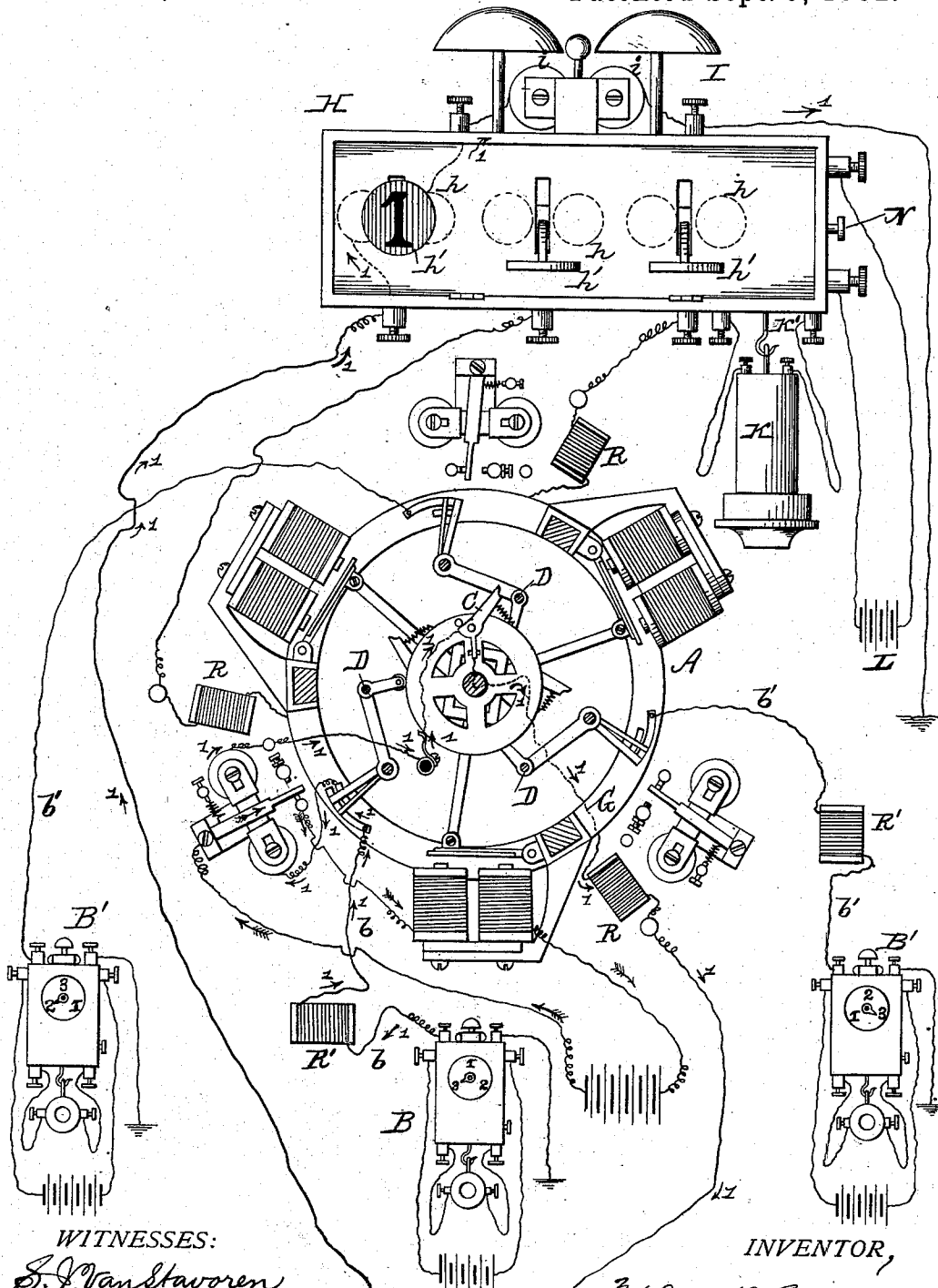


(No Model.)

M. D. CONNOLLY.
AUTOMATIC TELEPHONE EXCHANGE.

No. 263,862.

Patented Sept. 5, 1882.



WITNESSES:
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AUTOMATIC TELEPHONE-EXCHANGE.

SPECIFICATION forming part of Letters Patent No. 263,862, dated September 5, 1882.

Application filed October 29, 1881. (No model.)

To all whom it may concern:

Be it known that I, M. DANL. CONNOLLY, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Automatic Telephone-Exchanges or Circuit-Changers; and I do hereby declare the following to be a full, clear, and exact description of the invention, reference being had to the accompanying drawing, which forms part of this specification, and which is a diagram illustrating my invention.

My invention has relation to the automatic telephone-exchange system for which Letters Patent of the United States No. 222,458, dated December 9, 1879, were granted to myself, Thomas A. Connolly, and Thomas J. McTighe, and more particularly to the improvements thereon for which I and said parties jointly, by application filed August 29, 1881, applied for further Letters Patent of the United States. In said application we have shown an arrangement of parts whereby a subscriber's line leads to a switching mechanism at the central station, and from said mechanism leads normally to ground or return. Further, said mechanism is so arranged that by a progressive movement, dependent upon electric impulses sent over the subscriber's line and operating a relay at the central station, his circuit at the central station may be changed from "ground" to another subscriber's line, such change of circuit comprehending the automatic connection of lines. When such circuit leads to ground at the central station it is much shorter than when connection of lines is established, and as difference in the lengths of circuits produces variations in resistance therein it follows that the electric current flowing from a subscriber's local operating-battery meets with different resistances as his circuit at the central station changes from ground to "line." Still further, as the different lines leading to the central station vary in length, there is a corresponding variation in the resistance they oppose to the same electric current sent over them, so that as one subscriber makes connection successively over other subscribers' lines his operating-current encounters unlike resistances in different lines. Now, as such current acts upon a relay to effect the progressive movement whereby change of circuit and con-

nection of lines are established, and as a relay to work effectively should be adjusted to a given strength of current, and as the strength or force of such current lessens under resistance, it follows that with variable resistances to meet and overcome as the progressive movement proceeds the relay's action cannot be uniform, and that said progressive movement will be more or less faulty.

The first part of my improvements relates to this feature; and it consists in providing an artificial resistance in the ground or "return" at the central station, so as to equalize the resistances of ground and line. The second part of my improvements consists in rendering lines which are unlike in length equal in resistance; and it consists in locating in each line, except the largest one, an artificial resistance. Thus when an exchange is organized a maximum resistance should be selected equal to or in excess of the resistance of the longest line leading thereto. All the shorter lines will have artificial resistances located in them, either at the central station or at the subscribers' local stations, or at any point between the same, the amount of resistance in each line being dependent upon the length of such line, and inversely as such length, so that the resistance in all lines will be equalized, producing the same effect as if the lines were equal in length and sectional area. In the ground or return at the central station an artificial resistance will be placed, so as to bring the resistance of ground-circuit at central station up to the resistance of line. If the lines have a common ground at central station, one resistance will be sufficient; but as by the further improvements hereinafter described an independent circuit to ground for each line is necessary or expedient, a separate ground-resistance for each such line at the central station is or may be expedient or desirable. In operating the switching mechanism at the central station it sometimes may happen that a desired connection of lines is not effected. This may result from a defect of the working mechanism, from inaction of a subscriber's battery or the central-office battery or generator, from an imperfect contact in some of the circuits, from leakage of the electric current, or other cause. In such case a subscriber starts the dial mechanism at his own local box. When the index on such dial reaches the number or symbol belonging to some other line

the seeking or calling subscriber naturally supposes he has effected through the central office a connection with such other line, and rings a call. The necessary contact or connection at central station not having been effected, he fails to get any response and is ignorant of the reason. If the switching mechanism at the central station has for any reason failed to operate correctly, he has no means of calling up the central office over his line, and so loses all power of communication over the line until the defect in his own line has been remedied. So, too, if a subscriber seek the line of another already engaged, he cannot effect connection therewith, the contact-bar of the latter, during engagement, being swung out of position for contact, as fully described in the aforementioned joint application. His working mechanism remains correct, and he has a circuit to ground which will enable him to reach "home" or call up any other line; but he is not apprised of the reason why he cannot get a particular line he seeks but fails to connect with. Still further, subscribers may desire from time to time to call up the central office for various purposes. To do this with and under the arrangement of parts shown in said joint application, it would be necessary, in order to get communication with the central station, to operate the switching mechanism at said central station to establish connection with a line or contact-bar in such mechanism assigned to the central office's particular use.

The third part of my improvements relates to the provision of means whereby if a subscriber fails to get, for any reason, connection with a line he seeks, the fact of such failure will be announced at the central station when the calling subscriber rings for the party he seeks and whose line he may suppose he has, so that the central office may correct such failure and establish the connection, or, in the case of a line already engaged by one party and sought by another, inform the calling party why the connection cannot then be had. Said improvements also relate to and comprise means whereby any subscriber may at any time and without operating the dial mechanism at his own box or local station call up the central office and be placed in communication therewith or with any line leading thereinto. This part of my improvements consists in the combination, with the automatic switching mechanism at the central office, of an electric annunciator and alarm (either or both) located in the ground or return circuits of the lines leading into such mechanism, and operative by a current the reverse of that which will operate the relays of such automatic mechanism.

Referring to the accompanying drawing, A represents an automatic exchange or switching mechanism constructed on the plan described in the aforesaid application, and which therefore need not be more particularly herein described.

B B' represent the boxes of local subscribers whose lines *b b'* lead to the central station.

All the lines have like (though not identical) circuits at the central station, so that to follow one will be sufficient for all. The circuit of line *b* through the machine is shown by arrows I. It will be seen that it passes at all times through the "tripper" C, or traveling circuit-maker of such line, and that when such tripper is "at home," or not in contact with any of the contact-bars D, said circuit goes to ground or return, G. When the tripper is in contact with a bar D the circuit is shifted from ground at central station to the line to which bar D in contact with it belongs. Now, as already remarked, as this makes a longer circuit than to ground direct, I equalize the resistances by locating an artificial resistance, R, in the ground-circuit at the central station. When each line has a separate circuit from the machine or switch to ground such resistance will be located in each such separate ground-circuit. As the lines vary in length, and correspondingly in resistance, I equalize all by artificial resistances in each line, as at R'. Thus, for example, say line 1, the longest, has a normal resistance of, say, twenty ohms, line 2 a normal resistance of, say, fifteen ohms, line 3 a normal resistance of ten ohms, and line 4 a normal resistance of only five ohms. I equalize the resistances by placing in lines 2, 3, and 4 artificial resistances R' of five, ten, and fifteen ohms, respectively. Now, a current passing over any one of these lines to ground at central station meets a resistance of twenty ohms; but when two lines are connected the resistance is doubled, or is, say, forty ohms. There is thus a difference of, say, twenty ohms resistance between circuit to ground at central station and over connected lines. To equalize this I locate in the ground-circuit at central station an artificial resistance equal to the resistance of the longest line. In that imagined above it would be twenty ohms. By these means the resistances throughout are equalized, so that the relays work uniformly, whether a subscriber is making circuit to ground at central station or over any particular line.

If a subscriber in operating his switching mechanism fails to get a connection with a bar of another line, his circuit is to ground at central station. It is so with all lines leading to the automatic exchange or switch A. Let each subscriber have a separate circuit to ground at the central station and these circuits lead to an annunciator, H, as shown. Each line has an electro-magnet, *h*, in such annunciator for operating a "drop" or "shutter," *h'*, therein. Each line has also, if desired, an electric bell, I; or the circuits of all lines may lead from their annunciator-magnets to one bell, which will thus be an alarm common to all; or the annunciator may be so constructed that the dropping of a shutter will close an open circuit to the bell, and thus cause the latter to ring.

The bell or bells may be dispensed with and the shutters or drops form the alarm in themselves. The annunciator drops or shutters should be carried on polarized armatures, and

the magnets thereof so arranged—*i. e.*, reversely with reference to the relay magnets—that a current which will operate said relays will not operate the drops or shutters, and vice versa.

5 If a bell or bells, I, be employed, it or they must be polarized if in the same circuit with the shutter-magnets, and the same arrangement relative to the relay be preserved—*i. e.*, the bell magnet or magnets *i* must attract their
10 armatures to ring by a current the reverse of that which operates the relay. The reason is this: In the progressive movement of the tripper the circuit is always through the relay and alternately to ground at central station and
15 over other lines to distant stations or subscribers. In making this progressive movement the current is of one direction, so as to operate the relay. Were the annunciator and bell in ground-circuit at central station capable
20 of being operated by a current of the same direction, the moment the current became shifted from line to ground in making the progressive movement said annunciator and bell would be operated. This is not desirable. Hence the
25 arrangement, as described, is such that not until the current over line is reversed by a subscriber (which reversal takes place when a subscriber rings after having ceased the progressive movement) is the annunciator or bell
30 in the central ground-circuit operated.

In the ground-circuit of each line at central station, or in shunts thereof, there are means for placing a telephone or telephones properly
35 in line, together with a battery or generator for sending back over the line a current of such direction as not to effect a movement of the relay in such line, yet to ring the bell of the subscriber at his own box or station.

40 K represents the telephone; K', its switch; L, the battery, and N a push-button for these purposes.

The operation therefore is as follows: A subscriber manipulates his box or dial instrument to effect connection with another line, and then
45 rings by a reversed current. If the sought connection has been established at the central office, the alarm is sent over the connected lines without affecting any of the parts at such central office. If, however, from any cause such
50 connection has not been effected, the seeking or calling subscriber has then a ground or return circuit at central station. When he rings by his reversed current the annunciator drop or shutter and the bell which are in said
55 ground or return circuit are operated, thus indicating that a subscriber has failed to make a desired connection, and further notifying the central office who such subscriber is. The central-office attendant thereupon throws the
60 required battery on the line of such subscriber, and sends back an alarm by a current which will not work the polarized relay in circuit, puts a telephone or telephones (transmitter and receiver) into the circuit, and thus learns
65 who it is the subscriber seeks to connect with. Having learned this he establishes the connection between the seeking and the sought line,

either by direct manual operation or by working the calling subscriber's relay, thus making the circuit direct over both lines, the annunciator, &c., in the central ground-circuits of
70 such lines being cut out in forming the connection. So, too, if a subscriber seek another, and ring when he thinks he has effected connection therewith, if such other be already engaged and his contact-bar D be swung out so
75 that such connection cannot be obtained, as such seeking subscriber has his ground-circuit at central office, such ringing will notify the central office, as before described, and the latter
80 will be able to notify the calling party of the engagement which prevents his getting communication with the party he seeks. Still further, if a subscriber wishes at any time to call
85 central station without operating his dial-instrument, all he has to do is to merely ring in the usual manner—that is, by sending a reversed current from his own box over his line. His tripper at the central station being in its home position, his circuit there is to ground.
90 The annunciator and bell there, being in such ground-circuit, are operated by such reversed current, as already described in the cases where his tripper has left home to seek another line, but failed to get it.

95 As normally there is no electrical current in the ground-circuits at the central station, the annunciator should be so constructed that its drop or shutter will be moved so as to be brought into display position when its magnets are energized by currents of the proper
100 direction. If desired, the ground-resistance mentioned as the first part of my improvement may be constructed of the annunciator or bell magnets (either or both) in the ground-circuits
105 at the central office.

I prefer to have separate ground-circuits for each line at the central office, and to have an annunciator with a shutter or drop for each
110 line, so that the central office may instantly know not only that a party has sought a line and missed connection, but who that party is; but the annunciator shutters or drops may be dispensed with, the lines at central station all have a common ground, and a bell be placed
115 in this ground. Under this arrangement the central station may be called by any subscriber without operating the dial mechanism of his box, and failures to effect connection will be notified through the same means. In such latter case the central office has to look up the
120 missed connection, whereas with the annunciator drops or shutters the failing or calling line is designated. Hence as an annunciator without a bell or a bell without drops or shutters may be employed, my invention embraces
125 either or both arrangements, the term "alarm" including both. I have shown such alarm and the equalizing resistances combined with the particular automatic switch mechanism illustrated and referred to; but my claims are not
130 restricted thereto, and are intended to include any and all substitutes for said particular switching mechanism.

What I claim as my invention is as follows:

1. In a circuit-changer or exchange-switch having means for changing circuit from ground or return to different lines, the combination, with the ground-connection, of artificial resistance therein to equalize it with line, substantially as set forth.
2. In an exchange system comprising a series of convergent or divergent lines leading to or from a central office or station switch, the combination, with the lines and switch, of artificial resistances in such lines to equalize the latter, substantially as set forth.
3. In an exchange system comprising a series of convergent or divergent lines leading to or from a central office or station switch and normally grounded thereat, the combination, with such switch and the ground and line circuits, of artificial resistances in such circuits to equalize the same, substantially as set forth.
4. In combination with an automatic exchange or switch operating by a progressive movement to establish connection between normally-independent lines, and which, in effecting such movement, changes circuit from ground or return to line, resistances in such ground or return and line circuits to equalize the resistance of such circuits, substantially as set forth.
5. In a circuit-changer or exchange comprising means for effecting connection of normally-independent lines by a progressive or step-by-step movement controlled by impulses sent through a relay, and operating a traveling circuit-maker which alternately shifts from ground to line, the combination, with such relay and traveling circuit-maker, of circuits having their resistances equalized by means substantially as described.
6. The combination, with an automatic switch whose lines are normally grounded at or return from a central office, of an annunciator or alarm (either or both) located in such ground or return circuit at the central office, substantially as and for the purpose set forth.
7. The combination, with an automatic exchange, switch, or circuit-changer which operates to effect connection of normally-independent lines by a progressive or step-by-step movement, and which, in operating, changes circuit from ground or return to line, of an annunciator or alarm located in the ground or return circuit to notify the central office of failures to establish connection of lines, or to call up said central office without operating the switching

mechanism, substantially as shown and described.

8. The combination, with an automatic telephone exchange or switch which operates by a progressive or step-by-step movement to effect connection of normally-independent lines, and which, to effect said connection, causes a circuit-maker to travel from line to line and alternately to shift circuit from ground to said lines, and vice versa, said movement being controlled by electric impulses sent over line through a polarized relay, of a polarized annunciator or alarm located in or connected with the ground or return circuits of said exchange or switch, and arranged to operate responsively only to a current the reverse of that which will operate said relay, as set forth.

9. The combination of an automatic switch or progressive or step-by-step movement circuit-changer, an annunciator in the ground or return circuit thereof, a telephone in a shunt or normally cut-out branch, a battery or generator, and means for throwing the same onto line in such circuit, whereby the central office can be called without operating the automatic switch, or will be notified automatically of failure of any attempt to connect lines through the automatic switch, and can send an alarm and communicate over the line with the seeking subscriber to learn and supply his wants, substantially as set forth.

10. In an exchange comprising a series of lines converging to a central office or station, and connected with switching mechanism at such office, where they are normally grounded, or whence they normally return, said lines being connected at their outward termini with boxes having appliances whereby may be sent currents of one direction to operate the switching mechanism and currents of opposite direction to ring an alarm without operating the switching mechanism, the combination, with such switching mechanism, boxes, and connections, of an annunciator or alarm located in the ground circuit or circuits of the lines at the central office, and operative by currents which will not actuate the switching mechanism, substantially as set forth.

In testimony that I claim the foregoing I have hereunto set my hand this 27th day of October, 1881.

M. DANL. CONNOLLY.

Witnesses:

S. J. VAN STAVOREN,
CHAS. F. VAN HORN.