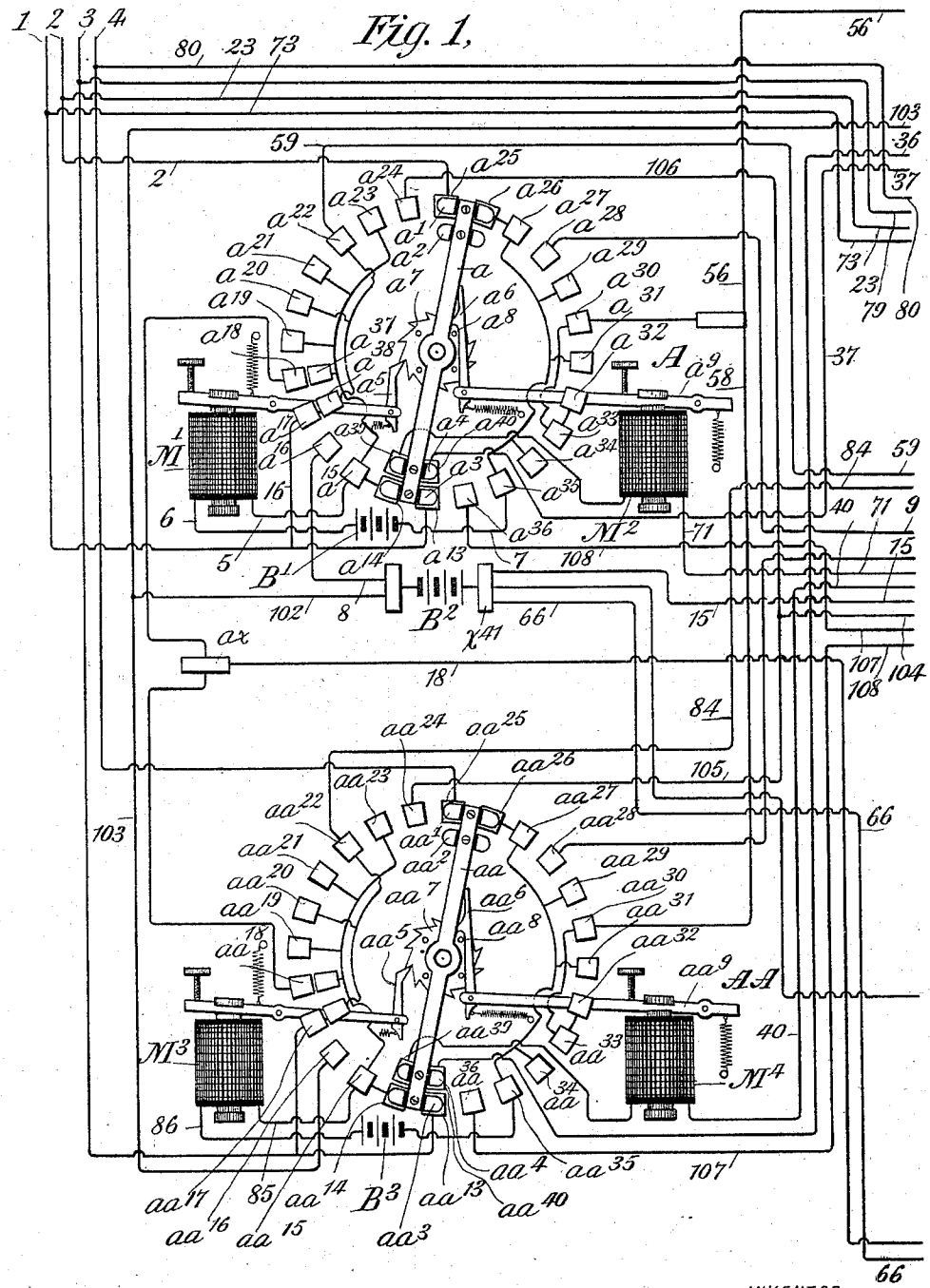
(No Model.) 8 Sheets—Sheet 1.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 573,859. Patented Dec. 29, 1896.

Fig. 1.



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(No Model.) 8 Sheets—Sheet 2.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

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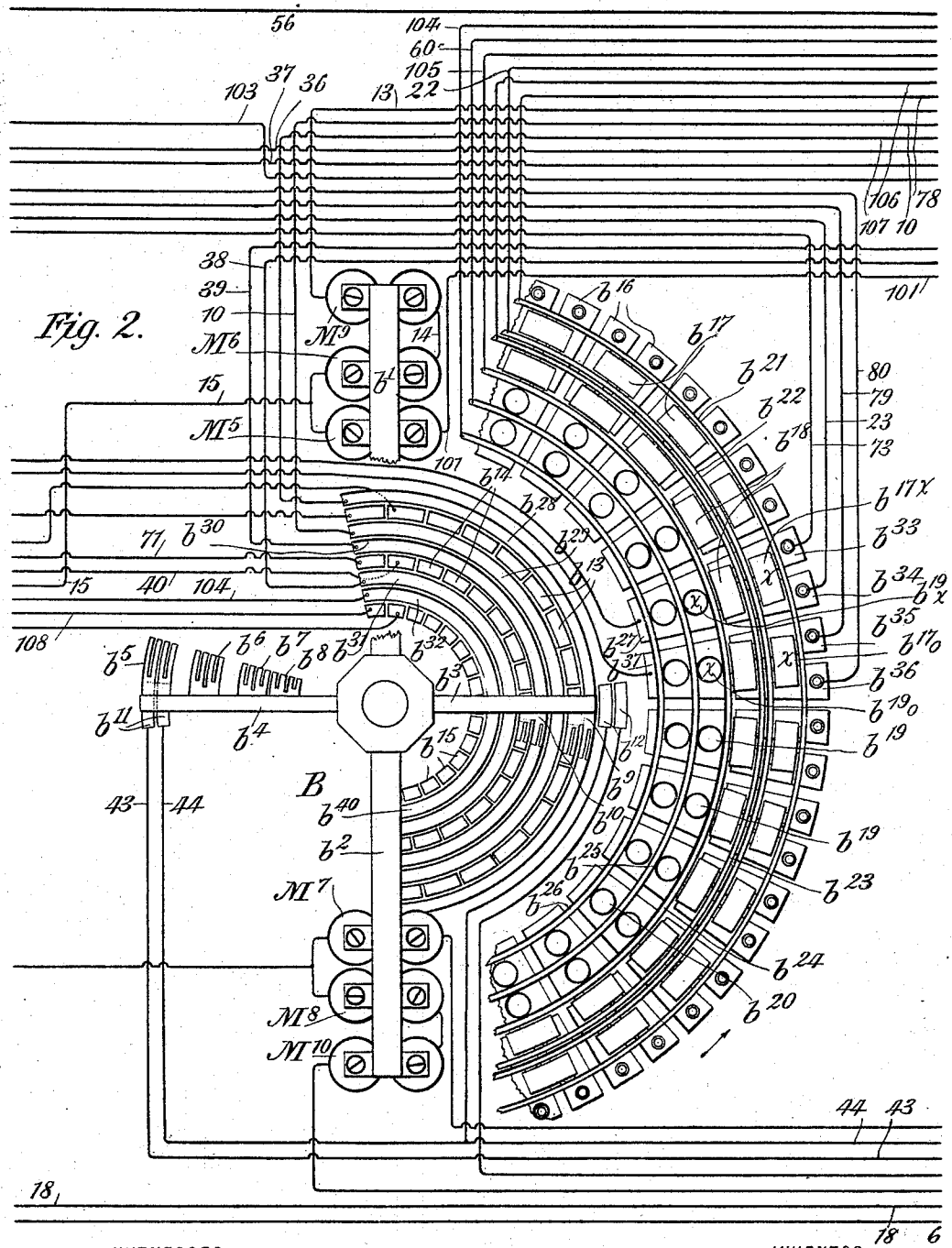
Fig. 2.



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(No Model.) 8 Sheets—Sheet 3.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

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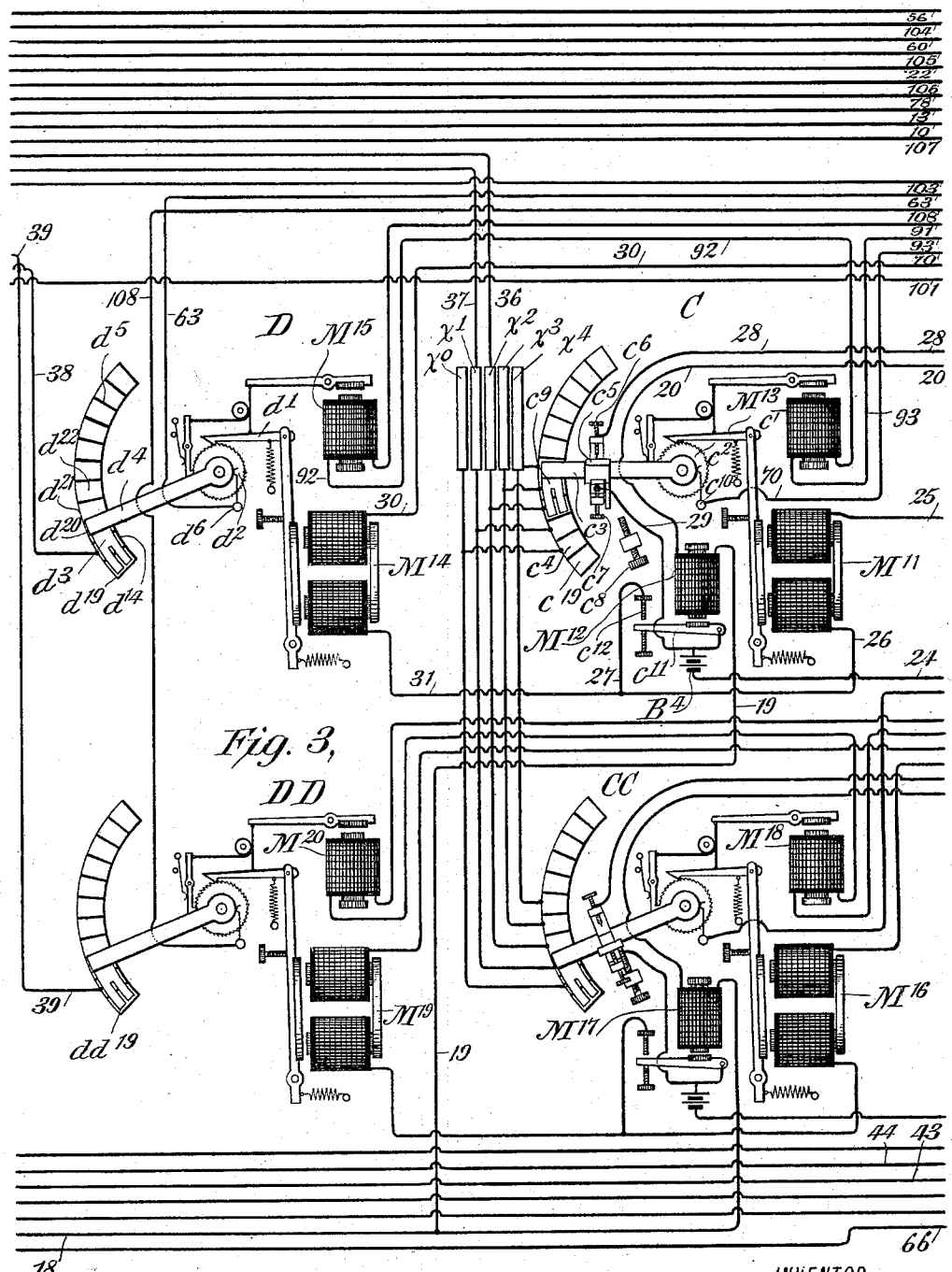

Fig. 3.

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(No Model.) 8 Sheets—Sheet 4.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

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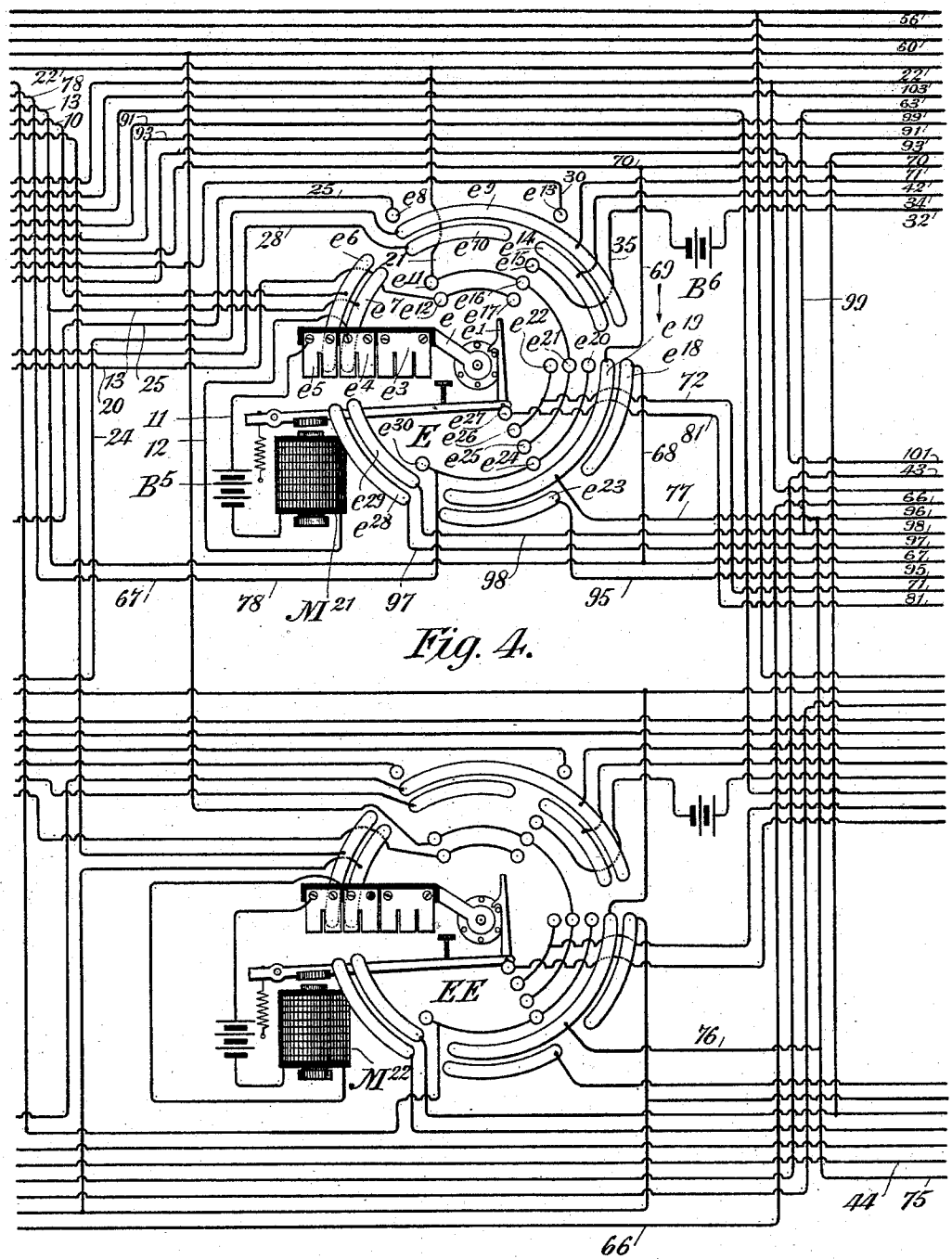

Fig. 4.

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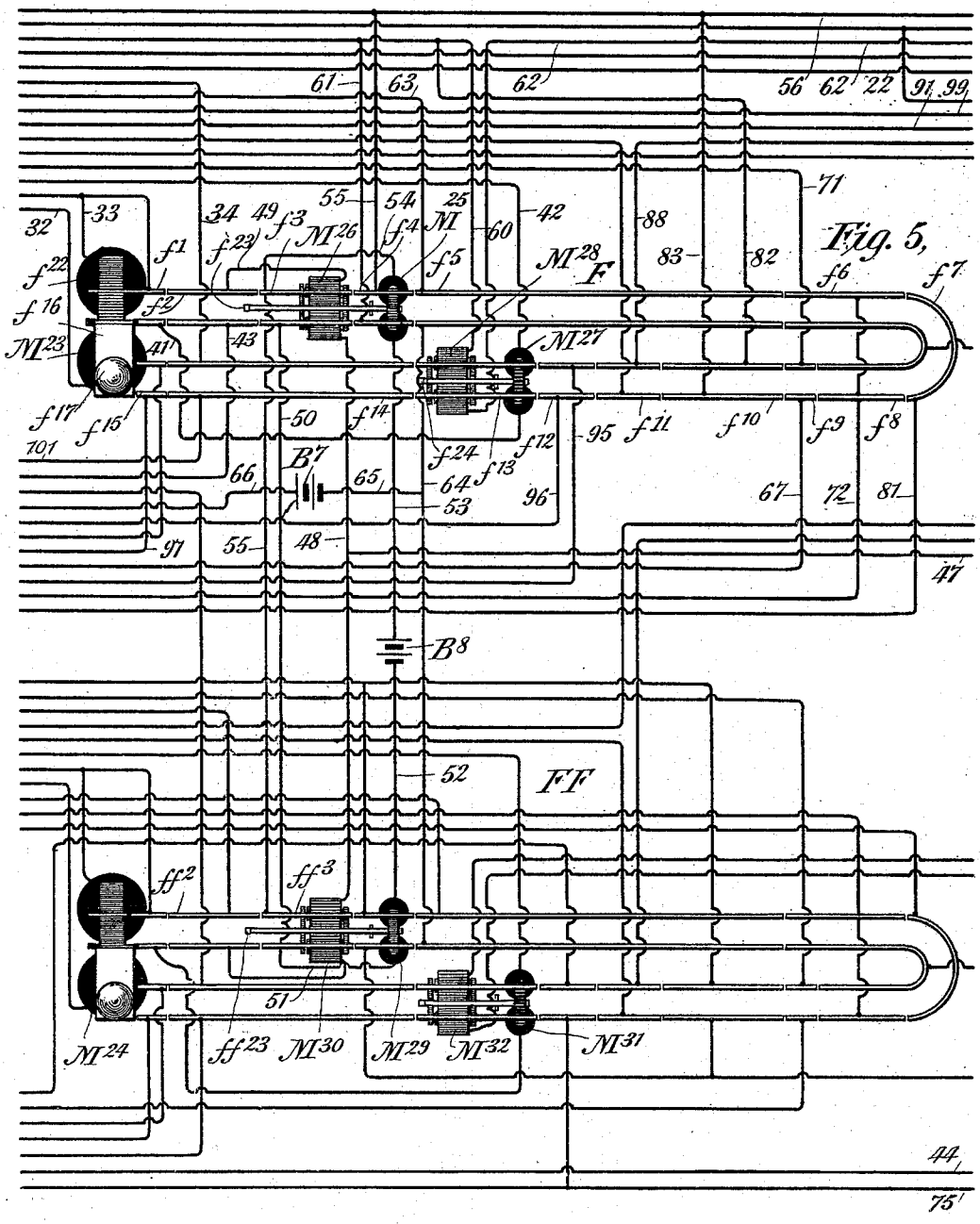
(No Model.) 8 Sheets—Sheet 5.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 573,859. Patented Dec. 29, 1896.



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(No Model.) 8 Sheets—Sheet 6.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 573,859. Patented Dec. 29, 1896.

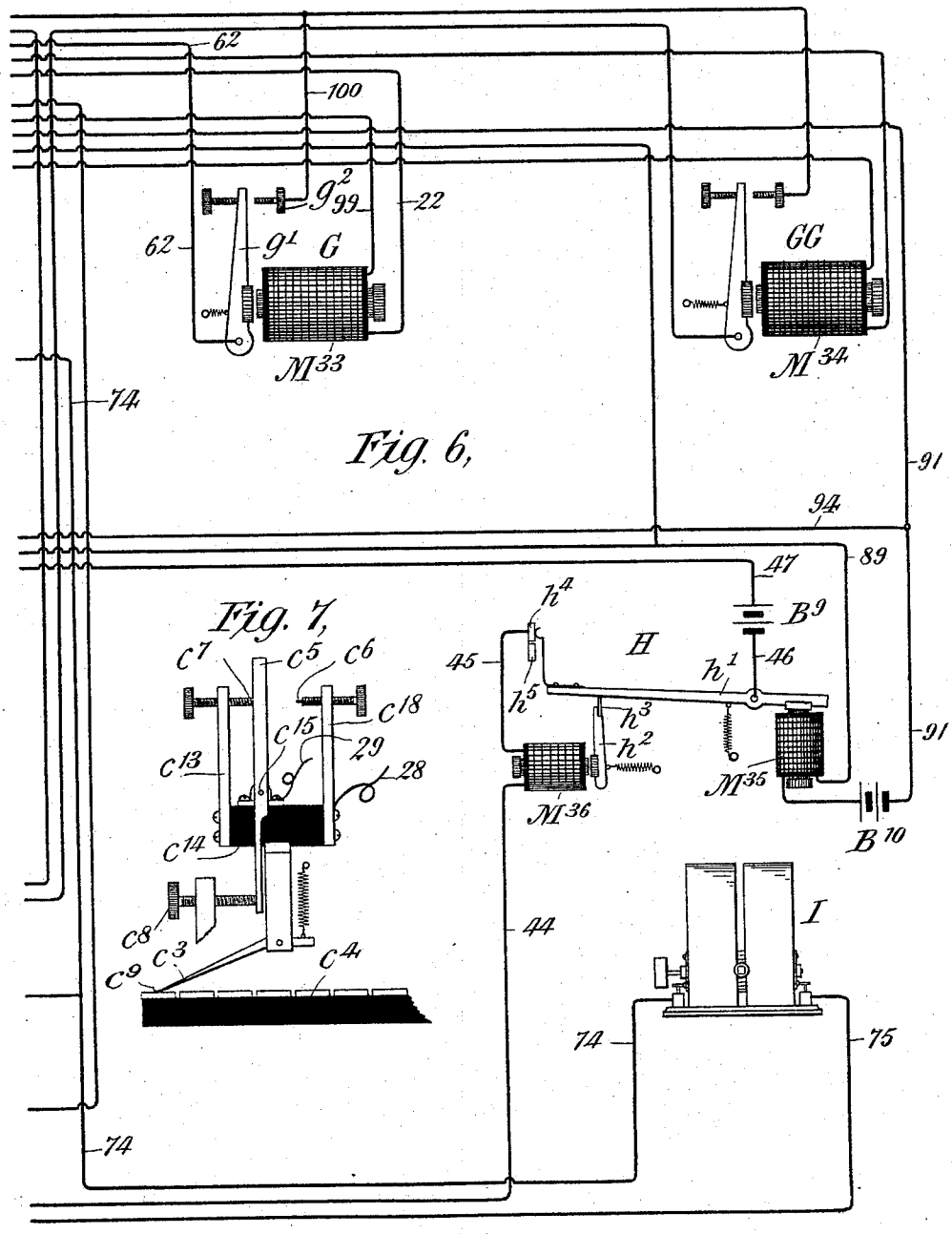

Fig. 6,

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(No Model.) 8 Sheets—Sheet 7.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 573,859. Patented Dec. 29, 1896.

Fig. 8,

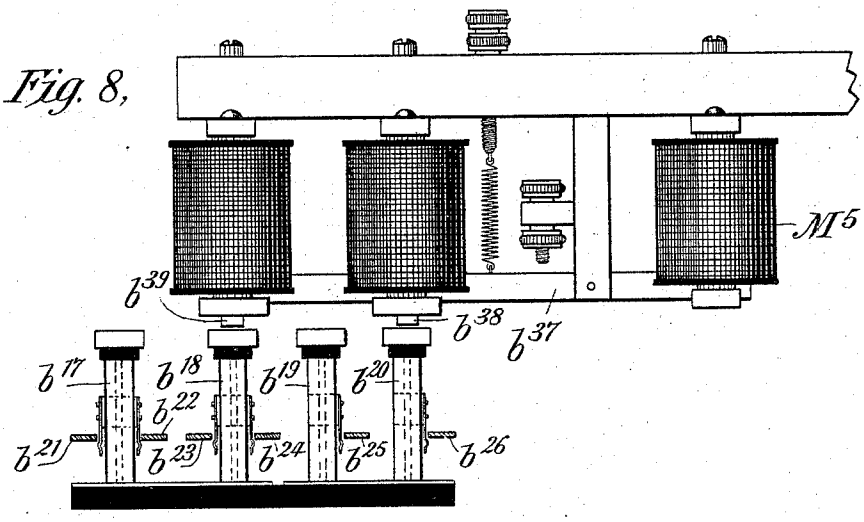
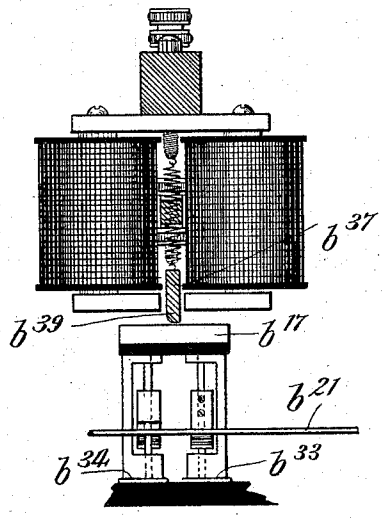


Fig. 9.



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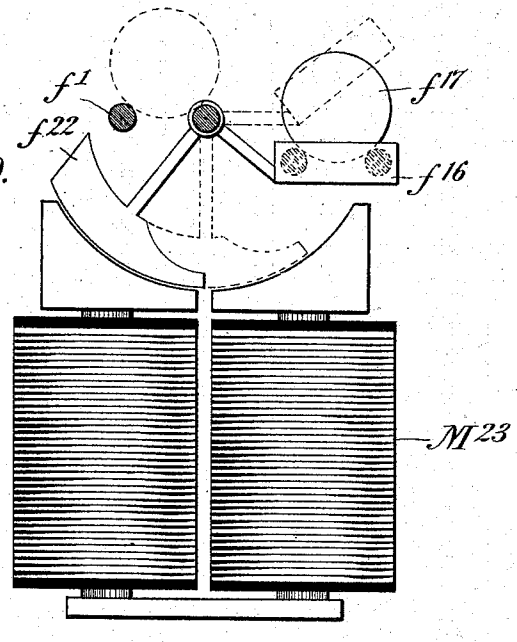
(No Model.) 8 Sheets—Sheet 8.

R. CALLENDER.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 573,859. Patented Dec. 29, 1896.

Fig. 10.



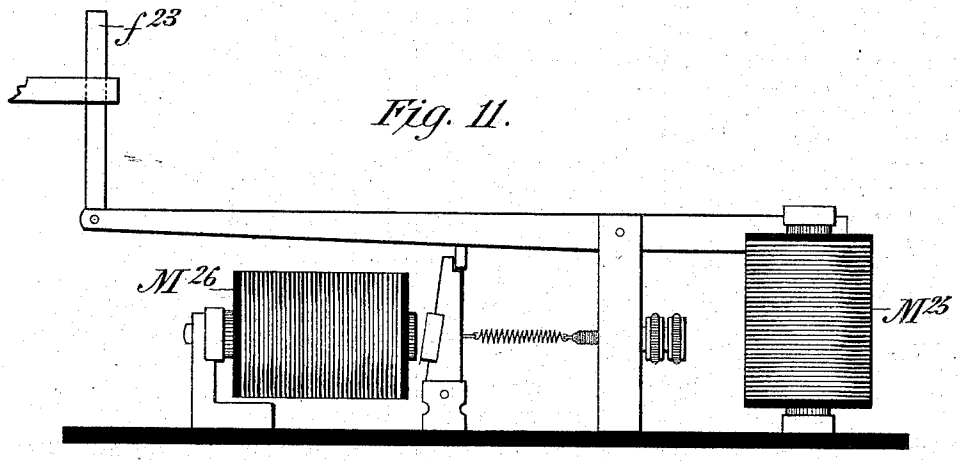


Fig. 11.

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UNITED STATES PATENT OFFICE.

ROMAINE CALLENDER, OF BRANTFORD, CANADA.

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 573,859, dated December 29, 1896.

Application filed March 19, 1893. Serial No. 583,986. (No model.)

To all whom it may concern:

Be it known that I, ROMAINE CALLENDER, a subject of the Queen of Great Britain, residing at Brantford, in the Province of Ontario and Dominion of Canada, have made a new and useful Invention in Automatic Telephone-Exchange Systems, of which the following is a specification.

The present invention is directed to improvements in automatic telephone-exchange systems, and particularly to improvements upon a prior invention described in a United States Patent issued to me on the 2d day of January, 1894, and bearing the issue number of 511,874.

In that specification I have described and claimed a system of automatic intercommunication in which the connections are made through the instrumentality of portable circuit-closers automatically released and directed to the proper connecting-point. I have also claimed a percentage-circuit selector and other features of novelty.

The present invention is intended to simplify the method of intercommunication and apparatus referred to, and the features of novelty are essentially as follows: first, the substitution of percentage-signaling tracks for the individual runways or tracks described in my former patent; second, the substitution of percentage-controlling switches for the numerous switches described in the former patent just referred to; third, the improved means for registering the numbers of the telephones called and for making the registration effective; fourth, in the simplified electrical circuits herein described, and, fifth, in the details of construction of the entire apparatus, as hereinafter described.

The various features of novelty which I deem as of my invention are particularly pointed out in the claims at the end of this specification.

Referring to the drawings which constitute a part of this specification, and in all of which like letters and figures represent like parts wherever used, Figures 1, 2, 3, 4, 5, and 6 are diagrammatic views illustrating the complete and operative parts of a system by showing the circuit connections and mechanism entire for two independent lines which are shown at the top of Fig. 1; Figs. 2 to 6, inclusive, showing those parts of the apparatus adapted to be used by all of the lines in common. Fig. 7 is a side elevational view of the gravity-operated switch or separator. Figs. 8 and 9 are side and end elevational views of the selecting-electromagnets and armature-headed plungers. Fig. 10 is an end elevational view of the operating mechanism for discharging a portable circuit-closer along a track or runway. Fig. 11 is a side elevational view of the mechanism for arresting the motion of the portable circuit-closer when it reaches certain points on the tracks or runways shown in Fig. 5.

In my previous patent hereinbefore referred to the impulses sent into the exchange by the signaling subscriber were caused to operate mechanical turn-tables or switches for the purpose of discharging a portable circuit-closer along that one of the individual tracks corresponding to the number of the telephone called and of thus eventually connecting the caller and the called by the interception of the circuit-closer at a point where the two lines crossed each other. In the present application these turn-tables and tracks as direct means for connecting are abolished. In their place a numeralizing apparatus is substituted for giving effect, electrically, to the registration made by the signaling subscriber of the number of the telephone with which he desires connection. This numeralization is effected through the instrumentality of an apparatus in part similar to my selector and designated the "connector."

In the present apparatus the signaling subscriber, on turning in his call to the central station, has apportioned to him there one of a plurality of signal-registering mechanisms not in use at the time his call arrives. His call being registered on the numerical receivers of the division apportioned to him is next made effective by the numeralizing apparatus, which selects the line called for, if it is not in use at the time, and connects it to the line of the signaling subscriber through the instrumentality of the connector.

The division of apparatus selected by the signaling subscriber includes a signaling track or runway, and over this a portable circuit-closer is released and caused to move at the time the signal is registered for the pur-

pose of signaling to the subscribers when they are connected. This track also acts as a clearing-out apparatus for controlling the mechanisms of its division, and it acts also as an auxiliary for placing the individual switching mechanisms of the subscribers temporarily connected with it into operative relations with the remainder of the automatic mechanisms.

Referring now to the drawings in detail, the whole of which represent central-station apparatus only, and first to Sheets 1 to 6, inclusive, which should be placed side by side in sequence, there are shown at the top of Fig. 1 two pairs of metallic circuits, lines 1 and 2 being for telephone No. 1 and lines 3 and 4 being for telephone No. 2. These circuits run from the subscribers Nos. 1 and 2 to the central-station apparatus here shown, and each circuit includes the usual telephone transmitter, receiver, and magneto call-bell located at the subscriber's telephone-box and each provided with a circuit-interrupting transmitter, which may be similar in form to that shown in my United States Patent No. 515,110, issued February 20, 1894.

A and AA are switches, the arms of which, a and aa, are adapted to be moved forward progressively step by step under the influence of the propelling-electromagnets M′ and M³. These switches are individual, one for each subscriber, the switch A belonging to subscriber No. 1 and the switch AA belonging to subscriber No. 2. The brushes a' a^2, &c., of these switches are adapted to make contact with the various plates over which they travel, and they bring the subscribers' lines into varying relation with the remainder of the central-station apparatus. The electromagnets M² and M⁴, acting on the pins a^8 and aa^8, by means of the pawls a^6 and aa^6 and armature-levers a^9 and aa^9, cause the arms a and aa of these switches to move forward three steps at a time, for a purpose that will be made clear in the description of the mode of operation.

In Fig. 2 is shown the selector and connector B. The arms b', b^2, b^3, and b^4, projecting from the hub, are adapted to be rotated continuously under the influence of an electromotor and in the direction shown by the arrow at the lower right-hand corner of the drawings. M⁶ and M⁸ are selector-electromagnets for bringing into electrical connection with the conducting-rings b^{25} and b^{26} any of the selector-armature-headed plungers b^{19} or b^{20}. M⁹ and M¹⁰ are connector-electromagnets for bringing into electrical connection with the conducting-rings b^{21} b^{22} or b^{23} b^{24} any of the oblong armature-headed plungers b^{17} or b^{18}. M⁵ and M⁷ are releasing-electromagnets for restoring selected plungers to their normal position, the details, Figs. 8 and 9, showing these parts more clearly. The brushes b^5 are adapted to make contact once in every revolution with the plates b^{11} and b^{12}. The brushes b^6, b^7, and b^8 make progressive contacts in their revolution with the individual plates b^{13} b^{13}, &c., b^{14} b^{14}, &c., and b^{15} b^{15}, &c. Each two plates similar to b^{16} are for the line-terminals of an individual subscriber, and they are adapted to bring these line-terminals into electrical connection with the conducting-rings b^{21} b^{22} and b^{23} b^{24} through the instrumentality of the oblong armature-headed plungers b^{17} b^{18} when said plungers are in their uppermost positions. (See Fig. 8.) Each plate similar to b^{27} is adapted to connect a conductor from other apparatus to the conducting-rings b^{25} b^{26} through the instrumentality of the round armature-headed plungers b^{19} b^{20} when said plungers are in their uppermost positions. The conducting-rings, together with the rows of armature-headed plungers arranged around them, control access to the various divisions of the signal-registering apparatus. The continuous metallic rings b^{28} and b^{29} are feed-rings for divisions 1 and 2, respectively, and they are adapted to be brought into successive contact with the individual plates b^{13} b^{13} by the revolving contacting-brushes b^9 and b^6. The conducting-rings b^{30} and b^{31} are adapted to be brought into successive contact with the individual plates b^{14} b^{14} by the revolving contacting-brushes b^{10} and b^7. The conducting-ring b^{32} is adapted to be brought into successive contact with the individual plates b^{15} b^{15} by the revolving contacting-brush b^8.

In Fig. 3 is shown the signal-registering apparatus for two divisions, C D being for the first division and CC DD being for the second division. As these mechanisms are alike, differing only in their external connections, a description of the parts for controlling the registration of signals for division 1 is here given. C is a step-by-step apparatus adapted to make contact with any one of the plates c^4 upon which it may rest. M¹¹ is its operating-electromagnet and M¹³ the releasing-electromagnet, which allows the step-by-step mechanism to fall back to its normal position against the stop c^8. The mechanism C is termed the "units numerical receiver." c^5 is a gravity-operated switch or separator. (Shown more clearly in Fig. 7.) It is normally at rest against the stop c^8, but as soon as the numerical receiver is operated and has come to a position of rest the gravity-lever c^5 falls forward against the contact-screw c^6 and closes a local circuit through relay-electromagnet M¹² for the purpose of switching the signaling impulses into the step-by-step mechanism D, termed the "tens numerical receiver." The step-by-step mechanisms C and D together give a capacity of registration up to ninety-nine. The system here shown having only a capacity for registering numbers up to ninety-nine no gravity-operated switch or separator is shown on the mechanism D, but it is to be understood that when another step-by-step mechanism or hundreds numerical receiver is added, giving signal-registering capacity up to nine hundred and ninety-nine

numbers, then an additional gravity-operated switch or separator becomes necessary for the mechanism D in order that a circuit may be made up for hundreds impulses through the additional or hundreds numerical receiver. These receivers control the action of numeralizing or making effective the numbers registered on them, and their circuits will be clearly described in the course of the description of the mode of operation of the whole apparatus.

Fig. 4 shows the percentage-controlling switches for two divisions, E being the switch for controlling division 1 and EE being the switch for controlling division 2. Referring to the switch E, M^{21} is the operating-electromagnet for causing the arm d to move around in the direction shown by the arrow, carrying the contact-brushes e^3, e^4, and e^5 over the contact-plates lying in their paths. The parts and action of switch EE are identical with those of E, the external connections only differing.

Fig. 5 shows the signaling tracks or runways for two percentage-divisions, F being for the first division and FF for the second. M^{23} is the operating-electromagnet for discharging the ball or portable circuit-closer onto the first section of track f'. The track has a continuous downward inclination or grade and the ball, therefore, impelled by gravity, proceeds along over the various sections f', f^2, f^3, &c., until it finally falls into the trough or hopper at f^{16} ready for another excursion. The various sections f', f^2, f^3, &c., are for causing the closure of certain circuits as the metallic circuit-closer bridges the rails, and these circuits will be made clear in the course of the description. The electromagnet M^{25} is for placing an obstruction in the way of the ball or moving circuit-closer, as shown in Fig. 11, where f^{23} is the point raised from between the tracks to intercept the rolling ball and hold it there until the release-electromagnet M^{26} operates to drop the point f^{23} and thus allow the ball to travel on. The electromagnets M^{28} and M^{27} act in the same manner at the track-section f^{18}, for a purpose to be described later. The parts of the signaling track or runway FF are exactly similar to those of F and require no detailed description.

Fig. 6 shows the general release-relays G and GG for divisions 1 and 2, respectively. One of these relays is automatically placed in shunt with the final circuit, made up between any two subscribers' telephones, so that when a release impulse traverses the line from either telephone the relay G or GG of the division in use causes the restoration to normal of the pair of connected lines, as well as of what apparatus may then be under the control of the two subscribers connected through the divisions controlled by G or GG.

Before describing the mode of operation it would be well to state that in this system every subscriber has one switch at the exchange similar to A or AA in Fig. 1. Each subscriber's switch is normally in the position shown, and in that position the subscriber has direct control over his switch, but is not in operative connection with any of the remaining apparatus. On turning in a preliminary impulse, however, each subscriber may alter the position of his switch A or AA and thus bring himself into operative connection with the selecting and switching mechanism.

I will now describe the mode of operation of the apparatus illustrated in Figs. 1 to 6, inclusive, assuming, first, that No. 2's circuit or line is not in use. I will then describe the operation of the apparatus upon the assumption that No. 2's circuit or line is in use.

Subscriber No. 1 causes a single preliminary current impulse to be transmitted from the signaling-battery, located at his transmitter, over the line 1 to the contact-plate a^{13}, resting under brush a^3, carried by the arm a of the switch A. The contact-brushes a', a^2, a^3, and a^4 are insulated from the arm a. The circuit, therefore, traced to the plate a^{13} under the right-hand side of the brush a^3, passes, by way of brush a^3, to left-hand plate a^{14}, over which it is also resting, thence by way of short conductor to plate a^{15}, and by short conductor 5 to propelling-electromagnet M', thence by conductor 6 to the battery B', thence by short conductor 7 to plate a^{35}, thence by conductor connecting that plate to plate a^{27}, and through that plate and short conductor to plate a^{26}, thence through brush a' to a plate a^{25}, and back by conductor 2 to the subscriber's signaling-battery, located at his telephone. The subscriber's local battery and the central-station battery B' are thus placed in series, and the closure of the circuit just described causes the switch-arm a to move forward one step under the influence of the electromagnet M', operating its armature-lever, and by pawl a^5 communicating motion to the ratchet a^7. The brush a' of the arm a is thus caused to be brought over and into contact with the plates a^{27} and a^{28}, while the same motion causes the brush a^3 at the other end of the arm a to be brought over and above and into contact with the plates a^{15} and a^{16}. The circuit just described is ruptured by this movement, as the contact-brushes are moved from the plates through which the circuit was completed. The placing of the subscriber's battery in series with the central-station battery is not a necessary feature of my apparatus, as I have already shown in my former patents how the subscriber's lines may terminate at relays in the central station. The movement of the switch A, just described, having brought plates a^{27} and a^{28} into electrical connection with each other and the same movement having also connected together, electrically, plates a^{15} and a^{16}, a new circuit is thus made up through the central-station apparatus. This circuit I term the "selecting-circuit," as by means of it any individual switch, such as A or AA, may be operatively connected to the signal-

registering and other mechanism required for making up the connection between any two telephones.

It would be well to remark here that under my system a plurality of signal-registering mechanisms is provided in proportion to the computed maximum number of simultaneous users of the system. For instance, if there are one hundred subscribers connected to the exchange, and if ten per cent. is the maximum percentage of simultaneous users, then the signal-registering and auxiliary mechanisms C, D, E, F, and G, Figs. 3, 4, 5, and 6, would be multiplied ten times, while the selecting and connecting apparatus shown at B in Fig. 2 would have ten double rows of conducting rings and plungers instead of the two double rows shown. I have purposely shown two complete selecting and connecting divisions for the purpose of simplifying the drawings and description. The foregoing reference to the percentage of use shows clearly how the system is extended. The preliminary impulse over the circuit described and the consequent movement of the arm a of the switch A in Fig. 1 over the plates a^{27} a^{28} and a^{15} a^{16} brings the switch A into position for selecting some one of the duplicate sets of apparatus controlled by the rotary mechanism B, Fig. 2. It will be noticed that the subscribers' line-terminals 1 and 2, ending at plates a^{13} and a^{25}, are now in open circuit, as the brushes a^3 and a' are now on other plates. The circuit now to be traced, therefore, is entirely within the exchange and is as follows: commencing at the battery B^2, Fig. 1, and to the left and up by short conductor 8 to plate a^{16}, thence through brush a^3, now resting on the plate, to plate a^{15} and down and to the left by short conductor 5 to electromagnet M′, thence by conductor 6 to the battery B′, thus placed in series with battery B^2, thence by conductor 7 to the plate a^{35}, and then by the inner conductor from that plate to plate a^{27}, upon which the brush a' is now resting, thence through the brush a' to the plate a^{28} and to the right by conductor 9 and to Fig. 2, terminating at its individual selecting-plate of the series b^{13}. Presuming that brush b^6 is the first one to pass over the individual plate at which terminates conductor 9, the circuit may now be traced and continued from conductor 9 and its individual plate through brush b^6, supposed to be now connecting the individual plate with the divisional feed-ring b^{29}, thence by way of conductor 10 up and to the right and through Fig. 3 to Fig. 4 and down and to the right, terminating at the contact-plate e^6 of the switch E, which controls the first division of the percentage mechanism. It will be noticed that one side of the contact-brush e^5 is resting on the plate e^6. Consequently the circuit may be traced by way of the brush e^5 and short conductor 11 to the battery B^5 and electromagnet M^{21}, and, returning by way of conductor 12 to the contact-brush e^4 and thence to plate e^7, upon which that brush is resting, it leads from the plate e^7 to the left by conductor 13 and up and through Fig. 3 to Fig. 2 and down to connector-electromagnet M^9 of the first division. Passing through the coils of M^9 and by way of short conductor 14, it leads through selector-electromagnet M^6 of the first division to conductor 15, to the left and down, and again to the left to Fig. 1, where it leads to battery B, the starting-point.

It will be obvious that instead of coupling up in series the batteries B′, B^2, and B^5, I may use one battery B^2, and may control the switches A and E by relays. Such a plan is shown in my former patents, and I have illustrated it in the manner here shown in order to simplify the circuits.

The action brought about by the closure of the foregoing circuit is as follows: The switch-arm a of the switch A is advanced another step under the influence of the circuit closed through the propelling-electromagnet M′, so that the brush a' now rests on plates a^{29} and a^{30}, while the brushes a^3 and a^4 at the other end of the arm a now rest on plates a^{17} a^{18} and a^{37} a^{38}, respectively. Simultaneously with the foregoing action the connector and selector electromagnets M^9 and M^6 of the apparatus shown in Fig. 2 were just over those armature-headed plungers of series b^{17} and b^{19} with which the connecting-plates b^{33}, b^{34}, and b^{27} register. The closure of the circuit through the electromagnets M^9 and M^6 at the time these magnets are passing over the plungers connected with plates b^{33}, b^{34}, and b^{27} causes the oblong armature-headed plunger $b^{17\times}$ to be raised into electrical connection with the conducting-rings b^{21} and b^{22} and the round armature-headed plunger $b^{19\times}$ to be raised into electrical connection with the conducting-ring b^{25}. The closure of the same circuit, through electromagnet M^{21} of the divisional controlling-switch E, Fig. 4, causes the arm e of that switch to advance, carrying with it the brushes e^3, e^4, and e^5, and thus bringing these brushes into electrical connection with the contact-plates e^8, e^9, e^{10}, e^{11}, and e^{12}. Several new circuits are now brought into action as a consequence of the acts just described.

Referring to Figs. 2, 8, and 9, it will be noticed that the oblong armature-headed plungers have two metallic contact-springs insulated from each other. It will also be noticed that when the plunger is raised the right-hand spring (see Fig. 9) contacts with the outer conducting-ring b^{21}, while the left-hand spring makes contact with the inner conducting-ring b^{22}. It will further be noticed that when the round-headed plunger b^{19} (see Fig. 8) is raised it makes connection with the conducting-ring b^{25}. For convenience of reference the duplications of percentage mechanisms are termed "divisions" 1, 2, &c. In the drawings only two divisions are shown. The parts of division 1 of the percentage apparatus are as follows: In Fig. 2 the outer row of oblong armature-headed plungers b^{17},

with the conducting-rings b^{21} b^{22}, and the outer row of the two rows of round armature-headed plungers b^{19}, with its conducting-ring b^{26}. The electromagnets M^9 and M^6 belong also to the first division, and the parts C D, Fig. 3, E, Fig. 4, F, Fig. 5, and G, Fig. 6, constitute the remainder of the apparatus proper to division 1. The percentage apparatus of division 2 includes the inner rows of oblong and round-headed armature-plungers b^{18} and b^{20}, together with their conducting-rings b^{23}, b^{24}, and b^{26}, and the electromagnets M^{10} and M^8. The remainder of parts proper to division 2 are C C, D D, Fig. 3, E E, Fig. 4, F F, Fig. 5, and G G, Fig. 6. The switch H and magneto-generator I are for the common use of all the divisions. Returning now to Fig. 1 and remembering that subscriber No. 1, having turned in a preliminary impulse and having selected division 1 of the central-station apparatus for his own use, is now supposed to be sending in impulses representing the number of the telephone with which he desires connection.

As already described in my United States Patent No. 515,110, one impulse represents 0, two impulses represent the number 1, three impulses represent the number 2, &c. Subscriber No. 1 therefore desiring connection with subscriber No. 2 causes three impulses to be sent over his line as follows: by conductor 1, left-hand upper corner of Fig. 1, down to where it sends off a branch 16, through branch 16 to plate a^{17}, upon which plate and plate a^{18} the brush a^3 is now resting, through the brush a^3 to plate a^{18}, thence by conductor 17 through common connecting-plate $a^{\times}$, thence by conductor 18 through Fig. 2 to the center of Fig. 3, and by conductor 19 to the relay-electromagnet M^{12}, thence by conductor 20 to Fig. 4, to the contact-plate e^{12} of the switch E. Thence by way of contact-brush e^3 and plate e^{11}, upon both of which plates e^{12} and e^{11} the brush is now resting, the circuit leads up by conductor 21, and joining conductor 22 it proceeds through Fig. 3 to Fig. 2 and down to the conducting-ring b^{22}. From the conducting-ring b^{22} the circuit leads through left-hand contact-spring, (see Fig. 9,) and through left-hand binding-post plate b^{34} (see Fig. 2) it passes by way of conductor 23 to conductor 2, Fig. 1, and out over the line to the starting-point, the subscriber's station. The three impulses sent over this circuit through the coils of the electromagnet M^{12} of the signaling apparatus C in Fig. 3 cause the armature c^{11} to be drawn forward against the contact-screw c^{12} three times. This closes a local circuit from battery b^4 by conductor 24 to Fig. 4, to contact-plate e^9 of the switch E, thence through brush e^5, now resting on this plate, to plate e^8 and conductor 25 to the propelling-electromagnet M^{11}, and through it and by conductors 26 and 27 to the contact-screw c^{12}, through lever c^{11}, and back to the starting-point, the battery B^4. The armature lever of the propelling-electromagnet M^{11} being thus drawn forward three times the pawl c', acting on the ratchet c^2, causes the arm c^3 to make three forward steps, carrying with it the brush c^9 from its normal resting-place on plate c^{19} to that plate on which it is shown as resting. The gravity-operated switch c^5, Fig. 3, (shown more clearly in Fig. 7,) now comes into play. Referring to Fig. 7, it will be noticed that the free lever c^5 has a perpendicular or balanced position and that it is restrained from falling against c^6 in this its normal position by the adjusting-screw c^8. When the mechanism is carried away from the adjusting-screw c^8 by the action of the arm c^3, (see Fig. 3), the free lever c^5 has a tendency to fall forward against the contact-screw c^6, and thus complete the circuit about to be described. It cannot close this circuit, however, until the arm c^3 ceases its forward motion for some appreciable time, as the effect of the impulses passing through the electromagnet M^{11} is to cause the oscillation of the free lever c^5 back and forward between c^6 and c^7 without resting against c^6 long enough to operatively close the local circuit. The time interval of circuit-closure following the cessation or departure from periodicity of the impulses through the electromagnet M^{11} is regulated by the weight or length of the lever c^5, by the distance between c^7 and c^6, or by placing a fan-blade on c^5 to offer greater resistance to the air as it is moved. When, therefore, the impulses cease long enough to allow of the positive forward motion of the free lever c^5, a circuit is closed as follows: From the lever c^5, Fig. 3, to the contact-screw c^6, thence by conductor 28 to contact-plate e^{10}, thence by brush e^4, now resting on the plate, and by conductor 12 to the electromagnet M^{21}. Passing through the coils of the electromagnet and through battery B^5 to brush e^5 it leads to plate e^9 and by conductor 24 to battery B^4. Thence by branch conductor 29 it leads to the pivoted end of the lever c^5, as shown clearly in Fig. 7. The circuit-closure through the electromagnet M^{21} causes the arm e of the switch E in Fig. 4 to advance another step, causing the brushes e^3, e^4, and e^5 to register with plates e^{13}, e^9, e^{14}, e^{15}, e^{16}, and e^{17} of the switch E. It will be remembered that the number being registered is "2." If the number being registered was higher than nine—say "10"—or any other number requiring two numerals to express its numerical value, the action of the switch E, just described, prepares a new circuit for the succeeding impulses representing the tens, the units, as just described, being turned in first, tens next, and so on. The switch E so changes the circuit of the relay-electromagnet M^{12}, Fig. 3, that the second set of impulses is sent through the coils of the electromagnet M^{14} instead of, as just described, through M^{13}. The contact-plate e^8 and conductor 25 being disconnected from plate e^9 by the forward motion of the switch-arm e, the electromagnet M^{13} is taken out of the relay-circuit, and the

second set of impulses therefore passes from the battery B^4 by conductor 24 to Fig. 4, to plate e, thence through brush e^5 and plate e^{13}, thence by conductor 30 to Fig. 3, to the electromagnet M^{14}, and thence by conductors 31 and 27 to the contact-screw c^{12}, and through the lever to battery B^4, the starting-point. It will thus be noticed that a second set of impulses would be registered on the receiver D, Fig. 3. Returning now to Fig. 4, a new circuit may be traced from the battery B^6 at the upper right hand of Fig. 4 to the right by conductor 32 to the operating-electromagnet M^{23}, Fig. 5, for discharging the circuit-closing ball f^{17} onto the first track-section f' of the signaling-track F. Passing through the coils of the electromagnet M^{23} and then by way of conductors 33 and 34 back to Fig. 4 to plate e^{14} of the switch A, the circuit now leads from plate e^{14}, through brush e^4, now resting on it, and through plate e^{15} and by conductor 35 back to battery B^6. The closure of this circuit causes the electromagnet M^{23} of the signaling-track F, Fig. 5, to tip over the circuit-closing ball f^{17} onto the first section of the track f', as shown in Fig. 10.

Before describing the circuits closed by the ball as it passes along the various sections of track f' f^2 f^3, &c., it will be well to trace the remaining circuits controlled by the switch E in Fig. 4 in the position it was in, and which position, it will be remembered, was that of the brushes e^3, e^4, and e^5 over the contact-plates e^{13}, e^9, e^{14}, e^{15}, e^{16}, and e^{17}.

The new circuit about to be described is a compound circuit that may include any one of the subscriber's individual switches A or AA in Fig. 1. It is termed the "numeralizing-circuit" for the reason that the actual circuit affected depends entirely upon the number registered by a single receiver C or CC, or the two receivers C D or CC DD. To make clear the scope of the numeralizing system, it will be necessary to refer to Fig. 3, where x^0, x', x^2, x^3, and x^4 represent a series of conducting-plates. Each conducting-plate has a conductor running to an individual switch, as shown in the drawings, where in Fig. 3 conductor 36, attached to plate x^2, runs to, and through Fig. 2 to Fig. 1 and down and to the left to plate aa^{40} of the switch AA. In a similar manner conductor 37 at Fig. 3 runs to and through Fig. 2 to Fig. 1 and down and to the left to plate a^{40} of switch A. In this way a conductor would run from each one of the plates x^0 x', &c., up to x^9. The higher numbers from x^5 to x^9 are not shown; but they will be clearly understood to be connected one plate each to the remaining receiver-plates lying in the path of the brush c^9. For registration of a number higher than nine the units-receiver C, Fig. 3, is not alone sufficient. For numbers of two-numeral-place value, such as "10," "11," "12," &c., up to "99," the two receivers C and D are necessary, the receiver C to indicate the units and the receiver D to indicate the tens. It will be noticed that in Fig. 3 a conductor 38 runs from one of the plates lying under the brush d^3 of the tens-receiver D. This conductor leads through to Fig. 2 and terminates at a conducting-ring b^{30}. In a similar manner the conductor 39 in the lower part of Fig. 3 runs to Fig. 2 and terminates at a conducting-ring b^{31}. The arm d^4 of the receiver D in Fig. 3 is shown in its normal position, the position it holds when the apparatus C only is called upon to register some unit value not higher than nine. The remaining circuits controlled by the switch E, Fig. 4, in the position it was left may now be traced. It will be remembered that the circuit-closing ball f^{17}, Fig. 5, was discharged on the section of track f' by action already described. As soon as the ball reaches this track-section a circuit is closed, as follows: from the inner side of track-section f', by conductor 41 to and through electromagnet M^{27}, by conductor 42 to the left to Fig. 4, to conducting-plate e^9, thence through brush e^5 and conductor 11 to the battery B^5, and through electromagnet M^{21} and by conductor 12 and brush e^4 to plate e^{14}, and thence by conductor 34 it passes to the outer rail of section f' of track F through the ball, thus completing the circuit. This circuit, it will be noticed, is a shunt from that already described, but including also the battery B^5 for operating the electromagnet M^{21} of the switch E. The electromagnet M^{27}, thus energized, elevates the point f^{24}, (shown also in Fig. 11,) for a purpose to be noted later. The switch E is moved forward another step by the circuit-closure through the electromagnet M^{21} assuming a new position over the plates e^{18}, e^{19}, &c. The ball now passes onto section f^2, where it is intercepted by the point f^{23}, (shown also in Fig. 11,) which point f^{23} is normally in its higher position ready for intercepting the ball. The object of this particular mechanism is to provide for that case where several subscribers using the different divisions of signaling-tracks, such as F or FF, &c., might proceed to numeralize or select the same subscriber wanted at the same instant of time. The intercepting obstacles f^{23} and ff^{23} are caused to be removed in rapid succession, so as to give preference to the first subscriber reaching any of the sections f^2 or ff^2. In the event of two or more subscribers entering the sections, such as f^2 and ff^2, at the same instant of time, the mechanism gives arbitrary preference to one or the other, as will be described, and allows it to numeralize before proceeding to remove the similar obstacles successively at the other track-sections, such as f^2 and ff^2. It will now be presumed that f^{17} is the only ball at present on any track, and as it is resting on section f^2, waiting for the obstacle f^{23} to be removed, a circuit may be traced as follows: from the inner side of the track-section f^2 by conductor 43 to Fig. 4, through Fig. 3 to Fig. 2, to the left-hand one of the plates b^{11}, passing through the unin-

sulated brushes b^5 to the metallic arm and through the other brush to conductor 44 and through Figs. 2, 3, 4, and 5 to Fig. 6, where it leads through the electromagnet M^{36}, and then by conductor 45, contact-plate h^4, and lever h' to conductor 46 it passes through battery B^9 and through conductor 47 to Fig. 5, and up by conductor 48 to and through release-electromagnet M^{26}, and by conductor 49 to the track f^2 and through the ball to the other side of the track. The closure of the circuit through the electromagnet M^{36}, Fig. 6, ruptured the circuit now being described and causes the remaining interceptors, such as ff^{23} in Fig. 5, to remain in their uppermost positions until the ball f^{17} in its progress along the track F shall have again placed the switch H in operative position to allow of the other interceptors, such as ff^{23}, being released consecutively by the rotation of the brushes b^5 in Fig. 2 on the plates b^{11} or b^{12}. The closure of the same circuit just described having operated the release-electromagnet M^{26} in Fig. 5, as shown more clearly in Fig. 11, the intercepting obstacle falls below the level of track-section f^2 and allows the ball to pass onto section f^3. On this section of track the ball closes a circuit as follows: from the inner rail of track-section f^3 by conductor 50 to and through the inner rail of track-section ff^3 of signaling-track FF, thence by conductor 51 to electromagnet M^{29}, thence by conductor 52 to the battery B^8, thence by conductor 53 to the electromagnet M^{25}, and thence by conductor 54 to the outer rail of track-section f^3, completing the circuit through the rolling ball now on that section. It will be noticed that this circuit may be continued from the outer rail of track-section f^3 down by conductor 55 to the outer rail of track-section ff^3 of the signaling-track FF. This allows a ball rolling on section ff^3 of the signaling-track FF to close a circuit through both of the electromagnets M^{29} and M^{25} by means of the same circuit and battery B^8 just described. It will be sufficient here to state that the object of this plan is to allow the first one of two or more balls entering any of the sections, such as f^3 ff^3, &c., to operate all such electromagnets as M^{25} M^{29}, &c., for the purpose of causing the succeeding balls to wait on the track-sections f^2 or ff^2 until the first ball has reached a point on the signaling-track where it will cause the intercepted balls to be released consecutively. The circuit just described, therefore, through the electromagnets M^{25} and M^{29} by the passage of the ball over the section f^3 of the signaling-track F causes the intercepting obstacles f^{23} and ff^{23} to be raised in the paths of any other balls attempting to run from sections f^2 or ff^2 onto sections f^3 or ff^3. The circuit-closing ball f^{17} now runs over section f^4, closing the following circuit as it passes along: from the outer rail of section f^4 by conductor 55 up to the top, where it joins conductor 56, and running to the left through Figs. 4, 3, and 2 to Fig. 1 to the connecting-plate, to which is joined short conductor 57, and along that conductor to plate a^{30} of the switch A. As the brush a' of the switch A is now resting on plates a^{29} and a^{30}, the circuit thus far traced now leads through that brush to plate a^{29} and thence by internal connection from plate a^{29} to plate a^{35} and through that plate by short conductor 7 to the battery B'. Passing from the battery by way of conductor 6 to the propelling electromagnet M' and thence by short conductor 5 it leads to plate a^{15}, from thence by internal conductor to the plate a^{37}, upon which is now resting the brush a^4. Through the brush a^4 to plate a^{38} it proceeds by way of internal conductor to plate a^{22}, and thence by conductor 59 it proceeds to Fig. 2, where it terminates at the plate b^{27} of the apparatus B. It will be remembered that the outer selector-plunger $b^{19}x$ was raised by action already described. Consequently the metallic plate b^{27} is in electrical connection with the conducting-ring b^{25}, and the circuit therefore proceeds by way of ring b^{25} and conductor 60, connecting with it through Figs. 3 and 4 to Fig. 5, where it joins conductor 61, and leading down and to the inner rail of track-section f^4 it completes the circuit. The closure of this circuit through the electromagnet M' in Fig. 1 causes the arm a of the switch A to be moved forward another step, thus bringing the brush a' over the plates a^{31} a^{32} and the brush a^3 over the plates a^{19} a^{20}. Leaving the switch A in this position, the remaining circuit controlled by the switch E, Fig. 4, in the position we left it, in combination with the circuit-closing ball f^{17}, now entering on section f^5 of the signaling-track F, Fig. 5, may now be traced. Commencing at the brush c^9 of the receiver C in Fig. 3, and by way of the contact-plate upon which it is resting out to the conducting-plate x^2, thence by conductor 36 to and through Fig. 2 to Fig. 1 and down to the left to plate aa^{40} of switch AA, connected directly to the line-terminals of subscriber No. 2 in a manner similar to that described in connection with the circuit of subscriber No. 1. The circuit leads from plate aa^{40} through brush aa^4 to plate aa^{39}, and thence by short conductor to three-step electromagnet M^4, thence by conductor 40 to Fig. 2, to individual plate, at which this conductor terminates. When brush b^7 passes over the individual plate at which terminates conductor 40, the circuit may be completed as follows: through brush b^7 to conducting-plate b^{31}, thence by conductor 38 to Fig. 3, where it connects to the normal resting-plate d^{19} of the switch D, thence by way of the brush d^3 and metallic arm d^4 and by contact-spring d^6 and conductor 63 it leads to the outer rail of section f^5 of signaling-track F. The circuit-closing ball f^{17} being now on this section of track, the circuit may be continued by way of conductor 64, leading from the inner rail of section f^5 to where it joins conductor 65 and leads to the battery B^7. From thence it leads by con-

ductor 66 to and through Figs. 4, 3, and 2 to Fig. 1, where it runs to the connecting-plate x^{41}, thence by conductor 15 to Fig. 2, to the electromagnet M^6, and by short conductor 14 to the electromagnet M^9, and by conductor 13 to where it joins conductor 67, and along that conductor joining to and proceeding by conductor 68 it leads to plate e^{18}. It will be remembered that the brushes of switch E are now resting on plates e^{18} e^{19}, &c. Consequently the circuit may be continued by way of the brush e^5 and conductor 11 to the battery B^5 and electromagnet M^{21}, thence by conductor 12 to and through brush e^4 to plate e^{19}, thence by conductor 69 to where it joins conductor 70, and proceeding by conductor 70 it runs to Fig. 3, to the brush c^{10}, and through it passes to the arm c^3 and brush c^9, the starting-point.

The circuit just described is the numeralizing-circuit, and from the foregoing description it will be evident that plungers at the apparatus B, Fig. 2, are chosen in accordance with the registration of the apparatus C D or CC DD in Fig. 3. When only one set of impulses is used for numbers not higher than nine, the only switch affected is C or CC in Fig. 3. It will be evident that if two sets of impulses were received one set would be registered on C or CC and the other set would be registered on D or DD.

Referring now to the apparatus C and D of Fig. 3, through which has been traced the last circuit, if a second set of impulses is received by this part of the apparatus it will be evident that the switch D will be moved out of the position shown in the drawings. Consequently a circuit could not be closed through any of the one-numeral-place values, such as "1," "2," "3," "4," &c., to "9," for the reason that the conductor 38, terminating at plate d^{19}, could not be part of the circuit, seeing that the brush d^3 would have been moved out of connection with it. In other words, the arm d^4 of the switch D must remain in the position shown if any one of the circuits 1 to 9 is required.

Referring now to the switch C and to the plates x^0 x' x^2, &c., it must be understood that from each of these plates run multiple conductors, such as 36 and 37, to all of the progressive switches in the system, such as A or AA, Fig. 1. For instance, the plate x^0 would send conductors to all switches A or AA whose second-numeral-place value could be expressed by "0," such as "10," "20," "30," "40," &c. In a similar manner the plate x' in Fig. 3 would send conductors to all switches, such as A and AA, whose second-numeral-place value could be expressed by "1," such as "11," "21," "31," &c.

Referring now to the switch D in Fig. 3, and which, it will be understood, is for registering the tens-values, d^{20}, d^{21}, and d^{22} represent plates from which conductors (not shown) are presumed to run, as does conductor 38, to conducting feed-rings lying in the paths of the brushes b^7 or b^{10} in Fig. 2. The plate d^{19} is an auxiliary for controlling the selection of any one of the numbers "1" to "9," inclusive. The plate d^{14} has no conductor attached to it, and it is blank for the reason that no two-place-numeral value begins with "0." The plate d^{20}, termed the "1-ten" plate, sends off a conductor similar to 38, but terminating at an independent section of the conducting-ring lying side by side with the individual contact-plates 10 to 19, inclusive, in the same way that the feed-ring b^{31} lies side by side with the individual plates at which terminate conductors 40 and 71. (See Fig. 2.) The section of feed-ring for the numbers "1" to "9" has immediately following it that section of ring for controlling numbers "10" to "19." This latter section is followed by another section controlling numbers "20" to "29," to which a conductor from plate d^{21} in Fig. 3 would run, and so on. It will be understood, therefore, that the switch C is used alone to select numbers up to "9," but that both switches C and D or CC and DD are required for selecting numbers higher than nine. It will also be understood that the switch C controls the value of the unit selected, while the switch D controls the value of the ten. It will therefore be understood that the switches C and D or CC and DD can select any number from "1" to "99" by the different positions they may be caused to assume. It will be obvious that this system of selection may be extended by the addition of switches, such as D or DD, giving capacity for registration up to "999," to "9,999," or "99,999," and so on, all that is required to make the extension complete being feed-rings for hundreds, for thousands, and for tens of thousands, &c., in the same manner as described for the tens, the selection of any value being determined by the indications of the switches C D or CC DD and the coincidence of brushes similar to b^7 or b^{10}, registering simultaneously with the active conductors. It will be remembered that the numeralizing-circuit was closed through the electromagnet M^4 of the switch AA in Fig. 1. The closure of the circuit through this electromagnet, termed the "three-step" magnet, causes the armature aa^9 and the pawl aa^6, acting on the quarter-spaced pin aa^8, to advance the arm aa, so that the brushes aa' and aa^4 immediately take up a position over plates aa^{31} aa^{32} and plates aa^{19} aa^{20}. The two arms a and aa of the switches A and AA are now in the same position. It will be noticed that the switch A of calling-subscriber No. 1 has advanced to its present position step by step, while the switch AA of the subscriber called (No. 2) has taken the same position at one movement by the action of the three-step electromagnet M^4. This action is readily understood from the statement that, whereas subscriber No. 1 had to select various portions of the apparatus for the purpose of registering and selecting the number called,

subscriber No. 2 takes no part in any of these acts and might have been himself calling for another subscriber while these movements of subscriber No. 1's apparatus were being effected. It will be noticed that the numeralizing-circuit described passes through plates aa^{39} and aa^{40} of the switch AA in Fig. 1. The position of the switch AA shown in the drawings being the normal one, it follows that no other subscriber could seize or affect the switch AA if subscriber No. 2 were using it himself for calling some other subscriber. In other words, it is impossible to interfere with a switch when once it moves from the normal position shown. Subscriber No. 2, however, was not using his switch AA, and consequently when subscriber No. 1 numeralized on the number "2" he at once seized the switch AA and put it out of the control of that subscriber, (No. 2.) The numeralizing-circuit also included electromagnets M^6 and M^9 of the apparatus B in Fig. 2. As the circuit closure can only take place when the electromagnets M^6 and M^9 are over the plungers of the number being numeralized, it follows that the plungers $b^{17}o$ and $b^{19}o$ are both raised, $b^{17}o$ into electrical connection with the rings b^{21}, b^{22}, and $b^{19}o$ into electrical connection with the ring b^{25}. The closure of the same circuit through electromagnet M^{21} of the switch E in Fig. 4 caused the brushes e^3, e^4, and e^5 to be moved forward into connection with the contact-plates e^{23}, e^{19}, e^{24}, e^{25}, e^{26}, and e^{27}. It may be well to notice here that the foregoing action has brought the switch AA, Fig. 1, of subscriber No. 2 into electrical connection with division 1 of the percentage apparatus, and consequently, as will shortly be shown, both switches A and AA are about to be controlled by the circuit-closing ball as it passes along the signaling-track F in Fig. 5. The ball now passes over section f^6 of the track F and in doing so closes a circuit as follows: from the inner continuous rail of sections f^6, f^7, and f^8, by conductor 74 to the magneto-generator I at the lower right-hand of Fig. 6, thence by conductor 75 to Fig. 4, and up and to the left by conductor 77 it connects to the plate e^{19} of the switch E, thence passing to plate e^{24}, through the brush e^4, it leads by conductor 78 to the left and up, and again to the left through Fig. 3 to Fig. 2 and down to the conducting-ring b^{21} of the apparatus B. It will be remembered that the right-hand contact-spring of the plunger $b^{17}x$ is now in electrical connection with the ring b^{21}. Consequently the circuit leads out by way of metallic plate b^{33} and conductor 73 to Fig. 1, where it joins the line 1 of subscriber No. 1. Passing out over that line to the subscriber's magneto call-bell it returns by conductor 2, and by the branch conductor 23 it runs to the right to Fig. 2 to the metallic plate b^{34}, electrically connected to the left-hand part of the plunger $b^{17}x$. Passing through that part of the plunger and into conducting-ring b^{22}, it leads by conductor 22 to the right through Fig. 3 to Fig. 4, where it leads by branch conductor 21 to the contact-plate e^{11}, thence by internal conductor to plate e^{25} it passes by brush e^3 and conducting-plate e^{26} and out by conductor 72 to Fig. 5 and up to the outer section of track f^6 of the track F, thus completing the circuit through the rolling ball.

It will be remembered that in tracing the foregoing circuit the conductor 75 from the magneto generator in Fig. 6 passed through the switch E in Fig. 4 and terminated at the conducting-ring b^{21} of the apparatus B. From this ring, in addition to the circuit already traced through the call-bell of subscriber No. 1, a shunt-circuit leads, by way of metallic plate b^{35} and conductor 79, to Fig. 1, where it joins the line 3 of subscriber No. 2. Passing out over that line to the subscriber's magneto call-bell, it returns by conductor 4 and branch conductor 80 to Fig. 2, where it leads to metallic plate b^{36} and through the plunger contact-spring to the conducting-ring b^{22}, where it takes the same path as that already traced back to the outer rail of section f^6 of the signaling-track F in Fig. 5. The ball now passes along section f^7 of the signaling-track F, keeping continuously closed a circuit through the call-bells of both connected subscribers, which is the same in all respects as that just described, except that on returning by conductors 22 and 21 at Fig. 4 to e^{11} it returns to the signaling-track by way of contact-plate e^{25}, on which the brush e^3 is resting, and through the brush to plate e^{27}, and thence by conductor 81 to the section f^7 of the signaling-track F. The ball now passes on to section f^8 and closes the same circuit through the call-bells of both subscribers, as was described in connection with the section f^6. It will be noticed that the bells will give one long continuous ring as the three sections of track f^6, f^7, and f^8 are, by the arrangement of circuits just described, electrically joined in one long section. The reason of the divisions is as follows: Should the line of subscriber No. 2 have been busy when called for by subscriber No. 1, the switch-arm aa of the switch AA in Fig. 1 would have been moved from out of the normal position shown in the drawing. Consequently the numeralizing-circuit would not have been operative, and the switch E in Fig. 4, instead of being in its present position over plates e^{23}, e^{19}, e^{24}, e^{25}, e^{26}, and e^{27}, would have been left one step back on the plates e^{18}, e^{19}, e^{20}, e^{21}, and e^{22}. Reference to conductor 81, leading from the middle section f^7 of the track F to the contact-plate e^{27} at the switch E, Fig. 4, will show that the said conductor would then be isolated, and that as it would not be brought into electrical connection with the plates e^{26} or e^{25} the ball in passing over section f^7 of the track F could not close the magneto circuit, and consequently the call-bell of subscriber No. 1 would give two disconnected rings, a busy-signal, as the ball passed over sections f^6 and f^8, the section f^7 thus be-

ing rendered neutral. Should the switch have been left on the brushes e^{18} e^{19}, &c., and the busy-call turned over the calling-subscriber's line as a consequence, the ball as it passed over section f^9 of the track F would close a circuit to step the switch E into its present position by way of conductor 67 to Fig. 4 and up by conductor 68 to contact-plate e^{18}, thence through brush e^5 by conductor 11 to the battery B^5 and through the electromagnet M^{21} and by conductor 12 to brush e^4 it would pass to the plate e^{19}, and thence up by conductor 69 to conductor 70, to the right by conductor 71 to Fig. 5, and to the inner rail of section f^9 of the track F, thus completing the circuit through the electromagnet M^{21} and advancing the switch E one step. However, as the switch is already in position over plates e^{23}, e^{19}, e^{24}, e^{25}, e^{26}, and e^{27}, it will be noticed that the ball passes over section f^9 of the track F without affecting the switch E when it is already in the position just described. The ball now passes on to section f^{10} and closes the following circuit: from the inner track by conductor 82 up to its junction with conductor 60, and to the left, through Figs. 4 and 3 to Fig. 2, it leads to the conducting-ring b^{25}. It will be remembered that the plungers $b^{19}x$ and $b^{19}o$ are in electrical connection with this ring. Consequently two branches of the circuit may now be traced, the first branch leading by plate b^{27} and conductor 59 to Fig. 1, to plate a^{22} of switch A, from a^{22} by internal conductor to plate a^{20} and through the brush a^3, now resting on the plate, to plate a^{19}, thence by internal conductor to plate a^{15} and by conductor 5 to the electromagnet M′, and through it and by conductor 6 to the battery B′, thence by conductor 7 to plate a^{35} and by internal conductor to plate a^{31}, thence through the brush a', now resting on this plate, and through plate a^{32}, connecting to plate a^{33}, and by internal conductor to plate a^{30} the circuit leads by short conductor 57 and up by conductor 56, through Figs. 2, 3, and 4 to Fig. 5, and down by conductor 83 to the track-section f^{10}, completing the circuit. In the same manner the shunt-circuit leading from the conducting-ring b^{25} in Fig. 2 passes by way of plate b^{37} and conductor 84 to plate aa^{22}, by internal conductor to plate aa^{20}, and through brush aa^3 to plate aa^{19}, thence by internal conductor to plate aa^{15}, thence by conductor 85 to the electromagnet M^3, passing through it, and by conductor 86, leading to the battery B^3. From thence by conductor 87 it leads to plate aa^{35}, and thence by internal conductor to plate aa^{31}. Thence it passes through the brush aa' to plate aa^{32} and to plate aa^{33}, and thence by internal conductor to plate aa^{30}, thence by conductor 58 to the top of Fig. 1, where it joins conductor 56 over the same return-path, as already described, to section f^{10}. The closure of this circuit causes the arms a and aa of the switches A and AA in Fig. 1 to be moved forward one step, bringing the brushes a' and a^3 of the switch A over plates a^{33} a^{34} and a^{21} a^{22} and the brushes aa' and aa^3 of the switch AA over plates aa^{33} aa^{34} and aa^{21} aa^{22}. The ball now passes over section f^{11} of the track F, and in doing so closes the following circuit: from inner rail by conductor 88 to Fig. 6 to where it joins conductor 89, thence by 89 to the electromagnet M^{35}, thence by conductor 90 to the battery b^{10}, thence by conductor 91, through Figs. 5 and 4, to Fig. 3, to release-electromagnet M^{15}, thence by conductor 92 to the electromagnet M^{13}, thence by conductor 93, to Fig. 5, to the section f^{11}, thus completing the circuit. The closure of this circuit causes the arm C^3 to fall back to its normal position. If the arm d^4 had been moved, it also would be returned to its normal position under the influence of its release-electromagnet M^{15}. The electromagnet M^{35} of the switch H in Fig. 6 was also included in the foregoing circuit, and as a consequence its lever h' is caused to assume its normal position—that shown in the drawings.

The circuit controlled by the switch H has already been described. It is for controlling the consecutive discharge of circuit-closing balls along the tracks, such as F and FF, as soon as a circuit-closing ball has reached the section f^{11}, just described. The ball now passes over section f^{12} of the track F and closes the following circuit: from the inner rail of f^{12} by conductor 95 to plate e^{23} at the switch E, Fig. 4, thence through brush e^5 and conductor 11 to battery B^5, thence through the electromagnet M^{21} and by conductor 12 to the brush e^4, thence to plate e^{18} and by conductors 77 and 96 to the outer rail of section f^{12} of track F. This circuit closure through electromagnet M^{21} causes the switch-arm e to take another forward step, bringing the brushes e^3, e^4, and e^5 into connection with the plates e^{28}, e^{29}, and e^{30}. The ball now passes on to section f^{13} of the track, in this apparatus designated the "waiting-track," and the ball rests against the obstacle f^{24}, raised by action already described. The subscribers are now connected and a talking-circuit is established, having in shunt with it a release-circuit of proper resistance for the purpose of causing the disconnection of the subscribers when conversation has terminated. These circuits may be traced as follows: commencing at conductor 1 in Fig. 1 and by branch conductor 73 to metallic plate b^{33} in Fig. 2, thence by plunger connection to the conducting-ring b^{21} and through it to the plunger $b^{17}o$, now electrically connected to this conducting-ring, thence by metallic plate b^{35} and conductor 79 to conductor 3 in Fig. 1 and out over the line of subscriber No. 2. Returning by conductor 4 and branch conductor 80, the circuit may be traced to metallic plate b^{36}, through plunger connection, through ring b^{22}, to plunger $b^{17}x$, through metallic plate b^{34}, through conductor 23 to conductor 2 in Fig. 1, then out over the line to subscriber No. 1, and back by conductor 1,

thus completing the talking-circuit. When conversation has terminated, the subscriber initiating the connection, in this case subscriber No. 1, sends a single current impulse over his line. The talking-circuit has just been traced, and it will be remembered that the conductors from the line-terminals of subscriber No. 1 lead to metallic plates b^{33} and b^{34} in Fig. 2. These plates are in connection with the conducting-rings b^{21} and b^{22}, and commencing with ring b^{21} and its conductor 78 the shunt-circuit leads to Fig. 4, to the plate e^{30} of the switch E, thence through the brush e^4 and by plate e^{29} to the conductor 98, to its junction with conductor 99 and through Fig. 5 to Fig. 6, to the coils M^{33} of the release-relay for division 1 of the apparatus, thence returning by conductor 22 it leads through Figs. 5, 4, and 3 to Fig. 2, where it terminates in the other conducting-ring b^{22}. This release-impulse passing through the coils M^{33} of the relay at G in Fig. 6 causes the armature-lever g' to be drawn forward against the contact-screw g^2 and closes a local circuit as follows: from the armature-lever g' by pivot and conductor 62 to Fig. 5, to the electromagnet M^{28}, thence by conductor 60 to Fig. 2, to conducting-ring b^{25}, thence through plunger $b^{19}x$ and metallic plate b^{27} it leads by conductor 59 to the contact-plate a^{22} of the switch A, thence through brush a^3 and by plate a^{21} and internal conductor to plate a^{15} it leads by conductor 5 to the propelling-electromagnet M', thence by conductor 6 to the battery B' and from the battery by conductor 7 to plate a^{35}, thence by internal conductor to plate a^{34} and through the brush a' to plate a^{33}, thence by internal conductor to plate a^{30}, thence by conductors 57 and 56 through to Fig. 6, and thence down by conductor 100 to the contact-screw g^2 and the armature-lever g' of the release-relay G. This release-circuit also sends off a shunt from the conducting-ring b^{25} in Fig. 2 through the plunger $b^{19}o$ of subscriber No. 2, as follows: by conducting-plate b^{37} and conductor 84 to plate aa^{22} of the switch AA in Fig. 1, thence through brush aa^3 and plate aa^{21} and by internal conductor to the plate aa^{15}, thence by conductor 85 to the propelling-electromagnet M^3, thence by conductor 86 to the battery B^3, thence by conductor 87 to contact-plate aa^{35}, thence by internal conductor to plate aa^{34} and by brush aa' to plate aa^{33}, thence by internal conductor to plate aa^{31} and by conductor 58 up to its junction with conductor 56, where it returns by the path already traced to the contact-screw g^2 of the release-relay G in Fig. 6. The closure of the circuits last described caused the switch-arms a and aa of the switches A and AA in Fig. 1 to assume new positions, the switch-arm a now having its brushes a' and a^3 over the plates a^{35} a^{36} and a^{23} a^{24}, while the switch-arm aa has its brushes aa' and aa^3 over the plates aa^{35} aa^{36} and aa^{23} aa^{24}. It will be remembered that this last circuit included the release-electromagnet m^{28} of the signaling-track F in Fig. 5. This causes the intercepting obstacle f^{24} to be withdrawn from in front of the circuit-closing ball f^{17}, now on the waiting section of track f^{13}, and consequently the ball now proceeds over track-section f^{14}. It now closes the following circuit: from the outer rail of section f^{14}, by conductor 101, through Figs. 4 and 3 to Fig. 2, thence through release-electromagnet M^5 of the arm b', thence joining conductor 15 and to the battery B^2 in Fig. 1, thence by conductors 102 and 103 it returns to Figs. 2, 3, and 4, to Fig. 5 and down to the inner rail of section f^{14} and through the circuit-closing ball, completing the circuit. The closure of the circuit through release-electromagnet M^5 in Fig. 2 caused the plungers $b^{17}x$ $b^{17}o$ and $b^{19}x$ $b^{19}o$ to be restored to their normal positions, electrically disconnected from the conducting-rings b^{21}, b^{22}, and b^{25}. This action will be understood by reference to Fig. 8, which shows a release-magnet M^5, operating a depressing-lever b^{37}, having on its under side depressing projections b^{38} and b^{39}, curved on the their under sides, as shown in Fig. 9. The ball in rolling over the track-section f^{14} of the apparatus F maintains a closed circuit through the release-electromagnet M^5 in Fig. 2, and consequently the depressing-lever b^{37}, (shown in Figs. 8 and 9,) as it sweeps over its division, acts to push down into their lowermost positions the plungers that were previously raised by the selecting act mentioned in the early part of this description. The circuit-closing ball f^{17} in Fig. 5 now passes on to the last track-section f^{15}, closing the following circuit: from the outer rail of section f^{15} by conductor 97 to the contact-plate e^{28} of the switch E in Fig. 4, thence through the brush e^5 and by conductor 11 and battery B^5 to the electromagnet M^{21}, thence by conductor 12 to the brush e^4 and to plate e^{29}, thence by conductor 98 to Fig. 5, to the inner rail of section f^{15} and through the ball, thus completing the circuit. The closure of the circuit through the electromagnet M^{21} causes the arm e of the switch E to take one forward step, bringing its brushes e^3, e^4, and e^5 over the plates e^6 and e^7, as shown in the drawings, its normal position. In the meanwhile the rotation of the arm b^4 of the apparatus B in Fig. 2, carrying with it the brush b^8 over the contact-plates b^{15} b^{15} and common feed-plate b^{40}, has closed circuits through the propelling-electromagnets M' and M^3 of the switches A and AA in Fig. 1, as follows: from feed-plate b^{40} by conductor 104 to Fig. 1, thence down by conductor 105 to contact-plate aa^{24}, through brush aa^3 to plate aa^{23}, thence by internal conductor to plate aa^{15} and by conductor 85 to the electromagnet M^3, thence by conductor 86 to the battery B^3 and by conductor 87 to contact-plate aa^{35}, thence through brush aa' to plate aa^{36} and by conductor 107 to Fig. 2 to the individual contact-plate of subscriber No. 2, and passing through the contact-brush b^8 it reaches the feed-ring b^{40}, the starting-point.

The remaining circuit leads also by conductor 104 to Fig. 1 and up by conductor 106 to contact-plate a^{24}, thence by brush a^3 to plate a^{23} and by internal conductor to plate a^{15}, thence by conductor 5 to the electromagnet M′ and by conductor 6 to the battery B′, thence by conductor 7 to the plate a^{35} and by brush a' to plate a^{36}, thence by conductor 108 to Fig. 2, to the individual plate of subscriber No. 1, and through the brush b^8 to the starting point, the feed-ring b^{10}. The switch-arms a and aa of the switches A and AA in Fig. 1 are thus stepped forward to their normal position, that shown in the drawings. Subscriber No. 1 has therefore connected himself with subscriber No. 2, and, the conversation having terminated, the release-impulse has caused the whole of the apparatus affected to be restored to its normal position, free for use by other subscribers. It will be understood that during the time these two subscribers were connected other subscribers could be interconnected through division 2 of the apparatus, namely, the selecting electromagnets M^8 and M^{10} of the apparatus B, and through the other apparatus of division 2 CC DD in Fig. 3, EE in Fig. 4, FF in Fig. 5, and GG and H in Fig. 6, the number of simultaneous connections possible in this apparatus depending upon the number of divisions of percentage apparatus, of which only two are shown in the drawings. In the case of subscriber No. 1 calling for subscriber No. 2 when the latter subscriber is using his line, the foregoing description will have made clear the fact that when any subscriber's line is in use the individual switch of such subscriber will be out of its normal position, and it has already been explained that when once a subscriber moves his own switch from its normal position it cannot then be affected in any way by any other subscriber. Should subscriber No. 1, therefore, call for connection with subscriber No. 2 when the line of the latter subscriber is in use, the whole of the acts take place, as already described, up to that point where the number registered by subscriber No. 1 is to be numeralized. It has been explained that the switches, such as A or AA, must be in their normal positions if the act of numeralizing or selecting a switch in accordance with the numerical registration is to be effected. Remembering, therefore, that subscriber No. 2 is using his line, and that consequently his switch AA has been moved out of its normal position, it follows that the numeralizing-circuit could not be closed, and as a result the switch AA would remain unaffected by the action of subscriber No. 1, while subscriber No. 1 would receive over his line the busy-signal of two disconnected rings. From this point the acts are the same as already described, the only difference being that the switch A of subscriber No. 1 would complete its phase alone, the switch AA remaining unaffected throughout. When subscriber No. 1 had received the busy-signal notifying him that the line called for was then in use, he would send a release-impulse over his line, as already described, and would thus restore his own switch A and the division 1 of central-station apparatus to normal condition.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. An automatic exchange system comprising subscribers' lines and individual switches at which they terminate normally under the subscribers' control, and means for giving an independent progressive motion to a switch on the reception of a preliminary impulse from the subscriber normally controlling it.

2. An automatic telephone-exchange system comprising individual switches, each switch normally under the control of its independent subscriber, means for giving an independent progressive motion to a switch on the reception of a preliminary impulse from the subscriber normally controlling it and additional means for connecting a switch in its progression to some one of a plurality of signal-registering mechanisms for registering the number of the telephone called.

3. An automatic telephone-exchange system comprising individual switches, each switch normally under the control of its individual subscriber, means for giving an independent progressive motion to a switch on the reception of a preliminary impulse from the subscriber normally controlling it and additional means for causing the switches in their progressions to be brought into operative relation with the instrumentalities for interconnecting them.

4. An automatic telephone-exchange system comprising apparatus for indicating separately the units, tens, hundreds, &c. value of the telephone called, a rotary selector for selecting a line in accordance with the numerical value of the combined indication, in combination with a series of individual switches, each switch normally under the control of its individual subscriber but having means for giving any switch an independent progressive motion on the receipt of a preliminary impulse from the subscriber normally controlling it.

In testimony whereof I have hereunto subscribed my name this 14th day of March, 1896.

ROMAINE CALLENDER.

Witnesses:
G. W. LORIMER,
LILLIE RUTTLEY.