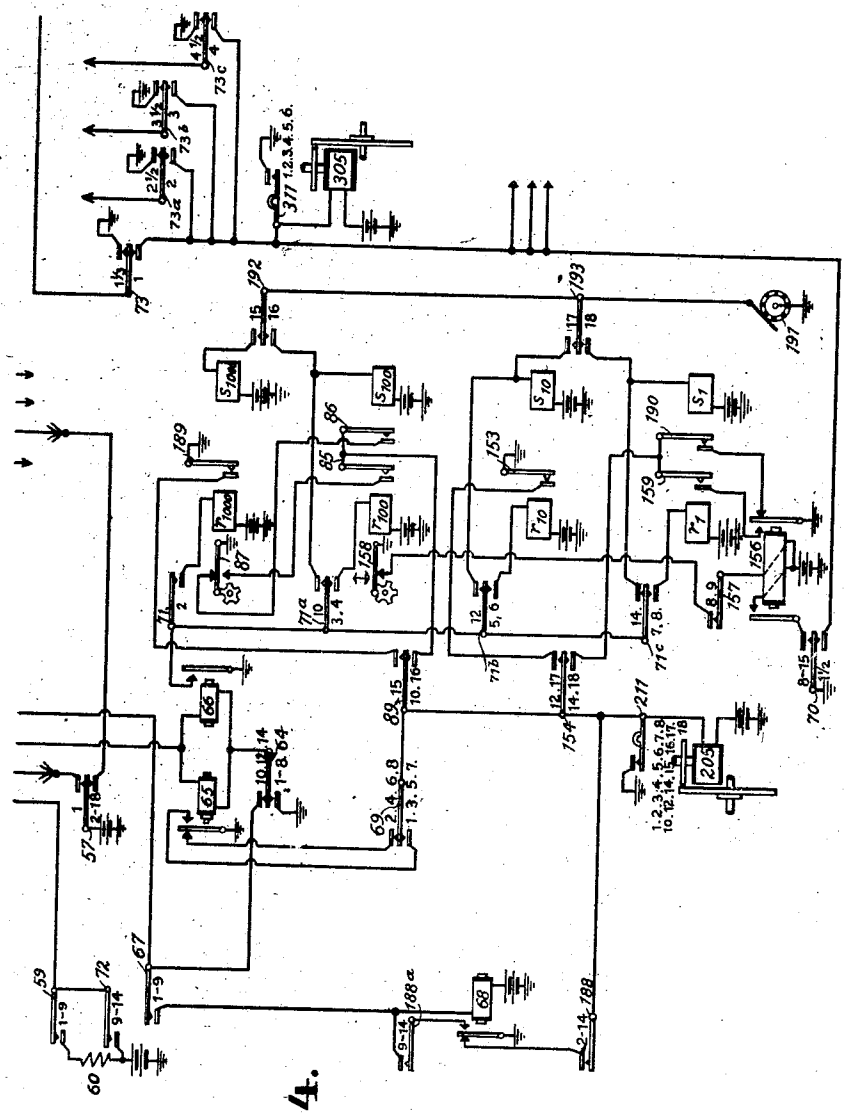


Fig. 4.

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

Inventor:
Frank R McBerty.
by John G. Roberts
Att'y.

F. R. McBERTY.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED SEPT. 13, 1912.

Patented July 13, 1915.

1,146,583.

6 SHEETS—SHEET 5.

Fig. 5.

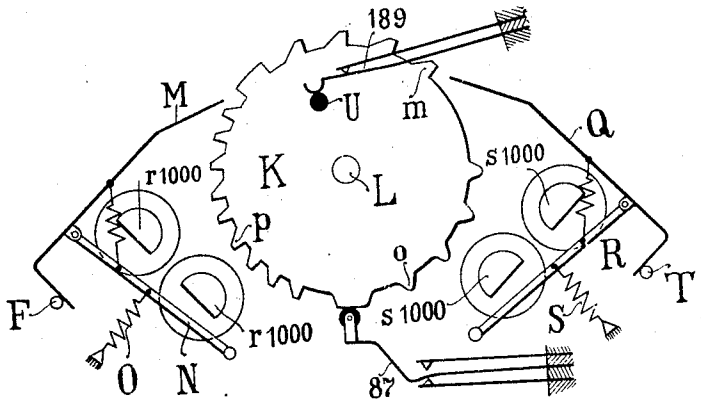
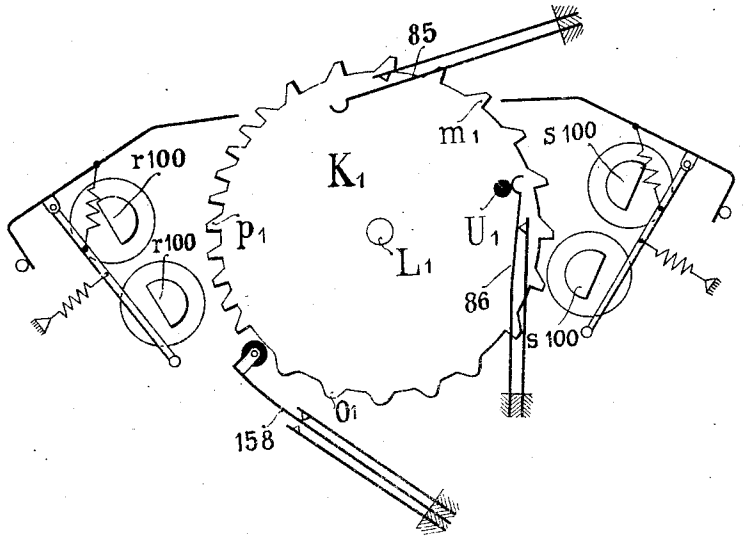


Fig. 6.



Witnesses:
O. M. Cuttle
H. R. Ross

Inventor:
Frank R. McBerty.
by John S. Roberts
Atty.

F. R. McBERTY.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED SEPT. 13, 1912.

1,146,583.

Patented July 13, 1915.

6 SHEETS—SHEET 6.

Fig. 7.

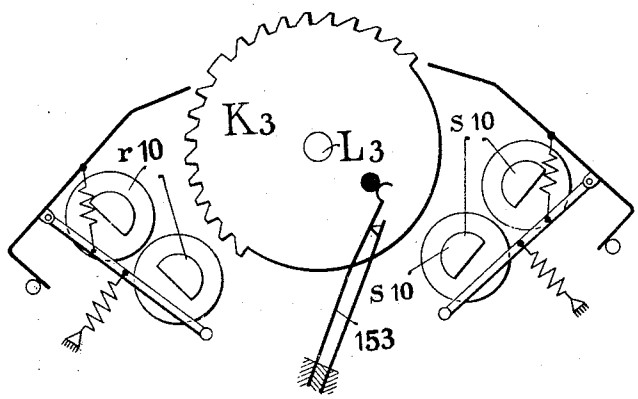
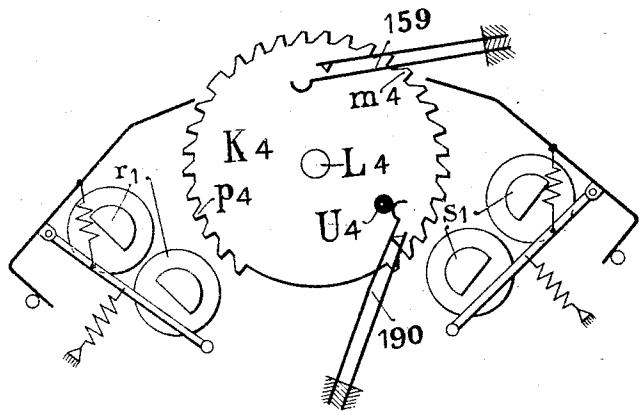


Fig. 8.



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

Inventor:
Frank R. McBerty.
by John G. Roberts
Att'y.

UNITED STATES PATENT OFFICE.

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

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

1,146,583. Specification of Letters Patent. Patented July 13, 1915.

Application filed September 13, 1912. Serial No. 720,170.

To all whom it may concern:

Be it known that I, FRANK R. McBERTY, a citizen of the United States, and a resident of Antwerp, in the Province of Antwerp and Kingdom of Belgium, have invented new and useful Improvements in Automatic Telephone-Exchange Systems, of which the following is a specification.

This invention relates in general to improvements in automatic switching apparatus for interconnecting the lines of a telephone exchange system, and is intended more particularly for a system in which the operation of the automatic switches for extending connection from a calling line to a wanted line is brought about in response to the action of sending apparatus manipulated by the subscriber at the calling station, but certain of the features to be described will also be applicable, as will be apparent to those skilled in the art, to systems of other characters, as for example a semi-automatic system, in which some of the switching or controlling operations are performed by an operator at the central office.

In British Patent No. 26079 of 1910 there is described an automatic telephone switching system in which impulses transmitted from the calling station and representing the number of the wanted line are received at the central office by registering devices which thereupon act as controllers to govern the selecting operations necessary to extend connection to the line represented by such registration. In the system of that patent the register equipment is adapted to be brought into association with a calling line by means of finder switches. Such finder switches may take an appreciable time to establish connection with a calling line, especially where a large number of contacts must be passed over, and the subscriber must wait before sending his call until the register equipment has been connected to his line by the finders; otherwise impulses might be lost.

In order to permit the operation of the subscriber's sender immediately upon the initiation of a call, as when the subscriber takes his telephone from its hook, the present invention provides for the direct association of a register-controller equipment with a calling line, without waiting for a line-finding or equivalent operation by which the calling line is connected to a first group selector, which operation may indeed take place while impulses are already being transmitted from the substation to the register. The connection of the register equipment to the calling line may be accomplished by a relay or relays operating directly between such equipment and the line, and a plurality of register equipments are preferably provided for a group of lines with means whereby a calling line will appropriate one of such equipments which is idle, the seized equipment being then rendered inaccessible to other lines of the group, another register equipment being then available to be appropriated by any of such other lines which may call. Provision is made whereby, after the registration of the number of the wanted line, the register-controller equipment is made free from the possibility of interference by the calling subscriber while its selector-controlling operations are taking place. This may be accomplished in a variety of ways; in the system shown a cut-off relay is operated when the registration is complete, such relay positively disconnecting the calling line from its extensions leading to the registers and switches.

Another feature of the invention relates to the organization of the register-controller equipment by which different series of impulses are caused to act upon different registers or counters, as for registering the different digits of the number of the wanted line, the arrangement involving a fast-acting relay for responding to each impulse, a slow acting device such as a relay responsive only to the longer interval between the different series of impulses, and a quick-acting shifting switch (preferably a sequence switch) brought into action by the slow acting relay. In order to reduce the time required between the different series of impulses while maintaining a maximum difference in the characteristics of the fast and slow relays to secure accuracy, the shift by which a register for a succeeding order of numerals is brought under control of the fast-acting relay in substitution for the first register, is brought about by a fast-acting shifting switch (sequence switch) which responds to a single movement of the armature of the slow-acting relay, but makes no further changes in the register circuits upon

the reverse movement which completes the oscillation of said armature. After registration of a given order of numerals on one register, therefore, the interval required before the next order may be registered need only be long enough to permit a single movement of the slow armature, to cause the action of the quick-acting shifting device; the next register being thus brought under control of the quick-acting relay without waiting for the reverse movement of the slow armature in completing its oscillation ready for the next shift.

This invention also provides for making the calling line test busy as a called line immediately upon its appropriation of a register equipment, while at the same time making it selectable by a line finder which may be set in operation as a result of the same act, and which line finder upon connection to such line maintains a busy test upon the multiple test terminals, both calling and called, after the register equipment has been disconnected. In the particular system to be described, it is convenient to provide a line relay for each line, in normal connection between a battery and the line circuit, to respond upon the closure of the line circuit at the substation, said line relay when energized causing the actuation of a register relay which directly connects a register equipment to the line. It is desirable that this line relay should not remain in permanent connection with the line during the operations of registration and selection, and during conversation, and therefore a cut-off relay is provided for disconnecting said line relay after it has performed its function.

The present invention includes as one of its novel features the operation of said cut-off relay by alternative circuits, the first of which is closed when a register equipment is connected to the line, and the second of which is completed when a line finder is in connection with the line, the latter circuit being thus maintained after the register equipment has finished its work and has been disconnected.

A plurality of line-finders should be assigned to each group of calling lines, and a feature of the present invention is the provision of means whereby the seizure of a register equipment by a calling line causes an idle one of such line finders to start in operation to find and make connection with such line. In the system as shown there is an automatic distributing switch for starting one line-finder after another as calls come in, and this distributing switch may conveniently be started by one of the contacts of the sequence switch associated with each register equipment, and this may be the same sequence switch which also causes the various circuit shifts required in bringing the register and controller magnets successively into operative relation to the devices with which they are to coöperate.

The stopping of a line-finder switch upon the terminals of a line may advantageously be governed by a test relay associated with the finder, which relay is so related to the mechanism of the switch and its associated circuits that it is controlled alternately over successively established test circuits of lines terminating in the switch and a circuit established by an interrupter or contact device forming a part of the switch. The test circuits referred to are multipled to corresponding test terminals on all the finder switches serving the lines of the group, and are normally closed. When, however, a line is calling, and until it has been connected to by a finder switch, the test circuit of such line is opened (as by the action of the same relay which connects a register equipment to the line). The test relay which controls the motive power of the line finder switch is connected to a test brush thereon and will alternately and continuously find circuit, when started, over the finder test terminals passed over, and the interrupter device, until the calling line is reached which will have its test circuit open, whereupon, the test relay will cut off the motive power of the finder switch. The circuit through the interrupter device which forms a branch from the circuit including the test relay and the test brush is useful not only to insure the energization of the test relay while the brushes are in transit from one set of terminals to the next, but also to secure the accurate stopping of the line finder brushes centrally upon the terminals of the calling line. This branch circuit, therefore, is arranged to be closed by the contact device or interrupter operated in the movement of the line finder brushes, said contact device acting to open the branch circuit only when the brushes are in accurate position upon the terminals of the line to be tested. The line finder test circuit may also be used, if desired, for another purpose, as for the operation of a message-counter or other toll device, which may be normally connected in such test circuit, but is preferably operated only by special current applied to said circuit under proper circumstances by apparatus associated with the selector switches.

In the particular system to be described, a distinct busy test circuit is provided in connection with each line, to guard against interference with a line when busy by a call from some other line; such test circuit being represented by multiple test terminals upon all of the final selectors which have access to such line. Normally a potential is applied to all such test terminals from a battery, through the cut-off relay that controls the connection of the line relay. The test relay of the final selector is responsive only to the

full normal potential on the test terminal, and a line is made to test busy by reducing such potential. In the case where connection is made to a line as a called line, the final selector establishes a path from the test terminal which reduces such test potential. Such a busy test guard is already known to those skilled in the art. The present invention provides means whereby such a test guard may be established immediately upon the appropriation of a register equipment when a line is calling. As shown the same relay which connects the calling line to a register may also render the line selectable by a finder and non-selectable by a final selector, and as shown this is accomplished by having said relay when energized open a branch which normally exists from the multiple "calling test terminals" of the line and close instead a branch to the multiple "busy test terminals". This branch may be simply transferred from one test circuit to the other, and when connected to the subscriber's busy test wire will also serve to complete the circuit of the cut-off relay which disconnects the line relay. In order to maintain the potential reduced at the busy test terminals (and also maintain the cut-off relay energized) after the register seizing relay has been released and the register equipment disconnected, another branch from the busy test wire of the calling subscriber may be established by way of a special brush of the line finder contacting with a multiple terminal of such test wire appearing on the terminal bank of the finder.

Another feature of the present invention relates to a practical organization of the system in such a way that the register-controllers may be set in accordance with a given system of notation or grouping of units, as the decimal system, and thereafter when acting as controllers, cause an equivalent selecting operation in accordance with some other system of notation or grouping. For example, it has been found advantageous to employ selectors each having direct access to two hundred lines, this being a particularly economical grouping, in view of average traffic conditions. The register equipment which receives the impulses according to the decimal system, must therefore operate in a modified manner when controlling selection in groups of two hundred instead of groups of one hundred as in the decimal system, and in adapting itself also to the sub-grouping into which the two hundred units (lines) of the main group may be divided.

Some other features of my invention relate to the disposition and operation of the various sequence switches (steering switches) used throughout the system shown. For example, the use of but a single sequence switch coöperating with both the line finder switch and the group switch individual to a connecting circuit; the sequence switch control of the registering and controlling equipment in its various stages of operation; and the sequence switch control of the message charging or rabbeting circuits.

Another feature has more particularly to do with the relay system by which the breaking down of a connection established or being established may be accomplished. Forming a part of this feature of the invention are many improved operations and convenient arrangements among which may be mentioned the method of preventing the initiation of a new connection by either party to a connection until his receiver has been restored to its hook; the method of placing the control of a selector, residing in a line relay, first under the control of a selecting circuit, then under the control of the calling party and finally under the joint control of the calling and called parties; and the disposition of the disconnection controlling (or supervisory) relays in association with a repeating coil at the final selector.

Other desirable and improved features forming a part of the invention will sufficiently appear from the description of the system shown. In this description, of course, the various novel features will be described in their application to a particular system, but it will be understood that they are capable of advantageous use in other systems where they may take forms differing widely from the forms herein shown, and, while in the interests of clearness, specific descriptive language must be used, such language is not intended necessarily as defining the limits of the invention.

One form of the invention is illustrated in the accompanying drawings wherein—

Figures 1 to 4 show diagrammatically a system embodying the invention of which Fig. 1 shows a substation line herein to be considered as the calling subscriber's line and also shows a suitable form of sending mechanism associated with the line at the substation, Fig. 2 shows a line finder switch serving the group of lines to which the line shown on Fig. 1 belongs, together with the connecting circuit and group switch to which the line finder switch shown is individual, Fig. 3 shows a final or line selector with its associated apparatus and one of the substation lines to which it has access, such line being herein considered as the called line. Fig. 4 shows one complete registering and controlling equipment and a distributing switch together with sufficient of the circuits of a second registering and controlling equipment to illustrate the relation between such equipments; Figs. 5 to 8 illustrate more in detail the register-controller devices included in Fig. 4 and indicate so far as is

necessary for a complete understanding of their structure and operation, their mechanical construction.

To properly view the complete system diagrammatically illustrated in Figs. 1 to 4, Fig. 2 should be placed to the right of Fig. 1, Fig. 3 to the right of Fig. 2, and Fig. 4 under Fig. 1.

In the specific sending arrangement and apparatus shown, the subscriber's sending mechanism at the substation is of the type in which a contact device is operated intermittently to close a circuit to ground from the line conductor to which it is connected, thereby causing corresponding intermittent shunting of the impulse receiving relays 65 and 66 for the time being associated with the line at the central station. The contact device in its operation closes such circuit to ground a number of times corresponding to each digit of the designation of the desired line and is so constructed that the last closure of the series of closures for each digit is of longer duration than the other closures of the series, such closure being of sufficient duration to accomplish the retraction of the slow acting shift relay 65 for purposes to be hereinafter described. The form of sender illustrated is one wherein the desired number is set up by manually operable levers, one for each digit, and upon the subsequent actuation of a power crank is brought into operation to transmit groups of impulses to the central office in accordance with the digits of the number so set up. An instrument of this type is disclosed in the British Patent No. 15569 of 1911. The other substation apparatus is of the usual common battery arrangement and together with the sender is connected with the central office by means of the usual line conductors *a*, *b*. There may also be associated with each line a message register such as is shown at 63.

It will be noted that the message register 63 is a number-indicator which counts or registers each successful connection; it may be of any well-known type. The term message register must be distinguished from the term register-controller, the latter term designating the mechanism shown in Fig. 4 which serves to receive the impulses representing the desired line and then to control the switches. The individual devices which receive the impulses are designated herein as register-controllers, there being a 1000's register-controller, a 100's register-controller, a 10's register-controller and a units register-controller. These form the essential parts of the registering and controlling equipments.

The circuits of the registering and controlling equipment are shown in Fig. 4, and the mechanisms are indicated in Figs. 5, 6, 7, and 8. The operating magnets of the 1000's register-controllers are indicated by *r*1000 and *s*1000; those of the 100's register-controller by *r*100 and *s*100; those of the 10's register-controller by *r*10, and *s*10 and those of the units register-controller by *r*1 and *s*1. There is also provided a sequence switch, the clutch magnet of which is marked 205, (Fig. 4) serving among other things to bring the several register-controllers successively into service.

The structure of the 1000's register-controller is indicated in Fig. 5. It consists of a disk K supported on a shaft L, the disk having teeth along its periphery adapted to be engaged and displaced by a pawl M mounted on an armature N of the magnet *r*1000, the armature being normally held retracted against a stop F by a spring O. To restore the disk K the magnet *s*1000 is provided having a pawl Q mounted upon its armature R, the armature being normally held retracted against a stop T by a spring S. The disk K carries an insulated stud U which in the normal position of the device closes contact 189. In addition to this spring a spring 87 is provided having an insulated roller bearing upon the periphery of the disk K. The arrangement is such that with the roller on top of a tooth the lower contact is closed, and with the roller in a notch between teeth the upper contact is closed.

The disk K is provided with ten teeth *p*, five teeth *m* the pitch of which is double that of the teeth *p*, and five teeth *o*, the pitch of which is equal to that of the teeth *m*. The magnet *r*1000 is intermittently energized in response to the impulses representing the thousands digit of the desired line which causes the disk K to be advanced in a clockwise direction, the number of steps corresponding to the number of impulses. When the device acts directly as a controller to determine a selecting operation, the magnet *s*1000 is intermittently energized by impulses transmitted from the selector and steps the disk K in a counter-clockwise direction. Due to the pitch of the teeth *m*, however, the number of impulses necessary to restore the disk K to its normal position is but one half of the number which caused its displacement.

In the system herein described the thousands register-controller does not act directly as a controller, the system shown being for only two thousand lines. It does, however, act indirectly by means of the spring 87 to assist in the control of selection in the manner to be hereinafter described. It is restored by a special impulse circuit through the magnet *s*1000 established after the completion of the selection controlling operation.

The numbers of springs in the four registers described agree with the numbers of springs shown in Fig. 4.

The 100's register-controller is shown in Fig. 6. It is also provided with a disk K1 mounted on a shaft L1; similarly in this device magnets *r*100 and *s*100 are arranged respectively to advance and restore the disk. It will be observed that this register-controller has two normal springs 85 and 86. The usual normal position for the disk is as shown with 86 closed. Under certain conditions, however, it is necessary that this register-controller should receive five extra impulses in order to accomplish the proper translation, in which case the disk operating under the control of the thousands register-controller will not be stopped when the normal spring 86 is reached, but will stop when the second or sub-normal spring 85 is reached. When the hundreds impulses have been received from the substation a spring 158 will close its lower or upper contact depending on whether the number of impulses sent in is odd or even.

In Fig. 7 is shown the 10's register-controller. This is of the type described in British patent specification No. 26,079/10. The disk K3 is mounted on a shaft L3. The magnet *r*10 steps the disk in a clockwise direction, and the magnet *s*10 restores it to normal, in which position contact 153 is closed. In this case as many impulses are required to restore the register-controller as operated to displace it.

In Fig. 8 is shown the units register-controller. The disk K4 mounted on the shaft L4 is driven in a clockwise direction by the magnet *r'* and in a counter clockwise direction by the magnet *s'*. In this register controller also there are provided two normal springs coöperating with the insulated stud U4. Which of these normal springs will operate effectively to cause the stopping of the disk in its return movement will depend upon the set position of the hundreds register-controller in a manner to be described. It is sufficient for the present to say that while the same number of impulses will accomplish the restoration of the disk to its usual normal position, that is, with U4 in engagement with the spring 190, as were received from the sender, there are connections in the extension of which it is necessary that the units register-controller receive ten additional impulses before coming to a stop in which case the stoppage will be controlled by the second or subnormal spring 159.

The exact relation of the various springs and magnets in producing the proper translation is hereinafter made clear.

For the sake of simplicity of illustration and description but one disk is shown in Figs. 6 and 8 illustrating the hundreds and units register controller devices respectively. In practice, however, three disks are preferably provided for the hundreds register (Fig. 6) which all revolve together on the shaft L1, and two disks for the units register which revolve together on the shaft L4. Referring to the hundreds register-controller device, the first disk has ten teeth *p*1, the second disk has teeth *m*1 having double the pitch of *p*1 but spaced entirely around the disk so that the register-controller may be returned to normal after a selecting operation, in which it has stopped in its second or subnormal position, by having the magnet energized from the interrupter 191 (Fig. 4) until the disk has been stepped around and the insulated stud U1 has closed the normal contact spring 86. The third disk has five teeth as shown at O1. Similarly the units register-controller shown in Fig. 8, is in practice constructed with two disks, the first having ten teeth *p*4 and the second having teeth *m*4 completely around its periphery and having the same pitch as *p*4. As in the case of the teeth *m*1 of the hundreds register-controller these teeth *m*4 are provided so that in case the disk has been brought to rest at the second or subnormal position with the stud U4 pressing on the spring 159, it may be returned to normal by having the *s*1 magnet energized from the interrupter 191 (Fig. 4) until the disk has been stepped completely around and the stud has finally reached the spring 190 closing the contact.

There is associated with the register-controllers a sequence switch whose power magnet is numbered 205. A distributing switch whose power magnet is numbered 305 is also provided to start line finders hunting for calling lines. The line finder and group selector shown in Fig. 2 have a common sequence switch, the power magnet of which is indicated by the number 105 and the final or line selector has also associated with it a sequence switch the power magnet of which is indicated at 505. The distributing switch springs 73, 73^a, 73^b, 73^c belong to the line finder starter or distributing switch 305, and the remaining sequence switch contacts of Fig. 4 belong to the registering and controlling equipment sequence switch. Sequence switches of the character indicated and referred to herein are fully disclosed and described in British Patent 20840 of 1909.

In Figs. 2, 3 and 4 the switch springs of the sequence switches are not shown in their actual arrangement, but are so located as to give a clear arrangement of the circuits. The position of the rotary elements of each sequence switch and the distributing switch in which any of its contacts (except the con-

tacts coresponding to 111 of the line finder sequence switch) are closed, are indicated by numbers placed adjacent to such contacts, each contact being open in all positions except those indicated by such reference numerals. For example, contact 81 top is closed in the fourth and fifth positions of the line finder sequence switch of which it forms a part, as indicated by the numbers 4, 5 adjacent thereto, and the alternate contact is closed in the 9th position as indicated by the figure 9 adjacent to such alternate contact; said contacts being open in all positions except those so indicated. In the case of the special contacts such as 111 the numbers are placed on the opposite side of the switch lever from its contact point and indicate positions in which the contact is opened, such contact being closed continuously while the rotary element of the sequence switch is in transit between positions indicated. It will therefore be understood that the special contact 111 of the sequence switch 105 is closed continuously between positions 1 and 3, 3 and 5, 5 and 7, 7 and 8, 8 and 9, 9 and 11, 11 and 12, and 12 and 1, but is open when the sequence switch is either resting in or passing through any one of these positions.

The group selector switch 400 (Fig. 2) and the line or final selector switch 500 (Fig. 3) are of the same general design and are of the multiple brush type. A switch of this general character is disclosed in the British Patent No. 26841 of 1909.

The line finder shown to the left of Fig. 2 is of the same general construction as the group switch except that the brushes are not latched but are normally in position to trail over the fixed terminals and the switch has no normal position. To establish connection with a calling line, the brush frame 100^a is rotated by the power shaft to which it is coupled by a magnetic clutch, and the brushes are trailed over the row of terminals. There are four brushes on the line finder to traverse the sets of four fixed terminals allotted to each line. The construction of the magnetic clutch may be like that of the selector switches.

Description of operation.—Assume that the subscriber whose substation is shown on Fig. 1 desires connection with the subscriber whose substation is shown on Fig. 3, and whose number is 1149. The calling subscriber therefore sets his sender mechanism to indicate 1149, and having removed his telephone receiver from its hook, operates the power lever of the sender. Upon removing the receiver, a circuit is established through line relay 53, which is energized and closes a circuit through the lower winding of first register relay 54, energizing such relay to close a holding circuit through its upper winding which circuit includes the lower winding of relay 52, and resistance 60. Relay 52 does not attract its armature because of the presence of resistance 60 in the circuit. Relay 54 closes the line conductors *a*, *b* to the conductors 61 and 62 leading to the registering and controlling equipment to which such relay is individual, such equipment being the one shown in Fig. 4. Relay 54 also closes a circuit through message register 63, and cut-off relay 51, causing the cut-off relay to be energized, thereby removing the control of the line relay from the calling subscriber, and also so reducing the potential on the test conductor of the line leading to the final selectors, due to the parallel path to ground through the message register, that such line will test busy therein. The message register is of such construction that it will not be actuated by current through the cut-off relay 51.

If the registering and controlling equipment shown in Fig. 4 had been busy the circuit for energizing the relay 54 would not have been established as the sequence switch spring 57 top would have been open. In this case, however, the spring 57 bottom would have been closed and the second register relay 55 would have been energized instead, over a circuit including the top front contact of the line relay 53 and the conductor 56^a. The energization of the second register relay 55 results in precisely similar effects as the energization of the relay 54 except that its locking circuit includes the top winding of the cut-off relay 52 and that the second registering and controlling mechanism instead of the first is connected to the calling line.

When the subscriber sets the levers *c*, *d*, *e*, *f*, of the sender mechanism to the number of the desired subscriber and pulls the crank, which winds up the spring, and releases it, the levers of the sender are returned to the normal position. Each of the levers has attached thereto a segment having tooth-like projections, which in passing below a spring *g* connect earth to the conductor *b* of the subscriber's line. After all the teeth of a segment have passed below the contact spring and all but one of the set of impulses which determines the thousands digit have been sent to the exchange, a connection to earth of longer duration will be produced by the wheel *h* when a projection of this wheel reaches the spring *i*. Now the second segment *d* in passing below the spring *g* causes a set of impulses corresponding to the number of the hundreds digit to flow through the conductor *b*, the last of which produced by the wheel *h*, is of longer duration and so on, until all the sets of impulses have been sent to the exchange when the sender mechanism will have returned to its normal position.

When the calling subscriber's line is con-

nected to the conductors 61 and 62 leading to the first registering and controlling equipment a circuit is closed through his substation for the relays 65 and 66 in parallel, and the relay 68. The energization of such relays by this circuit take place immediately upon the seizure of the equipment. The earth closures to the conductor *b* by the segment *c* of the sender mechanism short circuit the relays 65 and 66 but are not of sufficient duration to cause the retraction of the armature of the slow acting marginal relay 65. Only the quick-acting relay 66 responds to all closures. Thus relay 65 functions as a timing device which regulates the movement of the sequence switch 205 during the registration period. The relay 68 remains energized as long as the receiver is off the switch-hook and will if released close a circuit to start the sequence switch 205 for the restoration of the equipment to normal, as will be hereinafter described. The first energization of relay 65 closes a circuit over spring 69 bottom, for the register sequence switch power magnet 205. The sequence switch moves from position 1 to position 2. In passing from position 1 to position 2 an impulse is sent to the distributing switch power magnet 305 over spring 70 bottom thereby causing the distributing switch to advance one step, and cause an idle line finder to seek the calling line.

The distributing switch, indicated by power magnet 305 and the contact springs associated with it, is controllable by any one of the plurality of registering and controlling equipments accessible to the group of lines, as is indicated by the multiple conductors leading from the circuit closed at the register sequence switch spring 70 bottom. This switch operates to pre-select an idle line finder of the group which it controls and immediately upon the seizure of one of the registering and controlling equipments by the controlled line starts such pre-selected line finder hunting such line, then pre-selecting another idle line finder preparatory to the establishment of the calling condition in some other line of the group. This distributing switch is constructed in the same manner and acts similarly to a sequence switch but has no normal position. Assuming that it stands in its first position upon the initiation of the call being described, the impulse transmitted to its power magnet 305 by the closure of the register sequence switch spring 70 bottom will cause it to move out of its first position into its second position. Such movement will cause the contact spring 73 top to close a circuit over the finder sequence switch spring 74 bottom to drive such sequence switch out of its first position and into its third position. It will be observed that as soon as the operation of the line finder sequence switch, and thereby the line finder itself has thus started, the finder sequence switch spring 74 opened the circuit to the finder sequence switch at its bottom contact and closed at its top contact a connection to ground. This same operation takes place in the apparatus of each of the finder switches when taken for use, and it will therefore be seen that if, when the distributing switch comes into the second position, the second line finder, *i. e.*, the one individual to the conductor leading from the distributing contact spring 73^a is in use a circuit will be established to the power magnet of the distributing switch and it will move to its third position. In this manner the distributing switch will continue to move from position to position until it has found a line finder which is idle and will there remain until upon the initiation of another call it is necessary that it should start another line finder. The distributing switch has started into operation the line finder apparatus shown in Fig. 2 to produce the hunting and seizure of the calling line, and meanwhile, the registration of the call is progressing.

As the sequence switch 205 of the registering-controllers moves into position 2, the thousands register magnet *r*1000 is connected to the front contact of the quick-acting relay 66 over spring 71, and as this relay 66 responds to the successive impulses produced by the subscriber's sender, the magnet *r*1000 is correspondingly actuated, and the register disk is thus advanced one step for each such impulse. When the relatively long earth closure takes place at the end of the thousands impulses, the armature of relay 65 is released, and closes its back contact, establishing a circuit over spring 69 top to power magnet 205. The sequence switch moves into the third position. In this position the hundreds register magnet *r*100 is connected to the front contact of relay 66 over spring 71^a bottom, and when relay 65 is again energized, circuit is closed to power magnet 205 over spring 69 bottom and sequence switch 205 moves to position 4. In both positions, 3 and 4, the magnet *r*—100 is connected to the selecting circuit and receives the "hundreds" impulses in the same way that the magnet *r*1000 received the "thousands" impulses. When the hundreds impulses have been thus registered, relay 65 is again released and closes its back contact thereby sending the sequence switch 205 into position 5. In a similar manner the "tens" and "units" impulses are received and registered by the tens and units magnets *r*10 and *r*1, which will be connected in turn to the front contact of the relay 66, over the springs 71^b and 71^c in the 5th and 6th positions and 7th and 8th positions respectively. When all of the pulsations corresponding to

the various digits of the number of the desired line have thus been registered, the final long earth closure depriving relay 65 of current, closes the circuit to power magnet 205 through spring 69 top, driving the sequence switch 205 from position 8 to position 10.

As the sequence switch moves through position 9, at spring 72 bottom a circuit is closed direct to the conductor 58 (Fig. 1), thereby short-circuiting the resistance 60 permitting sufficient current to flow to energize the second cut-off relay 52, which by attracting its armatures disconnects the subscriber's station from the line during the subsequent selecting operations which are to be controlled by the register-controllers, as will hereafter be described.

It will be observed that a line which is idle has its test terminal 104 grounded through its message register 63; also a line which forms a part of an established connection has the same test terminal grounded in the same manner; when, however, a line is calling this ground connection is removed by one of the register relays 54 or 55, so that the line may be seized by a line finder. In view of the fact that the register relay by which this ground connection is opened is maintained operated until the selection-controlling operation is completed it is necessary that a ground connection be applied to the test terminal 104 as soon as the line is seized to render it nonselectable by other line finders. This is done by the finder sequence switch spring 76 top which connects the conductor leading to the brush 104^a to ground through a resistance substantially equal to the resistance of the message register 63.

The finder sequence switch 105 (Fig. 2) when it passed from position 1 to position 3, closed a circuit for the finder test relay 75, over spring 76 bottom, and when the brush 104^a of the line finder is on a terminal 104 of a non-calling line, to earth. Relay 75 when energized closes a circuit over spring 77 for power magnet 106 of the line finder to battery, said power magnet 106 causing the brush carriage 100^a of the finder to rotate. As long as the brush 104^a passes over terminals 104 of non-calling lines, relay 75 remains energized. When the brush 104^a passes from one terminal to another; *i. e.*, when the brushes are not centered upon the terminals of the lines, the finder interrupter 109 will maintain a circuit for relay 75 independent of the circuit through the test brush 104^a, to hold said relay 75 energized, said independent circuit being broken by the interrupter when the brushes rest in proper position upon the line terminals. When the brush 104^a reaches the terminal 104 of the calling line, the test relay no longer finds circuit to earth, (this path being open by reason of the excitation either of relay 54 or relay 55) and said test relay 75 will become deënergized. The circuit for the power magnet 106 is therefore broken at the front contact of relay 75, and the circuit of the holding magnet 110 is closed through the alternate back contact of said relay and spring 78, and the line finder is stopped. The brushes 101^a—104^a are now in connection with the terminals 101—104 of the calling line. Relay 75 also closes a circuit through spring 79 top, for the sequence switch power magnet 105. The finder sequence switch now moves from position 3 into position 5, in which movement spring 81 top is closed in positions 4 and 5, connecting relay 80 to the brush 101^a.

When the register sequence switch (Fig. 4) is in one of the positions 1—8 in which the subscribers' impulses are being received by the registers, relay 80 is energized, its circuit being over spring 81 top, brush 101^a, upper back contact of relay 52, the subscriber's station, lower back contact of relay 52, front contact of relay 54, conductor 62, windings of relays 65 and 66 in multiple, and spring 64 bottom. The finder sequence switch 105 remains in position 5 as long as the register sequence switch 205 is in one of the positions 1—8 and the relay 80 is energized.

At the same time that the ground was applied to the test terminal 104 by the finder sequence switch spring 76 top as above described to render the line non-selectable in any other finder switch, a substitute circuit was provided for the cut-off relay 51, by the finder sequence switch spring 96. This circuit which includes the brush 103^a and terminal 103, maintains the cut-off relay 51 energized so long as it is necessary that the line to which the cut-off relay is individual should be non-selectable as a called line *i. e.* until the breaking down of the connection and the restoration of the apparatus to normal. By means of this alternative circuit over the spring 96 the cut-off relay 51 is no longer dependent on the circuit heretofore established by the register relay 54 or 55 and the line relay 53 is maintained disconnected from the line.

As soon as all impulses have been received and the sequence switch 205 (Fig. 4) moves from position 8 into position 10, the circuit of relay 80 (Fig. 2) is opened at spring 64 bottom (Fig. 4), and it becomes deënergized, at its back contact closing a circuit through spring 92^b top for sequence switch power magnet 105 causing said sequence switch 105 to move from position 5 into position 7. At positions 6 and 7 of this sequence switch the selecting or fundamental circuit is closed: earth, spring 83 bottom, brush 101^a, terminal 101, upper front contact of relay 54, conductor 61, spring 64 top (Fig. 4), windings of relays 65 and 66 in

parallel, conductor 62, lower front contact of relay 54, terminal 102 (Fig. 2), brush 102ª, spring 84 top, winding of relay 80 to battery. Relays 66 and 80 are energized before the line finder sequence switch reaches its position 7, in which position a circuit for the power magnet of the brush-chooser 409 of the group switch 400 is closed over spring 88 bottom and armature of relay 80. The brush-chooser therefore begins to rotate.

The first step in the process of translation will now be considered. The subscriber's sender is constructed to transmit the impulses representing the number of the wanted line on the usual decimal basis, each digit being represented by a corresponding number of impulses and one additional impulse, that is to say, the digit 0 must be represented by one impulse, the digit 1 therefore requires two impulses, and so on. We have assumed the wanted line to be No. 1149; the subscriber's sender will, therefore, transmit two, two five and ten impulses successively which will be registered by the displacement of the disks K, K1, K2, K3, respectively a corresponding number of steps in a clockwise direction.

The system described uses two hundred point line switches, the terminals being arranged in ten levels of twenty sets of terminals each. The group switches similarly are two hundred point machines, there being ten levels and each level having twenty trunks leading to a group of final or line selectors. The first level of the group switch, therefore, has trunks leading to final switches on which are multipled lines 0–199, the second level trunks leading to final switches on which are multipled lines 200–399 and so on, the final level having contacts representing a group of trunks ending in final switches serving lines 1800–1999. The number of the desired line, which was assumed to be 1149, will therefore be reached over an idle trunk in the 6th level.

By studying the grouping it is apparent that the final switches having access to the lines in an even thousand are reached over the first five levels of the group switch, while final switches having access to lines in an odd thousand are reached over levels six to ten of the same group switch. Therefore the hundreds register controller in its controlling operation must come to the position in which it will cause the cessation of selection in the group switch either in a number of steps equal to half the number of impulses sent in from the substation or equal to half the number of impulses so sent in plus five additional steps. Of course it will be apparent that when the number of hundreds impulses received from the sub-station is odd, that is when they represent an even hundreds digit, the number of steps taken by the hundreds register controller in its counter-clockwise or controlling movement will be one-half of the next higher even number, plus the five additional steps, if necessary. The five additional steps, it will be obvious, are necessary when and only when the thousands digit of the number of the desired line is odd. In the case assumed, therefore, the thousands digit being odd, the hundreds register controller must not cause the cessation of the selecting operation until it, and the group selector brush-chooser, have taken six steps, that is one (half of the two hundreds impulses received) plus the five additional steps rendered necessary by the fact that the desired line is to be selected in the upper half of the group switch. The control of this operation of the hundreds register controller resides in the thousands register controller. The function of the thousands register controller, therefore, in the system shown, is to determine which contact, 86 or 85, on the hundreds register controller shall be effective when closed to cause the cessation of selection in the group switch and the stopping of the hundreds register controller. This is done by means of the teeth *o* and the contact spring 87 of the thousands register controller. If the thousands digit is zero (or in the case of a large system also if it is 2, 4, etc.) selection in the group switch will be in the lower half thereof and the five additional steps in the hundreds register controller will be unnecessary. Therefore the contact spring 87 of the thousands register controller is so arranged with relation to the teeth *o* thereon when it has taken the one step in response to the impulse from the sender, that the roller on the spring 87 will remain on the long tooth upon which it normally rests. The spring 87 will therefore maintain the ground connection for the conductor leading to the contact 86 of the hundreds register controller, see Fig. 4, which is the normal contact and therefore when the hundreds register controller has reached its normal position, the contact 86 being closed, the circuit will be established to cause the "change-over" or shifting operation by the register sequence switch to remove the hundreds register controller from the coöperative relation to the fundamental circuit and substitute therefore the tens register-controller. In the case assumed, however, the desired line is in the second thousand; that is, its thousands digit is one. Therefore the thousands register-controller has taken two steps and the roller of the spring 87 now rests in one of the notches between the teeth *o* and such spring is in position to close the ground to the contact 85 of the hundreds register-controller. Since no ground is connected to the contact 86, therefore, before the change-over and stopping of the hundreds register-controller can take place, such register-controller must be

stepped around to its sub-normal position in which the stud U1 closes the contact 85; that is to say in the case assumed, the hundreds register-controller will take six steps in its counter-clockwise or controlling movement. If the thousands digit had been 2 or 4, etc., the number of thousands impulses would have been odd and since the thousands register-controller would have taken an odd number of steps the roller of the spring 87 would be resting upon one of the teeth *o* and the operation would have been as described when the thousands digit was zero.

It has been stated that in the system shown, the function of the thousands register-controller is to determine which of the normal positions, that is, the normal or sub-normal positions of the hundreds register-controller, shall be effective for causing the cessation of the selecting operation in the group switch. It will be obvious in a system of 2000 to 20,000 lines that such thousands register-controller will also have the function of determining selection in an additional series of group selectors and that an additional or fifth register-controller will be necessary in each equipment to determine in which group of two thousand lines of the twenty thousand lines the selection in this additional group selector should take place. The translation between the thousands register-controller and this additional register-controller would take place along precisely the same lines as between the register-controllers shown herein and it will be obvious to one skilled in the art that the system may be expanded in this manner, not only to serve 20,000 lines but also to serve 200,000 lines or even more, all that is necessary being the addition of the corresponding register-controllers and group selectors. Translation also takes place in the final selector under the combined control of the hundreds register-controller and the units register-controller. So far as the hundreds register-controller is concerned, it is produced by the contact device 158 and the teeth *o*1, such device controlling whether or not, the self-locking relay 156 will be energized and locked to control the ground connection to the contact devices 159 and 190 of the units register-controller. If the hundreds digit is odd (1, 3, 5, etc.) a circuit will be prepared which, in the 8th and 9th positions of the register sequence switch, will energize and cause the locking up of the relay 156, to place the ground controlled by its right hand armature on the contact 159. On the other hand if the hundreds digit is even (0, 2, 4, etc.) when the sequence switch is passing through the 8th and 9th positions no circuit will be established for the locking relay 156 and the ground will remain connected to the contact 190. In this way it is determined whether the units register-controller will in its controlling operation be stepped a number of steps equal to the number of impulses which it receives from the sender, or such number of steps plus ten additional steps. The operation of the units register-controller will be more fully described in relation to the establishment of a connection.

As the line finder sequence switch 105 went into position 7 the relay 80 was energized, and the brush choosing power magnet 409 started to rotate its spindle. For each step taken by the brush chooser a ground circuit is closed to the battery side of the fundamental circuit by the interrupter 407. Although relay 80 (Fig. 2) remains energized this intermittent ground at the interrupter short circuits the stepping relay 66 at the register, (Fig. 4) hence relay 66 releases its armature and again attracts it once for each step taken by the brush choosing mechanism; and at each excitation of said relay 66 a local circuit is closed for the stepping magnet *s*100 of the register, whereby the latter is stepped back or in a counter-clockwise direction in unison with the advance of the brush-chooser. It has been assumed that the number of the desired line is 1149 and therefore the trunk lines leading to final selectors in which such line is accessible appear in the sixth level of the group switch. Therefore the hundreds register-controller (and the group selector brush-chooser) will take six steps before the register-controller causes the cessation of the selection by the opening of the fundamental circuit. This necessary operation will take place because the contact spring 87 of the thousands register-controller which has taken two steps, has in its set position, open the ground circuit normally connected to the contact 86 and closed the ground circuit to contact 85.

Therefore upon the sixth shunting of the relay 66, caused by the group selector brush-chooser moving into position to trip the set of brushes corresponding to the sixth level, the pin U1 of the hundreds register-controller will reach its second or sub-normal contact 85 and a circuit through the sequence switch 205, spring 89 bottom, contact 85 and spring 87 will be closed to move the sequence switch to position 12.

As sequence switch 205 leaves its 10th position, the fundamental circuit is opened at spring 64 top, thus breaking the circuit of relay 80 at the group selector (Fig. 2) and causing such relay to be deënergized immediately the brush-chooser interrupter opens the shunt to ground as the brush-chooser comes into position to trip the sixth set of brushes. Relay 80 deënergized breaks at its front contact the circuit of the brush-chooser power magnet 409 and the rotation of the brush-chooser ceases. Relay 80 also closes at its back contact a circuit to the

sequence switch power magnet 105 over sequence switch spring 92b top, which moves the sequence switch from position 7 to position 8. This is the trunk hunting position. In position 8 of the sequence switch a driving circuit for the brush carriage of the group selector is closed over back contact of relay 90, and spring 91, to power magnet 406, whereupon the brush carriage rotates and the selected set of brushes having been released hunts for an idle trunk in the selected group. The brush 403a, which is connected to earth over spring 95 bottom, left (high resistance) winding of relay 93, and relay 90, trails over the test terminals 403, and when it comes in contact with a terminal which is supplied with battery through resistance 92 (Fig. 3) and spring 92a, and which is not shunted by earth from another group switch circuit, the test relay 93 (Fig. 2) will be energized, and in closing its front contact will place a low resistance shunt through its locking winding around its relatively high resistance left hand winding, to cause this particular final switch to test busy to hunting brushes of other group switches. As soon as the brushes of the group switch are accurately centered upon the terminals of a non-busy trunk line the shunt about the relay 90 is opened at the interrupter 410 and the relay 90 is energized, breaking the circuit of the power magnet 406 at its back contact, and closing a circuit through the brush holding magnet 408 over its front contact and spring 94. Furthermore, it closes a circuit to sequence switch power magnet 105 over spring 92b bottom, thereby moving the sequence switch into position 9, in which position the line finder terminals 101 and 102 of the calling subscriber are connected through to the final selector 500 at springs 81 and 84 bottom. The terminal 104 to which the message register is connected is furthermore extended through to the final selector at the spring 95 top, and the ground applied to this terminal to render it non-calling is transferred from the upper contact of spring 76 to the upper contact of spring 95 through the test relays. The circuit of the cut-off relay 51 remains closed over spring 96 top (Fig. 2). The fundamental circuit is now closed for selecting the ten's digit of the wanted line, earth for this fundamental circuit being connected through spring 97 bottom (Fig. 3), and battery through the line relay 98 (Fig. 3) and spring 99 bottom. This fundamental circuit, since the register sequence switch is in position 12, the line finder sequence switch in position 9 and the final selector sequence switch in position 1, will include and energize the stepping relay 66, Fig. 4, and the line relay 98, Fig. 3. The energization of the line relay 98 closes, through spring 150 bottom, a circuit to drive the final selector sequence switch into its second position in which the fundamental circuit will remain unchanged and the line relay energized but in which a circuit will be established to cause the power magnet to rotate the brush-chooser spindle, such circuit being through the front contact of the relay 98 and spring 151 bottom.

At each step taken by the brush choosing mechanism a path to ground from the battery side of the fundamental circuit is closed through the interrupter 507 of the brush-chooser and spring 152 top. The line relay 98 (Fig. 3) will remain energized until the fundamental circuit is again broken at the spring 64 (Fig. 4). Relay 66 (Fig. 4) however at each step of the brush-chooser is de-energized to restore the ten's register-controller disk, which in restoring closes after the required number of steps a circuit over spring 153 and spring 154 top to the sequence switch power magnet 205 and the register sequence switch moves into position 14. As the sequence switch moves from position 12 into position 14, the fundamental circuit is opened at spring 64 top, and relay 98 at the line switch (Fig. 3) will be deënergized when the brush-chooser comes into position to release the proper set of brushes. A circuit is closed from the back contact of relay 98 to sequence switch power magnet 505 over sequence switch spring 155 top, and this sequence switch now moves into position 5.

As explained above, the line or final selectors 500 are 200-point machines, arranged in 10 levels of 20 lines each, the first 10 terminals of each level corresponding to the even hundreds of the particular 200-line group, while the second 10 terminals of each level correspond to the odd hundreds of the particular 200-line group.

In the number under consideration, viz., 1149, the hundreds digit is odd, consequently the terminals of this line will be in the second half of the selected level of the final selector. Therefore in bringing the selected set of brushes upon the terminals of the desired line, it will be necessary to select the 20th terminal of the row, instead of the 10th. The register sequence switch in passing through positions 8 and 9 closes the circuit of the translating relay 156 (Fig. 4) at spring 157 top to contact 158 on the hundreds register. Since in the present instance the hundreds register has been set by an even number of impulses, that is;—an odd hundred, relay 156 is energized and locks itself in a local circuit through spring 70 top. The energization of relay 156 selects the second or sub-normal contact 159 of the units register r1 to control the termination of the units selecting operation, and this contact is arranged ten steps behind the normal, so that the units register

before closing this contact must step back as many steps as it was advanced by the impulses received from the subscriber, and ten steps in addition.

With the register sequence switch 205 (Fig. 4) at position 14, and the final selector sequence switch 505 (Fig. 3) at position 5, the control of the final or units selection in the final selector will take place. The fundamental circuit being closed at springs 99 and 97 bottom and the relays 98 and 66 being energized, a circuit for the brush carriage power magnet 506 of the final selector is closed by relay 98 over spring 160 top and the brushes 501^a, 502^a, 503^a, are rotated. Upon passing the brush choosing spindle the selected set of brushes is released and for each set of terminals reached the interrupter 510 at the top of the switch closes a ground circuit to the battery side of the fundamental circuit over spring 161 top and spring 152 top, and the stepping relay 66 is thus intermittently operated to close and open the local circuit containing the stepping magnet *si* of the units register-controller. It will be recalled that ten additional impulses are involved in this particular selection so that the register does not stop when the spring 190 is closed, but goes on until the spring 159 is closed, which will be after twenty impulses have passed through relay 66, when a circuit is closed for the power magnet of the register sequence switch 205 over spring 154 bottom, and right hand front contact of the relay 156. The register sequence switch 205 will move from its fourteenth position.

The register sequence switch moving out of position 14 interrupts at spring 72 the circuit through relays 52 and 54 (Fig. 1) individual to the calling line, whereupon these relays are deënergized, relay 54 disconnecting the register-controller equipment and relay 52 again connecting the subscriber's line to the terminals 101 and 102 of the line finder 100. Furthermore, the register sequence switch 205 moving out of position 14 opens the fundamental circuit at spring 64 top, and relay 98 (Fig. 3) is deënergized, as soon as the brushes are centered on the selected terminal, and opens the circuit through power magnet 506 at its front contact, at the same time closing the circuit through holding magnet 508 at its back contact and spring 162 top. The deenergization of the line relay 98 at this time also closes the circuit for sequence switch 505, which moves and is carried from position 5 to its 11th position by spring 511. The 8th position is used only in hunting trunks leading to a private branch exchange.

As the sequence switch 505 is moving into position 6, the register-controller circuits are clearing out, hence when the relay 52 (Fig. 1) is deënergized and when spring 97 top and spring 163 top, (Fig. 3) are closed, the subscriber is connected through to the bridge circuit at the final selector containing battery and a repeating coil 164, so that the relay 165 is energized. Relay 165 in turn closes a circuit for relay 98 over spring 166 bottom. At positions 6, 7 and 8 of the final selector sequence switch 505, the called line is being tested, the test circuit being from the middle point of the battery over the left hand winding of relay 167, spring 168 top, relay 169, brush 503^a, to the test terminal of the called subscriber's line, and through the cut-off relay 51 of this subscriber to full battery.

If the potential on the test terminal of the selected line is the full testing potential; that is if there is no other connection to ground from the conductor connected thereto, the relay 167 will be energized. The lowering of potential on this test terminal may result either from the fact that the line desired is already calling, in which case the connection to the test conductor is one similar to any one of those described hereinbefore, whereby the cut-off relay 51 of the calling line was energized, or it may be because some other final selector has seized such line as a called line and by means of the test circuit such as the one under discussion has served to operate the cut-off relay 51 of such line, corresponding to the relay 51 shown on Fig. 1.

Assuming that the line desired is idle, the relay 167 is energized and closes a circuit for the relay 170, which circuit includes the spring 181 bottom. Relay 170 is immediately energized and closes at its right hand armature a circuit, through the right hand winding of the relay 167 direct to the brush 503 in substitution for the original test circuit through the left hand winding of such relay as already traced. It should be noted that the relay 169 is polarized and its response depends upon the direction of current flow in the test circuit. The object of having this relay polarized, however, since it relates solely to private branch exchange trunk hunting and party line ringing, which features in themselves form no part of the invention herein, will not be discussed. It is sufficient to state that in all cases where the line selected and tested is an ordinary subscriber's line, the direction of the current in the test circuit will be such as to cause the relay 169 to attract its armature; consequently, when the sequence switch comes into position 8, it will find already prepared a circuit through the front contact of the right hand armature of the relay 169, and the spring 155 bottom. This circuit will drive the sequence switch out of its 8th position and it will, under the control of its spring 511, move into its 11th position. It

will be observed, however, that this circuit controlled by the polarized relay 169 for driving the sequence switch is necessary if the called line on being tested is found idle as in that case the energization of the test relay 167 in position 6 or position 7 and as a result thereof the locked energization of the relay 170 establishes a circuit for the final sequence switch in its 8th position through the front left hand outer contact of relay 170 and spring 155 bottom. In any case therefore if the line tested is either an ordinary subscriber's line or is an idle line of any character the sequence switch will not stop in its 8th position.

It will be observed that when the relay 170 was energized in the 6th and 7th positions of the sequence switch it closed for itself a locking circuit including its inner left front contact and the spring 177. This circuit is maintained until the sequence switch passes out of its 9th position. In the 9th position, however, the sequence switch closes another locking circuit for the relay 170, through spring 178 bottom and front contact of the line relay 98. This circuit will be opened as the sequence switch passes out of its 11th position. At this time another circuit has been established for relay 170 including the front contact of relay 167 and the spring 181 bottom; this circuit is closed in the 11th and 12th positions of the sequence switch. In the 12th position of the sequence switch the original locking circuit for the relay 170 is reëstablished through the spring 177 bottom. It will thus be observed that in the normal operation of the system when the selected line has been found idle and the calling subscriber has not replaced his receiver upon its hook, the relay 170, having been energized in the 6th or 7th position of the final sequence switch, will be maintained energized until the restoration of the final selector apparatus has begun.

When the final sequence switch arrives in its 11th position, it is immediately driven to the 12th position by a circuit over the spring 155 bottom and the outer left front contact of the relay 170. In the 12th position the ringing current is applied to the desired line over left hand armature of the relay 169, ringing cut-off relay 171, spring 172 bottom and brush 502^a, and ground over spring 173 bottom and brush 501^a. Depending upon the polarity of the current source connected to the cut-off relay of the desired line, the relay 169 will determine whether positive or negative ringing current will be applied to the called line. The passage of the ringing current through the relay 171 will not energize such relay so long as the talking circuit is open at the subscriber's sub-station. When, however, the called subscriber answers by removing his receiver from its hook, the talking circuit is closed and sufficient current will pass through relay 171 to energize it. It thereupon closes a circuit for the final selector sequence switch through the spring 150 top, and the sequence switch will move into its 13th position. This is the talking position.

As the sequence switch 505 moves into position 13, the relay 98 is no longer controlled by the relay 165 alone but is now jointly controlled by both relays 165 and 175. This change in control is for the purpose of controlling the breaking down of the connection from either the calling or called station.

Disconnecting and message registering or coin collecting.—The breaking down of the connection may result from either the calling or called subscriber restoring his receiver to the switch-hook. In either case, however, the subscriber whose receiver has not been restored will be held locked to the connection so that his line circuit will not assume a condition as if calling, and seize a registering and controlling equipment.

It will be assumed that the called subscriber 174 restores his receiver to the switch-hook first. Relay 175 will then be deënergized, thereby opening the circuit of relay 98. Relay 98 on being deënergized, closes a circuit for sequence switch 505 over spring 155 top, which thereupon moves from position 13 into position 15. In positions 14 and 15 a circuit is again closed over front contact of relay 165 and spring 166 bottom and relay 98 again becomes energized.

When the sequence switch reaches its fifteenth position it is continued in motion by a circuit over spring 178 top, inner left armature of relay 170, front contact of relay 167, and spring 181 bottom. It thereupon moves into position 17, deënergizing relay 170 by the opening of spring 181 as it leaves position 15, which circuit has maintained the relay 170 energized since in position 14 the locking circuit through spring 177 was opened.

The deënergization of the relay 170 removes the test guard or condition of lowered potential from the test conductor of the called subscriber's line by opening at its right hand armature the circuit to the test brush through the right hand (low resistance) winding of the relay 167. The subscriber's line which has in the connection described been the called line is now free to be tested and seized by some other connection in course of establishment, or since its cut-off relay is no longer energized, to initiate a call.

As the sequence switch is passing through position 16 it completes the necessary circuits for causing the charging operation in any message register or toll device which may be associated with the calling line. The operation of the message register 63 shown

in Fig. 1 is accomplished by the closure thereto of a circuit including the registering battery 179 which battery is of sufficient potential to insure the operation of such register. The circuit is from battery 179, through the inner left hand armature of the self-locking relay 176, springs 180 and 92[a], terminal 403, brush 403[a], spring 95 top, brush 104[a] and terminal 104 of the finder switch, back contacts of the bottom armatures of the relays 55 and 54, message register 63 to ground and back to battery. It should be noted that this circuit was prepared by the locking up in the 13th position of the final sequence switch of the locking relay 176. This relay can only be energized in the thirteenth position of this sequence switch and then only if the called party's control or disconnecting relay 175 is energized. Having once been energized it is maintained locked up until the sequence switch has left its sixteenth position by a circuit through its right hand armature and front contact and spring 184 bottom. It will therefore be seen that while the message registering circuit is directly controlled by the final sequence switch in its sixteenth position, such circuit is prepared only in case the called subscriber has answered. This is for the reason that it is obvious that the relay 175 cannot be energized in the thirteenth position of the final selector sequence switch if the called line having been found busy the final selector had been restored to normal position in the eleventh position of such sequence switch (as will be hereinafter described) or if after connection had been extended to such line the subscriber had not closed the energizing circuit for such relay 175 by removing his receiver from the hook. Correspondingly the operation of a toll device associated with the calling line will be directly controlled by the final selector sequence at spring 163 bottom and spring 97 bottom, while the character of current transmitted will be controlled by the locking relay 176. That is to say, if the call has been successful the relay 176 being locked up the sequence switch will apply positive operating current from the front contact of the outer left hand armature of the relay 176 to the circuit of the calling line to charge the call by means of the spring 163 bottom. If on the other hand the call has not been successful the current transmitted to the line will be negative operating current from the back contact of the outer left hand armature of the relay 176 (such relay not having been energized) and such current will cause the charge for the call to be rebated. Furthermore, if the calling line has both a message register and a toll device associated with it, both will be operated as required in the sixteenth position of the sequence switch precisely as described, the circuits being prepared by the locking relay 176 and closed by the sequence switch.

As the final selector sequence switch passes out of its position 16 it opens the springs 97 bottom, 163 bottom and 92[a]. This opens entirely at the final selector the circuit of the trunk line leading from the terminals of the group selector for purposes to be described hereafter.

When the sequence switch arrives in position 17 it will find closed for its power magnet 505 a circuit over the left hand back contact of relay 170 and spring 150 top. It will therefore move into its eighteenth position.

When the final selector sequence switch passes from position 17 to position 18 a circuit is closed for the power magnet 506 over spring 160 bottom, back contact of relay 167, and spring 181 bottom, and the brush carriage is caused to move to normal. When it reaches normal position a circuit over interrupter 510, insulated segment 182, and spring 183 bottom energizes relay 167 by its left hand winding which opens the circuit of the power magnet 506 and closes circuit to the holding magnet 508 over spring 162 bottom. The energization of relay 170 due to the energization of relay 167 also completes a circuit for the sequence switch 505 over spring 155 bottom, causing the sequence switch to move from its 18th to its first or normal position.

It was explained above that when the sequence switch 505 moves into position 17, the circuit leading to terminal 403 of the group switch 400 is interrupted. This causes the deënergization of relay 90 (Fig. 2). The sequence switch at the group selector is at this time in position 9, and relay 90 when deenergized closes circuit to sequence switch 105 over spring 79 bottom, driving it into position 11. In positions 10 and 11 an earth connection is closed to the terminal 101 of the line finder 100 at spring 83 bottom, and battery is connected with the terminal 102 over relay 80 and spring 84 top, the holding circuit to the subscriber's cut-off relay 51 remaining closed at spring 96 top. If now the disconnect was originated by the called subscriber, as has been assumed, and the calling subscriber's telephone is still off its hook, relay 80 will be energized at position 11 of the sequence switch 105, and will hold the calling subscriber's line locked to the connection until he restores his receiver. When the receiver is restored, relay 80 is deënergized, and a circuit is closed for sequence switch 105 over spring 92[b] top, whereupon it moves into position 12. On leaving position 11, the circuit to cut-off relay 51 was interrupted at spring 96 top and the test guard indicating that the line was in use is

removed from the calling subscriber's line in all the final selectors in which it appears. With the sequence switch 105 at position 11 or 12, a circuit is closed to the power magnet 406 over spring 91 top and back contact of relay 90, and the brush carriage is rotated until the interrupter brush 410 contacts with the stop plate 186 when a circuit is closed to relay 90 over spring 187, which relay breaks the circuit of the power magnet 406 and closes a circuit to the holding magnet 408, so that the brush carriage is arrested at its normal position. Relay 90 at its front contact also closes a circuit to the finder sequence switch 105 through spring 92^b bottom and it moves from position 12 to normal position.

Considering now the case where the calling subscriber is the first to replace his telephone receiver on its switch-hook. Immediately the circuit of the relay 98 (Fig. 3) is interrupted at the front contact of relay 165 and a circuit is closed thereby to the sequence switch 505 now in position 13, by way of spring 155 top, driving it into position 15 from which position it will be immediately driven by the same circuit into position 17.

In position 16 of the final sequence switch a circuit is established through spring 166 top and the front contact of relay 175 for the relay 176. As the sequence switch reaches its seventeenth position although this circuit is maintained, the locking circuit for this relay 176 is opened at spring 184 bottom, so that now though the energization of the relay 176 and the restoration of the final selector depend entirely upon the relay 175 the called subscriber's line is not released.

In position 16 of the final selector sequence switch the operation of the message register or coin collector of the calling substation took place irrespective of which subscriber first replaced his receiver to its hook. At position 17 the conductor leading to terminal 403 of the group switch 400 is opened at spring 92^a bottom and the restoration of the group selector and the freeing of the calling line take place precisely as explained above. Relay 98, however, being deënergized while the final selector sequence switch is passing from position 14 to position 17, keeps the relay 170 locked over its back contact spring 178 top, and middle armature and front contact of the relay 170, thereby maintaining the test guard upon the called line. As soon as the called subscriber also replaces his receiver upon its hook-switch the relay 175 becomes deënergized, opening the circuit of the relay 176, which being deënergized, closes a circuit to relay 98 over spring 184 top, and spring 152 top. Relay 98 energized, breaks the circuit of the relay 170, which deënergizes and opens the circuit of the conductor leading to the test terminal 503 of the called subscriber's line circuit, and restoration of the final selector and its sequence switch to normal condition takes place as before explained.

Calling a busy line.—Had the desired line been busy, neither of the test relays 167 and 170 would have been energized at positions 6, 7, and 8 of the final selector sequence switch, hence when it reaches position 11, the relay 170 would not have been energized and the sequence switch stops in such position. Furthermore the relay 167 not having been energized a circuit will be closed for the power magnet 506 through spring 160 bottom, spring 181 bottom, and the brush carriage will rotate to its normal position, at which point the interrupter brush 510 makes contact with the insulated metal segment 182, closing a circuit over spring 183 bottom, to relay 167, said relay opening the circuit of magnet 506 at its back contact and closing a circuit to holding magnet 508 at its front contact. At the same time it closes a circuit for relay 170, which in turn closes a circuit over spring 155 bottom to sequence switch 505 which moves into position 12. Since the brushes of the line switch are at their normal position, a circuit is closed in positions 12 and 13 through interrupter brush 510, and spring 183 top for sequence switch 505. It therefore moves into position 15, as it moves into position 14, closing a circuit over spring 166 and front contact of the relay 165, to energize relay 98. In position 15 the busy-back circuit at spring 185 bottom is closed to the repeating coil 164, to inform the calling subscriber that the line called is busy. When the calling subscriber restores his receiver to the switch-hook, the deënergization of relay 165 causes relay 98 to be deënergized and close a circuit to sequence switch 505 over spring 155 top, whereupon it moves into position 17.

The sequence switch in passing through position 16, does not register or charge the call since relay 176 has not been operated. However, at the back contact of the left hand outer armature of relay 176 current of proper character is applied to the circuit of the calling subscriber to cause the rebating of the charge for the call in the well-known manner. As the sequence switch reaches position 17, it opens the circuit leading to terminal 403 of the group switch 400 at spring 92^a, which causes the deënergization of the relay 90 at the group selector and the restoration of such selector and its associated apparatus, as also the restoration to normal of the calling subscriber's line to take place forthwith, as has been hereinbefore described, the finder sequence switch not stopping in its eleventh position, as the circuit of the calling substation being open the relay 80 is not energized.

When the final sequence switch reaches

position 17, it will find the relay 170 de-energized and the restoration to normal of the final sequence switch will immediately take place, the final selector already being in its normal position, and the circuits for driving the sequence switch out of its eighteenth position being already prepared.

Premature disconnection.—By reference to Figs. 1 and 4 it will be seen that the relay 68 is included in the circuit extending from battery through the subscriber's station and back to the relays 65, 66, and also that such relay 68 is so located in this circuit that it will only be deënergized by the opening of the circuit, being wholly unaffected by the grounding of the circuit at the sender mechanism. So long, therefore, as the normal operation of the sender and registering and controlling mechanism progresses, the relay 68 will remain energized, and in the 9th position of the register sequence switch a locking circuit is closed for it through sequence switch spring 188ª. If at any time after the register sequence switch has left its normal position the relay 68 should be deënergized, such sequence switch would be driven continuously by a circuit including the back contact of relay 68 and spring 188 until it had passed out of its fourteenth position, from which stage of operation the entire registering and controlling equipment would restore itself to normal prepared for a new cycle of operation.

The relay 80, Fig. 2, in the fifth position of the finder sequence switch is also controlled in parallel with relay 68, Fig. 4, by the circuit extending to the subscriber's station. In this position deënergization of this relay 80 will drive the finder sequence switch into its seventh position and if on arriving in such position the fundamental circuit has not already been closed at the registering and controlling equipment the same circuit will be maintained for the sequence switch and drive it into its eighth position, and the immediate restoration to normal of the finder sequence switch will take place, the group selector being already in its normal condition, no selection having taken place. This restoration of the finder sequence switch will be controlled by circuits hereinbefore described in connection with the description of normal disconnection after the sequence switch has reached its ninth position. To drive it out of its eighth position a circuit is established through spring 79 top and back contact of relay 75; the circuit including the spring 194 which in the normal operation would maintain this relay energized being open at the contacts 407 of the group selector brush chooser which is in its normal position. It will be apparent therefore that if the calling subscriber should abandon the call at any time before the registration of the designation of the desired line is complete the deënergization of the relays 68 and 80 would cause the registering and controlling equipment and the finder switch apparatus respectively, immediately to be restored to normal ready to be used in connection with some subsequent call. The register sequence switch on reaching its fifteenth position in this restoration would establish in turn circuits to restore any of the register-controllers that might be in an off-normal position. This same operation takes place in the normal operation of the system shown to restore the thousands register-controller, the hundreds and units register-controllers, if either or both of them are in their subnormal positions or any other position than their true normal position, and the tens register-controller if by any mischance it is not in its normal position. In the fifteenth position of the register sequence switch a circuit is closed from the thousands register restoring magnet *s*1000 through spring 192 top to the impulser 191. The restoring magnet *s*1000 being intermittently energized steps the disk of the thousands register-controller in a counter clockwise direction until in the normal position thereof the contact 189 is closed, when a circuit for the register sequence switch is closed over spring 89 top, and moving out of its fifteenth position it opens spring 192 top thereby preventing any further movement of the thousands register-controller disk. In position sixteen a similar circuit is closed over spring 192 bottom for the magnet *s*100 and the hundreds disk is stepped in a counter clockwise direction until in its true normal position a circuit is closed to the sequence switch over spring 89 bottom the normal contact 86 of the hundreds register-controller and the contact 87 top of the thousands register controller. Similarly the tens register-controller if off normal will be restored in the seventeenth position by a circuit over spring 193 top, and upon reaching normal will cause the sequence switch to be moved to its eighteenth position by a circuit including the spring 154 top and normal contact 153. In this position, the eighteenth, the units register-controller will be restored by a circuit over the spring 193 bottom and on reaching its true normal position by closing a circuit over the spring 154 bottom, the normal contact 190 and the back contact of the relay 156, the locking circuit for this relay having been opened at spring 70 top when the sequence switch left its fifteenth position. The entire registering and controlling equipment is now in normal condition.

The abandonment of the call by the calling subscriber at any time after registration is complete, that is, after the register sequence switch has left its eighth position

will have no effect until selection in the final selector is complete. This is accomplished by the same means that prevents such subscriber from interfering maliciously or otherwise with the proper progress of the selection-controlling operation, that is by the energization of the second cut-off relay 52, Fig. 1. This relay which is energized, as has been before described, as soon as registration is complete disables the calling subscriber's line by opening it at both of its armatures and maintains it disabled until selection is complete, that is when the final selector sequence switch leaves its fifth position and the register sequence switch leaves its fourteenth position. Now when the final selector comes into its tenth position no circuit for energizing the relay 170 will exist as the relay 98 is not energized, the calling subscriber having hung up his receiver and opened his substation circuit. Having been deënergized in position 10 the relay 170 cannot be energized in position 11 and the sequence switch will stop in such position. The deënergization of the relay 170 in position 10 has removed the test guard from the selected line and caused the deënergization of the test relay 167. The final selector therefore restores to its normal condition just as has been described in considering the selection of a busy line, only in this case the sequence switch will not stop in position 15 as the busy tone is unnecessary the subscriber having abandoned the call, and the circuit for driving the sequence switch into position 17 being already prepared as the armature of the relay 98 is already attracted. Restoration proceeds from this point as has been already described. Of course if the line selected had been busy the relay 170 would have had its armatures in their retracted position when the sequence switch reached position 10 and restoration would have taken place in a similar manner.

If the calling subscriber abandons the call while the ringing of the called subscriber is going on, that is, in the twelfth position of the final selector sequence switch, the consequent retraction of the armature of the relay 98 will establish a circuit for the sequence switch 505 over spring 155 top, which circuit will also be closed in the thirteenth and fifteenth positions of the sequence switch and it will move directly into its seventeenth position, where the relay 175 being energized the restoration of the final selector apparatus will take place as in the normal operation of the system as has been before described.

In all cases when the final selector sequence switch moves out of its sixteenth position and by opening the spring 92ª has caused the deënergization of the relays 90 and 93 of the group selector, the restoration of the group selector and the finder switch apparatus will take place as has been fully described.

It should be noted that in each of the selectors shown the brush-choosing device is restored to normal either in the talking position of the respective sequence switches or in a subsequent position if the talking position was not maintained sufficiently long to complete its restoration. The restoring circuit of the group selector brush-chooser includes that contact of the device 407 which is closed at all times except when the tripping spindle of the brush-chooser is in normal position and the spring 88 top. Similarly the restoring circuit for the brush-chooser of the final selector includes the corresponding contact of the device 507 and the spring 151 top.

I claim:—

1. In an automatic telephone exchange system, the combination with a plurality of lines, a registering and controlling equipment at the exchange, means for associating the same with a calling line, a connecting circuit including a calling line finder switch and a group selector, and a selection controlling circuit leading from said equipment to said group selector through contacts of said calling line finder switch.

2. In an automatic telephone exchange system, the combination with a plurality of lines, a registering and controlling equipment at the exchange, means for associating said equipment with a calling line, a line finder, and means controlled by said equipment when so associated for causing said line finder to seek for and connect with said calling line.

3. In an automatic telephone exchange system, the combination with a plurality of lines, senders at the calling end thereof, a registering and controlling equipment at the exchange adapted to record the designation of the desired line, means for associating said equipment with a calling line, a plurality of connecting circuits terminating in line finders, and means actuated by said equipment while recording such designation to start an idle line finder to connect with said line.

4. In an automatic telephone exchange system, the combination with a plurality of lines, a registering and controlling equipment at the exchange, means for associating said equipment with a calling line, and means for thereafter preventing interference with said controlling equipment by another of said lines.

5. In an automatic telephone exchange system, the combination with a group of lines, a plurality of registering and controlling equipments, means for operatively associating an idle equipment with a calling line, means for isolating said equipment and

for causing an idle equipment to be accessible to the remainder of said lines.

6. In an automatic telephone exchange system, the combination with a plurality of lines, a registering and controlling equipment controllable over any one of said lines, and relays for operatively associating said equipment with calling lines.

7. In an automatic telephone exchange system, the combination with a plurality of lines, registering and controlling equipments to be set from a calling substation, and relays adapted to connect an idle equipment with a calling line and render the same inaccessible to the remainder of the lines.

8. In an automatic telephone exchange system, the combination with a group of lines, registering and controlling equipments accessible to each of said lines, and relays individual to the lines adapted when energized by a calling condition of a line to connect an idle equipment direct with the calling line conductors.

9. In an automatic telephone exchange system, the combination with a plurality of lines, a registering and controlling equipment, means for associating the same with said lines, senders at the calling ends of said lines for operating said registering and controlling equipment, selectors adapted to extend the connection under control of said equipment, and switches associated with said equipment and controlled by the number of impulses transmitted by the sender to cause selection of the desired line by said selectors in accordance with some other numerical system than that under which the equipment was set by said impulses.

10. In an automatic telephone exchange system, the combination with a plurality of lines, a registering and controlling equipment, means for connecting the same to said lines, senders associated with said lines for transmitting groups of impulses to said equipment according to the designation of the desired line, selectors controlled by said equipment, and switches associated with said equipment and controlled by the numbers of impulses contained in the said groups of impulses adapted when the equipment controls said selectors to vary the number of one or more of the said individual groups to cause the selection of the desired line according to the grouping arrangement of the lines on said selectors.

11. In an automatic telephone exchange system, the combination with a plurality of lines, a register controller device, means for associating the same with said lines, senders associated with said lines for operating said register controller device, a selector adapted to extend the connection under control of said device, and a switch associated with said device and controlled by the number of impulses transmitted by the sender, said switch controlling a plurality of circuits by any one of which during the controlling operation of said selector it may terminate the travel thereof, the particular circuit closed depending upon the number of impulses transmitted by the sender to said register controller device.

12. In an automatic telephone exchange system, the combination with a plurality of lines, a registering and controlling equipment comprising a series of register controller devices, senders associated with said lines for transmitting a group of impulses to each of said register controller devices, selectors controlled by said equipment, and means associated with one of said devices for determining according to its set position, determined by the number of impulses contained in the corresponding group, which of a plurality of alternative operations shall take place in another of said devices when selection is taking place.

13. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment, means for associating said equipment with said sender to receive the groups of impulses corresponding to the digits of the number of the desired line, and a sequence switch for preparing said equipment to receive the different groups of impulses transmitted by said sender.

14. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of register controller devices, means for associating said devices successively with said sender to receive the groups of impulses corresponding to the digits of the number of the desired line, selectors for extending the connection, and a sequence switch adapted successively to place said register controller devices into operative relation with the corresponding selectors to control their selecting operation.

15. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices, selectors for extending the connection, and a sequence switch adapted to place the said register controller devices successively in operative relation to the sender to receive the groups of impulses representing the digits of the desired line.

16. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices, selectors for extending the connection, and a sequence switch adapted to place the said register

controller devices successively in operative relation to the sender to receive the groups of impulses representing the digits of the desired line, and to place said register controller devices successively into operative relation to the corresponding selectors to control selection.

17. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the number of the desired line transmitted by said sender, selectors for extending the connection, and means for placing the said register controller devices successively in operative relation to the sender to receive said groups of impulses, and to place said register controller devices successively into operative relation to the corresponding selectors to control selection, and after the various selectors have operated establishing circuits to restore said register controller devices to normal position.

18. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the number of the desired line transmitted by said sender, selectors for extending the connection, and a sequence switch adapted to place the said register controller devices successively in operative relation to the sender to receive said groups of impulses, and to place said register controller devices successively into operative relation to the corresponding selectors to control selection, and after the various selectors have operated establishing circuits to restore said register controller devices to normal position.

19. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the number of the desired line transmitted by said sender, selectors for extending the connection, and means for placing the said register controller devices successively in operative relation to the sender to receive said groups of impulses and successively to place said register controller devices into operative relation to the corresponding selectors to control selection, and an impulser, said impulser being successively associated with said register controller devices after the various selectors have operated, to restore said devices.

20. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the number of the desired line transmitted by said sender, selectors for extending the connection, and a sequence switch adapted to place the said register controller devices successively in operative relation to the sender to receive said groups of impulses and successively to place said register controller devices into operative relation to the corresponding selectors to control selection, and an impulser, said impulser being successively associated with said register controller devices after the various selectors have operated, to restore said devices.

21. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment, means for associating said equipment with said sender to receive the groups of impulses corresponding to the number of the desired line, an electromechanism adapted to prepare said equipment to receive the different groups of impulses, and a timing device controlling said electromechanism.

22. In a telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the number of the desired line transmitted by said sender, a fast-acting relay responding to all impulses in said groups, and a timing device adapted at the conclusion of transmission of each series of impulses to the corresponding register controller device to shift the operative relation of the fast acting relay to the next register controller device.

23. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the number of the desired line transmitted by said sender, an electromechanism adapted to place the said register controller devices successively in operative relation to the sender to receive said groups of impulses and a slow-acting relay controlling said electromechanism.

24. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the

number of the desired line transmitted by said sender, a slow acting relay responding only between the transmission of groups of impulses, a fast acting relay responding to all impulses in the groups, and an electromechanism for placing said fast acting relay successively in operative relation to said register controller devices, the changeover operation by said electromechanism being controlled by said slow acting relay.

25. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment comprising a series of registering and controlling devices adapted to receive the groups of impulses corresponding to the digits of the number of the desired line transmitted by said sender, an electromechanism, a slow and a fast acting relay associated with said equipment and adapted to be associated with the sender of the calling line, said slow-acting relay when so associated causing said electromechanism to operatively associate the first register controller device with the fast-acting relay to receive the first group of impulses. and upon its deënergization at the conclusion of the registration of said group of impulses to operatively associate the next register controller device with said fast acting relay, maintaining such association upon the closing of its circuit prior to the transmission of the next group of impulses.

26. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment at the exchange adapted to be associated with a calling line to record the designation of the desired line, selectors adapted to extend the connection under control of said equipment, a switch adapted to be actuated in initiating a call for associating said sender with said equipment and means actuated by the premature restoration of said switch for restoring said equipment without affecting said selectors.

27. In an automatic telephone exchange system, the combination with a plurality of lines, a plurality of connecting circuits, finders for associating idle connecting circuits with calling lines, test conductors for said lines terminating on said finders, interrupters carried by said finders, means actuated in initiating a call for causing a finder to seek the line wherein said call has originated, the continuation of travel of said finder in seeking said line being controlled alternately over test conductors of non-calling lines and a circuit established by the interrupter of said finder.

28. In an automatic telephone exchange system, the combination with a plurality of lines, a plurality of connecting circuits, finders for associating idle connecting circuits with calling lines, test conductors for said lines terminating on said finders, interrupters carried by said finders, means actuated in initiating a call for causing a finder to seek the line wherein the call has originated, the continuation of travel of said finder in seeking said line being controlled alternately over test conductors of non-calling lines and a circuit established by the interrupter of said finder, the said interrupter circuit causing the travel of the finder switch to continue after the calling line terminals are reached until the brushes are centered on said terminals.

29. In an automatic telephone exchange system, the combination with a plurality of lines, finder and selector switches to which said lines are multipled as calling and called lines respectively, means for connecting said finders to calling lines, a registering and controlling equipment, means for associating said equipment with a calling line independently of the association of said line with a finder switch, and means actuated in initiating calls for rendering said lines selectable by said finders but non-selectable by said selectors.

30. In an automatic telephone exchange system, the combination with a plurality of lines, finder and selector switches upon which said lines are multipled as calling and called lines respectively, a relay actuated in initiating a call in one of said lines, and a contact arm controlled thereby for rendering said line selectable by said finders but non-selectable by said selectors.

31. In an automatic telephone exchange system, the combination with a plurality of lines, automatic finder and selector switches for interconnecting said lines, a pair of relays at one of said selectors, one for the calling and one for the called line controlling disestablishment of the connection, means actuated by the operation of the calling party's control relay for causing the restoration to normal position of said finder and selectors except the final one of said selectors connected with the called line, and means controlled by the operation of the called party's control relay for causing the restoration to normal position of said selectors without affecting the connection of the finder with the calling line.

32. In an automatic telephone exchange system, the combination with a plurality of lines, finder and selector switches for interconnecting said lines, a relay at the finder, a pair of relays at the final selector, one for the calling and one for the called line controlling disestablishment of the connection, means actuated by the calling party's control relay for restoring to normal condition all of said selectors except the final one connected to the called line, and means actu-

ated when the called party's control relay is actuated first to transfer the control of the restoration to normal of the apparatus of the calling subscriber's line to said relay associated with the line finder operated when the calling subscriber performs the disconnecting act.

33. In an automatic telephone exchange system, the combination with a plurality of lines, registering and controlling equipments, means for associating an idle equipment with a calling line, a plurality of finders, and a distributing switch for controlling the starting in operation of a line finder and controlled by the registering and controlling equipment associated with the calling line.

34. In an automatic telephone exchange system, the combination with a plurality of groups of lines, a plurality of registering and controlling equipments for each group, means for associating idle equipments with calling lines, a plurality of line finders, and a distributing switch under the control of the registering and controlling equipments of each line group adapted to respond to the seizure of an equipment by a calling line to start the next idle line finder switch of said group hunting for such calling line.

35. In an automatic telephone exchange system, the combination with plurality of groups of lines, a plurality of registering and controlling equipments for each group, means for associating idle equipments with calling lines, a plurality of line finders, and a distributing switch under the control of the registering and controlling equipments of each group adapted to respond to the seizure of an equipment by a calling line to start the next idle line finder switch of said group hunting for such calling line, and to preselect another idle line finder switch so that upon the seizure of a registering and controlling equipment by another calling line the distributing switch is prepared forthwith to initiate the operation of said line finder.

36. In a telephone exchange system, the combination with a plurality of lines, automatic switches for interconnecting said lines, a supervisory or disconnect relay under the control of the calling line at one of said switches, and a line relay at said switch controlling the selecting operation thereof, said line relay operating in the control of the selecting operation independently of said supervisory relay.

37. In a telephone exchange system, the combination with a plurality of lines, automatic switches for interconnecting the same, a line relay at one of said switches controlling its selecting operation during the establishment of the call and initiating its restoration upon the disestablishment of the call, and a disconnect relay for the calling line, said line relay upon the establishment of the connection being controlled by said disconnect relay.

38. In a telephone exchange system, the combination with a plurality of lines, automatic switches for interconnecting the same, supervisory or disconnect relays at one of said switches, for the calling and called lines, a line relay at said switch controlling its selecting operation and the initiation of the disconnecting operation, said line relay being placed under the joint control of both said supervisory relays upon the establishment of the talking connection.

39. In a telephone exchange system, the combination with a plurality of lines, automatic switches for interconnecting the same, a repeating coil at the final one of said switches, and disconnect relays one on each side thereof for the calling and called lines.

40. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, automatic switches for interconnecting said lines, a registering and controlling equipment comprising a series of registering and controlling devices, means for connecting the same with said lines to receive the designation of the desired line from said senders, and with said automatic switches to control selection, and means for preventing interference by the subscriber with such control.

41. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, automatic switches for interconnecting said lines, a registering and controlling equipment, means for connecting the same with said lines to receive the designation of the desired line from said sender, and means actuated upon completion of registration for disabling the calling line to prevent interference with the selector control.

42. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, automatic switches for interconnecting the same, a registering and controlling equipment, means for associating the same with said lines to record the designation of the desired line, a circuit adapted to actuate said means upon the initiation of a call, said circuit including a relay which operates upon the completion of the registration of the call to so affect the calling line that interference with the selector control is prevented.

43. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, automatic switches for interconnecting said lines, a registering and controlling equipment, means for connecting the same with said lines to record the designation of the desired line, and a relay adapted to be oper-

ated upon the completion of registration to open the calling line circuit during the selector control period.

44. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, automatic switches for interconnecting said lines, a registering and controlling equipment, means for associating the same with said lines to record the designation of the desired line, a circuit adapted to actuate said means upon the initiation of a call, said circuit including a marginal relay operating upon an increased flow of current upon the completion of registration to prevent interference by the calling line with the selector control, means for causing such increased flow at the termination of registration and means for deënergizing said relay upon completion of the selector controlling operation to reëstablish the calling line circuit.

45. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment, selectors controlled thereby for interconnecting said lines, means for associating said equipment with said lines, a cut-off relay associated with a calling line, and alternative circuits for said relay one of which at least will maintain it excited at all times during which such line is in active coöperation with said automatic apparatus.

46. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment, finders and selectors controlled thereby for interconnecting said lines, means for associating said equipment with said lines, a cut-off relay associated with said lines, the initial energization of said cut-off relay being under control of said equipment associating means and being thereby maintained energized until such line has been extended through a finder, a circuit associated with said finder, said circuit maintaining the said relay energized until disestablishment of the connection.

47. In an automatic telephone exchange system the combination with a plurality of lines, a line finder switch adapted to extend said lines, a line relay and a cut-off relay associated with each line, said cut-off relay being responsive to the first automatic operation initiated by said line relay to cut off said line relay from said line before it has been extended by said line finder switch.

48. In an automatic telephone exchange system, the combination with a plurality of lines, senders associated therewith, a registering and controlling equipment, a line relay controlling the association of said equipment with a calling line, and a cut-off relay first operated upon such association to cut off said line relay from the said line.

Signed at Antwerp, in the Province of Antwerp and Kingdom of Belgium, this 20th day of August 1912.

FRANK R. McBERTY.

Witnesses:
G. De Lersy,
N. Adams.