(No Model.)

G. LEE ANDERS.

TELEPHONE EXCHANGE APPARATUS.

No. 252,986. Patented Jan. 31, 1882.

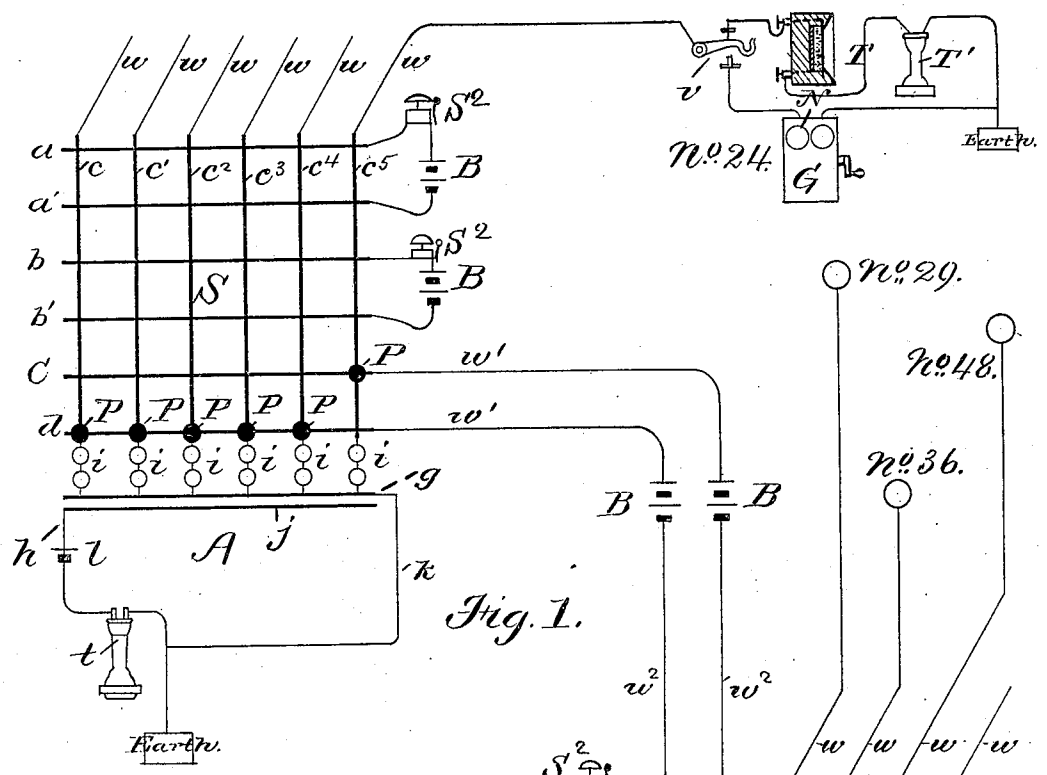

Fig. 1.

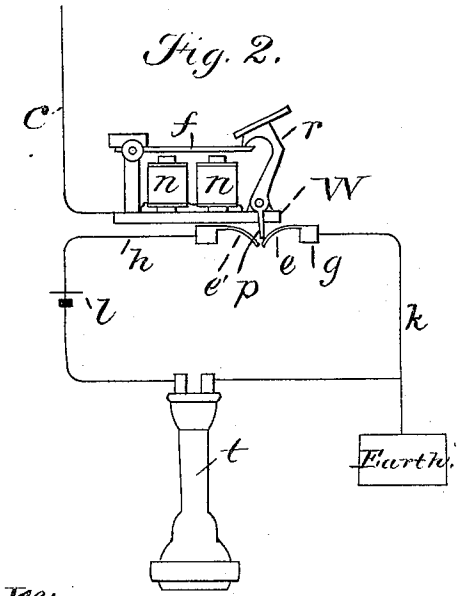

Fig. 2.

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TELEPHONE-EXCHANGE APPARATUS.

SPECIFICATION forming part of Letters Patent No. 252,986, dated January 31, 1882.

Application filed August 8, 1881. (No model.)

To all whom it may concern:

Be it known that I, GEORGE LEE ANDERS, of London, in the county of Middlesex, England, have invented certain Improvements in Telephone-Exchange Switching and Signaling System, for use in connection with telephones working by direct battery-currents, of which the following is a specification.

My invention relates to an organization of electric circuits and apparatus for direct intercommunication by means of speaking-telephones, in which one or more central stations are connected by means of wires radiating therefrom to a number of sub-stations situated at various points within the surrounding district. The organization and arrangements of the lines and instrumentalities in the central station or stations are such that any two sub-stations within the district may, at a moment's notice, be placed in direct telephonic communication with one another, or that any sub-station in one district may be speedily and readily placed in direct communication with any other sub-station in an adjacent district. Such a system is ordinarily called a "telephone-exchange system." In such systems as now commonly arranged the radiating wires, after passing through the signaling apparatus at one or more sub-stations, are terminated by a connection with the ground, and are also grounded at the central station after passing through an indicating-instrument.

My invention, while based on the same general plan and operating definitely to the same end, yet differs materially in the arrangement of circuits for oral communication, in the instruments employed, effectually simplifies both apparatus and manipulation, and tends to great economy in battery-power and labor. Heretofore each subscriber has been provided with a transmitting-telephone, in which the current of a local battery, varied in strength by the impact of the sound-waves acting through the medium of a diaphragm on a variable resistance included in the circuit, is passed through the primary circuit of an induction-coil, the secondary circuit of the same coil being connected in circuit with and forming part of the line. The induction-coil has been so employed, as it has been considered impracticable to vary the comparatively high resistance of a line-circuit by the action of the voice on a single transmitter sufficiently to reproduce with accuracy articulate sounds of the requisite strength or volume. The necessary variation of the current has therefore been accomplished in a short primary circuit, and the induced currents thus caused in the secondary coil have been made the actual medium of communication. The employment of the induction-coil in this capacity has necessitated the use of a battery at each sub-station. To obviate this necessity and to confine the batteries to the central station or stations, reducing materially their cost by greatly diminishing the number of cells required, and at the same time to retain the batteries which are actually in use always under the care and supervision of the attendants at the central station, is one of the primary objects of my invention. By my invention, moreover, I aim at increasing the speed of making complete connections for telephonic conversation. By this I designate the entire process of receiving a call-signal from any sub-station, of responding thereto, of signaling the required station, and of connecting the two separate lines together for conversation.

The further objects of my invention are as follows: the ready proportionment of the proper amount of battery-power to the length of line connected, in order that the volume of the reproduced sounds may be uniform, irrespective of the length of line actually in use, and the reduction of the work of connection and signaling at the central offices to an absolute minimum.

To the accomplishment of these purposes my present invention consists in certain improvements in apparatus and in the arrangements of circuits and batteries, whereby the connection and disconnection of lines and the signaling of branch and sub stations may be effected with greater convenience and facility than has heretofore been possible.

It consists, further, in the use of a battery or batteries so arranged and connected as to sub-

serve at the will of the central-station attendant the double purpose of signaling the required sub-station and of supplying the necessary current for the transmitters.

In the system which is the subject of my present invention the several radial lines, after passing through the signaling-instruments at the sub-stations, continue to the central station, there passing through the switch-board in the usual manner, and thence through an indicating-annunciator to the ground. When by reason of a signal received from a sub-station the annunciator at the central office drops, the normal line-circuit to the ground direct is destroyed and a new circuit established through a listening-telephone to earth by means of the electric switch which I have shown and described in my former application of April 21, 1880, No. 8,018. The operator, ascertaining from the calling subscriber the name or designating number of the subscriber desired, connects the first or calling subscriber to the uppermost of a pair of connecting cross-strips on the switch-board and connects the line of the subscriber wanted to the lower or complementary strip of the same pair. One pole of a battery is connected to each of these strips, so that when the strips are connected, as described, the battery is put into circuit between the two subscribers, and serves, first, to signal the subscriber who is wanted by ringing his vibrating bell, and, second, to supply the current necessary for the operation of the transmitters. As the mere act of connecting the two lines with the two cross-strips connects the battery in circuit, it is evident that in this system no special calling or signaling devices—such as keys or circuit-closers—are necessary; neither is time occupied by the act of such signaling or calling, as has heretofore been necessary.

Each subscriber is furnished with a magneto-generator and a vibrating bell, the generator being used to signal the central station when intercommunication with some other sub-station is desired. As the bell is a vibrator, the continuous current of the battery at the central station is caused by its vibrations to flow intermittingly, and thus the signals given at the second sub-station are reproduced upon a single-stroke electro-magnetic instrument of any suitable character placed in the circuit of the battery at the central station, which by its response indicates to the attendant that the signal is duly given at the sub-station. These arrangements, as hereinafter explained and described, are made with a view of treating and acting upon a call or signal from one central or branch station to another in precisely the same manner as on those received from the sub-station direct, and the act of connecting a subscriber through from one branch or central station to another gives the call at the second station automatically, and simultaneously puts the sub-station giving the original call into connection with the second central station, so that without the further intervention or assistance of the central station, to which the original sub-station is normally connected, the subscriber may communicate his wishes to the second station, to which his desired correspondent is connected.

In the drawings illustrating my invention, Figure 1 is a general diagram of an exchange system comprising two central stations, each having a series of subscribers' lines and sub-stations centering therein, the whole arranged in accordance with my invention; and Fig. 2, a detail drawing, showing the connections of the electric switch operated by the annunciator at the central station.

In Fig. 1, A and D are two central stations, or one may, if preferred, be denominated a "central" and the other a "branch" office. Each is the centering-point of a number of subscribers' lines, *w w w*, radiating and extending therefrom in different directions to the sub-stations or subscribers' offices, which are usually designated, for convenience, by specific numbers, where, after passing through the electro-magnets of a vibrating bell, N, they are connected to the ground. The said circuits are at the central stations connected with a convenient switch-board, S S′, for making connections between the different pairs of circuits, in order that any sub-station may be connected with any other sub-station for conversation, and after traversing the vertical bars $c\ c'\ c^2\ c^3\ c^4\ c^5$ of the switch-board the circuits are continued to and connected with suitable annunciators, *i i i*, passing thence to a conducting-bar, *g*, common to all of them, and in permanent connection by the wire K with the earth. The connections of the switch-boards S S′ are peculiarly arranged, as will be seen by reference to the drawings.

The vertical strips or wires *c c′* are intersected by transverse strips *a a′ b b′*, and so on, which are used as connection-strips. These are arranged in pairs, and each pair is connected to a main battery, B, in such a manner that the cross-strips so connected form virtually the poles or electrodes of such battery. It is essential to the proper working of my invention that when any two lines are connected through a switch-board for conversation the sub-station desiring a connection shall be connected to the upper strip, *a*, of a pair, and the sub-station to be called shall be connected to the lower strip, *a′*, so that the battery shall be in direct circuit with the telephones of the compound line, composed of two subscribers' lines connected for conversation.

S^2 is a single-stroke bell or other suitable electro-magnetic testing device in the battery-circuit.

In addition to any desired number of connecting-strips arranged in pairs and coupled with a battery, B, as described, I arrange a suitable number of single strips, C *d*, at each central station, which in station A, for example, are respectively connected by wires *w′* to

one pole of an auxiliary battery, B′, the other pole of said battery being connected to line-wires w^2, leading out of the central station and entering other central stations, D, at the vertical strips of the switch-board, and passing through their respective annunciators to earth in exactly the same manner as if they were subscribers' lines. Similar horizontal connecting-strips, C *d*, are also represented in the switch-board at station D, likewise connected to auxiliary batteries and leading out. These may be led in turn to station A, there to enter the switch as subscribers'-lines; or they may, if required, be extended to a third central station. The lines so extending between different central stations and connected on to the single transverse strips are intended for trunk-lines, and by their use a sub-station connecting with one central station may readily be connected with any station in another district.

A certain number of trunk-lines are extended between each two central stations, and for convenience I arrange the transverse strips to which they are connected at or near the bottom of the switch-board, as shown in the drawings. I do not, however, confine myself to this arrangement, as it is obvious that it may be varied in many ways without departing from the principle involved.

P P are connecting-plugs, which are normally inserted between the vertical line-strips of the switch-board and the annunciator, and serve to maintain the connection with the ground; but when two lines are to be connected together the plugs of the two respective lines have to be transferred from their normal position to the points of intersection between those lines and the connecting-strips made use of, as shown in the drawings.

The annunciators *i* are arranged on the plan shown in Fig. 2, wherein the circuit, after traversing the upright metallic strip *e*, continues through the electro-magnet *n n*, and is then attached to the metallic frame W, and thereby to the annunciator-bar *r*, the heel *p* of this pressing against the spring *e*, which is in permanent connection with the ground-plate *g*, completing the circuit.

It is obvious that any current coming over the line and charging the electro-magnet will cause the armature *f* to be attracted, releasing the bar *r*. This falling by its own weight removes the pressure of the heel-piece *p* from the spring *e* and transfers it to the opposite spring *e′*, thus changing the path of the circuit to the wire *h*, battery *l*, telephone *t*, and to earth.

As an operator is stationed with the telephone always to his ear, any order or request spoken from the subscriber's station is speedily heard and attended to.

At each sub-station are placed a vibrating bell, N, to receive call-signals from the central station, a magneto-generator, G, which is used to call the central station, telephonic transmitting and receiving instruments T T′, and an automatic switch, *v*.

In this system I necessarily employ a transmitter which is operated directly from the battery at the central office. Such a one is the telephonic transmitter patented by Henry Hunnings in England, September 16, 1878, No. 3,647, wherein carbon in a state of coarse powder is inclosed between a vibrating diaphragm and a fixed metal plate. The metal plate is connected to one terminal and the diaphragm to the other, and no induction-coil is used. The line-circuit entering the subscriber's station continues normally through the vibrating bell to ground, the telephones being in a branch circuit, which is maintained open by the weight or influence of the telephone upon any of the well-known forms of automatic switch in common use. When the telephone is removed from the hook the circuit is changed from the bell to the telephone branch circuit. The main-line circuit is then directly through the electrodes of the transmitter and the coils of the receiving-telephone, and as the transmitter is dependent upon the central station for battery-power, as soon as the annunciator-switch drops the current of the battery *l* is sent over the line, and in the act of speaking its strength is varied by the action of the transmitter at the sub-station.

The transmitter T being directly in the line-circuit, instead of operating by the intervention of an induction-coil, as is usual in the use of the ordinary Blake or Edison transmitter, it is obvious that no battery is necessary at the sub-station. All the requisite battery is therefore maintained at the central stations A D, where it may readily be proportioned to the length of line in use, and is always under the care of proper attendants. A further advantage is also obtained by the fact that a much smaller number of cells will be necessary, as only a certain proportion of subscribers converse at the same time, and hence the batteries can be used for many lines successively, where as heretofore one or more cells of battery have been at all times necessary at each sub-station.

For a receiving-instrument I may use an ordinary Bell telephone, or I may use a telephone wherein the magnet is of soft iron magnetized by the battery-current, which is always flowing in the circuit when connections are made for conversation.

I may also incorporate my receiving and transmitting telephones in one instrument, as described in a separate application for Letters Patent, bearing even date with this, for a compound telephone.

In the drawings I have shown station No. 24 on the subscriber's line *w* entering central station A, connected up for communication with sub-station No. 48, the line of which terminates at central station D, by means of trunk-line *w w′*, and also two other lines centering in station D, connecting sub-stations 29 and 36 locally for conversation. In the first case the circuit is from the ground at station 24, through

telephone T′, direct-acting transmitter T, switch *v*, and line *w*, to the central station A; thence, *via* switch-board vertical strip c^5, connecting-plug *p*, horizontal strip *c*, wire *w′*, auxiliary battery B′, trunk-wire w^2, to central office D, where it enters vertical switch-board strip *c′*, and continues, *via* the upper connecting-strip, *a*, through bell *s*, battery B, connecting-strip *a′*, line *w*, to station 48, there, through the direct-acting transmitter and receiving telephone, to ground. In the second case, as shown, station 29 is in connection *via* line *w*, line-strip c^2, plug-connector, horizontal strip *b*, bell s^2, battery B, line-strip c^3, line *w*, to sub-station 36. The calling subscriber will in all cases, for the sake of uniformity, be connected to the uppermost of any pair of strips, and the respective batteries B B′ must in all cases be arranged in such a manner that when they are brought into the same circuit the poles of one shall coincide with the poles of the other. In the drawings this point is exemplified, as in each case the positive pole of the battery B is connected to the upper strip and the negative pole to the lower strip of a pair, while in trunk-lines represented in one switch-board by horizontal strips and in the other by vertical strips the battery will in each case be located at the end of the line which terminates in the horizontal strip, and the said horizontal strip will be connected to the positive pole of the auxiliary battery B′, and the other pole connected to the outgoing line to station D. Thus the power of the batteries will always be fully developed.

The operation of my system is as follows: No. 24 desires to communicate with No. 48. He makes the usual call on the central station, with which he is ordinarily connected by his magneto-generator. The current thus produced causes the annunciator *i* to drop, closing the circuit of the listening-telephone *t* and of the battery *l*. The current of the battery *l* flows over the line and vitalizes the transmitter T of station 24, enabling the subscriber there to communicate his desires to the listening operator at the central station. He says "Connect 24 with 48." No. 48, we will assume, is not connected to the same central station, but to another in a different part of the city. The operator will therefore take plug P on the line of 24 from its normal position, connecting the line to the ground-bar *g*, and will insert it at the intersection of the line-strip c^5, connecting with station 24, with the cross-strip C, which connects, through wire *w′*, auxiliary battery B′, and line w^2, to upright strip *c′* at station D, thence through the annunciator *i* belonging to that strip and to ground. This, as will be observed, completes a circuit over the route indicated from sub-station D, and the battery B′ being included therein, the current of the same causes the annunciator *i* of the strip *c′*, station D, to drop, bringing the second listening operator—the one at station D—into circuit with the waiting subscriber at 24, who again asks for 48. The operator at D will at once insert the plug of strip *c′* at the intersection of the upper cross-strip, *a*, of any pair and the plug of c^4, which is the continuation of the line of sub-station 48 at the intersection of c^4 with the lower cross-strip, *a′*, of the same pair, completing a circuit from 24 to 48 through the batteries B and B′. The necessity of uniformly connecting the calling subscriber upon the uppermost strip is thus made manifest, as if he were connected upon the lower one of the pair the batteries B B′ would be ranged in opposition to one another, thus weakening both, whereas by the practice described the current of one re-enforces that of the other. As soon as the plug of the station 48 is placed at the intersection of strip c^4 and *a′* the combined current of the batteries will traverse the line from 24 to 48, ringing the vibrating bell of 48. This ringing will in turn cause the electro-magnetic bell S^2 at the central station to vibrate, giving notice to the operator there that the call is received at 48, while the original calling subscriber 24 will, if he continues to listen, hear the same vibrations in his telephone, and if he has hung up his telephone his bell will ring in unison with that at station 48. As soon as the subscribers take up their telephones to converse their bells are cut out, and consequently the bell S^2 at the central station also ceases to vibrate, and the operator knows that the subscriber at 48 has attended to his call and is conversing with 24. Upon the conclusion of a conversation, when either or both subscribers hang up their telephones their vibrating bells are again brought into the main circuit and acted upon by the battery, and this, causing the bell or other instrument S^2 at the central station to once more pulsate, notifies the operator that the communication is concluded, and he is at liberty to disconnect the wires and restore the switching devices to their normal position, which he accordingly does.

The connection of any two sub-stations connected to the same central station, as shown at D, where sub-stations 29 and 36 are connected through the pair of connection-strips *b* and *b′* and battery B, is accomplished in the same manner, but is simpler, because the feature of the single strip C, the trunk or auxiliary battery B′, and the trunk-line w^2 does not enter into it.

From the hereinbefore-described operation it will be seen that the work of signaling and listening to ascertain when a conversation is finished, ordinarily devolving upon the operator at the central station, is, by the use of my improved system, completely dispensed with; that the annoyances inseparable from a local battery at every sub-station are obviated, and that the speed of connection and disconnection is materially increased without impairing the efficiency or reliability of the service. My invention is, moreover, particularly adapted for use on long lines, and when so employed it enables conversation to be transmitted and reproduced with a much greater volume of

sound and a clearer articulation than has heretofore been practicable.

The number of cells of battery necessary for a satisfactory use of my invention is to a great extent immaterial, inasmuch as practical experiment has demonstrated that while a line of fifty miles can be successfully operated by my invention with fifty cells of gravity-battery, the battery-power may be reduced to ten cells without perceptibly deteriorated results, and I have obtained good results on the same line with a battery-power of but one cell. It is advisable, however, to use a battery sufficiently large to operate the call-signals distinctly, and when the proper amount for any individual case has been ascertained by experiment it should not be exceeded, as less interference with other lines is manifested when a low battery-power is employed.

I am aware that a system of centralizing transmitter-batteries has been patented by Chas. E. Scribner, No. 243,165, dated June 21, 1881; but it refers to transmitters provided with the usual induction-coil, and, moreover, requires the use of an extra or special battery-wire. My invention refers to direct-acting transmitters, and the battery is placed directly on the lines connected for conversation, and is not restricted to any one or any special series of lines, but may be connected at will to any line or lines.

Having now described my invention, I claim—

1. The combination, with a series of lines emanating from a central office, and variable-resistance telephones in said lines at the subscribers' stations, of switch devices for connecting said lines with each other, and batteries connected with the said devices, substantially as described, whereby when any two lines are connected they are so charged with a battery-current that the variations of the resistance of one line produce variations of the current in both lines, and conversations can be carried on between subscribers on said lines with the aid of receiving-instruments, as set forth.

2. In a telephone-exchange system, the combination, substantially as hereinbefore described, of a central station or stations, a series of main lines radiating therefrom and connecting with sub-stations, switching devices, as indicated, whereby any two lines may be connected together through one or more central stations, a main battery placed at the central office in a loop connected with the switching devices, so as to be interposed in the circuit of any two lines so connected, and a transmitting-telephone at each sub-station, having its variable resistance or tension regulator directly in the circuit of said main battery, when so interposed for the purpose of varying the strength of current on the main line.

3. In a telephone-exchange system, the combination of a central station, two or more subscribers' lines radiating therefrom and connected with sub-stations, switching devices whereby any two lines may be connected together, transmitting-telephones in the main line at sub-stations, and a main battery located at the central station and brought into action only when included in the compound circuit composed of two lines connected for conversation, for the purpose of furnishing battery-power for the transmitting-telephone at each sub-station.

4. In a telephone-exchange system, the combination of a main-line circuit extending between a central station and a sub-station, a main battery located at the central station and normally on open circuit, but adapted for inclusion in the main-line circuit, and a transmitting-telephone at a sub-station, provided with a variable-resistance piece or tension-changer connected directly in the main-line circuit, the said telephone arranged to become operative only when the battery is included in the main circuit, substantially as hereinbefore described.

5. In a telephone-exchange system, the combination of a series of main lines, a series of sub-stations located thereon, a vibrating call-bell connected normally in the main-line circuit at each sub-station, switching devices whereby any two lines may be connected together, a battery permanently connected to said switching devices and normally on open circuit, but interposed in the circuit of any two lines when connected one with another, and an electro-magnetic testing-instrument in the circuit of said battery, and adapted to give a signal, when connected in the main-line circuit, under the influence of the vibratory bell at the sub-station, substantially as and for the purpose specified.

6. The combination, in a telephone-exchange system, of a main battery located at the central station and placed in the circuit of any two lines when connected together, and a direct-acting transmitter having its variable resistance included in the compound battery circuit so constituted, as and for the purpose specified.

7. In a system of electrical communication, a series of trunk-lines extending between any two central stations, the said trunk-lines being connected at one terminal through an annunciator to earth and at the other terminal to one pole of a main battery, the other pole of said battery being attached to an insulated switch-bar constituting a normally-open circuit, adapted to be closed by the connection of a subscriber's line to said insulated switch-bar, substantially as described, and for the purpose specified.

8. The combination, in a telephonic circuit, of two main lines, switching devices arranged as indicated to connect the said lines together at a central point common to both, a main battery interposed in the compound circuit constituted by the said two lines, at the junction

thereof, by means of said switching devices, and a battery-telephone having its variable resistance connected directly in said circuit, at the outer terminal of each line, as and for the purpose specified.

9. In a telephone-exchange system, the combination of a switch-board the vertical strips whereof are connected to the respective main lines and the horizontal strips in pairs to the poles of a main battery, and a series of main lines terminating in said switch-board through annunciators at an earth-plate common to the series, with a normally-open branch circuit, including a battery, *l*, and a telephone or telephones, and an electric switch attached to and actuated by each annunciator-magnet, and acting to transfer the main circuit from its normal direct connection with the ground-plate to the normally-open telephone branch, as described.

10. The combination, substantially as hereinbefore described, of two or more central stations, a series of subscribers' lines radiating therefrom and extending to sub-stations, connecting and switching devices whereby any two lines may be connected together, and a main-line battery to be included at the junction thereof and in the circuit so constituted, with a series of trunk-lines extending from one central station to another, and an auxiliary battery for each trunk-line, normally on open circuit, but in electrical communication with the trunk-line, and adapted to be brought into action by the connection of a subscriber's line to its connecting trunk-line.

11. In a telephone-exchange system, an electric switch-board having its vertical connecting-strips connected to incoming trunk-lines and subscribers' lines and a portion of its horizontal connecting-strips connected in pairs to the opposite poles of a main battery, the remaining portion of said horizontal strips being each one connected singly to one pole of an auxiliary battery, the other pole of which is permanently connected to an outgoing trunk-line, substantially as described.

12. In a telephone-exchange system, the combination, at a central station, of a subscriber's line-wire, a switch-strip serving as the open terminal of an auxiliary main battery, connecting devices for connecting the subscriber's line to the said switch-strip, a trunk-line permanently attached to the opposite pole of the said battery and extending to a distant central station, there terminating, after passing through an annunciator, in the earth, and at the said distant central station a normally-open branch circuit, including a battery and a telephone, and an automatic electric switch or circuit-changer, whereby, when the subscriber's line is connected to the switch-strip at the first central station and the circuit of the auxiliary battery is closed, the main-line circuit at the distant station is transferred to the normally-open branch, and the signal is given and the oral communication is established independently of any positive action thereto by the connecting operator, substantially as described.

13. In a telephone-exchange system, the combination, with vibrating circuit-breaking bells at sub-stations, of a main battery at the central office in the circuit of the strips for connecting any two subscribers' lines, and in circuit with said battery an electro-magnetic testing-instrument adapted to vibrate when any two lines are connected by means of said connecting-strips under the influence of and in correspondence with the circuit-breaking bell at the sub-station, whereby the signal given at such sub-station by the inclusion of the battery in the circuit is automatically repeated at the central station, substantially as and for the purpose specified.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 29th day of July, 1881.

GEORGE LEE ANDERS.

Witnesses:
A. M. ALLEN,
GEO. W. PIERCE.