(No Model.) 3 Sheets—Sheet 1.

H. V. HAYES & H. D. SEARS.

AUTOMATIC TELEPHONE SYSTEM.

No. 457,477. Patented Aug. 11, 1891.

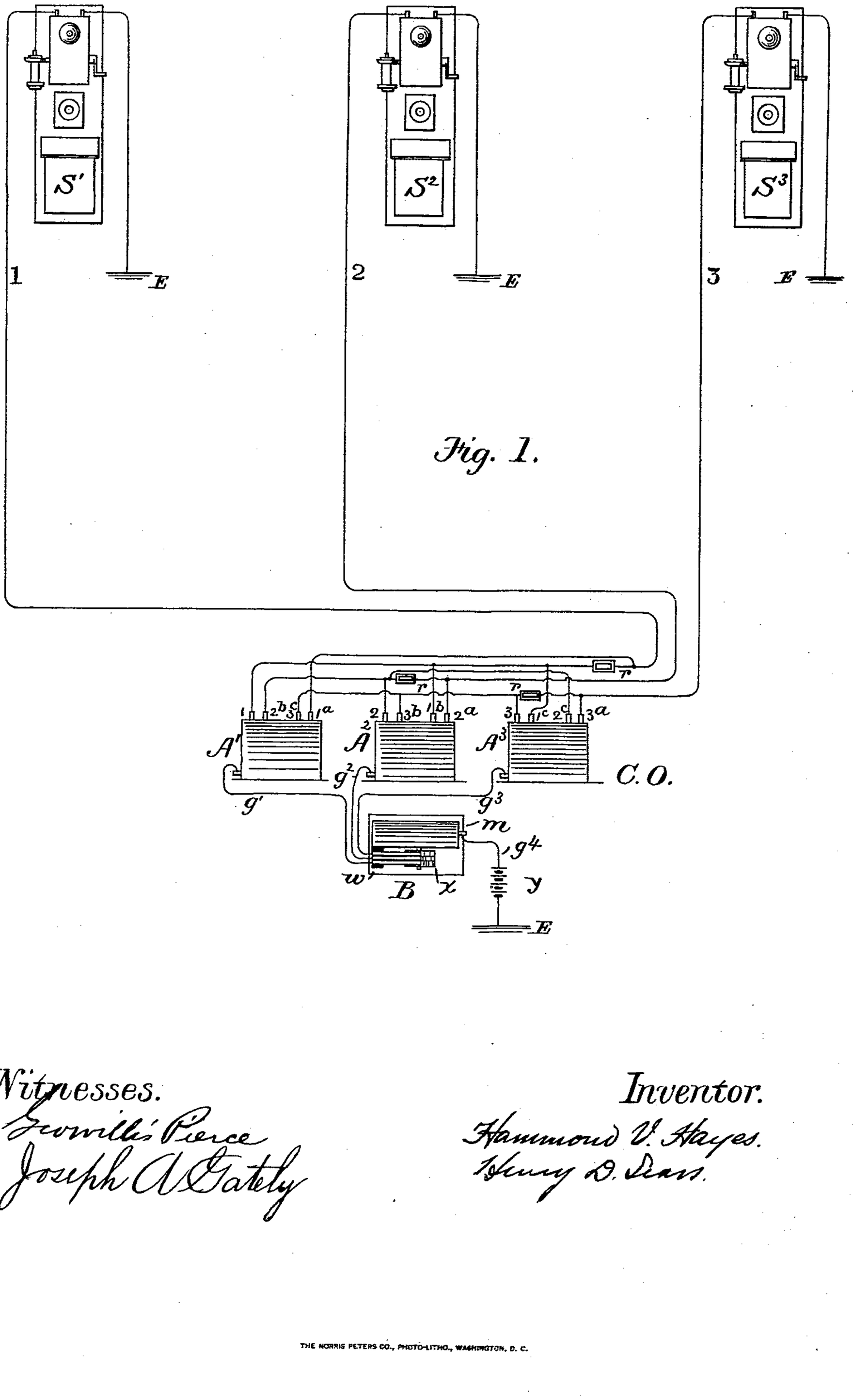

Fig. 1.

Witnesses.

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(No Model.) 3 Sheets—Sheet 2.

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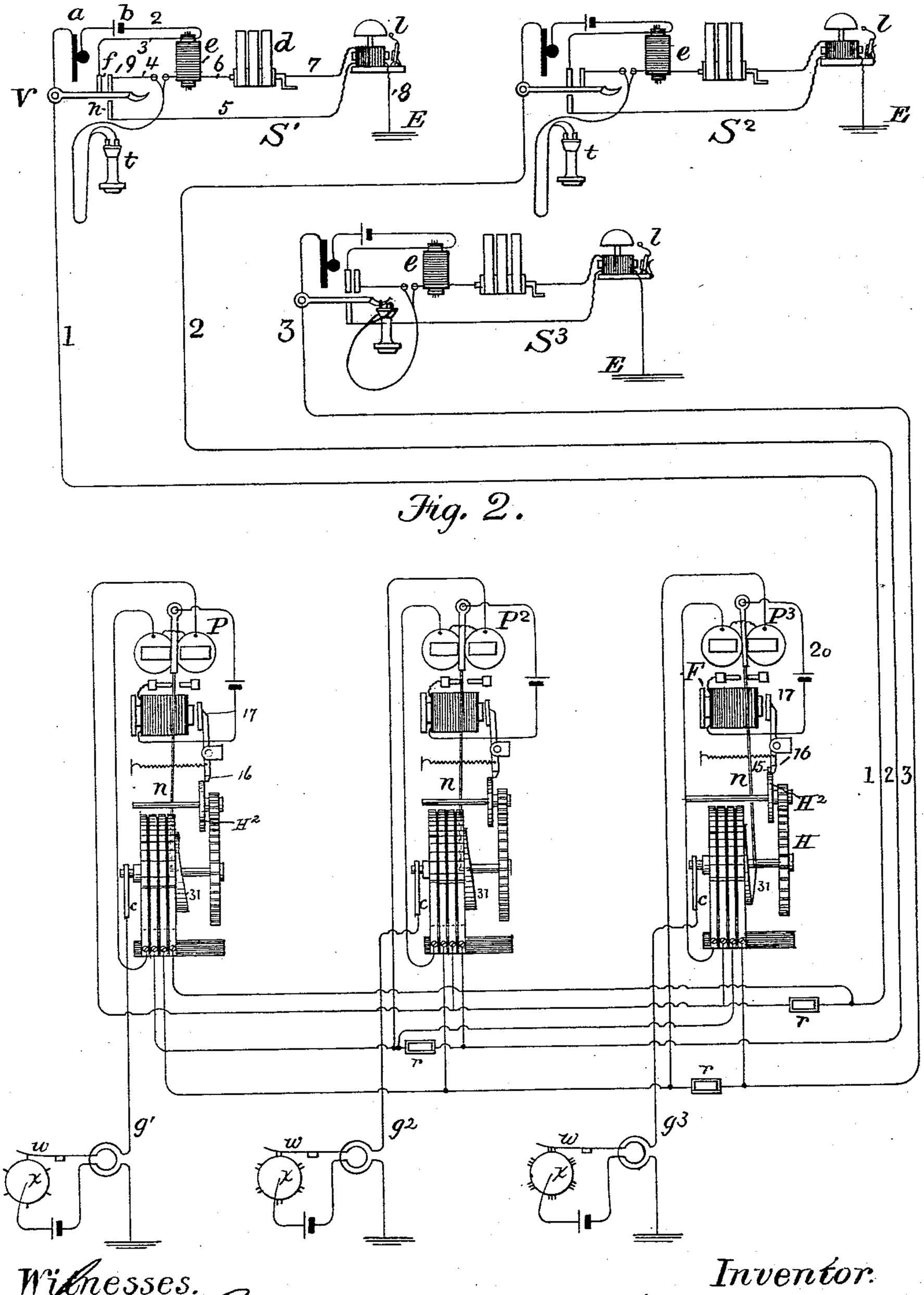
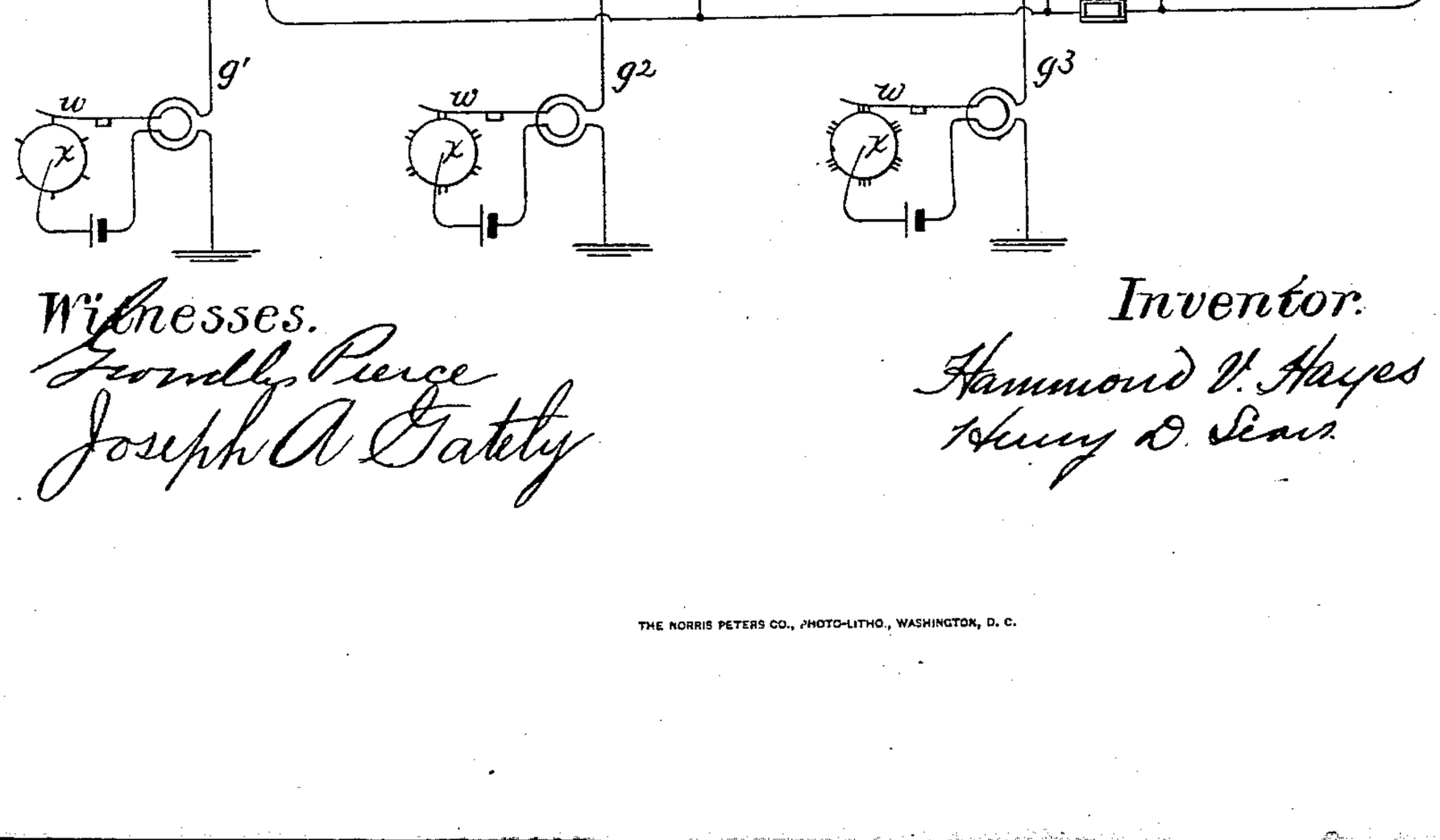


Fig. 2.



Witnesses.
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(No Model.) 3 Sheets—Sheet 3.

H. V. HAYES & H. D. SEARS.

AUTOMATIC TELEPHONE SYSTEM.

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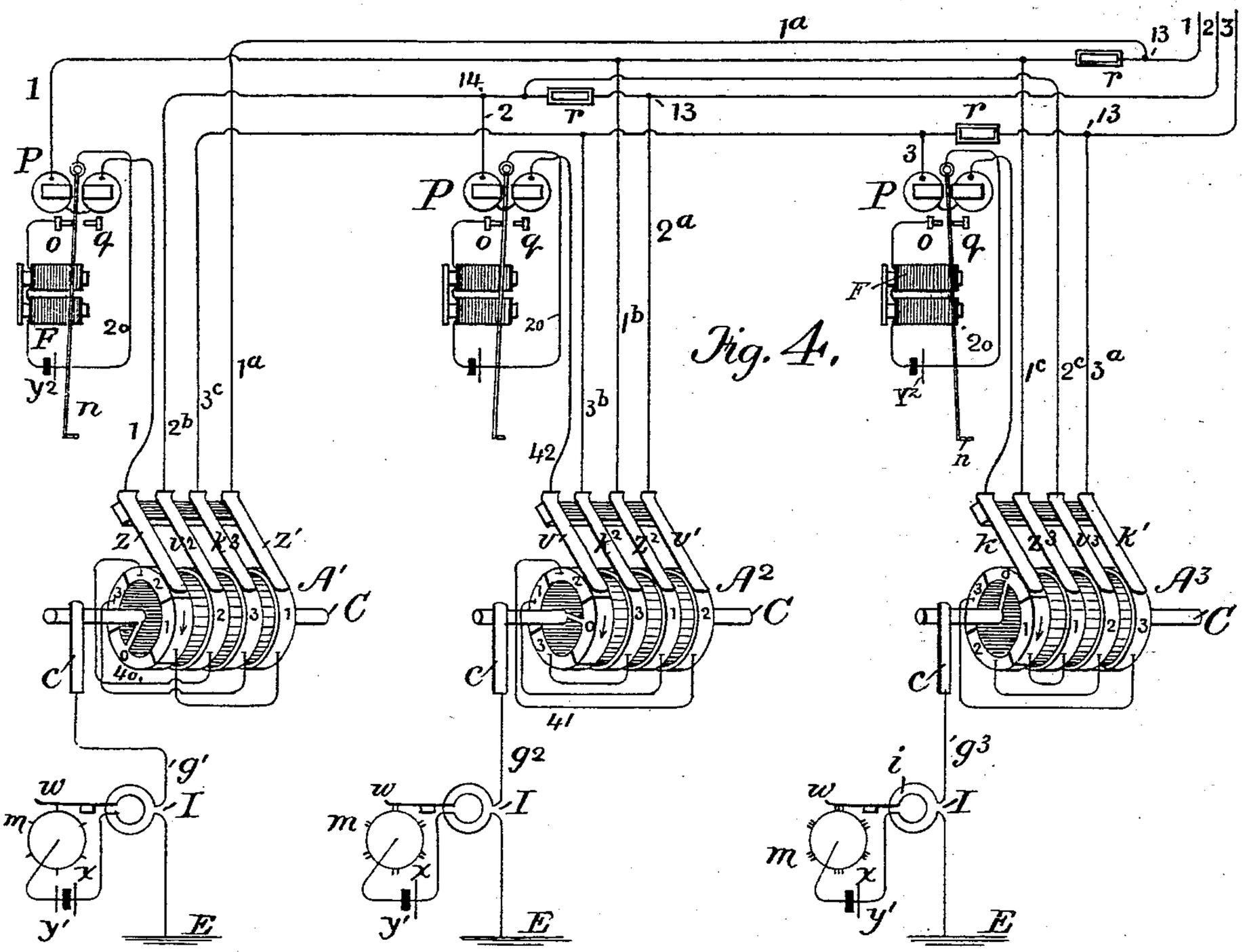

Fig. 4.

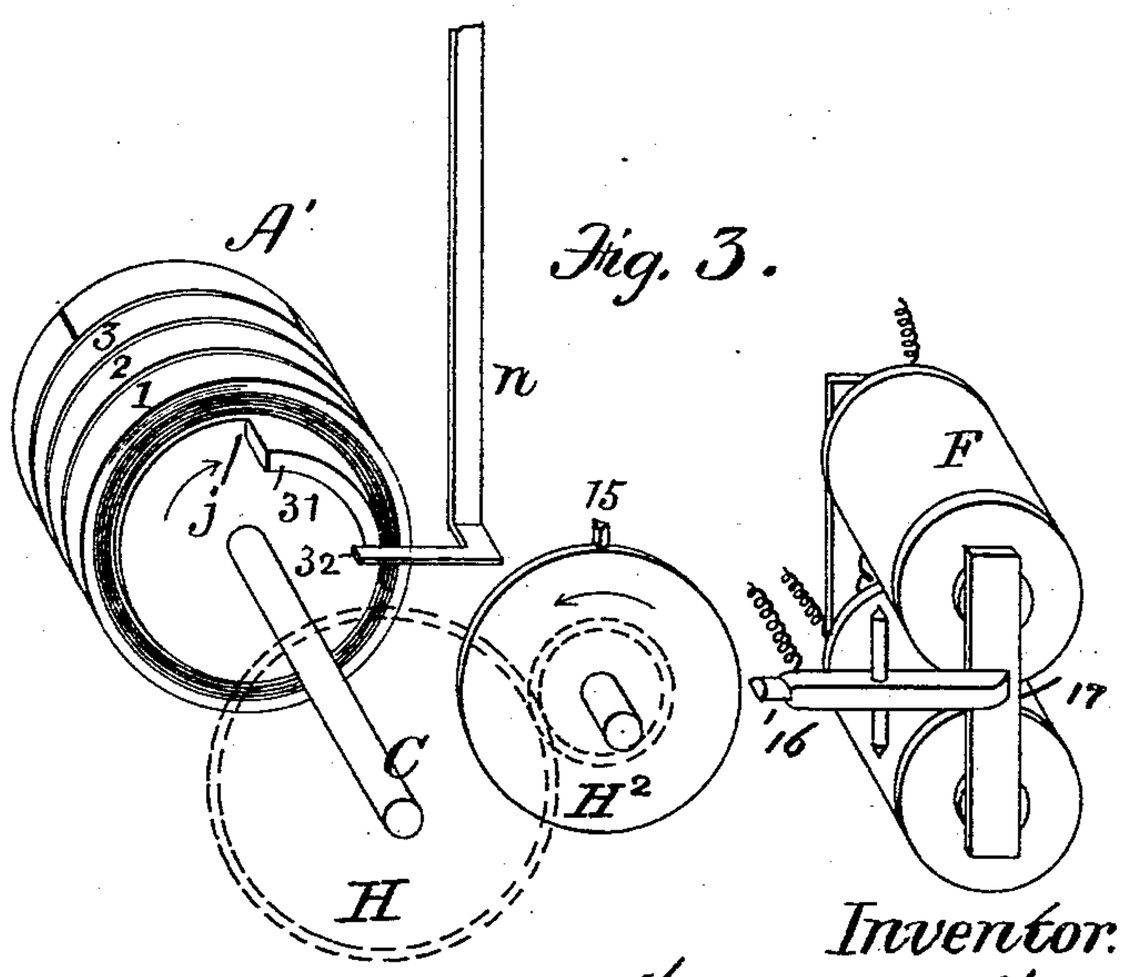

Fig. 3.

Witnesses.
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UNITED STATES PATENT OFFICE.

HAMMOND V. HAYES, OF CAMBRIDGE, AND HENRY D. SEARS, OF LYNN, ASSIGNORS TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

AUTOMATIC TELEPHONE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 457,477, dated August 11, 1891.

Application filed February 3, 1891. Serial No. 380,285. (No model.)

To all whom it may concern:

Be it known that we, HAMMOND V. HAYES, residing at Cambridge, in the county of Middlesex and State of Massachusetts, and HENRY D. SEARS, residing at Lynn, in the county of Essex and State of Massachusetts, have invented certain Improvements in Automatic Telephone Systems, of which the following is a specification.

Our invention concerns central station or exchange systems of intercommunication in which the speaking-telephone is employed.

The ordinary telephone-exchange is a well-known institution and is in existence and has been found useful in a great number of cities and towns. There are, however, many smaller centers of population where, for reasons which need not here be discussed, it has not been found practicable to economically establish and maintain on a commercially-remunerative basis such an organization. It seems therefore desirable to devise and construct a central-station organization in which the several ordinary functions and operations of the central-station switching and signaling appliances shall be carried out by automatically-acting mechanism under the intelligent control of the subscribers at the sub-stations and by means of the subscriber's apparatus. Various appliances and systems have from time to time been suggested tending to this end; but they have not been found practically successful, owing, as we believe, largely to the facts that the mechanism devised for the purpose has been complicated, that step-by-step or ratchet-and-pawl mechanisms have been involved in the apparatus at the central point, and that the operations to be performed by the subscriber have required more care and attention in their performance than experience has indicated can be expected. By our invention we seek to furnish a system of intercommunication for such places as are unable to sustain a regular central-station organization, whereby in its operation each sub-station in the system shall be enabled to place its own line in connection with any other line converging to the same central point; to send call-signals to the desired sub-station over the compound line thus formed without in any degree impairing the connections thus established between the two lines constituting the component members thereof, and upon the completion of the communication to restore the original normal or resting condition of both of the interested lines. An additional object of our invention is to accomplish these operations without any other sub-station apparatus than that in ordinary use and without material change in the construction of said apparatus, and, furthermore, with central-station apparatus of the most simple and non-complicated character compatible with absolute certainty and accuracy of operation. Such an organization may consist solely of a number of short or exchange lines all radiating from the same central station to different surrounding sub-stations within a limited territorial area; or it may, if desired, in addition to such a series of lines, include one or more trunk lines leading to distant central stations.

The nature and character of the problem which we have set ourselves to solve may be stated as follows: Each station must be capacitated at the will and by the manipulation of its own operator to connect its own line with any other disengaged line in the system and to retain such connection as long as may be desired. Appliances must be arranged to prevent other lines or sub-stations from interfering with or interrupting any connection when formed between any two lines for through communication. The initiatory sub-station must be enabled to send call-signals to the station desired without affecting the central-station-connecting appliances. Upon the establishment of such a through line it is of course also essential that the normal central-station terminal connections of both lines be disconnected, and finally each subscriber initiating a connection with another must have the power also of restoring the normal connections upon the completion of a communication. In meeting these conditions by our invention we provide a central station, where the automatic connecting appliances required for the operation of the system are placed, and two or more lines may converge from sub-stations to this point. In this speci-

fication we show and describe three such lines, that number being amply sufficient to fully disclose the invention. At each sub-station is, as usual, a call-bell for receiving call-signals and a telephone, and also a magneto-electric generator for generating and transmitting outgoing currents, which are employed for effectuating the necessary circuit connections at the central station for sending the call to the sub-station of a desired line and also for restoring the normal arrangement when the communication is over. That the generator may be used for this variety of purposes it is adapted in a manner well understood to send either plus or minus currents at will, which may be effected either by providing it with a commutator, whereby the alternating currents it naturally develops are straightened into a current of uniform direction, and then adapting the crank to be turned in either direction at will or by allowing the crank to be turned in but one direction, in which case a pole-changing double key would be used to determine the direction of the outgoing current. We prefer, also, to wind the magnet of the call-bell with two independent windings, both of which connect at one and the same end with the earth-wire or other return-conductor, but which are alternatively connected with the main circuit according to the position of the hook-switch. One of these windings is adapted to exercise a more powerful magnetic influence than the other and is brought into the circuit when the switch is in its resting position. The purpose of this construction of generator and bell, in which the changes are but of minor character, will hereinafter appear.

The important elements of our invention are of course located at the central station. At that point every sub-station line is provided with one terminal normally closed to earth (or in the case of a metallic circuit system to the return-conductor) and as many normally discontinuous or disconnected terminal branches as there are lines in the system. Each line is provided with a motor-driven rotary commutating mechanism, which controls the condition and connections of its own normally-closed terminal and of one set of the normally-discontinuous terminals of all lines, including its own. This mechanism is ordinarily at rest, but can be started by the action of the sub-station operator, who by properly operating his generator can send over the line to the central station an electric current of determinate direction, which, acting through a polarized relay and suitable intervening appliances, permits the mechanism to be set in motion; and, when so started, its functions are first to disconnect the circuit from its closed resting terminal connection and then to connect it successively for a brief space of time with the other lines of the system through the respective normally-discontinuous terminals thereof with which it is associated. The several circuit-controlling mechanisms are preferably arranged to be each run by an independent motor, which conveniently is a clock-train. Any of them being started in the manner indicated above will, if no further action be taken, run for one complete revolution and will then come to rest in its initial position. Included in that portion of the circuit of each line which constitutes its normally-closed terminal extension is a device in perpetual operation, adapted to send signals to line, each main circuit having a separate and distinctive signal, so that, for example, if the operator at the sub-station of line No. 1 takes up his telephone and simply listens he will hear his own signal (say a single click) constantly repeated at intervals of a few seconds. Line 2 may give two clicks. Line three will have a three-click signal, and so on. A polarized relay included in each line governs a local circuit which includes an ordinary electro-magnet, and the armature of said magnet has a lever which normally holds the clock-motor at rest, but which, when the local circuit is closed, and the armature consequently attracted, allows the clock-motor, and of course the commutating mechanism, to run. Since in polarized relays as ordinarily arranged the armature stays on the side to which it was last attracted or at which it was last placed, it is evident in this case that the armature of the said relay, being attracted by the action of the sub-station operator to the position where it will close the starting-magnet local circuit, will stay there either until a reverse current be sent through the relay-coils, attracting the armature to the other side, or until it be mechanically pushed over to the other side. This being so, the commutating-cylinder once started will run until its controlling-circuit is opened by one or the other of the above modes of retracting the polarized relay-armature, and if the operator—say at sub-station No. 1—having started his mechanism continues to listen at his telephone he will first hear his own signal, will in a few seconds, as his line connects itself with No. 2, hear the signal of No. 2, and subsequently will hear the signal of No. 3, the change of signal at all times indicating that the line has now transferred itself to another. On hearing the signal of the line desired a second electric current is sent from the calling-station of like direction to the first; but the ground of the first line being cut off this current finds circuit through the polarized relay and normal terminal of the desired line and starts the mechanism thereof. A reversed current is then immediately transmitted, which acts first to stop both mechanisms and second to ring the bell of the second subscriber, and conversation can then be carried on. Since electro-magnets oppose the transmission of rhythmical currents, the polarized relay of the answering-line is shunted during conversation; but in order that it may be still responsive to currents sent for the purpose of

controlling the commutating mechanisms the shunt is made to include a sufficient resistance. On conclusion of a conversation the sub-station initiating the call rings off by again sending a current of starting direction. This renews the motion of both mechanisms, which run to the end of their revolution, a snail-cam on the main axis being so arranged relatively to the unison or zero stopping-point that just before such point is reached the said snail engages the end of the polarized relay-armature lever and mechanically pushes it back to its initial position, thus opening the local circuit and allowing the motor to stop the first time thereafter that the stop-stud reaches its detent. It is to be noted that the stop-stud is on an arbor of the clock-motor, which is so geared that in the present case, where there are four working-contacts of the rotary commutator—viz., the resting-contact and a contact for each line of the system—it makes four revolutions for a single revolution of the cylinder and snail-axis, and that the clock-motor can therefore be arrested each time the stop-arbor completes a revolution if a reverse current be previously sent through the polarized relay to cause its armature to open the local circuit; but the motor can only be stopped at its unison position, where the normal closed terminal is restored when the commutator-arbor has made a complete revolution. If there are a greater number of lines in the system, the same relative arrangement must be preserved, and either the stop-arbor must be speeded up or the space allotted on the commutator-drum must be shortened, for the stop-arbor must rotate as many times during a single revolution of the commutator as there are lines in the system.

We have thus stated in a general way the salient features of the system, and we will now proceed to set forth and finally claim the essential features of our invention. We desire, however, at this stage to remark that so far as we are aware the device for announcing in an automatic exchange the line which at any moment is connected with the calling-line, the double-wound call-bell, the double stop device, the snail to mechanically replace the polarized relay-armature, and the resistance-shunt for the polarized relay of the called line, which are very essential elements of our system, have not heretofore been utilized in any analogous organization.

In the drawings, Figure 1 is a diagram indicating in a general way the entire system. Fig. 2 is a similar diagram indicating more specifically the construction and arrangement of the circuits and apparatus at both central and sub stations. Fig. 3 shows so much of the motor mechanism as is necessary for a clear understanding of the double-stop movement and snail-cam device; and Fig. 4 is a diagram, on an enlarged scale, of the commutating mechanisms at the central stations with their main branch and local circuits.

Considering first Fig. 1, let it be understood that C O is the central and S′, S², and S³ the several sub stations. 1, 2, and 3 are the lines uniting the said sub-stations, respectively, with the central station. At each sub-station is its telephonic outfit, which outwardly does not differ from that ordinarily in use. Each line, as shown, has at the central station a series of branch terminals in number exceeding by one the number of converging lines. Each line is also furnished with a suitable resistance-coil r and has a commutating cylinder or drum capable of being rotated by clock-work or other suitable motor mechanism. These drums in the drawings are marked as A′, A², and A³. The several main lines each have two branch terminals extending to their own drum and one terminal to the drum of each other line. Line No. 1, for example, goes by its main branch 1, after passing the resistance r, to the connection with its own drum at the extreme left, where it finds its normal closed terminal, while branch 1^a, branching from the main line at a point external to the resistance, leads to the normally-discontinuous working connection of its own drum at the extreme right. Its branches 1^b and 1^c, leading, respectively, to the drums of lines 2 and 3, are both united with their main line through the resistance r, and this arrangement holds good for all lines. For each line one branch after passing through the resistance leads to the resting terminal at one end of its own drum and a second normally-open branch leads from a point external to the said resistance to a working terminal of the same drum and preferably at the other end thereof. The resting closed terminal extensions pass then from their respective drums by the wires g', g^2, and g^3, each to its own contact-spring w, which presses on the periphery of a signal-sending circuit-breaking wheel x, the signal of each being different, and then through the metal work of the circuit-breaking device to a common ground connection g^4 and battery y and to earth at E. The circuit-breaking wheels can all be on the same axis and are kept in constant rotation by a suitable clock-motor m, so that the signals of each wheel are at all times being transmitted over its respective line, the appliance as a whole being designated as B. The motor mechanisms, on the other hand, are quiescent, except when any sub-station is procuring a connection with or disconnection from the line of another. The earth terminals at the several sub-stations are also marked E. The electrical connections of the central station are more fully indicated in Fig. 4 than elsewhere.

The several commutating-cylinders A′, A², and A³ are provided each with rings completely encircling them, the said rings respectively representing and connecting with the several lines of the system, and as the cylinders are made of non-conducting material the said rings have no connection with each other therethrough. In cylinder A′ the

rings ranging from left to right are marked 2 3 1, in cylinder A^2 they are in the order of 3, 1, and 2, and in cylinder A^3 they range as 1, 2, and 3. It is seen, therefore, that the ring at the extreme right is the ring of the line to which the cylinder belongs. Upon each ring a contact-spring bears, which spring is a terminal of some one line, the springs z', v', and k', which bear on the end rings 1, 2, and 3, unite with their respective lines each at a point 13 outside of the resistances r by means of wires 1^a, 2^a, and 3^a. The remaining springs are united to their main lines by wires connecting therewith at any point on the office side of the resistance r. Thus at cylinder or drum A′ ring 2 is pressed upon by spring v^2, which in turn is united with line 2 by wire 2^b, and ring 3, through spring k^3 and wire 3^c, is united with line 3, and the same order or arrangement holds with respect to the other cylinders. At one end of each drum (in this instance the left) is a fourth ring divided up into as many conducting-segments as there are lines in the system, plus one. There are in this case four, all insulated from each other, which are marked, respectively, 1, 2, 3, and zero. At each drum segment 1 connects electrically with ring 1, segment 2 is connected with ring 2, and segment 3 with ring 3. The zero-segment in each case is connected electrically with the shaft and frame-work of the drum, and thence by contact-spring c or otherwise with the perpetually-operating device m. When the commutating-drums are at rest, the contact-springs z, v, and k all are on the zero-segments, and the lines 1, 2, and 3 are thereby normally closed to earth, the several frame-works being all grounded by wires g', g^2, and g^3, which, after passing through the signal device, find earth at E. Any suitable signal-indicating device may be employed.

In Figs. 2 and 4 it will be seen that we have shown an induction-coil and local circuit. The signal-wheel x for each line and the spring w, which bears peripherally thereon, are both included, together with the primary helix i of an induction-coil I, in the local circuit of a battery y'. The secondary helix of said induction-coil is in the portion g' of the main circuit between the line-drum and the earth E. Each make and break signal made in the primary circuit of course causes a like impulse in the secondary circuit, which, being a portion of the main line, enables the said impulse to manifest itself as a click in the telephone at the distant sub-station. A different device is, however, indicated in Fig. 1, where the break-wheels are in the main line, together with a battery y in the general ground-wire. In practice, of course, the distinguishing-signals of the circuit-breaking wheels, instead of being formed of raised teeth, as shown, are made of alternately conducting and non-conducting spaces on a smooth surface. Included in the normally-closed branches of the lines 1 and 2 and 3, between the resistances r and the contact-springs z, v, and k, are polarized relays P, one for each line, which by means of local circuits 20, including electro-magnets F, batteries y^2, contact-screws o, and their own armature-levers n, control the starting and stopping of the drums. The armature of the polarized relay P rests normally on the limit q, the local circuits being thereby held open, as in line 3; but when a starting-current is forwarded from the sub-station the said armature is at once attracted over to the other side, as in line 2 and 3, and the local circuits are closed. This will be more clearly understood by referring to Figs. 2 and 3.

It is not necessary to further describe the circuits in the central-station part of Fig. 2, since they are identical with those shown in Fig. 4. The stopping, starting, and unison mechanism need, however, an additional word. When the several machines are at rest, the armatures 17 of the electro-magnet are retracted by their springs, and the detents 16 on the end of the armature-levers are in line with the stop-studs 15 on the edge of the stop-arbor disks H^2, and the said stud 15 in fact is in contact therewith, the motor in virtue of said contact being held quiescent. At the same time the armature-lever n of the polarized relay P is held to that side which maintains the local circuit open, and the resting segment of all of the drums is under the first springs, the several lines being thus closed through the relays to earth. The projecting end 32 of the lever n at unison is also opposite the point j on the drum-arbor, being just behind the highest part of the snail 31. As we have already pointed out, in an exchange of three circuits the drum and wheel H on the drum-axis C will make but one revolution while the stop-disk H^2 makes four. If, then, the electro-magnet F is energized and its armature attracted but for an instant, the stop-stud is freed, and the motor starts, but will come once more to a stop the first time the stop-stud comes round, the drum A′ meanwhile having accomplished one-fourth of a revolution; but if the armature of the magnet F stay attracted until the fourth revolution of its disk is begun the polarized relay-armature n, having been retained where it holds the local circuit closed until that time, the hook 32 of said armature will be impinged upon by the snail 31 and gradually forced over to the other side, where it is left (the machine at the same time being at unison) until another call is initiated.

The sub-station arrangement is fully shown by the upper part of Fig. 2, and as all are alike it will be sufficient to describe one of them.

The apparatus at each sub-station comprises a receiving-telephone t, an automatic switch-hook V, a transmitter a, a local battery b, an induction-coil e, a call-bell l, and a call-generator d. Normally the receiving-telephone hangs, as usual, on the switch-hook,

and the said hook therefore occupies its lower position in contact with the terminal *h*. The main line, being connected with the switch V, is thereby continued by terminal *h*, wire 5, and bell *l* to wire 8 and earth E. The said bell has preferably two windings, one of fine wire, and consequently having many convolutions, and the other of coarser wire, and therefore of fewer convolutions. The finer winding is in the circuit described above, because this being the resting or alarm circuit it is required that the bell shall ring strongly for the purpose of calling the attention of the subscriber. When the telephone *t* is removed from the hook, the main circuit is transferred from the contact *h* to the upper contact 9 of switch V, and thence by way of wire 4, telephone *t*, secondary helix of induction-coil *e*, wire 6, call-generator, wire 7, and the coarse-wire winding of the bell *l*. The bell is introduced here, so that a slight ring will be heard each time that the subscriber operates his own generator, and the generator is placed in the telphone branch so that the subscriber can while operating the generator listen for the purpose of keeping informed of the progress of the drum at the central station. Both bell-windings connect after passing round the magnet-cores with the same ground-wire 8. The call-generator is organized in a manner well understood to send currents of either direction, as desired. This may readily be accomplished by fitting it with a commutator, whereby its alternate currents as generated are straightened with respect to the circuit, and by then turning the crank in one direction for positive and in the other direction for negative currents. Instead of determining the direction of current by turning the handle the handle may at all times be turned one way, and the current can then be directed as desired by reversing-keys. The commutator is preferably so arranged that the current of constant direction which it delivers is made in some degree intermittent, and we are thereby enabled to employ a simple electro-magnetic bell without an automatic break in the circuit, the vibrations thus being produced by the generator instead of by the bell.

In the operation of our automatic exchange, sub-station No. 1, let us suppose, wishes to speak with sub-station No. 2. He first removes his telephone from its support, and then by turning his generator-crank in a given direction he sends a starting-current to the central station and knows that his generator is working properly, because his own bell, being still in circuit by its low-resistance winding, rings gently. The current sent by this first ringing operation to line, acting upon the polarized relay at the central station, causes the armature of said relay to swing over and to close the local circuit of the drum-controlling magnet. The motor mechanism of the drum is thus released, causing the drum to revolve. The polar-armature stays over at the side at which it is last placed, and therefore the local circuit stays for the present closed, the drum continues to run, and the subscriber continues to listen at his telephone. The drum-contact leaves its resting position and passes its own connecting-segment, no signal being heard by the listening subscriber because the transit of the first segment has cut off the ground and ticking appliance; but continuing to listen (still supposing it to be No. 1 who has called) the subscriber in a moment or two hears a ticking signal—first, a succession of ticks in twos, then a succession of ticks in groups of threes, and so on, each successive line being represented by a different signal. As soon as segment No. 2 comes under the line-spring *z* the listening subscriber hears the two ticks. He thus knows that line No. 2 is now connected with his line and immediately sends another ring exactly like the first. This reaches the polarized relay No. 2 by way of line No. 1, relay P of No. 1, spring *z*, segment 2, wire 40, ring 2, spring v^2, wire 2^b, all at No. 1 mechanism, and then by branch wire 2 through No. 2 polarized relay to earth, and acting thereon starts the motor of clock No. 2. A reverse ring developing a current of opposite direction is then sent to line, and passing through both polarized relays operates them reversely, throwing both armatures over and opening both local circuits. Both motors will now stop as soon as the stud on the stop-disk reaches the conclusion of its revolution and comes in contact with the end of the neutral magnet-armature. The drum of No. 2 meanwhile has advanced, and the spring *v* now contacts with segment 2, which by wire 41 is united with ring 2 on the same drum, and line 1 is connected with line 2 by way of these devices, spring *v'*, wire 2^a, and the point 13 on main line 2. A continued reverse ring is now sent, and the current developed thereby reaching the second sub-station traverses the fine-wire winding of the call-bell and rings it loudly, giving the call. Conversation can now be carried on, and it is to be observed that between the points 14 and 13 on line 2 there are two paths, one through the polarized relay P, wire 42, spring *v*, segment 2, wire 41, ring 2, spring *v'*, and wire 2^a, and the other straight from the point 14 to the point 13, through the resistance *r*, which is made sufficiently large to permit the operation of the relay once more when the ring-off signal is sent. By this arrangement the opposition presented by the polarized coils to the passage of the voice-currents is minimized, the relay being shunted, while at the same time the relay is left where it can be reached for the operation of its motor. On the conclusion of a communication a signaling-current of direction the same as that at first sent is transmitted by the subscriber who called. This actuates both polarized relays, swinging their armatures into position to close their local circuits. The magnets included in the said circuits permit their clock-

motors to start, and in both mechanisms, as the unison-point comes round, the snail 31 pushes over the relay-armature and opens the local circuit just before unison is reached, so that the clock must stop before a second revolution can begin.

If at any time any sub-station shall start its motor mechanism and shall then for some reason conclude not to call another, his cylinder will simply make one full revolution, because the polarized relay-armature attracted to either side will remain there until forcibly moved to the other, but on the conclusion of said revolution will stop, the armature being forcibly pushed over by the snail. It should be noted that the resistances *r* are also useful at the time when any subscriber has stopped his own drum on the connection with the desired line and proceeds to actuate the drum of the second line by means of the polarized relay thereof by acting to divert a sufficient amount of current through the said relay, instead of suffering the main portion thereof to pass over the second line to the sub-station. We desire, furthermore, to state that it is not essential that the local circuit through which the polarized relays control their respective drums shall normally be open and shall he closed to effect the release of the motor mechanism. This arrangement can of course readily be reversed, and the local circuit, where desired, can initially be closed and be opened by the action of the polarized relay to effectuate the starting of the mechanisms.

We claim—

1. In an automatic telephone-exchange system, a series of lines converging to a central station from a series of sub-stations, a motor-driven circuit-changing drum at the central station of each line, the said drum being normally at rest, maintaining the circuit of its own line closed, but capable of revolving and of thereby disconnecting its own line from its normal terminal and connecting it with each of the several lines of the system successively through their respective drums and their controlling mechanisms, stopping and starting mechanism for each drum, comprising a normally-open local circuit, an electro-magnet included therein, the armature-lever of said magnet normally constituting a detent for the drum-motor, but adapted upon the closing of the local circuit to disengage the same, a polarized relay in the main-line circuit, controlling the said local circuit, the armature of said relay being adapted to rest where last placed to move and close the local circuit when a current of given direction is caused to traverse the main line and to move reversely and open the local circuit when a current of opposite direction traverses the main line, a mechanical shifting device, such as a snail-cam, mounted on the drum-axis and adapted to move the said relay-armature to its resting position on the completion of a single revolution of said drum and thereby independently of main-line currents to open automatically the local circuit and stop the drum at unison, and a constantly-operating signal-transmitting device for each line included in the normal circuit-terminal thereof and adapted when the said line is not in use to send a distinctive signal indicating its number over its own circuit and also over any circuit which may have connected itself therewith, all substantially as described, and for the purposes set forth.

2. In an automatic telephone-exchange system, the combination of a circuit-changing drum for each line and a branch from each other line extended thereto, controlling mechanism for the said drum arranged to permit the revolution thereof or to arrest the same, as required, and a polarized relay in each main line controlling the said mechanism, all at the central station, the said drum in a single revolution being adapted to disconnect the normal terminal of its own line and to connect the said line successively with each of the other lines and the said controlling mechanism being adapted to stop the said drum when its line is connected with any other line and to start the same when desired, with an electrical generator or its equivalent at the sub-station, constructed to develop and transmit at will currents of given direction to actuate the polarized relay of its own line or of any connected line and thereupon to set the corresponding drum or drums in motion, or currents of opposite direction to arrest the motion of the said drum or drums at any desired moment, and also to give the call-signal upon the bell at the station of the connected line, substantially as described.

3. In a telephone-exchange system capable of being operated from the several subscribers' stations, a series of lines converging from sub-stations to a central station, a constantly-operating circuit-changing signal-transmitter at the central station for each line connected with said line when at rest and transmitting thereover the designating-signal thereof, a motor-driven circuit-changing drum for each line also at the central station controlling the normal closed terminal of its own line and normally-discontinuous branch terminals of all lines, each drum being normally under the control of the sub-station of its own line and adapted to revolve when started thereby and thereupon to disconnect its own designating-signal apparatus and to successively connect in place thereof the designating-signal apparatus of each of the other lines, and a telephone at each sub-station, wherein the said designating-signals can be reproduced, whereby the operator at each sub-station may be notified as each line successively is brought into connection, substantially as described, and for the purposes specified.

4. In combination with a motor-driven circuit-changing or commutating drum held normally at rest by the engagement of a stop-pin carried by one of the motor-arbors with a suitable stop-lever and connecting a main cir-

cuit with a closed terminal branch, but capable of revolving and adapted thereupon to disconnect the said branch and to connect the said main circuit successively with each of a series of free terminals representing other lines of a local circuit, an electro-magnet included therein, the armature-lever thereof being extended to form the said stop-lever, a polarized relay included in the said main circuit, provided with an armature adapted to respond to current reversals in the said main line, the said armature forming part of said local circuit and determining by its position the open or closed condition thereof and being also provided with a hooked bar extending to and lapping over one end of the circuit-changing drum, and a mechanical shifting device, such as a snail-cam, mounted on the said end of said drum and so placed as to engage the said bar when in position to effect the starting of said drum and thereby to restore the relay-armature to its position of rest and to enable the drum to be arrested at unison on the conclusion of each revolution.

5. In an automatic telephone-exchange system, a series of sub-station lines converging to a central station and each there provided with a closed circuit-terminal branch including a device for constantly sending designating-signals over said branch and with a series of normally-discontinuous terminal branches equal in number to the number of lines in the system, a circuit-changing drum for each line associated with its own closed terminal and with one of the discontinuous terminals of all lines normally maintaining the connection of said line with its closed terminal, but capable of revolving, of thereby connecting said line successively with the others and of being stopped during such connection, a polarized relay at all times in the main-line circuit, acting to stop and start said drum, and a balancing resistance for each line located at a point between the said relay and the junction of that one of the normally-discontinuous terminal branches which extends to the drum of its own line, whereby the relay-magnets of a called line when connected with a calling-line may be shunted by a resistance sufficiently high to allow the relay to respond to disconnecting or other currents transmitted over said calling-line.

6. The combination, in an automatic telephone-exchange, of a clock mechanism and a drum or cylinder adapted to be driven thereby, a main-line circuit, a polarized relay included therein having an armature responding to reversals of current and adapted to stay on the limit-stop at which it is last placed, a local circuit controlled by said relay-armature and opened and closed thereby, an electro-magnet included therein and provided with an armature, a lever therefor and a bar projecting from the said lever, the said bar being arranged in or out of line with a stop-pin carried by a speeded arbor of the clock mechanism and thereby adapted to stop or start the same according to the attracted or retracted position of the armature, whereby the stopping and starting of the clock mechanism is caused to depend upon the direction of the main-line current traversing the polarized relay-coils, and means, as indicated, for mechanically moving the armature of said relay to its normal position at the completion of a single revolution of the drum, whereby the said drum is automatically stopped at unison.

7. The combination, substantially as hereinbefore described, at a telephone-station, of a main-line switch or circuit changer having a resting and a working position and contact, branch circuits leading from both, a telephone included in the branch circuit represented by the working contact, and a generator of electricity included with the said telephone in the said branch circuit, whereby the operation of the said generator may be directed by the condition of the main circuit, as indicated by sounds produced in the telephone.

8. The combination, substantially as hereinbefore described, at a telephone-station, of an electro-magnetic call-bell having its magnet wound with two distinct and separate windings, a main-line switch or circuit changer having a resting and working position, a branch circuit united to the said main line when the said switch is in its position of rest and including one of the said windings of said bell-magnets, whereby the said bell is enabled to receive an incoming call, and a second branch circuit adapted to form a continuation of the main line when the said switch is in its working position and including the call-sending generator and the other winding of said bell-magnets, whereby outgoing signals also may be noted upon the same bell.

9. In an automatic telephone-exchange and at the central station thereof a revoluble circuit-changing drum or cylinder for each line normally at rest and adapted to be started or when in motion to be stopped by the action of the armature of a polarized relay included in said line, conducting-rings, one for each line in the system, mounted on the said drum, an additional ring divided into insulated segments exceeding said number by one, a contact-spring representing line-terminals resting on each ring, one of the said segments of the final ring being electrically united to a designating-signal-sending device and to earth to serve as a normal circuit and the remaining segments being each connected with one of the said conducting-rings, a resistance included, together with said polarized relay, but external thereto, in the branch circuit of each line, which leads to the segmental ring of its own drum, and a branch terminal of said line extending from a point thereon external to said resistance to one of the solid rings of said drum, which ring is

united to the segment immediately following the unison-segment, substantially as described, and for the purposes set forth.

10. In an automatic telephone-exchange and at the central station thereof, a circuit-changing drum for each line, the said drum controlling the closed circuit-terminal of its own line, one of the normally-open branch terminals of its own line, and a branch terminal of each other line in the system, a polarized relay in each main line adapted to start and stop the drum of its own line, a resistance in each line external to said relay sufficiently high to divert a sufficient portion of current from a calling-line through said relay to operate the same, and mechanism, as indicated, whereby each sub-station may connect its own line with any desired line by acting through its own polarized relay and may then act upon the polarized relay of said second line and thereby start the drum thereof for the purpose of disconnecting the said second line from its normal closed terminal.

11. In a telephone-exchange system, two or more electric lines converging from sub-stations to a central station, an automatic revoluble circuit-changing drum for each line at the central station controlling terminals of all lines, the said drum acting when in operation to connect its own line once in each revolution with each other line in the syste and being responsive to relatively-revers currents transmitted from the sub-statio its own line or from the sub-station of a d ferent line which has initiated a connection therewith, and a constantly-operating signal-transmitter included in the normal circuit of each line, also at the central station, and transmitting over said line or connected lines designating-signals representing the number thereof, substantially as and for the purposes specified.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 27th day of January, 1891.

HAMMOND V. HAYES.

Witnesses:
GEO. WILLIS PIERCE,
JOSEPH A. GATELY.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 29th day of January, 1891.

HENRY D. SEARS.

Witnesses:
GEO. WILLIS PIERCE,
JOSEPH A. GATELY.