(No Model.) 2 Sheets—Sheet 1.

T. N. VAIL.

TELEPHONE EXCHANGE SIGNALING CIRCUIT AND APPARATUS.

No. 274,857. Patented Mar. 27, 1883.

Fig. 1.

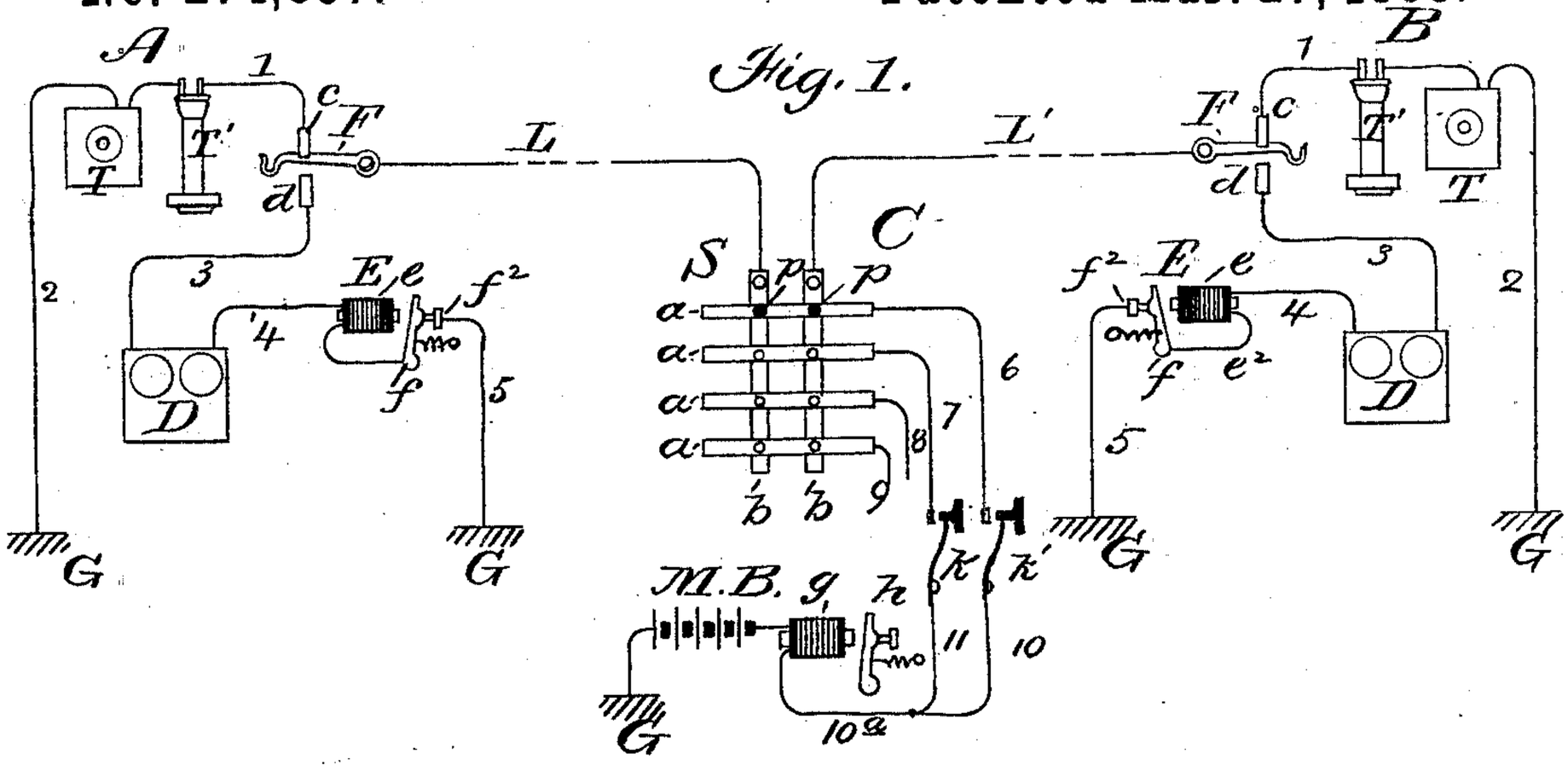

Fig. 2.

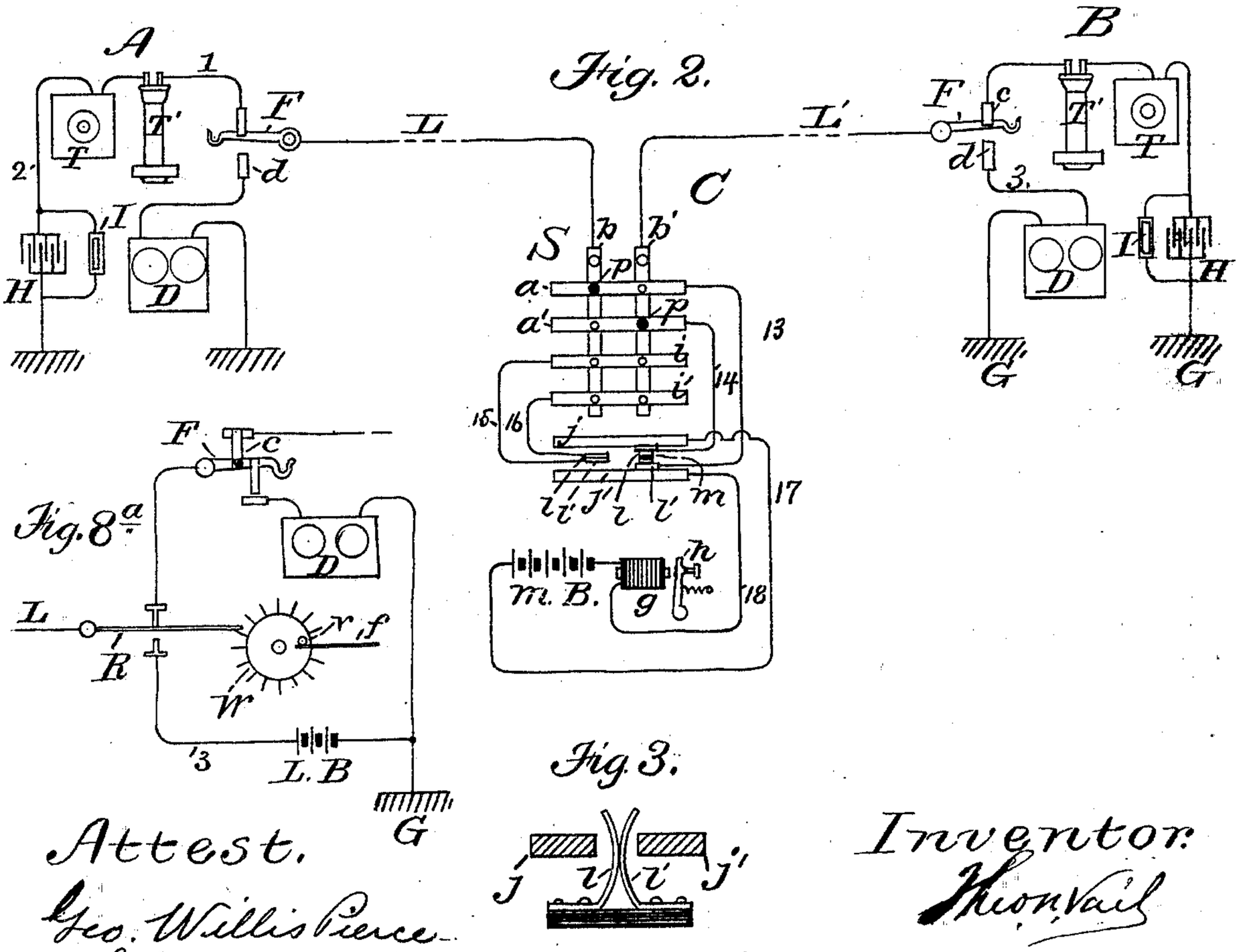

Fig. 8a.

Fig. 3.

Attest.

Geo. Willis Pierce.

Thos. D. Lockwood.

Inventor:

Theo. Vail

(No Model.) 2 Sheets—Sheet 2.

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Fig. 4.

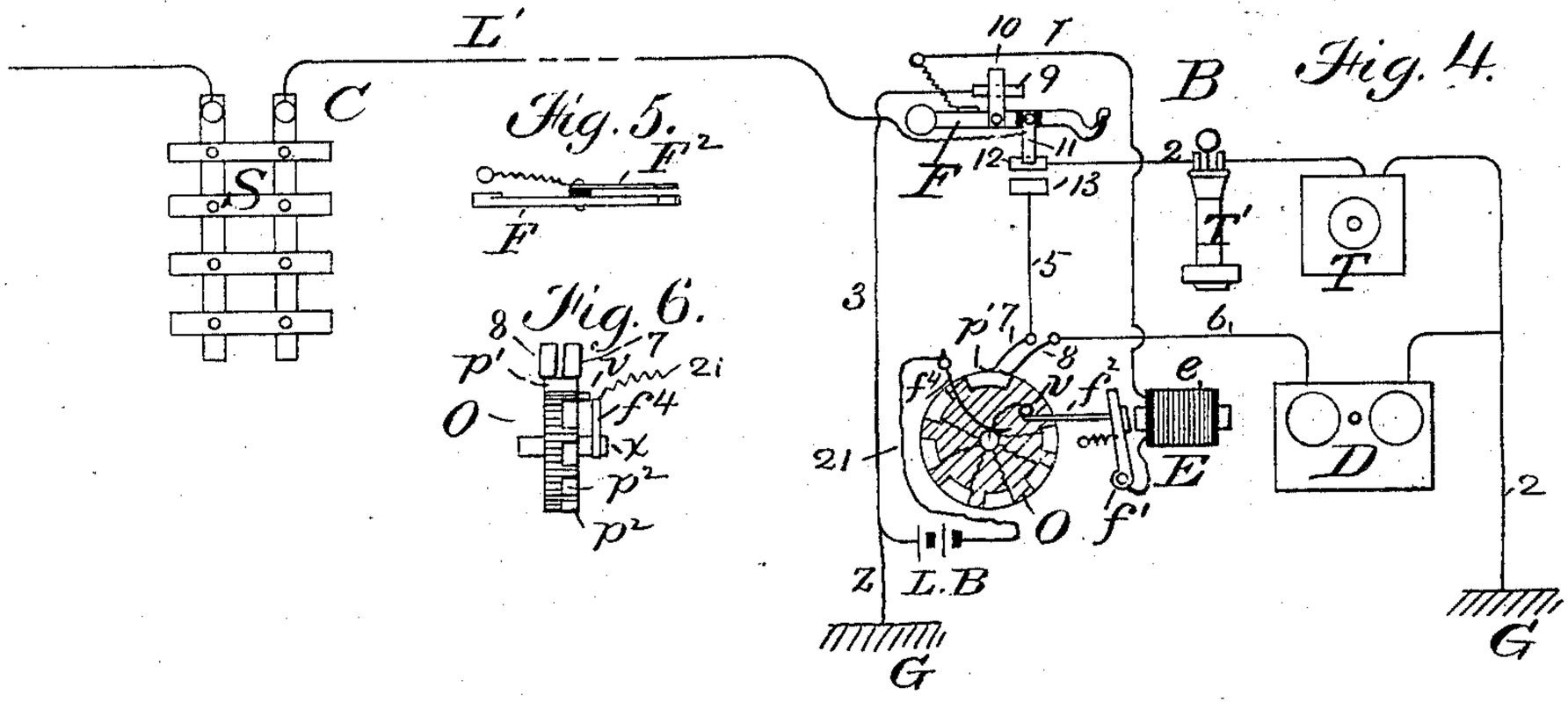


Fig. 5.

Fig. 6.

Fig. 7.

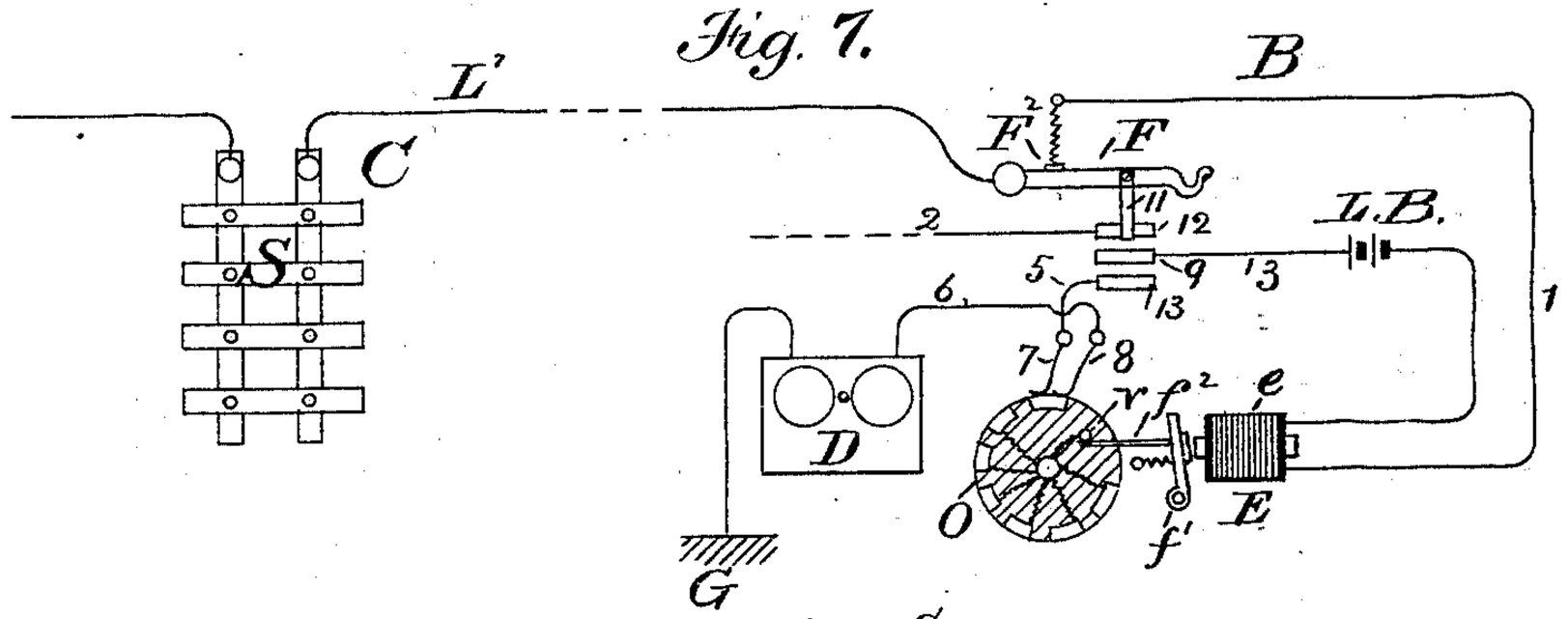


Fig. 8.

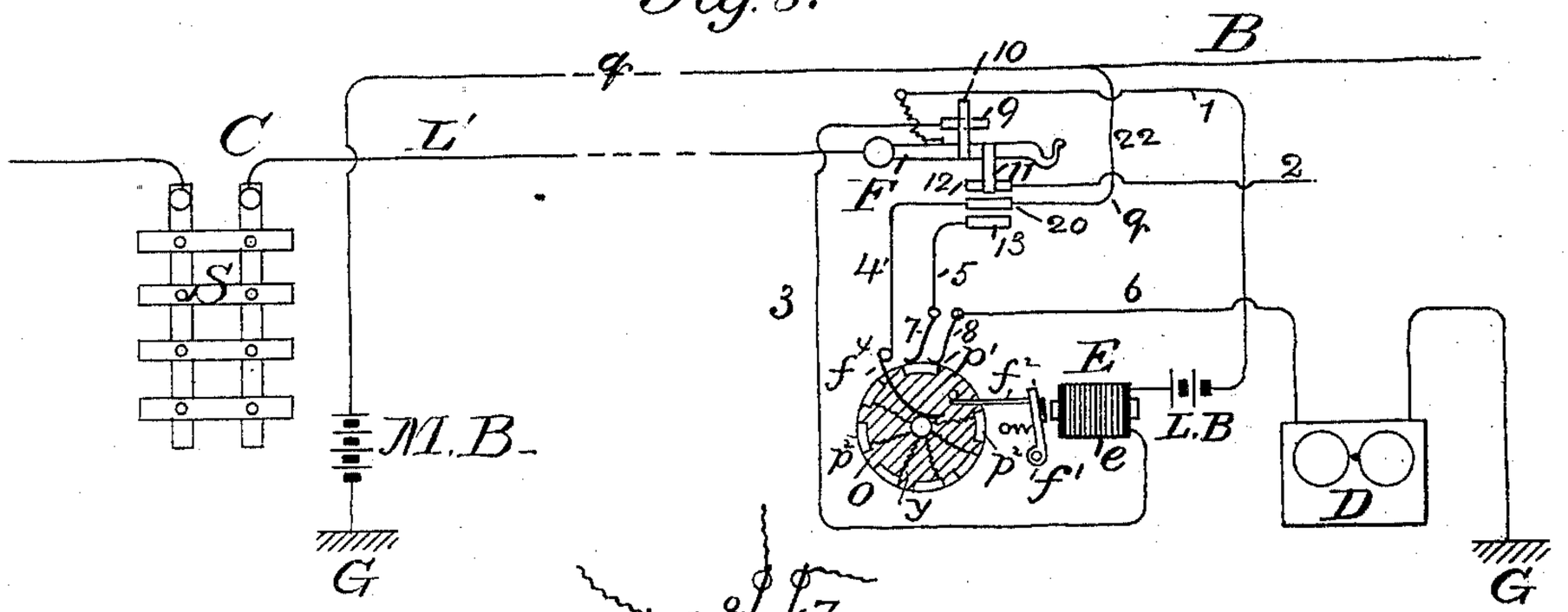
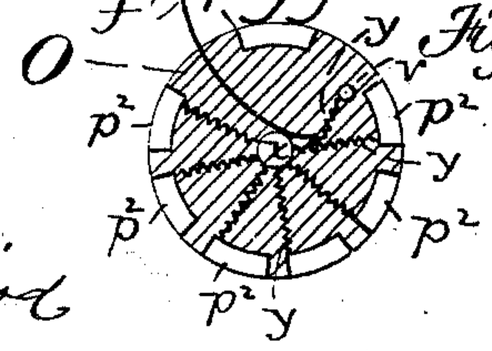


Fig. 9.



Attest.
Geo. Willis Pierce.
Thos. D. Lockwood

Inventor:
Thos. Vail

UNITED STATES PATENT OFFICE.

THEODORE N. VAIL, OF BOSTON, MASSACHUSETTS.

TELEPHONE-EXCHANGE SIGNALING CIRCUIT AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 274,857, dated March 27, 1883.

Application filed December 18, 1882. (No model.)

To all whom it may concern:

Be it known that I, THEO. N. VAIL, of Boston, in the county of Suffolk and State of Massachusetts, have invented certain Improvements in Telephone-Exchange Signaling Circuits and Apparatus, of which the following is a specification.

My invention relates to the operation of telephone-exchanges or central-office systems of telephonic intercommunication, and particularly to the construction and arrangement of the apparatus at the sub-stations and the central station of such exchanges with reference to the rapid and prompt disconnection of lines from one another upon the conclusion of a conversation.

Experience has demonstrated that it is desirable, in view of the fact that many calls have to be delayed on account of the line called for being already in use, that as soon as any line is disengaged the central station shall be enabled to readily ascertain its condition, so that the business of the office, which is always heavy, may be accelerated.

The object of my invention, therefore, is to enable the supervising operator at the central station to become promptly appraised of the conclusion of conversation between any two sub-stations the lines of which have been connected at the central station for the purpose of oral communication, in order that no time may be lost in disconnecting the said lines from one another, and in re-establishing their normal earth-connection at the central station switch-board; and, furthermore, to accomplish this independently of the volition of the subscriber at either sub-station, and without the necessity of any positive action on the part of either, except the usual act of replacing the telephone.

To this end my invention consists, broadly, in certain instrumentalities, which are placed at each sub-station, and so adapted and arranged that upon the conclusion of a communication between any two subscribers the simple act of replacing the telephone in its usual support shall operate to produce a certain abnormal condition in the main-line circuit; and also in other and complementary devices placed at the central station, in connection with and forming a part of the said central-station apparatus, whereby the attendant by a simple operation is enabled to ascertain the condition of the main circuit, and consequently whether the conversation between the subscribers is or is not concluded.

In order to ascertain whether or not the conversation between any two subscribers has terminated, it has heretofore been customary to adopt one of three plans—either to retain the call-annunciator magnet of each connected line in circuit with the compound line formed of any two subscribers' lines or to insert a special annunciator in the connecting-link between the two, whereby signals may be transmitted from the sub-stations to the central station in the same manner as the initial call-signal for interconnection was made; or to connect the two required lines together, leaving out the call-annunciators, and attach to any point on the connecting-link between the two lines a branch line to earth, including an annunciator. When this method is adopted, and a signal is transmitted from either terminal station, a portion of the signaling-current is transferred to the earth branch and passes off through the annunciator thereof, giving a disconnecting signal. Or to dispense altogether with any signaling device, whether looped into or branched from the combined circuit, and simply to connect the central-station telephone with the said combined circuit at occasional intervals, whereby the central-station operator is enabled to listen to any conversation passing and to disconnect the lines on the discontinuance of the same. Each of the foregoing plans has its disadvantages, which render their use more or less objectionable. The first plan adds to the electrical resistance and electromagnetic retardation of the line, thus deteriorating the quality of the transmitted articulations, besides depending for success upon the punctuality and reliability of the subscriber who is required to send the disconnecting signal. The second labors under the constant objection of an earth derivation and a leakage of the current thereat, with a consequent weakness of its useful effects during conversation between the two sub-stations, and is also dependent upon the active co-operation of the subscriber, which, as a rule, is not to be relied upon. The third necessitates a constant watch

and supervision of all connected lines, and entails much undesirable labor upon the central-office operator, and is also objectionable to the subscribers themselves, who prefer absolute privacy of communication. These practical disadvantages I aim to obviate by my invention.

In the drawings, which illustrate and form a part of the specification, Figure 1 is a diagram illustrating one plan of carrying out my invention, in which the replacement of the telephone brings into the line an electro-magnetic vibrator, which, on the application of a battery at the central station, becomes active, and rapidly makes and breaks the circuit. Fig. 2 represents a second plan, by which the replacement of the telephone greatly diminishes the line-resistance, and by the consequent increase of the strength of current permits an electro-magnet at the central station to become vitalized. Fig. 3 is a detail of the device employed in Fig. 2 to loop in the battery and testing-instrument. Figs. 4 and 7 are modifications in which the replacement of the telephone tends, by means of an electro-magnet and trip movement, to release a clock-work rotating a circuit-wheel, the said circuit-wheel intermittently making and breaking the main-line circuit. Fig. 5 is a detail of the hook-switch, and Fig. 6 an edge view of the circuit-wheel used in Figs. 4, 7, and 8. Fig. 8 is another modification, in which the central station is signaled and the circuit-wheel put in operation by a current derived from the central station itself. Fig. 9 is a front view of the circuit-wheel, and Fig. 8ª shows a method by which the circuit-wheel is made to throw pulsations of electricity to line.

In Figs. 1 and 2, C represents a central telephone-station, of which S is the switch-board. L and L′ are lines radiating from the switch-board to sub-stations A and B. It is well known that in practice a great number of lines so radiate; but two are sufficient to exemplify my invention, and therefore to avoid complication in the drawings I have shown but two. Entering each sub-station, the line runs first to the hook-switch F, its subsequent course depending upon the position of the said switch. The telephone, when not in use, is hung upon the hook, and by its weight brings the substance of the hook into contact with a contact-spring, *d*, which leads through wire 3, signal-bell D, wire 4, electro-magnet *e*, wire e^2, armature *f*, back stop, f^2, and wire 5 to the earth G, the line being thus normally to earth through the bell. When the telephone is removed from the hook, the hook, impelled by a retracting-spring, (not shown,) flies up and makes contact with the upper spring, *c*. This leads by wire 1, telephone T′, transmitter T, and wire 2 to the earth. The two lines L and L′ are shown in Fig. 1 as being connected together on one of the horizontal bars *a* of the central-office switch-board S for through oral communication. Each line is permanently connected at the central-office end with a vertical bar, *b*, and by inserting plugs *p* at the suitable intersecting points they may be united on any of the horizontal bars *a*, as shown. The horizontal switch-bars *a* are, by means of wires 6, 7, 8, and 9, connected with key-anvils, which with their keys *k* and *k′*, may be located in any convenient position. The keys—one for each horizontal bar—are united by wires 10 11 by means of a common wire, 10ª, to which any number of the key-wires may be attached, with an electro-magnet, *g*, and thence to battery M B and to ground. The electro-magnet *g* is provided with an armature, *h*, and as its circuit is normally open, being completed only when any of the keys are pressed, the armature usually is retained against its back stop by its retracting-spring. It will be noticed that at each sub-station the bell-branch circuit is through the armature *f′* and its back stop, f^2, and therefore when any strong impulse of electricity is passed through the electro-magnet E the armature is drawn forward, breaking its own circuit, and consequently the circuit of any line of which it forms a part.

The ordinary magneto-currents used in calling are not sufficiently strong to affect the electro-magnet E. It is therefore ordinarily quiescent during signaling and conversation; but when two lines are connected, as in the drawings, and the central-office operator desires to ascertain whether the conversation has concluded, he presses the key *k′*, connected with that horizontal bar, and this operation connects the battery M B and the electro-magnet *g*, by means of the branch wire 6, with the pair of united line-circuits L and L′. So long as the telephones at the two sub-stations are in use and the conversation is proceeding the only result at the central station accruing from the pressure of the key is the attraction of the armature *h* by the magnet *g*, for the mere addition of a battery-current to the telephone-current produces no apparent result; but if the conversation has concluded and the telephones have been hung up the bell branches are both brought once more into circuit, and with them the automatic electro-magnetic circuit-breakers E, and upon the pressure of the key *k′* by the central-station operator the current from the main battery M B traverses the lines in both directions, passing through the circuit-breakers E, causing them to become operative and vibrate their armatures, at each vibration breaking and closing the circuit on the back stop, f^2.

The armature *h* of the central-office magnet is not provided with circuit-breaking points, but necessarily responds to the intermittent pulsations of electricity produced by the vibration of the sub-station circuit-breakers, and vibrates in correspondence therewith, whereby the central-office operator is apprised that the lines are to be disconnected, knowing that if the conversation is still in progress his armature will the moment the key is pressed advance only; but if the conversation has con-

cluded the central-station armature will on the pressure of the key immediately begin a series of rapid vibrations.

At the central station one battery, electro-magnet, and armature may be common to a series of line-circuits, and be connected with each of the connection-strips *a* of the switch-board by means of branch wires and keys, as shown in the drawings. I also may unite the circuit-breaker E and bell D at each of the sub-stations in one instrument, forming a vibrating bell.

In Fig. 2, although I use the switch-board S at the central station and the hook-switch F at the sub-stations and connect the sub-stations and central station by line-wires L L′, as in Fig. 1, the instrumentalities which particularize my invention are somewhat different, and are constituted as follows: At each sub-station the bell branch 3, to which the line is normally, by the depression of the hook-switch under the influence of the telephone, united, includes only the signal-bell D, the circuit-breaker E being omitted. The telephone branch, to which the line becomes united by the elevation of the hook-switch when relieved from the weight of the telephone, includes, in addition to the usual telephone, T′, and transmitter T, a rheostat or high resistance, I. This may be adjustable, or may be of a constant magnitude—for example, ten thousand ohms. This I bridge by a condenser, H, so that the rhythmical pulsations of electricity, by which articulate speech is reproduced, will not be impeded by having to pass through the rheostat, it being well understood by those skilled in the art that the said rhythmical impulses are readily transmitted through a condenser by induction. By the united use of these instrumentalities I maintain a very high resistance in the talking-circuit, and at the same time prevent that resistance from diminishing the sound of transmitted speech.

At the central station, in convenient proximity to the switch-board S, I place two parallel bars, *j* and *j′*, one of which, *j*, is connected by a wire, 17, directly with one pole of a battery, M B, while the other bar, *j′*, connects by wire 18 with the other pole of the battery, after passing through the electro-magnet *g*. Arranged between this pair of parallel strips I place a series of spring-jacks, of the character delineated in Fig. 3, each consisting of a pair of leaf-springs, *l l′*, and normally pressing against one another. One spring-jack is alloted to each pair of the connection-bars *a* in the switch-board S, and each of the said switch-board bars is permanently connected by a wire with one of the springs of one of the spring-jacks. In the drawings it will thus be seen that of the uppermost pair of bars, *a a′*, *a* is united by wire 13 to spring *l′* of its own jack, while *a′* is similarly united by wire 14 to the spring *l*, which normally presses against the spring *l′*, making contact therewith, the two jointly constituting the spring-jack. In connecting any two lines together in this system I use a pair of connection-bars, *a*, instead of one, as in Fig. 1, and when any two lines are connected for intercommunication their course through the switch-board is thus traced: From line L to vertical bar *b*, and by plug *p* to cross-bar *a*, and by wire 13, spring *l′* of the spring-jack, thence by contact between the springs to *l*, and by wire 14, horizontal switch-bar *a′*, plug *p*, vertical switch-bar *b′*, and thence to line L′. The two parallel bars *j* and *j′* form the normally-open terminals of the battery M B, and have no contact with any circuit until the two springs of the spring-jacks are forced apart by inserting a suitable wedge, *m*, between them. When this is done the outside surfaces of these springs make contact with the bars *j*, thus looping the battery M B and magnet-coil *g* into any two lines which may at that time be connected with the spring-jack. When the apparatus at the central and sub stations is arranged as hereinbefore described, the state of the line may be ascertained at once by pressing a wedge between the jack-springs of the required line. This may be done by arranging over the several jack-springs a key-board and a set of press-keys, which, when pressed, will insert a wedge, as described. If the line is in use and the sub-stations are conversing, no effect will be made manifest on the central-office instruments, because the rheostats at each of the sub-stations are in circuit, and their resistances are so great that the battery-current is materially weakened, and has no power to attract the armature of the electro-magnet *g*; but if the conversation is concluded and the telephones are in place the rheostats are cut out, the resistance of the line reduced to its normal condition, and the battery-current is sufficiently strong to actuate the testing-magnet *g*. In this case, then, the operator knows the instant that he inserts the wedge *m*, and thus introduces the battery into the circuit, that if his testing-magnet responds the conversation is concluded, and that he may disconnect the lines, and that if the testing-magnet does not respond the conversation is not concluded, and that more time is required.

In the plan which I show in Fig. 4 the central-station devices may be identical in character with those shown in Fig. 2; and I may here state that although I have represented the electro-magnetic device at the central station to be simply an electro-magnet and armature any other instrument, as an electric bell or annunciator, may readily be substituted therefor.

I will now describe the sub-station arrangement shown in Fig. 4.

F is the hook-switch, which carries two flat contact-springs, 10 and 11, the former being electrically connected with the metal hook and the latter insulated therefrom. On the inner side of the hook-lever, and affixed thereto, but insulated therefrom, is a second metal bar, F^2,

terminating also in a hook which coincides in position with the main hook, as shown in Fig. 5. The incoming line is united with the spring 11, and, as usual, when the hook is depressed and the telephone hanging thereon, is connected with earth through a signal-bell. When the telephone is removed the hook transfers the line to a second branch leading through the telephones to earth.

A circuit-wheel, O, having, as shown in Fig. 6, one conducting-plate, p', stretching completely across its periphery, and a number of others, p^2, partly across, is suitably arranged to rotate by means of a clock-movement when released, and through the broad contact-piece or conducting-plate p' the bell-branch circuit is led, and may be traced, *via* hook-contact 13, wire 5, contact-spring 7, wheel-plate p', contact-spring 8, wire 6, bell D, and ground-wire 2. The telephone-branch leads directly through the telephone T′ and transmitter T to earth from the hook-plate 12.

A local battery, L B, which in practice may be the transmitter-battery, has one of its poles connected with the ground by a wire, z, the same pole being also united by wire 3 with the plate 9 above the hook. The spring 10 slides over the plate 9, making frictional contact therewith when the hook moves up or down.

Attached to the auxiliary hook F′ (see Fig. 5) is a wire, 1, which leads to one terminal of an electro-magnet, E, issuing from the other terminal thereof. The circuit proceeds through the armature-lever f' and the detent f^2, which projects from the rear of said lever, to the pin v, which is inserted in the side of the circuit-wheel O, from whence it continues, by means of the radial wire y, to the arbor x of the wheel, and from there, by the contact-spring f^4, which bears on the said arbor, and the wire 21, back to the other pole of the local battery. The local-battery circuit is normally open at the plate 9, and may be also opened at the hook, where, when the telephone is in place, it is completed by the telephone-ring. It may also be opened between the point v on the circuit-wheel and the projecting detent f^2.

In practice the spring 7, pressing on the edge of the circuit-wheel, is fixed in front of the spring 8, as shown in Fig. 6, and as soon as the rotation of the wheel commences the spring 7 only makes contact with the intermittent metallic plates, the spring 8, connected with the signal-bell, being thus insulated and pressing on the non-conducting substance of the wheel until the rotation of the wheel has concluded, and both springs once more rest upon the plate p', which is common to both.

The operation of these devices may be described in the following manner: When the telephone is on the hook the ring by which it hangs makes the electrical connection between the two hooks F and F², and the line is complete through the signal-bell line to earth. When a call is received and the bell D rings the subscriber takes his telephone from the hook, which flies up until the spring 11 rests on the plate 12, thus connecting the main line through the telephones to earth. As the local circuit is opened by taking the telephone from the hooks, and thus removing the electrical connection between the hooks F and F², and before it can close by contact between the springs 10 and plate 9, the electro-magnet E remains inoperative; but when the conversation is concluded and the telephone is replaced the local circuit is once more closed between the hooks by the telephone-ring, and when the spring 10 passes over the plate 9 on its way down the local circuit is for an instant completed, and the course of the local-battery current is from the positive pole of the battery, *via* wire 3, plate 9, contact-spring 10, hook F, telephone-ring, parallel hook F², wire 1, magnet-helix e, armature-lever f', pin v, radial wire y, arbor-spring f^4, and wire 21, to the negative pole of the battery. The magnet E, being thus energized, attracts its armature, which withdraws the detent from the pin v, whereupon the wheel, propelled by a suitable clock-train, rotates its alternate conducting and non-conducting spaces, passing under the spring 7, leading to the line and central station, and by means of the ground-wire z, attached to the local battery, electrical impulses are sent over the line to the central station over the following route: ground-wire z, battery L B, wire 21, spring f^4, arbor x, radial wires y, and conducting-plates p^2, contact-spring 7, wire 5, plate 13, spring 11, and line L′. These pulsations are, owing to the character of the circumference of the wheel, intermittent, and when the central-office operator presses his key or inserts his wedge, as in Fig. 2, he at once becomes cognizant that the line is now disengaged, because his testing-instrument so indicates by its successive and intermittent movements. If that instrument be a telephone, he also understands the condition of the line instantly, as a telephone responds at once to electrical changes of whatever nature.

The circuit-wheel is so arranged with respect to its motive power as to be capable of adjustment to any desired rate of speed, and I prefer such a rate as would produce one revolution of the wheel in about five minutes. The alternate conducting and non-conducting spaces upon the edge of the wheel may be of any desired number, but I have for the sake of clearness in the drawings refrained from showing a large number.

If a battery is arranged at the sub-station, as in Fig. 4, to send successive pulsations toward the central station, no battery will be required at the central station, but a testing-instrument only.

In Fig. 7 I present a modification of the plan described in Fig. 4, in which the local battery L B has no ground branch. The circuit-wheel, therefore, instead of sending electrical impulses to the line and toward the cen-

tral office, merely has the function of alternately breaking and making the line-circuit, and the presence of the central-office battery is an essential in the operation of this plan.

Fig. 8 represents still another modification in the details of the plan described fully in Fig. 4, in which I show my invention operated in connection with the system of automatic signaling patented by Thomas D. Lockwood July 11, 1882, No. 260,884. The line is in metallic connection with the hook-switch F, which is also provided with the parallel hook F^2. The extreme upper and lower contact-plates, 12 and 13, are, as usual, connected respectively with the telephone and signal-bell branch circuits, the latter through the broad plate p' on the circuit-wheel, and by means of the contact-spring 11 the line is brought into connection at the ends of its up-and-down movement with these branches. The local circuit, by which the tripping of the circuit-wheel mechanism is effected, is led through the contact-plate 9 and spring 10 and through the two hooks, but not through the armature-lever f' of the electro-magnet E. Hence the sole office of the local circuit is when closed to energize the helix e of the magnet E on the down movement of the hook-switch, and thus trip the circuit-wheel. Between the terminal plates 12 and 13 of the telephone and bell branches is a third contact-plate, 20. This is connected by a wire, 4, with the spring f^4, that presses on the arbor of the circuit-wheel O, and by the radial wires y also with the conducting-plates p^2, which are let in on one side only of the edge of the wheel. The plate 20 is also connected by a branch wire, 22, with an electrical-supply circuit, q, which, in accordance with the patent I have hereinbefore cited, is constantly charged by a source of electricity, preferably located at the central station. This supply-wire is common to a number of sub-stations, which it enters by branch circuits 22. It is obvious that as the hook-switch F descends under the weight of the telephone or rises when the telephone is removed, the spring 11, while in transit from the bell-branch plate 13 to the telephone-branch contact-plate 12, or vice versa, must pass over the intermediate plate, 20, coming into frictional contact therewith. As it passes upward the only result is to place the main line L in momentary connection with the constantly-charged plate 20, and thus to send a pulsation of electricity to the central station over the main line to give a signal at the central station. As the hook passes downward a second momentary signal is given, followed by successive signals produced by the rotation of the circuit-wheel, this being, as hereinbefore described, tripped only during the downward movement of the hook-switch. While the wheel is in rotation the normal ground terminal of the line L is removed, the spring 8 rubbing on the non-conducting periphery of the wheel only, and the said line is, by means of the spring 7 and the alternate conducting-plates p^2 of the wheel, brought into intermittent contact with the charged supply-line, whereby the electrical impulses continue to go to line during the rotation of the wheel, and when the said rotation is concluded the earth-connection through the bell branch is restored.

In Fig. 8^a another method is shown, in which a contact-spring, R, connected with a main line, is acted upon by the spokes of a rotating wheel, W, which places the said spring in intermittent contact with a battery, L B.

In Figs. 7 and 8 I have not thought it necessary to show the telephone-instruments, and have merely indicated them.

Having now fully described my invention, I claim—

1. In a telephone-exchange system, the combination of a central station, a series of sub-stations, a line connecting each sub-station with the central station, automatic devices at the sub-stations whereby the electric condition of the line is altered at the close of a communication, and a test apparatus at the central station which indicates upon the depression of a key or by equivalent means, as specified, whether the communication is at an end, substantially as described.

2. In a telephone-exchange system comprising a central station and a series of sub-stations, the combination of a signaling device at the sub-stations automatically brought into operation by the switch-hook in hanging the telephone thereon, and a testing device at the central station, which upon being applied by the operator indicates whether or not the telephone at the sub-station has been restored to its hook, substantially as described.

3. The combination, with devices at the sub-station, brought into operation by the movements of the telephone-hook when the telephone is replaced thereon to change the electric condition of the line, of testing apparatus at the central office, comprising a local battery, means for closing the same, and an indicating device, which, when the circuit is closed by the operator, shows whether the telephone has been replaced upon its hook, substantially as described.

4. The combination, at a sub-station in a telephone-exchange system, with the main line, the signal-bell and telephone branch lines, and an automatic switch actuated by the removal and replacement of the telephone to place the said main line in electrical connection with either of said branches, of a rotary intermittent circuit-changer, a local battery and circuit controlling the movements of the same, and a circuit-closer operated by the automatic switch in the said local circuits, and adapted to become operative only during the movement of the said automatic switch from the telephone to the bell branch, whereby when the telephone is put in place on the conclusion of a communication the rotary circuit-changer is actuated and continues to close and break the main-line

circuit or to transmit electrical pulsations over the main-line circuit for a definite period, substantially as and for the purpose set forth.

5. In a telephone-exchange system, the combination, substantially as hereinbefore described, with a main line, of the signal-bell and telephone branch lines, an automatic switch actuated by the removal from or replacement of the telephone in its support to place the said main line in contact with either of said branch lines, a rotary intermittent circuit-changer, a local battery and circuit controlling the movements of the same, a circuit-closer in the said local circuit operated by the automatic switch, and adapted to become operative during the movement of the said automatic switch from the telephone to the bell branch all at each sub-station, and of an electro-magnetic testing-instrument, and devices for connecting the said instrument with any pair of interconnected lines at the central station, whereby when the telephone is replaced on the conclusion of a communication the rotary circuit-changer is actuated and continues to change the electrical condition of the main-line circuit for a definite period, and whereby the said changes may be noted at the central station, as described.

6. The combination, substantially as hereinbefore described, of a local battery and circuit, a rotary circuit-changer, an electro-magnet, armature, and armature-lever controlling the same, all in the said local circuit, a lever-switch forming a support for the telephone when in place, and consisting of two parallel hook-levers attached to but insulated from one another, and each forming a portion of the local circuit, a metal telephone-ring, by which the telephone is suspended from the said hooks, and which, when the telephone is in place, connects the two hooks electrically, and a circuit-closer, also in the local circuit, actuated by the lever-switch, the whole being inoperative during the movement of the lever-switch when the telephone is removed, the local circuit being then opened at the hook by removal of the ring before it is closed at the circuit-closer, but operative when the telephone is replaced, whereby the action of replacing the telephone closes the local circuit, energizing the electro-magnet and permitting the rotation of the rotary circuit-closer, as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 14th day of December, 1882.

THEO. N. VAIL.

Witnesses:
GEO. WILLIS PIERCE,
THOS. D. LOCKWOOD.