No. 639,186. Patented Dec. 12, 1899.

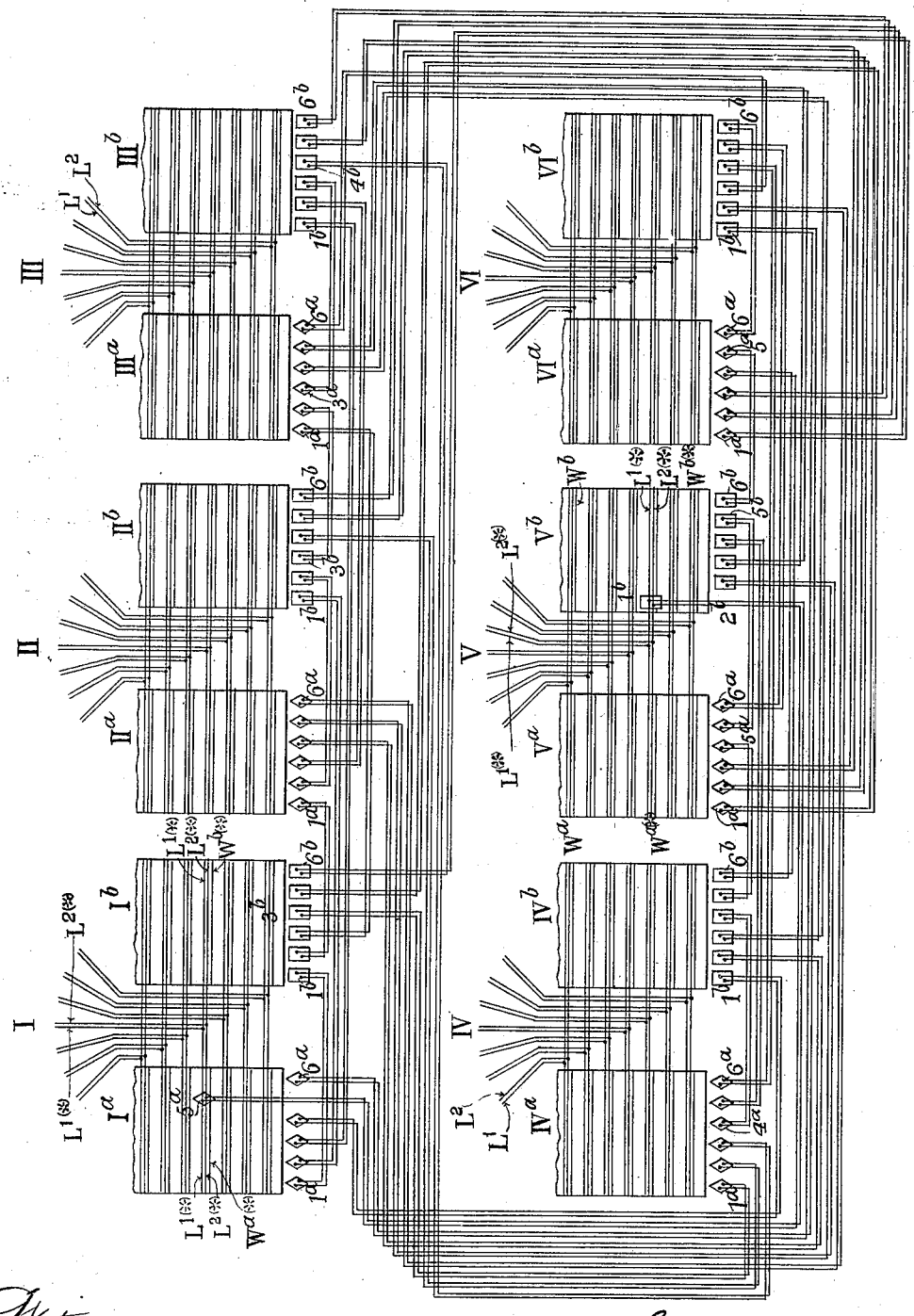
G. SELIGMANN-LUI.

SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 1.

FIGURE 1.



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No. 639,186. Patented Dec. 12, 1899.

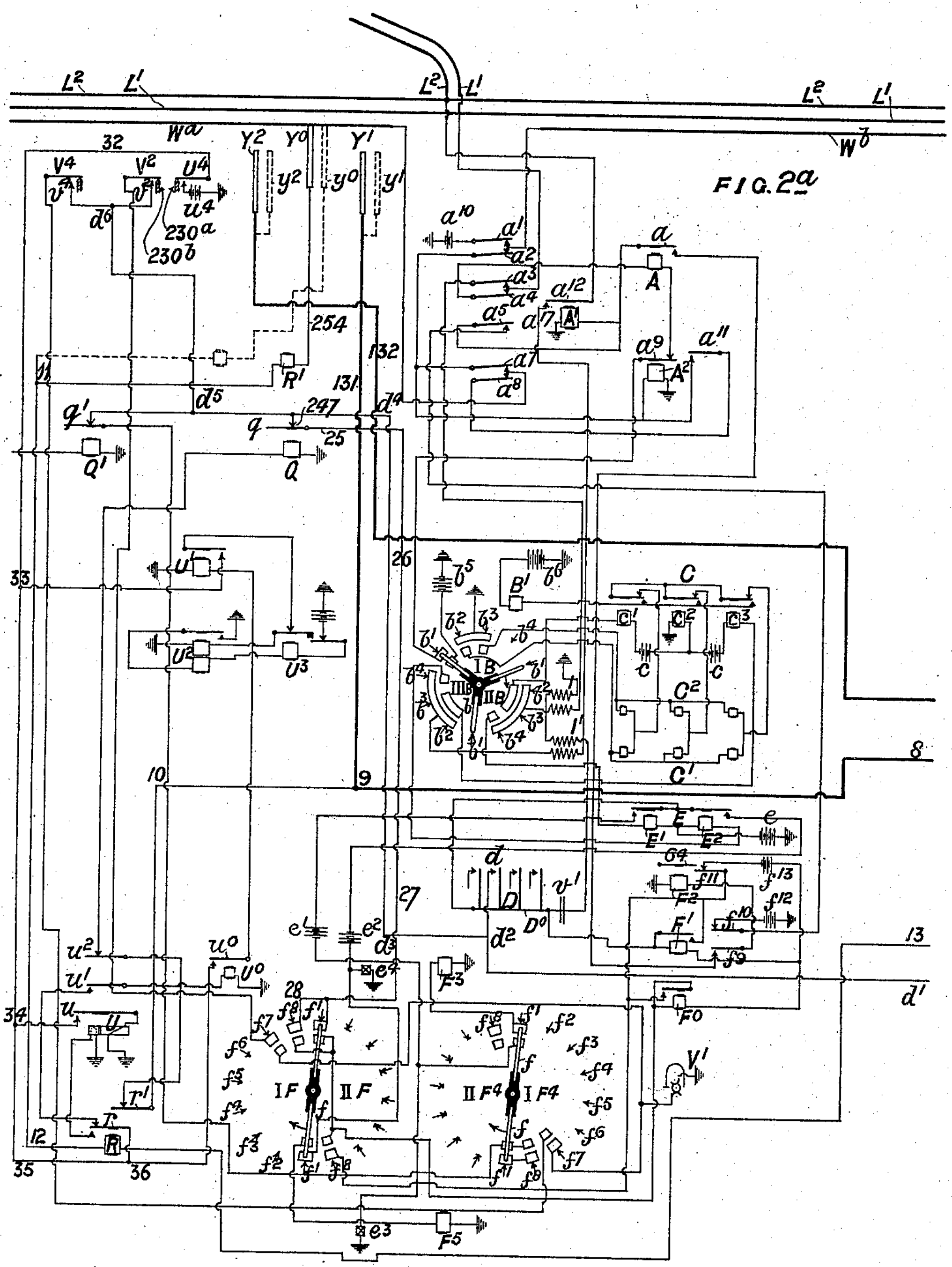
G. SELIGMANN-LUI.

SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.)

15 Sheets—Sheet 2.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 639,186. Patented Dec. 12, 1899.

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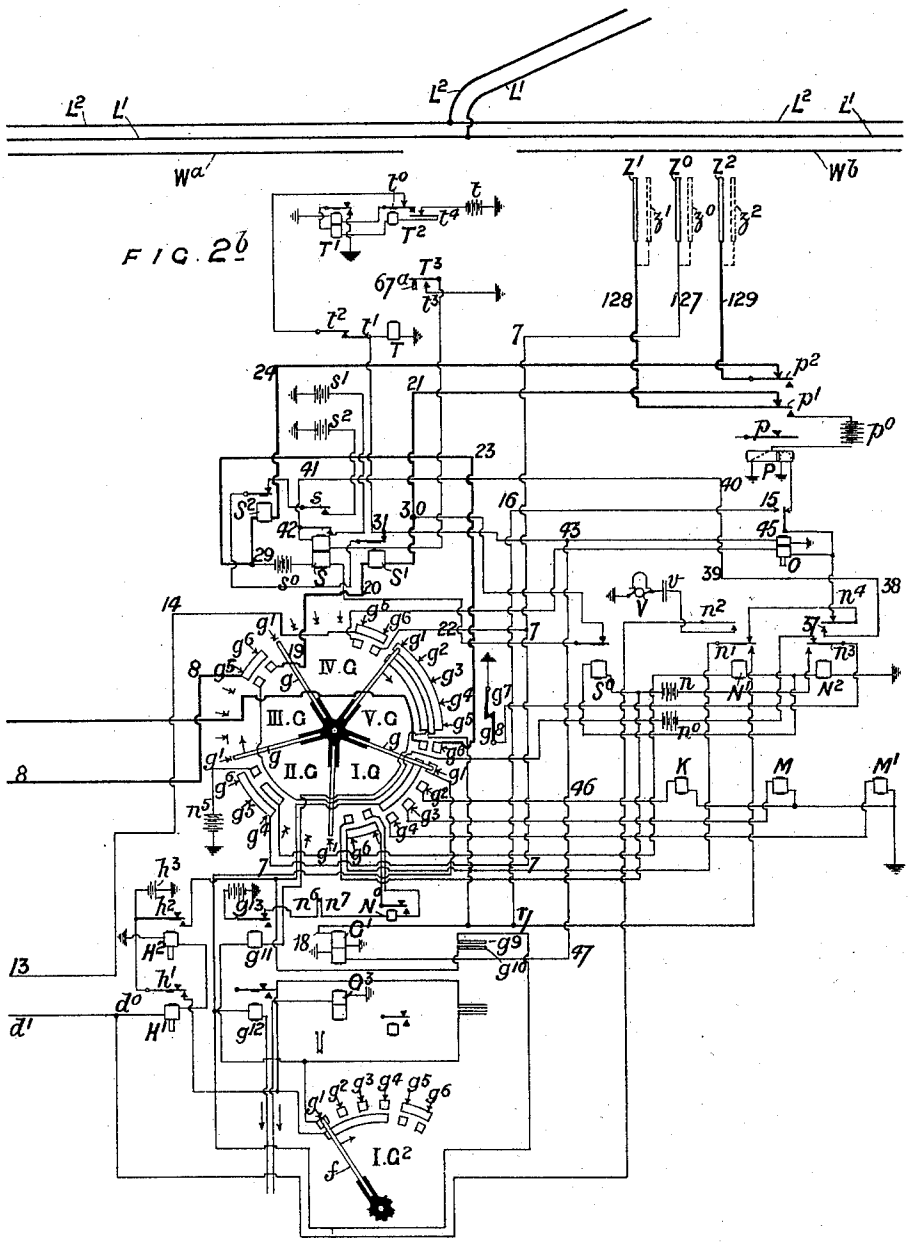
SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 3.

FIG. 2b



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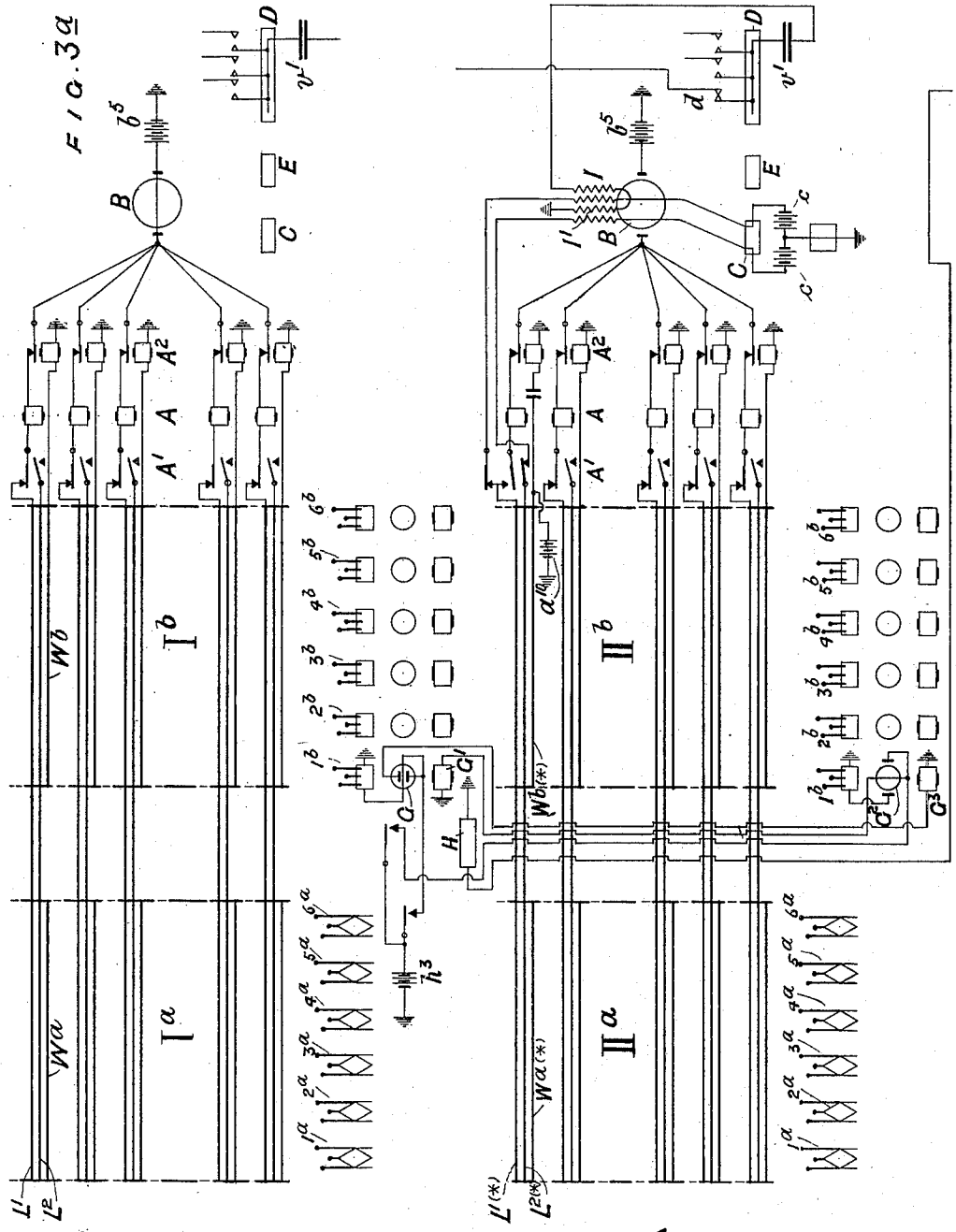
SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 4.

FIG. 3a



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No. 639,186. Patented Dec. 12, 1899.

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SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

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(No Model.) 15 Sheets—Sheet 5.

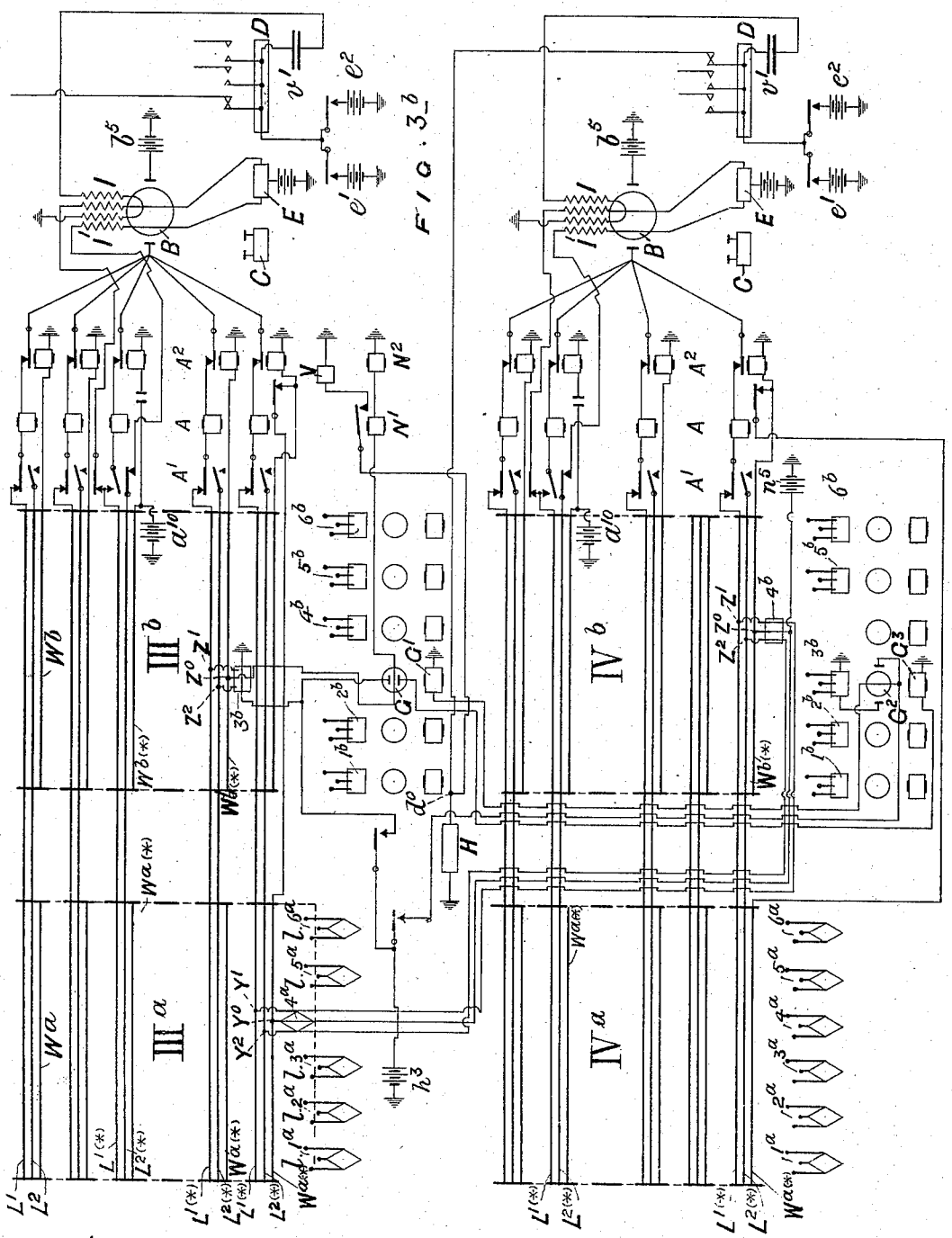

FIG. 3b

Witnesses
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SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

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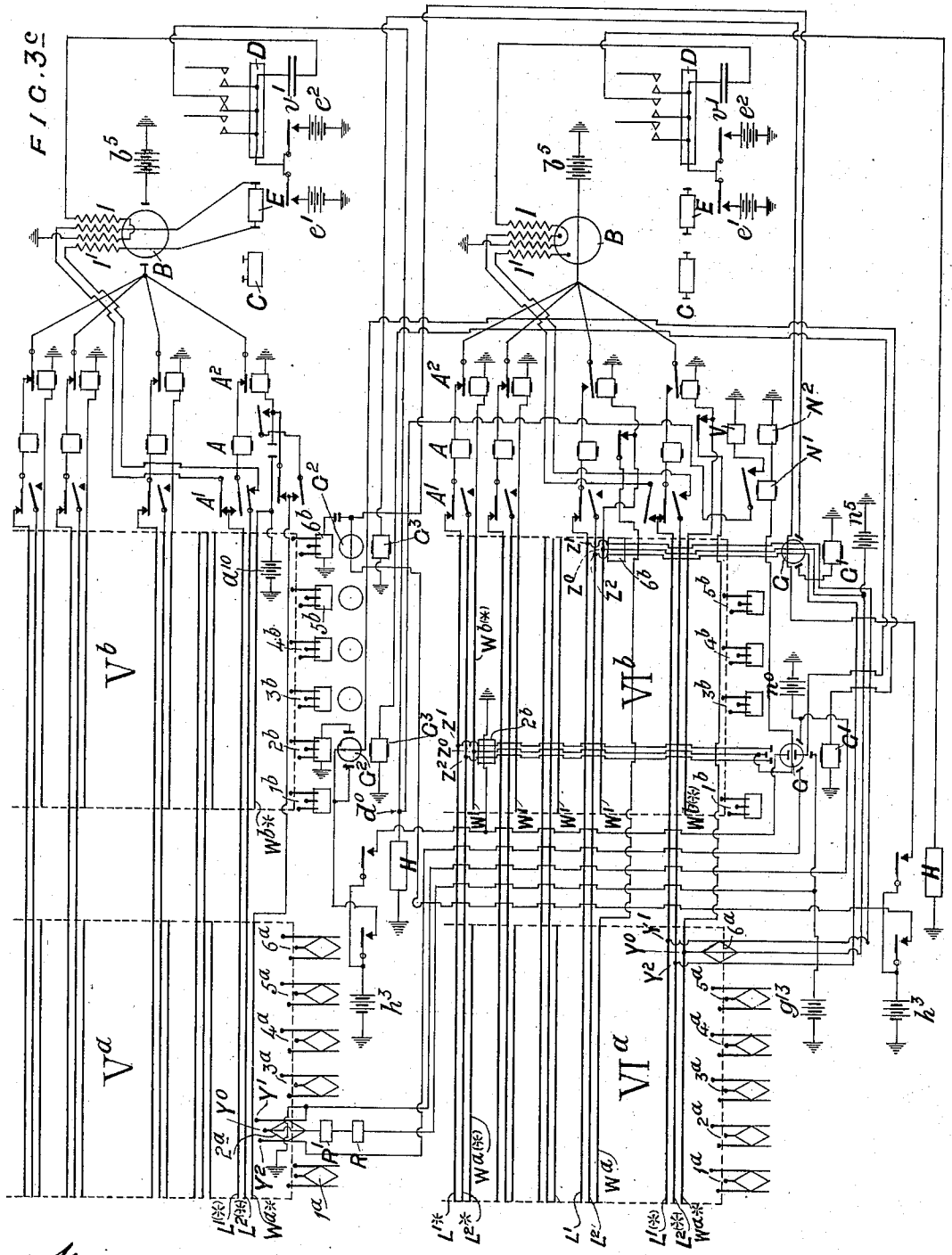
FIG. 3c



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SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

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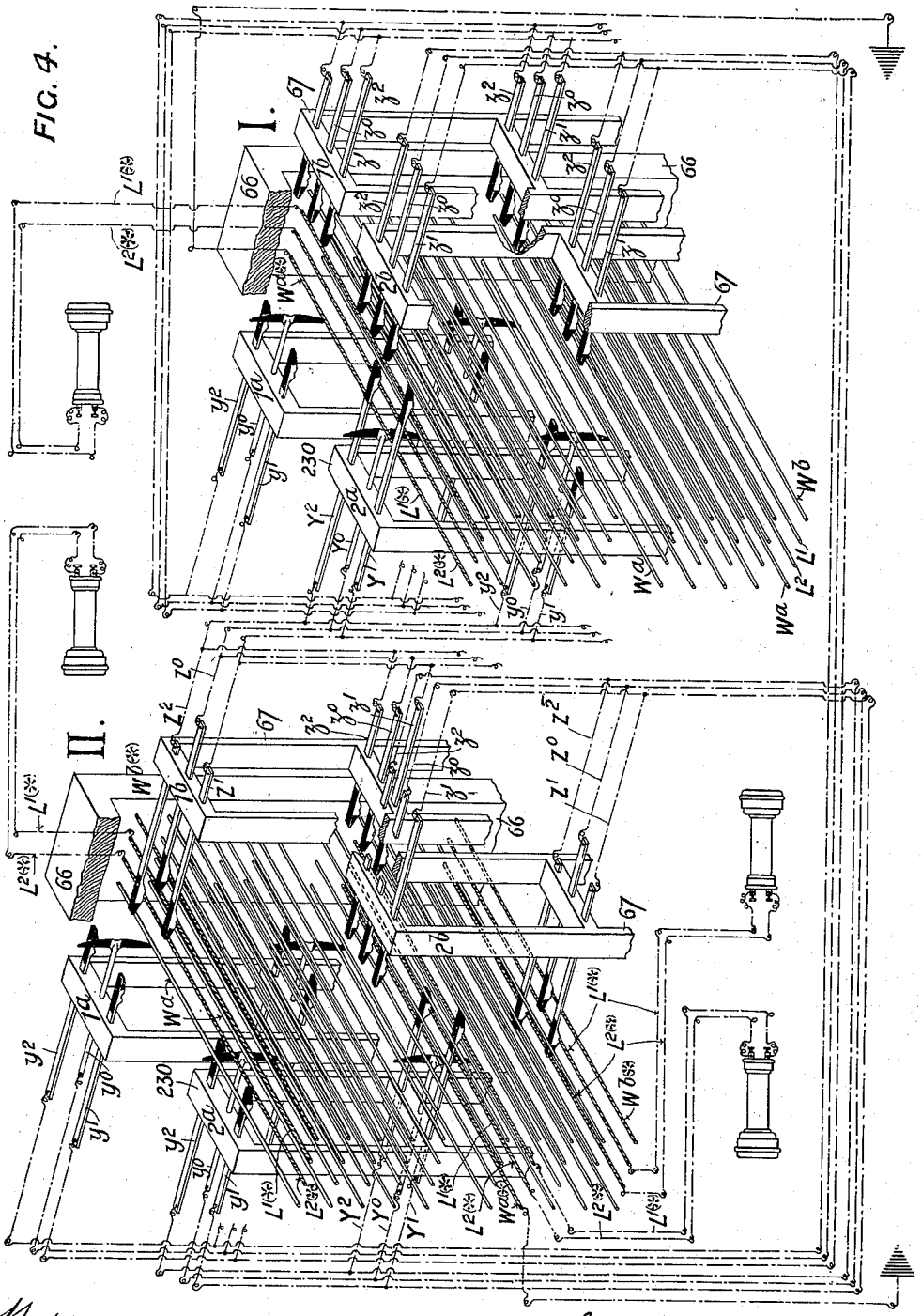
FIG. 4.



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SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 8.

FIG. 6.

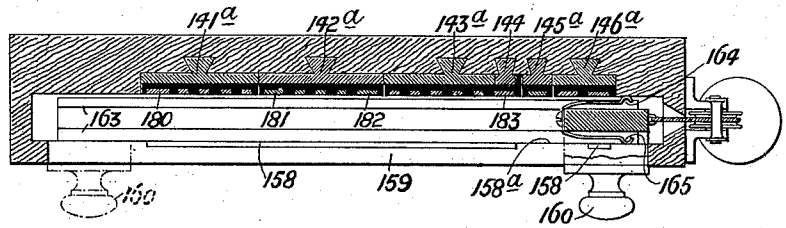
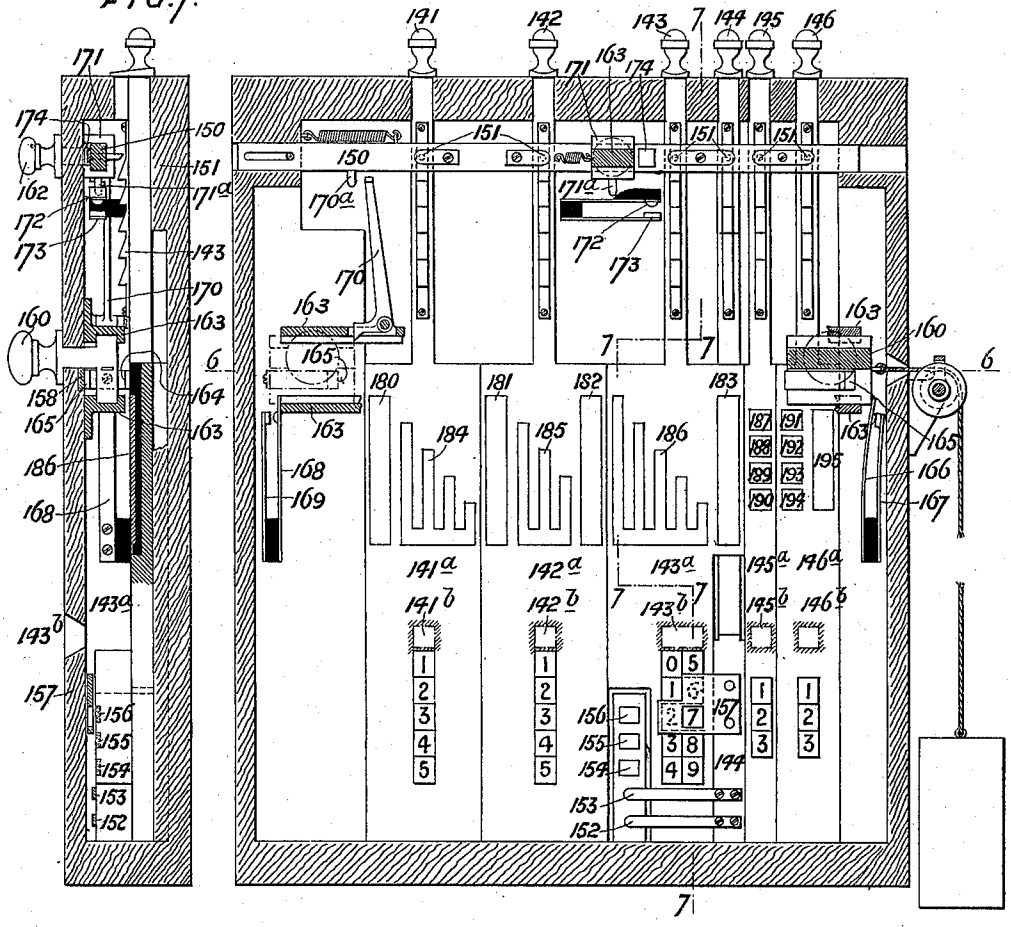


FIG. 7.

FIG. 5.



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G. SELIGMANN-LUI.

SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 9.

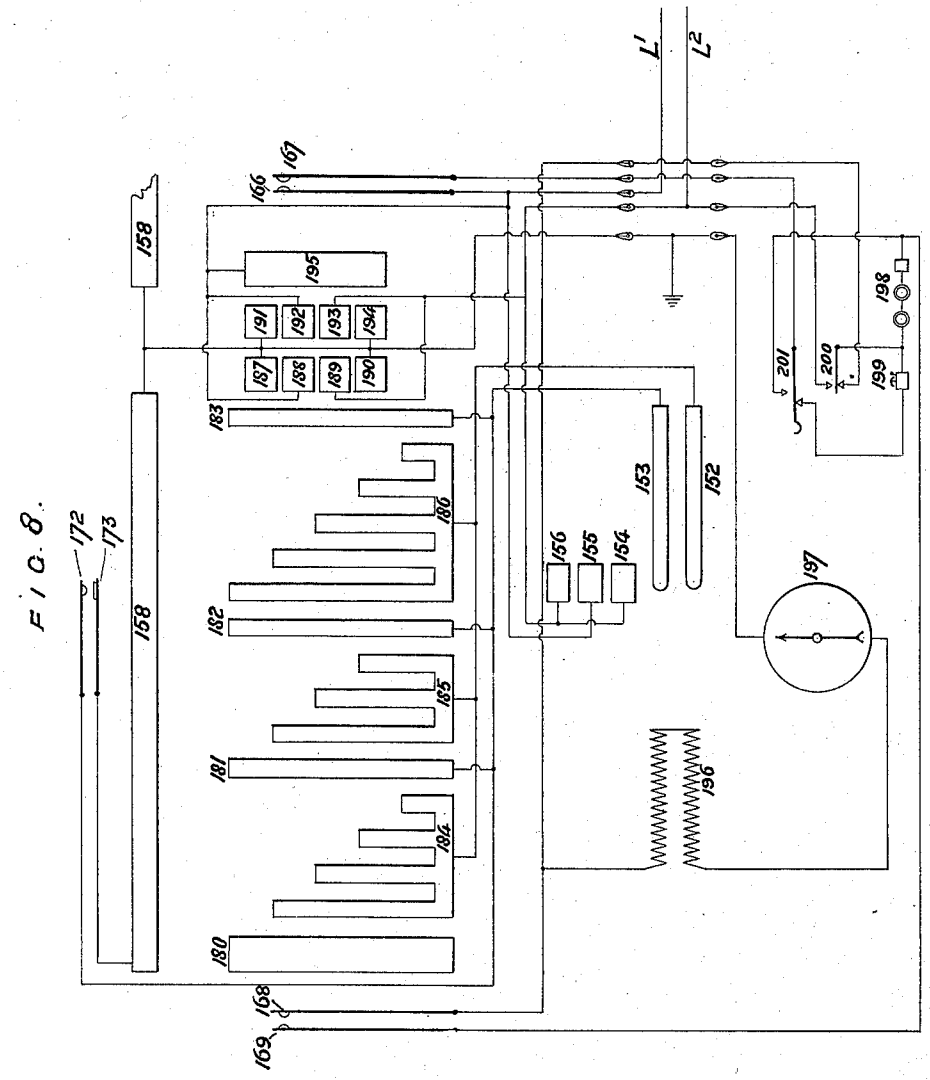

FIG. 8.

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No. 639,186. Patented Dec. 12, 1899.

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SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 10.

FIG. 12.

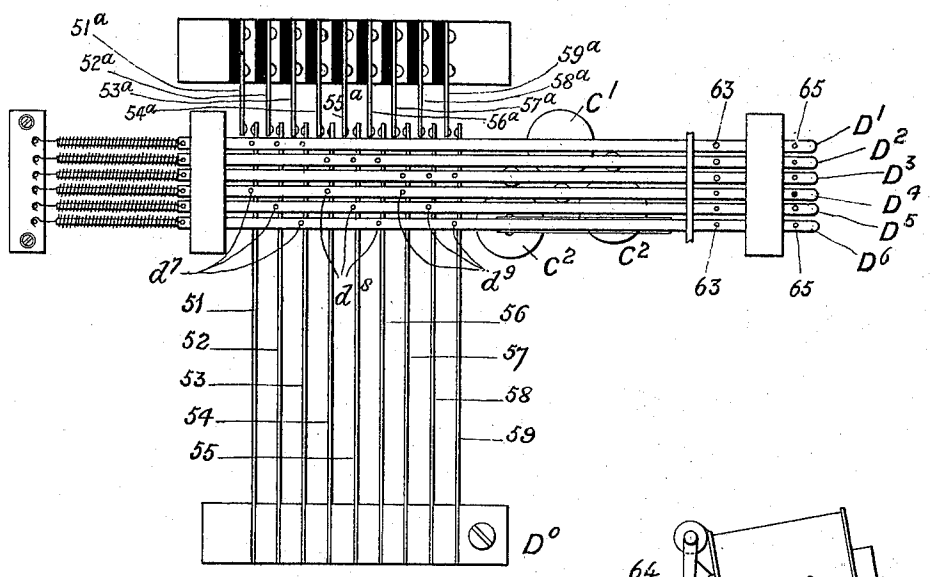


FIG. 13.

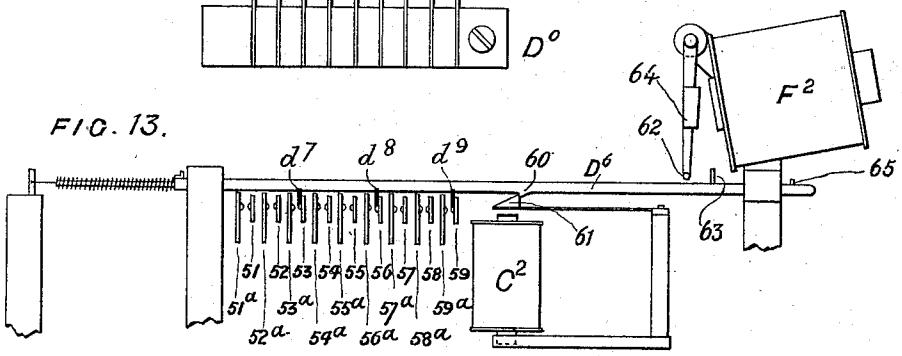


FIG. 9.

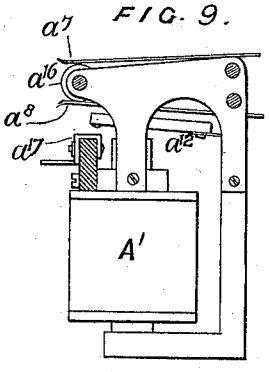


FIG. 10.

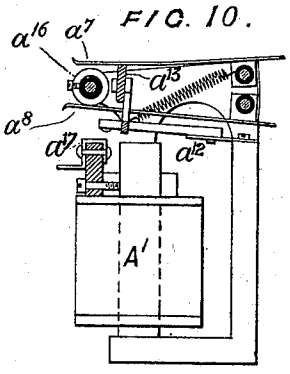
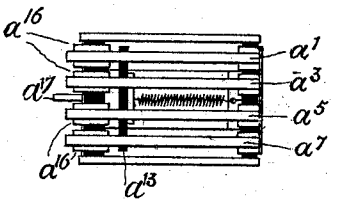


FIG. 11.



Witnesses
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No. 639,186. Patented Dec. 12, 1899.

G. SELIGMANN-LUI.

SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet II.

FIG. 15.

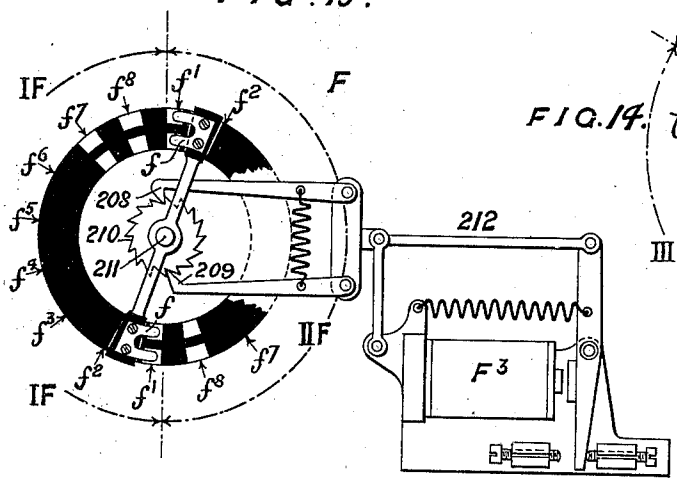


FIG. 14.

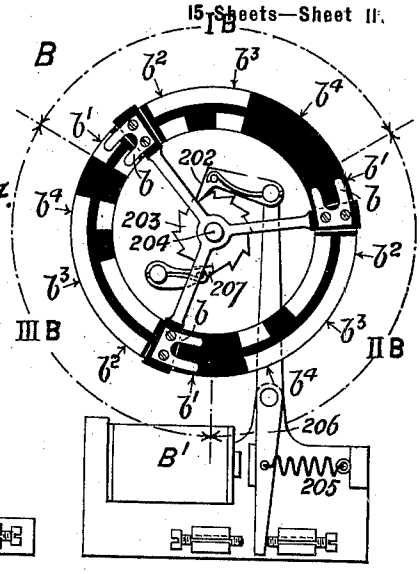


FIG. 17.

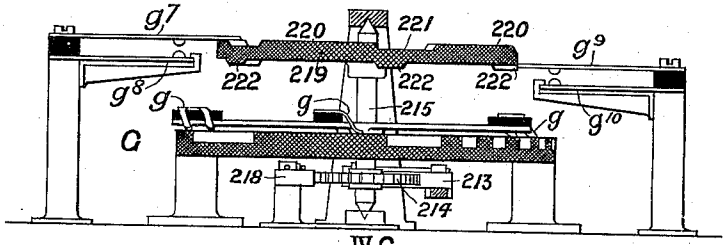
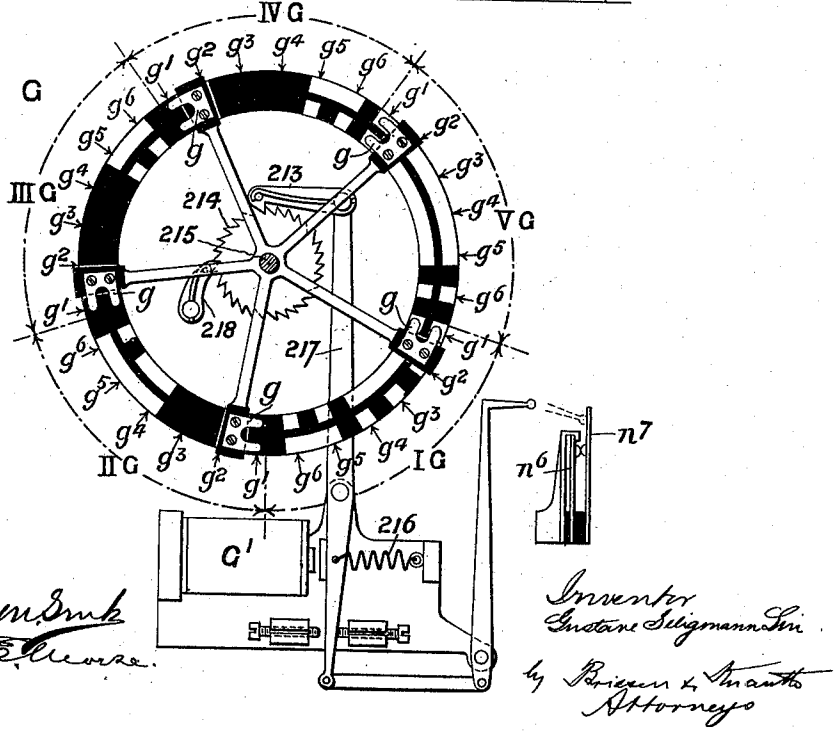


FIG. 16.



Witnesses
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G. SELIGMANN-LUI.

SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

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FIG. 19.

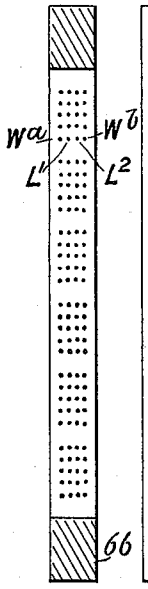


FIG. 18.

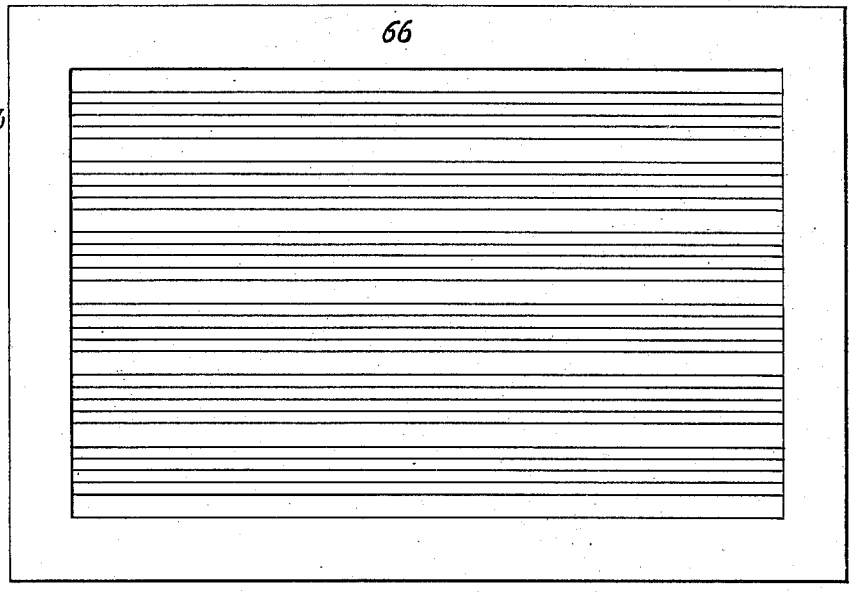
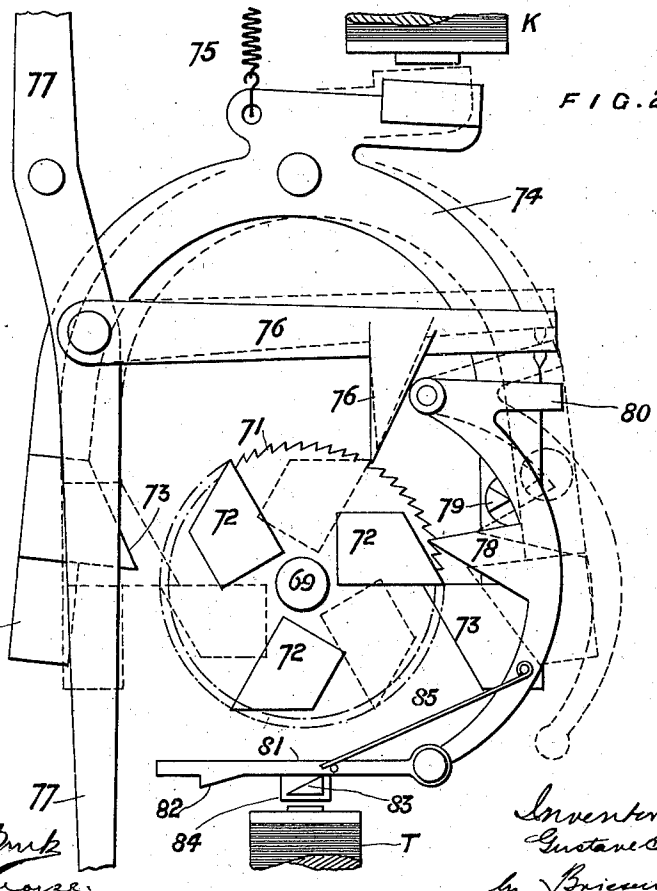


FIG. 22.



Witnesses
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SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

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FIG. 21.

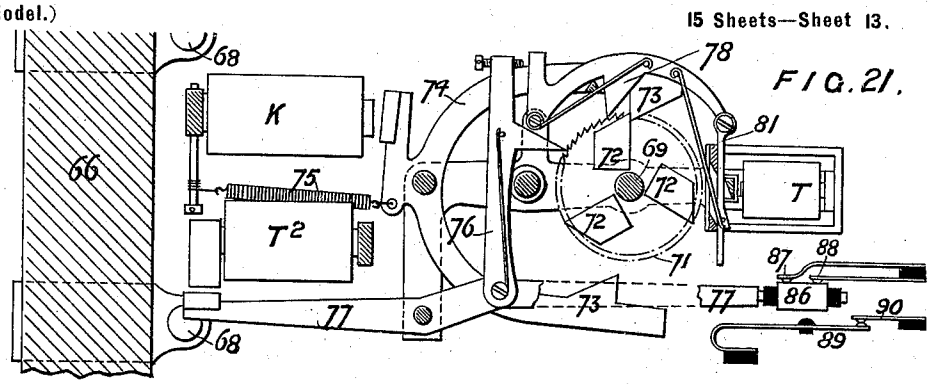


FIG. 20.

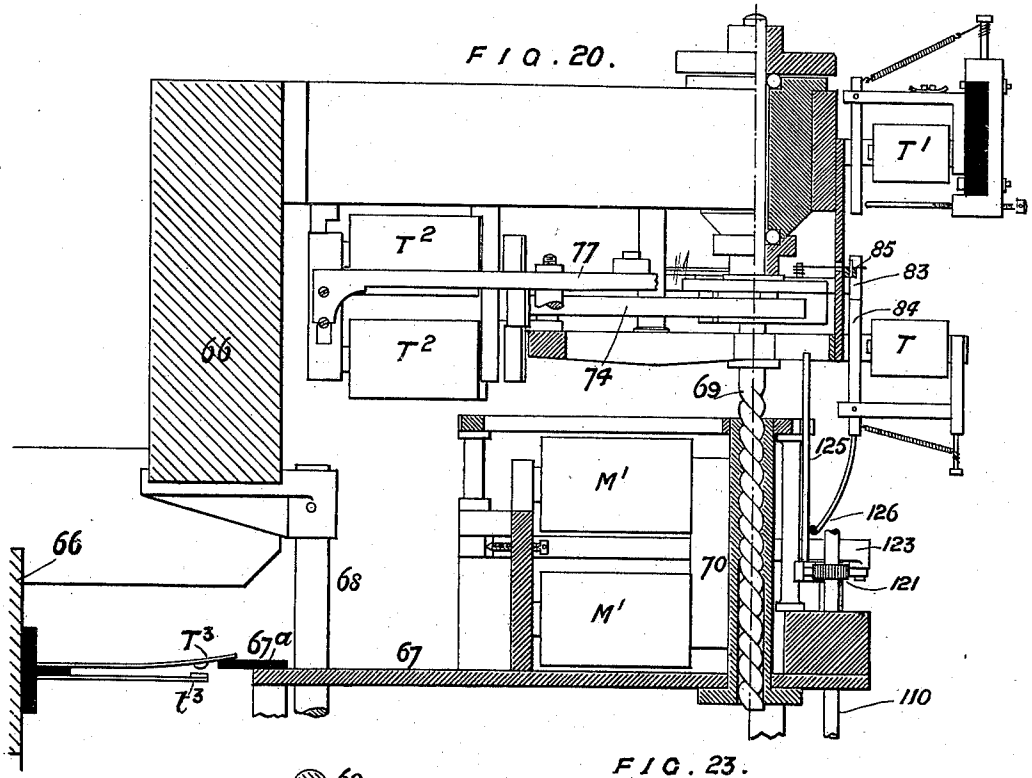
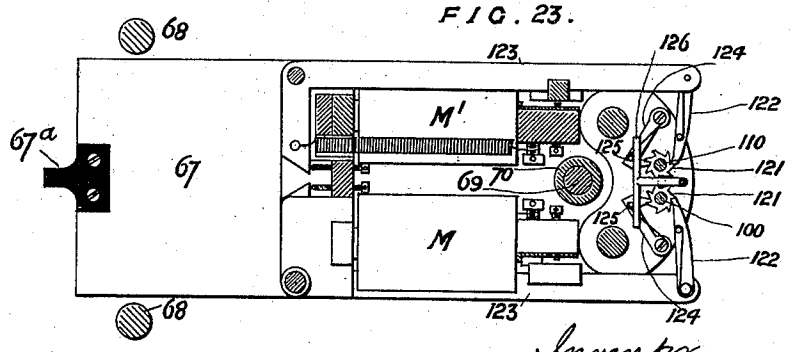


FIG. 23.



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SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 14.

FIG. 24.

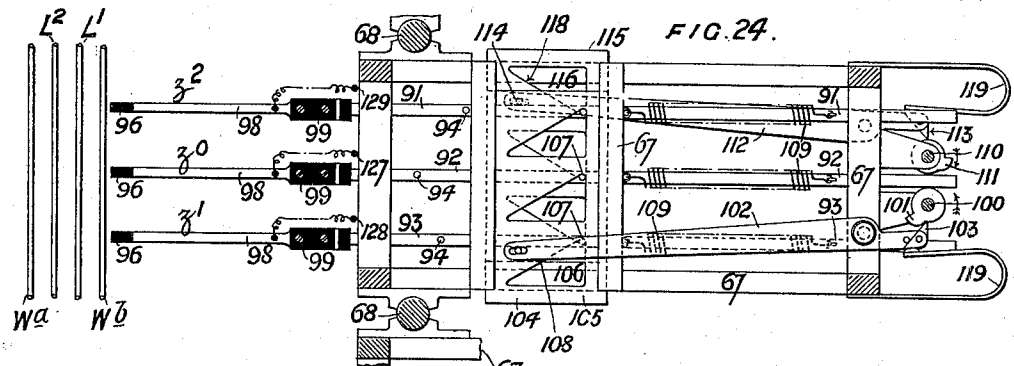


FIG. 25.

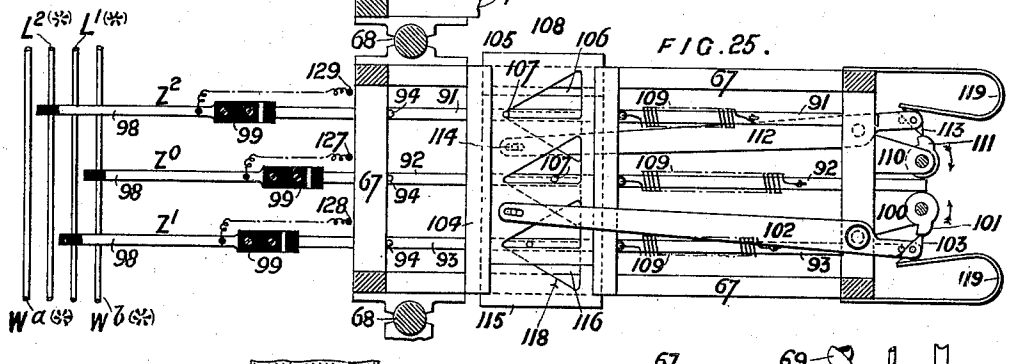
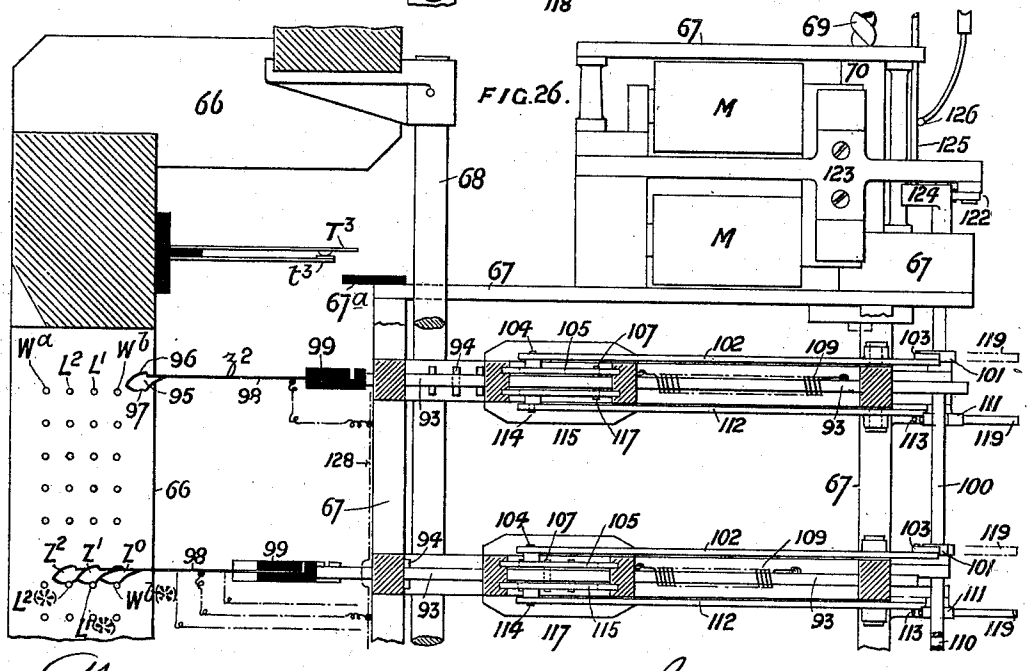


FIG. 26.



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No. 639,186. Patented Dec. 12, 1899.

G. SELIGMANN-LUI.

SYSTEM OF AUTOMATIC TELEPHONE EXCHANGES.

(Application filed May 27, 1898.)

(No Model.) 15 Sheets—Sheet 15.

FIG. 27.

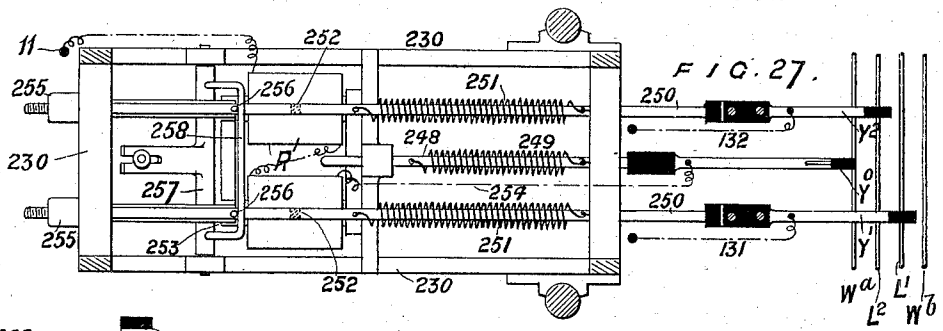


FIG. 29.

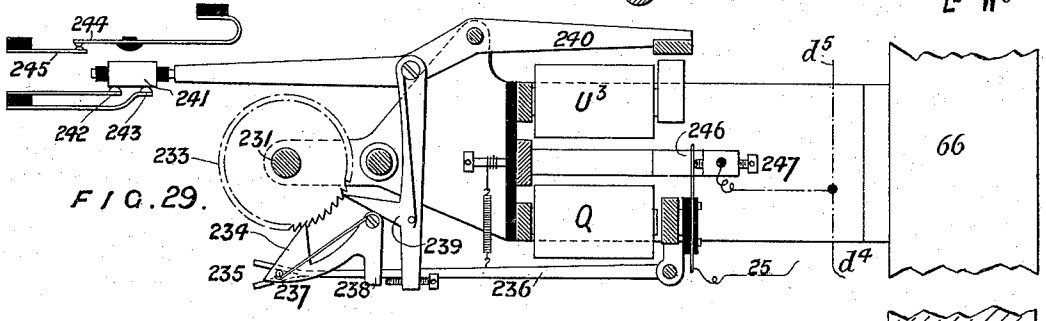
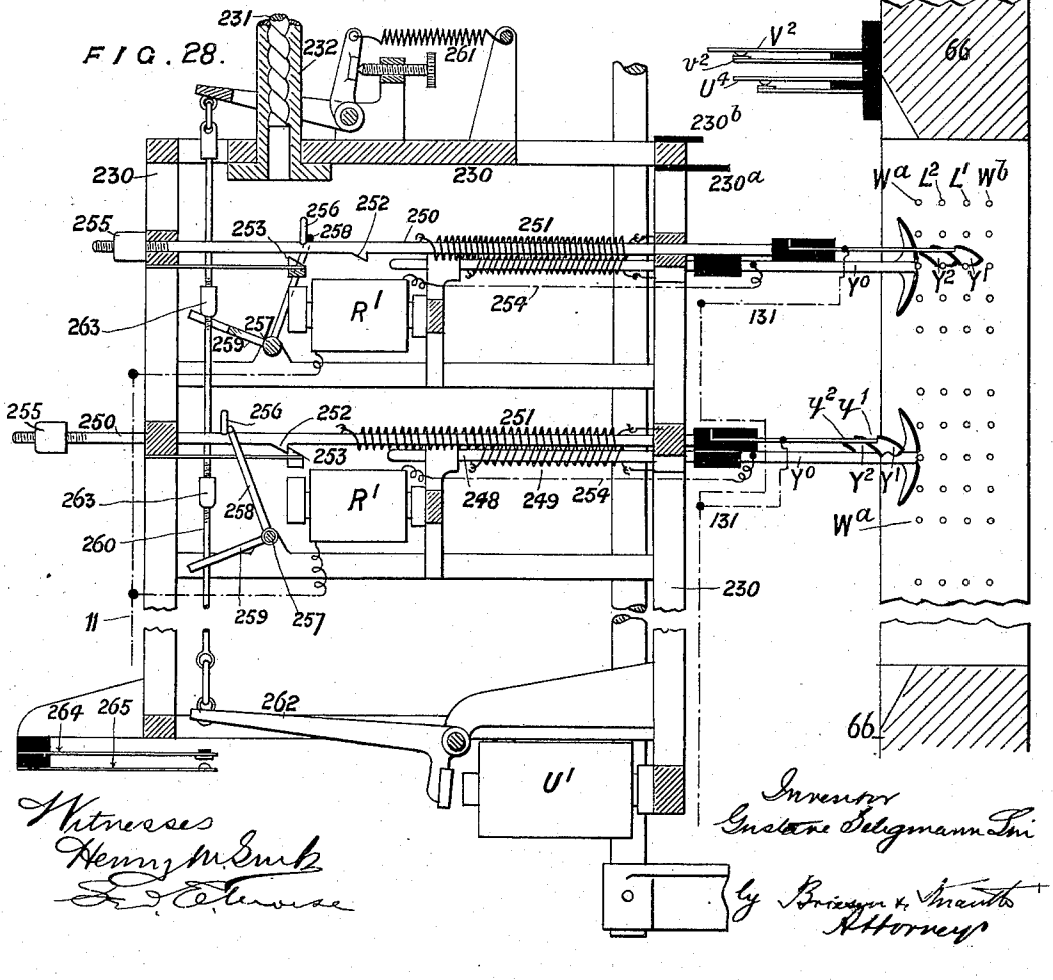


FIG. 28.



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UNITED STATES PATENT OFFICE.

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SYSTEM OF AUTOMATIC TELEPHONE-EXCHANGES.

SPECIFICATION forming part of Letters Patent No. 639,186, dated December 12, 1899.

Application filed May 27, 1898. Serial No. 681,916. (No model.)

To all whom it may concern:

Be it known that I, GUSTAVE SELIGMANN-LUI, gentleman, a resident of 78 Rue Mozart, Paris, France, have invented new and useful Improvements in Systems of Automatic Telephone-Exchanges, (for which an application for patent has been filed in Great Britain, dated October 29, 1897, No. 25,151,) of which the following is a full, clear, and exact description.

This invention has for its object to enable telephonic communication to be automatically established between the lines of a telephonic system.

The subscribers' lines are divided into groups and are presented at the exchange on coupling-boards, so as to be accessible by electrically-operated coupling devices, there being combined with each group of lines as many such coupling devices as there are groups of lines, the arrangement and operation of these coupling devices being such that any line of any group may by means thereof be put in telephonic connection with any other line of the same or of any other group. For the purpose of enabling that coupling device to be selected which is in relation with the two groups comprising the lines between which it is desired to establish telephonic connection there is provided for each group of lines a set of operative mechanism, (for the service of all the lines of that group,) and each line is provided with means of making connection with said mechanism. As soon as telephonic connection has been established between any two lines the said mechanism again becomes available for use, while the connection established remains undisturbed, so that several independent telephonic connections may be successively established and concurrently maintained.

In the drawings, Figure 1, Sheet 1, is a diagram illustrating in an elementary form the distribution of the coupling devices relatively to the coupling-boards at the central station, two of the lines being represented in telephonic connection. Figs. 2^a and 2^b, Sheets 2 and 3 combined, form a diagram of the electrical connections of one of the sets of mechanism at the exchange and of a coupling device. Figs. 3^a, 3^b, and 3^c, Sheets 4, 5, and 6, together illustrate successive changes of electrical connection incidental to the operation of said mechanisms. Fig. 4, Sheet 7, is a diagrammatic perspective view of part of the coupling-boards appertaining to two groups of lines and of certain of their coupling devices, the connections of several sets of line and service fingers being indicated, but the electromagnetic mechanisms being omitted and telephonic connection being shown as having been established between certain of the lines. Fig. 5, Sheet 8, is a face view of a signal composing and transmitting apparatus, the front of the casing being removed. Fig. 6, Sheet 8, is a horizontal section on line 6 6, Fig. 5, the racks being raised to their full extent. Fig. 7, Sheet 8, is a vertical section on line 7 7, Fig. 5. Fig. 8, Sheet 9, is a diagram of the electrical connections of the said apparatus. Figs. 9, 10, and 11, Sheet 10, are respectively an elevation, a vertical section, and a top plan of an electromagnetic commutator forming part of a connector. Fig. 12, Sheet 10, is a plan view of the main selector, certain of the electromagnets being omitted. Fig. 13, Sheet 10, is an elevation of this selector, certain only of the electromagnets being shown. Fig. 14, Sheet 11, is a plan of the main distributer. Fig. 15, Sheet 11, is a plan of the distributer for returning the main distributer to rest. Fig. 16, Sheet 11, is a plan of the distributer through which is actuated the coupler selected by the main selector. Fig. 17, Sheet 11, is an elevation of part of the same distributer. Figs. 18 and 19, Sheet 12, show a face view and cross-section of a coupling-board. Fig. 20, Sheet 13, shows in part-sectional elevation the traversing-screw mechanism of a coupler. Fig. 21, Sheet 13, is a plan of the escapement mechanism controlling the traversing screw. Fig. 22, Sheet 12, is a similar view on a larger scale. Fig. 23, Sheet 13, is a part-sectional plan of mechanism which controls a selector of contact-fingers, which mechanism is also shown in sectional elevation in Fig. 20. Figs. 24 and 25, Sheet 14, are plan views of two of the sets of contact-fingers, appertaining to a coupler for making connections with a line to be "called," one of the sets of fingers being shown in the operative position. The figures also show the corresponding portions of

the selector of contact-fingers. Fig. 26, Sheet 14, is a corresponding elevation, partly in section, of the same two sets of contact-fingers. Fig. 27, Sheet 15, is a plan of the mechanism of one of the sets of contact-fingers appertaining to a coupler for making connection with a line "calling." Fig. 28, Sheet 15, is a side elevation, part sectional, of certain portions of the same coupler, showing two sets of contact-fingers, the one set being in the operative position. Fig. 29, Sheet 15, is a plan view of the traversing-screw-releasing mechanism and of the mechanism for returning the said coupler to position of rest.

Similar numerals and letters of reference denote like parts in all the figures.

I will first define certain terms of nomenclature.

By "distinct" signals or currents are meant signals or current emissions presenting (relatively to each other) such differences that each will influence differently the same group of receptive apparatus and by "distinct combinations" are meant combinations of signals differing from each other in the nature, order, or number of the constituent signals.

I designate "electromagnetic commutator" any arrangement in which a single electromagnet controls the simultaneous making or breaking of several electrical connections.

I designate "connector" a combination of an electromagnet and of electromagnetic commutators, whereby the calling-subscriber's line to which such connector appertains may be connected to "selecting and manipulating" mechanism allocated to the service of the group of lines to which that subscriber's line belongs.

I designate particularly as "distributer" the known type of commutator in which connection is established between contacts arranged in two concentric circles by a brush rotated step by step. The circles may be divided into a number of equal sectors, in which pairs of contacts to be simultaneously connected occupy corresponding positions, there being as many equidistant brushes (carried by insulating-arms) as there are sectors, so that the sectors into which a distributer is divided represent so many contemporaneous cycles of operation, at the completion of which each brush passes on to position of repose at the beginning of the next sector, each brush thus taking the place of the preceding one for the next cycle, so that no retrograde motion is necessary.

By the name of "selector" I designate any combination of electrical and mechanical devices whereby (in response to a predetermined combination of signals) the continuity of a predetermined electric circuit is established, each selector controlling a certain number of electric circuits, whereof the continuity of any one is completed (to the exclusion of all the other circuits) only in response to the emission of the corresponding distinct combination of signals. Such selector (which may be variously constructed) is based on the principle that the establishment of the continuity of each of the circuits under its control depends on the suppression of a certain number of electrical or mechanical "obstacles," each of the said obstacles being under the control of a different part or "member" of the selector, each member of the selector operating to suppress the obstacles in certain circuits and leave them in others, according to the distinct signals by which it is influenced, the complete suppression of the obstacles in a given circuit being dependent on the conjoint action of the several members of the selector, which respond each in turn to the action of the signals respectively addressed to them, the presentation of these members to the action of the signals being effected by connecting these members successively to the "calling line" through the medium of a distributer.

By "coupling device" is meant a pair of electrically-conjoined apparatus termed "couplers," the two couplers of a pair being respectively designated the "called-line coupler" and the "calling-line coupler," the former being adapted to make connection with the line of a subscriber to be called and the latter to make connection with the line of the subscriber calling and so to complete the direct telephonic connection between those two lines.

For the purposes of this system there is provided at each subscriber's station a "signal composing" and transmitting device for determining the nature, order, and number of signals sent in making a "call."

The apparatus at the central station is as follows, viz:

(*a*) A connector (at the extremity of each line) whose function is to establish (between the line to which it appertains and the selecting and manipulating mechanism common to the group to which the line belongs) a temporary electrical connection, which is broken automatically when the manipulation is completed.

(*b*) A single set of selecting and manipulating mechanism (for the common service of the lines of a group) by which the coupling devices are actuated. This mechanism comprises a main distributer, a main selector, a manipulator, and "return-to-rest" devices, the functions of these elements being as follows: By the main distributer the various members of the selector and the manipulator are successively connected to the line calling. By the main selector the subscriber calling is enabled to select a particular coupling device. By the manipulator the signals sent by the subscriber calling are translated into local currents, which are transmitted to the coupling device selected. By the return-to-rest devices the connector of the line which has made or attempted to make a call and likewise the main distributer and the main selector used for that purpose are automatically

returned to their initial position when done with.

(*c*) A pair of "coupling-boards," the one being used when a line upon it is to be called and the other being used when a line upon it is calling. Upon each coupling-board appear (in the form of contact wires or pieces) the two wires of each subscriber's line of the group to which the board belongs, and also a local "service-wire" for each line, the service-wires appertaining to the same line on the two boards of a pair being quite distinct. In each board the service-wire and the "line-wires" appertaining to a subscriber's line are arranged in a horizontal row and in regular order from front to back of the board, while the rows of wires appertaining to different subscribers of the group are superposed, there being, for instance, five rows (superposed at regular intervals) appertaining to five different subscribers and then a vacant space, then five more rows appertaining to five other subscribers, and so on. In practice the two coupling-boards of a pair would be combined in one, and it is to be understood that wherever I refer to "coupling-boards" I mean to also include the idea of using a single board comprising two members, and vice versa.

(*d*) Coupling devices for the use of each group of subscribers' lines, there being duplicate, triplicate, or more sets of such coupling devices for each of the circuits controlled by the main selector. Each coupling device is composed of two members termed "couplers," of which the corresponding parts are in electrical connection with each other, one of said members, termed the "called-line" coupler, being used for making contact with the line to be called, the other member, termed the "calling-line" coupler, serving for making contact with the line calling. All the calling-line couplers appertaining to the lines of the same group are side by side in front of the calling-line coupling-board of this group, whereas the called-line couplers appertaining to these same coupling devices are distributed, one in front of each of the called-line coupling-boards of different groups of lines. Consequently when a subscriber desires to make a call there will always be available a coupling device (among those controlled by the main selector and the manipulator of his group) whereof the called-line coupler is in front of the called line coupling-board on which the line to be called appears, while the associated calling-line coupler is situated in front of the calling-line coupling-board on which appears the line of the subscriber calling, only the called-line coupling-board of the line called and the calling-line coupling-board of the line calling being used. The called line and calling-line coupling-boards are in practice combined in one, the line-wires being common to both and the two service-wires being distinct, the called-line couplers being placed at one face of the board and the calling-line couplers at the other face. Telephonic connection will be established when the called-line coupler has made contact with the line of the subscriber called and the calling-line coupler has also made contact with the line of the subscriber calling. This position of "conversation" is illustrated in Fig. 1 in respect of the line L'^{*} L^{2*} of a calling subscriber in group I and the line L'^{*} L^{2*} of the called subscriber in group V. To accelerate the making of connection with the line to be called, the called-line coupler has several sets of contact-fingers, of which one set only is used, the other sets being rendered (or left) inactive by means of a "selector of contact-fingers," the coupler being so moved as to bring the set of contact-fingers to be used opposite the line to be called and that set being "selected" by mechanisms actuated in succession through the medium of a distributer.

(*e*) Return-to-rest devices, which enable the coupling device which has been used to be returned to its initial position when done with.

Before giving a detailed description of the circuits and mechanisms it is necessary to choose a particular type of telephonic line-wire system and apparatus, because the number of distinct signals available for use differs according as the lines of the system have an earth-return or complete metallic circuit and according as it is or is not permissible to locate at each subscriber's station batteries capable of furnishing the operative currents or signals. Consequently upon the number of "distinct signals" available depends the arrangement of the signal-composing device and likewise the arrangement of the selectors by which the diversity of these distinct signals is utilized. I will therefore take as example a two-wire system and suppose that the batteries furnishing the operative currents or signals and even the battery which serves for conversation are (for each group of subscribers) concentrated at the central station to which the lines of the group converge; but the modifications involved if another example be chosen do not materially affect the system.

In a central-battery system the manipulation of high resistances at the station of the subscriber calling enables three sorts of distinct signals to be obtained—viz., current through the one wire earthed without resistance at the subscriber's station, current through the other wire earthed without resistance at the subscriber's station, and current through both wires connected in series without any resistance being interposed between them and without being earthed at the subscriber's station. It is only necessary that the battery be put to earth by its middle at the central station. I will first suppose that a main selector having two members will suffice, and I will afterward show how a greater number of subscribers' lines could be provided for.

In order to prevent erroneous combinations

of signals, a signal composing and transmitting device such as shown in Figs. 5 to 8 is used. It consists of fixed and adjustable contacts and a double brush 164 165, movable in guides 163. Six vertically-sliding racks 141 142 143 144 145 146 when raised engage with pins 151 on a horizontal slide-bar 150. Five of the racks carry tablets 141^a 142^a 143^a 145^a 146^a, each of which bears contact-pieces, hereinafter described, and a column of numbers, the adjustment of each rack determining which of its contact-pieces are brought into the path of the contact-brush 164. The rack 144 carries two spring-fingers 152 and 153, which, according to the adjustment of this rack, make contact, respectively, with fixed contact-pieces 154 155 or with fixed contact-pieces 155 156. It also carries a shutter 157, having two apertures arranged diagonally and situated in front of the double column of figures on the tablet 143^a. The front of the casing carries a conductive strip 158, fixed in the path of the brush 165, this strip 158 being interrupted by a gap 158^a opposite to the contact-pieces 187 188 189 190 and 191 192 193 194, carried by the racks 145 and 146. The front of the casing has a slot 159 for the handle 160 of the double contact-brush, a slot for the handle 162 of the sliding bar 150, and five windows 141^b 142^b 143^b 145^b 146^b opposite the columns of figures carried by the correspondingly-numbered tablets. According as rack 144 is adjusted the one or other aperture of its shutter 157 coincides with the one or other half of the window 143^b, so that the column of figures opposite the other half is masked. The double brush 164 165 is normally held toward the right—for instance, as shown by a weight connected to it by a cord—so that the block which carries the brush presses the spring 166 against the spring 167. When at the other end of its course this block presses the spring 168 against the spring 169 and is retained by a detent 170, as shown dotted in Fig. 5. On the bar 150 is a block 171, having a handle 162 and free to be slid upon the bar 150 to an extent limited by a stop 174, so that when the handle is moved to the right the block alone will be moved at first, and by means of a stud 171^a it will cause a spring-contact 172 to bear against a contact 173. When the block meets the stop 174, the sliding bar 150 is moved also, whereby the pins 151 are disengaged from the racks and a pin 170^a on the bar 150 acts on the detent 170, so as to release the contact-brush 164 165 and allow it to be returned by the weight to normal position. To allow of the rack-teeth slipping past the pins 151 when the racks are raised, the pins are spring-pressed into engagement with the rack-teeth by leaf-springs carried on bar 150.

The contacts carried by tablet 141^a comprise a plain conductive strip 180 and also a comb-like plate 184, having four contact-limbs of lengths so graduated that one or more of said limbs will be presented in the path of brush 164, according to the adjustment of the rack 141. The tablet 142^a carries plain strips 181 182 and between them a comb-like plate 185, having three contact-limbs of lengths so graduated that one or more of said limbs will be presented in the path of the brush 164, according to the adjustment of rack 142. The tablet 143^a carries a graduated comb-like plate 186, having five limbs, whereof the number presented in the path of the brush 164 depends on the adjustment of rack 143. It also carries a plain strip 183. The plain strips 180 181 182 183 are at least of such length as to be respectively presented in the path of the brush 164 along with any one or more limbs of the comb-like contact-plate carried by the same tablet. The tablet 145^a carries a vertical row of contacts 187 188 189 190, separated by narrow spaces whose width is less than the width of the brush 164 and whose relation to the teeth of the rack 145 is such that when the rack is adjusted two of the contacts will always be presented together in the path of the brush 164, which thus establishes on its passage connection between the two contacts so presented. The tablet 146^a carries a similar row of contacts 191 192 193 194 and also a plain contact-strip 195.

The two wires L' L^2 of the subscriber's line are connected, L' to the contact-plate 155 and L^2 to each of the two contact-plates 154 156. Strips 181 182 183 are connected to the spring-finger 153, and the comb-like pieces 184 185 186 are connected to the other spring-finger 152, so that the relative connections of the line-wires L' and L^2 with the sets of contacts 181 182 183 and 184 185 186 will depend on the adjustment of rack 144. On the other hand, the connections of the small contacts 187, 188, 189, and 190 and those of the similar contacts 191 192 193 194 and that of the contact 195 are not capable of reversal and are as follows: 188 192 195 are connected to the line-wire L', 189 193 to the line-wire L^2, and 187 190 191 194 and the two parts of the contact-strip 158 (shown at top of Fig. 8) are connected to earth. Normally the wire L' is earthed through 166 167, through the telephone-bell 199, the high resistance 196, and an indicator 197; but as soon as the brush 164 165 is moved by handle 160 contact is broken at 166 167 and the wire L' is isolated. When the brush-block presses the spring 168 against 169 and when the telephone-receiver is taken off the hook, the line-wire L^2 is put to earth through the conversation apparatus 198, the high resistance 196, and the indicator 197. Lastly, of the two springs 172 173 (shown at the top of Fig. 8) the latter is permanently to earth and the former is connected to the contacts 181 182 183, in whose reversals of connection it participates.

The operation of the signal composing and transmitting device is as follows: Normally the line-wire L^2 is isolated, and the line-wire L' is to earth through a resistance of from one thousand to two thousand ohms. As soon

as the subscriber after having adjusted the racks begins to move the brush 164 165 the wire L′ is also isolated. Then the following effects are produced in succession:

First. A signal of invariable kind is sent over a grounded circuit, the wire L′ being put to earth when the double brush 164 165 passes over the contacts 195 and 158, the line being again isolated when the brush 164 quits the contact 195.

Second. A signal is sent which is variable in kind, according to the adjustment of the rack 146, the effect (according as the brush 164 passes over the two contacts 191 192 or over the two contacts 192 193 or over the two contacts 193 194) being respectively to put wire L′ to earth without resistance or to connect wires L′ L^2 in series without resistance and without earth, or to put line L^2 to earth without resistance, the effect being followed in either case by isolation.

Third. A signal is sent which is variable, according to the adjustment of rack 145, (the possible nature and effect of the signals being the same as described in the previous paragraph,) followed by isolation.

Fourth. According to the adjustment of rack 144 the strips 181 182 183 are either connected to the line-wire L′ and the graduated comb-shaped contacts 184 185 186 are connected to the line-wire L^2, or, inversely, the signals being as next described under *a* or *b*, as the case may be. (*a*) The wire L′ is earthed once, and the wire L^2 is earthed a variable number of times, according to the adjustment of rack 143. Wire L′ is earthed a second time, and the wire L^2 is earthed a variable number of times, according to the adjustment of rack 142. The wire L′ is earthed a third time, and the wire L^2 is earthed a variable number of times, according to the adjustment of rack 141, the brush being finally engaged by detent 170; (*b*) or inversely, as regards the respective effects produced on the lines L′ L^2. I will suppose that wire L′ was connected with the strips 181 182 183 and wire L^2 with the graduated comb-shaped contacts 184 185 186. When the double brush 164 165 reaches the end of its course, all the signals necessary for actuating the connector, the main selector, and the manipulator will have been sent, and the calling subscriber has only to listen at his receiver in order to ascertain (by the absence or presence of a buzzing or musical sound) whether the line of the subscriber to be called is disengaged or not. Whatever may be the result of this test, the calling subscriber then moves the handle 162 toward the right, thereby first pressing spring 172 against 173, and so sending a final signal similar to those sent by the passage of the brush over plates 181 182 183—*i. e.*, by hypothesis, putting line-wire L′ to earth—the further movement causing the bar 150 to release the double brush and the racks. The racks then fall, and the brush is returned to its initial position by the weight. To prevent too rapid or irregular motion of the brush and consequent malformation of the signals, the speed of its forward motion may be controlled by any suitable retarding means. The telephone transmitter, receiver, and bell are as usual, except that the spring 200, actuated by the hook-switch 201, whereby the transmitter-battery is ordinarily thrown in or cut out, now connects or isolates the line-wire L^2.

Since for each adjustment of a rack a certain figure is exhibited at the corresponding window, then if the distinctive number of each subscriber corresponds with the group of figures exhibited when the racks are adjusted for calling that subscriber it will follow that it is only necessary in order to call a certain subscriber to so adjust the racks as to exhibit his distinctive number and then to move the double brush from end to end of its course. The telephone-receiver will then indicate by silence or by the noise heard whether the line wanted is disengaged or not, and the final signal completes the manipulation for establishing communication or returns all the parts to rest, as the case may be.

Before describing the mechanism and circuits at the central station it will be convenient to refer to Fig. 1, which illustrates in an elementary form the distribution of the coupling devices with regard to the coupling-boards at the central station, the subscribers' lines being supposed to be divided into six groups I II III IV V VI, each group comprising any number of lines, but only a few being indicated.

I^a II^a III^a IV^a V^a VI^a are the calling-line coupling-boards, and I^b II^b III^b IV^b V^b VI^b are the called-line coupling-boards, pertaining to the several groups, the wires of each line of a group appearing on both boards and a distinct service-wire being provided for each line on each board.

1^a 2^a 3^a 4^a 5^a 6^a represent diametrically by lozenges the calling-line couplers, and 1^b 2^b 3^b 4^b 5^b 6^b represent by rectangles the called-line couplers, each such coupler being supposed for the sake of simplicity to have only one set of fingers for making contact with the line and service wires on the coupling-boards, the line-fingers alone being indicated, together with the corresponding speaking-circuits. The line-fingers of each calling-line coupler are electrically connected each to the corresponding finger of the associated called-line coupler, the couplers being associated as follows: by coupling the fingers of 1^a, group I, to the fingers of 1^b, group I; the fingers of 2^a group I, to the fingers of 1^b, group II; the fingers of 3^a, group I, to the fingers of 1^b, group III, and so on; the fingers of 1^a, group II, to the fingers of 2^b, group I; the fingers of 2^a, group II, to the fingers of 2^b, group II; the fingers of 3^a, group II, to the fingers of 2^b, group III, and so on.

L′ L^2 are the subscribers' lines, those which are in telephonic connection being distin-

guished by an asterisk. It will be seen that a calling line in group I has been connected for telephonic conversation with a called line line in group V by the called-line coupler 1^b at coupling-board V^b having first been brought opposite to and having made contact with the line $L'^* L^{2*}$ and by the associated calling-line coupler 5^a at coupling-board I^a having been then brought opposite to and having made contact with the calling line

The diagram does not illustrate the service-fingers nor the service and main selector circuits; but it is to be understood that each set of fingers comprises a third finger for making contact with service-wires, and that the service-fingers of associated couplers are electrically connected through the circuits and mechanisms hereinafter described. This will be apparent from Fig. 4, which represents in perspective and in an elementary form the coupling-boards of two groups of lines and certain of the coupling devices located thereat, each of the two couplers which together constitute a coupling device being shown as having more than one set of contact-fingers, and the connection between fingers of like function in the one and the other of associated couplers (to the exclusion of the electromagnetic mechanism) being also shown. Telephonic connection between certain of the lines presented on the coupling-boards is shown as having been established by one of the sets of contact-fingers in each of certain of the associated couplers being represented in position of contact with the appropriate line and service wires on the board—viz., between one line in group II and another line in the same group by one of the sets of fingers of each of the associated couplers 2^a and 2^b of that group, and between another line in group II and a line in group I by one of the sets of fingers of each of the associated couplers 2^a of group I and 1^b of group II, the lines so connected being distinguished by shading in said Fig. 4 and the fingers referred to being shown as projected into contact therewith. In order to explain how this telephonic connection is established, I will refer to Figs. 2^a and 2^b, Sheets 2 and 3 combined, which represent the mechanism for the service of the group to which the calling-line belongs and the connections with the calling-line coupler and the called-line coupler and the corresponding service and selector circuits. It is to be noted that of the two contacts between which moves an armature or a contact spring the resting contact is always shown above and the working contact below, except that in the commutator A' these relative positions are reversed.

The connector consists of an ordinary electromagnet A, an electromagnetic commutator A', having contact-springs a' a^2 a^3 a^4 a^5 a^7 a^8, (see also Figs. 9, 10, and 11,) and an electromagnetic commutator A^2, having one contact-spring a^{11}.

The main distributer B (shown separately in Fig. 14) comprises three equal sectors I B II B III B, and three equidistant insulated brushes b, concurrently rotated step by step over the sectors by the action of an electromagnet B' and mechanism hereinafter described. Each brush b is moved over a sector in four equal steps, (indicated by the pointers b' b^2 b^3 b^4,) and each sector presents in the path of the brush successive pairs of insulated contacts arranged in concentric circles, the two contacts of a pair being on the same radius. In some cases successive contacts in the same circle are joined in one; but whether this be the case or not the contacts in each sector will be referred to, respectively, as the "pairs" at b' b^2 b^3 b^4, as the case may be. The brush-spindle 204 has a ratchet-wheel 203, with which engages a pawl 202, moved in the one direction by a spring 205 and in the other by the armature-lever 206 of electromagnet B', so that each of the three brushes b is advanced one step each time coil B' ceases to be excited. 207 is a detent engaging with wheel 203.

C are relays which receive the signals from the line calling and by which these signals are translated into local currents and transmitted first to the one and then to the other of the two groups C' C^2, (each comprising three electromagnets,) appertaining to the two members of the main selector D, hereinafter described.

The manipulator is formed by a double relay E.

F is a distributer for returning to initial position the connector of a line which has made a call. This distributer comprises two equal sectors I F II F, Fig. 15, and two brushes f f, each traversing a sector in eight steps, (indicated by the pointers f' f^2 f^3 f^4 f^5 f^6 f^7 f^8,) certain of which denote the positions of pairs of contacts arranged in concentric circles. In the sector I F there is a pair of contacts at the positions f' f^7 f^8. In the other sector II F there are pairs of contacts, at the positions f' and f^8 only. The actuating mechanism comprises two oppositely-acting pawls 208 209, engaging with a ratchet-wheel 210 on the brush-spindle 211 and connected by a rod 212 to the armature of electromagnet F^3, so that the brushes f of the distributer will be advanced one step when the armature is attracted and another step when the armature is returned to position of repose by the action of a spring.

F^0 is an ordinary electromagnet.

F' is an electromagnetic commutator having two contact-springs f^9 and f^{10}. F^2 is another electromagnetic commutator having one contact-spring f^{11} and of which the coil is also the return-to-rest coil for the main selector D, the apparatus F F^0 F' F^2 serving to return to rest not only the connector appertaining to the calling line, but also the main distributer B and the main selector D appertaining to the group to which that line belongs.

Another similar set of mechanism, whereof

only the distributer F^4 and its coil F^5 are shown, fulfils the same functions, the one or the other of these two sets being brought into action according as the first signal transmitted by the manipulator E is a positive or a negative current.

It being understood that only one of the circuits controlled by the main selector D is represented in the diagram, H is the polarized double receiver located at the extremity of this circuit, whereby the signals sent by the manipulator E are translated into local currents actuating the one or the other of two or more twin (called-line) couplers corresponding to this circuit.

The distributer G, Figs. 2^b and 16, whereby the operative currents are successively directed to the various organisms which constitute the one or the other of the said twin couplers, has a coil G', with double winding, and is divided into five equal sectors I G, II G, III G, IV G, and V G and five insulated brushes g, all fixed on the same spindle and each traversing a sector in six steps, indicated by the pointers g' g^2 g^3 g^4 g^5 g^6. As in the distributers previously described, there are pairs of insulated contacts arranged in concentric circles, certain of the contacts being in one with the succeeding contact or contacts of the same circle. In sectors I G and V G there are pairs of contacts at all six positions of the brush. In the sector II G there are pairs of contacts only at the positions g^4 g^5 g^6, and in the sectors III G and IV G at g^5 and g^6 only. The spindle 215 of the brushes g carries a ratchet-wheel 214, engaged by a pawl 213, moved in the one direction by a spring 216 and in the other by the armature-lever 217 of electromagnet G', so that the distributer-brushes g are advanced one step each time that the coil G' is excited, 218 being a detent. 219 is a disk of insulating material fixed on the brush-spindle 215. (See Fig. 17.) It may be supposed to be divided into five sectors, each sector corresponding to a brush g and forming a cam whereby in the first four positions of the distributer-brushes the two contact-springs g^7 g^8, Fig. 17, are kept separated from one another, and in the sixth position of the brushes electric connection is established between the contact-springs g^9 g^{10}. These effects may be produced, for example, by forming the one face with projections 220, (each corresponding in position and angular extent with the first four steps of a brush,) acting on the spring g^7, each projection being followed by a recess 221, corresponding to positions g^5 and g^6 of the brushes, the other face of the disk having recesses each corresponding to the first five positions of a brush, followed by projections 222, corresponding to the sixth position g^6 and acting to press spring g^9 against spring g^{10}. To control the movements of the other (or twin) called-line coupler, which corresponds to the same circuit of the main selector D, there is a second similar distributer G^2, of which only the coil G^3 and the contact-pieces of the first sector I G^2 are shown in Fig. 2^b.

g^{11} and g^{12} are two ordinary electromagnets associated with the coils G' and G^3.

n^6 n^7 are two contact-springs which are separated by the armature of G' when it reaches the end of its stroke in working position.

I I', Fig. 2^a, are two induction-coils.

M M, Fig. 2^b, are the electromagnets which actuate the two members of the contact-fingers selector, (shown in Figs. 20, 23, and 26,) which leaves (or renders) inactive the various sets of contact-fingers of the called-line coupler, except the one set which is to connect with the line to be called. K, Figs. 2^b and 21, is the electromagnet which controls the mechanism whereby this set of contact-fingers is brought into operative position.

L' L^2, Fig. 2^a, are the two wires of the calling line, and L' L^2, Fig. 2^b, are the two wires of the called line, the conditions of "calling" and "called" being, however, hypothetical.

N' N^2 are two electromagnetic commutators each having a single contact-spring n' n^3, respectively, by means whereof the test is made whether the line to be called is disengaged or not and by which the subsequent operations are initiated.

N^0 is an ordinary electromagnet.

O is a polarized electromagnet in indifferent equilibrium, having two windings in its coil.

P is an electromagnetic commutator having two contact-springs p' p^2 and a double winding.

The combination of mechanisms H, G, g^{11}, K, M, M', N', N^2, O, and P constitute the instrumentalities necessary for connecting the called-line coupler of a coupling device with the line to be called.

Q, Figs. 2^a and 29, is the electromagnet controlling the traversing mechanism of the calling-line coupler which is electrically connected to the called-line coupler under consideration, and Q' is the electromagnet controlling the traversing mechanism of that calling-line coupler which is connected electrically to the other (or twin) called-line coupler, these two calling-line couplers being distinguished as "quasi-twins," because they are respectively connected to called-line couplers which have been defined as "twins."

R, Fig. 2^a, is an electromagnetic commutator having an armature r and a single contact-spring r'.

R', Figs. 2^a, 27, and 28, is a small electromagnet which controls the mechanism whereby the set of contact-fingers of the calling-line coupler which is to connect with the line calling is brought into operative position.

The apparatus Q, R, and R' comprise the parts necessary for connecting the calling-line coupler of a coupling device with the calling-

line and so completing the telephonic connection between the lines of the called and calling subscribers.

S, Fig. 2^d, is an electromagnetic commutator having one contact-spring *s* and two distinct windings in its coil.

S^0 S' S^2 are ordinary electromagnets, the two latter being of very low resistance and low self-induction.

T, Figs. 2^b, 20, and 21, is the electromagnet which actuates the mechanism whereby the contact-fingers of the called-line coupler are returned to rest.

T' is an ordinary electromagnet having two windings.

T^2 is the electromagnet which actuates the mechanism whereby the whole frame and mechanism of the called-line coupler is returned to its initial position, this magnet determining the breaking of two pairs of contacts 87 88 and 89 90 when its armature is attached, the one break, 87 88, occurring when the armature begins to move and the other, 89 90, when it reaches the end of its stroke.

T^3 is a contact-spring which is kept raised from its contact t^3 by a projection 67^a on the frame of the called-line coupler when the latter is in its normal position of repose.

U, Fig. 2^a, is an electromagnetic commutator having two contact-springs u' u^2.

U^0 is an ordinary electromagnet.

U', Figs. 2^a and 28, is the electromagnet which actuates the mechanism whereby the contact-fingers of the calling-line coupler are returned to their initial position.

U^2 is an ordinary electromagnet with two windings.

U^3, Figs. 2^a and 29, is the electromagnet which actuates the mechanism whereby the calling-line coupler is returned to its normal position.

U^4 is a contact-spring which is held raised off its contact by a projection 230^a on the frame of the calling-line coupler when the latter is in its normal position.

The apparatus S S^0 S' S^2 T T' T^2 T^3 U U^0 U' U^2 U^3 U^4 constitute the parts necessary for returning to rest under all possible circumstances the called-line coupler and the calling-line coupler, which together constitute a coupling device.

V, Fig. 2^b, and V', Fig. 2^a, are two current-generators, the currents being either alternating in direction or merely periodic, but always of high frequency.

v, Fig. 2^b, and *v'*, Fig. 2^a, are condensers, the one, *v*, separating the generator V from the rest of the circuits and the other, *v'*, separating the induction-coils I I' from the local mechanisms at the central station.

V^2 is a contact-spring which is raised from its contact v^2 by a projection 230^b on the frame of the calling-line coupler when the latter is in its normal position. V^4 and v^4 are similar pieces on the quasi-twin calling-line coupler.

The apparatus V V' *v v'* V^2 v^2 I I' constitute the parts necessary for producing and transmitting (in all necessary cases) the buzzing or sonorous signal which denotes that the communication desired cannot be had for the moment.

W^a W^b, Fig. 2^a, are the service-wires for the line L' L^2, (which it will be supposed is about to make a call on the calling and called line coupling-boards of the group to which that line belongs.) Similarly W^a W^b, Fig. 2^b, are the service-wires for the line L' L^2 (which it will be supposed is about to be called) on the calling-line coupling-board and called-line coupling-board of the group to which that line belongs.

Y^0, Figs. 2^a and 28, is the service-finger, and Y' Y^2 are the line-fingers, of that set of contact-fingers of the calling-line coupler which is supposed to be the set to be used. y^0 y' y^2 are similar parts of another set.

Z^0, Figs. 2^b, 25, and 26, is the service-finger, and Z' Z^2 are the line-fingers, of that set of contact-fingers of the called-line coupler which is supposed to be the set to be used, z^0 z' z^2, Fig. 24, being the similar parts of another set.

In order to facilitate the comprehension of the effect of the signals sent by the subscriber calling, I have illustrated in Figs. 3^a, 3^b, and 3^c the principal results produced by the successive signals above referred to, the lines being grouped as before.

I^a II^a III^a IV^a V^a VI^a are the calling-line coupling-boards, and I^b II^b III^b IV^b V^b VI^b are the called-line coupling-boards. Opposite to each calling-line coupling-board are the six calling-line couplers 1^a 2^a 3^a 4^a 5^a 6^a, the contact-fingers of each of which are represented by three lines, the middle one, Y^0, being the service-finger, and Y' Y^2 (see Fig. 28) the line-fingers. Similarly, opposite each called-line coupling-board are six called-line couplers 1^b 2^b 3^b 4^b 5^b 6^b, in each of which Z^0 is the service-finger, and Z' Z^2 the line-fingers, (see Fig. 26,) the fingers of the calling-line couplers being in electrical connection with the corresponding fingers of the associated called-line couplers and the distribution of the couplers relatively to the coupling-boards being supposed to be as illustrated in Fig. 1, but only those connections of a calling-line coupler with a called-line coupler being represented which are specially referred to. The circles below the called-line couplers indicate the corresponding distributers G or G^2, and below these circles are shown diagrammatically the electromagnets G' or G^3, which determine the movements of these distributers, respectively. As regards the connections which undergo change in consequence of the movements of these distributers it is to be understood that a circle traversed by a line indicates that connection is established along that line, and that where a line is interrupted, either inside the circle or just outside, the gap being bounded by two short cross-lines the circuit is there broken, and similarly wherever a like gap occurs.

To the right of each called-line coupling-board are shown the connectors for the respective lines on that board, the parts of each connector being represented diagrammatically, and also the main distributer B, the main selector D, and the manipulator E for each group, C being the calling-line relays. All the lines of group I are idle, none of them being either calling or called or engaged in conversation; but the called-line coupler 1^b of group I is supposed to be in position to receive selection-signals, from a line of group III, and consequently its distributer G is represented as blocking in position of rest the twin called-line coupler controlled by the same selector-circuit—namely, coupler 1^b of group II.

The following description applies in general to Figs. 2^a and 2^b and incidentally to Figs. 3^a, 3^b, and 3^c, which illustrate in respect of different lines the principal effects successively produced, those lines which are specially referred to in the latter figures as "calling" or "called" being distinguished by an asterisk.

Signal No. 1.—First. The line-wire L′ is put to earth without resistance by the double contact-brush 164 165 of the signal-composing device, Figs. 5, 6, and 7, passing over the contacts 195 158. This wire L′ is normally connected by the spring a^4, Fig. 2^a, of the commutator A′, Figs. 9, 10, and 11, by the coil A, by the resting-contact and armature a^9 of A^2, and by brush b, uniting the pair of contacts at b' of sector I B of distributer B, to a battery b^5, which is similarly connected permanently and "in waiting" to all the line-wires L′ of the group. The voltage of this battery is insufficient to energize the electromagnet A so long as the resistance of one thousand to two thousand ohms remains interposed at the subscriber's station; but when this resistance is cut out and the wire L′ is put directly to earth, Fig. 8, the armature a of electromagnet A closes (at its working contact) the circuit of the local battery b^6 through the coil B′ of the main distributer B and the coil of the electromagnetic commutator A′. Two effects are thereby produced.

(a) The armature of B′ being attracted, Fig. 14, is in position to advance the main distributer B one step as soon as the exciting-current ceases.

(b) The commutator A′ is operated and the spring a^5, Figs. 9, 10, and 11, comes upon its working contact, whereby the circuit of the local battery f^{12}, Fig. 2^a, is now closed through the coil of A′, whereby the armature and contact-springs of A′ are retained in working position independently of the current of battery b^6, which brought them there. The contact-spring a', which is connected to earth through a small battery a^{10}, makes contact with the service-wire W^b of the calling line on the called-line coupling-board of the group, whereby this isolated wire is raised to the potential of battery a^{10}, with the result that thenceforth no other subscriber who may call can make connection with the line now calling. The contact-spring a^7 of commutator A′ puts the service-wire W^a of the calling line on the calling-line coupling-board of the group to earth through the coil of commutator A^2, whereby to prepare for the final coupling of the line calling with the line called, if the latter is disengaged. The contact-spring a^4 becomes disconnected from the wire L′, with which the contact-spring a^3 becomes in turn connected, whereby the line-wire L′ is connected to the contact at b^2 b^3 b^4 on the sector II B of the main distributer B, while the armature a^{12} of commutator A′, coming onto its working contact a^{17}, connects the line-wire L^2, which was theretofore isolated, with the contact at b^2 b^3 b^4 on the sector III B of the main distributer B.

Second. The contact-spring a^4 being disconnected from the line-wire L′ just after the battery f^{12} has been connected by the spring a^5 with the coil of commutator A′, the earthing at the subscriber's station of the battery b^5 is cut off, the coil A becomes inert, and its armature a returns to its resting contact, thus cutting the earth connection of the battery b^6 through coils B′ and A′. The coil B′ thus becoming inert, its armature is returned and the brushes of the main distributer B are advanced one step. The brush b on the sector I B having quitted the pair of contacts b', the battery in waiting b^5, which was thereby connected in common to all the line-wires L′ of the same group, is thus cut out from all those lines and the indicators 197, Fig. 8, at the stations of all the subscribers of that group, no longer receiving current, assume a position denoting that the main selector D and the manipulator E common to the group are in use and that therefore no subscriber of that group can for the moment make a call.

Signal No. 2.—The nature of this signal depends on the adjustment of rack 146 of the signal-composing device, as above explained. The brushes b of the main distributer B having reached the position b^2, the line-wires L′ L^2 are in connection with the group C of three relays c' c^2 c^3, whose well-known arrangement enables the production of the three kinds of distinct signals possible in the two-wire and central-battery system under consideration. Two of these relays, c' and c^3, are placed one on each side of the battery c, the middle of which is to earth through the third relay c^2, and (accordingly as the signal sent consists in putting to earth without resistance the one or other of the wires L′ L^2 or in joining these two wires without interposed resistance and without earth) the relays c' c^2 or the relays c^2 c^3 or the relays c' c^3 will be excited by the current. The three armatures of the relays c' c^2 c^3 are connected together and the three working contacts are connected to the battery b^6 through the coil B′. The three resting contacts are connected to the one terminal of each of three electromagnets C′, the other terminals of which are to earth, through the pair of contact-pieces b^2 on the sector I B of

the main distributer B, these three electromagnets C′ constituting the mechanism controlling the first member of the main selector D. According to the nature of the signal sent the armatures of a certain two of the group C of relays are depressed and one remains at rest. Consequently that one of the three electromagnets C′ is excited which corresponds to the combination formed by the two armatures depressed. The first member of the main selector D is therefore actuated, its operation depending on the nature of the signal sent. The current which excites this electromagnet C′ also traverses the coil B′, whose armature being attracted is in position to advance the brushes of the main distributer a second step as soon as the cessation of the current allows the armatures of the two relays of the group C which were influenced to return to rest and so cut the circuit of battery b^6.

Signal No. 3.—The nature of Signal No. 3 depends on the adjustment of rack 145 of the signal-composing device, and the receptive apparatus are the same as for Signal No. 2, except that the brushes of the main distributer B, having reached their third position b^3, the local current is in response to this signal directed by the relays C to the second group of electromagnets C^2, which are similar to those C′, but are now connected to earth by the brush joining the pair of contacts at b^3 on the sector I B of distributer B. These electromagnets C^2 constitute the controlling mechanism of the second member of the main selector D. When one of these magnets is excited, the second member of the selector will be actuated in accordance with the nature of the signal. The two members of the main selector D having thus been successively actuated, that particular selector-circuit will be completed which corresponds to the selective combination resulting from the action of the second and third signals sent. Each selector-circuit controls twin called line couplers, and we will suppose that the one now completed is that represented in Figs. 2^a and 2^b by $d\ d^2\ d'\ d'$ as being still open at contact d. On the cessation of the signal No. 3 the brushes b advance to the fourth position, whereby the line-wires L′ L^2 are connected with the manipulator E by the pairs of contacts b^4 on the sectors II B and III B of the main distributer B.

In group II of Fig. 3^a the line calling (the uppermost one on board II^a) having sent the signal No. 1, whereby it has been connected to the relays C and afterward the signals Nos. 2 and 3, which have actuated the main selector D, the continuity of one of the selector-circuits is established at d. The battery a^{10} is connected to the service-wire W^{b*} of the line calling, so that this line cannot now be called. All the lines of the group are cut off from the battery b^5.

Signal No. 4.—The signals, invariable in number, sent when the brush 164 of the signal-composing device passes over the contact-strips 183 182 181 are distribution-signals, and the signals, variable in number, sent when the brush passes over the comb-like contacts 186 185 184 are selection-signals. These two kinds of signals differ, since the one or other kind of signal is consequent on the one or the other of the line-wires L′ L^2 being put to earth, in response to which action the one or the other of the electromagnets E′ E^2 of the manipulator E is excited by the current of battery e and attracts its armature.

Signal No. 4 is a distribution-signal, produced (by hypothesis) by putting to earth the line-wire L′, whereby the armature of electromagnet E′ is attracted to its working contact. The armatures of the electromagnets E′ E^2 are connected together and to a metallic piece at D^0, whence starts the particular selector-circuit whose completion is determined by the combined effects of signals Nos. 2 and 3, whereas the working contact of electromagnet E′ is connected to a battery e' and to earth through the pair of contacts at f' on the sector I F^4 of the distributer F^4 and by the coil F^3 of distributer F, while the working contact of E^2 is connected to a battery e^2 of opposite polarity to that of battery e', and to earth by the pair of contacts at f' on the sector I F of the distributer F and by the coil F^5 of distributer F^4. The armature of E′ coming onto its working contact, a current is sent from battery e' through the selector-circuit, which has been completed and also through the coil F^3. The result is twofold.

First. The polarized double receiver H, located at the extremity of the selector-circuit under consideration, operates according to the direction of the current which it receives.

Second. The brushes of distributer F advance one step when the current passes through its coil F^3 and another step when the current ceases, thus arriving at the position f^3. Thenceforth communication is cut between the battery e^2 and the coil F^5 of the distributer F^4, so that the coil F^5 will be uninfluenced by currents which may be subsequently sent from the battery e^2 when the latter is earthed through the resistance-coil e^3, which has the same resistance as the coil F^5. If by different adjustment of rack 144 the first distribution-current had been sent by earthing the line-wire L^2, the current sent to the polarized double receiver H would have been of opposite direction and the brushes of distributer F^4 would have advanced, while the distributer F would have been rendered insensible to currents from battery e'.

The polarized double receiver H may be composed of two single polarized relays H′ H^2, of which the one or the other operates according to the direction of the current. Suppose the relay H′ to work in response to the currents emitted by battery e', which are, by hypothesis, the distribution-currents, the relay H^2 will work in response to the selec-

tion-currents emitted by the battery e^2. The armatures h' h^2 of the two relays H' H² are, moreover, connected to the same battery h^3. Now the circuit from the working contact of relay H' reaches earth through the pair of contacts at g' on the sector I G² of the called-line distributer G², of which the brushes are supposed to be in position of rest, through the electromagnet g^{11} and through the coil G' of distributer G. Conversely the circuit from the working contact of H² reaches earth through the pair of contacts at g' on the sector I G of the called-line distributer G, through the electromagnet g^{12}, and through the coil G³ of the distributer G². The effect of the first distribution-current is then, by carrying the brushes of distributer G to g^2, to cut off all communication of the battery h^3 with the coil G³ of the distributer G², which is then blocked in position of rest, and consequently the corresponding called-line coupler (not shown) is rendered inactive and uninfluenced by any signals. On the other hand, the brushes of distributer G having reached g^2, the first of the mechanisms controlling the movements of the called-line coupler associated with that distributer is able to receive selection-currents from the battery h^3. If the first distribution-signal had been of opposite direction, produced by earthing the wire L² and the working of the relays E² and H², the distributer G and the corresponding called-line coupler would now have been blocked and the distributer G² and the called-line coupler associated with this distributer (the twin called-line coupler) would have been in position to operate.

In group III of Fig. 3ᵇ the line calling (third from the top) is shown as at the moment when (after the signal No. 4) it transmits to the manipulator E the distribution and selection signals, and when those signals (translated by the manipulator into local currents) pass through the selector-circuit completed and act on the double polarized relay H. It has been supposed that the two called-line couplers controlled by the selector-circuit completed are 1ᵇ and 1ᵇ opposite the coupling-boards Iᵇ IIᵇ of groups I and II, and the example shows the called-line coupler of group No. I as about to be actuated, while the called-line coupler of group No. II has the coil G³ of its distributer G² blocked in position of repose.

Signal No. 5.—This is a selection-signal, which determines the extent of traverse of the called-line coupler with respect to the coupling-board. The brushes of distributer G being at g^2 connection is established (by the brush g on the sector I G) between the working contact of the electromagnet H² and the electromagnet K, which controls the propelment mechanism of the called-line coupler, circuit being made from ground at battery h^3 to ground at right of Fig. 2ᵇ. This mechanism, therefore, advances a number of steps equal to the number of selection-currents in signal No. 5, and the result is that the called-line coupler descends until one of its sets of contact-fingers comes opposite to the contact-wires on the called-line coupling-board of the the line to be called.

Signal No. 6.—This is a distribution-signal. This signal, like signal No. 4, acts first on the distributer F, of which the brushes f advance one step during the passage of the current of battery e' and a second step on the cessation of the current, thus arriving at the position f^5, and, secondly, on the distributer G, of which the brushes are brought to g^3, where the brush g on the sector I G establishes electrical connection between the working contact of relay H² and the electromagnet M, which actuates the first member of the contact-fingers selector.

Signal No. 7.—This is a selection-signal whereby the electromagnet M receives as many emissions from the battery h^3 as there are (in this signal) earthings of the line-wire L², the effect being to operate the first member of the contact-fingers selector.

Signal No. 8.—This is a distribution-signal whereby the brushes of distributer F are brought to the position f^7 and the brushes of distributer G are brought to the position g^4, where connection of the working contact of relay H² is made with the electromagnet M'.

Signal No. 9.—This is a selection-signal whereby the electromagnet M (see Figs. 20 and 23) receives as many current-emissions from battery h^3 as there are (in this signal) earthings of the wire L², the effect being that the second member of the contact-fingers selector is actuated. The signals Nos. 7 and 9 having thus operated the first and the second members of the contact-fingers selector, the conjoint effect produced is that only those contact-fingers of the called-line coupler which are opposite to the line-wires L' L² and service-wire Wᵇ belonging to the line to be called are allowed to make contact with those wires on the called-line coupling-board. Several cases may now arise.

First case—Line disengaged.—If the line to be called is disengaged, its service-wire Wᵇ is to earth through the coil of commutator A². This is normally the case, as will be seen by referring to the connections of the service-wire Wᵇ, which are shown in Fig. 2ᵃ as in position of repose. Now on the brushes of distributer G arriving at g^4 the service-finger Z^0 of that set of fingers of the called-line coupler which have been set free has been connected by the brush on the sector II G to the two test-commutators N' N², which are themselves connected to earth. When the service-finger Z^0 of the called-line coupler makes contact with a service-wire Wᵇ, which is to earth, no effect is produced on N' N², the generator V remains isolated, and the subscriber calling hears no buzzing or sonorous sound at his receiver denoting that the line is engaged.

Group IV of Fig. 3ᵇ shows how (signals No.

1 to No. 9 having been sent) the test is made of the line to be called. The calling-line is the second from the top of board IV^a, and it has been supposed (*a*) that the called-line coupler actuated was the one 3^b of group III, (*b*) that the fingers of this coupler have made contact with the line to be called, which is the second from the bottom of board III^b, and (*c*) that this line is not engaged. The called-line coupler, which is the twin of the one used and which is shown as placed in front of the board IV^b, has the coil G^3 of its distributer G^2 blocked in position of rest. "Communication established" is also shown between the bottom line of coupling-board III^a and the bottom line of coupling-board IV^b, so as to denote the presence of the potential of testing-battery n^5 in the service-wires W^{a*} and W^{b*} of the lines engaged in conversation. The subscriber calling then sends the final signal, which acts like the distribution-signals on the distributers F and G. I will first consider the distributer G, of which the brushes advance one step and reach g^5. The current of battery g^{13} passes (by the armature and resting contact of electromagnet g^{11}, the springs n^6 n^7, electromagnet N^0, the pair of contacts at g^5 of the sector I G, the armature n' of N$'$ and its resting contact, the spring n^4 of N^2 and its resting contact, and the armature and the resting contact of the indifferent polarized relay O) to the first circuit of the commutator P and attracts its armature p and the two contact-springs p' p^2. At the same time the armature of N^0 is brought onto its working contact and forms a path for the current of battery g^{13} (independent of the brush g on the pair of contacts at g^5 of sector I G) as long as the springs n^6 n^7 remain in contact. The current of battery p^0 passes through the second circuit of P, the working contact and the spring p', the wire 128, the line-finger Z$'$, the line-wire L$'$, the resistance 196, the bell 199, and the indicator 197 of the subscriber to be called. Using, preferably, trembler bells of the kind which work by short-circuiting instead of by cutting out their coils, the circuit will remain complete and the bell will continue to ring until the subscriber by unhooking his receiver cuts the connection to earth and finally breaks this circuit. From this point the description will be resumed later on. At the sectors II G and V G of distributer G there is no change. At the sector III G a battery n^0, which the coming in contact of the springs g^7 g^8, Fig. 17, puts to earth through the armature n^3 and its resting contact sends (through the wire 7 8 9 10, the spring r' and its resting contact, the spring w^2 and its resting contact) an uninterrupted current to the electromagnet Q, Figs. 2^a and 29, which determines the traversing movement of the calling-line coupler. This coupler then commences to move across the calling-line coupling-board, its service-fingers Y^0 y^0 rubbing against the service-wires W^a of the various lines which they pass. At the sector IV G the battery g^{13} is connected, by the circuit already described and the first winding of the polarized relay O, to the wire 14 13, the common commutator R, and the wire 12 11, whence are branched the wires appertaining to the service-fingers Y^0 y^0 of the different sets of fingers on the calling-line coupler, each such branch comprising the electromagnet R$'$, which controls the putting in operative position of the line-fingers of its set. The circuit may thus be completed by any one of the service-fingers as soon as that service-finger meets with an earth. Now by following out on Fig. 2^a the connections, when at rest, of the service-wire W^a on the calling-line coupling-board it will be seen that the service-wire W^a of an "idle" line is completely isolated, and it has already been seen that the service-wire W^b of a line calling is to earth through the coil A^2 of its connector. Lastly, it will be presently seen that the service-wire W^a of a line "in course of conversation" is connected to one of the poles of a battery of which the other pole is to earth and that such service-wire is raised to a potential nearly equal to that of this battery, so that if this battery has a suitable voltage and polarity it will be in "opposition" to the battery g^{13} when a service-finger of a calling-line coupler comes into contact with the service-wire W^a of an engaged line, and consequently then there will only pass in the circuit referred to a current much too weak to operate the electromagnets R R$'$. It will thus be seen that no current capable of actuating these electromagnets can pass except when one of the service-fingers of a calling-line coupler meets the service-wire W^a of a line calling, and in the same group there can only be one line calling at a given moment, since only one selector and manipulator are provided for the group.

In group V of Fig. 3^c the line calling (the bottom one on board V^a) has brought the called-line coupler 2^b onto the line to be called (the top one of the board VI^b) and has ascertained that this line is disengaged, and the final signal has been sent, which sets the calling-line coupler in motion. This coupler has not, however, yet met with the service-wire W^{a*} on the coupling-board V^a; but the battery g^{13} is connected to the service-finger Y^0 through R and R$'$ (see Fig. 28) in readiness to arrest the movement of the coupler as soon as the service-finger Y^9 meets with the service-wire W^{a*}, which, as mentioned under signal No. 1, has been put to earth through the coil A^2 of the connector appertaining to the line calling. When the service-finger Y^0 thus meets the service-wire W^{a*}, the commutator R, being energized, cuts the circuit of the current which energizes the electromagnet Q, and the traversing movement of the calling-line coupler is therefore arrested. The electromagnet R$'$ is also energized and allows the line-fingers of the set to which it appertains to come into operative position,

whereby unbroken connection is established from the station of the subscriber calling (by his line-wires L′ L², the line-fingers Y′ Y², and the wires 131 132, Fig. 2ª, connected thereto) to the pairs of contacts at g^6 of the sectors III G and V G of the distributer G. Lastly, the polarized electromagnet O is energized, its armature is separated from its resting contact, cuts the current of battery g^{13} from the first circuit of the commutator P, where it has become unnecessary, and sends it by the branch 15 16 17 18 through coil G′, so that the brushes of distributer G advance one step and arrive at the position g^6, which is the conversation position, the current of battery g^{13} continuing to pass through the armature and the working contact of N^0 after the brushes g have quitted the pairs of contacts g^5 until the armature of G′ on completing its working stroke separates the springs n^6 n^7. The effects of this last movement are as follows: At the sector I G the battery g^{13} is cut out. At the sectors III G and V G the wires 131 132 from the line-fingers Y′ and Y^2 of the calling-line coupler are connected, respectively, to the wires 19, 20, 21 and 23 24, Fig. 2ᵇ, which terminate at the resting contacts of the springs p' p^2 of commutator P, so that as soon as this commutator P is returned to position of rest by the subscriber called unhooking his receiver telephonic connection is established between that subscriber and the subscriber calling. At the sector II G battery n^5 is connected with the service-finger Z^0 of the called-line coupler. The connection of this finger with the test-commutators N′ N^2 is broken, and it is connected at the sector IV G with the service-finger Y^0 of the calling-line coupler. Thereby the service-wire W^b of the line called and the service-wire W^a of the line calling become raised to a potential so much the nearer to that of the battery n^5 as the resistance of the coils A^2 (of the connectors by which these lines are to earth) is the higher relatively to the resistance (which is always very low) of the wires 254 11 12 7 127, which connect the service-fingers Y^0 Z^0. The characteristic condition of an engaged line is thus realized on the called-line coupling-board in respect of the line of the subscriber called and on the calling-line coupling-board in respect of the line of the subscriber calling. Lastly, the current sent from the battery n^5 to the coil of the commutator A^2 (appertaining to the connector of the line calling) excites this commutator, whose armature is depressed and remains fixed in working position so long as the current in question passes—that is to say, as hereinafter explained, throughout the duration of the conversation. During the whole of this time all communication is cut off between the line L′ and the distributer B. At the same time by its contact-spring a^{11} a branch is established from the one terminal of the coil of the commutator A^2 to the contact-spring a^8 of the commutator A′, which for the moment is isolated.

I will now revert to the distributer F, of which the brushes before the sending of the final signal were at the position f^7. This final signal advances the brushes of distributer F two steps, one step during the passage of the current, which brings the brushes to the position f^8, and the second step on the cessation of the current, by which the brushes regain their initial position. Now at the passage of the brush f on the sector II F to the pair of contacts at f^8 the current of the local battery f^{13} passes through the electromagnet F^0, and then as soon as the armature of F^0 comes onto its working contact, another path being opened to this same current, the armature of F^0 is retained in working position even after the brush f has advanced a step. On the other hand, the pair of contacts at f^8 on the sector I F and the pair at f' on the sector II F are connected together, the contact-pieces of these pairs which are on the innermost circle being connected to one pole of the battery f^{13} beyond the electromagnet F^0 and the contact-pieces of these pairs on the outermost circle communicating by the wire 28 27 26 25 with the armature of the electromagnet Q, which controls the traversing motion of the calling-line coupler. Another circuit going from the other pole of the battery f^{13} traverses the commutator F′ and joins the main selector D, whence by the selector-circuit completed and the branch d^2 d^3 d^4 it reaches the resting contact of the armature q of electromagnet Q. This circuit remains thus interrupted so long as the traversing movement of the calling-line coupler continues and becomes closed when (the service-finger of said coupler having met with the service-wire of the line calling) the armature of Q returns to rest. Then (whether the brush f be still on the pair of contacts at f^8 on the sector I F or whether it has already arrived on the pair of contacts at f' on the sector II F) and only then the circuit of the commutator-coil F′ is completed. This commutator operates, closing (by its own armature and its working contact) a local circuit of battery f^{13}, which retains the commutator in its working position. At the same time the spring f^{10} is separated from its resting contact and the spring f^9 is brought onto its working contact. The movement of spring f^{10} cuts off the battery f^{12}, by which the commutator A′ was maintained in its working position. This commutator A′ therefore returns to rest; but the springs of each pair comprised in that commutator being so regulated that the position of rest shall be established before the working position is relinquished, and vice versa, the current which reached the coil A^2, connected with the service-wire W^a of the calling-line coupling-board through the contact-spring a^7, continues to reach it without interruption by the contact-spring a^8 and by the communication which the contact-spring a^{11} of this commutator A^2 establishes with the terminal of the coil. The latter therefore remains excited and its

armature remains in working position. At same time by the contact-spring a^2 the service-wire W^b of the called-line coupling-board is raised to the potential of wire W^a, a potential nearly equal, as above explained, to that of the battery n^5. The characteristic condition of a line in course of conversation is therefore fulfilled also (on his own called-line coupling-board) in respect of the line of the subscriber calling. The movement of spring f^9 closes the circuit of battery b^6 through the coil B′ of the main distributer B and the coil F^2 of the electromagnet, by which the main selector D is returned to rest. The coil F^2 being excited and being very powerful returns the main selector D to rest and at the end of its stroke separates the spring f^{11} from its resting contact. The various local circuits which were supplied by the battery f^{13} are thus cut, the electromagnet F^0 and the commutator F′ return to rest, the spring f^9 is separated from its working contact, and (the circuit of the battery b^6 being thus cut) the brushes of main distributer B advance one step, which brings them to position of rest. Thus as soon as telephonic connection is established between the line of the subscriber calling and that of the subscriber called the apparatus for common use by all the lines of a group are automatically returned to normal position ready for use by any other subscriber of the group.

The group VI of Fig. 3^c shows the state of things when the calling-line coupler having met with the service-wire W^{a*} of the line calling (in this case the bottom one on coupling-board VI^a) has been stopped at this line, and when the subscriber called (whose line is in this case the fourth from the top of coupling-board VI^b) having unhooked his receiver telephonic connection is established. The service-wires W^{a*} and W^{b*} of the line calling are connected together at the electromagnet A^2 of the connector belonging to that line, the service-wires W^{a*} and W^{b*} of the line called are similarly connected, and, lastly, the service-wires of the one are connected to the service-wires of the other (by the distributer G of the called-line coupler employed) and communicate with the testing-battery n^5. The communication of the other lines of the group with the battery b^5 is restored, and the apparatus B C D E for common use are returned to rest, and, lastly, the called-line coupler employed has the coil G′ of its distributer G blocked in position of rest against any currents which may be sent by the double polarized relay H, while the twin called-line coupler has the coil G^3 of its distributor G^2 put into circuit with this same relay H, whereby this twin coupler is rendered available for use.

The talk being finished, the two couplers constituting the coupling device which was used, and likewise the accessory parts, are returned to rest as follows: The branch 29 30, Fig. 2^b, comprises the central transmission-battery s^0 and also the first circuit of commutator S, and the electromagnets S′ S^2 are placed one on either side of the branch 29 30 in circuit with the two coupling-wires 20 21 and 23 24, respectively. As soon as the called-line coupler quits its position of rest the spring T^3 comes onto the contact t^3, which is to earth, and consequently as soon as the current of the central battery s^0 has once excited the first circuit of the commutator S (which only happens when at least one of the two subscribers has come "on line" in position to talk) the armature of this commutator itself closes (through the second circuit) the current of the battery s', and thus retains itself in working position, and at the same time the battery s^2 is permanently connected to the spring s_2 but the circuit of this battery (requiring for its completion the contact of the armature of each of the electromagnets S′ S^2 with its resting contact) remains broken in at least one point so long as both subscribers have not (by hanging up their receivers after finishing their conversation) cut off the current of battery s^0 in both the electromagnets S′ S^2 at once. Then only the interrupted current of battery s^2 passes first to electromagnet T, which brings about the return to rest of the contact-fingers of the called-line coupler. The return-to-rest mechanism of these fingers having arrived at the end of its stroke presses together two springs t' t^2 and switches the current of the same battery s^2 to the mechanism which returns the called-line coupler to its initial position by a step-by-step motion. The principal element of this mechanism is an electromagnet T^2, Figs. 2^b and 21, and the current from the battery s^2 passing through the resting contact and armature t^0 of this electromagnet T^2 to the first winding of the auxiliary electromagnet T′ attracts its armature, which closes (at its working contact) the circuit of another battery t through the electromagnet T^2 and the second winding of T′. The armature of T^2 being attracted first cuts off the current of the battery s^2 and advances the return-to-rest mechanism one step, and then on reaching the end of its stroke separates the spring t^4 from its resting contact. Both the windings of T′ thus ceasing to be excited, its armature returns, and similarly for the armature of T^2, since this electromagnet also ceases to be excited. The current of battery s^2 is therefore reëstablished and brings about another step, and so on until the called-line coupler has been returned step by step to its initial position, where it separates the spring T^3 from its contact. The commutator S then ceasing to be retained in working position returns to rest and cuts off the current of the battery s^2. This mechanism differs from a trembler mechanism in that the armature t^0 of the electromagnet T^2 necessarily travels through the whole length of its stroke. At the same time as to the electromagnet T the battery s^2 also sends a current through the branch 31 43 45 to the second winding of the

polarized electromagnet O in the required direction to return it to rest and also by the branch 31 43 46 47 to the second winding of coil G' of the distributer G, whose brushes advancing one step are returned to position of rest.

In passing from the sixth position to the position of rest the brush on sector II G of distributer G cuts the connection of the battery n^5 with the service-fingers Z^0 Y^0 and cuts the connection of these fingers with each other. The commutator A^2, ceasing to receive current, returns to rest, whereby the communication is broken between the service-wire W^b of the called-line coupling-board and the service-wire W^a of the calling-line coupling-board, on which the calling line appears and returns the whole of the connector to its initial position. On the other hand, when the calling-line coupler quitted its position of rest it allowed the spring V^4 to come onto its contact connected to the battery u^4. At the same moment the commutator R is retained in its working position, so that the current of the battery u^4 passes first (by the branch 32 33 34 35 36, the armature r, and its working contact) to the first winding of the commutator V, then through the armature u and its working contact to the second winding of this commutator V, of which the armature u is held in working position independently of the movements of the armature r, and establishes by its spring u' and its working contact a communication between the electromagnet V^0 and the resting contact of the armature r. As soon then as the current of battery n^5 is cut off from the commutator R by the return of the brushes of distributer G to initial position the armature r returns to rest and the current of the battery u^4 is permanently sent to the electromagnet V^0 and then (by the armature u^0 and its working contact) to the electromagnet V', Figs. 2a and 28, which actuates the mechanism for returning to rest the contact-fingers of the calling-line coupler, and, lastly, the electromagnet V' having operated and its armature arriving at the end of its stroke the current is sent through the branch 33, the working contact, and armature of V' to a return-to-rest mechanism V^2 V^3, (similar to that of the called-line coupler,) whereby the calling-line coupler is returned step by step to its initial position, the return movement being arrested when, by the spring V^4 being raised from its contact, the commutator V and electromagnet V^0 are permitted to return to position of rest. All of the mechanisms employed for establishing and maintaining telephonic connection between two lines have now been returned to their initial position.

Second case—Line engaged in conversation.—The service-wire W^b appertaining to a line (whether calling or called) is connected, as soon as this line is in course of conversation, to one of the poles of battery n^5, of which the other pole is to earth, and is raised to a potential nearly equal to that of this battery. Suppose, then, that signals Nos. 1 to 9, inclusive, are sent in the endeavor to establish connection with a line which is already "engaged." The brushes of distributer G having been brought to the position g^4 and the appropriate set of contact-fingers (of the called-line coupler) having been set free, then, by the fact of the service-finger coming into contact with the service-wire W^b of the engaged line, a current is established from the battery n^5 (through the service-wire W^b, the service-finger Z^0 of the called-line coupler, the wire 127, the wire 7, and the pair of contacts at g^4 of the sector II G of distributer G) to the commutators N' and N^2, whose armatures n' n^3 and springs n^2 n^4 come into working position. The generator V of alternating or periodic currents is connected (through a condenser v, spring n^2, and its working contact) to the selector-circuit (made use of in this attempt to establish connection) at d^0 before its point of entry into the polarized receiver H. The electric impulses of the generator V are then transmitted by the wire d^0 d' d^2 d to the main selector D, to the condenser v', and to the induction-coils I I', which transmit the currents by induction to the line-wires L' L^2 of the subscriber now supposed to be making an unsuccessful call, and this subscriber on listening at his receiver connected to the wire L^2 perceives a buzzing or sonorous sound, by which he is informed that the line wanted is engaged. Communication being momentarily impossible, the subscriber who has made an unsuccessful call sends the final signal, whereby all the mechanisms which have been actuated in the attempt to make a call are returned to their initial positions. As the calling-line coupler has not quitted its position of rest, it follows that when the brush of the distributer F in response to this final signal passes over the position f^8 of the sector I F and comes to rest at the position f' of the next sector II F the circuits described in the previous case for the return to rest of the connector, main distributer, and main selector are already formed without interruption or gap, and consequently these mechanisms are immediately returned to initial position. As regards the called-line coupler, the brushes of its distributer G move to position g^5, leaving in working position the commutators N' N^2, which remain connected to the service-finger Z^0 through the pair of contacts at g^4 g^5 of the sector II G and to the service-wire W^b of the engaged line. The battery n^0 (which in the case of "line disengaged" determined the setting in motion of the calling-line coupler) is cut out, and in its place the earth is put (by springs g^7 g^8 and by the armature n^3) to the local battery n, which fixes the commutator N^2 and electromagnet S^0 in their working position independently of the other apparatus. Now the final signal above referred to only reaches the coil G' of the distributer G by first traversing the small electromagnet g^{11}, of which the armature is

attracted, and consequently at the moment when the distributer-brushes reach the position g^5 the battery g^{13} is cut off from the pair of contacts at g^5 of the sector I G; but when the current which constitutes the final signal ceases the electromagnet g^{11} ceases to be excited, its armature returns to rest, and the current of battery g^{13} (prolonged, as previously described, by the electromagnet N^0 after the brush has quitted the pair of contacts at g^5) is switched (by the pair of contacts at g^5 of the sector I G, by the armature n' and its working contact, and by the wires 17 18) to the coil G′ of the distributer G, of which the brushes are advanced one step and reach the position g^6. It is necessary that the armature of the electromagnet G′ shall return to its position of repose a little quicker than that of the electromagnet g^{11}, which is easily insured by suitable regulation. The brushes of distributer G passing to the position g^6, the connection is cut between the service-finger Z^0, and the commutators N′ N^2. The commutator N^2 remains fixed in working position by the battery n, but N′ returns to rest, and the current of the battery n is switched (by the pair of contacts at g^6 of the sector I G, by the armature n' and its resting contact, the spring n^4 and its working contact, and the wire 37 38 39 40 41 42) through the second winding of commutator S to the spring T^3 and to its earth-contact t^3. The branch 29 30 being, moreover, cut between the armature and the resting contact of the electromagnet S^0, the two electromagnets S′ S^2 are therefore necessarily in position of repose. When, therefore, the armature of S is attracted by the action of the current of battery g^{13} and is fixed in working position by the current of battery s', everything is prepared for battery s^2 to act, as described in the preceding case, so as to return the distributer G and the called-line coupler itself to position of rest. By the return of distributer G to rest the earth connection is cut (at springs g^7 g^8) from the battery n, and the commutator N^2 also returns to rest. All the parts have then returned to their initial positions.

Third case—Called-line coupler in use.—Telephonic connection having been established between a line of a certain group and a line of a certain other group, it may happen that another subscriber whose line is comprised in the first-mentioned group desires to speak with another subscriber whose line is comprised in the last-mentioned group. Now the called-line coupler which the second subscriber of the first-mentioned group would require to use is already in use and the second subscriber desiring to call must not be able to disturb nor to overhear the conversation already in progress and must be notified that he cannot for the moment make the desired call. It follows, since the called-line coupler in question is already in use, that the brushes of its distributer G are in the sixth (or conversation) position. Now when the brush on the sector V G passes from position g^5 to g^6 all communication is cut between the battery h^3 and the coil G′, which is therefore inaccessible by the signals which might be sent by a second subscriber who desires to make a call. On the other hand, since the called-line coupler in question is in use the associated calling-line coupler is in use also and has therefore left its initial position. Consequently the spring V^2 has come on to its contact v^2, and at the moment when the second subscriber desiring to call (having sent signals Nos. 1 to 9, inclusive) listens at his receiver the distributer F, whose brushes are then at the position f^7, establishes electric communication between the alternating-current generator V′, and the induction-coils I I′, (by the pair of contacts at f^7 of the sector I F, the spring V^2, its contact v^2, wire d^6 d^5 d^4 d^3 d^2 d, the main selector D, and the condenser v',) and the buzzing signal denoting that communication cannot be obtained will therefore be heard.

Fourth case—Use of the twin coupling device.—It is obvious that the contingency considered in the previous case is the more likely to arise the greater is the number of lines contained in each group and that the greater the number of lines in each group the greater is the complexity and weight of the coupling appliances. It may therefore be necessary for these and other practical reasons to limit the number of lines in each group; but, on the other hand, it is desirable to avoid the excessive complexity of the main selector, which would be entailed by excessive multiplication of the groups. A means has been devised of reconciling these conflicting conditions, such means consisting in the combination with each selector-circuit of what have been designated twin coupling appliances, whereof the called-line couplers are situated at the called-line coupling-boards of different groups, which may be regarded as virtually subdivisions of one large group. The one or the other of these called-line couplers will be brought into action, according to the polarity of the first signal sent, so that by this means the same selector is enabled without increased complexity to control, say, twice as many coupling devices as it would otherwise be able to control, or, in other words, each coupling appliance may be of only half the complexity and weight which would otherwise be necessary to enable intercommunication to be effected between the same number of subscribers. It being understood, then, that each circuit of the selector can control either of, say, two called-line couplers, (designated "twin" couplers,) it is to be understood that each of these called-line couplers is in electrical connection with a calling-line coupler, the two calling-line couplers (thereby brought indirectly into relation with the same selector-circuit) being designated "quasi-twin" couplers, each quasi-twin coupler being operated only through the medium

of the associated twin coupler, each twin coupler and its associated quasi-twin coupler together constituting a coupling device.

I will now explain how the fact that a called-line coupler is already in use does not entail the inaction of the twin coupling appliance which is controlled by the same circuit of the main selector. Now it has been shown (in the description of signal No. 4) that from the first step made by the brushes of distributer G of the called-line coupler the electromagnet G^3 of the distributer G^2 appertaining to the twin coupling appliance was completely cut off from the battery h^3 and rendered inaccessible to any distribution-signal, which fact debars the twin called-line couplers from receiving any "selection-signal;" but when the brushes of distributer G pass to the sixth or conversation position—that is to say, at the moment when the main distributer and main selector again become available for use—the communication is cut at the sector V G, as above described, between the battery h^3 and the coil G′ of that distributer. On the other hand, one of the five cam projections 222 of the disk 219, Figs. 16 and 17, makes contact between the two springs g^9 g^{10}, and as these are connected, respectively, with the two contacts of the pair at g' in the sector I G the connection which was broken at the first step made by the brushes of the distributer G is restored and coil G^3 of the twin distributer G^2 can receive distribution-currents. Consequently the twin called-line coupler can receive selection-currents and be actuated at will. The fact of a called-line coupler being engaged in no way involves the sending of the buzzing or engaged signal to the subscriber who desires to use the twin called-line coupler, since the distribution-currents suitable for actuating the distributers of the two twin coupling appliances controlled by the same selector-circuit are of opposite polarities. One of the distributers F responds to currents of the one kind, (those which act on G′, for instance,) whereas the distributer F^4 responds to those which act on the coil G^3 of the distributer G^2 of the twin coupling appliance. When the brushes of distributer F^4 reach the position f^7, the generator V′ is connected no longer to the spring V^2, but to the spring V^4, which fulfils the same function for the quasi-twin calling-line coupler. On the other hand, at the moment when the subscriber who desires to make use of this twin coupling appliance listens at his receiver before sending the final signal, the quasi-twin calling-line coupler is still in its position of rest, and consequently V^4 is separated from its contact v^4. Therefore no electrical impulses can pass to the induction-coils I I′ nor by them to the line-wires, and consequently no buzzing signal is sent.

I will now describe some constructional examples of the special mechanisms employed, it being understood, however that the invention claimed is not limited thereto, as other mechanisms may be used to produce the same results.

Connector.—As a type of the electromagnetic commutators employed, Figs. 9, 10, and 11 show in elevation, section, and plan the commutator A′, forming part of the connector. It is an electromagnet whose armature a^{12} carries a cross-bar a^{13}, of insulating material, which acts upon contact-springs a' a^2 a^3 a^4 a^5 a^7 a^8. When at rest, this cross-bar a^{13} separates the upper springs a' a^3 a^5 a^7 from the contact-rings a^{16}, with which the lower springs are in contact. When the coil is excited, the lower springs a^2 a^4 a^8 are separated from and the upper springs touch the contact-rings a^{16}. All the springs and rings are insulated from each other and are regulated independently. The armature itself establishes a contact in the manner of a relay with an insulated contact-piece a^{17}. A greater or less number of pairs of contact-springs and contact-rings may be used, according to requirements.

Main selector.—The main selector shown in Figs. 12 and 13 comprises nine long contact-springs 51 52 53 54 55 56 57 58 59, fixed to a metallic piece D^0 and adapted to make contact, respectively, with nine contact-pieces 51^a 52^a 53^a 54^a 55^a 56^a 57^a 58^a 59^a, mounted on insulating-supports. The coördinating mechanism of this selector comprises two members, each formed of three rods D′ D^2 D^3 and D^4 D^5 D^6, respectively. Each rod is spring-pressed and has a tooth 60, which is engaged by a detent 61, forming the armature of an electromagnet, there being three electromagnets C′, (of which only one is shown,) which control the rods D′ D^2 D^3, and three electromagnets C^2, (of which two are shown in Fig. 12,) which control the rods D^4 D^5 D^6. Each rod carries three lugs d^7 d^8 d^9, of insulating material, which (when the rod is engaged by the corresponding detent 61) bear, respectively, against three of the contact-springs and separate them from their contacts, these lugs being so placed that in each member each of the three rods engages with different contact-springs, the distribution of the lugs being dissimilar for the two members. In the first member the rod D′ engages with the springs 51 52 53, the rod D^2 with the springs 54 55 56, the rod D^3 with the springs 57 58 59, whereas in the second member the rod D^4 engages with the springs 51 54 57, the rod D^5 with the springs 52 55 58, and the rod D^6 with the springs 53 56 59. Each contact-spring is thus held retracted by a rod of each member and can only come onto its contact when both of these two rods have been released by the disengagement of their respective teeth 60 from the detents carried by the armatures of those two of the electromagnets C′ C^2 which are energized and which correspond to these rods.

65 are stops to limit the movement of the rods.

The main selector described enables nine

selector-circuits to be controlled. The return to rest is obtained by means of the electromagnet F^2, (shown in Fig. 13,) whose armature 64 carries a cross-bar 62. When any one of the rods D′ to D^6 is released, a pin 63, which it carries, comes against the cross-bar 62, whereby the rod is moved back when the armature 64 is attracted.

Coupling-boards.—The line-wires and service-wires of the coupling-boards might obviously be any suitable metallic pieces electrically connected in rows, but wires are preferred. Instead of two separate boards for each group, as has been assumed, Figs. 4, 18, and 19 show the called-line coupling-board and the calling-line coupling-board combined in one. It consists of an open frame 66, of insulating material, in which are stretched wires arranged in rows, each of four wires equally spaced in the same horizontal plane.

The middle two wires are the line-wires L′ L^2 of a subscriber, the outer wires being the service-wires, whereof W^a is used when the line is calling and W^b is used when the line is called. Five such rows of wires are superposed at regular intervals, consecutive sets of five wires being separated by a vacant space equal to twice the vertical distance between consecutive wires. At one side of the board are situated the calling-line couplers 1^a 2^a 3^a 4^a 5^a 6^a and at the other side the called-line couplers 1^b 2^b 3^b 4^b 5^b 6^b.

Coupling appliances.—A called-line coupler is represented in figures 20 to 26, inclusive. In Fig. 20 the coupler is shown in position of rest, and in Fig. 26 it is shown as having made one step downward and as having made contact by its second set of contact-fingers with the line and service wires to which those fingers have been brought opposite. It comprises a frame 67, capable of being traversed vertically between guides 68. Upon said frame are mounted as many superposed sets of contact-fingers as there are sets of five rows of wires on the coupling-board, the sets of contact-fingers being spaced at distances equal to the height occupied on the board by five rows of contact-wires and the succeeding vacant space. Each set of contact-fingers comprises three fingers adapted to be projected horizontally across a row of wires on the board and to respectively make contact with the line-wires and the service-wire in front thereof. By the vertical traversing movement the whole of the sets of contact-fingers may be moved downward step by step until one of the sets comes to the level of the wire on the coupling-board which belongs to the line wanted, only five steps at most being required to bring opposite to a given line the set of contact-fingers which corresponds to the five rows in which that line is found. The coupler also comprises a contact-fingers' selector mounted on the frame 67, whereby that particular set of contact-fingers may make connection with the wires on the coupling-board to the exclusion of all the other sets of contact-fingers. With this object the contact-fingers' selector may act mechanically by preventing all the sets of contact-fingers except the set selected from touching the contact-wires, or it may act electrically by putting (or by leaving) in the telephonic circuit only the set of contact-fingers selected.

It is obvious that the various sets of contact-fingers should be mechanically independent if they are permanently connected electrically, and that they should be electrically independent if they are mechanically connected. An example of the first case is shown in Figs. 24, 25, and 26, wherein all corresponding fingers (of the different sets of fingers carried by the coupler) are shown as electrically connected through their stems with wires branched upon a common wire— that is to say, all the fingers Z^0 are connected with a wire 127, all the fingers Z′ with a wire 128, and all the fingers Z^2 with a wire 129.

The traversing movement might be upward or downward; but in Figs. 20 to 26 this movement is a descending one along a screw-spindle 69, controlled by an escapement under the operation of the electromagnet K, a complete oscillation of the escapement permitting a descent equal to the space between two consecutive rows on the coupling-board. The contact-fingers' selector has two members acting mechanically, their operation being such as to allow only the proper set of contact-fingers to touch the wires on the coupling-board, the two members being respectively actuated by the electromagnets M and M′, Figs. 2^b, 20, 23, and 26.

The return to rest of the coupler is effected by two successive movements, of which the first returns the contact-fingers to their initial position, and the second returns (step by step) the whole coupler to initial position by raising it along the screw-spindle 69, T, T′, and T^2 being the electromagnets which bring about this movement.

The vertical screw 69 is mounted in collar-bearings carried by the frame 66. 70 is a traversing nut on which is mounted the frame 67 of the coupler. The screw 69 has an escapement-wheel 71 (see Fig. 22) fast upon it and provided at the under side with three equidistant lugs 72, which are engaged alternately by the pallets 73 of the escapement-anchor 74, which is caused by a spring 75 to normally assume the position shown in full lines in Figs. 21 and 22, while the electromagnet K when excited causes the anchor to assume the position shown by dotted lines in Fig. 22. The number of lugs 72 and their pitch would be such in relation to the pitch of the screw 69 that a complete oscillation of the anchor 74 to and fro allows the nut 70 to descend along the screw 69 a distance equal to the interval between two consecutive rows on the coupling-board. The rotation of the screw 69 in the opposite direction for the return-to-rest motion is effected by the two electromagnets T′ T^2, the one T^2 acting on

the ratchet-wheel 71 by a pawl 76, jointed to its armature-lever 77, a detent 78 engaging wheel 71 to prevent retrograde movement between the impulses of pawl 76. In order that this mechanism 76 78 shall not obstruct the revolution of the screw 69 in the other direction during the descent of the coupler, a pin 79, fixed to one arm of the escapement-anchor 74, causes (at the first movement of the anchor) the detent 78 to be lifted out of engagement with wheel 71, an arm 80 on the detent being also caused to abut against the driving-pawl 76, whereby 76 and 78 are simultaneously disengaged from the ratchet-wheel 71, as shown in dotted lines in Fig. 22. A latch 81, jointed to a prolongation of the detent 78 and provided with a bevel-surface 82, slides at the same time over the beveled end 83 of the armature 84 of electromagnet T, passes beyond it, and is caused by a spring 85 to engage with that armature, so as to hold the driving-pawl 76 and detent 78 out of engagement with the ratchet-wheel 71 until by the attraction of the electromagnet T the armature 84 is retracted and releases the latch 81. The electromagnet T is the one which (in order to return to rest the contact-fingers of the called-line coupler) is the first to receive the "clearing-off" signal, so that the pawl 76 and detent 78 will not become reëngaged until their action is again required. The insulated metallic contact-piece 86, Fig. 21, is carried by the armature-lever 77 of T^2, and in the position of repose of the armature the contact 86 makes a bridge connection between two springs 87 88 and at the end of the stroke of the armature separates the springs 89 and 90 from each other. It thus produces the same effect as the springs l^0 and l^4 and their resting-contacts. (Described in reference to Fig. 2^b.)

Each set of contact-fingers comprises, as shown in Figs. 24, 25, and 26, three contact-fingers Z^0 Z' Z^2, carried, respectively, by stems 91 92 93, the middle one, Z^0, being the service-finger. They are normally held retracted, as shown at z^0 z' z^2 in Fig. 24 and the upper part of Fig. 26. Each stem is pressed forward by a spring 109 and has a stop-pin 94, the three stop-pins of a set being so placed that the service-finger cannot move beyond the service-wire, and the line-fingers can reach the line-wires with which they are respectively to make contact. Thus in Fig. 25 and the lower part of Fig. 26 Z^0 is in contact with W^b and Z' Z^2 are in contact, respectively, with L' and L^2. Each contact-finger consists of a metallic head 95, adapted to enter between the adjacent rows of wires, its edges being covered with insulating material 96, except at the recess 97 at the under side, where the finger makes contact with the wire. Its shank 98 is a spring fixed to a block of insulating material 99, fixed to the end of the corresponding stem 91, 92, or 93.

Contact-fingers' selector.—The mechanism of the contact-fingers' selector comprises two members. The one member comprises a vertical shaft 100, carrying cams 101 at different heights and adapted to act on levers 102, there being a cam 101 and lever 102 for each set of contact-fingers, the cams being spaced at various angular distances apart around the shaft. To one end of each lever 102 a wiper 103 is jointed in such manner as to cause the lever 102 to be oscillated when the wiper is struck by a cam 101, rotating in the direction of the arrow, the wiper being free to yield and allow the cam to pass without actuating the lever when the shaft 100 is rotated in the opposite direction. The other end of each lever 102 is connected by a slot and stud 104 with a retaining-plate 105, fitted to slide in a horizontal plane in guides in a direction at right angles to the stems 91 92 93. Each retaining-plate 105 has three triangular apertures 106, in which enter studs 107, projecting upward from the stems 91 92 93, there being one such aperture 106 for each stem, each aperture being in the form of a right-angled triangle, of which the oblique side 108 acts as a cam to move the stud 107 and the stem to which the stud is fixed, and thus retract the stem against the pressure of its spring 109 when the plate 105 is moved in one direction in its guides. The other member of the contact-fingers' selector comprises a second cam-shaft 110, carrying cams 111, which act on levers 112 through jointed wipers 113, the levers being connected by pin and slot 114 with retaining-plates 115, having triangular apertures 116, entered by studs 117, and whose oblique sides 118 are oppositely inclined to the sides 108 of the apertures 106 in the retaining-plates 105. There is a cam 111, a lever 112, and a retaining-plate 115 for each set of contact-fingers, the retaining-plates 105 and 115 appertaining to the two members of the selector being respectively above and below the stems 91 92 93 of the sets of contact-fingers, the studs 107 and 117 of said stems respectively engaging in the apertures of the said plates 105 115. The levers 102 112 are moved in opposite directions by their cams, and the levers and retaining-plates are normally held in position of repose by springs 119. In this position the pins of the stems 91 92 93, which engage in the triangular apertures of the plates 105 115, are normally retained close against the bases of said apertures, as shown in Fig. 24, by the one or the other, or both, of the plates of a pair; but if shaft 100 be turned so that any one of the cams 101 acts on the corresponding lever 102 and plate 105 the plate will be so moved that the oblique sides of its apertures cease to obstruct the forward movement of the stems 91 92 93. No forward movement of these stems will, however, take place unless the associated plate 115 also ceases to obstruct the forward movement of the same stems. This happens when the cam-shaft 110 (of the second member of the selector) already occupies or is rotated to such a position that the associated plate 115 is

caused by the action of the corresponding cam 111 and lever 112 to assume a position (relatively to the stems) analogous to that to which plate 105 has been brought by the action of cam 101, as above described, or conversely, plate 105 may be left in such position that it does not obstruct the contact-fingers of the set to which it belongs, and the plate 115 may be brought by the cam 111 to the corresponding position. The three stems being thus in either case entirely freed will then be projected forward by their springs 109, and the fingers Z^0 Z' Z^2, carried by them, will make contact with the wires W^b L' L^2 (on the coupling-board) of the row to which the fingers have been brought opposite, the forward movement of the fingers being so limited by the stops 94 that each finger will make contact at 97 with the wire to which it corresponds. This the active position of the fingers is shown in Fig. 25 and the lower part of Fig. 26. The retraction of this set of contact-fingers is effected at the desired moment by the action of one or both of the retaining-plates 105 and 115 appertaining to that set of fingers, said plate or plates being so moved by the action of springs 119 that the cam-like inclined sides of the triangular apertures, acting on the pins of the finger-stems, cause the set of contact-fingers to be retracted.

The cam-shafts 100 and 110, respectively, receive angular motion through ratchet-wheels 121, engaged by pawls 122, carried by the armature-levers 123 of the electromagnets M M'. Coiled springs (not shown) tend to return the two shafts to position of rest, but are prevented from so doing by spring-pressed detents 124, which retain the shafts 100 and 110 in the position to which they are moved by the electromagnets M M', respectively. On each shaft there are as many cams as there are sets of contact-fingers in the coupler; but the arrangement of the cams is different for the two shafts, being such that for a given angular motion of each shaft there will be only one set of contact-fingers, both of whose retaining-plates will concurrently permit the contact-fingers to be projected forward into and remain in operative position. The number of sets of contact-fingers in the coupler determines the number of current emissions in the selection-signals in conformity with the formula $x=(m+1)(n+1)-1$, in which x is the number of sets of contact-fingers, while m and n represent the number of current emissions in the signals Nos. 7 and 9, respectively. Thus the comb-like contacts 185 184 (having three limbs and four limbs, respectively) are adapted to meet the case wherein $x=(3+1)(4+1)-1=19$ sets of contact-fingers. For such a number of sets (which may be distinguished as No. 1, No. 2, &c., to No. 19, counting from the top downward) the arrangement of the cams may be as follows: On the shaft 100 the cams 101 corresponding to sets Nos. 16, 17, 18, 19 are in action when the shaft is in position of rest. Then for an angular advance of that shaft equal to one tooth of its ratchet-wheel the cams brought into action will be those of sets 11, 12, 13, 14, 15, for an advance equal to two teeth those of sets 6, 7, 8, 9, 10, and so on, whereas on shaft 110 the cams 111 corresponding to sets Nos. 5, 10, 15 are in action when that shaft is in position of rest. For an angular advance of that shaft equal to one tooth of its ratchet-wheel the cams brought into action will be those of sets 4, 9, 14, 19, and for an angular advance equal to two teeth those of sets 3, 8, 13, 18, and so on.

As the movements of the shafts 100 and 110 are made in response to selection-signals transmitted by the comb-like contacts 184 185 of the signal-composing device, it follows that if one or other shaft is to be left stationary the corresponding signal must not be sent. Therefore the one or other comb-like contact 184 185 must not be presented in the path of brush 164; but as the distribution-signals are required in any case it follows that the plain contact-strips, which alternate with the comb-like contacts, must extend beyond the combs in the upward direction, as shown in Figs. 4, 5, and 8, so as to admit of those plain strips being presented in the path of the brush without the one or the other of the comb-contacts 184 185 being so presented if and according as circumstances require that the one or other selection-signal should be omitted.

The return-to-rest mechanism for the fingers is as follows: To the detents 124 are fixed two vertical rods 125, which (during the whole descent of the coupler) remain in position to be acted on by the T-head 126 of an arm attached to the armature-lever 84 of electromagnet T, so that when the latter is excited by the return-to-rest current, as already described, it attracts its armature, and the T-head 126, acting on the rods 125, disengages the detents 124 from ratchet-wheels 121, whereupon the shafts 100 and 110 (or whichever one of them may have been rotated) will be returned to rest each by a spring, (not shown,) so that the set of contact-fingers (supposed to have been projected forward by the action of the cams) can be returned to rest by the action of the inclined sides of the apertures of the corresponding retaining-plates when such plates (or plate) are (or is) returned by the action of springs 119.

Other forms of contact-fingers' selector might, however, be used. For instance, an arrangement similar to that hereinafter described in respect of the calling-line coupler might be used, each set of contact-fingers being under the control of a small electromagnet, the two series of currents which have been employed to rotate the cam-shafts being used to rotate the brushes of two small distributers and, according to the combinations formed by these two brushes, the current of a special signal will be sent to the one or other of these small electromagnets and set

free the one or other set of contact-fingers. The contact-strip 180 in the signal-composing device, Fig. 5, which is shown without connection, would be used for sending this special signal, the said strip being for this purpose coupled to the strips 181 182 183. In this case it will be necessary to add a pair of contact-pieces between the fourth and fifth pairs of each of the five sectors of the distributer G and two pairs of contact-pieces between the sixth and seventh pairs of the distributer F. Similarly all the sets of contact-fingers in a called-line coupler may be connected so as to make contact all at once with the rows of wires of the coupling-board to which they are opposite, the contact-fingers' selector having in this case for function (by means of two distributers such as have just been referred to) to put (or to leave) electrically in circuit the set of contact-fingers to be made use of to the exclusion of all the others.

Calling-line coupler.—The calling-line coupler shown in Figs. 27, 28, and 29 is similar (as regards general construction, arrangement, and operation) to the called-line coupler, from which, however, it differs in various respects, as hereinafter pointed out. It comprises a supporting-frame 230, carrying as many sets of contact-fingers as there are sets of five rows of wires in the coupling-board, the sets of fingers being superposed and spaced like those of the called-line coupler. The calling-line coupler is fitted to slide in vertical guides, in which it is capable of descending by a continuous movement when released by the action of a single prolonged current emission sent in response to the final signal. This movement might, however, be an upward traversing motion. The two line-fingers Y' Y^2 of each set of three contact-fingers are normally retained out of operative position by suitable means, as shown at y' y^2 in Fig. 28, while the service-finger Y^0 is free and is always pressed forward by a spring, so that during the traversing movement of the coupler the service-fingers rub against the service-wires W^a of the coupling-board. As soon as one of these service-fingers Y^0 meets the service-wire W^a of a line calling the traversing movement of the coupler is arrested, as explained under the heading of Signal No. 9, Case 1, "line disengaged," and the line-fingers of the set to which that service-finger appertains are released and come into contact with the line-wires L' L^2 of the line calling. In the example shown in Figs. 27, 28, and 29, the coupler descends along a screw-spindle 231, Figs. 28 and 29, mounted in collar-bearings carried by the frame 66 of the coupling-board in the same way as the similar screw 69 of the called-line coupler and at the opposite side of the coupling-board. Upon this screw-spindle travels a nut 232, by which the frame 230 is supported, and to the screw is fixed a ratchet-wheel 233, with which engages a spring-pressed detent 234. The descending movement of the coupler begins when by the electromagnet Q being excited its armature-lever 236 (which engages by its forked end 235 with a pin 237, fixed to detent 234) disengages said detent from the ratchet-wheel 233, an arm 238 of said detent in turn disengaging the driving-pawl 239 from the ratchet-wheel 233. The reverse rotation of the screw 231 and the consequent return of the coupler to its initial position, are effected by means of the electromagnet V^3, whose armature-lever 240 carries the driving-pawl 239 and also the insulated metallic piece 241, which latter breaks in succession the electric connection between the springs 242 243 and 244 245. The insulated spring 246 and contact-screw 247 serve to establish the connection (which is represented in Fig. 2^a as formed directly) between the armature of electromagnet Q and its resting contact.

Fig. 27 is a part-sectional plan of the mechanism of one set of fingers. The stem 248 of the service-finger Y^0 is constantly pressed by its spring 249 toward the service-wires W^a. The said finger is insulated from its stem and has a T-shaped head, as shown in Fig. 28, the vertically-extending arms of the T being faced with insulating material and slightly recurved, as shown, the most salient portion of the curved face being conductive. The purpose of this T-shaped head is to prevent the finger entering between any two adjacent rows of wires or even to enter the gap between different sets of wires, the conductive portion of this T-head making contact with only one service-wire at a time.

The line-fingers Y' Y^2 are similar to those of the called-line coupler. They are carried by stems 250, each pressed forward by a spring 251 and each provided with a tooth 252, which is engaged by a detent 253, the two detents, which correspond to the two line-fingers Y' Y^2 of a set, being mounted upon the armature of an electromagnet R', electrically connected by wire 254 to the service-finger Y^0 of this set. When this electromagnet R' attracts its armature, the detents 253 are disengaged from the teeth 252, and the line-fingers Y' Y^2 are projected forward to an extent limited by stops 255, so that the fingers Y' Y^2 will respectively make contact with the line-wires L' L^2 of the row to which they have been brought opposite.

For effecting the return to rest of the fingers Y' Y^2 each stem 250 has a pin 256, and for each set of fingers there is a rock-shaft 257, having a U-shaped arm 258, adapted to engage by its transverse portion with both of the pins 256, the rock-shaft having another arm 259, (at right angles to the arm 258,) through the forked end of which passes a pull-rod 260, which is attached at one end to a spring 261 and at the other to the armature 262 of electromagnet V' and which carries collars 263. When the stems 250 are liberated and moved forward by their springs 251, their pins 256 oscillate the arms 258 and 259, bringing the arm 259 close up to the correspond-

ing collar 263, so that when the electromagnet V′ is excited and attracts its armature 262 the collar 263 (acting on the forked arm 259) rocks the shaft 257 in the opposite direction and through the arm 258 and pins 256 retracts the stems 250 and reëngages their teeth 252 with the detents 253. The rod 260 is common to all the sets of line-fingers on the coupler, so that whichever set has been brought into use will be retracted by the operation of magnet V′. The springs 264 265 serve to establish the contact, which is described with reference to the diagram Fig. 2ª as being made between the armature and working contact of electromagnet V′ for the purpose of sending the clearing-off current to the magnets V^2 V^3, by which the calling-line coupler is raised to initial position after its line-fingers have been retracted.

If the number of subscribers is such as to require a greater number of selector-circuits than can be controlled by the main selector above described, which has nine circuits, two means are available.

First. A sort of compound selector by making dependent on a primary main selector of the kind described a number of circuits respectively leading to the metallic piece D^0, Fig. 12, of as many secondary main selectors, two racks carrying contacts exactly similar to those of rack No. 145 being interposed between racks 144 and 145 in the signal-composing device. The first signal sent will act as described on the connector, while the four following signals then sent would determine the choice of the secondary main selector, which in turn would determine the selector-circuit dependent on that secondary main selector, the number of selector-circuits possible being in that case $9 \times 9 = 81$.

Second. Such multiplicity of apparatus may, however, be avoided by using a main selector having more than two members and controlling more than nine selector-circuits. For instance, I may use a selector having twenty-seven contact-springs similar to those described and having three members, each member being formed, as before, of three rods, each controlled by its own electromagnet and each rod acting by nine insulated lugs on nine contact-springs. To actuate such a selector having three members, there would be introduced between racks Nos. 144 and 145 an additional rack carrying contacts similar to those of rack No. 145.

In both the above cases there must be added to each sector of the main distributer B as many additional pairs of contact-pieces as there are racks added to the signal-composing device, the remainder of the apparatus remaining unchanged.

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

1. In an automatic telephone-exchange system, the following instrumentalities in operative combination, viz: subscribers' lines divided into groups, the lines of each group being presented on its own coupling board or boards having calling and called line contacts in pairs whose members correspond to the two members of a line, and service-contacts for the service of the exchange mechanisms, said line and service contacts being regularly arranged in series of rows so as to be accessible by a plurality of suitably-located coupling devices, a plurality of coupling devices, each comprising two independently-movable, electrically-propelled, and electrically-associated mechanisms termed couplers, said couplers being respectively appropriated, the one for making connection with a called line, and the other for making connection with a calling line, each coupler being adapted to move across its board, the said couplers comprising a plurality of sets of line and service contact-fingers, said sets respectively corresponding to the several series of rows of contacts on the coupling-board, each set comprising a pair of line-fingers whose members are appropriated to make contact respectively with the members of a pair of line-contacts, and a service-finger appropriated to make contact with the service-wire corresponding to such pair of line-contacts so that each set of line and service fingers is adapted to make contact with the line and service contacts of one or another row of contacts of the series to which that set corresponds; all the fingers of like function in the one coupler being in electrical connection with each other, and a magnetically-operated multiple switch or distributer in connection with the called-line coupler for connecting the same at predetermined moments with the fingers of corresponding function of the associated coupler, there being as many couplers of each function located at each coupling-board of similar function, as there are groups of lines, and the couplers, of the kind appropriated to make connection with calling lines, which are located at any one calling-line coupling-board, being electrically associated with couplers, of the kind appropriated to make connection with called lines, which are severally located at called-line coupling-boards severally appertaining to different groups of lines; so that each said coupling device is adapted to telephonically couple together any two lines on the coupling-boards at which the two couplers, forming said coupling device, are respectively situated.

2. In an automatic telephone-exchange system, the combination of subscribers' lines divided into groups, the lines of each group being presented by line and service contacts, coupling-boards or pairs of coupling-boards respectively representing different groups of lines, coupling devices for connecting the subscribers' lines for conversation, the location of their constituent couplers relatively to the coupling-boards being such that those

couplers which appertain to any one group of lines are electrically associated with couplers which severally appertain to different groups of lines, and comprising in their structure two electrically-operated couplers, respectively distinguished as called-line coupler and calling-line coupler, said couplers being independently movable each across a coupling-board, and each comprising a plurality of sets of electrically-controlled contact-fingers, the fingers of like function of all the sets comprised in each coupler being electrically connected, and the fingers of the called-line coupler being electrically connected at predetermined moments with the fingers of like function, of the calling-line coupler, and a multiple switch or distributer for effecting such connection and by which also the movements of the called-line coupler as a whole are controlled, an electrically-operated selector for controlling the sets of fingers of the called-line coupler, electromagnetic mechanism in the circuit of the service-finger of each set for controlling the sets of fingers of the calling-line coupler, each such electromagnetic mechanism being dependent for its action (on the one hand) on the action of the distributer of the called-line coupler and (on the other hand) on the completion of its own circuit, by the service-finger of the corresponding set of fingers of the calling-line coupler making contact with the service-contact (of the calling line) which has been earthed, through the operation of an electromagnetic commutator or connector appertaining to that line, there being such a commutator in connection with each line.

3. In an automatic telephone-exchange system, the combination of subscribers' lines divided into groups the lines of each group being presented by line and service contacts, a plurality of coupling devices each composed of two electrically-associated mechanisms or couplers independently and electrically movable across the line and service contacts of a group of lines, one of such associated couplers being appropriated for making connection with a called line, and the other for making connection with a calling line, each such coupler being provided with a plurality of sets of line and service contact fingers, electrical connections between the fingers of like function of all the sets of the one coupler, and means for connecting the same at predetermined moments with the fingers of like function of all the sets of the associated coupler, electrically operated or controlled contact-fingers' selecting mechanism, said mechanism being constituted by a plurality of members, the operations of the several members being so coördinated that by their conjoint action one only of the several sets of contact-fingers will be enabled at one time to make operative contact with a set of line and service contacts.

4. In an automatic telephone-exchange system, the combination of subscribers' lines divided into groups, the lines of each group being presented by line and service contacts, a plurality of coupling devices each composed of two electrically-associated mechanisms or couplers independently and electrically movable across the line and service contacts of a group of lines, one of such associated couplers being appropriated for making connection with a called line and the other for making connection with a calling line, each such coupler being provided with a plurality of sets of line and service contact fingers, the fingers of like function of all the sets of the one coupler being electrically connected with each other and connected at predetermined moments with the fingers of like function of all the sets of the associated coupler, a multiple switch or distributer in connection with the called-line coupler for effecting such predetermined connection, contact-fingers' selecting mechanism for the called-line coupler, the said selecting mechanism being constituted by a pair of cam-like retaining-plates for each set of contact-fingers, the plates of each acting independently on the contact-fingers of a set, and independently-operated cam-shafts common to all the pairs of plates of a coupler to operate the same, with means for so coördinating the operation of the cams that by their conjoint action one only of the several sets of contact-fingers will, at one time, be enabled to make operative contact with a row of line and service contacts.

5. In an automatic telephone-exchange system, the combination of subscribers' lines grouped on coupling-boards substantially as described, a plurality of coupling devices each composed of two electrically-associated mechanisms or couplers independently and electrically movable each across a coupling-board and provided each with a plurality of sets of contact-fingers electrically associated as described, the two couplers of a coupling device being adapted, the one to make contact with calling lines and the other with called lines, the electrically-operated contact-fingers' selector for controlling the contact-fingers of the coupler for making contact with a called line being under electrically-operated combined escapement and propelment mechanisms the escapement mechanism being adapted to throw the propelment mechanism out of action and to permit the said coupler to move step by step across the coupling-board in the one direction, and to control the extent of such movement, and the propelment mechanism being adapted to cause the said coupler to return step by step in the opposite direction.

6. In an automatic telephone-exchange system, the combination of subscribers' lines grouped on a coupling board or boards as described, a plurality of coupling devices combined with said coupling board or boards each such coupling device being constituted by two electrically-operated couplers (respectively distinguished as called-line coupler and

calling-line coupler) with electrical means for moving the said couplers each across a coupling-board, each coupler comprising a plurality of sets of electrically-controlled contact-fingers, the fingers of like function of all the sets comprised in each coupler being electrically connected, a rotary multiple switch or distributer associated with each coupler appropriated to make contact with called lines, a combined escapement and propelment mechanism associated with the called-line coupler, circuit connections such that the movement of the coupler as a whole will be controlled by said distributer; a contact-fingers' selector, circuit connections of the said distributer with the respective members or operative mechanisms of the contact-fingers' selector adapted to determine the bringing into operative position of any one set of contact-fingers of the called-line coupler, the circuit connections being such that the coördinated operation of the mechanisms of the said contact-fingers' selector will also be controlled by said distributer; and circuit connections of the said distributer with the service contact-finger and with the actuating mechanism of the line contact-fingers of the calling-line coupler (associated with the called-line coupler to which said distributer appertains) the connections being such that the fingers of the called-line coupler will be electrically connected at predetermined moments with the corresponding fingers of the calling-line coupler.

7. In an automatic telephone-exchange system, the combination of subscribers' lines grouped on coupling-boards as described, a plurality of coupling devices combined therewith, each composed of two electrically-associated couplers independently and electrically movable across a coupling-board and provided each with a plurality of sets of contact-fingers electrically associated as described, the two couplers of a coupling device being respectively adapted to make contact with calling and called lines an electrically-operated contact-fingers' selector controlling the contact-fingers of the coupler adapted for making contact with a called line, electrically-operated mechanism associated with each such calling-line coupler and adapted to set the calling-line coupler in motion across the coupling-board, when actuated by a current, a distributer appertaining to the associated called-line coupler, a selector and service circuit by which the associated couplers are connected, said distributer, and said selector and service circuit forming a path for the passage of a current to actuate the mechanism for setting the calling-line coupler in motion, and electrically-operated arresting mechanisms adapted to arrest the motion of the calling-line coupler, actuated by a current transmitted to such mechanism through the service-finger circuit of the calling-line coupler, on the completion of said circuit by a service-finger of the calling-line coupler meeting a service-wire which has been put to earth, and an electromagnetic commutator or connector appertaining to the line to which such service-wire belongs for putting said service-wire to earth.

8. In an automatic telephone-exchange system, the combination of subscribers' lines divided into groups, the lines of each group being presented by line and service contacts to coupling devices composed of pairs of electrically-operated coupler mechanisms each having sets of contact-fingers, those of the one coupler being selectively controlled and being electrically associated at predetermined moments with those of the other coupler, a multiple switch or distributer for effecting such control and association, the several pairs of associated couplers being located with regard to the groups of lines in the manner described; an electromagnetic multiple commutator or connector connected with each subscriber's line and adapted to establish at the required moment temporary connections of the line-wires and service-contacts (of the line to which it appertains) with the various elements of electromagnetic apparatus at the central station; a combination of electromagnetic apparatus for each group of lines for use in common by all the lines of a group such combination comprising an electromagnetically-actuated rotary main distributer or multiple switch, formed of a plurality of sets of pairs of contacts and of a plurality of brushes revolved together as one over the pairs of contacts, whereby to effect a plurality of circuit changes at each step made by the brushes, a propelment mechanism to actuate the brushes responsive to successive signals of one kind; a main selector comprising a plurality of circuits and a plurality of movable contacts, a plurality of electromagnetically-operated mechanisms, controlling groups of movable contacts of the selector to each of which mechanisms the signals sent are switched in turn by the main distributer, the individual action of each such mechanism depending on the nature of the signals, and the action of the several mechanisms being so coördinated that their conjoint action will be effective to complete one out of a number of selector-circuits respectively connected to the operative mechanisms of different coupling devices; and a manipulator formed of relays and batteries adapted to transmit through the selector-circuit completed, local currents corresponding to the signals which the manipulator receives through the main distributer substantially as herein specified.

9. In an automatic telephone-exchange system, the combination of groups of subscribers' lines with service-wires, coupling devices operatively arranged with respect to the groups of lines, said coupling devices being composed of pairs of electrically-operated couplers, having sets of electrically-associated and selectively-controlled contact-fingers, a set of electromagnetic apparatus for common

use by the lines of a group, an electromagnetic multiple commutator or connector for each line for connecting the line-wires and service-contacts, of the line to which it appertains, with the various elements of the said set of electromagnetic apparatus for common use by the lines of a group; a main distributer, main selector, and manipulator for common use by a group, a rotary return-to-rest distributer or multiple switch formed of a plurality of sets of pairs of contacts and of brushes electromagnetically revolved together as one, whereby to concurrently effect various circuit changes; and electromagnetically-operated mechanisms to which local currents are sent through said return-to-rest distributer, said mechanisms being respectively adapted to return to initial position the line-connecter which has been operated, and the main distributer, main selector, and manipulator of the group to which that line belongs.

10. In an automatic telephone-exchange system, the combination of subscribers' lines divided into groups, and presented by line and service contacts, to coupling devices composed of pairs of electrically-operated couplers, having sets of contact-fingers selectively controlled and electrically associated at predetermined moments as described, the several pairs of associated couplers being located with regard to the groups of lines in the manner described; and connected with each subscriber's line an electromagnetic multiple commutator designated a connector adapted to act as described; and combined with each group of lines a set of electromagnetic apparatus (for use in common by all the lines of the group) comprising an electromagnetically-actuated rotary main distributer or multiple switch, constructed and adapted to act as described; a main selector comprising electromagnetically-operated mechanisms, to each of which in turn the signals sent are switched by the main distributer, the action of the said mechanisms being so coördinated that their conjoint action will have for its effect to complete one out of a number of selector-circuits; and a manipulator formed of relays and batteries adapted to transmit through the selector-circuit completed, local currents corresponding to the signals which the manipulator receives through the main distributer; and the following devices combined with each circuit controlled by the main selector, viz: a double polarized receiver, two rotary distributers or multiple switches, and two different called-line couplers (designated twin couplers) located at different coupling-boards and each provided with electromagnetically-operated mechanism controlling its motion across the coupling-board, and with a contact-fingers' selecting mechanism determining the bringing into operation of one or the other of its sets of contact-fingers, and circuit connections of the double polarized receiver with the distributers, and of the distributers with the mechanisms of the respective couplers of such a character that one or the other distributer and one or the other coupler will be actuated according to the polarity of the first current by which the polarized receiver is influenced, while the other distributer and the other coupler are blocked in position of rest.

11. In an automatic telephone-exchange system, the combination of subscribers' lines divided into groups, and presented by line and service contacts, to coupling devices composed of pairs of electrically-operated couplers having sets of contact-fingers, selectively controlled and electrically associated at predetermined moments as described, the several pairs of associated couplers being located with regard to the groups of lines in the manner described; an electromagnetic multiple commutator or connector connected with each subscriber's line adapted to act as described and combined with each group of lines a set of electromagnetic apparatus (for use in common by all the lines of the group) comprising an electromagnetically-actuated rotary main distributer or multiple switch, constructed and adapted to act as described; a main selector comprising electromagnetically-operated mechanisms, whose action is so coördinated as to complete one out of a number of selector-circuits; and a manipulator adapted to transmit through the selector-circuit completed, local currents corresponding to the signals which it receives; and combined with each such circuit a double-polarized receiver, two rotary distributers or multiple switches, and two different called-line couplers (designated twin couplers) located at different coupling-boards and each provided with electromagnetically-operated actuating mechanism and with a contact-fingers' selecting mechanism, the circuit connections of the double polarized receiver with the distributers and mechanisms of the twin couplers being such that one or the other will be actuated according to the polarity of the first current by which the polarized receiver is influenced; and the following elements combined with each of the twin called-line couplers controlled through the same selector-circuit, viz: a calling-line coupler; each of such two calling-line couplers (designated quasi twins) being provided with electrically-operated mechanism adapted to set the coupler in motion by a current transmitted to said mechanism through the distributer appertaining to the associated called-line coupler, and through the line-finger circuit of the associated couplers, and means for effecting such action, each calling-line coupler being also provided with electrically-operated mechanisms adapted to arrest the motion of the coupler by the action of a current transmitted to such mechanism through the service-finger circuit of the calling-line coupler, on the completion of said circuit by a service-finger of the calling-line coupler meeting a service-

wire which has been put to earth by the previous operation of the connector appertaining to the line to which such service-wire belongs.

12. In an automatic telephone-exchange system, the combination of subscribers' lines divided into groups, and presented by line and service contacts, coupling devices to which said subscribers' lines are presented composed of pairs of electrically-operated couplers having sets of contact-fingers with means for selectively controlling and electrically associating the same at predetermined moments as described, the several pairs of associated couplers being located with respect to the groups of lines in the manner described; a connector comprising an electromagnetic multiple commutator connected with each subscriber's line, a set of electromagnetic apparatus combined with each group of lines (for use in common by all the lines of the group) comprising an electromagnetically-actuated rotary main distributer or multiple switch, constructed and adapted to act as described; a main selector comprising electromagnetically-operated mechanisms to each of which in turn the signals sent are switched by the main distributer, the action of the said mechanisms being so coördinated that their conjoint action will have for its effect to complete one out of a number of selector-circuits; and a manipulator formed of relays and batteries adapted to transmit through the selector-circuit completed, local currents corresponding to the signals which the manipulator receives through the main distributer; and with each such circuit a double polarized receiver, two rotary distributers, and two called-line couplers (designated twin couplers) located at different coupling-boards, the circuit connections of the double-polarized receiver with the distributers and mechanisms of the twin couplers being such that one or the other will be actuated according to the polarity of the first current by which the polarized receiver is influenced; and a calling-line coupler, combined with each of the twin called-line couplers controlled through the same selector-circuit, each of such two calling-line couplers (designated quasi twins) being adapted to be set in motion by a current transmitted to its mechanism through the distributer appertaining to the associated called-line coupler, and through the line-finger circuit of the associated couplers; such calling-line coupler being also adapted to be arrested by the action of a current transmitted to its mechanism through the service-finger circuit of the calling-line coupler; and the following instrumentalities combined with the line-connectors, and with the main distributer, main selector, and manipulator common to the group, and with the mechanisms of the called-line couplers (designated twins) that are controlled through the same selector-circuit, viz: two return-to-rest rotary distributers each formed of a plurality of brushes electromagnetically revolved over a plurality of sets of pairs of contacts, of which the circuit connections (with the mechanisms of the called-line couplers, with the connectors of the lines of the group, and with the main distributer, the main selector, and the manipulator common to the group,) are such that the action of one or the other return-to-rest distributer will be dependent on the previous operation of the distributer of the twin called-line coupler with which such return-to-rest distributer is associated, and will have for its effect to transmit local currents to the several mechanisms with which it is combined whereby to return to initial position the line-connector, main distributer, main selector, and manipulator appertaining to the group.

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