(No Model.) 2 Sheets—Sheet 1.

# T. D. LOCKWOOD.

## AUTOMATIC TELEPHONE EXCHANGE.

No. 372,378. Patented Nov. 1, 1887.

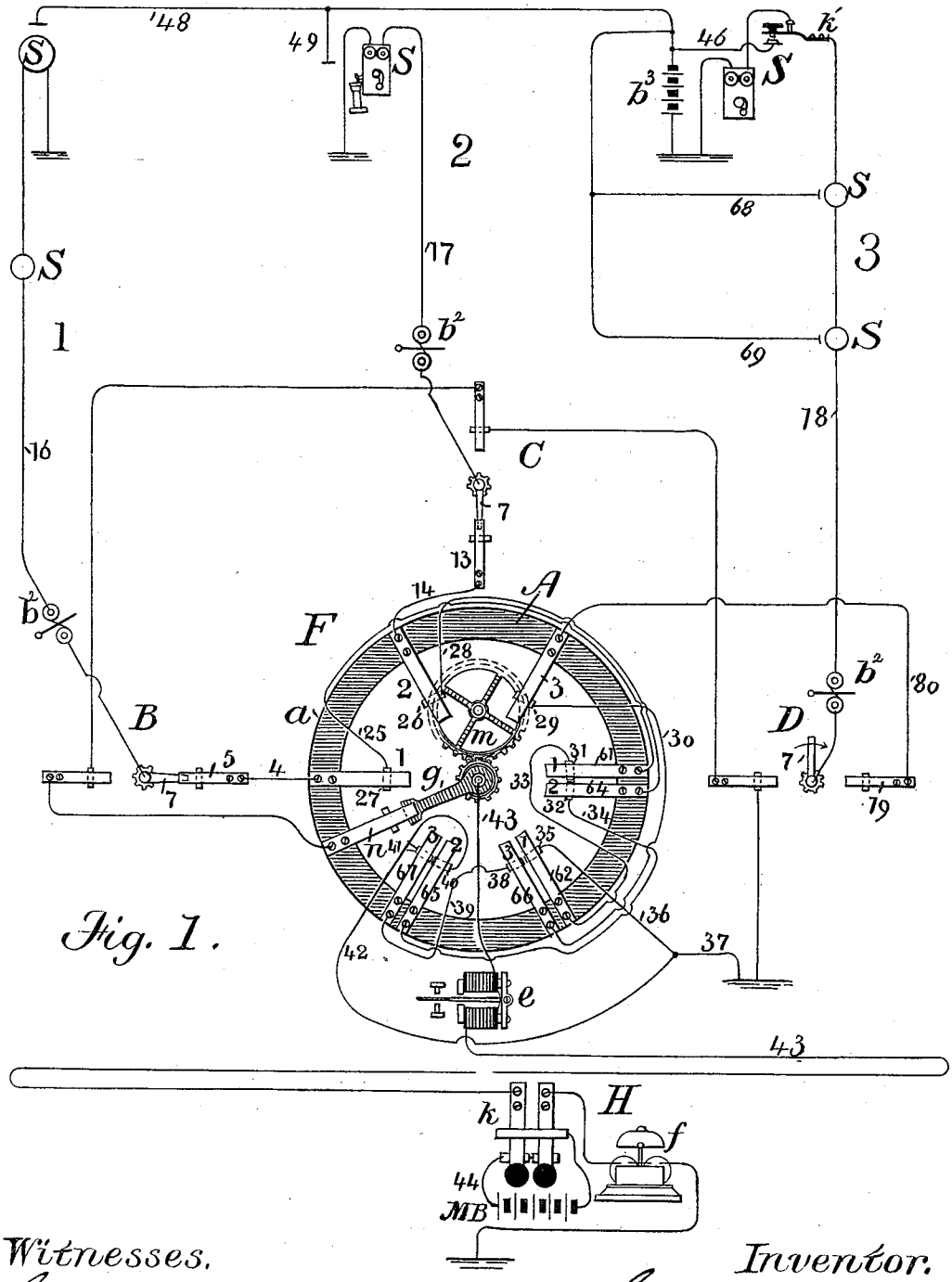


Fig. 1.

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(No Model.) 2 Sheets—Sheet 2.

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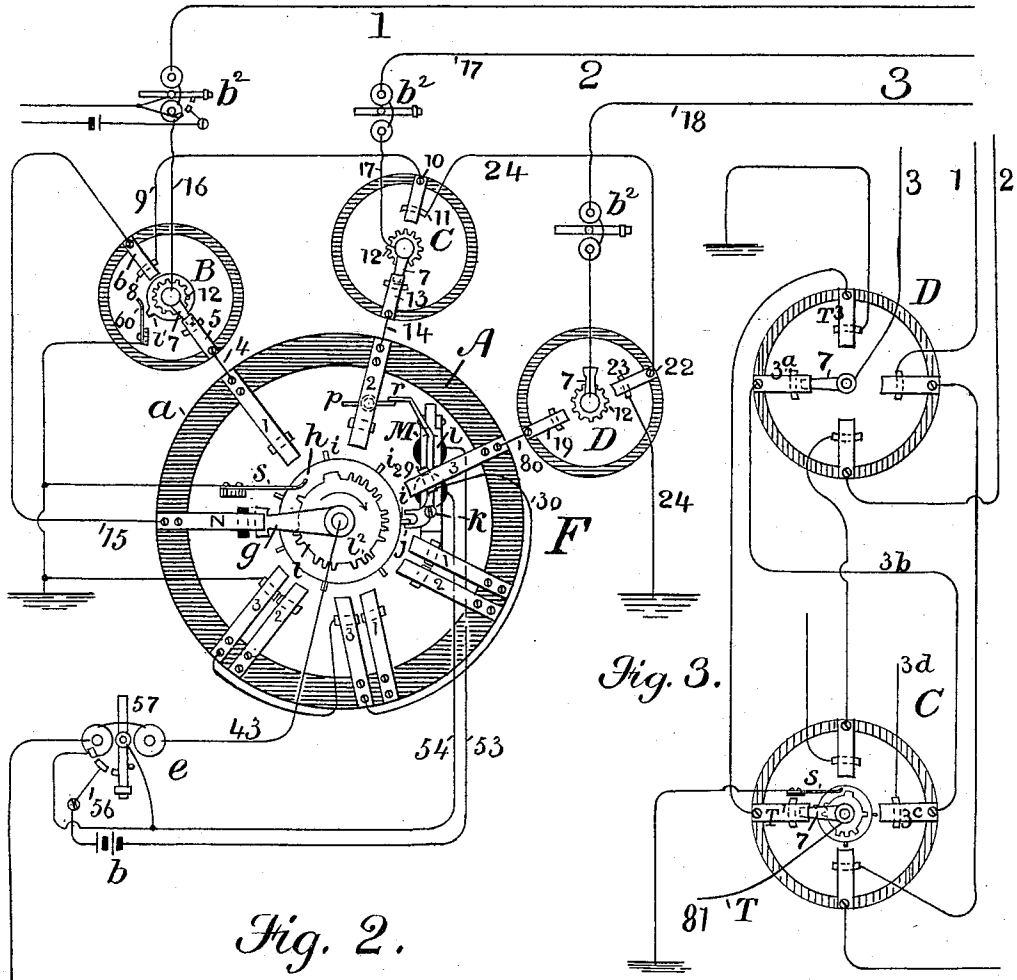
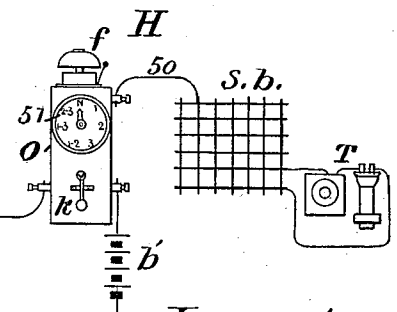



Fig. 2.

Fig. 3.




Witnesses.

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# UNITED STATES PATENT OFFICE.

THOMAS D. LOCKWOOD, OF MELROSE, MASSACHUSETTS.

## AUTOMATIC TELEPHONE-EXCHANGE.

SPECIFICATION forming part of Letters Patent No. 372,378, dated November 1, 1887.

Application filed April 11, 1887. Serial No. 234,408. (No model.)

*To all whom it may concern:*

Be it known that I, THOMAS D. LOCKWOOD, residing at Melrose, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Automatic or Auxiliary Telephone-Exchange Systems, of which the following is a specification.

My invention relates to central-office systems of electrical intercommunication of that class in which the several subscribers are provided with suitable mechanisms and appliances, and in which the several circuits are so arranged that the subscribers themselves are enabled to effectuate the necessary changes and commutations at a station to which a number of lines converge, or are enabled to place themselves in connection through a common trunk-line with a distant main or central station, where the operator, also by means of the said trunk-line, is enabled to connect the several lines together, as desired, at their point of convergence.

I contemplate especially the application of this invention to telephonic intercommunication, as indicated by the drawings accompanying this specification. Such a system, therefore, implies and requires a main central station, an auxiliary central station, a trunk-line extending between them, and a number of substations radiating from the auxiliary station, each to one or more sub-stations. Such an organization, I am well aware, is not broadly new, having been shown and described in Letters Patent issued to Theodore N. Vail August 11, 1885, and numbered, respectively, 324,191 and 324,192, and, further, in Letters Patent issued to myself on February 9, 1886, numbered 335,708, to all of which reference may be made. In an application for Letters Patent filed by Isaiah H. Farnham March 26, 1887, Serial No. 232,522, is also described such a system, in combination with an automatic motor-actuated circuit-changer located at the auxiliary station, and which is adapted to be operated from the main central station to place the trunk-line in electrical connection with any one of the sub-station lines or to terminate such connections at will, restoring the normal conditions.

My present invention constitutes, especially, an expansion and improvement of the invention described in the said application, and its object is to enhance the scope of the apparatus described therein, and generally to employ the circuit-changer there described, not only for the connection of any one of the sub-station circuits with the trunk-line, but also to effect the union of any two of the said lines.

To this end it consists in causing each circuit to pass through a number of contact-springs, both mounted singly and also in close proximity to like springs of each of the other circuits of the system and in range of the circuit-changing arm, whereby the said arm representing the trunk-line may, when operated from the central station, connect itself and its own line with any one of the sub-station lines, or with any two, by the latter operation also uniting the said two in such a way that the sub-stations located thereon may signal or converse with one another.

It also consists in providing for each of the said sub-station lines an independent circuit-changing arm actuated by mechanism identical in character with that of the trunk-line circuit-changer, whereby the said sub station line may by the action of a person at any sub-station be disconnected from its spring-contact extensions and be connected directly with the trunk-line, which for that purpose is extended through a series of spring-contacts, one of the said contacts being within range of each of the said subordinate circuit-changers.

It consists, furthermore, in an alternative or modified apparatus for the sub-station lines, in which, in addition to passing the trunk-line, as represented, by a spring-contact through the path of the sub-station-line circuit-changer, I also cause each of the other sub station lines to be similarly represented, so that each of the entering lines at the auxiliary central station has, first, a circuit-changing arm capable of being controlled by the sub-stations on its own line, and has also a continuation of its line from the normal point of rest of the said arm through a series of spring-contacts, one in the line of movement of the circuit-changer of each of the other lines, whereby each line is enabled to place itself directly into connection with each of the other lines by means of its own circuit-changer and the contact-spring of the desired other line, lifting at the same time the

spring of the said other line from its normal contact.

When the latter form of apparatus is adopted, the trunk-line apparatus is materially simplified, and the trunk and sub-station line apparatuses are identical in construction and character.

In the drawings which illustrate this invention, Figure 1 is a diagram of the several sub-station and trunk line circuits, representing their path through the auxiliary-station apparatus. Fig. 2 is a similar diagram showing other details of apparatus, and Fig. 3 is a diagram indicating a modified circuit arrangement.

In the drawings, H represents the main central station, F the auxiliary station, and S a series of sub-stations connected with the several lines 1, 2, and 3, one or more on each line.

At the auxiliary central station F is a circuit-changing apparatus, A, actuated by a suitable motor, which is indicated by the spur-gear *m*. This motor is controlled by an electro-magnet, M, Fig. 2, its armature *l*, stopping device *k*, and arresting-disk *h*, the latter being provided with a number of stop-points, *i*, equal in number to the number of different positions which the circuit-changing device is required to stop at, this in the present case being six in addition to the normal point of quiescence.

It is not considered necessary further to describe the motor or its stop mechanism, since it forms no part of my invention, and since it is fully described in the application of I. H. Farnham, hereinbefore cited.

The circuit-changing arm *g* is, when at rest, in contact with a flat spring, *n*, and the trunk-line 43, extending between the main station H and the auxiliary central station F, is at the latter in circuit with the said arm, which forms a movable terminal thereof, and with the polarized relay *e*, which controls the motor. Each of the sub-station lines 1, 2, and 3 likewise terminates in a similar motor-driven arm, 7, which, however, has but two stopping positions—namely, first, upon its own extension contact-spring, and, second, upon one of a series forming, as hereinafter to be described, part of the normal extension of the trunk-line. These subordinate circuit-changers are mounted in their own frames C and D. In Fig. 2 these are shown, the arms 7 of B and C being in place and that of D being in transit from one contact to the other. The main or trunk circuit extension may be traced from spring *n* over wire 15 to the spring 6 at the sub-station-line apparatus B. This, when at rest, lies upon the contact 8, from which the wire 9 extends to the spring 10 at apparatus C. This spring in turn rests on contact 11, from which the wire 24 leads to spring 22 at apparatus D. This finally rests upon the contact-anvil 23, which is connected with the earth as a terminal by wire 24.

At the apparatus A are attached a series of contact-springs representing each sub-station line alone and a second series of paired contact-springs, the several pairs comprising a spring representing each line closely associated with a similar spring of each other line. Each of these springs is successively passed by and brought into contact with the circuit-changing arm *g*. Thus in the drawings, proceeding in the direction of the arrow, it will be observed that mounted on the non-conducting ring *a* are, respectively and alternately, the springs 1 2 3 singly, and then a pair of springs, 1 and 2, a second pair, 1 and 3, and a third pair, 2 and 3. This completes the series of contacts for a system of this size; but of course the system is by no means so restricted, but is adapted for a greater number of wires, if necessary, it being in like manner understood that such systems are only applicable where a small number of lines converge, and that when the number of such lines exceeds six or eight it is more economical to establish a regular central-office exchange; but the contact-springs mounted on the insulating-frame *a* being arranged as described, the circuit-changing arm *g* will, when set in motion, successively engage and raise from their normal contacts the singly-arranged springs of their several circuits and then the several paired springs, and after being started from its initial point will come to rest on the next stop-pin *i* in engagement with the next contact-spring. In no case will the arm *g* travel more than the space from one spring or one pair of springs to the next without first stopping at and in connection with the first spring or pair at which it arrives after the last stop, the stop-pins *i* being arrested by one of the detent-pins *j*, which are controlled by the electro-magnet M, and which by their engagement with the said stop-pins actuate a second stopping device, *r*, which arrests the fan *p* of the motor.

It is of course necessary when any line is connected with the trunk-line or with any other sub-station line that its normal earth-terminal shall simultaneously be disconnected, and for this purpose the circuit of each line is led consecutively through its own single spring and the resting or normal contact thereof, and from the said resting-contact to each of the paired springs of the same line and their resting-contacts, the last in series of the said contacts being connected with an earth-terminal, and it is the function of the rotating circuit-changer, therefore, not only to make contact with the single-circuit springs and to unite through its substance the paired springs, but also in each case to raise the said single or paired springs from their normal contacts.

I will now trace the several sub-station circuits through the apparatus of the auxiliary station.

The first sub-station line, 1, (see Fig. 1,) entering by its line-wire 16 from the sub-stations, passes first through its own controlling-relay $b^2$ and then to its circuit-changing arm 7, which is the permanent terminal of said line. This arm 7 rests under and in contact with the flat

spring 5, this being mounted on the non-conducting frame of the apparatus B. From this point the normal extension continues to earth through wire 4, spring I, mounted on non-conducting frame *a* of the main apparatus, resting-contact 27, wire 25, spring 61, resting-contact 31, wire 33, spring 62, resting-contact 35, wire 36, and earth-wire 37. The second line, No. 2, in the same way may be traced over line-wire 17, relay *b*, circuit-changer 7, spring 13, wire 14, spring 2, contact 26, wire 28, spring 64, contact 32, wire 34, spring 65, contact 40, wire 42, and earth-wire 37. So, also, the third line, No. 3, entering by wire 18 and terminating in the rotating arm 7, may be traced *via* spring 19, wire 80, spring 3, resting-contact 29, wire 30, spring 66, resting-contact 38, wire 39, spring 67, resting-contact 41, wire 42, and earth-wire 37.

The springs 1, 2, and 3 are the singly-mounted springs of their respective lines. The spring 61 of line 1 is mounted in close proximity to the spring 64 of line 2. The spring 62 of line 1 is mounted close to the spring 66 of line 3, and the spring 65 of line 2 is mounted close to the spring 67 of line 3. Thus each line has one spring-contact in close proximity to a like contact of each other line. The outer end of the circuit-changing arm *g* is made broad, so that it can rest in contact with both springs of a pair at once and form the connecting-link between them. The motor *m* is, as hereinbefore stated, set in motion and stopped by the mechanism operated by the electro-magnet M, this being in turn controlled through the local circuit 53 and 54 of a battery, *b*, located at the auxiliary station, by means of a delicate polarized needle-relay, *e*, the needle of which, 57, is adjusted to move in response to currents of a given direction only, and thereupon to close the said local circuit at the points 56. The relay-magnets *e* are in the trunk-line main circuit, and are controlled over the said line 43 by means of apparatus located at the central station, the principle of which is shown in Fig. 1 and one exemplification thereof in Fig. 2. In Fig. 1 the said apparatus is indicated by a circuit-closer, *k*, which, when pressed, unites the line to a normally-disconnected battery-wire, 44, and causes the current of the main battery to flow to line through the magnet of a signal-bell, *f*. In Fig. 2 the same functions are fulfilled by the apparatus *o*, which closes the battery *b'* to line by key *k* through the bell *f*, while the action of the said key mechanically and through suitable gears also rotates the pointer over the dial 51, affording an indication of the progress of the arm *g* at the auxiliary station. When the key *k* is at rest, the circuit of line 43 is by wire 50 to the switch-board *s b*, where it may be united with any other line centering at the station H, and where it may be connected with the operator's telephones T. The bell *f* is for the purpose of receiving a return-signal, indicating the line or lines with which the circuit-changing arm in its progress will next connect, and is a convenient guide for the operator. The operation of the return-signal will be understood by reference to Fig. 2, where it will be seen that a circuit breaking and closing wheel, *l*, is placed on the arbor of the circuit-changer *g* and revolves with it. The trunk-line circuit is open during the periods which elapse between the disengagement of the said circuit-changer from one contact-spring or from one pair of such springs and its engagement with the next, and during these periods the teeth $l^2$ of the signal-wheel *l*, or that portion of them which constitute a signal indicating the line or lines next to be connected, graze the free end of the ground-spring *s*, and the trunk-line is thus closed to earth as each tooth passes over and makes contact with the earth-spring. For instance, if the arm *g* is leaving its normal contact and approaching the spring I of the first sub-station line, one tooth only makes contact with the spring *s*, and the bell *f* at the central station gives one stroke, and so on in each other step of the said circuit-changer.

I do not claim as my invention the instrumentalities I have last described, these being embodied and claimed in the application of Farnham, which I have already cited.

If, now, the operator at the central station H wishes to connect the main or trunk line with one of the sub-station lines 1, 2, or 3—say 3—he presses his key and sends a current to line. This starts the motor, which comes first to rest on spring I, meanwhile sending also a return-signal. He again presses the key a second time and a third time, allowing the motor to reach successively springs 2 and 3, between each two springs transmitting the indicating return-signal, so that the operator is at all times apprised of the position of the circuit-changer. Arriving at spring 3, the end of the arm *g* lifts the said spring from its contact 29, and the trunk-line is thus placed in direct connection with line 3, which may be continued as long as desired, and as the controlling-relay is not responsive to rapidly-alternating pulsations of electricity any of the sub stations S on line 3 may be rung up by the central station, and conversation may be carried on; or the trunk-line may, at the central station H and through the switch-board, be connected with any other line entering the said switch-board.

If it be desired to connect from the central station any two sub-station lines together at the auxiliary station, (say 1 and 2,) the motor is caused to advance one more step than those already described, which brings the end of the arm *g* below the pair of springs 61 and 64, raising these from their continuation-contacts 31 and 32 and uniting them electrically through the substance of the end of the arm *g*, which, in addition to thus providing a connecting-link between the two, affords a medium of communication between both lines and the central station, whereby the operator there can ring over both lines at once, converse with the

sub stations on both lines, and can listen to ascertain when the communication between them is completed.

I have shown and described means whereby the central station is enabled to communicate independently with any sub-station line, or to connect two lines together, and it remains only to describe the means I employ to enable any of the sub-stations to connect their line with the trunk-line 43. For this purpose it is that each sub-station line is provided, also, at the auxiliary station A with subordinate connecting apparatus B, C, and D. At each of these the said lines terminate in their respective circuit-changing arms 7, these being actuated by motors represented by the spur-wheels 12, which motors are controlled by electro-magnets operated by polarized relays $b^2$ in their respective circuits exactly as in the case of the trunk-line. Each of these circuit-changing arms is likewise provided with return signals $l'$, which indicate their position, in the manner hereinbefore described, by closing the circuit upon the ground-springs 60 during the period of rotation. These devices are only shown in connection with line No. 1 in the drawings, Fig. 2, but are of course employed in connection with all alike. The circuit-changers differ, however, from the principal device A in that each arm has but two positions—viz., its normal position in connection with the spring 5, leading to the continuation through its several contacts and to earth, and its position in contact with the main or trunk line springs. At the apparatuses B and C the circuit-changing arms 7 are shown as being at rest on their normal contacts, while at D the arm 7 is assumed to be in the act of transit. The springs 6, 10, and 22 in the trunk-line circuit are respectively within range of the several arms, so that when the arm 7 of any line is by the action of any sub-station on such line brought to rest in contact with the trunk line spring it is disconnected from its own normal termination and is brought into direct connection with the trunk-line.

The polarized relays $b^2$ are preferably of the same type as that of the relay $e$ in the main line, and they are responsive only to a current of like direction, but reversely sent through their coils—that is, if the relay $e$ is responsive only to a plus current sent from the central station the relays $b^2$ are in like manner responsive only to a plus current sent from the sub-station. Thus when the trunk-line is united with any one of the sub-station lines a minus current sent from either direction will affect the relay of the other line, but not of its own, as such a current would in its own relay be of the direction to which said relay is irresponsive, while it would pass through the relay of the connected line in reverse direction, and hence would have an effect thereupon identical with the plus-current sent from the other station. As will hereinafter appear, this arrangement is available for the purpose of disconnection.

If a sub-station S on any line—say 3—desires to connect with the trunk-line, either for direct communication through the central station or to desire the central station to connect the said sub-station line with one of the other lines centering at F, a current of suitable direction is first sent, which, as already described, releases the circuit-changing arm 7 of its own line from its normal contact 5 and permits it to travel round until arrested in the same manner as in the apparatus A in contact with the main-line spring 22, where it stops until the motor is again actuated. The line 3 is now in direct communication with the trunk-line 43 and can ring up the central station H without affecting the integrity of the connection, since the polarized relays do not respond to ringing-currents. After attracting the attention of the central station, the sub-station operator may state his wants. If he desires to connect through the central station H, the operator effects such through connection by means of the switch-board $s\ b$; but if the sub-station operator wishes his line connected with 2 or 3 the central station will first send a reverse current, which, as hereinbefore described, will affect the relay $b^2$ and restore the arm 7 to its normal position, and will then proceed by means of the principal circuit-changer to connect the two lines in the manner already described. Disconnection may also in the former event be effected similarly by the sending of a reverse current by the central station, and the circuit-closing key $k$ is for that purpose made as a reversing-key; or, alternatively, it may be understood that the sub-station operator, after making his wishes known, may at once restore his own circuit-changer to its normal position by sending a current of the same direction as before, and that the connection at the auxiliary station will be made by means of the arm $g$ of the trunk-line; or, if any sub-station have connected its own line by means of its own arm with the trunk-line, it may, by sending another pulsation of the same direction as before, disconnect itself, the relay of the trunk-line being irresponsive thereto.

Each sub-station may have a battery provided exclusively for the purpose of operating the controlling-relay $b^2$ and motor, or may use its transmitter-battery for this purpose; but I prefer to use a supply-line, 48, common to a number of subscribers and connected at one end thereof at any suitable station with a battery of sufficient power, $b^3$. The other pole of this battery is connected with the earth, and the supply-line 48 extends by normally-open branches 46 49 68 69, &c., into the several sub-stations, these branches terminating at the anvils of suitable signaling-keys, $k'$, at the said sub-stations, so that by depressing the said keys the current from said battery may be directed over the sub-station lines.

In the modification shown in Fig. 3, the principal circuit-changing appliance A is dispensed with, and each sub-station line as well as the trunk-line has a compound circuit-changer of its own, in which such line is represented by a rotatory circuit-changing arm, 7, in contact when at rest with its own contact-spring, and thereby connecting with the normal extension of its own line through a series of spring-contacts, one at each other circuit-changing appliance of the system, and finally terminating in an earth-connection. The diagram shows a portion of a system of one trunk and three sub-station lines, the circuit-changers of the trunk-line and of sub station line 3 only being shown, while such portions of sub-station circuits 1 and 2 as enter these circuit-changers are also indicated. C and D are the two circuit-changers. To C the line T enters at 81, and passes, first, to its own circuit-changing arm 7, which, as usual, is adapted to be rotated by a motor. It thence continues through a series of contact-springs, $T' T^3$, one at each appliance, finally terminating at an earth-connection. Thus by its rotating arm it is enabled to connect itself with the contact-spring of each or any of the other lines, as may be desired, and, being represented by a contact at each of the several circuit-changers of the other lines, it may be connected with by any of them when so desired. At circuit-changer D the line 3 enters and passes likewise first to the rotating arm 7, thence to spring $3^a$, wire $3^b$, spring $3^c$ at circuit-changer C, wire $3^d$, and so on. Lines 1 and 2 may be similarly traced; but as their circuit-changers are not included in the drawings they are only shown as passing through contacts at the circuit-changers C and D. In the operation of this modified system the return-signal is used, as in the first plan; but the difference in operation is that each sub-station line or trunk-line effects its own connection with any desired line by allowing its own rotating arm to move round until it reaches the spring of the line desired, where it is arrested and retained until the desired sub-station is called and communicated with.

The return-signals are in the modification provided as usual, each circuit-changing arm having on its own arbor a signal-wheel indicating the signal of the line next to be connected and the earth-connection spring *s*, and each sub station having a bell in its battery-circuit.

As the telephone-circuits at the several sub-stations do not differ from the well-known and usual arrangements, I have not considered it necessary to describe them.

I claim—

1. The combination, in an automatic exchange system, of a series of electric line-circuits converging to a central point, a series of circuit-changing arms, one for each line-circuit, adapted to rotate by motors controlled from the stations of said lines, and a series of spring-contacts in the path of each of said arms, said contacts being connected with and representing other lines of the system, substantially as and for the purpose set forth.

2. The combination of a trunk-line extending between a main and an auxiliary central station, a rotating circuit-changing arm therefor at the auxiliary station in permanent connection therewith and adapted to be actuated, as described, by a motor controlled from the central station, a series of sub station lines, each extending from one or more sub-stations to the auxiliary stations, and a similar rotating circuit-changing arm for each of the said lines, an extension-circuit for the trunk-line, and a series of contact-springs included therein, each resting upon a point leading to the next, and the last to an earth-connection, and one of the said series being located in the path of each of the sub-station line-circuit-changing arms, a series of other extension-circuits, one for each sub-station line, and a series of contact-springs in each, the said springs each also resting upon a point leading to the next, and the last to an earth-connection, but all of the springs being in the path of the trunk-line rotating arm and adapted to be connected therewith, and being arranged in the said path both singly and paired with the springs of other lines, whereby each sub-station line may be enabled to raise a trunk-line spring from its normal connection and to connect itself therewith, and whereby the trunk-line may be enabled to raise the contact-springs of any sub-station line from their normal connections and to connect itself therewith, or any two with one another, substantially as hereinbefore described.

3. The combination, substantially as hereinbefore described, of a series of electric line-circuits extending from one or more sub-stations to a central station, a series of circuit-changing arms, one for each line, permanently connected thereto and adapted, when actuated by a suitable motor, to rotate and to place itself successively in connection with one or more contact-springs arranged in its path and representing other circuits, and a polarized relay for each line at the central station to control the operation of the motors, with a supply-wire extending in normally-open branches into the said sub-stations, a battery connected in the circuit of said supply-wire and grounded at one pole, and a key or other suitable appliance for closing the said supply-wire circuit upon any of the sub-station lines for the purpose of operating the said polarized relay.

4. The combination, substantially as hereinbefore described, of a series of electric line-circuits extending from one or more sub-stations to a central station, a series of circuit-changing arms, one for each line, permanently connected thereto and adapted, when actuated by a suitable motor, to rotate and to place itself successively in connection with springs arranged in its path and representing other cir-

cuits, and a return signal for each circuit-changer, comprising a signal-wheel and earth-contact spring at the central and a bell in the battery-circuit at the sub-station, for the purposes specified.

5. The combination of two or more lines, each provided at a central station with a circuit-changing arm constituting a movable terminal, a series of contact-springs within the range of said movable arms and constituting fixed terminals, and a polarized relay in each line adapted to respond to currents of one direction only when sent from a distant station on its own line, as indicated herein, whereby each line, when connected with another, (the polarized relays of both lines being in circuit,) may effect disconnection by sending a current of proper direction to act upon its own relay, said current being inoperative with respect to the relay of the other line, or by sending a current of opposite direction to act upon the relay of the other line, substantially as specified herein.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 8th day of April, 1887.

THOS. D. LOCKWOOD.

Witnesses:

GEO. WILLIS PIERCE,

FRED J. F. SCHWARTZ.