G. W. & J. H. LORIMER.

G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

AUTOMATIC TELEPHONE EXCHANGE.

APPLICATION FILED NOV. 26, 1901. RENEWED JUNE 5, 1918.

1,294,285. Patented Feb. 11, 1919.

22 SHEETS—SHEET 1.

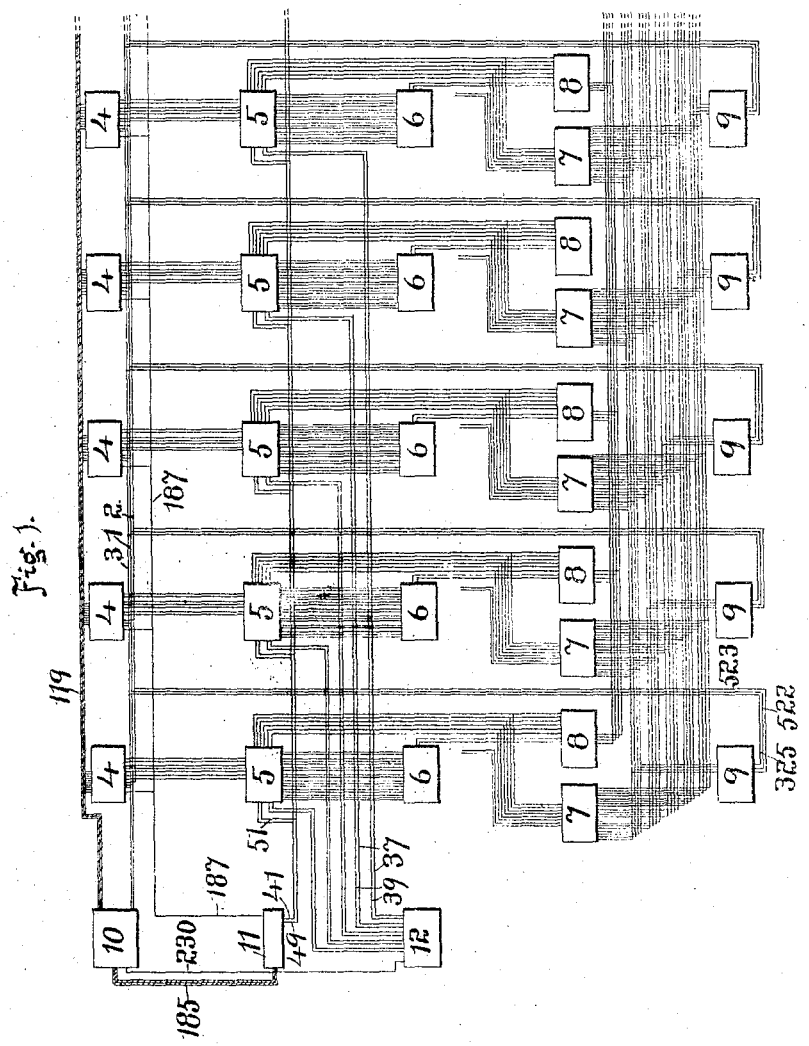

Fig. 1.

Witnesses:
Otto Greenberg
H. C. Townsend

Inventors
G. W. Lorimer
G. W. Lorimer
adm'r of the estate of
J. H. Lorimer

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G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

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22 SHEETS—SHEET 2.

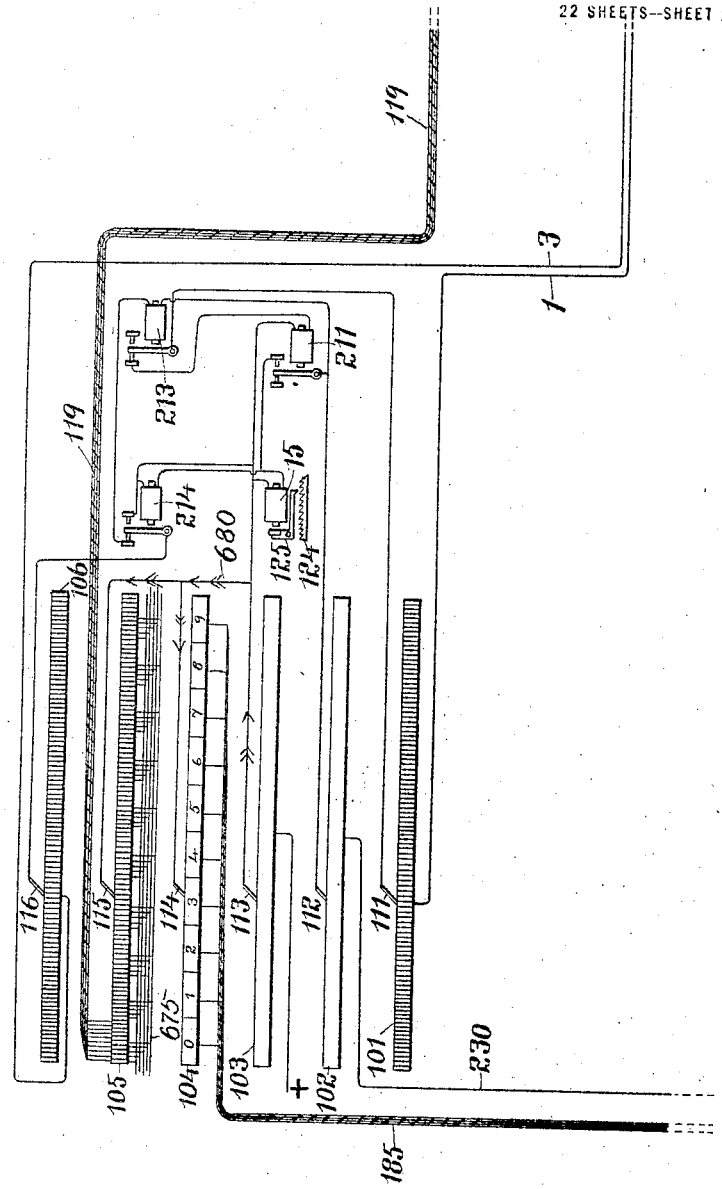

Fig. 2.

Witnesses:
Otto Eisenberg
H. C. Townsend

Inventors
G. W. Lorimer
G. W. Lorimer
Admr's of the estate of
J. H. Lorimer

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22 SHEETS—SHEET 3.

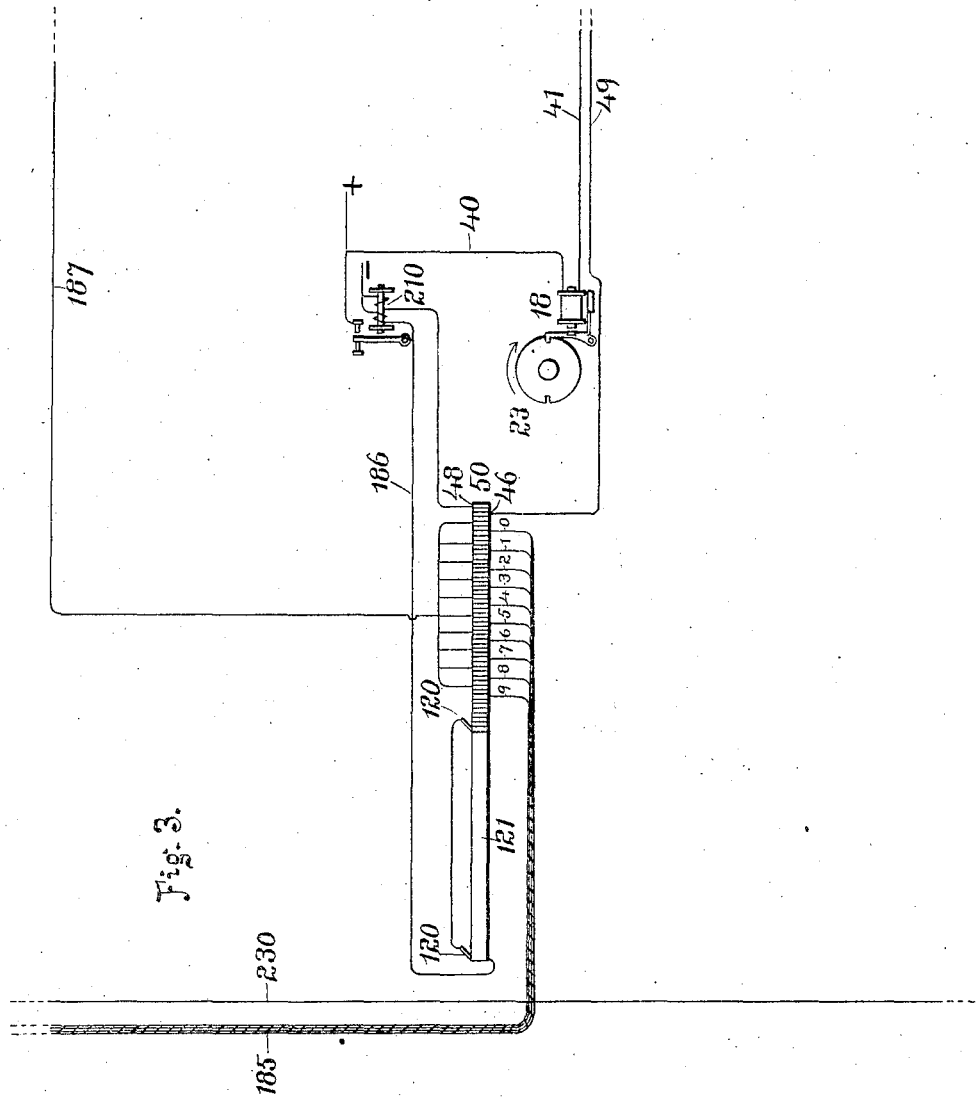

Fig. 3.

Witnesses:
Otto Greenberg.
H. C. Townsend

Inventors
G. W. Lorimer
G. W. Lorimer
Adm'r of the estate of
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22 SHEETS—SHEET 4.

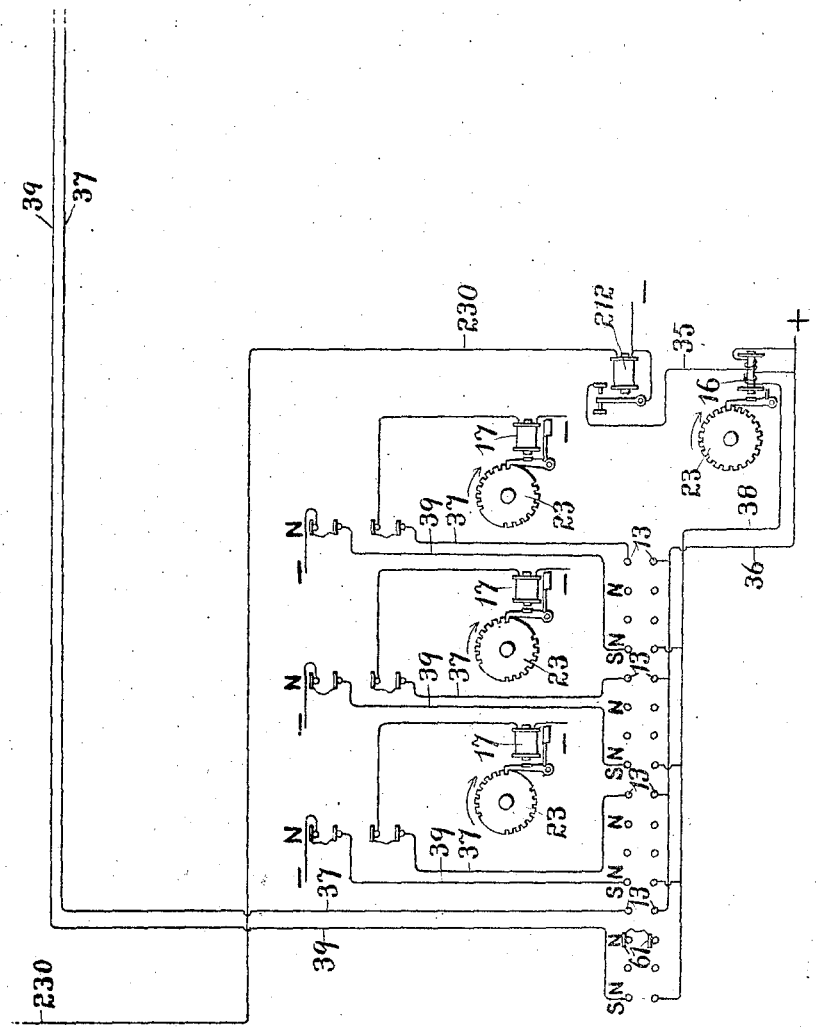

Fig. 4.

Witnesses:
Otto Isenberg
A. L. Townsend

Inventors
Geo. W. Lorimer
Geo. W. Lorimer
Adm'r of the estate of
J. H. C. Lorimer

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22 SHEETS—SHEET 5.

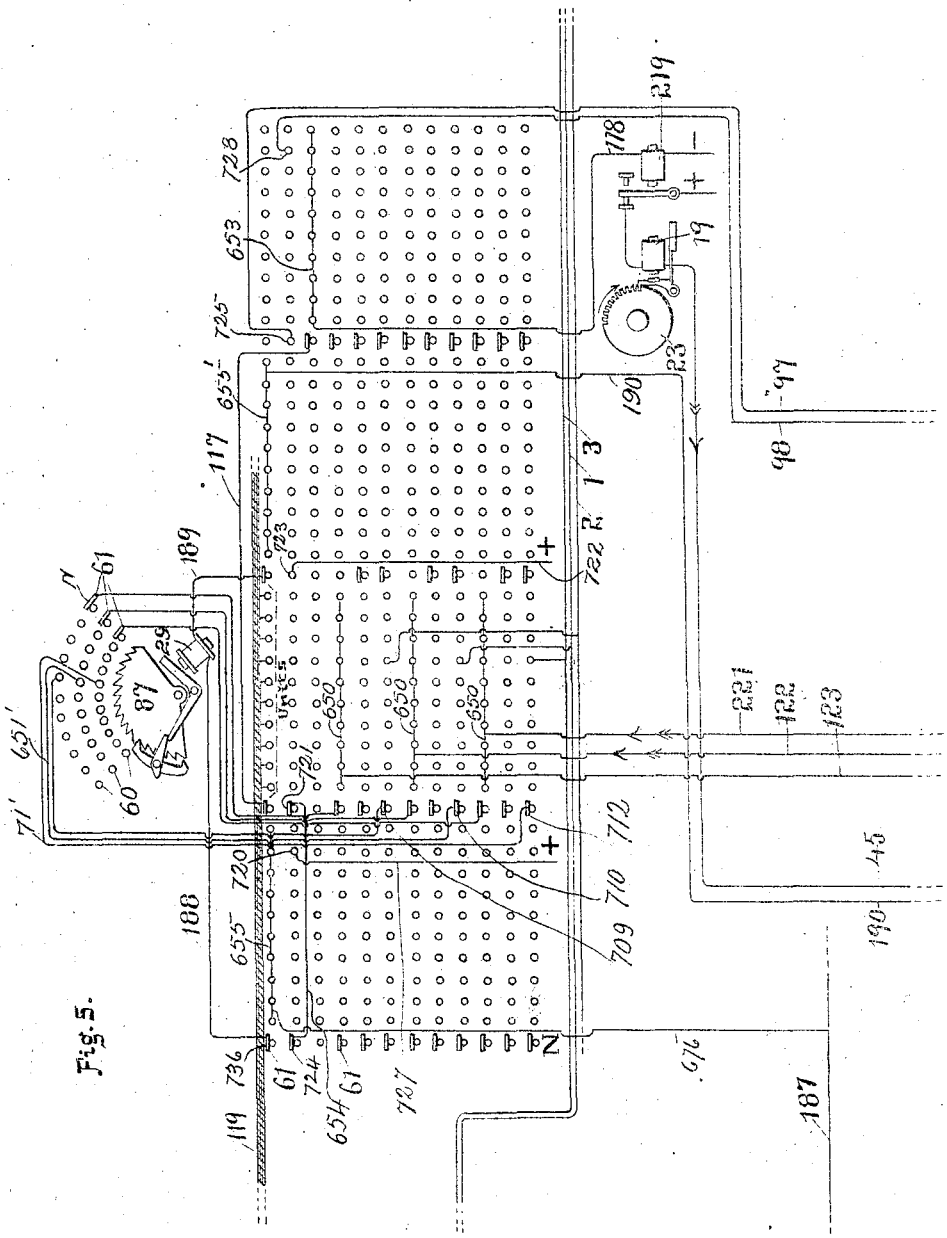

Fig. 5.

Witnesses:
Otto Greenberg
H. L. Simmons

Inventors
G. W. Lorimer
G. W. Lorimer
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AUTOMATIC TELEPHONE EXCHANGE.

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Patented Feb. 11, 1919.

22 SHEETS—SHEET 6.

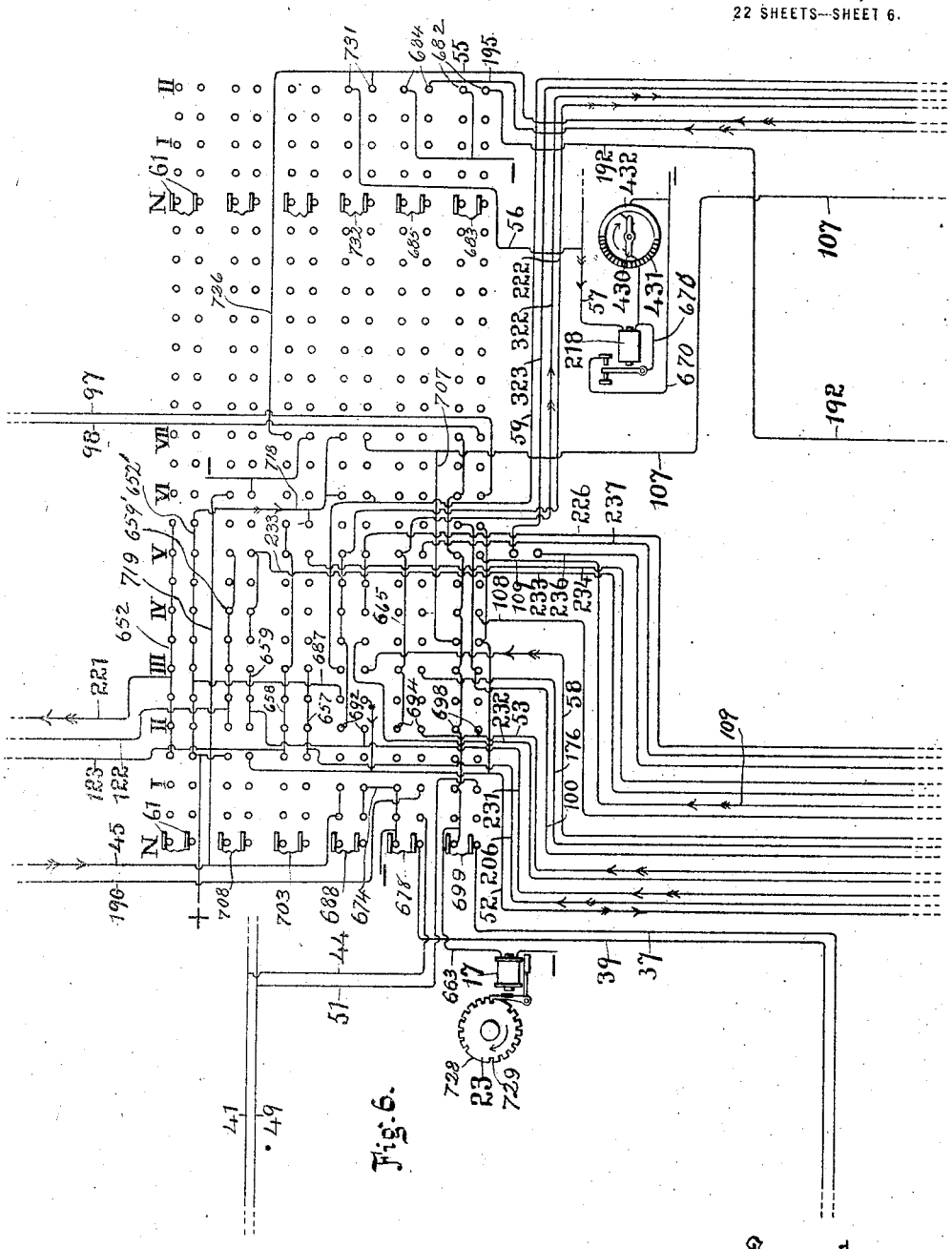

Fig. 6.

Witnesses:
Otto Isenberg
H. C. Townsend

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AUTOMATIC TELEPHONE EXCHANGE.

APPLICATION FILED NOV. 25, 1901. RENEWED JUNE 5, 1918.

1,294,285. Patented Feb. 11, 1919.

22 SHEETS—SHEET 7.

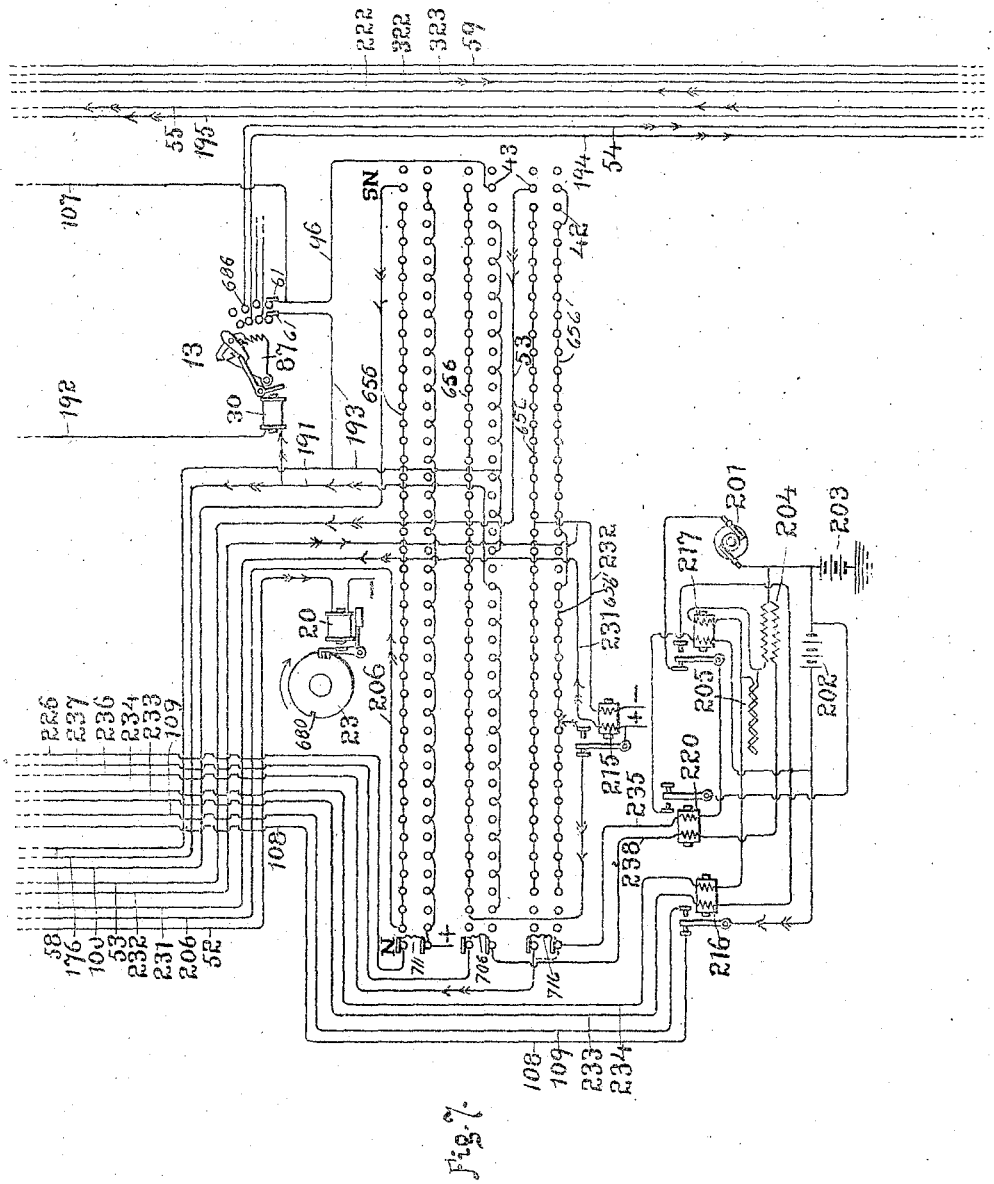

Fig. 7.

Witnesses:
Otto Greenberg
H. C. Townsend

Inventors
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Admr's of the estate of
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AUTOMATIC TELEPHONE EXCHANGE.

APPLICATION FILED NOV. 26, 1901. RENEWED JUNE 5, 1918.

1,294,285.

Patented Feb. 11, 1919.

22 SHEETS—SHEET 8.

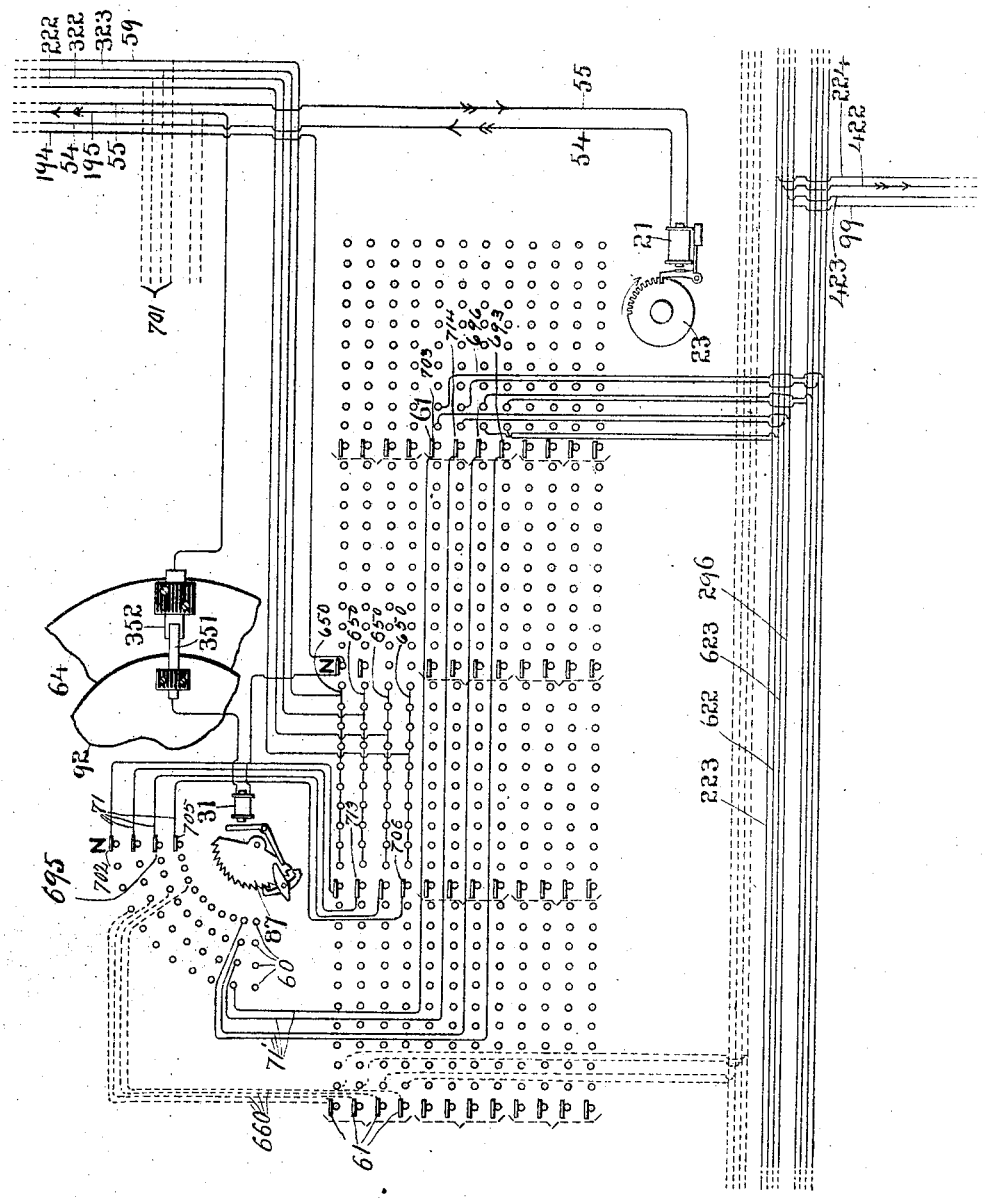

Fig. 8.

Witnesses:
Otto Greenberg
H. C. Townsend

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Admr's of the estate of
J. H. Lorimer

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Patented Feb. 11, 1919.

22 SHEETS—SHEET 9.

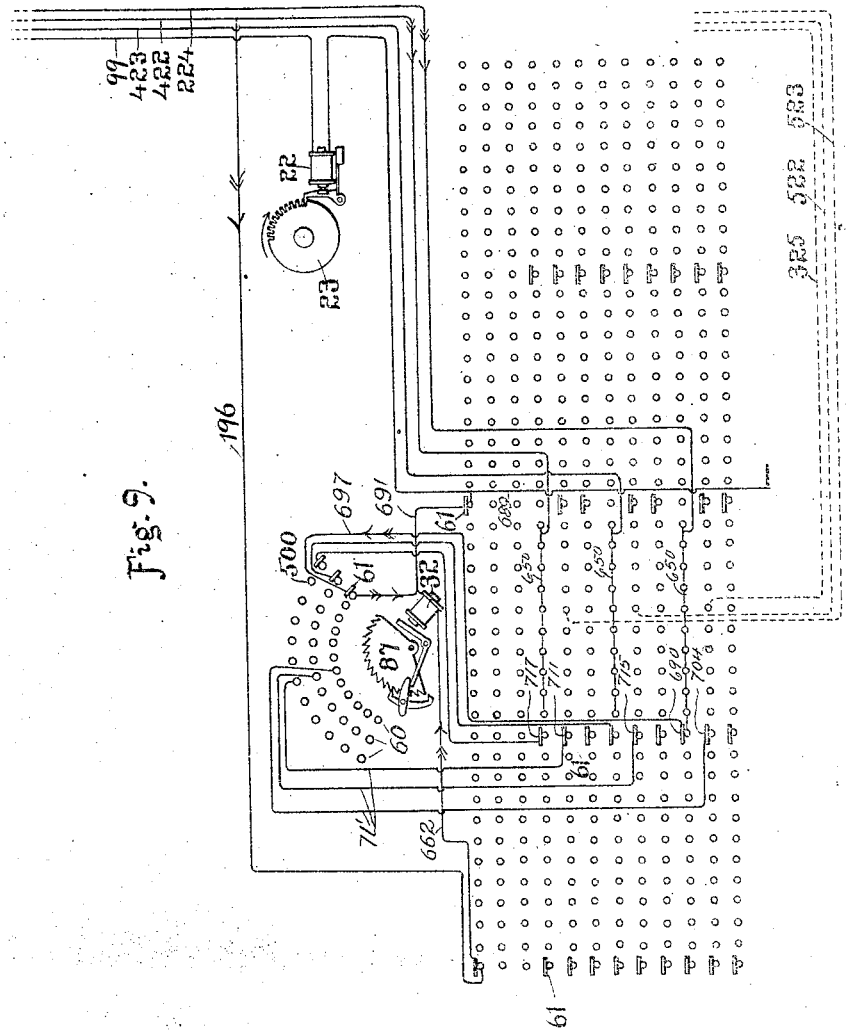

Fig. 9.

Witnesses:
Otto Greenberg
O. G. Townsend

Inventors
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Geo. Lorimer
Exec's of the estate of
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AUTOMATIC TELEPHONE EXCHANGE.

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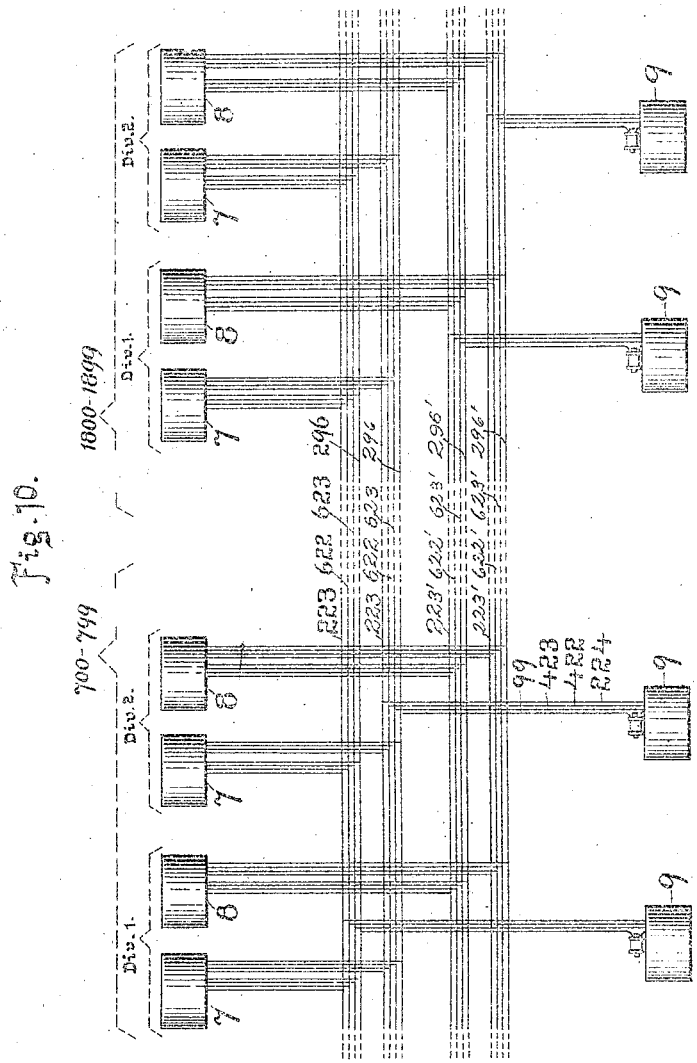
1,294,285. Patented Feb. 11, 1919

22 SHEETS—SHEET 10.

Fig. 10.



Witnesses:
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H. C. Townsend

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G. W. Lorimer
Admr's of the estate of
J. H. Lorimer.

G. W. & J. H. LORIMER.

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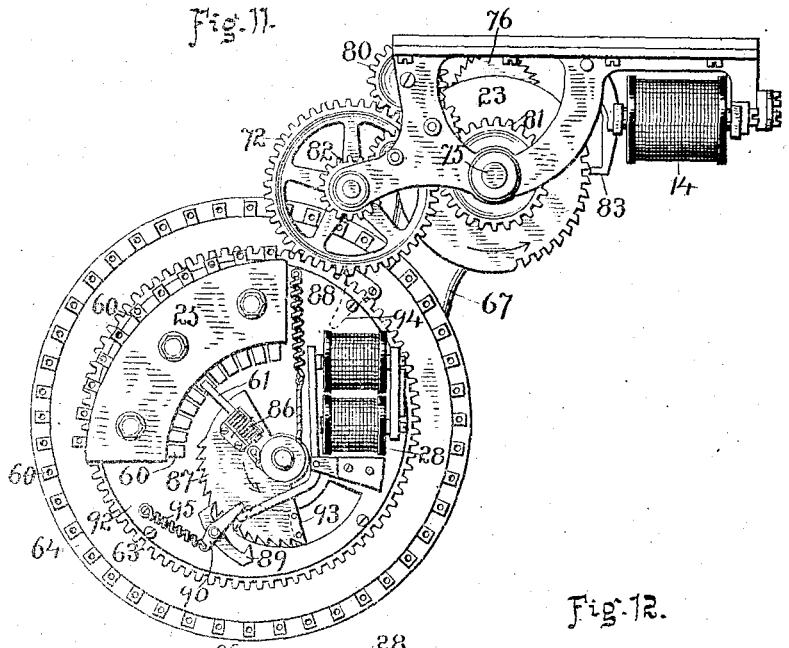
22 SHEETS—SHEET 11.

Fig. 11.



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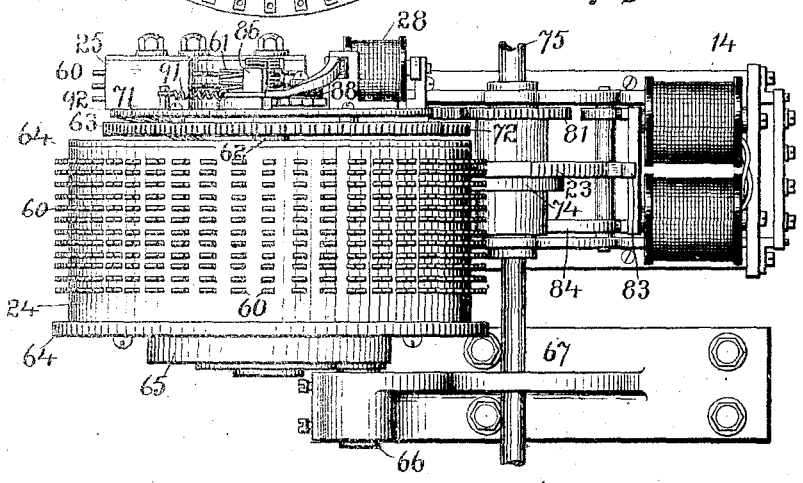

Witnesses:
Otto Greenberg
O. L. Townsend

Inventors
Geo. Lorimer
Geo. Lorimer
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J. H. Lorimer

G. W. & J. H. LORIMER.

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22 SHEETS—SHEET 12.

Fig. 12.

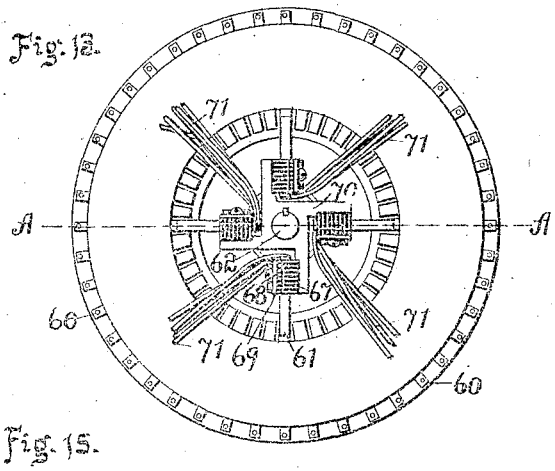
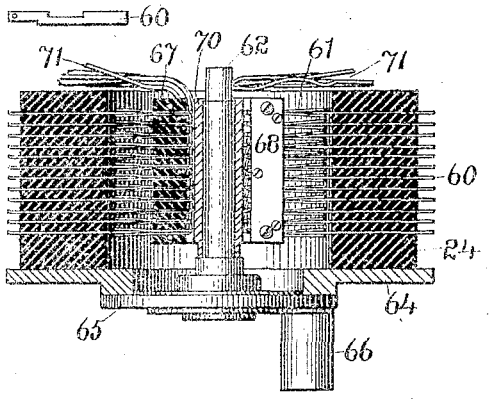


Fig. 15.

Fig. 14.



Witnesses:
Otto Greenberg
H. C. Timmons

Inventors
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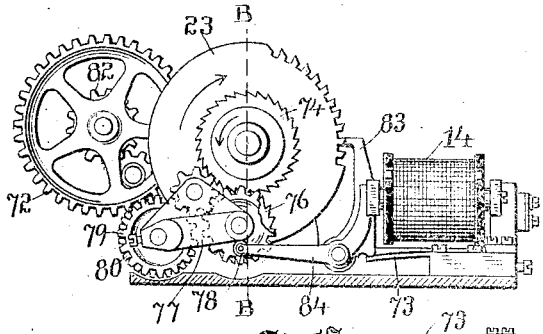
22 SHEETS—SHEET 13.

Fig. 16.



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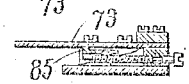

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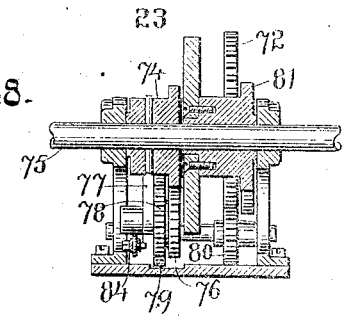

Witnesses:
Otto Greenberg
H. C. Townsend

Inventors
Geo. W. Lorimer
Geo. W. Lorimer
Administrator
J. H. Lorimer

G. W. & J. H. LORIMER.

G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

AUTOMATIC TELEPHONE EXCHANGE.

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1,294,285. Patented Feb. 11, 1919.

22 SHEETS—SHEET 14.

Fig. 19.

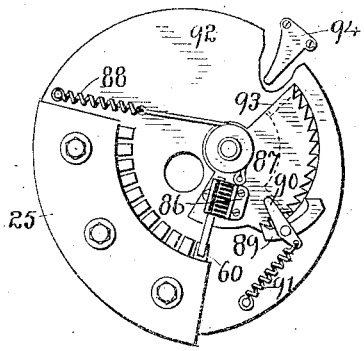
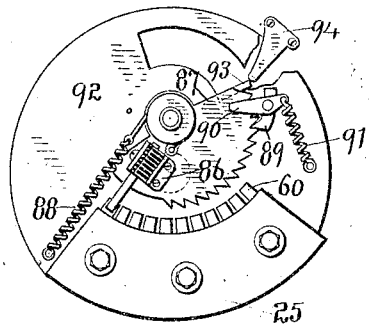


Fig. 20.



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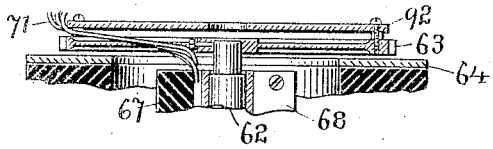
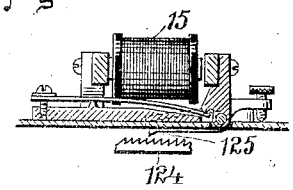


Fig. 28.



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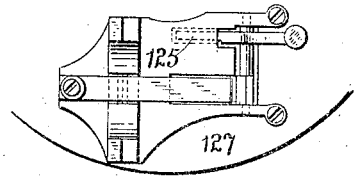

Witnesses:
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H. Townsend

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Geo. W. Lorimer
Admr's of the estate of
J. H. Lorimer

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AUTOMATIC TELEPHONE EXCHANGE.

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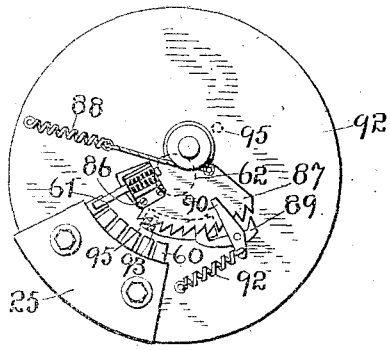
22 SHEETS—SHEET 15.

Fig. 22.



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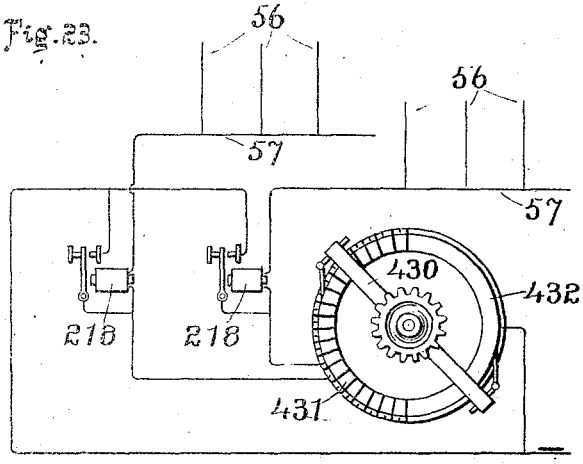

Witnesses:
Otto Greenberg
L. Townsend

Inventors
G. W. Lorimer
G. W. Lorimer
admr's of the estate of
J. H. Lorimer

G. W. & J. H. LORIMER.

G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

AUTOMATIC TELEPHONE EXCHANGE.

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22 SHEETS--SHEET 16.

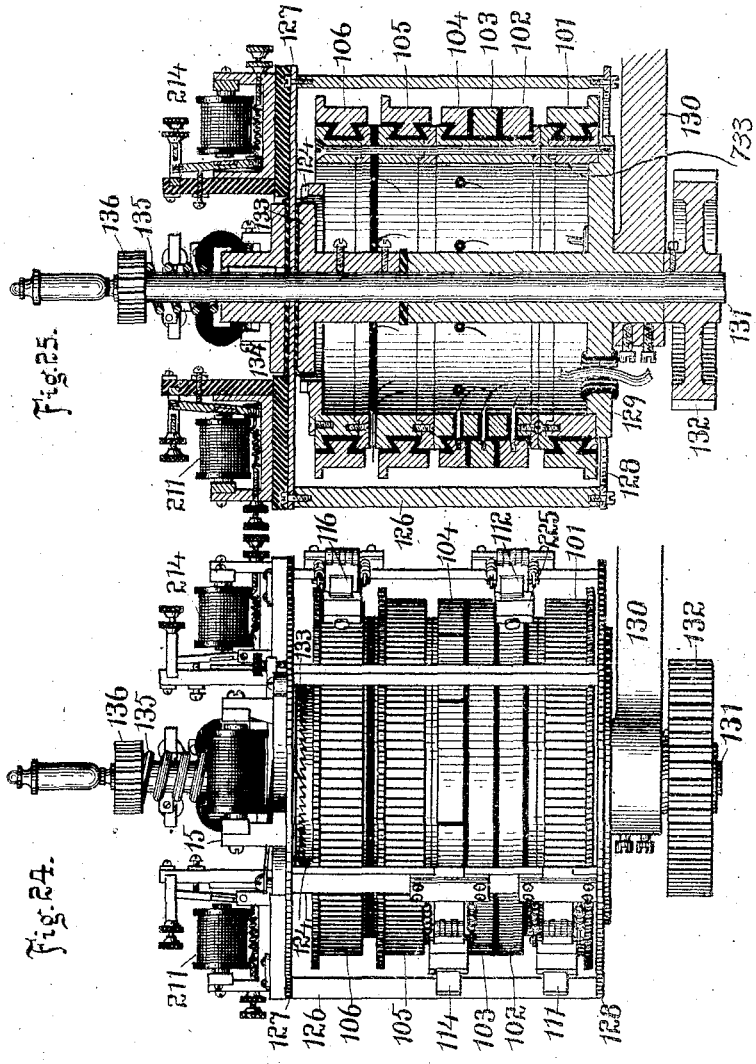

Fig. 25.

Fig. 24.

Witnesses:
Otto Greenberg
H. C. Townsend

Inventors
G. W. Lorimer
G. W. Lorimer
Admrs of the estate of
J. H. Lorimer

G. W. & J. H. LORIMER.

G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

AUTOMATIC TELEPHONE EXCHANGE.

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Patented Feb. 11, 1919.

22 SHEETS—SHEET 17.

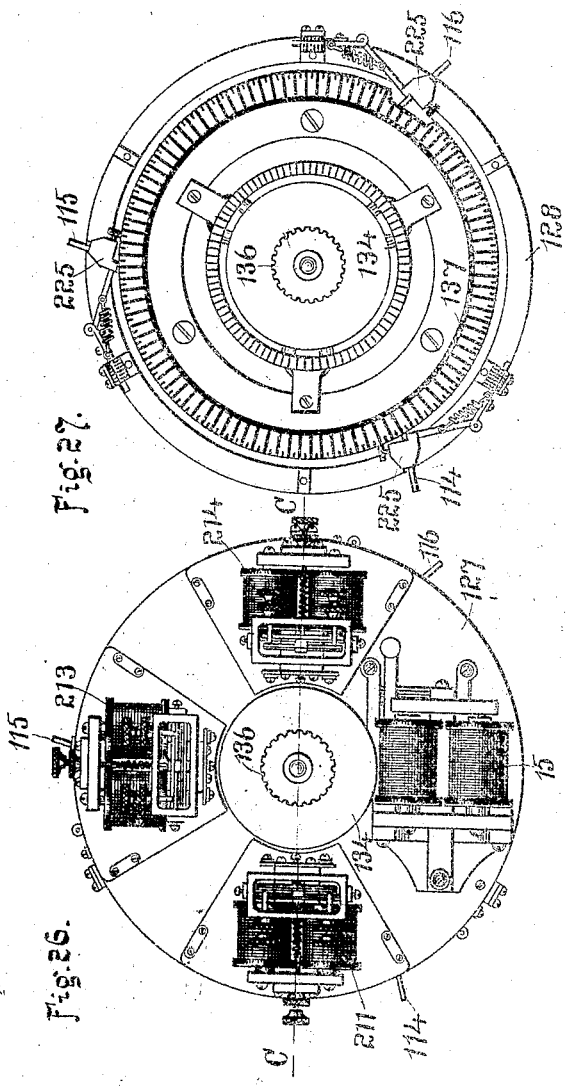

Fig. 27.

Fig. 26.

Witnesses:
Otto Greenberg
H. C. Townsend

Inventors
Geo. Lorimer
Geo. Lorimer
Admr's of the estate of
J. H. Lorimer

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G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

AUTOMATIC TELEPHONE EXCHANGE.

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1,294,285.

Patented Feb. 11, 1919.

22 SHEETS—SHEET 18.

Fig.30.

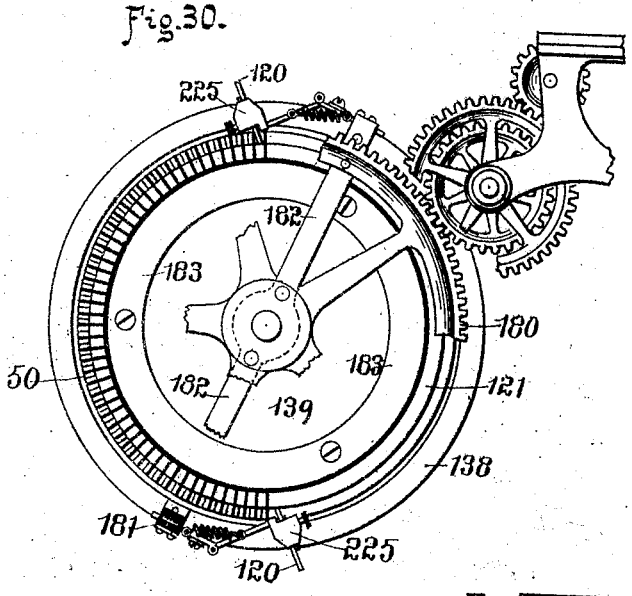
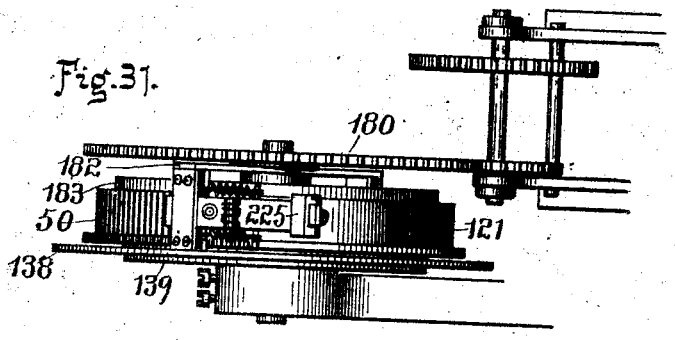


Fig.31.



Witnesses:
Otto Greenberg
H. Townsend

Inventors.
G. W. Lorimer
G. W. Lorimer
adm'r of the estate of
J. H. Lorimer

G. W. & J. H. LORIMER.

G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

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APPLICATION FILED NOV. 26, 1901. RENEWED JUNE 5, 1918.

1,294,285. Patented Feb. 11, 1919.

22 SHEETS—SHEET 19.

Fig. 33.

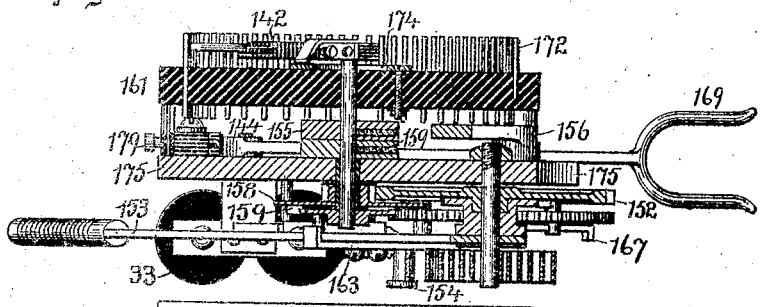
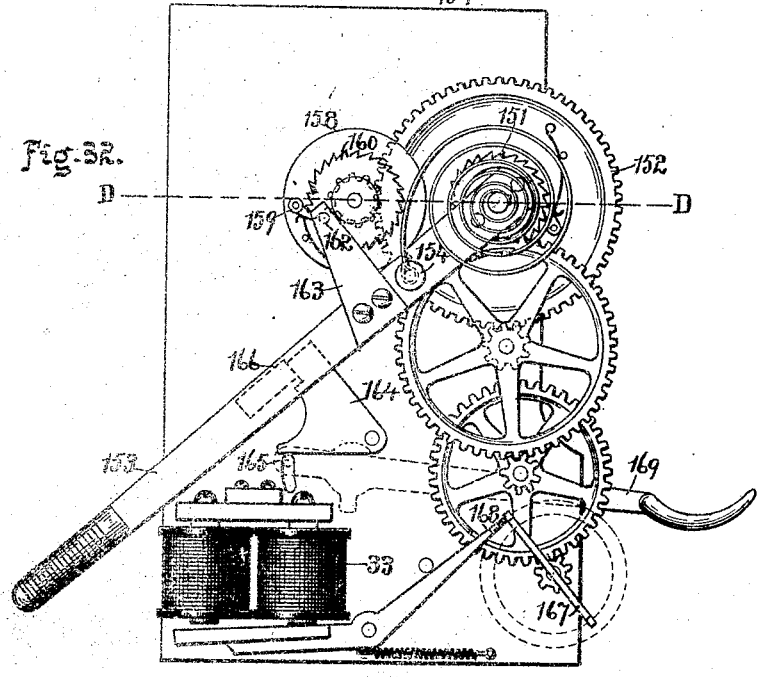


Fig. 32.



Witnesses:
Otto Greenberg
A. L. Townsend

Inventors
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G. W. Lorimer
admr's of the estate of
J. H. Lorimer

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G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

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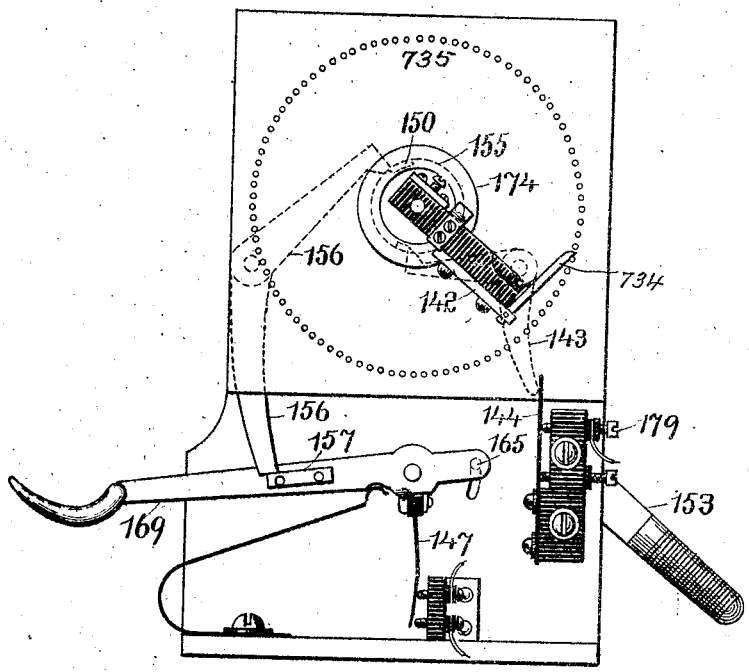
APPLICATION FILED NOV. 26, 1901. RENEWED JUNE 5, 1918.

1,294,285.

Patented Feb. 11, 1919.

22 SHEETS—SHEET 20.

Fig. 34.



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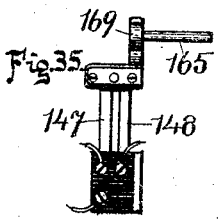

Witnesses:
Otto Greenberg
H. C. Townsend

Inventors
G. W. Lorimer
G. W. Lorimer
admr's of the estate of
J. H. Lorimer

G. W. & J. H. LORIMER.

G. W. LORIMER, ADMINISTRATOR OF J. H. LORIMER, DEC'D.

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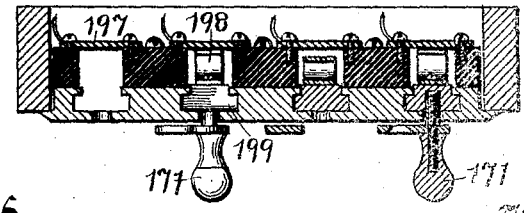
1,294,285. Patented Feb. 11, 1919.

22 SHEETS—SHEET 21.

Fig. 37.



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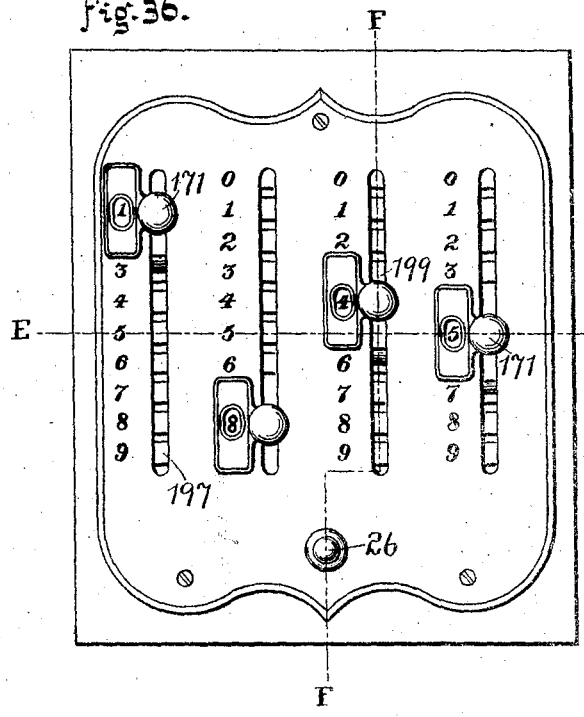
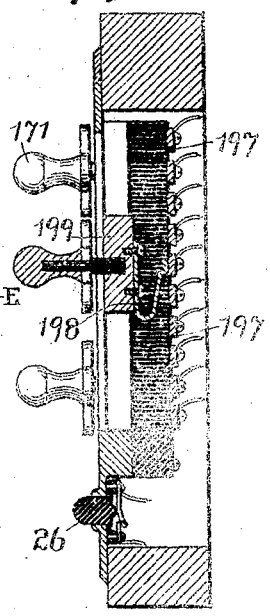


Fig. 38.



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AUTOMATIC TELEPHONE EXCHANGE.

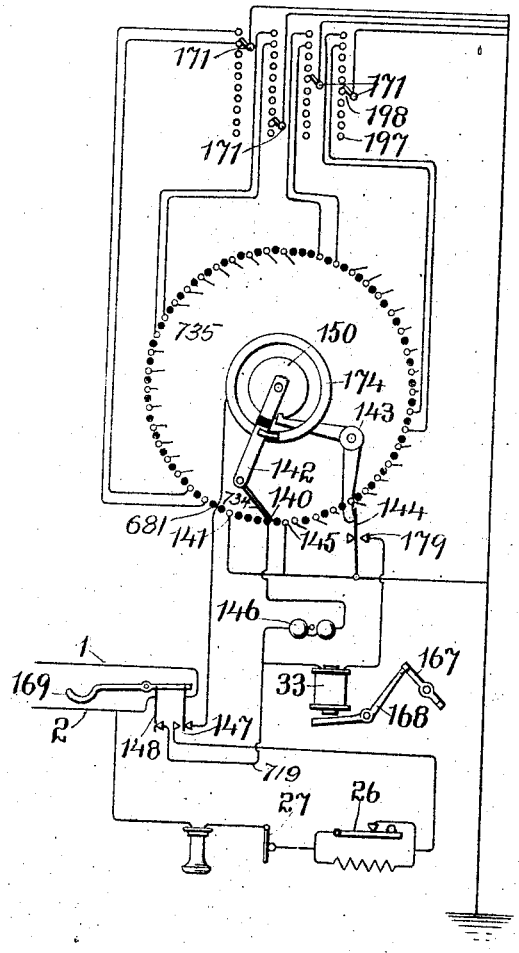
APPLICATION FILED NOV. 26, 1901. RENEWED JUNE 5, 1918.

1,294,285.

Patented Feb. 11, 1919.

22 SHEETS—SHEET 22.

Fig. 39.



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UNITED STATES PATENT OFFICE.

GEORGE WILLIAM LORIMER AND JAMES HOYT LORIMER, DECEASED, OF PIQUA, OHIO, BY GEORGE WILLIAM LORIMER, ADMINISTRATOR, OF PIQUA, OHIO, ASSIGNORS, BY MESNE ASSIGNMENTS, TO WESTERN ELECTRIC COMPANY, INCORPORATED, A CORPORATION OF NEW YORK.

AUTOMATIC TELEPHONE-EXCHANGE.

1,294,285. Specification of Letters Patent. **Patented Feb. 11, 1919.**

Application filed November 26, 1901, Serial No. 83,691. Renewed June 5, 1918. Serial No. 238,399.

To all whom it may concern:

Be it known that we, GEORGE WILLIAM LORIMER, a subject of the King of Great Britain, resident of Piqua, in the county of Miami and State of Ohio, and JAMES HOYT LORIMER, deceased, late a subject of the King of Great Britain, have invented certain new and useful Improvements in Automatic Telephone-Exchanges, of which the following is a specification.

This invention relates to that class of apparatus known as automatic exchanges whereby any one of a number of substations, such for instance, as telephone subscribers' stations may be put in electrical connection with any other substation without requiring the services of central office operators, through the automatic operation of central office apparatus common to the substations and controlled by them over wires or circuits connecting said substations with the central office.

The invention claimed in the present application relates more particularly to the employment of central energy for talking, signaling and for adjusting central exchange apparatus as disclosed in our prior application for patent filed April 24th, 1900, Serial No. 14,075.

The first part of the invention claimed in the present application and described in our previous application before referred to relates to the employment of central energy not only for the purpose of controlling or actuating those parts of the exchange apparatus which require to be set to different positions according to the different numbers of the various subscribers' stations, but also for the purpose of oral transmission by the usual contact or battery transmitters at subscriber's station and also for ringing up the called subscriber.

One part of our invention consists, broadly, in the use of central energy for talking combined with means controlled by a signal from a subscriber's station for connecting said source of central energy and a repeating induction coil with the calling and called subscribers' circuits after the setting of the exchange apparatus to the desired positions by the selecting impulses.

Another part of the invention consists in the use of central energy for signaling controlled as hereinafter described and claimed.

Our present application also relates to certain improvements on the apparatus described in our prior application before referred to, and the object of this part of the invention is to prevent racing or interference with the position of the called subscriber's signal transmitter by the action of the ringing current in case his transmitter should be in the preliminary impulse position at the instant the calling subscriber presses his button.

To this end the invention consists in the provision at the central office of a suitable relay operated over a circuit completed by the movement of the called subscriber's transmitter to preliminary impulse position and acting at the central office upon the circuits thereof to prevent the ringing currents from going to the called subscriber's station and changing or disturbing the position of his apparatus when the calling subscriber presses his button. The calling subscriber will then get the line busy indication, and will desist from the attempt to call, while the called subscriber will be left free to continue his call.

In our prior application, as in the present case, we have described a subdivision of the subscribers' or substation lines into groups, each group comprising any convenient or desired number of lines, say for example, 100, and the provision for each group of main lines, of groups, sets or divisions of telephone exchange switching apparatus constituting practically duplicates of one another and adapted alike to be used by any one of the substations of a group of lines for effecting connection with the line of another substation. In practice as many sets or divisions are employed as may be necessary to permit the maximum number of substations to be accommodated that will probably desire to use the exchange at the same time. Experience having demonstrated that the maximum is under ordinary commercial conditions from 7 to 10 simultaneous connections, there would be provided for each group of lines or section of the exchange from 7 to 10 duplicate sets or divisions of connecting apparatus, each embracing de-

vices to be presently described. Provision is also made whereby any substation initiating a call may automatically seize and appropriate to its use one of the percentage of devices thus embraced in the exchange and which may be idle at the required time of use. Provision for preventing interference in the use of it by the several substations is also provided and the apparatus for effecting this embraces, among other things, a means for giving control of the exchange apparatus or a set or division thereof to the lines non-simultaneously and in fixed order of rotation, preferably through the medium of a circuit changer which closes circuit to the various lines comprising a group of lines successively. The various devices being thus provided in number corresponding to what may be called the traffic demand of the system, it is obvious that they will constitute a percentage less than the whole number of main lines which they serve or, in other words, will be less in number than the whole number of main lines of a group which may be connected to any group or set of such connecting apparatus.

In the following description the term "connector" is used to mean any device in the form of an electric switch, which, by selective action, may establish connection with any one of a number of different circuit wires or connections leading to or from said connector. By preference, we use that form of switch in which fixed contact points or terminals and a coöperating movable brush or brushes are employed. The term "connector" is hereinafter employed to designate the devices called primary connector, secondary connector and interconnector, as the function of these portions of the apparatus is peculiarly to select one out of a multiplicity of lines, circuit or connections. However, in parts of the description and claims where more specific designation seems to be appropriate, they will be spoken of as circuit selecting switches. The same term "circuit selecting switch" is peculiarly appropriate for the same reason to the device hereinafter called thousands register. What we more particularly designate as a division of connecting apparatus embraces preferably the following devices and inasmuch as our exchange is organized on the basis of providing a percentage only of apparatus for effecting connections, it will be obvious that the same kind of connectors belonging to a number of divisions for the same section of the exchange taken collectively constitute a group of devices less in number than the whole number of substation lines of any group. Thus, for instance, taking the devices hereinafter termed "secondary connector" which is used to establish connection with the substation lines of a group when they are called lines, there would be for such group of lines a series or group of secondary connectors less in number than the whole number of the group of lines served thereby. To said divisions of which there may be a number, as stated before, 7 or more, embrace in our exchange, preferably, in each division the following devices whose function in the combination will be more particularly hereinafter ascertained:

1st: A device termed "secondary connector" which is a circuit selecting switch upon which all lines of a group of lines are represented and which may be adjusted to establish connection with a substation line when such line is a called line. Each of the group of secondary connectors comprising the connectors upon the several divisions is accessible for this purpose from any one of the whole number of subscriber's lines, a secondary connector that is for the time being, idle, being automatically selected and isolated from use by other lines than the line employing it as will be hereinafter more particularly set forth.

2nd: A primary connector upon which all the lines of a group of lines are represented and which may be adjusted to form connection between the substation line used as a calling line and the circuits or connections over which the selective signals are conveyed to the signal receiving apparatus and over which also talking connection is finally established. By using a group or multiplicity of such primary connectors forming a percentage of the main lines called and each capable of use by any one of the whole number of a group of lines and by providing, through such connectors, suitable connections to groups or series of signal receiving devices and circuit selecting switches, we are enabled to adjust the amount of apparatus required to the traffic demand and thus make unnecessary the use of individual pieces of apparatus for each line.

3rd: A rotary switch for changing the connections of various parts of the apparatus at the various stages of the operation of the circuit selecting switches and the devices through which the calling line may signal the called line and may form at the central office the talking connection.

4th: A signal transmitter controller coöperating with the signal transmitter at the substations in a special way which is not, however, an essential in the carrying out of the broad principles of our invention.

5th: An interconnector which is a circuit selecting switch used in a train of circuit selecting actions whereby the calling line may be finally placed in connection with a secondary connector on which the lines of the same group as the calling line are represented or with a connector to which any other group of lines of the exchange belong,

thus making it possible eventually for the calling subscriber of any group of lines to establish connection with any subscriber of the whole exchange by selecting and adjusting an idle secondary connector of the group of secondary connectors to which the called subscriber's line belongs.

6th: A thousands register which is employed when the exchange embraces more than a certain number of sections or groups of main lines, say 10; said thousands register is in fact a circuit selecting switch which is employed when the circuit selecting actions required to enable a calling subscriber's main line to be placed in connection with a called subscriber's main line are more than three in number; said thousands register is a circuit selecting switch which is set to position corresponding to the value of the digit in the thousands place of the called subscriber's number after which the selective action proceeds through the interconnector and secondary connector under the control of selective signals corresponding respectively to the hundreds, tens and units places of the called subscriber's number.

From the foregoing it will be understood that our apparatus in its preferred form is organized to operate in accordance with the decimal system of notation, although it is obvious that in principle it is not restricted to such system.

7th: Certain relays termed signal relay, release relay and ringing relay, and accessory devices to be described hereinafter.

The terms mentioned in the above seven heads are used only for convenience of description. The functions of the various devices will be better understood from the general description of the devices themselves and their manner of operation from which it will readily be seen that some of the functions of the rotary switch, signal transmitter controller and interconnector might be performed by other parts. When the apparatus is organized upon a percentage basis throughout, we employ in addition and for each group or multiplicity of divisions of connecting apparatus certain devices whereby any one of a group of lines used as a calling line may, before sending its selecting signals, be automatically placed in connection with that portion of an idle division of connecting apparatus which it is necessary for a line to employ in automatically establishing a connection to a connecting wire leading to an idle secondary connector of the group to which the called subscriber is assigned. This apparatus, as already stated, is controllable by the lines of the group in which the call originates non-simultaneously and in fixed order of rotation and its action in giving such non-simultaneous control to said lines is preferably effected primarily by means of a progressive contact maker or circuit changer forming a part of the device termed a "decimal indicator." Associated with said decimal indicator are a decimal register controller and division starter, which said three devices are common to a number of divisions of connecting apparatus. These devices as combined with the primary connectors constitute collectively speaking primary line connecting apparatus whose function is to connect a calling main line to one out of a number or group of idle primary connecting wires over which the selective signals controlling the circuit selecting switches are received.

The terms decimal indicator, decimal register controller and division starter are also used only for convenience of description.

When the revolving line finder portion of the decimal indicator finds a contact connected to a substation line on which a call has been initiated, it halts, but is restored to the use of other substation lines after the calling line has appropriated to its use apparatus in an idle division of connecting apparatus. Coincidently with the seizure of apparatus in such an idle division, a guarding electric potential is established whereby the calling line may be protected from seizure by any other line of the exchange as hereinafter more fully described.

In addition to a line finder, the decimal indicator preferably embraces means for automatically determining the position to which the primary connector of the seized division shall be set to establish connection from the calling line.

The division starter is a device employed in association with the decimal indicator to seize upon and appropriate to the use of a calling line, apparatus in an idle division.

The decimal register controller merely aids in setting the primary connector to connection with the line calling.

According to the broad principles of the invention any suitable means may be employed for bringing into operation an idle set of connecting apparatus by any calling line either coincidently with the initiation of the call which is preferable for the purpose of expediting the operation, or by means of a signal given at any time by the calling lines.

The several divisions of connecting apparatus with the associated means for permitting any calling line of a group of lines to pick out an idle division constitute a section of exchange apparatus that is a complete unit adaptable for use as an exchange for 100 subscribers or that may be used in connection with other similar sections for an exchange embracing as many groups of substation lines as may be desired, each group comprising an arbitrary number, say 100, substation lines. For an exchange of 10 groups or 1000 substations, the thousands

register is not necessary, but if additional sections or groups of main lines be employed, it is desirable to use the thousands register. We then use in each of the aforesaid divisions an additional interconnector for each additional ten groups or 1000 substations. Such additional interconnector would be merely a circuit selecting switch duplicating in its construction and manner of operation the interconnector for the first thousand and the thousands register would be a circuit selecting switch operating in response to the first or thousands place selecting signal to pick out a circuit selecting switch, (interconnector) controlling the connections to a set of idle tertiary connecting wires running to those groups of secondary connectors which belong to that thousand of subscribers' lines embracing the line of the called subscriber and that particular group of hundred lines embracing said called subscribers' lines. An idle secondary connector or main-line-circuit selecting switch having thus been chosen through the circuit selecting action of the thousands register followed by the circuit selecting action of the chosen interconnector, said idle final main-line-circuit selecting switch is adjusted by the selective signals corresponding respectively to the tens and units of the called subscribers' number. By this train of circuit selecting actions taking place through successively operating circuit selecting switches and by using for each step of the train a group of like circuit controlling switches forming a percentage only of the whole number of wires or connections from which it may make a selection, it becomes possible to accommodate 10,000 substations with a little more than ten times the amount of apparatus and connections that would be used for an exchange of 1000, whereas with most systems heretofore employed the number of line contacts and the complication of apparatus increases as the square of the number of substations served. It will be obvious from the subjoined description that this principle of employing a percentage of circuit selecting switches is in our apparatus extended to include not only the final main-line-circuit selecting switches, namely, the secondary connectors, but also the interconnectors or circuit selecting switches acting at the hundreds stage of selection and in the case of the use of a thousands register, such percentage principle is shown as applied for those switches which respond to the first selective signals sent from a substation. When, however, any thousands register or any interconnector has been selected and made available for the use of any main line, it is for the time being and during its use individual to that line and in that sense is as completely a main switch as if it were assigned permanently to the use of that one line and could at no time be used by any other. While it is preferable to carry out the percentage principle through the whole system of selecting switches and interconnecting wires, such principle may be availed of only for a portion of the train of selecting actions.

The circuit selecting switches, namely, primary connector, secondary connector and interconnector may each consist of two switches whose movements are coördinated in order to establish connection between a particular wire or connection in the apparatus and the line contact or point desired. This coördination of movement is employed for the purpose of reducing the distance or extent of movement which would otherwise be necessary.

Upon one of said switches all the lines or circuits are represented in points, but said points are divided into groups and the brushes which ride over the respective groups are connected to contacts or points of a second switch which is termed the "register", and which may have its brushes adjusted to find the brush which rides upon the points of the particular group in the first named switch where the circuit desired is represented.

As well understood in the art, however, two movements on intersecting lines may be given to a device carrying a brush or brushes and by the coördination of these movements the particular group and contact point desired in said group may be found. It is preferred, however, to use the expedient of two independent switch arms, one of which is adjusted to find the group of points in which the line desired is located, while the other is adjusted over the points of said group to select or find the particular point wanted. Each primary connector, secondary connector and interconnector, according to this preferred plan, embraces therefore a switch having contacts or points for all of the lines or circuits, and a second switch having a limited number of contacts connected respectively with brushes riding over the groups or sub-divisions into which the contacts of the first named are supposedly divided. The second switch is herein termed the "register". The first is the "cylinder" or "cylinder switch". The two constitute the connector.

As the register portion of the device may be of comparatively small dimensions, it may be operated by means of a stepping or escape magnet. For the cylinder portion of the connector, or rather for operating the brushes thereof, it is preferable to use a power constantly acting which is coupled to and uncoupled from the shaft carrying said brushes by means of a suitable clutch magnetically controlled.

The switches may, however, be adjusted

and brought to rest in the desired position by the magnetic or electromagnetic actuating or controlling device, as will be well understood by electricians.

In our prior application, we have claimed broadly the subdivision of the subscribers' lines into groups and the provision for each group of two or more main-line circuit selecting switches, (secondary connector) each adapted to serve all the lines of that group in a manner to establish connection with any one of the lines as a called line and the further provision of means whereby any one of all the groups of lines when used as a calling line may establish a connection with an idle one of the group of secondary connectors in any one of the whole number of groups so as to be able to establish a connection with a subscriber in any one of the whole number of groups of lines, and, therefore, with any line of the whole exchange.

We have also claimed in said application the provision of a primary connector and a secondary connector on each section of the exchange, the primary connector being appropriated to forming connection with calling lines, and the secondary connector to forming connection with the called lines and intermediate devices whereby a connection may be established between the called line found upon the secondary connector and the calling line found upon the primary connector.

We have further claimed therein an exchange having a primary connector and secondary connector on each section as described, and suitable means for establishing a connection between the primary connector of one section of the exchange; also the subdivision of the sections of the exchange into groups or grand divisions, each accommodating a thousand more or less substation lines, and each provided with suitable main-line-circuit selecting switches, and further; providing and making available to the substation lines a series of interconnectors or circuit selecting switches controlling respectively connections leading to the secondary connectors of said grand divisions so as to permit any main line, by an automatically controlled action, to pick out a particular one of the series of interconnectors assigned to a thousand grand divisions and by such interconnector to establish connection with one of the secondary connectors in that division and through the adjustment of the latter to establish connection with the called line.

We have also claimed in said application the establishing of a guarding potential for a calling line as soon as the substation initiates a call whereby the line of said substation may be automatically protected from seizure by any other line and a similar guarding potential (as soon as the secondary connector is set or adjusted to proper position) whereby the called line may be protected from seizure by any other line than the one first calling.

This protection against interference is secured by rendering the part or parts of the connecting apparatus inoperative by means of an electro-magnet operated from the circuit or portions of the apparatus on which the guarding potential is established. One of the ways in which this magnet may act is to cut off the controlling or releasing current by which the parts are set to position for effecting connection, but said magnet might be made to act in other ways, as well understood in the electric art, so as to render the device inoperative in a manner to prevent interference.

The preferable way of using this guarding potential is to make it control, through a suitable magnet, the action of a circuit closing device which must go to circuit closing position in order to form a talking connection between the calling and called subscribers' lines.

In said application we have also set forth, as in the present case, the use of a "consecution controller" by means of which the calls coming from a number of lines at the same time are spaced out upon the interconnectors of the various sections, so as to prevent the same line from being seized at its secondary connector from two or more lines at the same instant under conditions to be described hereinafter. This device supplements the spacing out of the signals coming from two or more lines of the same section, which is produced by means of a decimal indicator, which brings said lines into operative connection with the exchange in succession, and the two together absolutely prevent interference between substations that may endeavor at the same time to effect connection with the same substation.

In the subjoined description and claims the term "main-line-circuit selecting switch" is used to designate switches that make connection to subscribers or substation lines and in contradistinction to the term "local-circuit selecting switches such as the interconnectors which only control connections between substation or main lines".

In the accompanying drawings, Figure 1 is a skeleton diagram of one section of the exchange, but shows only five of the ten divisions of connecting apparatus; Fig. 2 is a diagram illustrating the connections of the decimal indicator and other parts conveniently shown therewith; Fig. 3 shows diagrammatically the apparatus termed decimal register controller, and Fig. 4 illustrates the division starter and some of its connections; Fig. 5 illustrates diagrammatically a form of primary connector for one of the divisions; Fig. 6 is a similar view of the rotary

switch; Figs. 7, 8 and 9 are similar views of the signal transmitter controller, interconnector and secondary connector. For convenience the thousands register, signal relay, release relay and ringing relay of one division together with some other parts are also shown in Fig. 7; Fig. 10 is a skeleton diagram showing how different sections of the exchange are connected to one another; Fig. 11 is a general plan of the cylinder switch, the register, and the controlling magnet and mechanism connected therewith; Fig. 12 is a side elevation of the same apparatus; Fig. 13 is a plan view of the cylinder switch with the parts supported at the top of the rotary shaft removed; Fig. 14 is a cross vertical section on the line (A—A) Fig. 13; Fig. 15 is a detail showing one of the contact pieces of the switch cylinder; Fig. 16 is a plan of the clutch and its connected mechanism looking from beneath; Fig. 17 is a detail showing the adjustment for the retractor spring of the armature, Fig. 16; Fig. 18 is a cross section on the line (B—B) Fig. 16; Figs. 19 and 20 are plan views of the register illustrating the manner in which it is restored to zero; Fig. 21 is a vertical section through the parts secured to the brush carrying shaft of the cylinder switch; Fig. 22 illustrates a modification in the maner of restoring the register to zero; Fig. 23 illustrates the consecution controller; Fig. 24 is a side elevation, and Fig. 25 a vertical section on the line (C—C) Fig. 26, of a preferred construction of the decimal indicator; Fig. 26 is a plan of the same; Fig. 27 is a plan view with the plate which carries the magnets and brushes removed; Fig. 28 is a detail side elevation of the stop magnet for the decimal indicator, and Fig. 29 is a detail plan of the frame with the magnet removed; Fig. 30 is a general plan view of the decimal register controller; Fig. 31 is a side elevation of the same; Fig. 32 is an elevation showing the preferred construction of apparatus used at the substation; Fig. 33 is a horizontal cross section on the line (D—D) Fig. 32; Fig. 34 is a rear elevation of the apparatus shown in Fig. 32; Fig. 35 is a detail view showing the switch springs and contact stops, Fig. 34; Fig. 36 is a face view of the indicator used in connection with the signal transmitter at the substation; Fig. 37 is a cross section on the line (E—E) of Fig. 36, and Fig. 38 is a cross section on the line (F—F) of Fig. 36; Fig. 39 is a diagram of the connections of the substation apparatus.

In the skeleton diagram, Fig. 1, the principal parts for five divisions of one section are shown. The parts are thus designated: 4 is the primary connector; 5 is the rotary switch; 6 is the signal transmitter controller; 7 and 8 are two interconnectors respectively for the first and second thousands of the exchange; 9 the secondary connector; 10 the decimal indicator; 11 the decimal register controller, and 12 the division starter.

The various connections between the parts may be more readily followed by placing the diagrams, Figs. 2, 3, 4, 5, 6, 7, 8 and 9, respectively in the same general relative position in which the parts 10, 11, 12, 4, 5, 6, 7, 8 and 9 respectively are shown in Fig. 1.

Before describing in detail the several parts of a division, a construction of a cylinder switch and clutch, and a register switch suitable for various parts will be first described.

Cylinder switch.

Referring to Figs. 11 to 15, the fixed contacts 60 are pieces of wire or sheet metal formed preferably as indicated in Fig. 15, and anchored in plaster-of-Paris or other insulating material. In the diagrams the contact ends of these pieces are shown by circles. Their inner ends project for engagement by the switch brushes, while their outer ends are left free for the attachment of wires or conductors. The cylinder shown has 12 longitudinal rows of contacts 60 each row or ring containing 44 contacts, or four quadrants of 11 contacts each, but might have a greater or less number. Four corresponding sets or gangs of brushes of which there are 12 in each vertical row, engage with the inner ends of the contacts and are carried by shaft 62 driven by gear wheel 63.

The cylinder 24 is fastened between two plates 64. The lower one is secured to a plate 65, carrying a bearing for the shaft 62, and provided with a depending pivot 66, that enters a socket in the bracket 67, secured to the frame of the apparatus. This construction permits the cylinder to be swung away from its driving gear and allows ready access to the outer ends of the contact plates or points around its whole periphery. Each brush 61 consists, preferably, of two springs turned up at their forward edges to permit them to slide readily into contact with the ends of the plates 60, and grasp said ends between them. The brushes 61 are set in slots cut in a block 67, of vulcanite or other insulating material, and are secured therein by clamp plates 68, secured to the face of the block 67, and insulated from the brushes by the sheets 69 of non-conductor. Wires 71 secured to the inner ends of the brushes pass out through the upper end of the cylinder 24 to connect to other parts, or connect the brushes in pair so as to connect the two contacts 60, upon which they are for the time bearing, and thus close circuit between the two wires attached respectively to the outer ends of said contacts. The blocks 67 are fastened to the face of the arms of casting 70, secured to the shaft 62.

The device, as thus constructed, affords a

rotary switch or circuit closer that may be very cheaply constructed, with a large number of contact points, since the contacts 60 may be stamped or cut in quantities from sheet metal, and being assembled in a mold in proper position all that is required in order to complete the switch cylinder is to cast the insulation around them in the form shown.

By connecting the contacts 60 to the circuits to be controlled, or to one another in rows, or in any desired relation, and by connection of the brushes 61 to one another, or to other parts through the wires 71, the device may be used for the primary connector, the secondary connector, the interconnector, the rotary switch and the signal transmitter controller, or for other parts, although for some of these parts not all of the contacts and brushes need to be utilized.

The parts to which the wires 71 connect depend upon the use to which the device is put; that is to say, what part of the apparatus it is employed in. Generally the connections are to the contacts, brushes and electromagnet of the device termed "the register" and, as illustrated in Figs. 5, 8, and 9. The two contacts 60, whose brushes are bridged, may be any two contacts and cannot well be identified at this point. The two contacts may be connected in very many ways, as for instance, shown in Figs. 5 and 9.

The manner of connecting them for the primary connector, rotary switch, signal transmitter controller, interconnector and secondary connector, is shown in the various diagrams illustrating such several parts, and it can only be understood from an inspection of those diagrams and the reading of the general operation following later on.

The movement of the shaft 62 may be controlled in any desired way, as for instance by means of an electromagnet 14 operating on a clutch between the wheel 63 and a suitable driving power.

The electromagnet 14, when energized, connects the wheel 63 with a suitable driving power, and when deënergized, permits the clutch to disconnect the wheel 63 and driving power so that the shaft 62 will come to rest.

The clutch.

The clutch and gear may be of the following or any other desired construction. (See also Figs. 16, 17 and 18). 72, is a wheel gearing to wheel 63 upon the brush carrying shaft 62. The shaft of wheel 72 carries a wheel 82 geared through idler wheels with a wheel 81 rotating loosely on shaft 75, and having clutch control disk 23 fastened to its hub. The edge of the disk is cut or notched to permit the entrance of a dog 83, carried by elbow lever 84. An electromagnet 14 operates the lever and brings a serrated wheel 76 into engagement with a serrated wheel or disk 74 keyed to a power-driven shaft 75. When the wheels are engaged power is transmitted to the wheel 72, and wheel 63 of the brush carrying shaft from shaft 75 through wheel 78 on the same shaft with wheel 76 through an idle wheel to wheel 79, and a second wheel 80 on the same shaft with 79 and gearing to the wheel 72. Wheels 76 and 78 are mounted in a pivoted frame 77, which also carries the idler wheels connecting wheels 78 and 79, and is operated by a roller on the end of the armature lever 84. The gearing shown is such that the wheel 63 with the brush carrying shaft 62 to which it is attached will make one whole revolution for one whole revolution of the disk 23, and the notches in the quadrant where they are shown close to one another are so spaced that the brushes will pass from one vertical row of contacts in the switch cylinder to the next vertical row while the edge of the disk revolves a distance equal to that between the centers of adjoining notches. As soon as the magnet lifts the dog out of the notch and causes the clutch to engage, the disk 23 will begin to revolve so that the dog 83 rides on the continuous edge of the disk between the notches. It keeps the clutch engaged until the next notch is reached. The clutch will then be automatically disengaged if the magnet be then discharged. The wheel 72 and disk 23 will then come to rest together with all the other parts geared up to them, such as wheel 63 attached to the brush carrying shaft 62. A momentary action of the magnet will lift the dog out of the notch in the disk and immediately set the parts to revolving. The notches are so spaced as to cause the cylinder brushes to advance one or more, or any desired number of whole steps, depending upon the space between the notches. It is obvious that the longer the space the farther the brushes carried by the shaft will revolve before the dog finds another notch. When it finds said notch, it will drop into it and disconnect the clutch, thus bringing the brushes to rest. In some cases it may be desired to have the brushes revolve over a number of contacts in the cylinder before they come to rest. The arrangement of the notches suitable for the primary connector, rotary switch, signal transmitter controller, interconnector and secondary connector, is shown on the diagram of these devices, Figs. 5, 6, 7, 8 and 9.

The disk (Figs. 11 and 16) shown is notched suitably to bring the brushes to rest in 11 different positions, namely, normal or N, O, and 1 to 9 inclusive; that is to say, in 10 different positions after leaving the normal position N; and then to cause the brushes to make a three-quarters revolution without stopping. This arrangement of

notches is suitable for the primary connector or secondary connector when the contacts are arranged according to the decimal system. When the dog is lifted from the last notch of the group shown, the disk and the brush shaft will make three-quarters of a revolution without stopping until the dog finds the normal or first notch of the group, when it will come to rest. The arrangement of notches may obviously be varied to suit the requirements.

The register.

This may be constructed as shown in Figs. 11 and 12. 25 is a sector of insulating material like plaster-of-Paris in which any desired number of rows of contacts 60 are anchored, and in position to be engaged by a gang of brushes 61, as many in number as the rows of contacts. Brushes 61 are mounted in an insulating block secured to a support 86 that in turn is fastened to an escapement sector 87. The number of rows of contacts would depend upon the number of connections to be made in each of the various positions which the register brushes are caused to take by the signals from the subscriber's station. For the primary connector there would be, preferably, three rows as shown by the three curved parallel rows of contacts at the top of Fig. 5. Through the contacts of one row the connections for the No. 2 side of the various lines of a section would be made and through the middle row for No. 1 side, while the inner row of contacts would serve for making the simultaneous connections with the corresponding guard wires which furnish the guarding potential already described for each line. For the interconnector, as shown in Fig. 8, there would be four such rows of contacts corresponding respectively to the four bus wires 223, 622, 623 and 296, in each set of bus wires. For the secondary connector three such sets would be employed as shown in Fig. 9, said three sets corresponding respectively to the three tap wires 325, 522, and 523, which are joined to the No. 1 and No. 2 sides of the line, and to the guard wire 3 in multiple with the connections taken to said wires from the contacts in the cylinder of the primary connector. When the register is used in connection with the cylinder switch, it is preferably mounted on a plate 92 secured to gear wheel 63 so as to revolve with the brushes of the switch cylinder. It is so mounted in the case of the primary connector, secondary connector and interconnector. In the case of the thousands register no cylinder switch is necessary, since the number of the possible connections required to be made through it is comparatively small. Thus, in the case of an exchange of 5000 subscribers requiring 5 interconnectors for each division of each section, the thousands register would be required to complete one of five circuits only. In each curved row of sector contacts there would be provided for the primary connector, 11 contacts. To the first of them upon which the brushes 61 normally rest, no connection would be made, and this contact is termed the "normal contact". The succeeding contacts, 10 in number, correspond respectively to the values 1 to 9 inclusive, and the character 0. The first contact engaged by the brushes after reaching the normal is assigned to the zero character, and the succeeding ones in order corresponding to the values 1, 2, 3, 4, 5, 6, 7, 8 and 9.

As will be seen, therefore, in the decimal system, and for the purpose of making the connections required, each of said contacts after the normal contact would have a connection from it to a separate brush of the switch cylinder. In the case of the secondary connector, the diagram of which is shown in Fig. 9, 12 contacts would be provided in each row, the first of which would be the normal contact, the next marked 500 a dead contact (that is, it would have no connection) since in the case of the secondary connector it is desired that the connection should be temporarily opened after the brushes make their first step. The succeeding 10 contacts furnish the connections 0, 1, 2, 3, 4, &c. the same as in the case of the primary connector.

A spring 88 secured at its free end to a strap wound around the hub of the escapement sector tends to turn the sector in the direction of the arrow and cause the brushes to move one whole step for each to and fro movement of the scape lever 89, which is moved in one direction by the armature of magnet 28 adapted to engage an arm 90, and in the other by a spring 95.

The brush of the register normally rests on a contact with which in the case of the primary connector no connection is made, and this is normal position. Upon the movement forward to the next contact by the action of magnet 18, or magnet 29, Fig. 5, it will form an electrical connection to one of the brushes of the cylinder switch if said first contact be utilized as an electrical contact. In the primary connector, Fig. 5, this contact would be connected to that brush of the cylinder which moves over cylinder contacts for the first 10 lines of the section, and the next contact or set of three contacts in the same curved line would be connected to the brush or brushes belonging to lines 10 to 19, and so on. The manner of connection of said contacts with brushes of the cylinder may be clearly understood by reference to Figs. 5 and 9. The three rows of sector contacts for the register are shown arranged in an arc of a circle at the top of the figure in each case, and the rows of contacts of the cylinder are shown projected in straight

lines. The movement of the cylinder brushes is across the figure from left to right, and the movement of the sector brushes is in the arc of a circle over the contacts arranged above the plate 87, and in a direction from right to left. The contacts engaged by the brushes of the register at the fourth step forward from normal position are shown connected to three brushes of the cylinder. The three similar contacts of said register sector at the various positions occupied by the register brushes in moving over them in the arc of a circle would be similarly connected each to their own set of three cylinder brushes.

In the case of the secondary connector as shown in Fig. 9, the first set of three contacts engaged by the register brushes and marked 50° are not used as electric contacts, and are hence called "dead contacts", so that at the first step forward of the brushes the only effect would be to break the connections made to the normal or zero contacts of the contact sector. At the second step forward the register brushes would make a live connection to a set of three contacts which would be connected in the same way as the set of contacts first engaged by the brushes of the register in Fig. 5. The fifth set of live contacts in said sector is shown in Fig. 9, as connected to its set of brushes in the cylinder.

The scape teeth and pallets are so formed that the scape sector may be forced back to zero position when the support plate 92 upon which the register is mounted is rotated by the superior force of the driving power for shaft 62, thus bringing the lug 93 depending from the sector through an opening in the plate 92 against and past an obstruction such as a post 94 upon the fixed cylinder 24, or other fixed support (see Figs. 19 and 20). The support plate 92, as above stated at the beginning of the description under this head, is secured to the gear-wheel 63, so as to rotate with it. After the register has been used in establishing a connection, it is necessary to reset it to normal position ready for another use. The pivotal center of the sector is eccentric to the center upon which the plate 92 turns, so that by proper adjustment of the overlap of the lug 93 and post 94, they will clear one another at the instant the sector brushes reach the normal position and the support 92 may then continue its forward movement around to normal ready for another operation. If the register be mounted on a fixed support, it may be restored by the action of a pin on a rotary part. In this case, the pin upon the rotary part would engage with the lug 93, in just the same way that said lug, when the register is mounted upon a rotary support, engages with the fixed post 94, as previously explained.

The desired connections between cylinder brushes and register brushes may be made by wires 71 (see Figs. 13 and 14) which are sufficiently flexible to allow for the comparatively small relative movement of the parts. Any desired connection between the register contacts and cylinder brushes may be made directly either by the connections 71 or by other means.

Divisions.

The preferred construction of the various portions of the connecting apparatus in one division of a section and the general connections and functions of the same are as follows:

It will be assumed that each substation is connected with the central station by two wires 1, 2, adapted for use as a metallic circuit in communicating with any other substation. In the several diagrams, Figs. 5–9, the fixed contact points are indicated by the small circles. The cylinder contacts are shown in 12 straight parallel rows and the register contacts in the three or more curved rows.

Primary connector.

For each primary connector the apparatus described in connection with Figs. 11–18 may be utilized without material alteration. This device places any substation of the section on which it is located in connection with the other portions of the apparatus in the same division.

As shown in the diagram, Fig. 1 and as already stated, a group of such primary connectors, (4, 4) would be employed for a group of main lines, and each is available for use by any line of the group so as to place any main line in connection with some one of a number of normally idle connecting wires or sets of wires which become, for the time being, an extension from the main line calling to the apparatus which receives the selective signals and to the circuit selecting switches by whose combined operation a talking circuit is established to the line called by adjustment of a secondary connector. There being five primary connectors, there would be five primary connecting wires or sets of wires with an idle one of which a calling main line would establish connection by sending a preliminary electrical impulse. As already stated the primary connectors are organized on a percentage basis and the number of the same available to each group of subscribers' lines is less than the whole number of subscribers in that group. They may be described as circuit selecting switches or connectors whose function is to pick out or select any main line of a group when used as a calling line and establish connection between said selected main line and a terminal of a local

circuit or circuits of the exchange apparatus. Said terminal forms the terminal of a circuit or circuits which receive the selective signals sent from the main line station and also by preference is in effect a terminal of a cord circuit over which the calling and the called line are connected in the exchange apparatus.

The two sides 1 and 2 of each line are connected to two contacts 60 assigned to it on the switch cylinder, by branch wires as indicated in Figs. 1 and 5, where one such line is shown.

Since the line as shown is connected to a contact adapted to be engaged by a cylinder brush which is connected to a contact of the register engaged by the brushes of the latter in the 4th position from normal, said line would be one in the 4th 10; that is, in the thirties. Since the cylinder contact to which it is connected is reached by the cylinder brush after passing successively over contacts 0, 1, 2, 3, 4, 5, the units value of the number designating such line would be 6.

If, then, the register brushes and the cylinder brushes be adjusted the required number of steps to reach the contacts to which the connections are made, as shown in the figure, it is obvious that by connecting up the register brushes to the desired circuit a path will be opened from the line to said circuit over which signals from the substation apparatus may be sent and over which when the desired connections are established, talking may take place. All the other lines of the 100 in the section to which the primary connectors belong would be similarly connected to other contacts on the switch cylinder.

In addition to two line contacts for each line a guard contact is provided connected in a similar way with a guard wire 3, one for each line. Wire 3 is a local wire at the central station.

This wire is connected to all the guard contacts of the corresponding subscriber's line on all the 10 primary connector cylinders of the section in multiple and provides the guarding potential already described when a call comes from any line and the primary connector is set to open up a path for the signals from such line to the thousands register, the interconnector and the secondary connector. Each wire 3 has a connection to a cylinder contact in a row of 10 engaged by one of the cylinder brushes, which latter is connected to one of the contacts in one of the rows of the sector for the register, as shown in the case of the wire 36 just supposed. This wire 3 runs through all divisions of the particular section to which its subscriber belongs. It does not extend into other hundreds sections.

When the primary connector opens up a path for the signals from any particular line, it also makes connection for the wire 3 of that particular line by way of a cylinder contact and cylinder brush 712 resting thereon, wire 71′ and contact of the register sector, to the register brush which has been adjusted with the line register brushes to rest on said contact, and to the lower of the three feed segments 650 which is connected to a wire 221.

By tracing the connection of wire 3 to the diagram Fig. 2 of the decimal indicator, it will be seen that it terminates in a contact engaged by a brush 116 which is joined to the lever of relay 214, so that when said lever makes contact with its front stop a connection will be established to a brush 113 riding on a feed plate 103 which is connected to a source of energy such as positive battery indicated by the sign +.

When the magnet 214 is energized (which is done by the action of relay 211 actuated by current from feed ring 103, brush 113, coils of relay 211, back contact of relay 213, brush 111 and line contact of decimal indicator, passing over the calling subscriber's line as soon as brush 111 finds the contact of the calling line in the row of line contacts in a ring 101) the guard wire 3 for that calling subscriber will be temporarily charged and all the guard contacts for the line of that subscriber on the cylinders of all the 10 secondary connectors in the same section, and which guard contacts are all connected in multiple to said line 3 in the same way as the guard contacts for that line on all 10 primary connectors of the same section, will also obviously be charged. Should, then, any other subscriber attempt to make connection with the calling subscriber and set any unused secondary connector in the latter's section, the guard bus wire of the bus wire set used by such other subscriber and running through all sections of the exchange will become charged through said secondary connector and this will result in preventing the apparatus which said second calling subscriber employs from going to the position where he can make or establish connection with the line of the first calling subscriber. This is effected by the action of the current supplied from said charged bus wire upon a relay which in turn controls the action of the clutch magnet of part of the apparatus, as may be best described in the general operation.

After the relay 211 ceases to be energized (which occurs shortly after the call is initiated) and the brushes 111 and 116 resume their revolution, the charging of the guard wire 3 is maintained over a connection from the rotary switch in the same division with the primary connector in use. This is from a source of energy indicated by the sign +

Fig. 6, at the upper left hand corner connected as shown to a long feed segment 652′ in the second horizontal row from the top and by bridging brushes which in the meantime will have moved onto segments 652 and 652′ and to wire 221, from which circuit is through the primary connector in use as already traced.

For the decimal system the 100 points for the 100 lines 1 would be arranged in 10 groups and each having 0 to 9 points, the contacts of one group being preferably in the same quadrant of the cylinder and in the same horizontal row. The points for the 2 and 3 lines would be similarly arranged. For each group a brush 61 is employed and the three brushes corresponding to the 1, 2 and 3 lines of the same tens group are connected to three contacts of the register sector upon which the register brushes rest simultaneously. The register brushes themselves connect respectively with three cylinder brushes that, as soon as they leave the normal position, come into contact with a row of connected points forming feed segments 650 to maintain connection with wires 122, 123, 221, corresponding respectively to the 1, 2 and 3 lines.

Suppose that lines 1 and 2 are the two sides of the line for subscriber No. 36. Since the 6 of this number is the sixth unit of the fourth 10 in one hundred, the two wires 1, 2, are connected to contacts in one of the quadrants which would be reached by particular cylinder brushes shown after the latter have passed successively over contacts 0, 1, 2, 3, 4 and 5, in the row of contacts engaged by the brush after leaving the position shown. Since the number 36 is in the fourth 10 in one hundred, the brush itself is connected to a contact of the curved sector of the register which would be engaged by the register brush after passing from the position shown successively over contacts 0, 1 and 2.

Lines to which other numbers are assigned would be connected in a similar manner to contacts of the cylinder, and the brushes riding over the quadrant in which said contacts are located would be connected to contacts of the register sector depending upon the tens value of the line number. Assume, for instance, that the brushes of the register moved over steps 0, 1, 2, 3, 4, 5 and 6, and then came to rest, this would be the position for all lines, say from 60 to 69 inclusive. Said contacts would be connected to cylinder brushes which would move over the contacts to which the lines 60 to 69 inclusive would be connected in regular order directly, each in the same way that the line 36 is shown connected.

To establish connection with the contacts for any particular line, the register brushes are adjusted to contacts of the register sector connected with those cylinder brushes 61 that ride over groups of cylinder contacts in which the contacts of the line wanted are located, and when said cylinder brushes are adjusted to the particular contact required in that group, connection is established from the No. 1 and No. 2 sides and 3 line of that substation to the wires 122, 123, and 221 respectively. With the arrangement shown, the maximum movement required of the cylinder brushes in order to find the contacts of any line or substation in the 100 assigned to a section is a quarter revolution of the brush shaft.

The wires 122, 123 are primary connecting wires and as many pairs are employed as there are primary connectors and as the service or traffic may demand, and connection is made with an idle pair of said wires in response to a preliminary electric impulse from a calling subscriber's station.

19 indicates the clutch magnet of the primary connector, which is charged to start the cylinder brushes and is discharged when they reach cylinder contacts corresponding to the units value of the number for the calling line as just explained. The control disk 23, has a normal and 10 additional notches which permit the clutch actuating lever to disconnect the cylinder shaft from the driving power in any one of the 11 positions which the brushes may be required to assume. The normal notch brings the brushes automatically to rest when the disk 23 completes a three-quarter revolution with the dog resting on the uncut portion after a call.

The clutch magnet is preferably controlled by the relay 219, joined to a line of contacts connected up to form a feed segment 653 in one quadrant, and thence by a pair of bridging brushes as indicated, with a series of contacts designated as the "units" row of contacts, with which it is put in connection successively. The latter contacts connect with different wires respectively in a cable 119 joined to the contacts of a divided units ring employed in connection with the decimal indicator, for the purpose of pointing out or indicating the units value of the number of the substation calling, as will be described farther on.

By this is meant that when a brush of the divided units ring rests upon a contact assigned to a particular number, as for instance, a number 6, in all tens of a hundred, said contact will furnish current to the contact numbered 6, in the units row of the series shown in the second quadrant of the top row of cylinder contacts, Fig. 5, and the latter being charged will, when the rear one of the two brushes connected to 117 rests thereon, supply current to magnet 219, through wire 117, and through the feed segment just mentioned, so that the magnet will be charged and will disconnect the

clutch and bring the brushes of the cylinder to rest, all in the position where they rest on the No. 6 contact of each quadrant of contacts in the cylinder.

The contacts of this units ring for the decimal indicator are shown projected on the plane of the paper at 105, Fig. 2; and the connection from one of said contacts is formed by a brush 115 to a brush 113 bearing upon another continuous ring 103 shown projected on the plane of the paper which is connected to a positive battery or other source of electrical potential, so that current may be supplied over the contact of ring 105, to one of the contacts in the units row at the top of the cylinder, Fig. 5, through cable 119.

When the connection is established from the relay 219 to that contact of the units row which corresponds to the units value of the calling substation number, the relay is charged. The magnet 19 is then discharged by the breaking of its circuit through the back contact of the relay and the connector comes to rest with the cylinder brushes in the proper position.

These cylinder contacts form stop controlling contacts since the action of the stop and the consequent position in which the primary connector will come to rest depend upon the selection by the cylinder brush of a contact which is connected to a circuit closed at a particular position of the decimal indicator.

The magnet 29 of the primary connector register is in a connection 188 between a pair of brushes 61 which, as soon as the cylinder brushes start into rotation, ride respectively upon feed segments made by connecting up rows of contacts and complete a circuit from 187 over which the register may be adjusted.

Another pair of cylinder brushes 721, 724, is bridged by a wire 654 and serves to close circuits to wires 98, 97, over which the clutch magnets of the rotary switch and other devices are energized in order to send the apparatus around to normal position after completion of a conversation.

The magnet 29 sets the register brushes to position corresponding to the tens value of the number assigned to the calling substation.

In the preferred manner of carrying out the invention the required number of impulses for this purpose is produced by a device at the central office which is hereinafter described under the head of "Decimal register controller" and is shown in diagram Fig. 3, connected by wire 187, with a feed segment 655, in Fig. 5. Magnet 29 of the register for the primary connector connects by wire 188 with a brush 736 adapted to engage with said segment when the cylinder switch begins to move. The action of this decimal register controller is regulated or adjusted according to the position assumed by a device common to the lines of a section and adapted to be set or stopped in different positions corresponding to the particular line calling.

The latter device is stopped by means of an electromagnet acting on a dog which controls the revolution of a contact arm moving over a series of contacts the same in number as the lines of a section. When the arm makes connection with the line calling, the magnet is charged and the device is brought to rest in the particular position assigned or belonging to that line.

For each division in each section of the exchange one primary connector is employed.

Rotary switch.

This device may be of any desired mechanical construction. Said device constitutes an auxiliary switch *aa'* for changing the connections of the various parts of the apparatus at different stages of the operation. The particular circuits so changed will be described in detail under the head of "General operation". It may be constructed from the switch cylinder previously described under the head "Cylinder switch" by connecting brushes in pairs to form bridging brushes, and by connecting up the contacts to one another and to the exterior circuits in the manner indicated in the diagram, Fig. 6, or in any other proper way.

This auxiliary switch may be locked or stopped in its various positions by the use of the mechanism described under the head "The clutch" following the description of the cylinder switch.

It will be assumed that the rotary switch completes its action, or moves from normal around to normal by making a half revolution of the brush carrying shaft, and that in such half revolution it assumes seven positions of rest as indicated by the roman numerals I. to VII. inclusive at the top of the diagram. The brushes each pass over one of the contacts 60, in moving from one position of rest to the next position of rest; if a clutch and gear such as already described under the head of "The clutch" be employed, the disk 23 would then have its notches spaced apart twice the distance of those indicated in the case of the primary connector. This device requires the use of but two of the vertical rows of brushes 61 already described under "Cylinder switch" and of the contacts of the cylinder it requires the use of those in the first half of the circumference starting from normal and a part only of those in the second half. The vertical rows of brushes employed may be those on the same diametrical line, and complete their operation by making a half

revolution. If the ratio of gearing described under the head of "Clutch" be such that disk 23 used with the clutch for the rotary switch makes one revolution for one whole revolution of the shaft carrying the vertical rows of brushes, it is obvious that two similar sets of notches on the disk should be provided, the first of which sets will operate for the first half revolution of the rotary switch, and the second for the next half revolution as shown on the disk 23, Fig. 6. In the Fig. 6, the dog engages with normal notch of one group and the brushes are in the corresponding normal position.

One rotary switch is used for each division of a section. When one division with its rotary switch is in use for connecting two subscribers and another subscriber of the same section of the exchange sends in a call, such call is received and transmitted by means of the next idle division. Hence, the rotary switch in any division need not be returned to normal until after the conversation has been finished and the apparatus of the division is restored to normal position. The principal functions of the rotary switch are as follows, although some of them may be performed by other parts of the apparatus.

When the rotary switch of the seized idle division starts, it breaks its own clutch magnet circuit, thus isolating it from interference, and immediately closes a [illegible] or circuits over which the primary connector is adjusted. It also preferably energizes the clutch magnet for the primary connector and starts the device termed decimal register controller which, by means of the register magnet adjusts the brushes thereof to the position corresponding to the tens-value of the number of the substation calling.

Immediately thereafter it starts the decimal indicator from the position of rest which it had assumed by the initial signal from the calling substation so that it may revert to the common use of other substations in the same section, and also completes a substitute connection for keeping the guard wire 3 of the calling substation charged. It also at this stage of the operation, prepares the circuit over which an interconnector of the same division may be started or operated, and further prepares the circuits over which connecting apparatus of the same division is operated or controlled by the signal transmitter controller for the purpose of adjusting them to position for finding the circuit of the called line in the same or any other section. Further, it closes connections for charging the guard circuit of the substation called upon the called substation's section as soon as connection has been established therewith, but first closes a test circuit by means of which the operation is controlled in such manner that if the line wanted be already in use, the apparatus would be automatically prevented from coming to position for establishing talking connection therewith.

In this test, a test relay 215 may be employed as set forth in the general operation under the head "Rotary switch, 3rd position". This relay is shown in Fig. 7 and may be the same relay that is hereinafter termed the "signaling relay".

If the line wanted is found to be idle, the rotary switch charges the guard circuit of said line and closes circuits whereby the calling substation may signal the called substation and communication may be carried on. At the conclusion of the conversation the rotary switch moves to break such circuit and closes others whereby directly, or indirectly, the parts may be restored to normal position.

The circuits thus closed for various purposes may be ones which are connected directly with the parts mentioned, or may be circuits which operate through the intervention of, or in coöperation with others; thus in the case of restoring interconnector to zero, the circuit closed by the rotary switch may be one which releases the primary connector, the latter in turn releasing or sending the interconnector to zero. Other functions of the rotary switch will be apparent from the description of the general operation.

Signal transmitter controller.

This device provides or produces electric impulses which operate or control the signal transmitter, the contact arm of which moves over units, tens, hundreds and thousands sets or segment of contacts. It also provided the stepping or controlling pulses for operating the thousands register and interconnector register of the same division, and the secondary connector seized upon any division of the same or any other section. It may also embody certain circuit closing devices through which the talking connection and other connections are made.

This device may consist of the switch cylinder previously described, and utilizes six horizontal rows of contacts and three pairs of bridging brushes connected up as shown in Fig. 7, or in any other suitable way. The two upper brushes operate as an impulse generator to actuate or control the signal transmitters. These impulses are produced by means of pairs of brushes 711 and 706 such as are described under the head of "Cylinder switch", said brushes being connected together and one of them arranged to move over a feed segment 656 formed by

connecting up a series of contacts in the cylinder as shown in the upper row, Fig. 7, segments 656′, one engaged by the lower and the other to move over the series of contacts, every other one of which is connected up to a suitable source of energy indicated by the sign + as shown in the second horizontal row. A similar arrangement is shown for the third and fourth rows.

The series of connected contacts forming the feed segment would be connected to the circuit on which the impulses are to be produced by the action of the brush in the second horizontal row which, as it passes over said contacts, obviously makes and breaks the circuit with the battery or other source of energy.

From the upper feed segment 656 the pluses pass to the line of calling subscriber by wire 206, Figs. 7 and 6, to a short feed segment 657 in the 6th row of contacts of the rotary switch cylinder and thence by bridging brushes when adjusted to contact therewith, to another feed segment 658, which is joined to 123, and from the latter to the line 2 of the subscriber's circuit, through the primary connector when the latter, as just described under the heading "Primary connector" has been adjusted to open up a path from the line for the signals from the substation apparatus.

The two middle rows similarly control the action of the thousands register, the interconnector register and secondary connector successively, by furnishing impulses of a number corresponding to the value of the numeral in a thousands place, the hundreds place, the tens place and the units place of the number of the called subscriber. These pulses are furnished from a generator indicated by the sign + joined to the armature lever of a relay 215 from whose back contact a connection is made to the feed segment or sector 656 in the third row. From the latter current passes to the upper one of a pair of bridging brushes 706 and through the interrupted series of contacts engaged by the lower one of said pair in the fourth row to a wire 191, or to a wire 193, according to the position of said brushes. During the first half of the revolution the pulses pass to the wire 191 which connects to the magnet 30 of the thousands register thereby setting the brushes of the latter forward a number of spaces or steps corresponding to the value of the numeral in the thousands places of the subscriber's number. In the second half of the revolution the pulses pass to the wire 193 and through the brush and contact of the thousands register which has been previously set, as just mentioned, and thence to the register of the interconnector over circuits formed through the rotary switch, as will be more particularly described in the general operation.

These impulses operate on the magnet 31 of the interconnector register diagram Fig. 8, to set the brushes thereof forward a number of steps corresponding to the value of the numeral in the hundreds place of the called subscriber's number.

In the next whole revolution of the signal transmitter controller the impulses sent during the first half of said second revolution pass by wire 191, by circuits which in detail will be traced in the general operation and act on register magnet 32 of the secondary connector, diagram Fig. 9, so as to set the brushes thereof forward a number of steps corresponding to the numerical value of the number in the tens place of the called subscriber's number.

In the last half of the second revolution of the signal transmitter controller the pulses pass by wire 193 over circuits to be traced in detail in the general operation and act upon the clutch magnet 22, diagram Fig. 9, for the cylinder switch of the secondary connector to cause the brushes of said cylinder switch to be set forward from normal position a number of steps or spaces corresponding to the numerical value of the number in the units place of the called subscriber's number.

The two lower rows operate to close the circuit for coils that temporarily hold up the relay armature of the signal relay 215, and for other purposes. These two rows consist of a long segment 656 and two shorter segments 656′, one engaged by the lower brush of bridging brushes 716 during the first half of each of the two complete revolutions or during the transmission of the thousands and tens pulses over wire 191, already described, and the other engaged by the lower brush during the second half revolution or during the transmission of the pulses over wire 193 for the hundreds and units of the signal as just described.

So long as the armature lever of the relay 215 is against its back contact, the pulses which set the register and cylinder brushes may pass through the circuit on the back contact, but when said relay is energized and the lever is drawn up, it is obvious that the pulses will cease to flow and actuate the register and clutch magnets. Hence, by causing said relay to be energized at some particular stage in the movement of the brushes on the signal transmitter controller the signal impulses which flow through said register and clutch magnets may be cut off. If this be done after three pulses have been sent, the remaining seven pulses will all be cut off because the armature lever will remain held up through the closure of the circuit from positive battery indicated by

the sign + through the armature lever, the front contact, a feed segment 656′, brushes 716, the segment 656 cooperating therewith, and back by wire 232 through the relay coil of relay 215 to the negative side of the source of energy. The relay, however, will be discharged when the brushes reach the interruption between the two segments 656′ or at the end of the second segment 656′, so that the armature lever may fall back and complete on its back contact the connection for permitting the pulses to flow through a register or clutch magnet by which the brushes of the various devices are set to position corresponding to the values of the numerals in the different places of the subscriber's number. The number of pulses which shall thus be permitted to flow by wires 191 and 193 is determined by energizing the magnet 215 at the proper stage in the revolution of the signal transmitter controller over the circuit from the source of energy indicated by the sign + through a coil of said relay 215 and by wire 231 connected to a short feed segment 659 in the rotary switch, Fig. 6, from which connection is made by the bridging brushes 708 to the longer segment 659′ joined to wire 122, which latter wire, as explained under the head of "Primary connector" is placed by said primary connector in connection with the calling line to open up a path for the signals from the substation apparatus.

This connection is from the side of the subscriber's circuit marked 1, and the connection therefrom to wire 122 is to the contact of the switch cylinder, Fig. 5, a brush 710 of the cylinder switch when the same has been moved to engage said contact, thence by wire 651′ to a contact of the register sector engaged by the middle one of the three register brushes 61 after the same has been adjusted forward the proper number of steps and from said middle brush to a cylinder brush adjusted to rest on the middle one of the contact segments 650, which is joined as shown to wire 122.

The instant at which the relay magnet shall be energized is determined by the action of a rotary circuit changer arm at the subscriber's station, to be described more in detail under the head of "Substation apparatus".

It is sufficient here to state that the No. 1 side of the line is connected at the substation diagram Fig. 39, by means of a ring 174, a brush bearing thereon to an arm 142 carrying a spring 734, which moves over a circle of pins 735, all of which are normally disconnected from earth. The circle is divided approximately into four sets of contact pins each containing 10, and each group is connected to a group of contact plates, 10 in number, one group for units, one for tens, one for hundreds, and so on. These contacts, 10 in number, are provided with a circuit closing button 171, which may be adjusted to place any one of the series of 10 with which it cooperates, into connection with the earth or other return wire. The arm 142 is caused to progress over said pins by the action of a step magnet 33, which is acted upon by the pulses sent over the No. 2 side of the line from the upper segment 656 of the signal transmitter controller joined, as already stated, to wire 206 and thence through the rotary switch and primary connector with the side No. 2 of the subscriber's line. As soon as the impulses over the side 2 have progressed the arm to reach the grounded contact pin which, it may be assumed, has required two pulses, the relay 215 will be energized over the 1 side of the line by the ground circuit, so that after the transmission of two pulses over the back contact of the relay to operate the register or clutch magnet in the thousands register, interconnector or secondary connector, as the case may be, further transmission of pulses over said back contact will cease, although the transmission of pulses over the subscriber's line to progress the arm 142 may continue so that the latter will complete its movement over the points connected severally to the 10 contacts engaged by button 171, and may pass on to the next series of points corresponding to the hundreds, units or tens place in the decimal system of numeration.

The circuit over which the relay 215 is thus energized at the proper time may be traced from positive battery (+) diagram Fig. 7, near relay 215, through a coil thereof, to wire 231, thence to a short segment 659, Fig. 6, brushes 708, segment 659′, wire 122, and through the primary connector as already traced by middle segment 650 of the switch cylinder, brush bearing thereon, middle brush 61 of the register, wire 651′ and to the cylinder brush 710 when adjusted to engage with cylinder contact connected to wire 1, thence over the line to the subscriber's station to the rear spring of the telephone hook 169, to the contact stop therefor, ring 174, brush engaging therewith and connected to arm 142, spring 734 carried by the latter, the point or pin reached by the latter and placed to earth through the adjustment of the button 171 to position of connection with that contact of the row engaged by it, which is connected to the contact reached by the spring on the arm 142, to the button 171, and thence by earth to the grounded pole of the generator whose positive pole is indicated by the sign positive (+) next to relay 215, Fig. 7.

N is the normal position of the signal transmitter controller brushes, in which position after making two whole revolutions,

the upper pair of brushes complete the signaling and talking circuit. The number of contacts in a circumference of the cylinder switch previously described being insufficient to provide the necessary number for the operation of this device in one revolution, it is preferred to connect up the contacts and circuits so that the action shall be completed in two whole revolutions, thus making it possible to utilize a switch cylinder having the same number of contacts as that used in the other parts of the apparatus.

The signal transmitter controller has three positions of rest; the first is the N or normal position; the second position is indicated at S N or subnormal position just before the end of the first revolution, and the third position is a second subnormal position on the same contacts just before it completes the second revolution and reaches normal again. The device may be started and stopped by means of a magnet 20 such as already described for the cylinder switch, and a clutch control disk 23, the gear being such as to permit the disk to make a half revolution for one whole revolution of the brushes. In the drawing the normal notch of the disk is engaged by the dog, and the two other notches on the same diametrical line correspond to the two subnormal positions. By other arrangements of gear, disk, notches, &c., the device might complete its actions in one revolution.

The contacts being connected up as shown, it is obvious that the two upper brushes will make and break the circuit formed through them, and that simultaneously the bridging brushes in the third and fourth rows will produce at the same time a similar action. Other connections are formed through this part of the apparatus, as will appear more fully from the general operation.

It is started into operation after a path has been opened up by means of the primary connector between said signal transmitter controller and the line from which the call comes. For this purpose its clutch magnet 20 is connected by wire 52 to a contact in the 4th horizontal row of the switch cylinder, Fig. 6, rotary switch diagram, which is engaged by the lower one of the second pair of bridging brushes 708 counting from the top, when the third pair of bridging brushes 703 counting from the top connects short segments 657 and 658 so as to place wire 206 leading from the upper segment 656 of diagram Fig. 7, signal transmitter controller into connection with wire 123, as already described, over which the pulses may be sent to the No. 2 side of the line to move the progressive contact maker 142 of the substation apparatus diagram Fig. 39.

The energizing circuit of the clutch magnet, diagram Fig. 7, is from positive battery connected to the switch cylinder contact, Fig. 6, in the third horizontal row, 4th from N position at the left, over the second pair of bridging brushes 708 to the cylinder contact Fig. 6, in the fourth horizontal row, to wire 52, through the magnet 20, Fig. 7, and to negative battery.

While it is preferred to use a signal transmitter controller and signal transmitter combined as hereinafter described to adjust the central office apparatus to the proper required positions, the invention is not limited to such particular arrangement, but other means may be employed for moving the devices to the desired position and there causing them to come to rest under the control of a signal transmitter at the substation upon which the number of the substation called is composed or set up. We prefer, however, to employ the plan herein described and which is herein claimed as an improvement on that system wherein the signal transmitter has a circuit maker and breaker which, by making and breaking the line circuit, causes an electromagnet at the central office to actuate the contact brushes of the various parts of the central station apparatus by means of a pawl and ratchet serving to move said brushes step by step.

Interconnector.

The main function of this device is to establish connection with that section of the exchange to which the called subscriber's line is connected and with an idle secondary connector in that section. When this has been accomplished signals are sent over said connections to open up a path through said secondary connector with the line called.

The number of interconnectors in each division corresponds to the number of thousands of subscribers in the exchange, that is, one interconnector is used to control the connections embracing the first thousand; a second interconnector to control the connections embracing the sections of the second thousand, and so on. In other words, the exchange is not only divided into sections throughout, but said sections are grouped, preferably, in tens, each group being herein termed a grand division or group, or in the decimal system a thousands group, and each group being served by its interconnector in the same manner as other groups. The diagrams, Figs. 1 and 10, show two interconnectors 7, 8, in each division, that is to say, the number proper for an exchange of 2,000 subscribers. It is obvious that each grand division or group might embrace a greater or less number of sections than 10. For each interconnector the cylinder switch and register constructed, combined and operated as in Figs. 11 to 21, may be used. This reduces the amount of movement which it is necessary to produce in order to open up the desired connection to a particular one of

a large number of sets of wires, said sets corresponding respectively to the secondary connectors of the whole exchange. The register would then act to select a group of cylinder brushes controlling connections to one particular section of a thousands group, and said group of brushes in revolving would select an idle secondary connector of that section.

In other words, and as will be apparent from the description of the operation, the register portion of the interconnector is the part thereof which effects a preliminary selection of any desired group of the secondary connectors which are the main-line-circuit selecting switches for establishing connection to any one of a group of main lines used as a called line.

In this instance the contacts of the sector for the register which are engaged by the register brushes at the first step forward of said brushes, would be connected to a particular group of brushes in the cylinder switch for the interconnector, and the latter brushes would make contact at each of the 10 successive positions of rest which they may assume, with contacts connected respectively to wires leading to the 10 secondary connectors of one particular section of the exchange. These would be, say the secondary connectors for the first hundred in the first thousand.

The contacts of the sector for the register, Fig. 8, engaged by the register brushes at the 2nd step forward would connect in a similar way with another group of four similar brushes coöperating with four rows of contacts, 10 in each row, which would be engaged by said brushes successively and which would connect in the several positions of the brushes with the 10 bus wires for the 10 secondary connectors of another section, which would be the second hundred of the first thousand, and so on for the 8 other sections of the first thousand. For the next thousand another interconnector would be used and would be called into operation over the thousands register if the number of the called subscriber were in the second thousand. Each secondary connector in every one of the 10 sections of the second thousand would be connected to its own set of four bus wires in the same way as the secondary connector in all sections of the first thousand, and said four bus wires would be extended through all sections of the exchange and in every section would be connected to the second interconnector of each division. By then moving the four brushes of the register of the one or the other interconnector according to which is called into operation by the thousands register, diagram Fig. 8, to position of connection with four contacts joined by wires 660 with a set of four cylinder brushes 61 as shown, and then moving said cylinder brushes forward through a quarter revolution, connection would obviously be established from the register brushes to all of the secondary connectors in a section in succession, and if the cylinder brushes were brought to rest in their second position forward from normal, connection would be then established with the secondary connector in the second division of said section. Hence, if there be 10 positions of contact for the register brushes, and 10 corresponding sets of cylinder brushes, each moving over four sets of contacts, 10 in each row, and the latter be joined respectively to wires leading to the 10 secondary connectors of one section, it would be possible to establish connection from said register brushes to any one of 100 secondary connectors.

The register should have four rows of contacts and corresponding brushes, and cylinder brushes in corresponding groups of four to provide four circuits through the interconnector in each of its adjusted positions. One of these circuits, which is that over which the signals for the tens value come, would be as follows:—from wire 322 which extends from the rotary switch, Fig. 6 diagram down through Fig. 7 diagram, to the third of the feed segments 650 counting from the top, thence to a corresponding cylinder brush resting thereon after the cylinder shaft has started, thence by one of the connections 71 to the register brush, third from top, thence to the contact 60 of the contact sector engaged by said brush in its 9th position, thence by cylinder brush 696 and from the latter to the cylinder contact to which the brush may have been adjusted and then by a tap wire as shown to a bus wire 622, which is one of a group of four numbered 223, 622, 623 and 296. Each of the other three circuits would be formed in the same way at the same time by other register brushes and contacts and by other corresponding cylinder brushes, contact segments and contacts in obvious manner, to open up a path through said secondary connectors to the other 3 bus wires. When a thousands register is used these wires constitute tertiary connecting wires since they are the wires which are selected by the "thousands" and "hundreds" signals and then form a path for circuits over which the third selective signal acts in adjusting the secondary connector or final main-line-circuit selecting switch so as to connect said tertiary wire or wires to the called main line. Two of these circuits make the talking and signaling circuit; the third is a link in the circuit furnishing guarding potential to the guard contact on the secondary connector of the called subscriber at his section, and the fourth circuit is used to adjust a part of the secondary connector seized. The second

may also serve as a test circuit by which the interconnector selects an idle secondary connector on the required section. Referring more particularly to Figs. 8 and 10, 223, 622, 623, 296, represent a set of bus wires corresponding to the 4 circuits just mentioned. As many of these sets are used for each interconnector as there are secondary connectors in all the sections of the exchange served by it. 622 and 623 are two sides of the signaling and talking circuit. 223 is a test or guard bus, and 296 serves for adjusting a part of the secondary connector. Taking one set of bus wires, a secondary connector on one division of a particular section has its parts connected to bus wires 223, 622, 623, 296, by corresponding tap wires 224, 422, 423, 99. This set of bus wires runs through all sections embraced in all grand divisions or groups of the exchange, and in each section is connected as shown in Fig. 8, by tap wires with contacts on one of the interconnectors in every division. If the secondary connector be in the first grand division or group each set of bus wires is connected to all the interconnectors 7, and if in the second thousand, to all the interconnectors 8 in every division of the whole exchange. All the secondary connectors in the same section are connected in regular order and in a similar way to contacts of the interconnector cylinders adapted to be engaged in succession by the same group of four cylinder brushes. Of these groups of brushes there are as many as there are sections of the exchange served by the interconnector, and each group of brushes is connected as shown with a particular set of contacts of the register adapted to be engaged by the four brushes thereof in one of its several adjusted positions of rest. The four brushes of the register are mounted upon the escape segment 87 which is adjusted by a magnet and escape lever as described under the head "The register." This magnet is numbered 31 in diagram Fig. 8, and the four brushes coöperating with the four rows of contacts in the contact sector are shown in their normal or dead position marked N. Connection between the four register brushes and wires 222, 322, 323, 59, corresponding respectively to bus wires 223, 622, 623, 296, is made by means of connected groups of cylinder contacts forming feed segments 650 and brushes (upper four in the second vertical row) adapted to ride thereon when the shaft of the interconnector starts into revolution. In normal position the register brushes rest on dead contacts. The other ten groups of cylinder brushes bracketed in groups of four each, and corresponding rows of contacts correspond to ten different sections served by the interconnector. 31 is an adjusting magnet of the register for the interconnector, and 21 a clutch magnet for the cylinder brushes, while 23 is the clutch control disk provided with 11 notches in one quadrant, one being the normal notch and the 10 others representing the 10 different positions which the cylinder brushes may assume in selecting an idle secondary connector. These notches, which with the disk 23 are the same as already described under the head of "The clutch" obviously permit the shaft carrying all of the cylinder brushes to be moved from their normal position indicated in the diagram Fig. 8 and to come to rest in any one of ten different positions in their first quarter revolution so as to make connection upon cylinder contacts corresponding respectively to one of the 10 secondary connectors in every section of the exchange. After such first quarter revolution the next movement of the brush carrying shaft would be a three-quarter revolution, since the disk 23 is uncut at its edge for a corresponding movement and the cylinder brushes would then resume the normal position or that indicated in the diagram.

Magnet 21 is controlled over wires 54 and 55 and magnet 31 over wires 194 and 195 which are connected with the register through a contact and brush of the cylinder and a supplemental contact 352 and brush 351 mounted respectively on the fixed and revolving parts 64, 92, all arranged so that when the interconnector starts the connection with magnet 31 will be broken. The signaling pulses which operate magnet 31 flow from the source of energy indicated by the sign + in signaling relay in Fig. 7 diagram, the long feed segments 656, third from top and through the pair of brushes 706 resting on the same and on the interrupted row of contacts immediately beneath the same in the second half of the cylinder, and wire 193 to brush of the thousands register which moves over a row of contacts over which said brush is adjusted by the action of magnet 30, Fig. 7, contact engaged by said brush and joined to a wire 194 leading to the interconnector corresponding to the value of the numeral in the 1,000th place of the called subscriber's number, thence by diagram Fig. 8, to a contact of the cylinder for the interconnector upon which normally rests the upper brush in the third row, then from said brush through magnet 31 which is connected to insulated brush 351 carried by the plate 92 which, as explained under the head of "Register" is secured to the gear wheel 63 and revolves with the brushes of the switch cylinder, thence to fixed contact 352 engaged by brush 351 in the normal position of the plate and itself mounted upon the fixed plate 64 which forms the head of the fixed cylinder carrying the rows of cylinder contacts as described under the head "Cylinder switch,"

thence to wire 195, back through the Fig. 7 diagram to a contact in the lower row of the rotary switch cylinder diagram Fig. 6, and by the pair of bridging brushes 685 of said rotary switch in the second position as indicated at top of vertical row, to another contact in the same vertical line with it, and to the negative pole of the generator as indicated by the sign — shown on the wire joined to the last named contact. These pulses move the register brushes Fig. 8, step by step so long as the armature lever of the relay 215 is against its back contact. When the magnet of the relay is excited by the current flowing over wire 231 and through the rotary switch, primary connector and No. 1 sides of the calling subscriber's line to ground through the signaling devices and indicator at said station by the path already traced under the head "Signal transmitter controller" the flow of pulses through the register magnet for the interconnector will cease and the brushes of said register will then come to rest. If they have been sent forward from normal three steps so as to rest upon the 3rd set of the electrically connected contacts in register contact sector, they will be in connection with a group of cylinder brushes which moves over the group of cylinder contacts that join with the 10 groups of bus wires to which are connected respectively the 10 secondary connectors in the 3rd one of the 10 sections controlled by that interconnector with which a connection has been established by action of the thousands register. The magnet 21 for controlling the position of the brushes in the cylinder of the interconnector is operated over a circuit which is closed as soon as the signal transmitter controller has sent over the long feed segment 656 and the two sets of interrupted contacts below the same Fig. 7, the two sets of pulses corresponding to the thousands and hundreds value of the called subscriber's number. The hundreds value of that number determines obviously from the explanation given under "Signal transmitter controller" the number of steps that the register brushes operated by magnet 31, Fig. 8, must be sent forward from normal position. The circuit of the magnet 21 is closed on contact No. 43 in the 4th row of contacts, diagram Fig. 7.

The circuit is from the armature lever of relay 215 connected directly to positive battery, to back contact thereof, long feed segment 656, 3rd horizontal row and by bridging brushes 706 to contact 43 when said brushes are just about to complete their first half revolution, wire 96, right hand or outer brush of the thousands register brushes adjustable by magnet 30, Fig. 7, to a contact 686 in line with that to which wire 194 is connected as just explained, to wire 54, to diagram Fig. 8, through magnet 21, back by way of wire 55, through diagram Fig. 7, to a contact 731 of the rotary switch Fig. 6, in the vertical row, under No. 2 position, 8th from the top and by a pair of bridge brushes 732 when adjusted to rest on 8th contact and contact immediately above the same, to wire 56, thence to a wire 57, to which a similar connection is made from all the rotary switches of the same section, then through a magnet 218, and to one of a number of contacts 431, Fig. 6, engaged by one arm of the continually revolving circuit changer 430 to the other arm thereof and to a feed segment 432 which is joined to the — side of the source of energy whose + side is connected to armature lever of relay 215. This is the connection at the first instant of closure of the circuit, but the magnet 218 immediately closes a circuit on its front contact so that after the arm 430 leaves the contact 431 just mentioned there will be still a complete circuit by way of the substituted wire or connection 670, Fig. 6. Since all the 10 rotary switches of the same section are connected to the wire 57, leading to a particular contact of the series 431, Fig. 6, any interconnector on the same section may have its magnet 21 actuated.

The interconnector for other sections would be connected over similar connections over arm 430, Fig. 6, but through a different contact of series 431, on which there would be as many contacts as there are sections in the exchange; hence, no two interconnectors which are on different sections can be actuated at the same instant. No two interconnectors which are on the same section can be actuated at the same instant because the lines of the same section are placed in connection with the devices which start the apparatus of the same section into operation, one at a time only by means of the revolving circuit changer consisting of a contact arm moving over a series of contacts to which the lines are separately connected in regular order, as more fully described under the head "Decimal indicator."

The supplemental contacts 352, 351, are employed only because all the contacts and brushes of the cylinder switch Fig. 8, are utilized in other ways. The brushes of the register actuated by magnet 31, Fig. 8, may be restored to normal in the manner already explained under the head of "The register."

In Fig. 10 the general plan of connection for an exchange of several thousands is shown. At the left a part of the eighth section for the first thousand is shown, namely the section for substations 700 to 799; and at the right a part of the ninth section for the second thousand or for substations 1800 to 1899. Two interconnectors of each section and their corresponding bus wires are shown. The bus wires for 2 of the 10 sets of bus wires for one of such sections are

shown at 223, 622, 623 and 296. Two similar sets for another section are marked 223′, 622′, 623′ and 296′.

In Fig. 8 the tap wires in full lines running from the interconnector correspond to the first two divisions of secondary connector in one section of the exchange. The dotted lines indicate the connections for a secondary connector of another section.

Secondary connector.

The secondary connector, diagram Fig. 9, may be substantially the same in mechanical construction as the primary connector. Its cylinder contacts are connected with the two sides of the line wire by taps 523, 522, and with a guard wire 3 of that line by tap 325. This wire 325 of the secondary connector diagram Fig. 9, is shown attached to the top wire 3 in Fig. 1. The tap wires 422, 423, and 224 joining the secondary connector with its bus wires correspond respectively to the tap wires just mentioned. The fourth tap wire leading to the bus, namely 99, connects to the clutch magnet 22 of the secondary connector and to negative battery or return. The taps 422, 423, are connected respectively with two brushes of the secondary connector register by feed segments and cylinder brushes engaging therewith as soon as the cylinder shaft starts into rotation as indicated, and the 224 wire is in connection with the third register brush over a third segment which begins at the normal position of a cylinder brush. From the contact of said register brush there is a normal connection for 224 to earth through a cylinder brush and contact where connection is broken when the shaft starts into rotation.

Register magnet 32 is in the connection 422, 196, from one of the bus wires to earth or return by a pair of connected cylinder brushes and contacts which close the connection in the normal position of the cylinder shaft only. These brushes in diagram Fig. 9 are shown as the top brushes in the first and third vertical rows. They are joined by a wire 662 in the circuit of which is the magnet 32. One of the contacts in the normal position of said brushes is joined to wire 196, and the other to earth or return as indicated by sign — at the bottom of the bank of cylinder contacts. The connection 196 is taken from tap wire 422 which is shown connected to the upper of 3 feed segments 650. When the cylinder brush in line with such segment moves over the same, it establishes the connection as shown to the upper or outer brush of the register whence the circuit continues after adjustment of said brush by magnet 32, to one of the contacts of the register sector to which the brush is adjusted and thence by the inner of the 3 wires 71′ to the cylinder brush 711 which is adapted to engage the cylinder contact connected to a tap wire 523. The latter is joined as shown in Fig. 1 to the No. 2 side of the subscriber's circuit and hence forms a part of the talking circuit. Grounding of such circuit over wire 196 connected to 422 is prevented because when the cylinder brushes of the secondary connector start to move to the position for establishing such talking circuit, the brushes joined by wire 662 through magnet 32 and to earth or common return break the connection 196.

When the cylinder brushes start, the register magnet's connection is broken, thus preventing interference with the talking circuit subsequently established over 422.

Combined with each secondary connector is a circuit closer and breaker which closes circuit in the normal position of the secondary connector and breaks circuit when the secondary connector is put into use and therefore out of normal position. When any moving interconnector in its search for an idle secondary connector reaches connection to a secondary connector in normal or idle position a circuit is established by the interconnector through said circuit closer and this causes the controlling circuit of the interconnector to be broken so as to bring the same to rest. This may be brought about through the intervention of a suitable relay such as 215, Fig. 7 acting on the circuit including clutch magnet for the interconnector, Fig. 8. Conveniently the said circuit closer and breaker consists of brush and coöperating contact on the register of the secondary connector engaged with one another in the normal position and shown as the inner one of the three register brushes and the first contact of the inner row of contacts, Fig. 9.

The cylinder brushes which ride upon contacts connected to tap wires 325, 522, 523, for the different lines are employed in groups of three, and each group is connected to a group of three register contacts adapted to be engaged by the register brushes in one of their several adjusted positions. The register brushes select one group of the ten groups of cylinder brushes, and the group of cylinder brushes selected, by riding over the ten contacts in one quadrant select the particular wires of the section which belong to the called subscriber. In the diagram the three register contacts which are engaged by the register brushes after they have moved five steps forward from the position 500 are shown in connection by wires 71′ respectively with 3 cylinder brushes in the second vertical row counting from the left. The contacts correspond to all subscriber's numbers running from 40 to 49 inclusive in the particular section for 100 subscribers on which the secondary connector is employed. The 3 cylinder brushes connected to the 3 register contacts engaged by the register at

their first step forward after leaving contacts 500 correspond to the first 10 subscribers of the section and the successive contacts of the register sector to the successive tens in regular order. In each row of 10 contacts engaged by the cylinder brushes of any one group the 10 corresponding subscriber's lines are connected in regular order by tap wires 522, 523, leading to the 2 sides of the line, as indicated in Fig. 1.

The manner of operation in opening up the connection between the tap wires leading from the bus wires and the tap wires leading to the subscribers' wires of the same section is substantially the same as the operation of adjusting the primary connector to open up the path between any subscriber's line and the wires 122, 123, diagram Fig. 5, leading to the rotary switch and thence to the interconnector.

The units value of the called subscriber's number determines the number of steps forward that must be given to the cylinder brushes Fig. 9, and the tens value governs the number of steps forward to be given to the brushes of the register. The cylinder brushes engage 10 contacts in making a quarter revolution, in doing which they pass over contacts corresponding to all the lines of the section. In returning to zero or N position by a forward movement through three-quarters of a revolution they are not required to perform any action. All subscribers' lines of the same section or group are similarly connected to the cylinder contacts of the 10 secondary connectors belonging to that group.

The clutch control disk is constructed to permit the cylinder brushes to be adjusted to any one of ten positions in a quarter revolution, and then to make a three-quarter revolution to normal position.

The first group of contacts engaged by the register brushes after leaving normal and indicated at 500, are dead contacts, upon which they rest temporarily at the instant of seizure by the interconnector, thus preventing any other interconnector from seizing the same secondary connector.

The register is adjusted according to the tens value of the called subscriber's station number, and the cylinder brushes according to the units value of that number.

There being one or more of such main-line-circuit selecting switches termed secondary connectors for each group of main lines and there being also for all of the main lines of all groups, a circuit-selecting switch (interconnector) one or more for each group of lines in which each of said secondary connectors is represented, it will be obvious that the operation for establishing a connection from any main line to a secondary connector and to a main line represented thereon involves a train of circuit selecting actions in which interconnectors operate as circuit-selecting switches to pick out an idle secondary connector in the desired group and that all lines may, by such circuit-selecting action, seize upon any secondary connector of any group. The interconnector switch by its selecting action picks out an idle secondary connector in that group of secondary connectors belonging to the group of lines which includes the called line and its action may be said to be of a two-fold character for it not only as a switch selects the required group but picks out or seizes upon one of said secondary connectors that may be idle or ready for use. The selection of the group, however, is apart from its selection of an idle member of that group for the former action takes place in obedience to the selecting signals sent by the transmitter while the latter action is an automatic action determined by the condition in which the secondary connectors are found as the interconnector proceeds in its search for one which is in normal position and therefore in position to close some test or trip circuit upon which the interconnector acts. The said secondary connectors are comprised in groups or series of secondary connectors each having a multiplicity of line connections greater in number than the number of secondary connectors in the group and said secondary connectors form a percentage less than the whole number of main lines and proportionate to the traffic demand.

It is preferable that the several connectors of any group, for instance, the group appropriated to making connection with the lines as called lines should be separate or individual pieces of apparatus or self-contained mechanism each having its own set of brushes, contacts and brush carrying shaft. This however is obviously not necessary in order to realize the broad principle of grouping and electrically connecting the lines and connectors. The number of selecting contacts on each interconnector (selecting switch) depends upon the number of selecting switches, (secondary connectors) employed, and if but one section of exchange with ten secondary connectors thereon be used, selecting contacts ten in number only would be required on the interconnector. It is preferred, however, to install each interconnector with a capacity for selecting secondary connectors in a large number of sections preferably ten.

The term "secondary" is employed in the term "secondary connector" in allusion to the fact that the movable elements or brushes of said instrument in establishing connection with the called line are used in analogous manner to that plug of a manual cord circuit which is placed in the called line terminal and is the second one of the cord terminals to be used by the operator, the other having

been already used in establishing connection with the calling line. Similarly we use the term "primary" in the term "primary connector" in allusion to the fact that the movable elements of the same correspond in function to the cord terminal of a manual exchange which make connection with a calling line when a call is received. Having regard to the action of those portions of the apparatus involving the primary connector, interconnector and secondary connector, the action may be thus outlined:

By the primary connector a calling line is connected to an interconnector, and the latter by the selecting signals selects a secondary connector in the required group, which secondary connector under the action of the further selecting signals, picks out the line called. There is thus formed from the contact of the secondary connector to the line called a circuit analogous to a cord circuit of a manual exchange. More or less of the apparatus required for selecting and adjusting the secondary switch or selector may be retained in the circuit thus established by the connecting of a calling line to a secondary switch and the automatic adjustment of the latter to select the line called.

Thousands register.

The thousands register is simply a selecting switch by whose means one of a number of interconnectors may be selected according to the value of the number for the substation called. This selecting switch may be of any desired construction and responsive to a selective signal or signals of any desired character sent from the substation. If more than two interconnectors are employed it is preferable to use a step by step selective switch. If said number be, for instance, in the first thousand, interconnector 7 will be brought into operative relation to the apparatus seized by the calling subscriber for the purpose of effecting connection with another substation. If the number of the called substation is in the second thousand, the thousands register is automatically set to make a second interconnector, namely, 8 operative, this connector being the one for establishing circuit with bus wires leading to sections of the exchange whereon substations 1,000 to 1,999 inclusive are represented. In the same manner, if the substation called be in the third thousand, the thousands register seized will be set to position to establish an operative connection for another interconnector whereby the calling substation might find the particular section in the said third thousands whereon the substation wanted is represented in contacts on an idle secondary connector. Its operating magnet indicated at 30 in the diagram Fig. 7 responds to the thousands signal sent through it from wire 191 and the long feed segment 656 through the interrupted row of contacts immediately below it which are engaged in the first half of the first revolution of the signal transmitter controller, Fig. 7.

The thousands register Fig. 7, may be constructed like the register already described, or in any other desired manner, but requires only two brushes and two rows of contacts, the first of which in each row are the N or zero contacts while the succeeding contacts connect respectively with the circuits of the different interconnectors in the same division. One brush connects through wire 107, with the rotary switch and devices controlling the operation of the interconnector, and the contacts connect with the operating magnets 31 and 21 for the register and cylinder brushes of the interconnector over wires 194, 54. The register magnet 31 is operated by signals corresponding to the hundreds value of the called subscriber's number, as already explained under the head "Signal transmitter controller" by impulses coming from the long feed segment 656 and brushes 706, Fig. 7, during the second half of the first revolution. The magnet 21 after the operation of the magnet 31 Fig. 8, releases disk 23 and couples up cylinder brushes of interconnector and is energized in the manner already explained by the current flowing over the contact 43, Fig. 7, as already stated. This register may be restored to zero with the other parts of the apparatus in any desired way. If it be mounted upon a fixed support, as for instance, the rotary switch cylinder, it may be arranged so that a projection upon its disk 87 will be engaged by either of two pins 95 carried by the wheel 92 secured to the shaft of the rotary switch as indicated in Fig. 22. One pin operates in the first half revolution of the rotary switch, and the next in the second half or after the second operation of the rotary switch. The pins automatically disengage the lug on the disk 87 as soon as the latter reaches normal position and as explained in connection with the operation of the register, Figs. 11, 12, 19 and 20. This is due to the fact that the disk would be pivoted eccentrically to the center around which the lug 95 shown in dotted lines Fig. 22 would revolve.

Relays.

The different relays employed in each division are indicated in the diagram Fig. 7. They may be mounted on any desired part of the apparatus. 215 is a signal relay, 216 is a release relay, 217 a ringing relay and 220 a special relay, all connected and operating as will be fully understood from the description of the operation. The release relay is used to close the circuit to a wire 109 for the purpose of energizing the clutch magnet of the rotary switch diagram Fig.

6, when the same is in the talking position, and thereby initiating the actions which send all the parts around to zero or normal position. The current for this purpose is supplied from batteries 203 and 202 working in series and connected to armature lever of relay 216, whence the current passes, when the relay is actuated, to front contact, wire 109, contact in the lower horizontal row of the rotary switch cylinder, Fig. 6, under position V, which is the talking position, and by the lower pair of bridging brushes 699 when in such position, to the long feed segment in the next to the lower row which is connected by wire 663 with the clutch magnet 17 for the rotary switch, and thence to negative battery or opposite pole of battery 203, Fig. 7.

201 is a generator of pulsatory or vibratory current which is connected to the circuit of the called subscriber by the operation of the relay 217 in any division, for the purpose of ringing the call bell at his station. 205 is a non-inductive resistance shunting the coils of relay 217 so that they shall not interfere with conversation; and 204 is an induction coil having two equal windings. 202 and 203 indicate sections of a continuous current generator which supplies energy for the various operations herein described. For the local operations at the central station but one section of said generator is ordinarily employed owing to the lower voltage required, but for the operations conducted over the circuits of the substations both sections are employed in series to give an increased voltage. For conversation, one section only of the continuous generator is used. The connection from said generators to the apparatus of one division is shown, but the apparatus of other divisions may be supplied from the same generators in multiple in obvious manner. For the sake of simplicity, these multiple connections are omitted on the diagram; so also are the connections by which positive and negative battery is supplied from the generators to the various parts as indicated by the signs positive and negative throughout the diagrams. The local circuits are, generally speaking, metallic circuits. Some of the operations are conducted between the substations and the central station over ground circuits, in which cases the ground represents negative battery.

The particular way in which the several relays described operate in connection with other parts of the apparatus will be set forth in detail in describing the general operation. Relays of any form or character may be employed and, generally speaking, the devices may be operated either on closed or on open circuit. This and other modifications in the manner of utilizing the relays to control actions of various parts of the current used to energize such relays and cause them to perform the necessary actions will be obvious to electricians.

Consecution controller.

This device serves for the whole exchange, and renders the connecting apparatus on different sections respectively capable of operation only in succession or one at a time by closing their operating circuits successively. Or, in other words, it spaces out signals coming at the same instant from subscribers' lines belonging to different groups in a manner to delay the action of the apparatus of one group so that it can only operate after the apparatus controlled by the different lines of the other group has progressed to the point where interference or confusion cannot result. The special object is to prevent interference if two subscribers on different sections should attempt at the same instant to connect with the same subscriber or with two different subscribers on the same section. Interference between subscribers of the same group calling at the same instant is prevented by the decimal indicator which connects them successively or one at a time only with the electromagnet which puts the exchange apparatus into operation.

The consecution controller may act mechanically or electrically, but preferably electrically. It comprises a continually operating circuit changer which intermittently but successively closes the operating circuit for some part of the apparatus for one section and then in succession similar circuits for other sections.

In connection with each circuit a device in the nature of a relay is provided whereby the closure is prolonged if, when first made, the apparatus on that particular circuit is ready to operate. This leaves the consecution controller free to move on and close circuits for other sections. Hence, the interconnectors will start one after the other and the one first operating will make connection with the set of bus wires belonging to a secondary connector to which the called subscriber is connected and will adjust said secondary connector to connection with his line. The guard bus wire for that secondary connector is then charged and also all guard points for the line called upon all the secondary connectors of the same section. When, therefore, the other calling subscriber by means of his interconnector adjusts another secondary connector to connection with the same called line he will get the "line busy" indication over a test circuit as hereinafter set out in detail.

The circuits closed are preferably those by which the interconnectors are started on their way to seize an idle secondary connector. The magnet is excited by current from

positive battery Fig. 7, connected to the lever of relay 215, back contact therefor, pair of bridging brushes 706 when they reach the contact 48, wire 96, register brush of the thousands register when adjusted to contact 686, then through wire 54 and to magnet 21, Fig. 8, by wire 55, back to contact 731 in the rotary switch cylinder to No. 2 position and to wire 56.

Fig. 23 illustrates a form of consecution controller suitable for this purpose.

430 is a continually revolving circuit changer arm whose contact springs sweep simultaneously over feed segment 432, and over a series of segments 431 insulated from one another and connected respectively with bus wires 57 each of which forms a common return bus for starting the magnet 21 of all the interconnectors for one section, and each of which is connected to the several interconnectors controlled by the same group of lines. This has just been fully explained under the head "Interconnector."

Each circuit contains an electromagnet 218 which, when energized, closes at its front contact a connection independent of that through the segment to the battery or common return, thus preserving the circuit for the interconnector clutch magnet 21 after the brush of the consecution controller leaves said segment. When the rotary switch moves forward, which it does after the idle secondary connector has been found, it breaks the circuit of the consecution controller and magnet 218, at the cylinder contacts 731, so that the magnet 218 loses its power and opens the branch connection 670. In practice the consecution controller may operate at such speed as to close its connection at intervals of every two seconds, so that a delay in the action of the interconnectors from the presence of the consecution controller may not at any time be more than two seconds.

Decimal indicator.

One of these is used for each section for the purpose of giving control of the apparatus on said section to the various subscribers' lines of that section in succession, and permitting a line to seize upon one of the idle divisions or sets of connecting apparatus for use in establishing connection with the called substation.

The decimal indicator has a circuit changing arm carrying brush 111, see Figs. 2 and 24, which closes connection to the lines of the sections in succession. It also comprises a device whereby the primary connector of the seized idle division may have its brushes automatically adjusted to position for connecting the calling line with the other parts of the apparatus in a division. For this purpose the decimal indicator embodies additional circuit changing arms carrying brushes 115 and 114, and divided contact rings 105 and 104, one termed the "units" ring and the other the "tens" ring.

Preferably the decimal indicator constantly revolves and is automatically brought to rest by a signal from a substation. As soon as the division of connecting apparatus seized by that station has passed beyond the point where it may be seized from some other calling substation, the decimal indicator resumes its revolution. The circuits of the decimal indicator and control magnets associated therewith are shown in Fig. 2. The decimal indicator also has a circuit changing arm carrying brush 116, and a divided contact ring 106 with segments, one for each line, whereby a guarding potential may be established on the guard contact of the calling line on all the primary connectors of the section. The mechanical construction may be such as shown in Figs. 24 to 26 inclusive.

101 is a divided line contact ring having one contact or segment for each line of the section. Said segments are mounted upon a backing plate or ring and clamped and insulated from one another as shown in the vertical section, Fig. 25, in a manner similar to the segments of a commutator for a dynamo.

106 is the guard contact ring also containing as many segments as there are lines in the section, and each connected to its appropriate guard wire 3.

102 is a continuous feed ring connected with a relay contact lever by brush 112, and joined by wire 230 running as shown from diagram Fig. 2, through diagram Fig. 3, to and through a relay magnet 212 which operates on a starting magnet 16, the latter in turn being used with devices for bringing one of the divisions of connecting apparatus into operation.

103 is a continuous ring through which by means of brush 113 current is supplied to the circuits passing through the decimal indicator.

105 is the divided "units" contact ring, and 104 the divided "tens" contact ring.

Rings 101 and 105 may be separately mounted and secured in position like ring 106. Rings 102, 103 and 104 are mounted upon the same backing ring or plate 733. All the backing rings are bolted together and to the head 129, and connections from the various rings and segments are taken out through the opening of the head 129 so as not to interfere with the free rotation of the brushes 111, 112, 113, 114, 115 and 116. Connection with segments of rings 101, 105 and 106, may be made by the shoulders or lugs upon them, and with rings 102, 103 and 104, by insulated pins passing through the backing ring. The brush holders are mounted upon arms 126 united at their lower ends in a stiff-

ening ring 128, and at their upper ends in a plate 127 to which rotation is imparted from a shaft 131 revolved by wheel 132 and carrying friction disks 133 and 134 which embrace the plate 127. By means of these friction disks and plate the parts of the decimal indicator may be brought to rest at any time and the driving power and shaft permitted to continue their rotation. This avoids the necessity of stopping the driving power whenever the stop magnet 15 is actuated. Disk 133 is fastened to the shaft, and disk 134 is connected with the shaft by a pin and slot connection, and is capable of longitudinal movement on the shaft. Plate 134 is forced against plate 127 by means of a spring 135, whose power is adjustable by a nut 136 mounted on the end of the shaft 131. 130 is a bracket which carries the plate or head 129. The latter affords a support and bearing for the rotary shaft.

The tens contact ring 104 contains 10 segments of equal length and its individual segments correspond respectively to the different values of the numeral in the tens place of the substation numbers.

The units contact ring contains 100 segments corresponding to the 100 units of the substation numbers and is divided into ten groups of ten each, the similar contacts of which groups are connected together; that is, the No. 1 contacts of all the groups are interconnected and similarly the No. 2 contacts are interconnected to form in effect 10 groups of contacts whose individual members are interspaced with one another. Each group of ten contacts occupying the same arc or portion of the units ring corresponds in position with one of the segments in the tens contact ring, so that the brush riding on the units contact ring may make connection with a units contact of any value from 0–9 inclusive, at the same time that another brush makes contact with a segment of any value in the tens ring. Hence, any number from 0 to 99 may be represented as to its tens and units value by a brush riding upon the tens contact ring in conjunction with the brush riding over the units contact ring, the number so indicated depending upon the circumferential position of the two brushes at any instant.

The manner of connecting up the segments of the units contact ring is more clearly indicated in the diagram, Fig. 2. The contacts of the units ring may be connected up in other ways, and the contacts of the two rings and the brushes riding on them arranged in different relations to one another from that shown, and yet permit the number of the 100 substations to be "indicated" by the two rings.

The several segments of the divided tens ring 104 connect in numerical order with corresponding wires in a cable 185, which wires lead to and are connected in numerical order to contacts of a device termed "decimal register controller" which will be presently described. This cable runs, as indicated in diagrams Figs. 2 and 3, from the ring 104 to a series of contacts numbered 0, 1, 2, &c., to 9 inclusive, Fig. 3. Over these contacts the relay 210 is operated to govern the number of impulses which pass to an electromagnet 29 for the primary connector register. By the action of the decimal register controller coöperating with the decimal indicator, the adjustment of the register to the tens value of the calling subscriber's number is accomplished. The 10 interconnected groups of contacts on the ring 105 connect in numerical order with wires in the cable 119, which wires are connected in numerical order with a set of 10 contacts on each of the 10 primary connectors for the several divisions of connecting apparatus. These contacts coöperate with magnet 219 on the primary connector Fig. 5, to bring cylinder brushes of said primary connector to position corresponding to the units value of the calling substation number.

All of the No. 1 contacts of the ten several groups are joined to one wire, and these wires represent each a different value in the units place. Each connection to a wire of cable 119 may be obviously made by simply connecting one of the contacts of the group representing the one value.

Mounted upon the plate 127 is a stop magnet 15, the armature of which is furnished with a dog 125 (see Figs. 28 and 29) adapted to engage with a crown stop ring 124, having 100 teeth properly located to cause the brushes to come to rest upon a contact segment when the dog is forced down into engagement with the ring by the action of the magnet. The blade spring as indicated in Fig. 28 keeps the dog normally raised, but the moment the magnet is excited the plate carrying the dog and the brushes come to rest, although the shaft 131 which drives the brush structure may continue to revolve.

This is due to the fact that the crown stop ring 124 is fixed to the stationary parts as shown in Fig. 25, to which the various contact rings are secured, while the magnet and dog are supported upon the rotating parts carrying the brushes and rotated by frictional connection with the constantly revolving shaft 131.

The relays 211, 213, 214, whose coil and contact stop circuits are connected with the brushes shown in diagram (Fig. 2) are also mounted upon the revolving structure, thus dispensing with the necessity for feed contact rings which would be required if they were mounted upon an exterior fixed support. Relay 211 is connected to a brush 111 bearing on the line contact ring 101, and may be operated from any substation of a

section as soon as the brush 111 finds the line contact of that substation in ring 101. Relay 211 controls the action of the clutch magnet 15, and relay 214 serves to charge the corresponding contact for the substation calling on the guard ring 106.

The circuit for the clutch magnet 15 is as shown in diagram Fig. 2, from the brush 113 bearing on ring 103 to one terminal of coil of said magnet 15, and from the other terminal thereof directly to the front contact of relay 211, thence by the armature of said relay to the brush 112 and to the continuation of the circuit by wire 230, down through diagram Fig. 3, and to and through the coils of relay 212. The relay 214 is in a branch around magnet 15 as shown between the wire leading from brush 113 and the wire leading to the front contact of relay 211. The contact on guard ring 106 is charged by current which passes through the circuit leading from brush 113 and magnets 15 and 214 to the front contact of relay 211 and armature lever, at which latter point the circuit branches, one branch passing to 112 and wire 230, and the other passing through magnet 213 and thence to back contact of relay 214, armature lever therefor and to brush 116 bearing on the contact to be charged.

The special functions and operations of these various relays and their operation in conjunction with the decimal indicator will be described in the general operation.

Decimal register controller.

One of these is used for each section. This device acts in connection with the decimal indicator to adjust the primary connector into position corresponding to the "tens" value of the calling subscriber's number, and the several circuits in cable 185, leading from the "tens" indicating ring of the decimal indicator operate as test circuits, which determine the number of impulses which shall be sent by the decimal register controller over the wire 187, which runs through all divisions and is tapped at each primary connector to the register magnet 29 thereof. While the impulses may pass from the decimal register controller to the wire 187 tapped to all primary connectors, said impulses will pass only through the register magnet of the primary connector in the division which is started in response to the call. As will be seen from the description of the general operation, the rotary switch of the division started completes the connection for the register magnet 29 of the primary connector in the same division with it as soon as the said rotary switch starts into operation. In all other divisions, however, the rotary switch is at rest and hence the circuits through the magnets 29 in such other divisions are open. The impulses are produced by the movement of the brushes 120 of the decimal register controller over a row of interrupted contacts in the divided ring 50, as will be presently described, but said impulses cannot flow until a suitable source of energy is connected to the brushes by the action of a magnet 210, which latter is energized by the current over one of the wires in the cable 185 depending upon which one of the contacts in ring 104 the brush 114 may rest on when the decimal indicator stops in response to the signal from the subscriber's station.

The decimal register controller is started directly or indirectly in response to a signal received from the calling substation, and when started revolves until it finds a wire of cable 185 rendered alive by contact of brush 114 with the tens ring in the decimal indicator. It then begins to send pulses into the magnet 29 of the primary connector in the division seized. It may be constructed as shown in Figs. 30 and 31.

This device may be driven and controlled by means of the clutch magnet and control disk such as already described. Its clutch magnet 18, Fig. 3, is energized to start the brushes into rotation over the circuit from positive battery, Fig. 3, connected to wire 40, to wire 41, to the rotary switch Fig. 6, and then by a tap wire 44 to one of a pair of contacts which are bridged by brushes 678, as soon as said switch starts into operation so as to form the connection to negative battery from wire 44. The brushes 120 complete their phase of action in a half revolution and hence the disk 23 has two notches separated from one another by half the circumference of the disk.

The brushes 120 thereof are connected together and are mounted in brush holders 225 secured to arms 182 fastened to the hub of a driving wheel 180, and provided with a stay ring 138 as in the decimal indicator. They revolve over a compound ring, one half of which, 121, is a continuous feed segment, and the other half of which is made up of separate insulated segments. Said compound ring is fastened to a backing ring by a clamp plate 183 and the backing ring is secured to a fixed hub or base 139 corresponding to the hub 129 of Fig. 25.

The shaft carrying arms 182 and wheel 180 may be supported in a similar manner to that of the decimal indicator.

In the divided segment 50, 10 of the contacts are connected in numerical order as already explained, to the 10 wires respectively of cable 185, the contact marked zero being connected to the wire which terminates in the segment marked 0 of ring 104, Fig. 2, and so on in regular order through the correspondingly numbered contacts and segments.

Between the contacts just mentioned in the divided ring 50 are contacts all con-

nected to wire 187. After leaving the contact connected to wire 187, and before reaching the next contact connected to the same wire, the forward brush 120 passes over the contact to which no connection is made. While said brush rests upon a contact connected to 187, it is by means of the rear brush, connected through the feed segment 121 and wire 186 with the armature lever of a relay 210. If said relay is excited the armature will be against its front contact which is joined to a battery or other source of energy. If, then, the circuit is closed to said source of energy and the forward brush then engages one of the contacts connected to wire 187, the current will pass over said wire, but will be immediately broken as the brush passes forward to the next contact connected to said wire. But, as will be obvious, if the relay is not excited, no current will flow to said wire 187. So long, however, as the relay is excited, current will first flow over wire 187 and will then cease flowing so as to produce a series of pulses as the forward brush moves onto and off of the contacts connected to said wire.

The charging of the magnet 210 is determined by the condition of the contacts connected to the wires in 185 and lying between those connected to wire 187. If the relay is charged, for instance, when the forward brush passes contact numbered 4, and is kept charged thereafter, the forward brush 120 will thereafter pass over 5 contacts connected to 187 and this will produce 5 impulses on the circuit 187 so as to set the register brushes of the primary connector forward 5 steps, 0, 1, 2, 3 and 4. Hence, the charging of the wire in 185 belonging to a segment in the ring 104 bearing any particular numeral may be made to produce on wire 187 the number of impules of the same numerical value, because when the forward brush finds the contact of the divided segment 50, which is connected to that wire of the cable, the magnet 210 will be charged over the circuit from positive battery Fig. 2, brush 113, wire 680, brush 114, wire of cable 185 to the correspondingly numbered contact in the divided segment 50, forward brush 120, then to rear brush 120, feed segment 121, wire 186, coil of relay 210 and negative battery. Up to this time no impulses will be sent over wire 187, for the reason already explained, but thereafter the forward brush will produce pulses flowing from positive battery Fig. 3, to the front contact of the relay and by feed segment 121, rear brush 120 and forward brush 120 connected in succession to the remaining contacts of the divided segment connected to wire 187.

The relay may be discharged by the action of current in an opposing winding through which current is sent from a contact 48 after the device has completed its action over the circuit from positive battery Fig. 3, front contact of the relay 210, relay lever, wire 186, feed segment 121, rear brush 120, forward brush 120, contact 48, and through said opposing winding, up to which time the relay has been held up by the direct connection from positive battery Fig. 3, front contact of said relay, armature lever therefor, coil of relay connected to said armature lever and directly to negative battery. When, however, the current flows through both coils as just explained, the magnet loses its power and the armature drops to its back contact so that the device is ready for another operation. Another contact 46 near the end of the divided segment 50 is connected to a wire 49 running through all divisions and connected in multiple to the magnets of the rotary switches in the first position thereof, to send the same forward to the second position. This takes place just before the forward brush engages contact 48, and the current flows through the clutch magnet 17 of the rotary switch from positive battery Fig. 3, to the front contact of relay 210, wire 186, feed segment 121, rear brush 120, forward brush 120, contact 46, wire 49, tap wire 51 and to and through the pair of contacts in the two lower rows of cylinder contacts, Fig. 6, in the vertical row under No. 1 position and by the bridging brushes 699 previously adjusted to such position by the movement of the switch forward from normal position and thence through wire 663 and magnet 17 to negative battery.

It will be understood that while there is a similar tap wire to every one of the 10 rotary switches, the current will flow only to and through that rotary switch which is in the idle division previously started by the action of current flowing from the division starter, as will be presently described, over bridging brushes 699 in their normal position, while at all other switches that have been left on normal position or have passed beyond the No. 1 position, the connection from 51 through the clutch magnet 17 will be opened.

The shaft carrying brushes 120 may be operated in the same manner as the shaft of the cylinder switch by means of a clutch controlling magnet 18 together with a clutch controlling disk 23 which, if geared to make one whole revolution for one whole revolution of the brushes 120 would, as indicated, have two notches diametrically opposite one another.

The clutch magnet 18 may be momentarily energized to start the device by an impulse from the seized idle division of connecting apparatus, for instance, from the rotary switch thereof, sent over the wire 41 connected to all the rotary switches or the section

in multiple. When the brushes 120 complete a half revolution the dog drops into the notch of the disk 23 and the brushes come to rest ready for another operation, that brush which was in the first half revolution, the rear brush, becoming at the next operation the forward brush.

Division starter.

This device (Fig. 4) responds to a call or signal from any substation of a section on which it is located for the purpose of making one of the normally idle divisions of connecting apparatus operative. It is preferably controlled from the decimal indicator when the latter responds to a call and comes to rest, but may be controlled directly or indirectly by a signal from the substation in any desired manner. This is done by means of an electromagnet 16 operating on a clutch which connects the brush-carrying shaft of the said division starter to a suitable driving power. When started, it closes a circuit for the clutch magnet of the rotary switch in one of the 10 divisions of connecting apparatus in the one section to which it belongs. If 10 sets or divisions of connecting apparatus are provided on a section, the division starter will have 10 starting positions. When it starts and seizes an idle division it automatically comes to rest again in position favorable for starting another idle division when the call comes from another line on the same section.

When any division is in use the starter is caused to pass the stop position corresponding to said division by proper electrical or mechanical controlling devices operating automatically. But when the division is idle the starter stops in position ready for starting said division.

Said automatic controlling devices consist preferably of a clutch operating magnet and two coöperating circuit controllers, one on the rotary switch and adapted to close circuit when the rotary switch is in normal position, and the other operated by the starter and acting to close another break in the circuit just before said starter reaches that position of rest from which it starts to bring the apparatus of an idle division into operation.

When the division starter moves from any of its positions of rest it starts the rotary switch of the corresponding idle division by any desired means, preferably by closing the circuit of the clutch or starting magnet for the switch or other portion of the division. The division starter is started by means of a clutch or stop magnet 16 brought into operation at or about the time that the decimal indicator comes to rest. For this purpose the circuit of the clutch magnet 16 may be closed by the line relay which responds to a call from any substation of the section.

The division starter may close and break circuit by means of a pair of bridging brushes moving over a double row of contacts and mounted upon a shaft driven and controlled by means of a clutch, electromagnet 16 and a control disk 23, suitably notched to allow the brushes to move from one contact over an intervening contact to another contact before they automatically come to rest again. The double row of contacts may be mounted in the same way as the contacts of the primary connector. Referring to diagram Fig. 4, contact points for four divisions of rotary switch are shown, there being for each division 4 pairs of contacts. For the ten divisions 40 pairs would be passed by the bridging brushes in one revolution of the division starter.

N is the normal stop position for the brushes, immediately after leaving which they pass over a pair marked 13 and send an impulse over a starting circuit 37 for an idle rotary switch in an idle division. This impulse flows from positive battery through wire 36, by a pair of contacts marked 13 and bridging brushes 61 when they leave the N position and pass over said contacts, to a wire 37 and thence to Fig. 6 diagram to a pair of contacts in the N position of the cylinder for the rotary switch and a pair of brushes 699 normally engaging the same, and thence by wire 663 to and through the magnet 17 of said rotary switch. This starts said rotary switch and allows its brushes to move forward from the normal position to the No. 1 position. It should be understood that there are as many leading wires 37 and pairs of contacts 13 in the division starter as there are rotary switches or divisions of apparatus, namely 10. The pairs at the S N positions complete circuits 39, which are test circuits and lead to contacts at an N position of some part of the apparatus in a division, preferably the rotary switch. There are as many of these circuits 39 as there are rotary switches. Each said circuit is complete when the rotary switch is in the normal position excepting at the contacts S N of which there are 10 pairs in the division starter, one for each rotary switch. The test circuit for any rotary switch would be as follows: from positive battery Fig. 4 diagram, to and through a winding on the magnet 16 which is opposite to the winding connected to wire 35, then through wire 38 to contacts S N and the bridging brushes of the division starter when moving over said contacts, then by a wire 39 to the rotary switch diagram 6, and over cylinder contacts engaged and bridged by the pair of brushes 678 when the rotary switch shaft is in normal position, and to negative

battery. The pairs of contacts between the N and S N positions are idle or space contacts.

The control disk 23 may make any number of revolutions for one whole revolution of the shaft carrying the brushes for the division starter. Its notches are uniformly spaced around its whole periphery, since the positions of rest of the division starter are uniformly spaced. The space between notches is sufficient to permit the brushes to make a forward movement from N position to S N position and from S N to N again. No connection is made in the position of said brushes on contacts marked N.

The clutch magnet 16 is preferably provided with two windings, one of which is a starting and the other a release winding. The circuit of the former is controlled by a relay magnet 212 which is preferably in a circuit closed on the decimal indicator. This circuit may be closed by the action of the relay 211 at the time the decimal indicator comes to rest and may be traced from positive battery Fig. 2, ring 103, brush 113, clutch magnet 15 and relay 214 in multiple, to front contact of the relay 211, relay armature lever, brush 112, ring 102, wire 230 through Fig. 3 diagram, to Fig. 4 and to and through the coils of relay 212 and to negative battery. When the magnet 16 is energized thereby it keeps the clutch engaged until the release winding acts, after which the dog may drop into a notch in the disk and bring the bridging brushes to rest. When the decimal indicator finds the calling line segment, thus causing relay 211 to be energized as already explained, relay 212 is charged and closes the circuit of one coil of magnet 16 at its front contact. The brushes of the division starter then leave their position on said contacts N and move to the contacts S N, in doing which they pass over contacts 13 and by closing the connection to 37 and to the clutch magnet of the rotary switch as already explained, start said rotary switch into action. On reaching the S N contacts it will complete a connection to a wire 39 from positive battery through the deenergizing coil on its own clutch magnet 16, by wire 38 to 39, and thence through the contacts on the rotary switch to which 39 is connected, said connection 39 being that for the rotary switch in the division next to that rotary switch which has just been started by the passage of the brushes over the contacts 13 as just stated. If said rotary switch be idle the connection would be complete by the bridging brushes 678 because they will be in the normal position and the clutch magnet 16 will, by the action of the current in the opposing coil, be discharged so that the dog may drop back into the notch and bring the brushes to rest momentarily on the S N position in the division starter. This position is retained so long as the circuits through both coils of 16 are kept closed, but the moment that the relay 212, Fig. 4, loses its power, which will happen the instant that the relay 211 is discharged through the break of the No. 1 side of the line by the instrument at the subscriber's station and which takes place automatically through the action of the apparatus in the division of apparatus seized at the central station, then the circuit through the front contact of relay 212 and one of the coils for magnet 16 will be broken so that the current which has been flowing in the coil connected to 38, and over contacts S N and 39 to the next idle rotary switch will immediately charge the magnet and couple the shaft of the division starter to the driving power. The brushes of the division starter will, therefore, immediately move on from S N position where they automatically come to rest, as just described, to the position N where they are immediately in front of contacts 13 which are connected to a wire 37 that leads to a rotary switch in the same division as that connected to wire 39 by the current over which the brushes were sent forward from said S N position. They will come to rest on the N position just stated, because when they move forward from said S N position they break the circuit over wire 39 and (the clutch magnet being thus discharged) when the brushes reach said N position the dog will drop into the notch, which is coincidently opposite said dog, and the clutch will be disengaged so that the brushes will come to rest.

This is the position for starting the rotary switch whose circuit 39 has just previously been found complete when the brushes reach the S N position. Had the division starter found the circuit over 39 incomplete on reaching the S N contacts, the clutch magnet 16 would have remained excited by the action of the current in the coil controlled by relay 212 and flowing from positive battery over the coil of magnet 16 connected to wire 35 and through front contact of relay 212 and by the armature lever thereof directly to negative battery, so that the starter would have moved on until it found an idle switch and would then come to rest as just explained by the action of current over the S N contacts connected to said switch.

This part of the apparatus might be constructed and connected up in other ways.

The division starter and the primary connectors controlled thereby constitute a primary line connecting apparatus adapted to connect a calling main line to an idle primary connecting wire or set of wires

122, 123 in response to a preliminary electrical impulse from a calling substation after which the selective signals passing over an idle wire produce the required adjustment of the interconnected selecting switches.

Substation apparatus.

At each substation an automatic signal transmitter is provided for setting the central station apparatus into position to make connection with the line called, by the action of signals or impulses sent over the line connecting said signal transmitter at the subscriber's station with the central station apparatus. Preferably an indicator is used at each subscriber's station having indicator buttons corresponding to the thousands, hundreds, tens and units of the decimal system. By setting these buttons so that they shall respectively indicate the values of the numerals in the different decimal places for the number assigned to the subscriber with whom connection is desired, any subscriber may prepare the circuits of the apparatus at his own station so that it will automatically send the proper character or number of signals by which the central office apparatus may be operated and caused to form a connection between such subscriber's line and the line of the subscriber wanted. At each substation there is also a ringing key for controlling a relay at the central office whereby the calling generator may be connected to the called subscriber's line, and in addition, there is a suitable telephone switch for connecting the two sides of the line to one another through the telephone transmitting apparatus during conversation, or for breaking such connections and connecting the two sides of the line to the parts of the signal transmitter apparatus. Suitable intermediate locking devices are provided between the switch and the signal transmitter, and of such character that the position of the switch cannot be changed while the signal transmitter is in operation, and so that on the other hand, the signal transmitter cannot operate unless the switch is in proper position.

Also the signal transmitter is preferably organized to send an initial signal in the manual operation of bringing it into action.

The circuit-changing parts of the substation apparatus and the mechanism for operating the same may be constructed in the manner to be now described or in any other suitable way. Referring to Figs. 32 to 39, 142 is a circuit changing arm having a spring actuated contact shoe or lever 734 movable over a series of contacts 735 connected in regular order to corresponding contact plates or points of the number indicator. The contacts engaged by the shoe may consist of pins 172 set in a plate 161 of insulating material. The active or circuit-making pins extend through the plate and are there connected to plates of the number indicator. Other pins 172 serve as space or insulating segments for engagement by the shoe. Their position with relation to the circuit making pins is indicated by the solid black points in the diagram, Fig. 39. Pin 140 engaged in the normal position of the arm 142 connects to the call bell 146. Pin 141 connected to earth is engaged to send the initial signal, and contact pin 145 is engaged by arm 142 to make an earth connection after it has passed over the last set of contact pins connected to the number indicator. The un-numbered contact pins comprise 4 sets or quadrants corresponding to and connected respectively with the units, tens, hundreds and thousands set of contact plates on the indicator.

The indicator (Figs. 36, 37, 38, 39) has 4 sets of contact plates 197, 10 in each row or set, and a corresponding indicator button 171 for each set. Said button carries and adjusts contact spring or plate 198 over the plates 197, and is provided with a proper index as shown to enable the subscriber to set the button to position corresponding to the numeral in one of the decimal places of the called subscriber's number and thereby place the contact spring in the corresponding proper position so that it will form connection with one of the series of plates 197 by which the line will be grounded and thereby cause the proper number or character of signal to be transmitted. Connection from the plate on which the contact spring so rests is formed to ground by the spring, the metal block 199 carrying the same and the metal guide plate which forms the face of the indicator and should be connected to ground in any proper way.

The connections of the first two indicator plates in each set to the corresponding contact pins of the 4 sets of quadrants of contact pins 172 over which the arm 142 passes, are shown in Fig. 39. The remaining pins of the sets are connected in regular order to the remaining eight plates in each row of the indicator. The mechanism for operating the arm 142 may be constructed as follows:

153 is the operating lever for the transmitter and 151 is a ratchet wheel that turns loosely upon a pin fastened to the frame or support 175 and engaged at its toothed edge by a pawl carried by a gear wheel 152 also rotating loosely on said pin. The operating lever 153 is fastened to the hub of the wheel 151, and serves to wind up a spring one end of which is secured to the pin 154, projecting from the lever, while its other end is secured to the fixed supporting pin for wheel 151. When the lever is

pulled down the spring is wound up. On letting go of the lever ratchet wheel 151 engages the pawl carried by the gear wheel 152, and the spring in unwinding turns said wheel. Gear wheel 152 engages a pinion carrying the wheel 158, to which latter is secured the pawl 159, engaging a ratchet wheel 160. Ratchet wheel 160 is secured to the shaft which carries the contact arm 142. The pinion carrying wheel 158 rotates on a bushing or bearing in which said shaft turns.

Wheel 160 carries a pin 162 adapted to be engaged by a hook 163, which is supported on the operating lever 153 and is so arranged as to turn the wheel 160 and thereby move the contact arm 142 forward from pin 140 to pin 141 at the end of the downward throw of the operating arm.

Wheel 152 gears also through a train of wheels with the rotary escapement 167, having two arms adapted to engage in turn with a pallet 168 carried by the armature lever of a stepping electro-magnet 33.

The pins or projections from the escapement 167, move in different concentric paths as indicated, and the pallet 168 when actuated by the magnet disengages one arm and allows a half revolution of the escapement, because the end of the pallet 168 is now in position to be struck by the projection from the shorter arm of the escapement which can revolve from the position shown in the drawings only half a revolution before it is thus stopped by the pallet 168. When the magnet is deënergized the pallet 168 releases the latter arm and allows another half revolution. One complete revolution of the escapement 167 takes place for each momentary impulse sent through the magnet 33. The gear of the mechanism is such that the arm 142 will move forward one whole step, or the space of two pins for each revolution of the rotary escapement.

169 indicates a switch preferably constructed to form the support for the telephone as usual in the art. The lever 169 operates on contact springs 147 and 148 connected respectively with the No. 1 and No. 2 sides of the line and engaging contact pins as indicated in the diagram, all in such manner that when the lever is down the spring 147 will connect line 1 with a continuous contact ring 174 on the face of plate 161, and thence by rubbing contact spring with arm 142, while the spring 148 connects line 2 through bell 146 with the normal contact pin 140, so that, as will be seen, the bell is in circuit between lines 1, 2, in the normal position of the apparatus.

Stepping magnet 33 is in a branch from 148 to a contact 179. Spring 144 engages 179 and connects this branch to earth as soon as the arm 142 is moved forward from pin 140 to pin 141 in the operation of pulling down the lever 153 to start the transmitter.

The spring 144 may be operated by means of an elbow lever 143 having a toe engaging with a cam disk 150 secured to the shaft of the contact arm 142, and having a notch or depression so located as to permit the spring 142 to break the ground connection when the arm 142 stands in normal position. The forward motion of the arm 142 and disk 150 in the direction of revolution of the hands of a watch and from the normal position shown brings the unmutilated portion of the disk into engagement with the toe of the elbow lever and moves the horizontal arm thereof downward, thereby moving the vertical arm sidewise against the pressure of the spring 144, which tends to throw the toe into the notch. When the toe is out of the notch on the unmutilated edge of the disk the spring 144 is pressed against the contact 179 and is kept in contact therewith until the notch on the disk revolves around opposite the toe, at which time the spring will throw the toe into the notch and will itself become disengaged from the contact 179. In this position, which is the normal position of the parts, the arm 142 completes the connection with a contact pin 140 connected as shown to the bell 146 and thence with the contact which is engaged by spring 148 when the telephone is on the hook 169 carrying said spring 148.

When the hook 169 rises under the action of a suitable spring, the springs 147 and 148 break the connections just described and connect the two sides of the line through the telephone receiver, telephone transmitter 27, and the ringing key 26. The latter device is adapted to throw a resistance into the circuit of the two lines.

In a shunt to the ringing key 26 is a resistance as shown. At the central office is a ringing relay 217, see Fig. 7, which, by the operation of the apparatus there, is included in the circuit of a calling subscriber's line. When the ringing key is depressed, the resistance is introduced into the circuit and the ringing relay, by going to its back contact, throws the ringing current on to the called subscriber's line, as will be more particularly described in the general operation. As will be seen, the operation of the ringing key does not disconnect the telephone receiver from the line and hence permits the ringing signal sent to the called subscriber's line to be received in the calling subscriber's telephone when repeated back by means of suitable devices at the central station, and which are operated by the ringing current going to the called subscriber's circuit.

In order that the switch 169 may be prevented from changing from normal position during the transmission of a call, a second

cam disk 155 is secured to the shaft of the contact arm 142 and is provided with a notch so located that a toe upon the pivoted lock arm or lever 156 will be forced into the notch by any suitable spring and free the arm 169 while the arm 142 is on the normal contact 140. When, however, the arm 142 is advanced, the cam disk draws the end of the lock lever into position to lock the lever 169 by coming into the path of the block or projection 157 on said lever. When, however, the arm 142 has transmitted a call and has advanced around to contact pin 145, the toe of the lever 156 drops again into the notch on the disk 155, so that lever 169 is again freed and may then change its position to connect the two sides 1, 2, of the line through the ringing key 26 and telephone apparatus.

To prevent the signal transmitter from operating in case the lever 169 be not in proper position to connect the two sides of the line to the signal transmitter, as would be the case if the telephone were raised before pulling down the operating lever 153, a pivoted lock or stop 164 may be provided. This is normally raised by a pin 165 on lever 169 when the latter is down, and then is out of the path of the block or projection 166 on arm 153, so that the latter may be depressed to its full extent and sufficiently to advance the arm 142 to pin 141. When, however, the lever 169 is in raised position, as would be the case if the telephone is off the hook, the stop 164 drops by gravity into position to be engaged by projection 166 and prevents the lever 153 from being pulled down to its full extent. Hence, the initial signal will not be transmitted when the arm 153 is pulled down, because it cannot be pulled down sufficiently far to cause the hook 163 to engage the pin 162 and thereby turn the wheel 160 and move the contact arm 142 forward. In this case the arm 153 will simply remain down with the projection 166 engaging the stop 164, the spring being held from unwinding by the escapement controlled by the magnet 33. No effect will then be produced in the central office apparatus, the line 1 being out of connection with earth at the subscriber's station. By pulling down the lever 169, however, lever 153 will be freed and may be thrown down to its full extent and the call initiated, but in this case the lever 169 will be held down in the proper position until the call is completed, as already explained, by the lock arm 156 and projection 157 on said lever 169.

The circuit is charged for the transmission of speech by a battery or other source of energy at the central office.

Other devices for causing the signal transmitter circuit changing arm to move forward step by step might be used in place of that described. It is preferable, however, to employ a mechanical power like that of a spring intermittently released by means of a magnet instead of depending upon the actuating power of the magnet alone.

Other means might be employed for causing the signal transmitter to complete a connection when it has been stepped forward a determined number of steps by the action of the stepping magnet 33. It is preferable, however, to use a separate set of indicator plates and buttons, connected as shown. It is obvious that the initial signal might be transmitted in any desired way by completing the earth connection from the 1 side of the line, but it is preferable to complete the connection automatically in the act of pulling down the operating lever for the signal transmitter.

General operation.

The general operation of the apparatus is as follows:

Normally all parts stand at rest excepting the decimal indicator and the driving power. As an example it will be assumed that subscriber No. 736 desires to call subscriber No. 1845.

After setting the indicator, Fig. 36, to the number 1845, the subscriber pulls down the arm 153 to its full extent, thereby moving the circuit changer arm 142 from contact 140 to initial contact 141 through engagement of hook 163 with pin 162. This grounds line 1 by spring 147, ring 174, contact arm 142 and contact 141, thereby sending the initial signal which excites stop relay 211 by current from positive over ring 103, (Fig. 2) brush 113, coils of relay 211 and back contact of relay 213 the instant that the brush 111 finds the segment 36 connected on line ring 101 to 1.

Relay 211 closes the circuit of clutch magnet 15 from positive battery, ring 103, brush 113, coils of 15 and front contact of relay 211, to brush 112 and ring 102, thus bringing the decimal indicator to rest with brushes 116 and 111 on the No. 36 segments by the instantaneous action of the clutch magnet which, as already explained, rotates with the shaft which carries the brushes 116, 115, 114 and 111, and has a dog which engages, when the magnet is excited, with a fixed stop ring 124. The brushes 116, 115, 114 and 111, all rotate together and the contacts in the several rings which they pass over are connected up in fixed numerical order to their several circuits and so that when the brush 111 rests upon contact connected to the side 1 of any subscriber's circuit of a section, the brush 116 will rest upon the contact connected to the guard wire 3, corresponding to that same line. Similarly the brushes 114 and 115 will rest upon contacts which correspond to the numerical value of the numer-

als in the tens and units places of the same subscriber's number and electrically point out or indicate the circuits for wires in cables 185 and 119 which it is necessary to charge in order to set the register and cylinder brushes of the primary connector in division seized to position where they will open up a path for the signals from the same line through the primary connector to the wires 122 and 123 and the apparatus of the same division, as already explained. Closure of circuit on the front contact of relay 211 to excite the clutch or stop magnet 15 at the same time supplies current from positive battery to the wire or connection 230 leading from ring 102 through the low resistance relay 212 of the division starter and to negative battery (see diagram Fig. 4.) This current which also excites the magnet 15 flows from positive battery connected to ring 103, by brush 113 constantly bearing thereon, to magnet 15, front contact of relay 211, to armature lever thereof, brush 112, continuous contact ring 102, wire 230, Fig. 2 diagram, then through Fig. 3 diagram, to and through the coils of relay 212 directly to negative battery, Fig. 4. This operates the clutch magnet 16 of the latter, by closing the connection from positive battery as indicated at lower right hand corner of Fig. 4, through one coil of said magnet and by wire 35 to front contact of relay 212, armature lever thereof and directly to negative battery.

Relay 211 also closes on its front contact the circuit through coils of the relay 214 in branch to 15 which relay charges the guard wire 3 of the calling substation with positive potential by connecting positive battery to the same through brush 113, front contact of relay 214 and brush 116 now at rest on the #36 contact of the guard contact ring 106, because it stops at the same time with the brush 111 and upon a contact corresponding to the line contact in ring 101. This charges all guard points of the #36 line on all the secondary connectors of the same section, because the guard points of said line in all of said secondary connectors are connected in multiple to wire 3 corresponding to that line and in the same manner as guard contacts belonging to said line on the cylinder of the primary connectors. Should any secondary connector on the section to which said number 36 line belongs be adjusted to position of connection with the tap wires 522 and 523 connected to the two sides of said line, the connection will at the same time be formed from the guard wire 3 of such line over tap wire 325 and through said secondary connector to tap wire 224 and bus wire 223 which extends, as already stated, past all divisions of all sections of the exchange, in the same way as the other three bus wires of the same set, and brings said guarding potential up to contacts of an interconnector in all divisions of all sections, thus preventing any other line on any section from forming connection with the line calling, even though said other line may adjust a secondary connector to the proper position, and also causing a "busy" signal to be given to the line attempting to make the connection, as will be described farther on. When the decimal indicator stops, brushes 114 and 115 come to rest on contacts of the units and tens indicating rings 104, and 105, so as to indicate or point out the number 36 on said rings and to establish connections over the proper wires in cables 185 and 119 for causing the parts of the primary connector in the division seized to come to rest in position to connect the two sides of the calling line 36 with wires 122, 123, and its 3 line with wire 221 (Figs. 5 and 6.)

The indicating brush 115 would, during each tenth of its revolution, make connection successively with the ten wires in the cable 119. It is so located with reference to the other brushes that when the brush 111 rests on the contact of any line, the units value of whose number is 1, the brush 115 will at the same time rest on a contact in ring 105 connected to the No. 1 wire in cable 119, and so on for all values in the units place. This makes it necessary, obviously, that there should be 10 different positions in the circumference of revolution of brush 115 in which it shall make connection with the same wire in cable 119 when the exchange is organized in the decimal system. When brush 111 engages a No. 36 contact, brush 115 engages one of the ten contacts of ring 105, all of which ten are connected to the No. 6 wire in the cable 119. It is convenient to connect all said 10 contacts to one of a series of wires 675, see Fig. 2, and similarly to connect each other set of 10 contacts corresponding to each units value to another one of said wires and in multiple as shown. The contacts corresponding to the numerical values 0, 1, 2, 3, 4, are shown as connected. At some point in the ring 105 a set of 10 contacts corresponding to the ten different values 0 to 9 inclusive are connected in regular order to the wires in cable 119. When the brush 115 rests upon a No. 6 contact the connection is formed from positive battery, Fig. 2 diagram, ring 103, brush 113, wire 680, brush 115, contact 105, a wire 675 to which said contacts would be connected, thence to the corresponding wire in cable 119 through the contact to which said cable wire is directly connected, to the No. 6 contact in the units row of contacts, upper row of primary connector Fig. 5, in each of the ten divisions of the section to which the calling line belongs. When the brush of the switch cylinder Fig. 5 connected to wire 117 passes over said No. 6 contact, which it does as soon as

the shaft of the primary connector in the division in use is started into operation by the action of the clutch magnet 19 whose circuit is closed by the action of the rotary switch in the same division over circuit 45, as will be presently explained, the current passes through said wire 117, and by the brush bearing on the feed segment 653, to and through relay magnet 219, to negative battery. This brings the cylinder brushes to rest in the No. 6 position. On the tens ring 104 the brush 114 similarly connects to the segment joined to a wire in cable 185 which corresponds to the tens value of the calling subscriber's station number. The segments of ring 104 are connected in regular numerical order and are 10 in number and correspond to the numerical values in one place of the decimal system. When current flows from brush 115, a branch current flows to brush 114 and then to No. 3 wire of cable 185 to the particular contact 3 of the divided segment of the decimal register controller so that, as fully explained under the head "Decimal register controller" impulses will flow over circuit 187 through the register magnet 29 of any primary connector whose cylinder brushes shall have been started into operation so as to bring the brush connected to the wire 188 into contact with segment 655, which is connected by a tap wire 676 to wire 187 running past all ten primary connectors for the one section and similarly connected by tap wires 676 to a segment 655 on each of said primary connectors. Since the line 36 calling is in the fourth ten, the register magnet 29 of the primary connector receives four pulses and moves the brushes forward 4 steps to the contact in the register sector which belong to brushes on cylinder in said primary connector moving over cylinder contacts for all lines numbered 30 to 39 inclusive.

At the division starter, Fig. 4, relay 212 closes on its front contact the circuit 35 from positive to negative battery and through one coil of the clutch magnet 16, thus starting the division starter by energizing the clutch magnet so as to free the clutch controlling disk 23 and connect the brush-carrying shaft of the division starter with the driving power, as explained under the head of "Division starter". This causes the bridging brushes to move on to a pair of contacts 13 and thereby close the circuit of the clutch magnet 17 for a rotary switch of an idle division of apparatus over the circuit from positive battery, wire 36 Fig. 4, contacts 13, wire 37, to contacts of the rotary switch Fig. 6, in N position and to negative battery. This starts the rotary switch and all its brushes move forward from the normal position, thus isolating it from interference and breaking the circuit of the clutch magnet 17, so that by the action of the disk 23 the switch will automatically come to rest in No. 1 position.

At the division starter, Fig. 4, the brushes after passing the contacts 13 just mentioned connected to a rotary switch of one division, automatically but temporarily come to rest in the S N position preceding the contacts 13 corresponding to the rotary switch of the next idle division of connecting apparatus (as already described in connection with the description of the division starter) by closing circuit of the deënergizing coil on 16 from positive battery, wire 38 contacts S N wire 39 and bridging brushes of the idle rotary switch in the N position, so as to neutralize the magnetism of the clutch magnet 16, and thus cause the clutch to be disengaged at the instant the dog, as already explained under the head "The clutch" finds the notch in the edge of the disk 23; but when the relay 212 is discharged by the action of relay 211, which occurs as soon as the decimal indicator begins to move again and reverts to common use, the circuit of the first acting coil on 16 is broken and the deënergizing coil operates to cause the division starter to move its brushes to the N position where it automatically comes to rest by the action of the disk 23 and dog.

As soon as the rotary switch of the seized division leaves the N position, it starts the brushes in the cylinder of the primary connector in the same division, by closing a connection for the clutch magnet 19 on the primary connector so that said clutch magnet will act on the clutch and connect the brush-carrying shaft in contact cylinder with the driving power, as already explained under the head "Cylinder switch" and "The clutch". The connection over which said clutch magnet 19 is energized can be traced beginning on diagram Fig. 5, at the lower right hand corner, from positive battery, through back contact of relay 219 used with said primary connector, coil 19, wire 45, bridging brushes and contacts of rotary switch between the N and No. 1 positions seventh and eighth horizontal rows, brushes 688 and then by wire 674 joined to a contact leading to negative battery. The rotary switch also starts the decimal register controller by closing the circuit for magnet 18 of the decimal register controller from positive battery, Fig. 3, by wire 40, coil 18, wire 41, leading to rotary switch diagram Fig. 6 and from which tap wires 44 lead in multiple to all the rotary switches of the section, pair of bridge brushes indicated at 678 and adapted as soon as switch starts to bear on contacts between N and No. 1 positions of the rotary switch seized and to negative battery. The latter connection is broken when the rotary switch reaches No. 1 position, but the connection 45 remains closed, as shown, the magnet 19 being only

discharged when the relay 219 is excited over cable 119, and breaks circuit 45.

Rotary switch No. 1 position.

In No. 1 position the rotary switch forms a connection with wire 49 by branch 51 (one of which branches leads to a rotary switch of each division from wire 49) to its own clutch magnet 17, by wire 662, and to negative battery, whereby it may be sent forward to the No. 2 position by an impulse sent over 49 from the decimal register controller when the latter completes its action.

In No. 1 position the rotary switch also closes a connection 190 from register magnet 29 of the primary connector in the same division to permit the latter to be operated by the decimal register controller which latter has been previously started by the rotary switch over connection 41.

In the decimal register controller (see Fig. 30 and diagram Fig. 3) one brush 120 moves over the series of selector contacts connected through cable 185 with the segments of the tens ring 104, Fig. 2, and the other brush 120 over feed segment 121 until the first brush 120 reaches that contact or division of the divided segment 50 which is alive through connection with positive battery by way of 103, Fig. 2, brush 113, brush 114 at rest on the segment 3 in the tens ring, wire of cable 185. Then the relay 210 is excited by current supplied through said cable and live contact of segment 50 to feed segment 121, wire 186, coil of relay 210 and negative battery. In the case supposed the No. 3 contacts in divided segments or rings 50 and 104 are those over which the circuit is completed. The relay 210 now closes a connection from positive battery to wire 186, brushes 120 and stepping contacts connected with wire 187 which runs through the various divisions of the section and at each primary connector is joined by a tap wire 676, with a feed segment 655 on the cylinder, which is adapted to be engaged by a cylinder brush 61 joined to wire 188 and thence through magnet 29 with a wire 189 connected to another cylinder brush moving over a connected series of contacts forming another feed segment 655′ and itself joined to wire 190 leading as already explained, to contacts in the first position of the rotary switch in the same division and to negative battery. The segments just mentioned are engaged by their brushes as soon as the primary connector starts into operation. The armature of relay 210 is temporarily held up by means of a coil on itself in a connection from positive battery through the front contact to said coil directly and to negative battery.

Since the brush 120 in the decimal register controller rides over four of the stepping contacts connected as explained under the head "Decimal register controller", to wire 187 after engaging the contact No. 3 in the divided segment 50 connected to wire No. 3 of the cable 185 as fully explained under the same head, four pulses are transmitted over the circuit just traced, and the brushes of the primary connector register move four steps over their contact sector or to position to bear upon contact points corresponding to the value of the numeral in the tens place, of the calling subscriber's number, namely, upon the No. 3 contact points.

The brushes of the primary connector cylinder having been started by the rotary switch in the same division as already stated, move over cylinder contacts 60 until the relay 219 is excited over a connection through bridging brushes of the cylinder which are joined to one another by connection 117, Fig. 5, and which, as soon as the brushes leave the normal position, ride respectively upon the feed segment 653 connected with relay 219 and upon a series of separate contacts marked "units" and connected respectively with the wires in cable 119. When the relay is excited by one of the brushes reaching the live units contact and which, as already explained, is the No. 6 contact rendered alive over No. 6 wire in cable 119 connected, as already explained, to one of the 10 No. 6 contacts of the divided units ring 105, Fig. 2, upon which brush 115 is brought to rest when the decimal indicator comes to rest, the current in clutch magnet 19 is broken and the brushes come to rest in position corresponding to the units value of the number of the substation numbered 736. As already stated it was assumed that the call was coming from station No. 736. This means that said station is numbered 36 in the 8th hundred of the exchange and accordingly all the primary connectors on the 10 divisions of the section of the exchange to which that hundred subscribers are connected will be connected in multiple to the subscribers wires of such section. The remaining hundreds of the first thousand of the exchange would be similarly assigned to and connected to sections of the exchange each containing the 10 divisions of the apparatus comprising, as already stated, a primary connector, a rotary switch, a signal transmitter controller, interconnector and secondary connector. The circuit actuating relay 219 may be traced from positive battery, Fig. 2, ring 103, brush 113, brush 115, segment in one of the groups of units ring 105, wire of units cable 119, to which all divisions of primary connector in the same section are similarly connected, tap wire from No. 6 wire in said cable to No. 6 contact in the selective units group at top row of primary connector seized, and by brush and wire 117 to feed segment 653, wire 118 and relay 219, thus breaking the

circuit of clutch magnet 19. The current flows to wire 118 because the feed segment 653 is engaged by the cylinder brush connected to wire 117 as soon as the cylinder brushes start into revolution through the action of the clutch magnet 19, as already explained. The brushes of the primary connector connecting with the No. 3 contacts of the primary connector register would be thus brought to rest upon contacts belonging to the 1, 2 and 3 lines of the subscriber calling, and said lines are now connected by brushes 61 of the register to cylinder brushes resting upon feed segments joined respectively to wires 122, 123, 221, leading to the rotary switch cylinder in the same division.

In the meantime 1 remains connected to earth at the substation over contact 141 through the act of pulling down the lever 153. The No. 2 side of the line at the substation is connected to earth through stepping magnet 33 by way of spring 148, contact therefor, magnet 33, contact 179 and spring 144, which has been operated by means of lever 143 and cam wheel 150, which moves with the arm 142 when the initial signal is sent. Magnet 33 having been put in circuit with 2 in this way, or any other suitable way, is ready to operate the signal transmitter by means of impulses flowing over line 2 from the signal transmitter controller through the rotary switch, by the path opened up by the primary connector from the line 2 of the calling subscriber to the said rotary switch, said impulses flowing from positive battery and upper feed segment 656, Fig. 7, to wire 206, as already explained.

In the decimal register controller the brush 120 in completing its movement restores its relay 210 to normal condition by closing connection through a deënergizing coil of said relay from positive battery to front contact of relay, wire 186, segment 121, brushes 120, contact 48, which is the last contact in the divided segment 50, and second coil of relay 210 to negative battery, and automatically comes to rest in normal position through the automatic action of its control disk 23. It also, and just before closing contact 48, sends the rotary switch forward from No. 1 to No. 2 position in order to prepare the circuits for the next stage of the operation and with the result to be presently described, by momentarily energizing the stop magnet 17 over the circuit from positive battery, contact of relay 210, 186, 121, brushes 120, contact 46, wire 49, running through all divisions of the section, tap wire 51 of the switch in the seized division, contacts 11th and 12th rows under the No. 1 position, and to negative battery through 663 and magnet 17.

It will be seen that as yet no connection is made in the rotary switch with 123, 122 and 221, and that hence no disturbance from such a connection can arise when the cylinder brushes of the primary connector during adjustment pass over contacts of another line which in another division may have been already connected through the primary connector of such division with 123, 122, 221, leading through the rotary switch there to other parts of the apparatus.

This will be understood when it is remembered that the cylinder contacts for each line in all ten divisions of primary connector are connected in multiple from the same wires 2, 1, 3, so that if line 35 for instance, be already connected up over another primary connector to wires 221, 122, 123, for that connector, the cylinder brushes of the primary connector used by subscriber 36 would, in passing over the No. 5 contact of the switch cylinder for the primary connector used by subscriber 36, close the circuit from any parts of the apparatus with which the wires 221, 122, 123, of the primary connector used by subscriber 35 may have been connected by the rotary switch in the same division with the latter and over said wires 1, 2, 3, to and through the primary connector in use by subscriber 36 and to the wires 123, 122 and 221 connected therewith.

In passing from the No. 1 to the No. 2 position, the rotary switch starts the signal transmitter controller, Fig. 7, in the same division by sending a momentary impulse through magnet 20 from positive battery, Fig. 6, contacts 3rd and 4th rows between the Nos. 1 and 2 positions, wire 52, magnet 20 and negative battery. The signal transmitter controller then makes nearly a whole revolution until it comes to rest automatically in the S N position or on contacts No. 43 by the action of the control disk 23 notched as shown. This is due to the fact that the next notch in the disk succeeding the notch for normal position which is the one with which the dog is shown engaged, lies just short of half the distance around the circumference of the disk, and inasmuch as the gear in this case is such that the disk makes a half revolution only for one whole revolution of the switch cylinder shaft used in such signal transmitter controller, it is obvious, as already explained under the head "The clutch," the said shafts and driving power must remain coupled up to the time the notch 680 finds the dog. Said notch is properly located to cause the clutch to disengage at the instant the cylinder brushes reach the contact No. 43. Here it remains temporarily at rest, but in its movement to this position it sends impulses over the side 2 of substation line to act upon magnet 33 and move the signal transmitter arm 142 forward a half revolution over the two

quadrants of commutator contacts corresponding to the "thousands" and "hundreds" order, and connected respectively to the plates in the thousands and hundreds rows of the indicator. It also sends impulses, synchronously with those passing over the line, to various parts of the connecting apparatus to set them in proper relative position.

Besides starting the decimal register controller, the rotary switch also, on the 5th and 6th rows, formed a connection from 206 to 123 over which the first impulse from the signal transmitter controller operates the magnet 33, at the subscriber's station and advances the arm 142 one full step to a dead position, thus breaking side 1 of the line at 141 and releasing the decimal indicator which thus immediately reverts to common use. This impulse goes over the No. 2 line from positive battery connected to second or interrupted horizontal row of cylinder contacts, as already explained, Fig. 7, bridging brushes, upper feed row 656 of contacts, 206, 123 through primary connector to 2, spring 148, 33, 144, 179 and earth. The No. 1 side being broken, the relay 211 on the decimal indicator is discharged, thus discharging the clutch magnet 15 and the decimal indicator then resumes its revolution. This is due to the fact that the charging circuit of the relay 211 is over the No. 1 line, as explained at the beginning under "General operation" so that upon the breaking of said circuit by the arm 142 in passing from initial contact 141 the relay armature for 211, Fig. 2, will fall back and open the circuit of the clutch magnet 15.

When the decimal indicator starts again into revolution through the actions described, it removes positive battery from wire 3 at the decimal indicator, but the rotary switch provides a substitute charge for said wire over wire 221 from positive battery, Fig. 6, two upper rows of contacts, 221, and to the primary connector. This charge is maintained through the remaining positions of the switch, as shown, until the brushes pass over to the No. 6 position, which is the position assumed at the close of conversation, and thus protects the lines in connection with one another from interference, through the attempt of another subscriber to make connection with the calling subscriber 736.

At the decimal indicator the brush 116 of the guard ring 106 is also kept alive from said wire 3 so that when it resumes its revolution and again finds the same segment, the relay 213 will be charged, thus breaking the circuit at its back contact from positive battery, feed ring 103, 113, relay 211, back contact of relay 213, relay lever and brush 111, 101 and 1. This prevents disturbance on the line of the calling subscriber when the brush 111 again finds segment 36. It also prevents the stopping of the decimal indicator again after it reverts to common use and while the call is coming in from the calling subscriber, because at the instant the brush 111 finds the line contact in 101, the relay 213 breaks the connection from the positive battery feed ring 103, through brush 113, relay 211, and back contact of said relay 213, and current is prevented from going to line 1 at this instant from said continuous feed ring 103, over the path named. The charging circuit of relay 213 is from the live brush 116 to back contact of 214, thence through coils of relay 213 to brush 112, 102 and by 230 to negative battery through low resistance relay 212 in the division starter. The latter relay is not actuated at this time because it is of low resistance or few ampere turns, and the resistance of the relay 213 cuts down the potential.

The decimal indicator might be caused to revert to common use in any other proper way by suitable devices set into action by a circuit closer carried by the rotary switch or other part of the apparatus, after the operation has been carried along to the stage described.

In leaving the No. 1 position the rotary switch breaks the connection 45, so that no effect will be produced on the clutch magnet 19 by any change in the position of the lever of relay 219, resulting from the movement of the brush 115 of the decimal indicator when the latter reverts to common use, which brush 115 sends current to said relay 219 at each revolution by the path already described through a wire of cable 119 and until the cylinder switch of the primary connector leaves the position in which it has been set for opening up the path from the calling subscriber to wire 221, 122, 123, and is sent around to normal position.

The rotary switch having been started from No. 1 position by the decimal register controller by current over the contact 46 in the divided segment 50 and circuit, as already explained, breaks the circuit or connection to its magnet 17 at the contacts engaged by the bridging brushes in No. 1 position and connected to 663, and automatically comes to rest in the No. 2 position by the action of its control disk 23. This is due to the fact that the next notch in said disk that finds the clutch dog is so located as to permit the dog to drop into it and disconnect the clutch at the instant the cylinder brushes in the rotary switch reach the No. 2 position, at which time the magnet 17 is discharged, and it is only again charged over the feed segment connected to 663 and the bridging brushes of the two lower rows of cylinder contacts after the actions which take place

while the brushes rest in this position have been completed.

Rotary switch No. 2 position.

The signal transmitter controller having been started by the rotary switch sending current over wire 52 in passing from the No. 1 to the No. 2 position, as previously explained, and having by an initial pulse advanced arm 142 at the substation so as to break the side 1 of the line with the result described, now continues to transmit pulses over 206 and 2, from positive battery, Fig. 7, upper pair of bridging brushes, wire 206, feed segments 657 and 658, brushes 703, Fig. 6, wire 123, to upper feed segment 650, cylinder brush now resting thereon, outer brush 61 of the register, contact in the outer row of the register sector contacts No. 6 and cylinder brush 709 now resting on cylinder contact connected to No. 2 side of subscriber's circuit, then to the magnet 33, as already traced in the case of the first impulse sent over this circuit, to earth or return. The first pulse, as already explained, moved the arm 142 forward from contact 141 over two pins to a dead or open circuit position, thus breaking the No. 1 side of the line to discharge the relay of the decimal indicator and allow the latter to resume its revolution. The next pulse after this initial pulse moves the arm 142 from the dead pin 681, Fig. 39, over the first contact in the first quadrant in obvious manner.

The arm 142 now moves over said contacts until it reaches the contact connected with the plate in the thousands row to which the indicator button has been set. The No. 1 side of the line is then connected to earth, thus energizing the relay 215 (Fig. 7) over the wire 231, rotary switch, 3rd and 4th rows, and side 1 of line, thus breaking circuit at back contact of relay 215 and closing circuit at the front contact. This circuit may be traced from positive battery, Fig. 7, at relay 215, through wire 231 to the short feed segment 659 of the rotary switch, Fig. 6, by bridging brushes to segment 659′, then to wire 122 and through the primary connector cylinder, cylinder brush adjusted to rest thereon, middle register brush, contact of sector middle row, 6th position, to a cylinder brush 710 which has been previously adjusted to the cylinder contact connected to No. 1 line, thence over line No. 1 to the subscriber's station, through spring 147, contact therefor, ring 174, arm 142, to that contact in the circular row to which the brush of the arm shall have been adjusted by the series of impulses, then to the corresponding contact plate of the indicator, thence to the indicator button or spring and to earth.

During the stepping of the arm 142 to this position, corresponding stepping pulses are sent through the magnet 30 of the thousands register from positive battery, Fig. 7, back contact of relay 215, bridging brushes, 3rd and 4th contact rows of signal transmitter controller, 191, 192, rotary switch 11th and 12th rows, and to negative battery Fig. 6. The first of these pulses goes immediately after the pulse that moves arm 142 (Fig. 39) to dead position.

The thousands button of the indicator having been set to the second contact plate, which is that appropriated for calling all lines in the second thousand and hence is the one with which connection must be made, to call substation 1845, two stepping impulses will have been sent through magnet 30 of the thousands register from the pair of brushes 706 riding on long feed segment 656 and the interrupted row of contacts beneath the same in the first half of the circumference before the relay 215 is energized, after which the circuit of said magnet is broken at back contact of relay 215 and the thousands register comes to rest. The impulses which actuate the magnet 30 synchronously with those flowing over the line to actuate the stepping magnet 33, Fig. 39, pass from positive battery connected to the armature lever of relay 215, back contact of said relay, long feed segment 656, bridging brushes 706, wire 191 connected to the interrupted row of contacts beneath the middle row 656, magnet 30, wire 192, to the rotary switch Fig. 6, thence by contacts 682 in the second position of the rotary switch and the bridging brushes 683 which have already been adjusted as described to rest thereon and to negative battery. During the transmission of the remaining pulses of the "thousands" set sent over line 2, the relay lever is held up by current over circuit from positive battery, Fig. 7, front contact of relay, bridging brushes 5th and 6th rows, 232 and to negative battery through coils on the relay. After the bridging brushes pass the thousands set of stepping contacts, this circuit is broken on the 6th row, Fig. 7, and the relay armature goes to its back contact where it closes the connection to be presently traced over which the impulses may flow to act on the magnet 31 for the register of the interconnector synchronously with the line impulses flowing over the line 2 of the calling subscriber in just the way that the thousands register magnet has been actuated.

In the meantime the arm 142 has passed the "thousands" quadrant and now begins to move over contacts of the hundreds order or second quadrant by the action of pulses sent by the signal transmitter controller at the first and second rows, second half of cylinder, simultaneously with which pulses are sent through register magnet 31 as follows: positive battery, back contact of relay 215, brushes 3rd and 4th rows moving over the hundreds set of stepping contacts, wire

193, brush of thousands register which has just been brought to rest on a contact of the inner row joined to interconnector No. 2 (which is the interconnector for all sections of secondary connectors embracing substations whose numbers are among the second thousand) wire 194, contact and brush of interconnector cylinder resting thereon in normal or N position, magnet 31, brush 351 and contact 352 engaging with one another in normal position of interconnector only, wire 195, which is the common return wire for all the interconnectors of the same division and there runs from Fig. 8 diagram, through Fig. 7 diagram, to the rotary switch diagram Fig. 6, and to negative battery through rotary switch contacts 684 9th and 10th rows and bridging brushes 685 which by the adjustment of the rotary switch to the No. 2 position are now resting on contact 684. The magnet 31 therefore steps the register brushes, Fig. 8, forward until arm 142 at the subscriber's station passes the commutator contact in the second quadrant connected with the No. 8 plate in the hundreds row of the indicator, or the one corresponding to the 9th hundred, at which time the relay 215 is again excited over wire 231 and line 1 by current from positive battery Fig. 7, connected directly to relay coil 215, wire 231, to diagram Fig. 6, segments 659 and 659′ and bridged brushes 708 resting thereon, wire 122, to primary connector Fig. 5, and through said primary connector to line 1, by the same path just traced in the case of the current which actuates said relay over line 1, when arm 142, Fig. 39, reaches the contact in the circle of pins which is connected to the second contact plate of the indicator. In this case, however, the arm has now progressed into the next quarter of the circumference of the row of pins engaged by it so that now the connection is from said arm to the No. 9 plate of the indicator and to the indicator button which has been adjusted to contact therewith and thence to earth in the same manner as in the case of the thousands button. The relay 215 at this instant breaks the circuit just traced through its back contact and magnet 31, and the brushes of the register come to rest after having been sent forward by nine pulses to position to engage with contacts joined to a group of brushes in the interconnector cylinder that ride in succession over points connected in regular order to different sets of bus wires belonging to the section of the called subscriber, namely 9th section in the second thousands, and there connected respectively with the 10 divisions of secondary connector.

The relay 215 is held on its front contact while the 10th pulse goes over line 1 and while the signal transmitter brush moves over the 10th contact in the fourth row, second half, over circuit just traced in the case of the thousands register magnet 30.

The circuit over which the relay is thus held up so as to cut off the last pulse which would otherwise flow to the register magnet of the interconnector is from positive battery connected directly to the armature lever of the relay to the front contact thereof, thence to the connected row of cylinder contacts 656′ to the bridging brushes 716 resting thereon and to the long segment 656 on which the upper brush of the pair rests, by wire 232, back to negative battery through the coil of the relay.

The arm 142 having been caused to pass the hundreds set of contacts, the holding circuit of the relay 215 is again broken at 42, 6th row (Fig. 7) thus causing the relay lever to go again to its back contact. This is due to the fact that the lower pair of bridging brushes Fig. 7, does not break the connection on the lower segment 656′ at 42 until after the upper pair of bridging brushes 711 has passed off of the interrupted row of cylinder contacts in the signal transmitter controller, second horizontal row, by which it produces the impulses that pass over the connection 206 and through line 2 and magnet 33, and actuate said magnet 20 times so as to cause the arm to pass the 20 contact pins in the first two quadrants corresponding respectively to the thousands and hundreds.

At 43, 4th row, the signal transmitter controller now comes to rest because the notch 680 in the disk 23, Fig. 7, comes in position opposite the dog connected to the clutch at the instant the cylinder brushes reach the vertical row in which contact 43 is located so that the clutch disconnects the brush-carrying shaft from the driving power. The signal transmitter controller thus closes the circuit from the back contact of the lever for relay 215 through clutch magnet 21, Fig. 8, to start the brushes of the interconnector cylinder over circuit from positive battery, Fig. 7, back contact of relay to the long feed segment 656 and by bridging brushes 706 of the switch cylinder to contact 43, 96, brush of thousands register previously adjusted by the first two impulses of the thousands set as already described to the second position and thus resting on outer contact 686 wire 54 running to interconnector No. 2, magnet 21, common return wire 55 for interconnectors of the same division through the Fig. 7 diagram to Fig. 6 and by contacts 731, rotary switch 7th and 8th rows, bridging brushes 732, tap wire 56, bus wire 57, common to the interconnectors of the section and joined to a particular segment on 431 of the consecution controller through the relay 218 individual to that segment. This circuit is not complete until the brush 430 in its revolution engages said segment

and then the magnet 218 is excited and keeps the connection to negative battery closed at its front contact by wire 670' and 670 after the brush 430 passes off the segment which it does immediately. The magnet 21 is then excited, thus starting the interconnector and the actions to be presently described follow.

Until the consecution controller, however, closes the circuit for the interconnector magnet, the actions of the apparatus are delayed and the rotary switch will remain on the No. 2 position because, as will be presently shown, it is only started to the No. 3 position by the action of the relay at the instant that the interconnector finds an idle secondary connector, and the signal transmitter controller remains at rest on the 43 contact because its clutch magnet is again operated over the connection 5[illegible]ly when the rotary switch leaves the No. [illegible]osition and passes to the No. 3 position. The current for thus operating the clutch magnet 21 is supplied from the long feed segment 652' Fig. 6, which is connected by a wire 687 with one of the pair of contacts the lower one of which joins, as shown, to the wire 52 and which contacts are adapted to be bridged by the pair of bridging brushes 688. If two different signal transmitter controllers on different sections of the exchange should start at the same instant in response to calls coming from substations on those different sections and thus the connection 96 should be closed for two interconnectors on different sections of the exchange at identically the same instant by said substations seeking connection with one and the same substation, said interconnectors would start into operation, one after the other, in the order in which the circuits for their clutch magnets were completed by the consecution controller, and the one first operating would be the first to establish the connection with the set of bus wires for the secondary connector of the called substation's section and would in one of said bus wires establish the condition which, as will be described, would prevent the connecting apparatus used upon the section and in the division of the second operating interconnector from going to talking position, and thus cause the second calling subscriber to receive the indication of "line busy".

That the interconnectors of said different sections would be compelled to act one after the other, will be obvious when it is remembered that the circuit for the clutch magnets 21 of all the interconnectors on one section is completed as already described over the wire 57, Fig. 6 diagram, running through all divisions of the same section and from said wire through one of the consecutive contacts 431 in the consecution controller, as already explained, while the same kind of connection for the interconnectors of all divisions in another section would be completed through another wire like 57 and another one of the row of contacts 431 of the consecution controller engaged before or after that one through which the circuit for the clutch magnets of the other section is completed. In other words, each contact in the divided segment 431 of the consecution controller represents the return connection for all the clutch magnets 21 of all the interconnectors in the 10 divisions of one section of the exchange. 20 contacts in the segment 431, each contact having its own magnet 218 and bus wire 57, would provide for 20 sections of central station apparatus and would place the circuits for the magnets 21 of all the interconnectors of one section in operative condition and immediately thereafter all the similar circuits for the next section and so on consecutively for all the sections.

The interconnector clutch magnet 21 having been energized as explained over the circuit 96 from the contact 43 on which the signal transmitter controller is now temporarily at rest, the shaft carrying the gangs of brushes in the cylinder thereof will begin to revolve and the set of interconnector brushes selected by the register (Fig. 8) now begin to move over the contacts connected respectively by taps to the set of bus wires until they find a set, the secondary connector of which, in the called section, is in normal position to connect the bus wire 223 of said set to negative battery over tap wire 224 Fig. 9, lower feed segment 650 cylinder brush 690 engaging said segment in the normal position of the cylinder brushes, inner brush 61 of the register Fig. 9, normal contact engaged thereby and by a wire 691 to a cylinder brush which in normal position engages a contact connected by wire 689 with negative battery. If said secondary connector were in use the connection just described would be opened owing to the movement of the parts away from normal position and hence no circuit described would be formed when the said interconnector brushes reached the contacts connected by tap wires to the bus wires to which the said secondary connector in use is connected. If the secondary connector be at rest, or in normal position, the connection just stated will be closed. This excites relay 215 over circuit from positive battery, Fig. 7, relay coils, wire 231, branch to 7th and 8th rows of rotary switch as indicated at 692, the upper one of which pair is joined with a short feed segment in the same row terminating in a vertical row under position V to wire 222 through Fig. 7 diagram to feed segment 650 4th row, interconnector cylinder brush, inner brush of register now resting on contact to which it was previously set by the hundreds pulses, a wire

71', cylinder brush 693 riding on contacts connected severally to the bus wires 223 which run through all sections of the exchange, and belong to the section wanted, contact of that bus wire 223 to which the idle secondary connector first found idle in that section is joined, tap wire 224 at said secondary connector, Fig. 9, feed segment, cylinder brush 690 in normal position joined to inner brush 61 of secondary connector on normal contact, and to negative battery by another brush 61 of cylinder resting on normal contact, connected by wire 689 to negative battery.

Until the relay 215 is excited it is obvious that the clutch magnet 21 of the interconnector Fig. 8 will remain excited over the circuit through the back contact of the relay, as just explained, and hence that the clutch for the interconnector will remain engaged since the dog being held up by the magnet, will not drop into any of the notches in the edge of the disk, which notches pass by the dog as soon as the clutch causes the brush-carrying shaft of the interconnector cylinder to revolve. But when the set of cylinder brushes in action finds the bus wire 223 of an idle secondary connector, at which time one of the notches in the disk is opposite the dog, the relay 215 will be excited as already described.

At the same time that it stops the interconnector by breaking circuit, relay 215 closes circuit at its front contact and thus actuates the magnet 32 of the secondary connector found idle, over circuit from positive battery, front contact of relay 215, segment 656', contacts 43 5th and 6th rows, wire 53, rotary switch 9th and 10th rows at pair of contacts 694, bridging brushes 678, connection 665, line 322 running through diagram Fig. 7, feed segment 650, 3rd row in the interconnector cylinder, cylinder brush now resting thereon, register brush 695 next to the inner one by connection 71, register contact No. 9 position, one of the connections 71', cylinder brush 696 now resting on contact joined to bus wire 622, tap wire 422 at the section of called subscriber, idle or seized secondary connector on said section, wire 196, bridging brushes 61 resting on normal contacts and joined through magnet 32 and wires 662 and 691 and to negative battery.

When the register magnet 32 is energized over the circuit just described, it acts upon the escape lever for the escape segment 87 and causes the register brushes to move one-half step forward toward the three dead contacts marked 500, Fig. 9. When the relay 215 is discharged by the movement of the rotary switches brushes 678 forward from the pair of contacts 694, and which takes place immediately as will now be described, the circuit of the magnet 32 over which it is energized as just stated is broken at the front contact of the relay, the register escapement moves in the reverse direction and allows the escapement sector 87 to move another half step so that the inner brush breaks the connection from 224 over feed segment 650 and cylinder brush 690 and connection 697 over which, as just described, the relay 215 is excited for the purpose of breaking the circuit through the interconnector clutch magnet 21, so that any subsequently acting interconnector will not stop on the bus wires of the secondary connector already seized by the action of the magnet 215 whose circuit, as already explained, is through the register brush connected to wire 697 and normal contact of the register connected to wire 691, Fig. 9.

At the instant the relay 215 is excited over the circuit through the brush 693 of the interconnector finding a bus wire 223 whose tap wire 224 is connected to earth through a secondary connector in normal position, as already explained, so as to cause said relay to close circuit on its front contact, it starts the rotary switch from position No. 2 by a circuit branched from that already described for actuating the magnet 32 of the secondary connector found idle. This circuit is the same as already traced over the front contact of the relay Fig. 7, by segment 656', bridging brushes 716, contact 43, wire 53 leading up to the pair of contacts 694 of Fig. 6, but a branch is taken from 53 to the pair of contacts 698 in the two lower rows of cylinder contacts. Fig. 6, immediately under the No. 2 position where the circuit is closed by the lower pair of bridging brushes 699, to wire 663, and to and through the clutch magnet 17 of said rotary switch to negative battery. This connects the clutch of the rotary switch to the driving power and moves the dog out of the notch in the disk 23 with which said dog engages in the No. 2 position of the parts and the disk moves to bring the next notch around beneath the dog, at which instant the pair of brushes 699 will be in position to engage the two contacts in the two lower rows of cylinder contacts in the vertical line with position 3. The circuit of the magnet having been opened when the brushes 699 leave the contacts at 698, it is obvious that the dog may again drop into the notch and bring not only the brushes 699, but all the other brushes of the rotary switch, to rest in the No. 3 position. Said rotary switch in moving forward breaks the connections already traced for the thousands register magnet 30 and the magnet 21 of the interconnector. This is because the pairs of cylinder brushes in the rotary switch which, as already described, complete said connections when in their No. 2 position, have left the pairs of contacts 692 and 694 in moving forward to the No. 3 position and have broken the connections at said contacts. The rotary switch also

breaks the energizing circuit of the relay 215 just traced by wire 231, wire 222, bus wire 223, 224, and normal contact of register in secondary connector, thus permitting the armature lever to fall back, and discharge magnet 32, thus causing the register brushes to come to rest on dead contacts 500 and break the connection of 224.

The relay lever now rests on its back contact in readiness for the transmission of tens and units impulses to the secondary connector, and the rotary switch starts the signal transmitter controller from S N position by momentarily closing the circuit of clutch magnet 20, from positive battery, Fig. 6, connected contacts forming feed segment 652′ by wire 687 leading therefrom to the upper one of a pair of contacts immediately succeeding the pair 692 in the 7th and 8th rows and engaged by bridging brushes 688 in passing from No. 2 to No. 3 position, 52, to clutch magnet 20 and negative battery. The rotary switch then comes automatically to rest in the No. 3 position because it breaks the circuit of its own clutch magnet and the dog drops into the next notch. The signal transmitter controller, being released, now leaves its first S N position and proceeds to move a whole revolution during which tens and units pulses are sent over line 2 and through the secondary connector seized on the section of the called subscriber.

The circuits by which these tens and units pulses are sent will be described under the next head. The signal transmitter controller makes a whole revolution because after the dog is lifted out of the notch 680 which, as explained, is the one corresponding to the 43 contacts, the next notch in the disk is diametrically opposite and, as already stated, the gear is such that the shaft carrying the cylinder brushes in the signal transmitter controller will make a whole revolution for one-half a revolution of the disk 23.

Rotary switch No. 3 position.

In this position the relay 215 is still connected by 231 with No. 1 side of line and arm 142, and the signal transmitter controller is still connected over 206 with No. 2 side of line and magnet 33.

The back contact of relay 215 is connected to the first set of stepping contacts of signal transmitter controller, and by wire 191, 176, through the rotary switch by the pair of cylinder brushes which are now in the No. 3 position, to wire 665, 322 to magnet 32 of the secondary connector register. A similar connection from 58 to 59, is formed by the rotary switch from the second set of stepping contacts for operating and controlling the magnet 22 of the secondary connector as will be presently described.

In this position the rotary switch also completes in the 11th and 12th rows, a connection from 100 (Figs. 6 and 7) over which it may be sent from the 3rd to the 4th position after the signal transmitter controller has passed the two sets of stepping contacts and has set the secondary connector to position to connect with the called subscriber's line. This having been done, the rotary switch may pass to the fourth position where it will close a connection which will charge the guard wire of the called subscriber over one of the set of bus wires connecting the interconnector used by the calling subscriber with the secondary connector seized by said interconnector and set by the last two sets of stepping impulses so as to open up a connection between two wires of said set of bus wires and the two sides of the called subscriber's line.

The signal transmitter controller having been already started, as described on its second revolution, first sends pulses over both 206 and 191, the former passing through magnet 33 at calling station over the side 2 of the line by the identical path already described in the case of the pulses which send the arm 142, Fig. 39, over the first and second quadrants in the circle of pins for transmitting the thousandths and hundredths signals. The arm 142 is thereby caused to move over the ten contact pins in the third quardant which connect severally with the ten contact plates adapted to be engaged by the tens button of the indicator set to the position as shown in Fig. 36 where it will expose or point out the No. 4 on the face of the indicator plate. Synchronously with the transmission of the first 5 pulses over the line 2 to send the arm 142 forward and over the fifth contact in the tens quadrant, pulses pass through magnet 32 of the secondary connector seized on section of called subscriber from back contact of relay 215, Fig. 7, to middle feed segment 656, first set of stepping contacts immediately beneath the same over the bridging brushes 706 moving on them and by way of 191, 176, rotary switch 9th and 10th rows, bridging brushes 678 adjusted to the third position, connection 665, wire 322 through diagram Fig. 7, to diagram Fig. 8, where connection runs from said wire 322 either to the third feed segment 650 in the cylinder of the interconnector for for the first thousand or to the similar segment for the interconnector of the second thousand. The connection for the first thousand is by one of the wires in the group 701. That for the interconnector of the second thousand is shown in the Fig. 8 in the full lines and this, it is assumed, has been started into operation by the completion of the connection 54 to its clutch magnet 21, through the action of the thousands register magnet 30, Fig. 7, as already explained. Its brushes will accordingly have left the position shown

and be in contact with feed segment 650. The connection from 322 by one of the branch wires 701 to the similar segment 650 of the interconnector No. 1, will, under the conditions supposed, be opened at the third feed segments 650 on the cylinder of said interconnector No. 1, because the cylinder brushes thereof will not have been started and will be hence in normal position out of contact with the feed segments 650. The connection from 322 will accordingly be by way of the feed segment 650 of interconnector 8, whose brushes have been started, the register brush 695, and thence to the sector contact to which it has been adjusted, as already described, by the hundreds signal and by one of the connections 71′ to the brush 696 which, as already described, has been brought to rest automatically on the cylinder contact connected to bus wire 622 and the idle secondary connector in the section of the called subscriber and by tap wire 422 for said secondary connector to wire 196, and by cylinder brushes and connections 692, 691, including the register magnet 32, to the negative battery by wire 689, as already explained in connection with the operation of setting the register brushes from normal position to the dead contacts 500. The pulses which then circulate through magnet 32 during the transmission of the pulses through magnet 33 at the subscriber's station, move the register brushes of the secondary connector forward until the arm 142 at calling subscriber's station in moving over pins in the third or tens quadrant of the circle pass the fifth pin which has been connected to earth by setting the indicator button in the tens row of said indicator.

The relay 215 is then excited over connection 231 and line 1 as already described, thus breaking the connection of the magnet 32 and bringing the register brushes to rest upon the No. 4 contacts of the register, where they remain because when the relay armature breaks the circuit of 32 it closes circuit on itself at its front contact to feed segment 656′ and by the lower pair of bridging brushes in the signal transmitter controller to the long feed segment connected by wire 232 to a coil of the relay until the signal transmitter controller passes through its "tens" phase and breaks the holding circuit of the relay on the 6th contact row as already explained, and permits the relay lever to drop back again. In the meantime the contact arm 142 has passed the "tens" quadrant and begins to move over the units quadrant of contacts while, at the same time, pulses are sent through magnet 22 of the secondary connector from positive battery to relay armature lever of 215, Fig. 7, feed segment 656 in the third row of cylinder contacts and bridging brushes 706 riding thereon and over the stepping contacts in the row immediately below and in the second half of the cylinder by 193, 58, rotary switch 7th and 8th rows under No. 3 position and to contact with which the pair of bridging brushes 688 have moved in Fig. 6, then from the upper contact of said pair to wire 59, down through the diagram Fig. 7, to the point where said wire branches to one of the set 701 and to the first feed segment 650 shown. The branch by wire 701 passes to the similar top feed segment 650 of interconnector No. 1, but said interconnector not having been started over the circuit of a wire like 54 connected to the first contact passed by the register brush of the thousands register, the circuit will be opened at the feed segment 650 of said interconnector No. 1, because the cylinder brushes will all be in their normal position. In the interconnector No. 2, the brushes have already moved forward and come to rest as previously explained, so that the circuit from 59 would be through said interconnector by the brush resting on upper feed segment 650, register brush 702 which, as already explained, has been moved to the ninth contact and thence by a connection 71′ to a cylinder brush 703 which has been adjusted and brought to rest on a cylinder contact connected, as already described, to a bus wire 296, thence over said bus wire to the secondary connector which has already been set into action on the called subscriber's section through tap wire 99, Fig. 9, clutch magnet 22 for the secondary connector cylinder switch and to earth by wire 689. The first of these pulses operates the clutch of the secondary connector and withdraws the dog from the first or normal notch in the disk 23, and the succeeding pulses permit the disk and the cylinder brushes to move past the positions corresponding to the succeeding notches and until the arm 142 of the transmitter in passing over its last or units quadrant finds the contact which has been connected to ground by setting the units button of the indicator. The relay 215 is then again excited by the current passing over the line 231 and the No. 1 side of the line by exactly the path described in the case of the thousands, hundreds and the tens pulses, and to the arm 142 which is however now moving over the units quadrant, and which, when it reaches the sixth contact pin therein forms the ground connection over the No. 6 contact plate and indicator button set to connection therewith. The arm will have reached this position by the action of six pulses sent through the magnet 33 at the substation Fig. 39, from the wire 206, and upper pair of stepping contacts Fig. 7, flowing through feed segments 657 and 658, by bridging brushes 703, Fig. 6, and thence by wire 123, over the primary connector, No. 2 line by the same path taken during the

thousands, hundreds and tens signals and six simultaneous pulses will have been sent over the circuit just traced through magnet 22 of the secondary connector in the called subscriber's section. But, at this instant, the relay being excited over line 1, will leave its back contact and cut off the further flow of pulses through magnet 22 which will therefore permit the dog of the clutch to immediately drop back into the notch in the disk 23 which presents itself to the dog when the cylinder brushes have reached the No. 6 contacts in the quadrant of the secondary connector or cylinder counting from the normal contact of that quadrant upon which the cylinder brush normally rests. The brushes retain this position because no further impulses can flow through the magnet 22 while the signal transmitter controller is sending the remainder of the units pulses over the line No. 2 of the calling subscriber, owing to the fact that when the relay lever is drawn up by the current over line No. 1, coincidently with the transmission of the sixth pulse, it remains held up by the circuit established through its front contact and segment 656', lower pair of bridging brushes 716 and wire 232 connected to a long segment 656 and to a coil of said relay as already explained, until the signal transmitter controller brushes have passed over the remaining portions of the contacts by which the set of ten pulses corresponding to the units place in the decimal system have been transmitted over the line No. 2 of the calling subscriber.

The brushes of the secondary connector cylinder are now upon the contacts for the No. 1 and No. 2 sides of the called subscriber's line, namely, the No. 45 line 9th section of the second thousand of the exchange, and upon the contact for the corresponding 3 line.

By the final pulse over 206 and 2, sent just before the signal transmitter controller reaches the S N contact, the arm 142 is sent to make contact on pin 145 connected to earth, Fig. 39, thus again placing the No. 1 side of the calling subscriber's line to earth so that current may again flow over said line but from the release relay 216 over the rotary switch in the 4th position for the purpose of sending said switch forward to the No. 5 or talking position when the calling subscriber lifts his telephone and as will be presently described.

On reaching the S N or No. 43 contact the signal transmitter controller automatically but temporarily comes to rest by the action of the notch diametrically opposite the notch 680 in its disk 23, but just previously thereto it breaks the hold-up circuit for relay 215 by breaking said hold-up circuit when the lower pair of bridging brushes pass the contact 42, thus permitting the lever to go to its back contact if the circuit to that coil of the relay 215 which is connected to 231 and is hence charged over line No. 1 and grounded pin 145 be at this instant broken. If the telephone receiver has been removed from the hook 169 before arm 142 reaches 145, the said circuit through 231 and line 1 will have been broken before the arrival of the arm at this contact, because the hook will then be freed by the lock lever 156, and the relay lever will therefore go immediately to the back contact.

If the telephone is not lifted until later, the circuit by 231 will be first broken in the rotary switch which will have left the No. 3 position through the action of the signal transmitter controller when it reaches or comes to rest in the S N position as just stated, where the connection 100 to the clutch magnet of the rotary switch is now completed over circuit from positive battery, Fig. 7, connected at the left to the 2nd horizontal row of contacts in the cylinder counting from the top and by the upper pair of bridging brushes 711 to the contact in the upper row, S N position, wire 100 to Fig. 6 diagram, to contacts in the vertical row No. 3 position and in the last two horizontal rows of cylinder contacts of the rotary switch, bridge brushes 699 which have reached the No. 3 position and clutch magnet 17 to negative battery. The circuit of the magnet 17 is broken when said brushes leave the No. 3 position, but the dog rides on the edge of the disk between the notches thus keeping the clutch engaged. Coincidently with the arrival of the cylinder brushes upon the cylinder contacts in the vertical row under the No. 4 position, the next notch will, owing to its location in the edge of the disk and to the ratio of gearing employed, be in position to allow the dog to drop into the notch and thus disconnect the clutch. Hence, all the cylinder brushes of the rotary switch will all automatically come to rest again in the No. 4 position. The circuit 231 will be broken in the rotary switch when the same leaves the No. 3 position because the segment 659 in the switch cylinder to which said wire 231 is connected comes to an end at the contact in the No. 3 position as shown.

The circuit just previously closed at the back contact of the relay 215, and thence by 3rd row and contact 43, S N position, is used in the test to be now described.

Before reaching the No. 4 position where it automatically comes to rest again, and again completes a connection for its clutch magnet, the rotary switch closes a test circuit through relay 215 operating now as a test relay, and 232 to guard wire 3 of called subscriber No. 1845, and at or about the

same time a connection from wire 96 contact S N position and back contact of relay 215 through control magnet 20 of signal transmitter controller, in the manner and for a purpose to be now described.

If subscriber 1845 has already undertaken to call another subscriber, his guard line or wire 3 will be alive or connected to positive battery either from his decimal indicator by the connection of brush 116, Fig. 2, with the contact of divided ring 106 in the decimal indicator for the ten divisions of the section to which said subscriber 1845 is connected, and in the same way as described at the beginning of the general operation in the case of the calling subscriber 736, or from the rotary switch seized by him, namely, subscriber 1845 by the connection 221 from segment 652 just as in the case of the rotary switch used by subscriber 736 at the beginning of the operation, and depending upon the stage reached in his subscriber 1845's call, and hence the test circuit closed by the rotary switch seized by subscriber 736 in his own section will be complete as follows: starting from secondary connector on section of subscriber 1845 which has been set to connection with the cylinder contacts for his 1, 2 and 3 lines, as already set forth, from positive battery charging his No. 3 line, as just explained at the beginning of the operation, to tap wire 325 leading to the cylinder contact of the secondary connector which has been engaged by a cylinder brush 704, by connection 71′ to the contact of the register sector in a row engaged by the previously adjusted brush of the register, to cylinder brush 690, lower feed segment 650, tap wire 224, bus wire 223, running through all sections of the exchange and past the interconnector No. 2 used, as already described, by subscriber 736, who was in the 8th section of the first thousand, cylinder contact of said interconnector joined by tap wire to said bus wire, a cylinder brush 693 which has been brought to rest on said contact, as already explained, a connection 71′ to the contact on the inner row of sector contacts to which the inner brush 705 has been adjusted, as already explained, then by a connection 71, to a cylinder brush 706 which has been brought to rest on a lower feed segment 650, then by wire 222 up through diagram Fig. 7, to diagram Fig. 6, and to the four cylinder contacts in a horizontal row the left hand one of which forms the upper one of a pair over which the bridging brushes 688 pass as the switch moves from the No. 3 to the No. 4 position, then by wire 232 connected to the lower one of said pair of cylinder contacts and to and through one coil of the relay 215 and to negative battery.

Therefore the relay 215 will be excited and no current can flow over the connection 96 to the control magnet 20 of signal transmitter controller from positive battery, back contact of relay 215, long feed segment 656, pair of bridging brushes 706 which are now on the vertical row of contacts under S N, contact 43, 4th horizontal row, wire 96, connection 107 to Fig. 6, branch 707 leading to upper of a pair of cylinder contacts passed by lower pair of brushes 699 in moving from No. 3 to No. 4 position and simultaneously with the passage of brushes 688 over the pair of contacts in the same vertical row by which the test circuit just described is closed, thence by a branch wire to wire 52 and to and through the clutch magnet 20 of the signal transmitter controller diagram Fig. 7 of calling subscriber 736.

Therefore, the signal transmitter controller will not now leave the S N position. But if subscriber's line 1845 be not in use and his wire 3 be dead, no current will flow over the test circuit just described through coil of relay 215 on the section of calling subscriber 736 and hence the armature of relay will remain against its back contact and the release circuit of 20 over the back contact of relay 215 being completed by the rotary switch, the signal transmitter controller passes one short step to the N position and there automatically comes to rest. This is because the notch in disk 23 from which the dog is withdrawn at this stage of the operation is the one diametrically opposite notch 680, and the next notch is at such a point that when the cylinder brushes have passed the space from S N position over the last vertical row of cylinder contacts and to the first vertical row marked N where they complete the whole revolution, the dog will enter said notch and free the clutch so as to stop the rotation of the cylinder brushes. This is the position which the signal transmitter controller must assume in order to establish through it and through the rotary switch, the talking connection as described under "rotary switch 5th position".

The rotary switch besides breaking the connection 231 at short segment 659, Fig. 6, from relay 215 to line 1 as just described in passing from 3rd to 4th position, also, and before reaching the 4th position, connects 1 with release relay 216 by the row of contacts immediately succeeding short segment 659 and connected to wire 233, so that its coils are in a circuit including arm 142 and contact 145, which circuit is closed in the rotary switch until it leaves the No. 4 position. The circuit is over the No. 1 side of the calling subscriber's line and through the normally closed contact of telephone switch so that the breaking of circuit at said contact may discharge the relay 216 which closes a circuit 108 by which the magnet 17 of the rotary switch will be energized so as to send the cylinder brushes thereof

forward to the No. 5 position. This circuit when complete charges relay 216 from batteries 202, 203, in series by 216, 233, rotary switch 3rd and 4th rows, bridging brushes 708 which bear thereon as soon as they leave the No. 3 position 122, middle feed segment 650, cylinder brush which has been brought to rest thereon, as already explained, middle one of the brushes 61 for the primary connector register and brought to rest on contact connected to 651′ to cylinder brush 710 brought to rest on cylinder contact connected to No. 1 line, 147, 142, 145 and earth, and breaks the circuit at the back contact of the relay. If the circuit is, however, open at the contact spring 147 of the hook lever, Fig. 39, by the lifting of the telephone either before or after the rotary switch has established such circuit, the connection 108 at the back contact of the relay 216 will be closed, thus causing the rotary switch to pass on from No. 4 to No. 5 position without stopping in the No. 4 position, because its clutch magnet 17 is energized over 108 as follows: from battery 202, 108, bridged contacts rotary switch 11th and 12th rows, lower pair of brushes 699 when in the No. 4 position to magnet 17 and negative battery.

In the usual operation of the apparatus the rotary switch comes to rest on this No. 4 position because the actions proceed to this point before the subscriber would naturally raise his telephone after seeing the arm 153 cease its retrograde movement. Therefore the circuit of magnet 216 will be complete at the contact spring 147 of the hook at this time, and hence the magnet will be charged over the No. 1 side of the line from the batteries and by wire 233 over the circuit just traced and the armature will be held off its back contact so that the release circuit 108 for the rotary switch will be open. The subsequent raising of the telephone sends the rotary switch forward by the action just described. It should be understood that the directions to the subscriber are to allow the arm 153 to fully complete its backward movement after being pulled down to start the signals and then lift the telephone from the hook and press his ringing key 26.

Rotary switch 4th position.

It being assumed that the line wanted is not busy and that the signal transmitter controller has therefore reached N position, the rotary switch completes a connection for charging the line 3 of the called subscriber through contacts on the signal transmitter controller N position, and keeps said wire 3 charged until it, (the rotary switch) leaves the No. 5 position at the conclusion of the conversation. This charging which gives said wire a guarding potential to protect the subscriber 1845 from interference is acquired from any source of electric energy and over path as follows: from positive pole of said source to lower of the two cylinder contacts bridged by the upper pair of brushes 711, Fig. 7, in their position under N, as shown, which is the normal or zero position, wire 226, to Fig. 6, to the short feed segment the beginning of which is engaged by the pair of bridging brushes 688 when they reach No. 4 position, to the longer feed segment engaged by the upper brush, to wire 222 connected to the same, through diagram Fig. 7, lower feed segment 650 of the interconnector whose cylinder brushes have been sent forward from normal position as already explained, brush 706, wire 71, brush 705 of the interconnector register, register contact to which said brush has been adjusted, as already explained, wire 71′, cylinder brush 693, which has been moved to cylinder contact connected to bus wire 223, then through the latter to the 9th section of the 2nd thousand of the exchange, to tap wire 224 leading to the secondary connector adjusted to connection with the 1, 2 and 3 lines of subscriber 1845, as already explained, lower feed segment 650, Fig. 9, cylinder brush 690, wire 697, inner register brush adjusted to sector contact which is joined by a wire 71′ to a cylinder brush 704 adjusted to rest on cylinder guard contact for subscriber 1845, which contact is connected by wire 325, with wire 3 of the called substation, from which the guarding potential is distributed to the guard contacts belonging to said subscriber on the cylinders of all the other nine secondary connectors on the same section joined in multiple by similar wires 325 to said wire 3.

As already explained, the signal transmitter controller coming to rest on the S N position, sends a current over 100 and through the rotary switch contacts No. 3 position to the clutch magnet of the latter to send said switch forward. Should the signal transmitter controller remain in this position, as would be the case if the line called be busy so that magnet 215 will be excited over the test circuit, and as already explained, the switch will nevertheless advance to the No. 4 position where there is still a connection for the relay 216 from battery 202, to the coil of relay 216, to wire 233, by the row of contacts immediately succeeding segment 659 to 659′ by bridging brushes 708 in No. 4 position and by wire 122, through primary connector as already traced to No. 1 line, which circuit will, however, be opened as already described at the end of the description under 3rd position by the lifting of the telephone, and the rotary switch will pass on to the No. 5 position as there described. Hence any attempt of another subscriber, as for instance, No. 952,

to now make connection with 1845, would be frustrated because the signal transmitter controller in the division seized by 952 on his own section, will be prevented from going from S N position after the seizure of any idle secondary connector on the section of 1845, in the same manner that the signal transmitter controller seized by station 736, would have been prevented, as already described, from going to N position in case wire 1845 had been itself a calling wire.

It being assumed that the rotary switch has come to rest in the No. 4 position, and that the subscriber thereafter lifts his telephone on seeing arm 153 at rest, the hook lever 169, will break the earth connection of 1. This discharges relay 216, which closes connection 108 already described, thus sending rotary switch forward from No. 4 to No. 5 position, where it again automatically comes to rest, but ready to be sent forward from this position at the conclusion of a conversation by the action of current over the connection 109 from the front contact of relay 216 when the telephone is again placed upon the hook lever so as to complete the connection from 1 to earth by 145 and thereby again charge the relay 216.

At the substation of the calling subscriber the release of lever 169, besides breaking the connection of 1 to earth, breaks at 148 the connection to 33 and bell 146, and connects the 1 to the 2 side of the line through telephone receiver, telephone transmitter 27 and ringing key 26 shunted by a resistance.

Rotary switch 5th position.

This is the talking position when the signal transmitter controller is at the same time in the N position.

The 1 and 2 sides of the calling line are now connected together at the central office, the connection being from 1 side to 122, contacts of rotary switch 3rd and 4th rows, 5th position, Fig. 6, 233, one coil of relay 216, battery 202, one coil of induction coil 204, ringing relay 217, another coil of relay 216, wire 234, contacts 5th and 6th rows of rotary switch, 123, and 2 side of line. The connections between line 1 and wire 122, and between line 2 and wire 123 are by the paths opened up by the primary connector as already described and have been set forth a number of times in connection with the signaling and other operations over said lines. The current does not flow to earth because the earth connection has been broken at calling subscriber's station at contact 145 by the forward movement of the arm 142 as just stated. In relay 216 the two coils neutralize one another's effects and the connection 109 for starting the rotary switch from the 5th position therefore remains temporarily open at the front contacts of the relay, while the relay 217 now opens a connection at its back contact.

The calling subscriber having, as just stated, taken the telephone off the hook, places the same to his ear and depresses the ringing key 26, thus throwing the resistance into the circuit and causing the relay 217 to close circuit on its back contact and send current from the ringing generator 201 through the bell of called subscriber.

This circuit may be traced as follows: from generator 201, supplying the relays of the division and sections in multiple, back contact of relay 217, 235, bridged contacts of signal transmitter controller, N position, 236, rotary switch contacts which could be located on the second half of its cylinder but in the No. 5 position of a pair of bridging brushes in one of the vertical rows of cylinder brushes to wire 323, through Fig. 7 diagram, to the interconnector No. 2 set as already described by the calling subscriber, feed segment with which cylinder brush 713 has been brought into engagement, register brush joined to 713 and adjusted to rest on the sector contact joined to cylinder brush 714 adjusted to rest on cylinder contact which is joined to the bus wire 623 over said bus wire to the 9th section of exchange in the 2nd thousand, tap wire 423, idle secondary connector previously seized on called subscriber's section, feed segment of cylinder, brush bearing thereon, middle register brush, cylinder brush 715, bearing on contact connected to 522, to 1 side of substation line 1845, brush 147, 142, 140, bell 146, 148, 2 side of called subscriber's line, tap wire 523, at central office, brush 61 of secondary connector cylinder bearing on contact connected to 523, outer contact of register sector, outer register brush resting thereon, brush and feed segment connected to 422, through interconnector to 322, over circuit already traced in reaching 196 to actuate register magnet 32, bridged contacts 9th and 10th rows of rotary switch, 237, bridged contacts of signal transmitter controller, 3rd and 4th rows, 238, one side of repeating induction coil 204, and back to opposite pole of generator 201. These currents operate inductively in the coil 204 and produce currents which flow in the other side of the induction coil to coils of relay 217 and one coil of release relay 216 over 234 to the lower one of a pair of contacts under No. 5 position engaged by the bridging brushes 703 when in such position, from the upper contact of the pair to the feed segment in the same row which is connected to wire 123 and through the path already opened up through the primary connector to and over calling subscriber's line 2, through his telephone and

back over the 1 side through the primary connector by path already traced to 122, to segment 659′, bridging brushes 708 when in the 5th position, to 233, the other coil of release relay 216 and to the induction coil through battery 202, this being the circuit just traced over which the ringing key operates relay 217 to cause the same to connect ringing generator 201 to called subscriber's circuit. These induced currents, by passing through the telephone receiver of the calling subscriber, produce a sound that gives notice to him that connection has been made and the call transmitted to the called subscriber. The release of the ringing key at the calling substation causes relay 217 to close connection on its front contact and to throw out the generator connection to 201 on its back contact. At its front contact a connection from one pole of battery 202 to wire 235 is made, so that the two sides 1, 2, of the called subscriber are now connected through one coil of 204 and said battery over the wires 235, 238, in just the same way that the two sides 1, 2, of the calling subscriber are connected over wires 233, 234, through the other coil of 204 and said battery. There is now, therefore, an inductive talking connection between the two circuits at the central office so that conversation may be carried on when the called subscriber, in response to the signal, lifts his telephone from the hook and his telephone switch by means of its springs 148 and 147 cuts out the bell and puts the telephone into circuit between the two sides of the line.

Inasmuch as the circuit of the called subscriber is, as just explained, from the calling generator by wire 235, through contacts in the N position of the signal transmitter controller, no currents will flow over his circuit from the signaling generator when the calling subscriber depresses his key, and hence no induced currents will be produced by the induction coil in the calling subscriber's circuit, and no answer-back signal will be heard at the calling substation if the signal transmitter controller has not previously passed from the S N position one short step to the N position. This it will fail to do in case, as already described in connection with the operation of the rotary switch in passing from the No. 3 to No. 4 position, said switch in applying the busy test should find that the line wanted is already in use, in which case the relay 215 would be prevented from closing the connection on its back contact to the clutch magnet of the signal transmitter controller at the time the brushes of the latter are on the vertical row of contacts under S N after making their 2nd revolution. In that event the calling substation would hear no signal on depressing his key, which would be notice that the line wanted is busy, and he would then restore the telephone to the hook, thereby connecting the No. 1 line to ground by contact 145 at his station.

This charges the relay 216 over line 1 and contacts in the 5th position of the switch to which the switch, seized by the caller attempting connection, moves automatically even although the signal transmitter controller may be retained in S N position. The current which actuates the relay 216 at this stage of the actions flows from section 202 of battery grounded through section 203, Fig. 7, through the relay coils to wire 233 to the lower of the pair of contacts engaged by cylinder brushes 708, Fig. 6. When in No. 5 position, feed segment 659′, wire 122, to segment 650 Fig. 5, brush resting thereon, middle register brush adjusted to rest on contact connected to 651′, to brush 710 and by cylinder contact No. 1 side and by path just described to ground at subscriber's station. This causes the relay 216 to close the connection 109 on its front contact over which current now flows to pair of contacts in the lower rows of cylinder Fig. 6, engaged by brushes 699 in their No. 5 position and to wire 663, through clutch magnet 17, energizing the latter and sending the rotary switch brushes forward to the next position and results in the same actions as are produced by hanging up the telephone at the conclusion of a conversation and as will be presently described.

It will be observed that in this operation the same source of electromotive force, namely, battery or section of battery 202 which is used for conversation, furnishes also electromotive force or energy for connections and disconnections.

In order to prevent interference with the position of the called subscriber's signal transmitter by the action of the ringing current in case his transmitter should, at the instant the calling subscriber presses his button, be in the initial signal position (in which case the ringing current would flow by 148 and 179 through the magnet 33 at the called subscriber's station) an additional relay may be employed. This relay is so connected to the circuits that it will be energized by current flowing through 148 and 179 at this stage of the operation, and will act in such manner as to prevent the ringing currents from flowing to the called subscriber's circuit. It is preferred to use a double wound relay such as indicated at 220, Fig. 7, and to have it act by rendering relay 217 unresponsive to the action of the calling subscriber's button. The two windings are in the two sides respectively of the called subscriber's circuit, so that under normal conditions neither ringing current nor talking current will affect it. Neither will

the relay have any effect on the speech, since there being no magnetism there will be no inductive effect. The relay will also serve to make better balance between calling and called lines, as they will be made thereby identical with exception of relay 217, which is rendered harmless by the bridging non-inductive resistance 205.

The relay 220 controls a local circuit running through an auxiliary coil on relay 217 which circuit is closed when the armature relay 220 is drawn forward. The effect of this auxiliary coil is to charge said relay 217 and prevent it from throwing the ringing generator onto the circuit in case, at the instant the calling subscriber presses his button to cause relay 217 to release its armature, the called subscriber's signal transmitter should be in preliminary impulse position, that is to say, with the arm 142 closing connection on the contact 141, and with spring 144 closing contact at 179. In that event a sort of compound circuit will be formed as follows, so as to energize the relay 220 and close the circuit of the auxiliary coil on relay 217. The combined voltage of batteries 202 and 203 will be applied to the No. 1 side of the line, the current being made to flow from ground at the central office to 235 by the front contact of relay 217, and thence through one of the windings on relay 220 to the No. 1 side of the line and directly to ground at the called subscriber's station. The current would flow after reaching 235, to the lower pair of contacts in the vertical row under N, Fig. 7, over the pair of bridging brushes 716 now in normal position, wire 236, pair of contacts in the vertical row under No. 5 position of the cylinder brushes for the rotary switch and from the upper of said pair to wire 323 down through the Fig. 7 diagram to the No. 2 interconnector which has been put in action as already described by the calling subscriber and is in the same division with the primary connector used by him in making the call, to a feed segment 650 on the cylinder of said interconnector, the brush 713 already adjusted to make contact therewith, by a connection 71 to the sector brush 2nd from top, to the contact sector to which it has been adjusted and which is connected by one of the wires 71′ with the cylinder brush 714, thence from cylinder contact connected to the bus wire 623, over said bus wire through all intermediate sections to the section of the called subscriber 1845, then by the tap wire 423 leading to the secondary connector already adjusted as described on said section to open up the path with the lines 1, 2, 3, for that subscriber 1845, to middle feed segment 650 in the cylinder of said connector to cylinder brush adjusted to rest thereon to the middle of the three register brushes, then by the one of the wires 71′ to the cylinder brush 715 adjusted to rest on the cylinder contact connected to wire 522, then to the No. 1 line of said called subscriber as indicated in Fig. 1, thence to said subscriber's station apparatus, to spring 147, contact 141 which is the preliminary impulse contact as already described and directly to earth by the wire to which spring 144 is connected. The battery 202 will also tend to send a current over 235 and the No. 1 side of the line, returning over spring 144 and contact 179 over the No. 2 side of the line and to 238, through the other winding of relay 220, to the opposite pole of battery 202. By proper adjustment of the line resistance, a potential at the terminal of the No. 1 side of the line at the called subscriber's station can be secured, which will be approximately equal to the potential at the connection between batteries 202 and 203 at the central office. Hence no current will actually flow over 238, thus leaving the relay 220 to be energized by one winding in the circuit 235, whereby said relay will be energized and its lever strongly held forward so as to close circuit of the auxiliary coil on relay 217. This auxiliary coil will prevent the lever 217 from going to its back contact when the calling subscriber pushes his ringing key. The caller will thus get a busy call. As no current flows in the 238 wire and 2 side of the line, the magnet 33 will not be affected.

At the conclusion of a conversation the calling subscriber returns his receiver to the hook, which charges relay 216 by grounding line 1 and sends the rotary switch forward from No. 5 position, thus breaking the talking and signaling circuit 233, 234, at the contacts in the 3rd, 4th, 5th and 6th rows. The current which charges the relay 216 passes from battery 202, through a coil thereof, to wire 233 Fig. 7, to Fig. 6 to the contact under No. 5 position 4th from top in the vertical row and to feed segment 659′ to which position the bridging brushes 708 have been adjusted as already described, to wire 122, then through the primary connector by the circuits already traced a number of times to the No. 1 line of calling subscriber thence at his station to spring 147 and contact therefor, arm 142 and contact 145 to earth. When the relay 216 is charged it closes the connection on its front contact by which current flows from battery 202 to wire 109, to the pair of contacts at the bottom of the rotary switch cylinder and into contact with which the brushes 699 have been adjusted to No. 5 position, thence over said bridging brushes to the connection 663, and through the clutch magnet 17 for the rotary switch cylinder. This sends the cylinder brushes forward from the No. 5 position and they immediately come to rest on the No. 6 position since the next notch in the

disk 23 reaches the dog coincidently with the arrival of the cylinder brushes on the contacts in the No. 6 position, the action being again as already explained. Between its 5th and 6th positions the rotary switch actuates the magnet 33 of the calling subscriber and steps the arm 142 from contact 145 to normal contact 140, over circuit from positive battery, Fig. 6, to the long segment 652′ in the second horizontal row from which a connection is made by 718 to a pair of cylinder contacts adapted to be engaged by the bridging brushes 703 in passing from position 5 to position 6, then from the upper of said pair of contacts by connections as indicated running to the short feed segment 658 which is connected to wire 123 running up to the primary connector and by the path opened up through the same to No. 2 side of the calling line, as already described, then at the substation of said subscriber to telephone switch spring 148, contact for the same, wire 719 through magnet 33 to contact 179 and spring 144 to earth. The spring 144 is at this time in connection with contact 179, because when the contact arm 142 is on the point 145 the lever 143 will be still held over by the uncut portion of the cam disk 150. The actuation of the magnet 33 releases the escapement device and permits the driving spring to move the arm 142 one step forward to its normal position which is that shown so that said apparatus is now ready to be used for another call. The rotary switch also sends an impulse through the magnet 20 of the signal transmitter controller to send it forward to N position in case it has been left in the S N position when the rotary switch makes the test as already described, thus putting the signal transmitter controller into position ready for use at some subsequent time. This impulse goes from contacts forming the pair in the two upper horizontal rows which are in vertical line with contact 43, bridging brushes 711 to wire 100, contacts 11th and 12th rows of rotary switch forming a pair of contacts in the two lower horizontal rows which are passed by the pair of bridging brushes 699 in moving from No. 5 to No. 6 position, and the upper one of which pair is connected to wire 100, then to the lower contact of said pair and by the horizontal connection shown, to 52 and magnet 20. The magnet 20 of the signal transmitter controller is therefore excited and the clutch dog being at such time in the notch diametrically opposite 680, will be withdrawn from the same but will, when the notch contiguous thereto is reached, which is the normal notch, permit the clutch to disengage and stop the cylinder brushes which would then be on the N or normal position. Rotary switch immediately passes on to the 6th position and comes to rest, closing the connection to its clutch magnet 17 from 97 and primary connector cylinder, over which it may be sent another step forward to the No. 7 position.

Rotary switch No. 6 position.

In this position the connection from magnet 19 of the primary connector is closed over a branch 719 Fig. 6, from 45 and through contacts 3rd and 4th rows of rotary switch to negative battery, thus connecting the cylinder brushes with the driving power so that they now revolve three quarters of a revolution to normal position where they automatically come to rest by the action of the disk 23. In this operation the magnet 19 is energized over the circuit through the pair of bridging brushes 708, which in No. 6 position of the rotary switch cylinder rest on the pair of contacts, one connecting with 719 and the other or lower one of the two directly to negative battery. While the brushes occupy this position the magnet 19 remains charged so that the dog may pass the remaining notches in the disk 23 and reach the uncut edge of the disk, after which the clutch will be held engaged, as already explained, until the disk has revolved around again to bring the first notch opposite the dog when the latter will immediately fall into the notch and thus disconnect the clutch and bring all the cylinder brushes of the primary connector to rest in their normal position. The secondary connector is also sent around to normal by current in a similar way, by closure of connection at the 7th and 8th rows of rotary switch from positive battery over wire 59, and circuit already described in connection with the setting of the brushes of the secondary connector cylinder under the control of the units pulses.

The current for this purpose flows from the positive battery Fig. 6, through the connected row of segments 652′ and by the connection 718 to the pair of contacts engaged by the bridging brushes 688 in their No. 6 position and from the lower of said pair to wire 59 through diagram Fig. 7, to the No. 2 interconnector which has been placed in action, as already described, to upper feed segment 650 of its cylinder then to the cylinder brush adjusted to contact therewith and to register brush 702 and to contact to which it has been adjusted in the use of said interconnector, then by a connection 71′, to a cylinder brush 703, thence over a cylinder contact connected to the bus wire 296 leading through all sections to the secondary connector used on the section of the called subscriber for making connection with his wires, then by a tap wire 99, through the clutch magnet 22, for said secondary connector, and to negative battery or earth as shown.

The cylinder brushes of the secondary

connector then rotate and finally bring up on the normal position when the normal notch reaches the dog for the clutch. The reason why the dog may drop into said notch at both the primary connector and secondary connector is that the circuits described as formed through the clutch magnets 19, 22, for the primary and secondary connectors are over contacts of the rotary switch and before such position is reached the clutch magnet for the rotary switch will have been energized so as to send the pairs of cylinder brushes 708 and 688 past the No. 6 position thereby breaking the circuits just described for said clutch magnets 19 and 22. The energizing of the clutch magnet for the rotary switch to produce this result is accomplished as follows:

As the primary connector passes to normal position it closes the connection from positive battery to bridged contacts on the 2nd row of primary connector cylinder, operating as the primary connector begins the last half of its revolution (and therefore after the dogs on the disks 23 of the primary and secondary connectors are well engaged with the uncut portion of the disks) to wire 97 and to the magnet 17 of the rotary switch. The current to energize said clutch magnet 17 flows from positive battery Fig. 5, by a wire 722, to a cylinder contact 723, thence to the cylinder brush 724 which passes contact 723 at the beginning of the second half of its revolution, then by bridge wire 654, to brush 721, to a contact 725 engaged by brush 721 when 724 engages 723, then from 725 to wire 97, to rotary switch diagram, the lower one of a pair of cylinder contacts under No. 6 position, bridging brushes 699, engaging said pair at this position and from the upper of said pair of contacts by the lateral connection shown leading to wire 663 and through the clutch magnet 17. The rotary switch therefore moves to the 7th position and again comes automatically to rest.

Rotary switch No. 7 position.

In this position of the rotary switch the interconnector is released by current passing from positive battery, Fig. 6 diagram, through the connected row of contacts 652' by connection 718, to a pair of contacts under the No. 7 position which in such position are engaged by the bridging brushes 688 and from the lower contact of said pair to wire 107 connected to the outer brush of the thousands register which, as already described, is adjusted to the sector contact 686 connecting with the interconnector No. 2, then by said contact over wire 54, to and through the magnet 21, Fig. 8, and back by wire 55 through the diagram Fig. 7, to a connection 726 of the Fig. 6 diagram, then to a pair of cylinder contacts engaged by bridged brushes 703 in the No. 7 position and from the lower contact of said pair to negative battery. The current in the clutch magnet 21 brings the clutch of the interconnector into action again and the cylinder brushes thereof begin to revolve together with the clutch control disk 23 for said interconnector and said circuit through the magnet remains closed until the group of notches in the edge of the disk has been passed and the dog can ride on the uncut portion of said disk. When the first or normal notch is reached the dog drops into it and brings the cylinder brushes to rest in the normal position. The dog is permitted to do this because the magnet 21 will have been discharged through the movement of the rotary switch from No. 7 position by the closure of the circuit through its own clutch magnet and contacts in the No. 7 position. The circuit so closed to send the rotary switch forward is over the brushes of the primary connector just before they reach their normal position. The path of this circuit is as follows: from positive battery, Fig. 5, by connection 727 to cylinder contact 720, cylinder brush 721 which engages 720 just before it reaches the normal position shown where it completes its whole revolution by connection 654, to the rear brush 724 which simultaneously rests on the cylinder contact 728, then by wire 98, to the rotary switch Fig. 6, and to a pair of contacts under No. 7 position, engaged by the brushes 699 in such position and by the lateral connection to wire 663 through the clutch magnet 17. This latter impulse is obviously a momentary impulse but sufficient to cause the clutch of the rotary switch to be fully engaged and to permit the disk 23 to move sufficiently to bring the uncut segment 728 under the dog thereby keeping the clutch engaged until the normal notch 729 comes under the dog when the clutch will be released and the cylinder brushes which are then in the N position will come to rest. The register brusnes of the primary connector, the interconnector and the secondary connector are all forced back to zero by the action of the fixed lug or stop which is engaged by the register escapement sector as the register moves bodily around with the cylinder brushes. The thousands register escapement sector is restored to normal by the action of one of the pins 95 on a revolving portion of the rotary switch as already described.

It has already been explained under "Rotary switch No. 3 position" that, by means of a test circuit, the apparatus will be automatically held and prevented from going to ringing and talking position if the line to be called be in use. This result may be accomplished by controlling the position of any portion of the apparatus. It has al-

ready been described how one part, as for instance, the signal transmitter controller, may be prevented from moving to contacts through which connection is established and maintained. The result might be accomplished by causing some portion of the apparatus to pass the position for establishing such connection.

Summary.

To briefly summarize the operation of establishing connection between substations 736 and 1845 by the particular arrangement of apparatus shown, the initiatory act of pulling down the transmitter lever at the substation 736 places the No. 1 side of the line to ground direct, and the No. 2 side of the line to ground through the transmitter operating or controlling magnet 33. This causes the current to flow over the No. 1 side of the line when the decimal indicator 10 finds the No. 36 line plate or contact and through the line relay 211 of said decimal indicator. The indicator is thus stopped on the No. 1 side of line 36. When it stops it starts the division starter 12 which had previously been stopped in position to start the idle part of the connecting apparatus. The division starter as soon as it starts, closes the circuit and starts an idle rotary switch 5, sending it from normal to No. 1 position. In moving to No. 1 position, the rotary switch starts the decimal register controller 11 and also the cylinder brushes of the primary connector 4 of the same division, which stop automatically in the position indicated by the decimal indicator 10, while at the same time the decimal register controller 11 in completing its revolution sets the register of the primary connector 4 to position indicated by the tens brush of the decimal indicator. This places the primary connector in connection with substation 736 and connects the 1, 2 and 3 lines for said substation with the rotary switch 5. As the decimal register controller comes to rest it sends the rotary switch to second position, thus starting the transmitter controller 6. The transmitter is then stepped forward in unison with said controller over the No. 2 side of the line. The first movement of the transmitter Fig. 39, breaks the circuit of the No. 1 line to the decimal indicator relay 211 and permits the decimal indicator to revert to common use. The guard line of the substation 736 is now charged and all guard contacts of said line are charged upon the primary and secondary connectors 4, 9, of the section, while the No. 1 line is connected to the signal relay 215 operating with the signal transmitter controller.

When the transmitter brush finds the contact pin connected to ground by the thousands indicator, the relay lever is drawn up. While it was against its back contact the thousands register 13 was stepped forward to find the interconnector 8 for the second thousands.

In engaging its front contact the relay lever closes circuit through the secondary winding of the relay which holds the lever in its forward position until the signal transmitter has passed the thousands set of pins. By this means the thousands register is left in position to connect the interconnector 8.

When the signal transmitter controller 6 passes the thousands stepping contacts, the relay lever is permitted to drop back and close circuit to the hundreds register of the interconnector 8 selected by the thousands register. The signal transmitter is now stepped forward together with the hundreds register of the interconnector until the transmitter finds the pin in its hundreds set of pins which has been grounded by the hundreds indicator. The signal relay lever is then drawn up and the interconnector register is stopped in connection with brushes of the interconnector cylinder which will pass over contacts representing all secondary connectors in the eight hundreds section of the second thousands of the exchange. The relay lever remains against its front contact until the transmitter has been stepped over the hundreds set of pins. The transmitter controller 6 steps the signal transmitter past the hundreds set of pins and in coming to rest permits the signal relay lever to drop back and start the interconnector cylinder brushes which revolve until they come to the contact connected to an idle division of the secondary connector 9 in the section of exchange for substation 1845 when they are stopped by current flowing over said contact and through one winding of the signal relay so as to cause the latter to break at its back contact the circuit of the controller magnet for the interconnector cylinder.

The rotary switch 5 is now started to 3rd position by circuit through the transmitter controller and relay lever which is against its forward contact. This breaks the circuit of relay magnet and allows relay lever to fall back again, and the signal transmitter controller 6 is again started and sends a third or tens set of impulses to the transmitter and to the register magnet on the secondary connector which has been seized and is isolated.

When the transmitter finds in its third or tens set the pin which has been grounded by the tens indicator, the secondary connector register stops on contacts connected to brushes of the secondary connector cylinder which pass over a set of contacts therein to one of which line 1845 is connected and stops as before because the signal relay lever breaks circuit at its back contact.

The transmitter controller passes the tens set of contacts and the relay lever again

closes on its back contact and the signal transmitter is now stepped over its units set of pins. The cylinder brushes of the secondary connector are now stepped forward until the transmitter finds the pin grounded by the units indicator and the secondary connector brushes are now in connection with line and guard points 1845. The rotary switch now moves forward to position, just in front of the talking position, and the transmitter having been given a final step by the signal transmitter controller, closes a ground for No. 1 side of the calling line over which the release relay 216 is operated by one of its windings.

The lifting of the telephone from the hook allows the release relay lever to fall back and cause the rotary switch to move forward to talking position. This completes the signaling and talking circuit provided that the test applied by the rotary switch in moving up to position just in front of the talking position, has found the line wanted disengaged so that the signal transmitter controller will have been caused to move forward the final short step from S N to N position, which is the talking position for it. The talking and signaling connection being then complete, substation 736 can call 1845 by operating the ringing key, which allows ringing relay to put calling generator into circuit of 1845 through one winding of the repeating coil 204. This sets up an induced current in the line 736 which informs substation 736 that the bell of called subscriber is ringing. The talking circuit is through transmitter controller on normal position and rotary switch on talking position. Had the guard contact of substation 1845 been charged by the said substation being busy, signal relay 215 would have been held up against its front contact, thus preventing the transmitter controller from going to the talking position.

When the telephone is placed on the hook, whether after a completed call, or a busy one, the ground circuit is completed through No. 1 side of line and release relay 216 and said relay lever is drawn up to its front contact so as to cause rotary switch to move forward from No. 5 or talking position. In moving to No. 6 position, the rotary switch sends an impulse that puts the signal transmitter to normal position ready for another call and also sends the signal transmitter controller forward from S N position to N position provided it has been left in S N position on the application of the busy test. The rotary switch then comes temporarily to rest in this 6th position where it initiates the train of operations by which the primary connector, interconnector and secondary connector together with the rotary switch are sent around to normal. As soon as the primary connector and rotary switch are at normal, they are in condition to be selected and seized by another calling substation.

All other devices and combinations of devices, circuits and apparatus described in the foregoing specification, but not claimed herein, are claimed in our previous application filed April 24th, 1900 wherein we have set forth and claimed broadly the general principle of working a telephone exchange with a group or series of main line circuit selecting switches termed secondary connectors for each of the groups of lines into which the substation lines of an exchange are divided and the further provision of automatically controlled switches and connections whereby any line of all the groups of lines may place itself in connection with any secondary connector of any group, which secondary connector may thereafter be adjusted by the selective signals to connection with the line called, said invention being capable of being carried out with many variations in its minor details, some of which details are specifically claimed in the present application.

What we claim as our invention is:

1. In an automatic telephone exchange, the combination with a signal transmitter at a subscriber's station and a relay at the central station for placing a ringing current upon the subscriber's line when called, of means for cutting off the ringing current responsive to current flowing over a circuit established at the called subscriber's station when his apparatus is in position to send a preliminary impulse.

2. In an automatic telephone exchange, the combination with the central office exchange apparatus, of devices at the central office controlled by the calling subscriber for causing ringing current to flow to the called subscriber's line, and a double wound relay placed in the two sides of the called subscriber's line and controlling the circuit of said devices.

3. In an automatic telephone exchange, a differential relay at the central office, means controlled by a calling subscriber for connecting the two coils of said relay to the two sides of a called subscriber's line, means for supplying current of one potential from the central office through both coils of said relay, and means for supplying additional potential to a single coil of the relay, as and for the purpose described.

4. In an automatic telephone exchange the combination of a source of electrical energy at the central station adapted to supply current to the talking circuits of calling and called lines at a given potential and also adapted to supply current of additional potential over one side of the called line, a differential relay included in the talking circuit of the called line and kept in a neutral condition when supplied with the source of

battery used for talking purposes but adapted to be thrown out of balance when the additional potential is supplied over one line and one winding of said relay, as and for the purpose described.

5. In a telephone system the combination with a plurality of lines, a plurality of sets of switches for the common use of said lines in interconnecting any two of them, a plurality of relays, one for each of the switches of one of the sets, means for placing an idle one of said relays under the control of a calling line, means under the control of said relay for adjusting the switch associated therewith, means likewise under control of said relay for adjusting a switch of another set, means for sending ringing current to a line to be called, means associated with the calling line for actuating said relay in adjusting the switches, and means associated with the called line for actuating said relay in controlling the application of ringing current thereto.

6. In a telephone system the combination with a plurality of lines, a plurality of switches, each of a different class, a single relay, means for actuating it for the purpose of controlling all of said switches in building up a connection to a desired line, means for testing said line, means for sending ringing current thereto, and means dependent upon the condition of said line for again actuating said relay to control the sending of ringing current thereto.

7. In a telephone system, the combination with subscribers' lines, automatically actuated switching apparatus for connecting lines, busy guard apparatus for said lines conditioned for operation by said switching apparatus, means at subscribers' stations for initiating calls to the central switching office, and means for applying signaling current to wanted lines, of means rendered effective by the means for initiating a call from any line to disable said means for applying signaling current to that line.

Signed at Piqua, Miami county, Ohio, this 19th day of November, 1901.

GEORGE WILLIAM LORIMER.
GEORGE WILLIAM LORIMER,
As administrator of the estate of James Hoyt Lorimer, deceased.

In the presence of—
CLARK B. JAMES,
WILLIAM C. JOHNSTON.