(No Model.) 4 Sheets—Sheet 1.

T. N. VAIL.

CENTRAL AND SUBSIDIARY TELEPHONE EXCHANGE SYSTEM, CIRCUIT, AND APPARATUS.

No. 324,192. Patented Aug. 11, 1885.

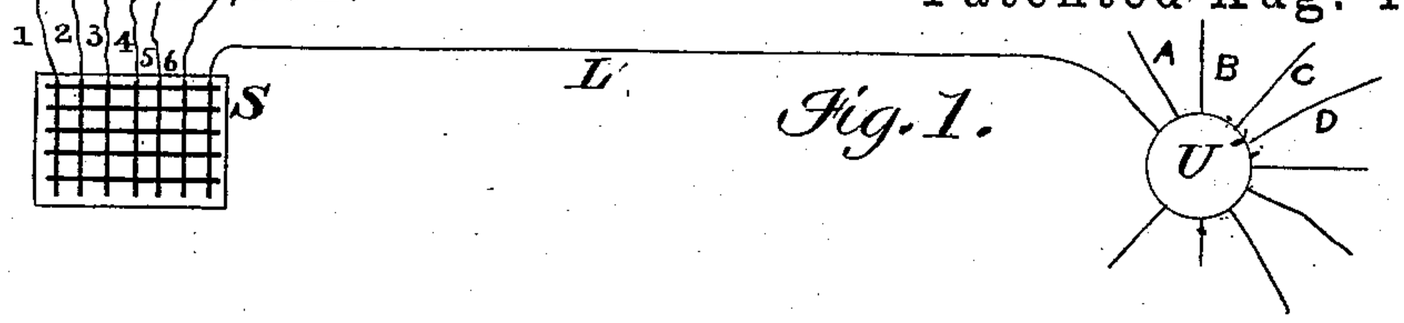


Fig. 1.

Fig. 2.

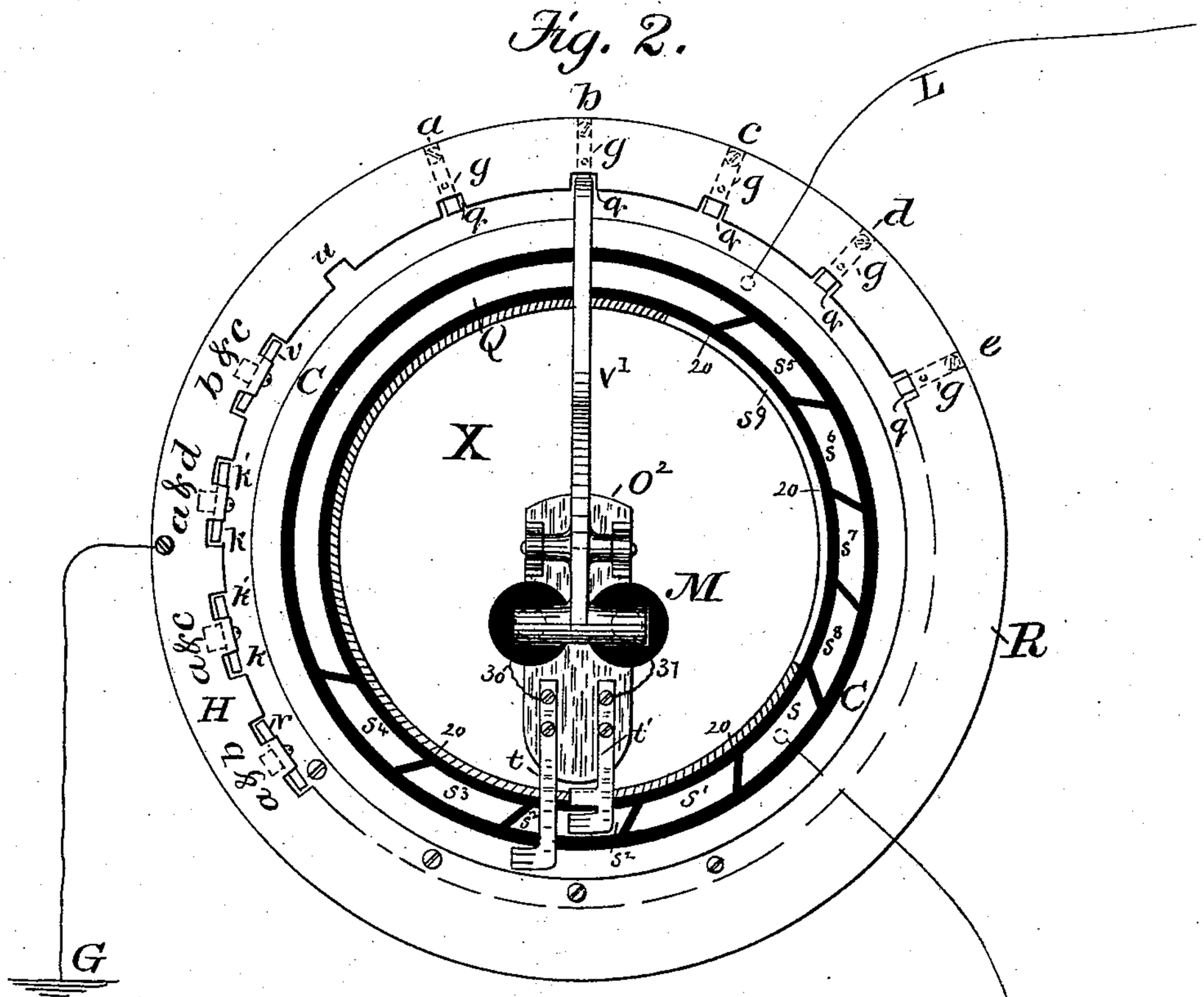
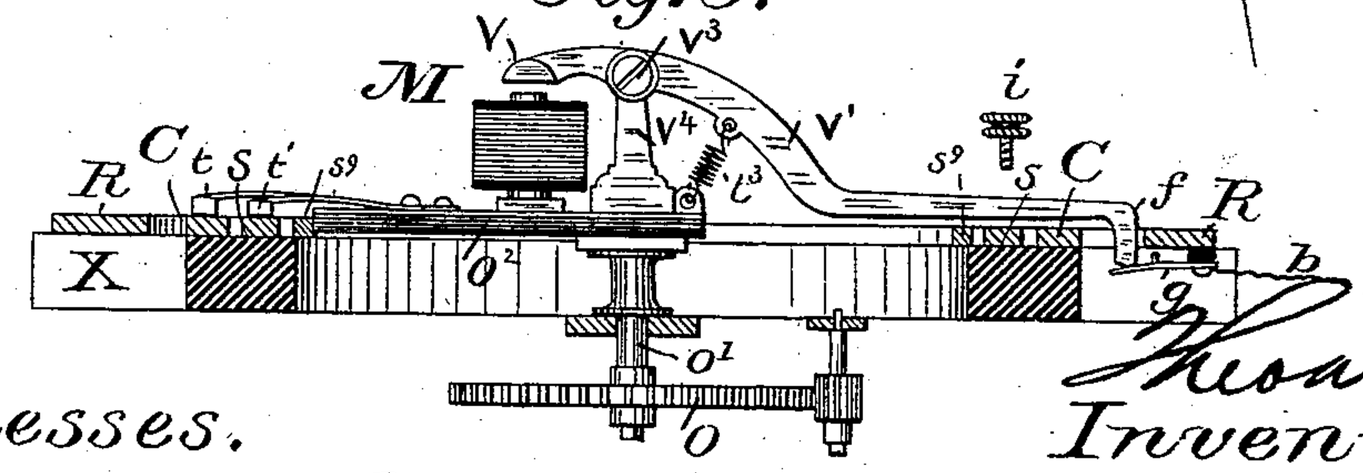


Fig. 3.



Witnesses.
Geo Willis Pierce
Thos D Lockwood

Inventor

(No Model.) 4 Sheets—Sheet 2.

T. N. VAIL.

CENTRAL AND SUBSIDIARY TELEPHONE EXCHANGE SYSTEM, CIRCUIT, AND APPARATUS.

No. 324,192. Patented Aug. 11, 1885.

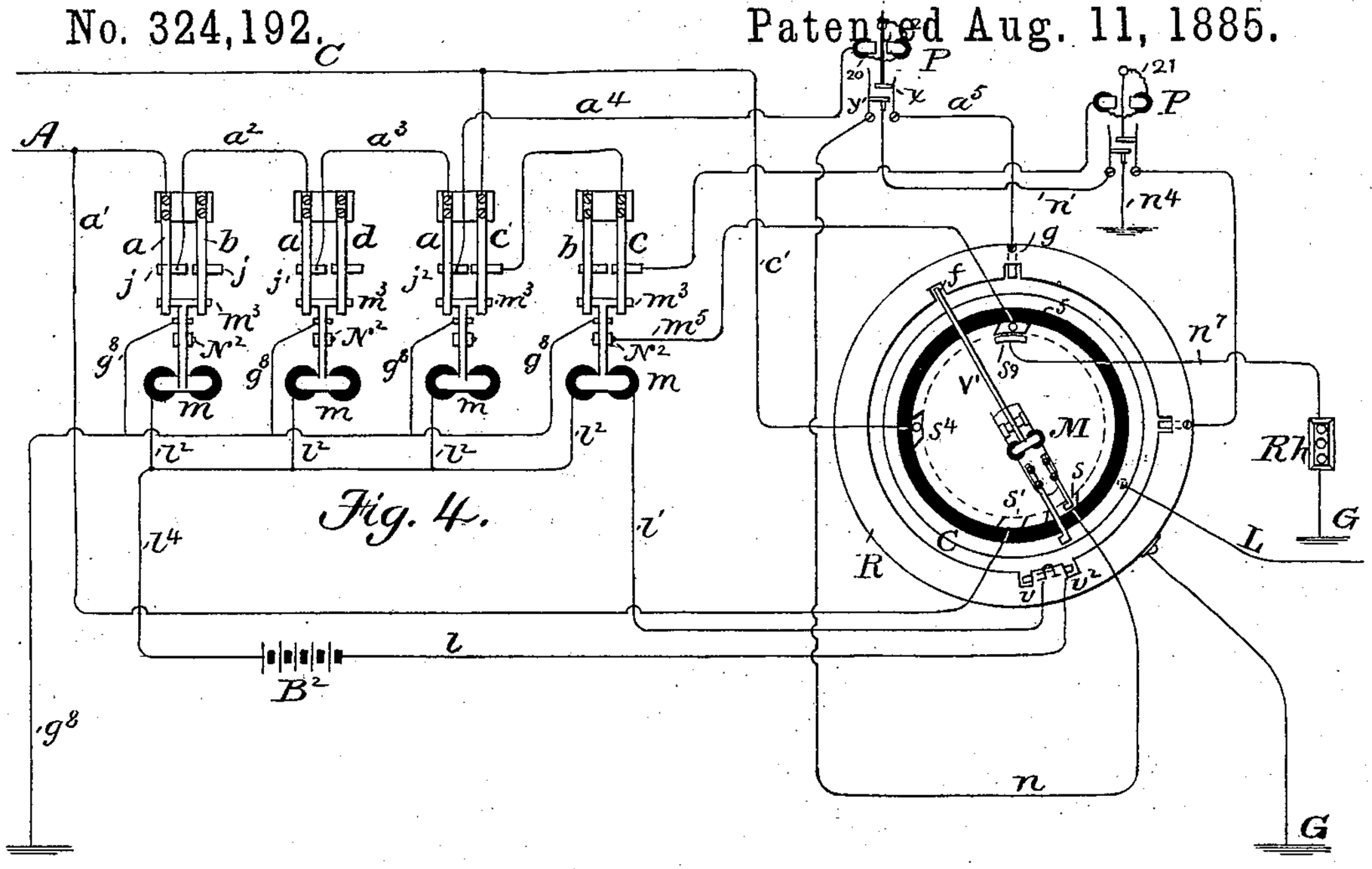


Fig. 4.

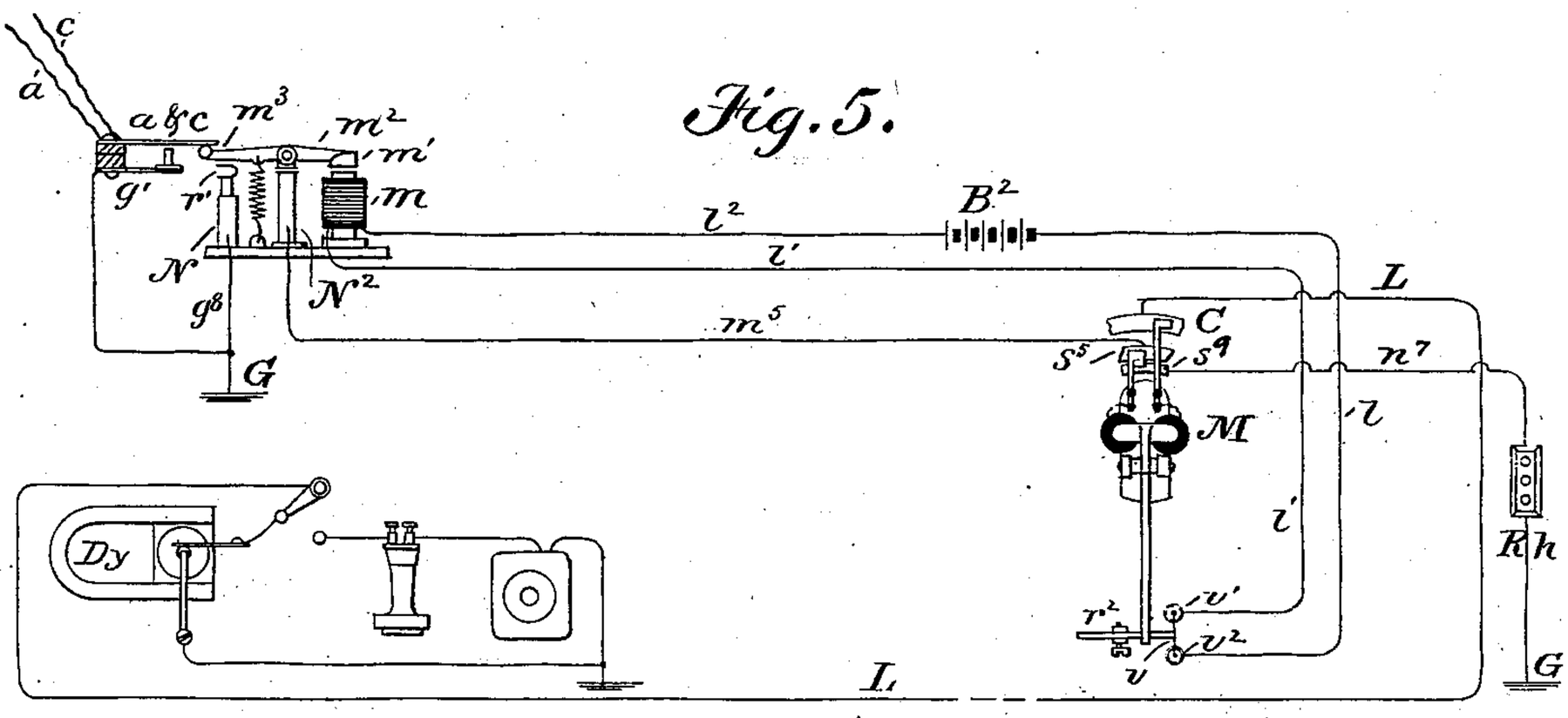


Fig. 5.

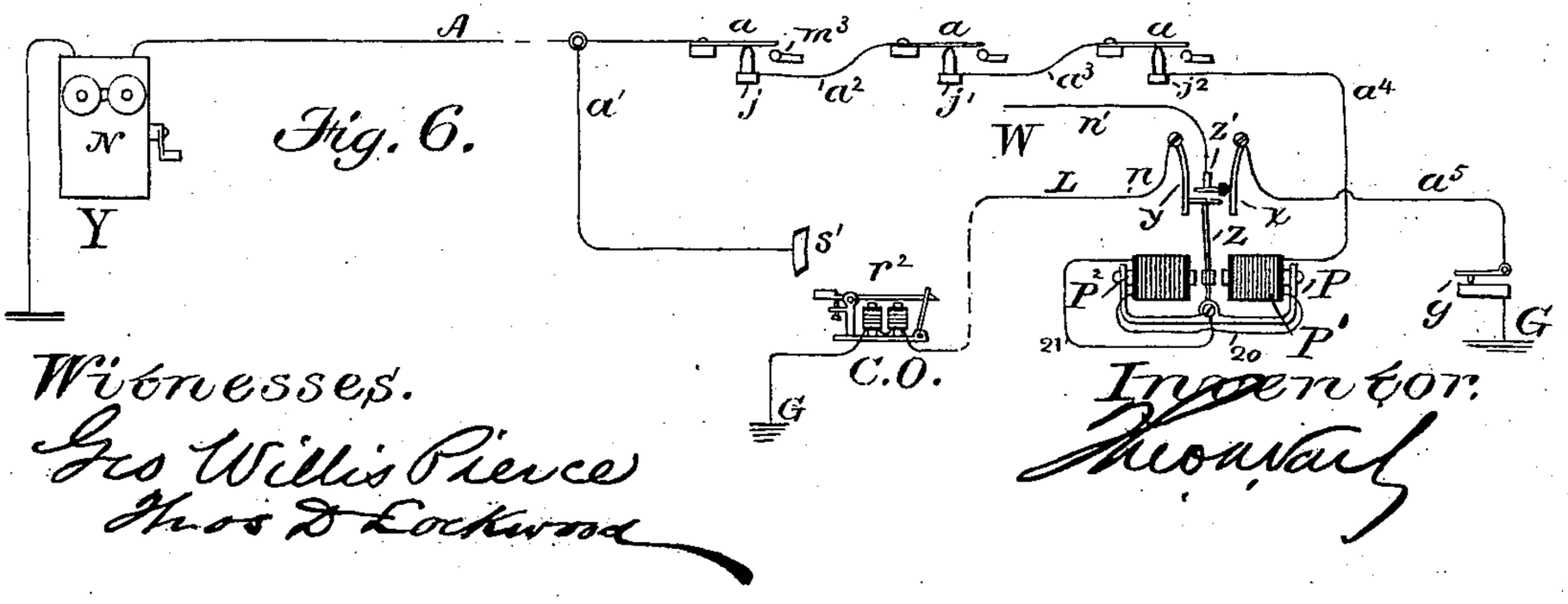


Fig. 6.

Witnesses.
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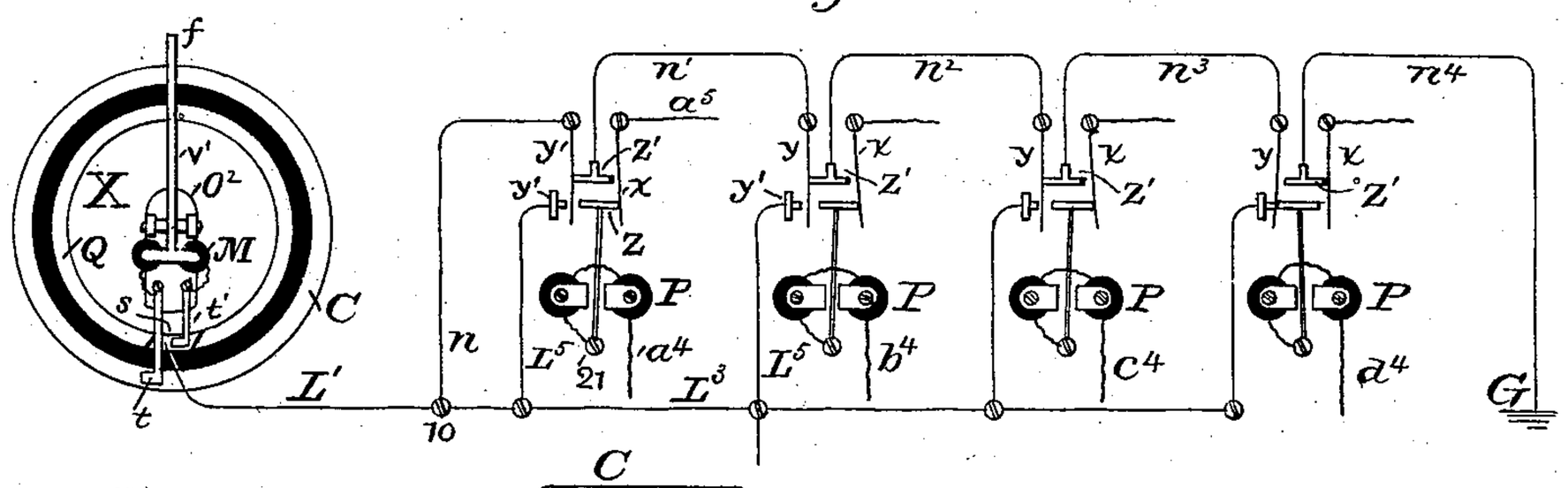
(No Model.) 4 Sheets—Sheet 3.

T. N. VAIL.

CENTRAL AND SUBSIDIARY TELEPHONE EXCHANGE SYSTEM, CIRCUIT, AND APPARATUS.

No. 324,192. Patented Aug. 11, 1885.

Fig. 7.



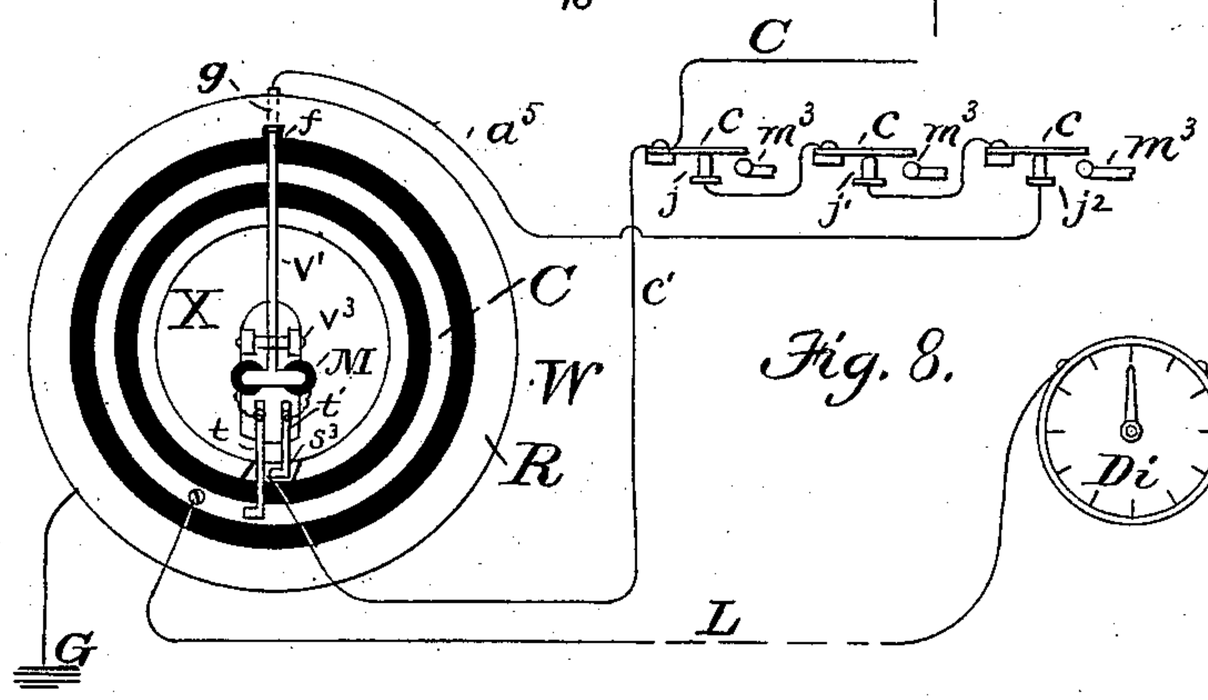
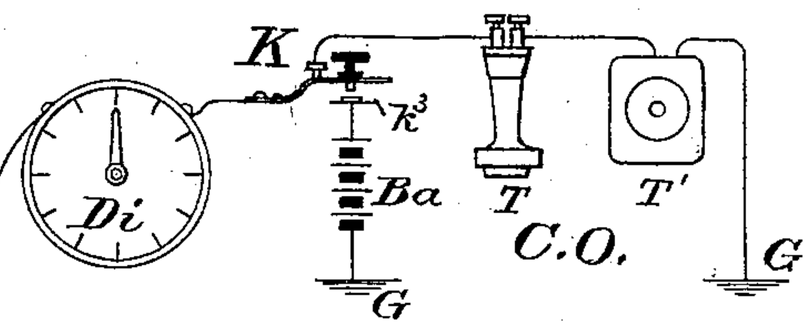


Fig. 8.



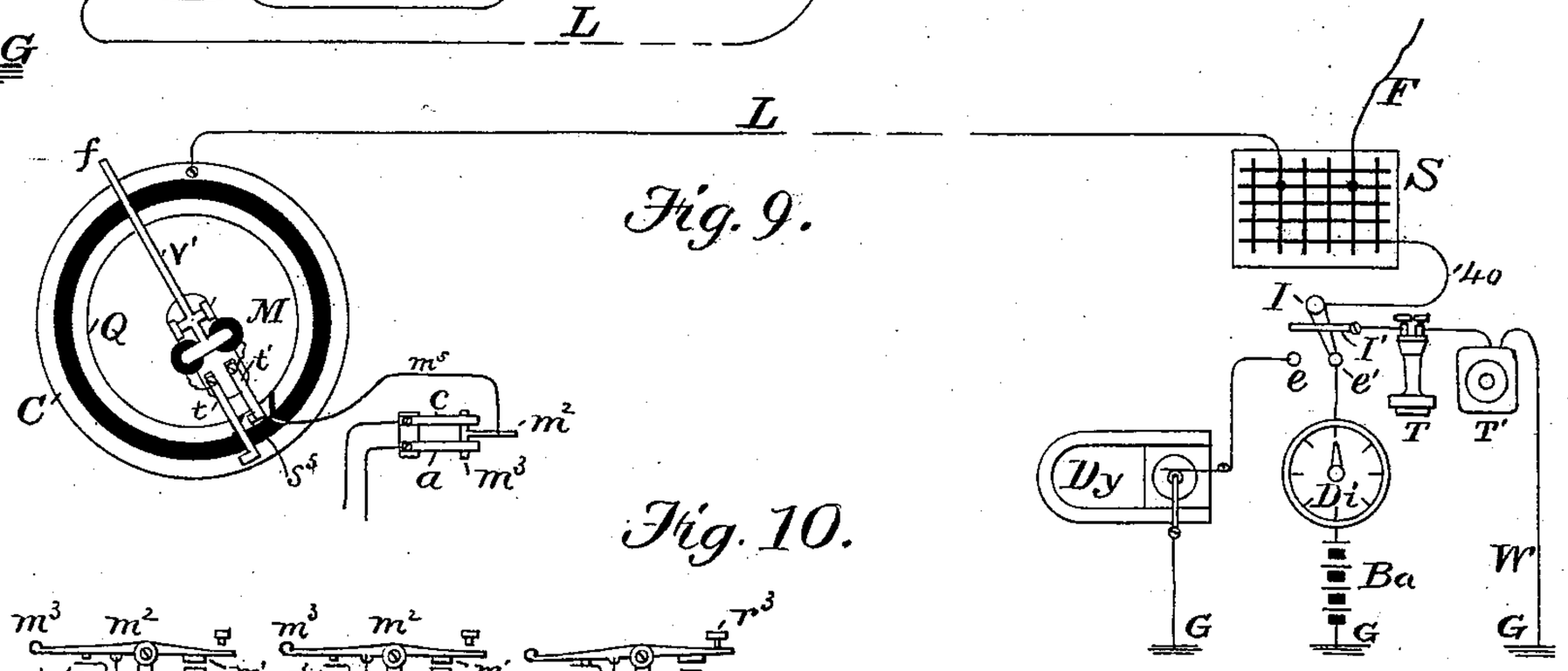
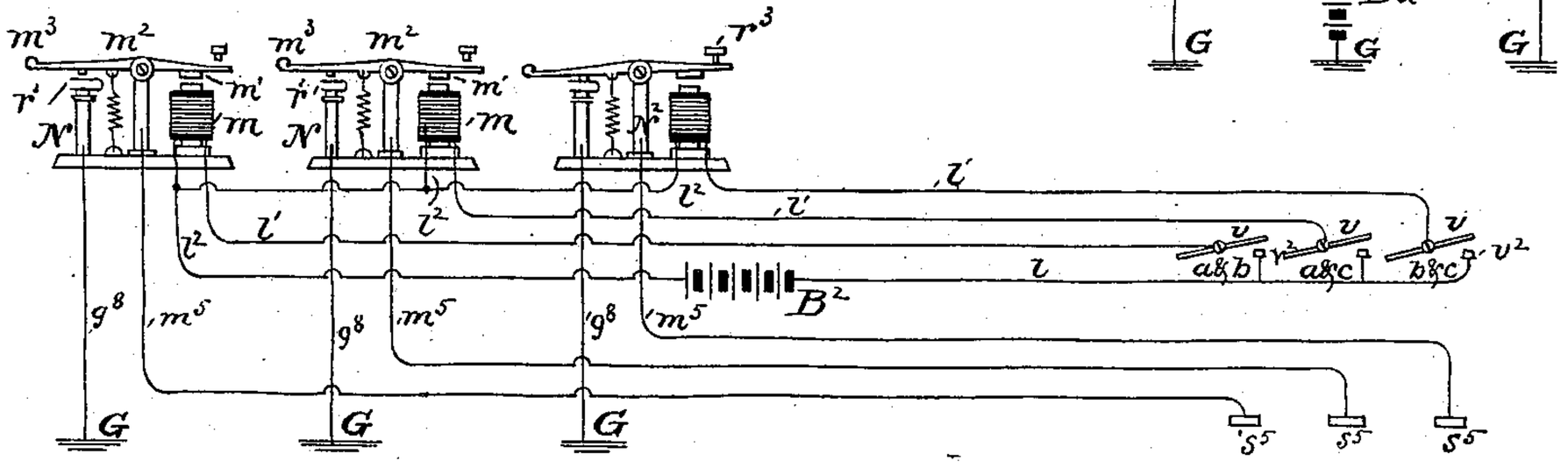


Fig. 9.

Fig. 10.



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(No Model.) 4 Sheets—Sheet 4.

T. N. VAIL.

CENTRAL AND SUBSIDIARY TELEPHONE EXCHANGE SYSTEM, CIRCUIT, AND APPARATUS.

No. 324,192. Patented Aug. 11, 1885.

Fig. 11.

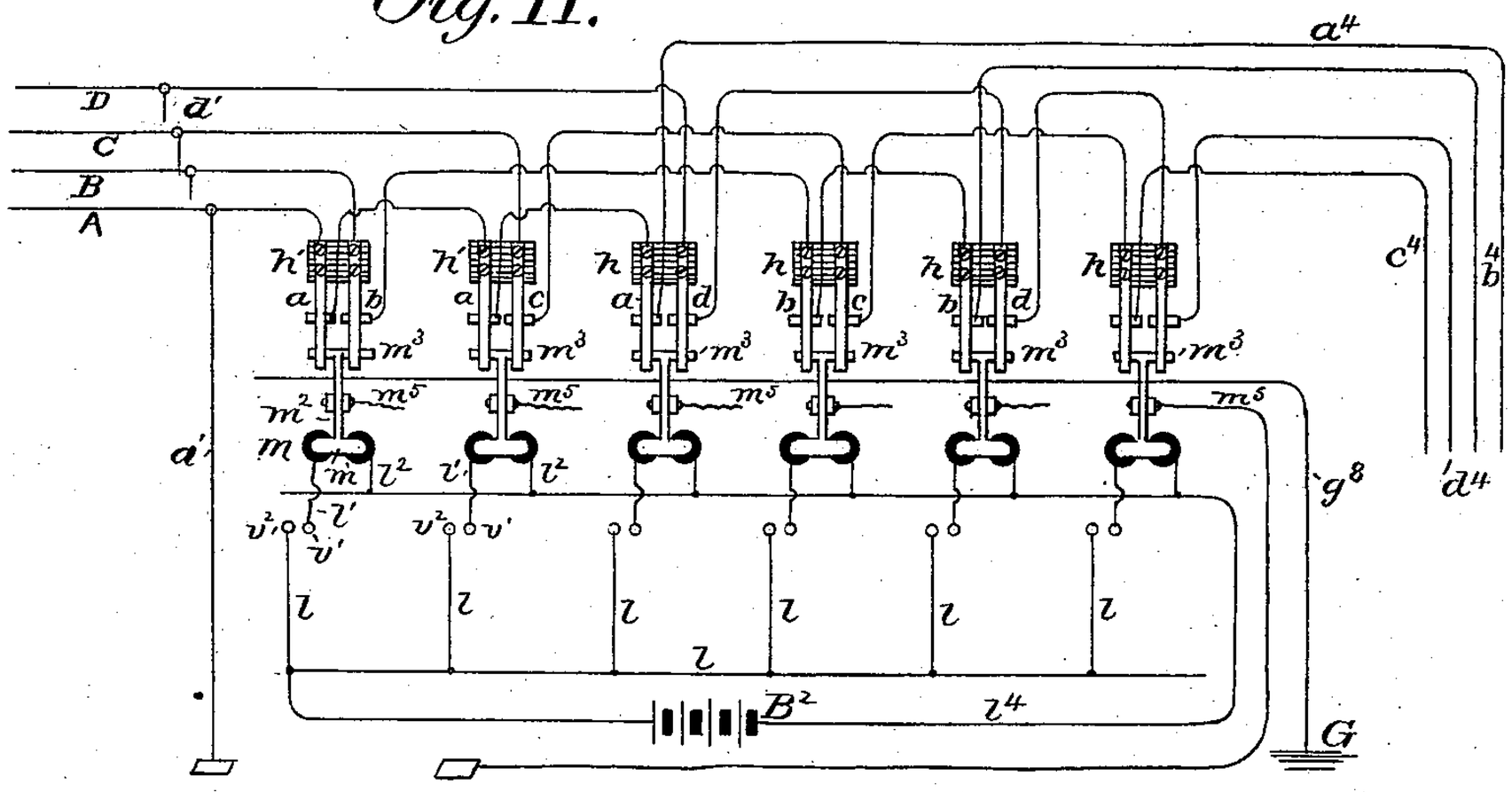


Fig. 12.

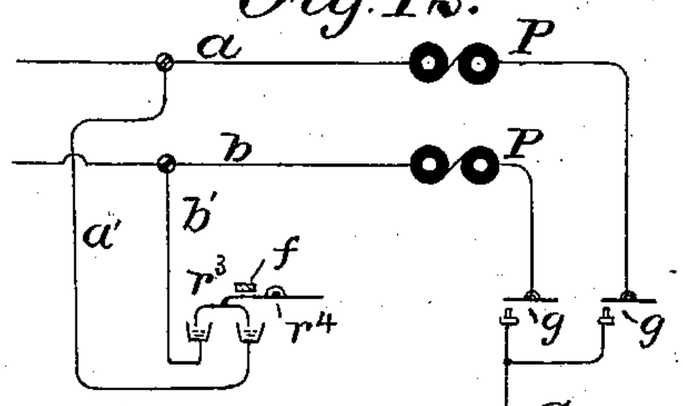


Fig. 13.

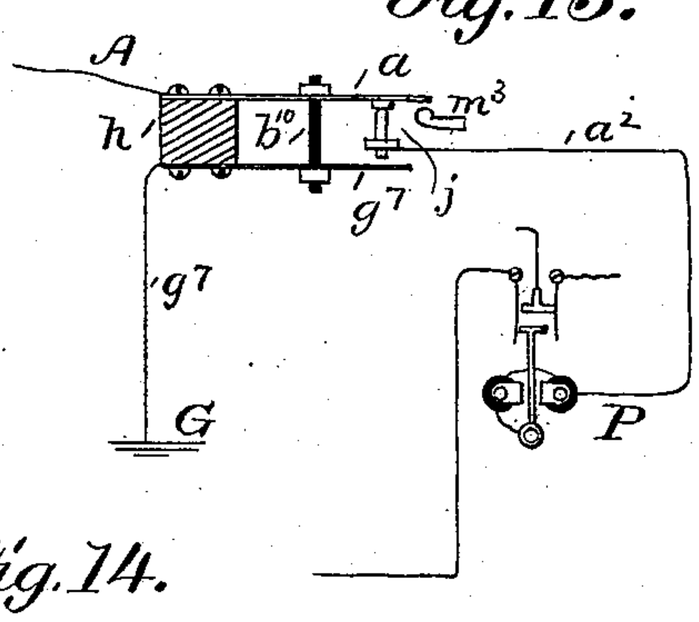
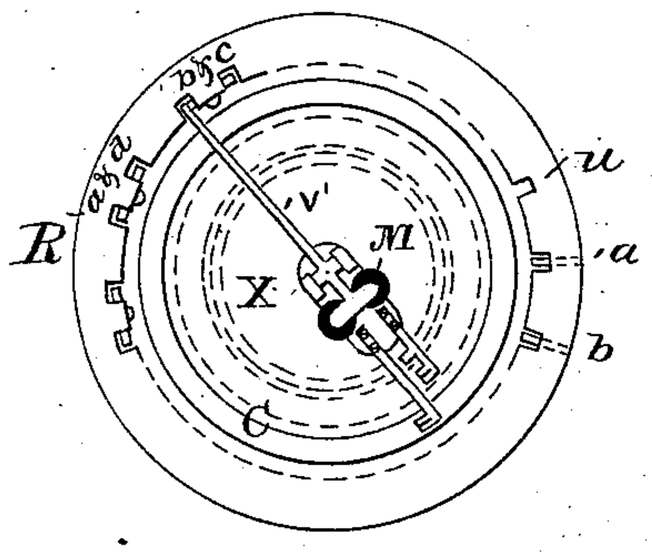


Fig. 14.



Witnesses.
Geo Willis Pierce
Thos D Lockwood

Thos. N. Vail
Inventor.

UNITED STATES PATENT OFFICE.

THEODORE N. VAIL, OF BOSTON, MASSACHUSETTS.

CENTRAL AND SUBSIDIARY TELEPHONE-EXCHANGE SYSTEM, CIRCUIT, AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 324,192, dated August 11, 1885.

Application filed May 7, 1885. (No model.)

To all whom it may concern:

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

My invention relates to systems of electrical intercommunication, and is intended especially for use in conjunction with articulating-telephones.

The ordinary telephonic "exchange" or "central office" comprises, as is now well-known, a central or exchange station to which a number of telephone lines converge, each having in circuit one or more sub-stations. These lines are so organized that any two of them may (usually through the medium of a switch-board) be electrically united in such a manner that direct communication may be had from stations on one line to stations on the other. This is effected by the act of an operator at the central station, who, upon being notified so to do, connects the two lines at the central point, first sending a call-signal to the sub-station desired.

Such telephone-exchange systems have proved to be very useful and popular in a large number of cities and towns. It has, however, been recently discerned that it is not commercially economical to establish exchanges organized on the above principle in very small towns or villages because a sufficient number of subscribers willing or able to pay a profitable price cannot be obtained, while in the majority of cases rents are equally high, and the attendance of an operator is as essential with forty as with one hundred subscribers. Many of the smaller centers of population are therefore deprived of telephonic privileges by reason of the above considerations; and reflection upon this point has led me to devise a remedy for the evil. I have accordingly devised a system of intercommunication for such towns as cannot readily sustain an ordinary central-office organization by which the several lines, after converging as usual to a central point, shall there meet a trunk line leading to a main central station, which may be located at the nearest large town, an automatic apparatus being, moreover, located at such point of convergence by which the presiding operator at the distant central station may select any given line from the number, connect it with the trunk line for communication through the said central office with a line radiating therefrom, may signal any line connected with such point of convergence, or may connect any two of such lines together, retaining at the same time the power of sending call-signals over the two lines so connected or of communicating with the said two lines, or either of them. I have also combined with the foregoing instrumentalities devices whereby any one of the said converging lines may be connected by the action of a sub-station operator with the main or trunk line, mechanism being at the same time brought into action whereby the other lines may be prevented from interrupting such communication.

In a separate application, which is filed simultaneously with this, I have shown and described another system, accomplishing in a different way substantially the same purpose. The said application discloses a number of lines converging to a central point, where they end in a common ground-terminal. A trunk line extending to a distant central station through an electro-magnetic apparatus and a clock-work-actuated rotating arm, controls the electric condition of the several converging lines, which are each provided with resistances. In the case I refer to no means are provided whereby the several sub-stations may connect their own line to the trunk line and signal the central station to the exclusion of the others, and consequently a portion of the electricity used in sending the call-signal is dissipated at the point of convergence and passes to earth there, while still another portion passes in like manner over the other lines converging to the same point. This, in accordance with the recognized laws of branch circuits and the function of the resistances included in each line, including the trunk line, is to prevent more than a small amount of the electricity utilized in the call from passing thus over the other lines and so wasting its energy. In the said system, moreover, each line runs, first, to a ground-switch, which may be mechanically altered in position and thrown into and out of connection by means of the rotary arm I have

mentioned, and, second, to a series of branches adapted to be connected in pairs by a similar circuit-changer to that used in the ground-switch, also operated mechanically by the rotary arm.

My present invention contemplates the accomplishment of the same ends in a way which is in some respects more perfect, and which, while equally simple, allows of greater scope of operation and provides fully for every step in the operation to be performed.

In order that my present invention may be more clearly understood I will briefly recapitulate the nature and features of the complex problem I seek to solve.

In the organization of electric circuits and instrumentalities contemplated by my invention it is requisite that each sub station shall have the power to signal the main or distant central station and to connect its own local line, directly at the point of convergence or auxiliary exchange, to the main line leading to the said main station for the accomplishment of such transmission of signals, and also for through connection with any other line radiating from the main or central station. It is essential that when so connected provision must be made to prevent any other sub-station line from obtaining a connection with the main line, and so interfering with the business passing between the first sub-station and the central station. The sub-station must also have power to restore the normal connections. It is moreover requisite that in making the aforesaid connection the sub-station shall be able to disconnect the normal ground-terminal of both his own line and the main or trunk line, and to connect the two lines so disconnected from earth together as one circuit. The main or central station, on the other hand, must have the power of selecting any of the sub-station lines, of sending call-signals over any of the said lines to the exclusion of the others, of connecting any two or any number of twos of the said lines together for intercommunication, and in doing so to disconnect them from their ground-terminals. It is also, if not essential, at least advantageous that the central station shall be enabled to signal simultaneously the two united lines, so that both may be made aware that all is ready for conversation; and, furthermore, that the central station shall also be enabled to supervise the communication and listen thereto, if desired, so that the conclusion of the intercourse may be instantly known and disconnections promptly made. Finally, it is requisite that the central station shall have the power to select any given line, to signal the same, and to hold the said line as long as may be desired for communication with other lines connected with said central station. To perform these functions perfectly and efficiently, I have found it necessary to employ apparatus which is at first sight somewhat complex, but which, when examined, will be found to be as simple as is possible without diminishing its competency.

To these ends my invention consists in and comprises a combination of the following instrumentalities, arranged and adapted to work co-ordinately with one another in the peculiar manner which I shall describe. I provide, primarily, a central station or exchange, an auxiliary or subsidiary central station, a series comprising any number of sub-stations, a series of local or sub-station lines connecting the several sub-stations with the subsidiary exchange, and a trunk line, or more, if desired, connecting the subsidiary with the main exchange. At each sub-station is, as usual, a set of telephone-instruments and call-signal sending and receiving appliances. At the subsidiary exchange is a special selecting apparatus actuated by a clock-train or other suitable motor, but controlled by electro-magnetic devices included in the trunk-line circuit and operated from the main station, while at the central station, in addition to the ordinary switch-board, by means of which any of the sub-station lines may be through the trunk-line united to other lines connected directly with the said central station and to the supervising telephones and calling apparatus, I provide a clock-work and dial adapted to run synchronously with the subsidiary-exchange apparatus and to indicate the motions thereof for the information of the manipulating operator. Each of the sub-station lines, upon entering the subsidiary exchange, passes successively through a series of spring-contacts, at each of which it is in close contiguity to a similar spring of one of the other lines, and after passing these contact-springs it continues through the spools or helices of a polarized relay, and through the armature of said relay, and thence to a ground contact-spring, this last being within range of and adapted to be operated by the selecting apparatus. In addition to these devices it is also provided with a normally-open circuit, branching from it at a point external to the outermost contact-spring, and leading inwardly to a segmental piece, with which a trailing spring of the selecting apparatus makes contact once in each of its revolutions. Beneath each pair of contact-springs, representing two lines, I place an electro-magnet, and when these magnets are vitalized by the passage of a suitable electric current through their coils, a lever, carrying a metal cross bar operated thereby, is caused to lift the two adjacent springs from their normal contacts and connect them together, thus uniting the two lines through the metal cross-bar. Any particular magnet may be energized by the closure of the local circuit in which it is included, and to that end a suitable number of such circuit-closers are placed within range of the selecting apparatus to be actuated thereby. The said selecting apparatus comprises a stationary circular frame within which an electro-magnet, having an armature and a long lever

therefor, is fixed upon a clock-motor so that the entire magnet and its appurtenances may revolve. The stationary frame has a series of notches at suitable points, and into these notches the end of the lever, otherwise traveling on the surface of the frame, is adapted to fall, and when such engagement is made the motor is arrested and the rotation stopped. One notch is the ordinary resting or unison point. A sufficient number of other successive notches placed singly inclose the ground springs of the several circuits, and when the lever end falls into any of them, it presses the ground-spring away from its normal connection and opens the circuit of that special sub-station line. Still another series of notches are arranged in pairs, and when the lever end falls into one of any of such pairs it is arranged to operate the connecting-magnet circuit-closer, while when it similarly falls into the other one of the pairs it is adapted again to open such circuit. To release the lever at first and start the motor the magnet is energized by a current of electricity transmitted from a source of electricity at the central station. The armature-lever is thus lifted from the unison notch and remains uplifted until the magnet is discharged. It may consequently be maintained in its raised position until it arrives at a point in its revolution near to the desired notch. It may then be released, and slides round on the surface until it arrives at the notch, into which it drops. I maintain control over the electro-magnet by providing its terminal with trailing springs, one of which trails at all times on a metallic ring, which is permanently connected with the trunk line leading to the main line, while the other rests normally on a segment leading more or less directly to earth, but is adapted to trail round a series of flat segments concentric with the main-line ring, the said segments being connected so that at the precise time when the lever-arm falls into the ground-notches of a given sub-station line the inner trailing spring rests on a segment connected to the branch leading to the same line, whereby at the moment that the trailing spring passes from its ground-segment it passes onto another segment, thus being at no time severed from a terminal earth, either at the subsidiary exchange or over one of the short lines. Still another series of segments are placed opposite the notches in which the lever-arm end operates the circuit-closers. The segments of this series lead to the several connecting-bars, so that a branch may be thus constituted over which the lines may be signaled or communicated with. The main or trunk line circuit after passing the normal ground-segment of the second trailing spring is led successively through a series of contacts controlled by the polarized relays of the sub-station lines, and by this means the sub-station lines are enabled to connect themselves with the trunk line.

My invention further consists in certain other details of instrument and circuit construction and arrangement, which will be fully described in the detailed description hereto annexed.

In the drawings which illustrate my invention, Figure 1 is a diagram indicating the nature of the system. Fig. 2 is a plan view of the selecting and connecting apparatus located at the subsidiary station. Fig. 3 is a sectional elevation of the selecting apparatus, showing its rotating capacity and the plan of removing the ground-springs. Fig. 4 is a diagram showing the arrangement of the terminal wires of the trunk and sub-station wires at the subsidiary exchange, as also the connecting listening and calling details. Fig. 5 is a detail diagram illustrating particularly the appliances and circuits employed in connecting two lines together and in calling and communicating with connected lines. Fig. 6 is a diagram illustrating the connections of a sub-station line complete, including the spring-contacts, polarized relay, trunk-line connection, and terminal ground-spring. Fig. 7 is a diagram of the terminal connections of the trunk line, the polarized-relay connections of the sub-station lines, showing the arrangement by which any sub-station line can connect itself with the trunk line, and showing, also, the arrangement of branch circuits, whereby other circuits are precluded from interfering with said connection. Fig. 8 is a diagrammatic representation of the compound circuit constituted when the trunk line, by the initiation of the central office, is placed in connection with any one of the sub-station lines, showing also the central-station apparatus. Fig. 9 is a diagram of the circuits, showing two lines connected together at the subsidiary exchange, and the trunk line connected so as to call, talk, or listen to both. Fig. 10 is a diagram representing the connection of the local circuits and connecting-magnets, with their listening attachments and continuity-preserving ground-connections. Fig. 11 is a diagram showing the manner in which two lines are connected, with the connecting-magnets and the circuits in which they are included. Fig. 12 shows a detail of a modification in which the local connecting-circuits are dispensed with, and in which branches from the several sub-station lines are led into juxtaposition to one another; and Fig. 13 shows a detail whereby the ground-circuit of the trunk line is maintained when any of the polarized relays are inadvertently left out of position. Fig. 14 is a plan view of the selecting apparatus.

In the drawings, with respect to Fig. 1, it is only necessary to remark that S represents a switch-board located at the main central station, from which radiate any number of electric lines 1 2 3 4, &c. A trunk line, L′, connects the said central section with a subsidiary central station, U, to which converge a series of other sub-station lines, A B C D, &c. The diagram is intended to indicate the nature of the system.

At the subsidiary exchange U is placed a selecting apparatus, X, comprising, as shown in Fig. 2, a circular bed-plate surmounted externally by a metal ring, R, connected with the ground and serving as the normal common earth-terminal of a number of comparatively short line circuits, *a b c d e*, &c. These circuits do not permanently unite with the substance of the ring R, but, as in Fig. 3, end in contact-springs *g*, insulated at their fixed ends from the said ring, but making contact therewith, in virtue of their resiliency, normally at the free end. The ring R is, opposite the free ends of these ground-springs, cut into apertures *q*, so that any body of proper size and shape falling into such apertures will fall upon the spring end, tending to force the same away from the ring, and by so doing to disconnect the ground terminal and open the circuit. At another portion of the internal peripheral edge of the ring R is another series of grooves arranged in pairs *k k'*, and centrally pivoted below these grooves, I place a small balanced bar, *v*, with its ends projecting both ways, so as to extend across each groove of the pair. The balanced bar *v* will, when tilted over in either direction, remain so tilted until an impulse given to the other end reverses it. It is therefore evident that if a body of suitable size, shape, and weight fall into one of the grooves *k* of a pair the bar *v* will be overbalanced and tilted in that direction, while if the body fall into the other groove the bar will be oppositely tilted and reverse its position. As many of these paired grooves and tilting bars are provided as there are pairs of circuits in the system. I have shown four to illustrate the arrangement, thus providing for circuits *a* and *b*, *a* and *c*, *a* and *d*, and *b* and *c*. This, of course, is incomplete, but is sufficient for explanatory purposes.

At still a third part of the ring R, I provide a single groove, *u*. This is to serve as a starting or unison point, and in this groove the actuating body, which is adapted to circumambulate the ring, normally rests, maintaining the moving power thereof in a temporary state of quiescence. Inside of the ring R, and separated therefrom by an air-space or by suitable insulating material, is a second ring, C. This is of metal, is continuous, and is in permanent connection with the main central station *via* the trunk line L. Concentric therewith, but separated by a ring of non-conducting material, is a third ring Q. This is not continuously conductive, but is dissected into a series of conducting-segments, *s s' s²*, &c., by the non-conducting partitions 20. Each of these segments is connected by a special wire to a different appliance. The segment *s* is connected by wire, through a series of contacts, with the earth. The series of segments may, as required, be arranged to complete the circle, and their several connecting-wires are attached to their under surface by binding-screws in a manner well understood. In the inner portion of the concentric rings which I have described a non-conducting base-board, O², is supported on a central vertical shaft, O', which is actuated by a clock-train or some equivalent motor, O. It will thus be seen that not only the base-board O² but that all the appliances supported thereon will participate in any rotary motion given by the motor O.

In the same vertical plane as the shaft O'—that is, in the center of the circle—is a standard, V⁴, on which an armature lever, V', is hung in pivots V³. This lever has an armature, V, supported in front of the electro-magnet M, and adapted to be attracted thereby, the said magnet being likewise affixed to the same base-board. The longer arm of the lever extends outwardly to the inner edge of the circle R, and is terminated by a bent end piece, *f*, which, when the apparatus is at rest, lies in the groove *u*, and serves as a detent for the motor, but which, when lifted out of the said groove by the power of the electro magnet, travels round on the surface of the ring R, being impelled by the motor, and, unless held up by the continued attraction of the magnet, falls into the next groove it arrives at. It, may, however, be so held up until a point is reached in its rotation immediately before any groove into which it is desired to fall, and, falling into such groove, the operation performed will be in accordance with the description heretofore given. The lever is normally held away from the electro-magnet core by its own weight, which may be assisted by the spring *t*³. When attracted by the electro-magnet, it is prevented from too closely approaching the core by the limit-stop *i*. The electro-magnet M is at all times included in the trunk-line circuit L, and it only remains to show how such connection is maintained, although the electro-magnet shares in the rotation of the motor O. This is effected by affixing to the base-board O² a pair of contact-springs, *t* and *t'*. The spring *t* has its foot bent at right angles and brought into frictional contact with the continuous metal ring C. It is also by means of the wire 30 brought into connection with one side of the electro-magnet. The wire 31, leading from the other magnet-spool, is in like manner attached to the second spring, *t'*, which has also its foot bent so as to trail upon the segmental ring Q. It will now be seen that the magnet M is at all times in the trunk-line circuit irrespective of its position, since the spring *t* is at all times pressing on the ring C, while the spring *t'* also presses on one of the segments, thus completing the circuit either through its normal connection or through one of the sub-station lines.

In addition to the foregoing features I also provide another long metal segment, *s⁹*, on the inner side of the segmental ring Q. This is permanently in connection with the earth through a high resistance, as will be hereinafter set forth, and the foot of the spring *t'* is sufficiently wide to come into contact with the

long segment s^9, in addition to the ring Q, while passing that portion of its route.

Referring now to Figs. 4, 5, and 6, I will describe first the connections of a sub-station circuit, and it must be understood that a description of one suffices for all, as all are connected alike.

Fig. 6 diagrammatically indicates the entire course of a sub-station line from one end to the other. Y represents the sub-station; W, the subsidiary exchange; A, the subscriber's line-wire connecting the two, and L the trunk-wire to the main central station. N is the call sending and receiving apparatus at the sub-station, which, as well understood, is also furnished with telephones. A magneto apparatus, as shown, may be employed, or, if preferred, a magneto-bell only may be used, supplemented by a battery and reversing-key. The apparatus N, however, I prefer, and it is to be understood that the generator is operated by turning the crank. By a suitable commutator I am enabled, in a well-known manner, to send currents of constant direction, said direction being determined by the direction in which the crank is turned. The line A from the sub-station, arriving at the sub-exchange W, bifurcates. The main branch passes on to a contact-spring, a. This bears upon a pin, j, which in turn is connected by a wire, a^2, with the second spring, a, bearing upon a second pin, j', and so on through wire a^3, a third contact spring and pin, and, in fact, through as many contacts as there are other wires in the system, finally passing by wire a^4 to a polarized relay, P, preferably of the form shown in Fig. 6, (the form shown in the other figures being entirely symbolic.) The circuit passes through the spool P', and then by wire 20 to the other spool, P^2, and by wire 21 to the armature z. The normal position of the armature z is right-handed, in which case its hammer-head would make contact with the spring x, this leading through wire a^5 and ground-spring g to earth. Such a normal position allows the opposite contact-spring y to press against the fixed contact-point z', which is united to wire n leading to the other similar contacts. The position shown in the drawings, however, represents the armature z as being attracted to the left, whereby its hammer-head is brought into contact with the contact-spring y, and this being in direct contact with the line L it is evident that when in this position the lines A and L are united at the sub-exchange, and that the sub-station Y and the distant central station are directly connected and may communicate with one another. The spring x being left unsupported of course falls on the standard z', but this being faced at that point with insulating material does not constitute an electrical contact. This diagram illustrates the manner in which any sub-station line may connect itself with the trunk line. The subscriber effects such connection by turning his crank in a predetermined direction, which generates a current of the proper polarity, the first pulsation of which causes the armature of the polarized relay to be attracted to the left side, while the succeeding pulsations transmit the call and affect the annunciator r^2 at the central station. It is to be observed that the peculiar construction of the polarized-relay contact-springs is arranged to maintain continuity, and by it the head of the armature z is enabled to make contact with the spring y before it relinquishes the spring x. As soon as the call is received, conversation may be carried on with the central station or with another line extending therefrom, and upon the conclusion of the communication the normal condition of the polarized-relay armature and its contacts may be restored by turning the crank of the instrument N at the sub-station in a direction opposite to that used in making a call. This, by sending a reversed current, will swing the armature z back into contact with the spring x, allowing the spring y to resume its position in contact with z'. Tracing now the other branch, a', of the sub-station line A from the junction point, we find that it simply is led to a metallic segment, s', where it remains normally disconnected. The said segment s' is located in the segmental ring of the apparatus, (shown in Figs. 2 and 3,) and lies in the path of the trailing foot of the spring t'.

The segments of the several sub-station lines, which terminate in the manner indicated in the secondary branches thereof, are so placed in the subsidiary-exchange apparatus in reference to the ground-spring of the same circuits that in the case of any circuit the trailing spring t' will be in contact with the one of the segments s' s^2, &c., at precisely the same moment that the end f of the lever-arm is passing over the ground-spring g, so that if the ground-spring is disconnected by the falling of the end f into the groove on the free end of the same, communication is simultaneously opened up with the circuit connected with such ground-spring by means of the trailing spring, the segment, and branch wire; and, furthermore, that the condition of the circuit is absolutely improved by such change, seeing that the said branch diverges from the line at a point external to the contact-springs, and that consequently the contact-springs are cut out.

It is necessary, of course, to provide means whereby, when any sub-station line has connected its line with the trunk line in the manner just described, other sub-station lines shall be precluded from interrupting such connection, and shall be prevented from interfering therewith or from taking the control of the said trunk-wire from the line already in possession thereof, assuming such control themselves. This I accomplish by the arrangement delineated in Fig. 7. In that drawing I have shown symbolically the apparatus X, arranged as hereinbefore described, and I also show the extension of the trunk-circuit from the segment s, upon which the trailing spring t' normally rests, to its earth-terminal. It will

be seen that the segment is united by the wire L′ and the wire *n* with the contact-spring *y*, that resting on the fixed point *Z′* of the first polarized relay P, from whence the circuit passes successively, the wires *n′*, *n²*, *n³*, and *n⁴*, the springs *y*, and the fixed contacts *z′* of the polarized relays of all the converging circuits finally terminating at the ground G. The relation of the several polarized relays P to the trunk-line L is thus explained, and it will be seen that any one of the lines controlling the relays may, by simply deflecting the armature *z*, transfer itself from its normal ground at the spring *x* to the trunk-line L, as represented by the spring *y*. The several relays P are connected with their lines A B C D, as shown in Fig. 6.

The non-interfering feature is accomplished as follows: From any point 10 between the first spring *y* and the segment *s*, I run a branch wire, L³, and from said branch I extend spurs L⁵, one for each relay, to a limit-stop, *y′*, behind the spring *y*. Whenever the spring *y*, by the action of the armature *z*, is forced away from the fixed contact *z′*, its backward movement is limited by the said stop, with which the spring *y* also makes electrical contact. Such a condition is exhibited in the case of the fourth relay shown, which is represented as being in contact with the trunk-line L, while the relays of the lines A, B, and C are connected with their normal terminals.

The addition of the branch line L³ and L⁵ accomplishes two well-defined and advantageous results. It is evident that by its use other circuits are prevented from interfering and breaking the connection with the trunk line, since the whole of the contacts between the relay using the line and the point 10 are shunted out of circuit; and it is also evident that even when such interruption is not attempted the line of communication is improved, both because a double line is thus provided and because the greater or less resistance inseparable from contacts in series is thus avoided.

From the foregoing explanations it will now be perfectly clear that to enable any sub-station to connect its own line with the trunk-line and main office it is not necessary to operate the rotary apparatus X, but merely to operate a single polarized relay. In describing the apparatus X, I indicated the character of the segmental ring Q. It seems proper at this point to describe the details thereof. The segment *s*, upon which the trailing spring *t′* normally rests, is opposite the unison-groove *u*, so that when the lever-arm is quiescent at the unison-point the trunk line is directed by the trailing spring through the relay-contacts, as described. When the arm V′ is released and advances round, it passes consecutively the several single or ground spring grooves *a b c d*, &c., and while the end *f* is opposite or in contact with any special ground-spring groove the trailing spring *t′* is invariably passing over the segment connected by branch wire with the line represented by the said ground-spring. Thus, if the lever end *f* is opposite ground-spring *b*, the spring *t′* is in the act of passing segment *s²*, as shown in Fig. 2. Opposite the paired grooves *k* and *k′* are other segments, *s⁵*, *s⁶*, *s⁷*, and *s⁸*, leading by wires to other points, as I shall hereinafter describe.

From this explanation it will however appear that directly opposite each groove or each pair of grooves is a segment with which the spring *t′* trails and by which some special operation connected with that groove or pair of grooves is effected. All the segments have their ends made angular or bias, so that the trailing spring may reach one before it leaves the other.

Fig. 8 clearly shows the arrangement by which the central-station operator can connect the trunk line L with any desired sub-station line. In this figure CO represent the main central station, provided with an operating-battery, a key, K, to direct the said battery to line, a clock-operated dial, D*i*, adapted to rotate synchronously with the apparatus X at the sub-exchange W, and with the usual outfit of transmitting and receiving telephones. The trunk line L connects the main and subsidiary exchanges together, and its fixed terminal is the metal ring C in the apparatus X. As already indicated, C is a line leading to a sub-station, dividing as it enters the sub-exchange, so that one branch passes through certain contact springs and points, terminating by means of the spring *g* on the circular ground-plate R, while the other branch, *c′*, leads to a segment, *s³*, opposite the ground-spring groove. The trunk-line L in this figure is represented as having been connected by the central station with the sub-station line C, and the through circuit may be traced from the ground at the central station through the telephones T T′, thence to the back contact of the signal-key K, through the magnet of the dial D*i*, and by line L to the metal ring C, thence by spring *t* to the electro-magnet, and by spring *t′* to the segment *s³*, wire *c′*, and thus to the line C, leading to the sub-station. The pressure of the lever end *f* on the ground-spring opens that branch of the circuit. In this position the main central station is in direct communication with the sub-station, the intermediate ground terminals of both trunk and sub-station lines being temporarily removed. To assume such position, the apparatus X being at zero, the central-station operator would press the key K to the anvil *k³*, thus bringing the line L into contact with the battery. This operation energizes the electro-magnet M, lifting the end *f* of the lever from the unison-groove and permitting the apparatus X under the influence of its motor to rotate. The pointer of the dial D*i* similarly is started, and indicates the progress of the lever-arm. Since it is desired to connect line C, the key is held down until after the pointer passes *b*, and is then released, thus withdrawing the battery from the line. The line C is now left in direct connection

with the trunk line L, and signals may be sent directly to the sub-station over both lines by using the magneto-electric generator D*y*, Fig. 9.

The electro-magnet M, at the intermediate station, X, is not adapted to respond to the rapidly-alternating impulses developed by the generator, hence it is not affected while the bell at the sub-station is rung, and when the attention of the sub-station is attracted the telephones at both central and sub-station are used and conversation may be carried on. It is obvious in this position, also, that no other converging line can interfere, since the connection with the trunk line is made at a point in the circuit thereof immediately after the electro-magnet M is passed.

By Figs. 4, 5, 6, 8, 9, 10, and 11, the apparatus by which any two lines converging to the same subsidiary exchange may be connected together, and both signaled, communicated with, or supervised while so connected, is made plain. From the foregoing description it is already evident how each sub-station line passes, after arriving at the subsidiary exchange, through a numerically-sufficient series of movable spring-contacts and fixed anvil-contacts before arriving at its polarized relay, and that at each of the said contacts it is in close contiguity to a similar spring and anvil contact belonging to one of the other converging circuits. At each of such pairs of circuit-springs I place an electro-magnet, *m*, provided with an armature, *m'*, attached to a balanced lever, m^2, this having at its opposite end a metal cross-bar, m^3. This cross-bar, as shown in Figs. 4, 9, and 11, is sufficiently long to extend across both of the line contact-springs, but normally is not in contact therewith, but rests, being retracted by a suitable spring, a short distance thereunder, the lever m^2 resting, as shown in the third instrument, Fig. 10, on a standard, N, furnished at its upper end with a curved contact-spring, *r'*, the function of which I shall shortly describe. The said lever is prevented from pressing too heavily on this spring by means of the back limit-screw, r^3. It is at this point evident that as long as the electro-magnet *m* is inert and non-magnetic the cross-bar m^3, withdrawn by the spring, exercises no influence on the line-circuit springs; but that as soon as any electro-magnet becomes by any means magnetized the armature will be attracted and depressed and the opposite end thereof, including the cross-bar, correspondingly elevated, and that the said cross-bar will in consequence of such elevation lift the two circuit-springs from their fixed points *j* and unite them together through its own substance. This being so, it remains to devise a method of energizing any of the said electro-magnets at will. I accomplish this as follows: I provide a common battery, B^2, and from a wire, *l*, united with one of its poles, I lead branches to one side, v^2, of the circuit-closers, controlled by the tilting lever *v*, shown in Fig. 2 as being balanced centrally, with its ends projecting across the bottom of the paired grooves *k* and *k'*. One of these levers controls each electro-magnet, and if the end *f* of the traveling arm V' drops into the proper groove—*k*, for example—the lever *v* is overbalanced and falls to that side, closing the circuit, and there it must stay, even if the traveling arm be lifted out, until the arm, dropping into the other groove, *k'*, of the pair, tilts the lever *v* in the opposite direction. A wire, *l'*, runs from one side of each electro-magnet *m* to the other side of its own circuit-closer, while from the other pole of the battery B^2 a wire, l^2, runs, which is branched to the other side of all the electro-magnets. Each electro-magnet is thus in a normally-open circuit, including the common battery B^2 and one of the circuit-closers *v*.

The circuit-closer, it may be noted, is not restricted to one form, but may be constructed, as in Fig. 5, of a balanced rod, r^2, furnished at one end with a light-metal cross-wire, *v*, dipping, when tilted in one direction, into two mercury-cups, *v'* and v^2, these constituting the two sides of the local circuit, or, as in Fig. 10, in which the balanced lever itself constitutes one side of the local circuit.

Let it now be assumed that two sub-station lines—say A and C—are to be united at the subsidiary exchange. A has signaled the main central station, and has signified his desire. The central-station operator may call C separately and notify him, and afterward connect the two lines; or he may proceed, as I shall now describe, to connect the two lines first, and then signal the two together. The central-office operator starts his own and the subsidiary clock-motors in the way I have hereinbefore specified, and as soon as he sees by his own dial that the end of the arm V' is approaching the notch or groove *k* of the pair *a* and *c* he releases his key, thus cutting off the battery. This permits the rotating magnet to become demagnetized, and the end *f* of the arm V' accordingly falls upon the surface of the outer ring, R, at the point H, and, continuing its rotation, falls in the notch *k* on arriving thereat, tilting the lever *v* and closing the circuit of the connecting-magnet *m*. The result is, of course, that the magnet *m* is at once energized, attracts its armature *m'*, and the other end of the armature-lever m^2 is uplifted, the cross-bar m^3 with which it is furnished thus being caused to raise the two circuit-springs *a* and *c* from their anvils *j*, as shown in Fig. 5, whereby the two sub-stations are united through the said cross-bar, and are simultaneously disconnected from their normal ground-terminals, from the succeeding contacts, and from their polarized relays. The union of the two lines may be traced in Fig. 4, where line A, entering, passes to its first contact-spring *a*, to anvil *j* by wire a^2, to its second contact-spring, then by wire a^3 to third contact-spring, this being in con-

tact with and elevated by cross-bar m^3, and through said cross-bar to contact-spring *c* and out to line C.

By the following arrangement two lines so connected may be simultaneously rung up and jointly conversed with, and otherwise supervised. Electrically connected with the pivot or supporting-post N^2 of each connecting-armature lever m^2 is a wire, m^5, leading to a segment, s^5, of the series of segments placed in the path of the trailing spring *t'*. Immediately opposite the pairs of connecting-grooves *k k'*—that is, opposite to the pair marked *a* and *b*—is the segment united with the balance-post of the magnet *m*, controlling that pair of circuits; and in like manner I provide a segment for every connecting-magnet pivot-post. Thus at the moment when the end *f* of the rotary arm drops into the groove *k*, the spring *t'* rests upon the segment s^5, and the trunk-line is thus prolonged from the rotating electro-magnet M to the segment s^5, and by wire m^5 to the amuture-post N^2, and through the amature-lever and cross-arm to the two lines A and C. Any electric current passing at this moment from the central station will divide between the two lines. Call-signals may therefore now be sent by means of the magneto-generator D*y* at the central station, which will ring the bells at both sub-stations at once, and the central station can also speak to both sub-stations, and listen to see if they commence properly to converse, also, later, to ascertain if the conversation is over. Such a position of the apparatus is shown in Fig. 9, where the two springs *a* and *c* are united by the cross-bar m^3, the trunk line L through the wire m^5, segment s^5, spring *t'*, electro-magnet M, spring *t*, and outer ring, C, thus constituting a branch circuit leading to the central station. The said line at the central station is connected with a switch-board, S, to which other lines are also attached. The switch-arm I may be capable of both rotary and downward movement, but normally springs upward against the back plate, I, through which it is connected with the telephones T and T'. The pivot of the switch I is united by wire 40 with the switch-board, and can thereby be plugged to the line L in a manner well understood. Moreover, by turning the switch I to the stud *e* the line can be connected with the generator D*y*, while by pressing it down on the stud *e'* it is connected with the battery B*a* and dial D*i*. It is also evident that in case it is desired to connect any two lines at once at the subsidiary exchange with one at the main exchange, this can be done by proceeding as hereinbefore described, and then plugging the trunk line on the same switch-board bar as the third line, F.

In order that the trunk line L may always be provided with a ground-terminal as the spring *t'* passes over the several segments, I provide the back post, N, of each connecting-magnet, upon which the armature-lever m^2 normally rests, with a ground-wire, g^8, and to the end that such ground-connection may not be too hastily removed as the lever moves upward, I surmount the said post with a curved spring, *r'*. As an additional precaution to this end, I provide the selecting apparatus with an inner segment, s^9, equal in length to all of the listening-segments s^5 s^6, &c., together, and connect the said inner segment by wire n^7 to earth G through a high resistance, R*h*. (See Figs. 4 and 5.) The foot of the trailing spring *t'* would in practice be wide enough to cover both segments, so that in no case can the trunk line lose its control of the electro-magnet M.

I have also found in practice that there is at least a possibility that the sub-station initiating a call, may, after operating its polarized relay and thus throwing its armature on the trunk-line side, neglect to throw it back again to its normal position before connection. This can of course be equally well accomplished by the central station, if a current of proper direction be sent over that line for that purpose. If, however, it should be inadvertently neglected by both parties, and the line connected with said relay be afterward united to another, it is obvious that after the rotary arm had completed its first revolution and dropped into the unison-notch *u*, it could not be again operated until the sub-station restored its relay armature to the proper side, because the trunk line, being disconnected from its normal ground by said armature and connected in lieu thereof with the sub-station line through said armature, would be open between the anvil *j* and the spring *a* at the point at which said spring *a* is elevated and connected to some other line; hence there would be no complete trunk-circuit, and the electro-magnet M could not be affected. It is equally out of the power of the sub-station to disconnect itself. To provide for this emergency I employ the device shown in Fig. 13. In that figure a^2 is the wire leading through the remaining contacts to the polarized relay P, and by the reversed position of the armature *z* to the trunk line L, as in Fig. 7. As long as the spring *a* lies on the anvil *j*, the trunk line finds an earth-terminal over line A, but when the said spring is lifted therefrom by cross-bar m^3, that ground-terminal is taken away. But I provide a lower spring, g^7, attached to the same block *h*, and fastened to the upper one in any desired way so as to participate in its movement. This lower spring is provided with a ground-wire, and as the upper spring is carried away from the anvil *j* the lower one is caused to make contact therewith, thus furnishing a contact and temporary ground-terminal for the trunk line L until the conclusion of the conversation, or until the relay-armature is reversed.

Fig. 12 simply indicates that my polarized relay method of enabling a sub-station line to connect itself with the trunk line may be adopted even when, as in my contemporaneously-filed application, I arrange the connecting-springs as branches instead of loops. In that figure *a* and *b* are portions of sub-station

lines A and B, *g* and *g* are the ground-springs thereof, and *a'* and *b'* are normally-open branches which end in contact-points or mercury-cups, as shown, r^3 being a contact bridge-wire carried by the tilting lever r^4, and adapted to be controlled by the end *f* of the rotating lever, and P P are polarized relays in the sub-station line circuits.

In the construction of the selecting apparatus X it is desirable to so arrange the working notches that the rotating arm will have a considerable space to travel after leaving the last of such notches before it comes to the unison-notch *u*, so as to insure that said arm will fall into the latter at the close of each revolution. Fig. 14 indicates this preferred construction, showing the notch *u* as placed at a considerable distance beyond the last pair of working-notches, *b c*.

The operation will readily be understood in connection with the foregoing descriptions.

In the rotary apparatus I use it must be understood that, once started, the clock-motor tends to continue its movement, but that the lever-arm will drop into the first groove it reaches, and, when released therefrom, into the next, and so on, unless the circuit is kept closed and in connection with the battery, in which case the arm will remain elevated and the motor will continue to revolve the magnet and arm until the battery is disconnected, after which the arm will again drop into the first groove it reaches. Thus any groove can by means of the pointer-dial be readily selected and the operations accelerated.

It will also be understood that any number of pairs can easily be connected at the same time, and that the rotary arm can be caused to drop into any desired groove at any time to see if the communication is over.

Having now fully described my system, I claim—

1. The combination, in a telephone-exchange system, of a main central station, a subsidiary or branch central station, a trunk line connecting the said two stations, a series of sub-station lines converging to said branch central station, a selecting mechanism comprising a rotatable arm or lever, located at the branch central station and controlled by an electro-magnet in the trunk line from the main central station, whereby any of the sub-station lines may be selected and united to the trunk line or connected with any other converging sub-station line, and means, substantially as indicated, whereby any of the said sub-station lines may unite itself to the trunk line, disconnecting simultaneously the branch-exchange ground-terminals of both of the said lines, substantially as hereinbefore described.

2. In a telephone-exchange system, the combination, substantially as hereinbefore described, of a main central station, a subsidiary or branch central station, a trunk line connecting the said two stations, a series of sub-station-lines converging to said branch central station, a selecting mechanism located at the branch central station, and comprising a clock-motor, an electro-magnet included in the trunk-line circuit and mounted on a vertical shaft driven by said motor, an armature and lever-arm therefor, a series of ground-switches, one for each convergent line, a series of circuit-closers, one for each pair of convergent lines, and a self-acting commutator adapted to connect the trunk line through the electro-magnet successively with each convergent line, for the purposes specified.

3. The combination, in a telephone-exchange system, of a main central station, a subsidiary or branch central station, a trunk-line connecting the said two stations, a series of sub-station lines converging to said branch central station, a selecting, governing, and connecting mechanism located at the branch central station and controlled from the central station by an electro-magnet in the trunk-line circuit, substantially as indicated, a polarized relay and armature therefor included in each sub-station line, and contact points and springs for the said armature, one of the said contacts being connected with the normal ground-terminal of the said sub-station line, and the other forming part of the normal circuit of the trunk line, whereby the sub-station line is enabled to connect itself through the said polarized relay with the trunk line, as and for the purposes specified.

4. In a branch or subsidiary telephone-exchange, a series of converging sub-station lines terminating at such branch exchange, a polarized relay for each of the said lines, having its helices and armature both included in the circuit, a contact-spring normally in contact with the armature and constituting a portion of the normal ground-extension of the sub-station line, a trunk line leading from the branch exchange to a point external thereto, and normally extended at the branch exchange through a series of contact springs and points, one contact at each relay, so that the relay-armature, when deflected from its normal position, is enabled to make contact with the trunk line by means of the said contact-spring, disconnecting simultaneously the ground-terminals of both lines, substantially as hereinbefore described.

5. In a branch or subsidiary telephone-exchange, a series of converging sub-station lines terminating at such branch exchange, a polarized relay for each of the said lines, having its helices and armature both included in the circuit, a contact-spring normally in contact with the armature, and constituting a portion of the normal ground-extension of the sub-station line, a trunk line leading from the branch exchange to a point external thereto, and normally extended at the branch exchange through a series of contact springs and points, one contact at each relay, so that the relay-armature, when deflected from its normal position, is enabled to make contact with the trunk line by means of the said contact-spring,

disconnecting simultaneously the ground-terminal of both lines, and a continuity-preserving device attached to the armature of the polarized relay, whereby the said armature is enabled to make contact with the trunk line spring before the normal contact with its own ground-spring is broken, as hereinbefore described.

6. The combination, substantially as hereinbefore described, in a branch or subsidiary telephone exchange, of a series of converging sub-station lines terminating at such branch exchange, a trunk line extending between the said branch exchange and a distant central station, the said line being normally grounded at the branch exchange, and a series of electro-magnetic switches at the branch exchange, comprising polarized relays, one for each sub-station line, and included in the circuit thereof, the armatures of said relays being in each case controlled by the sub-station line, and adapted to transfer the circuit of said sub-station line and also of the trunk line from their original ground-terminals to a new connection or union with each other, thus constituting a compound through line from the main central exchange to the sub-station, as specified.

7. In a branch or subsidiary telephone-exchange, a trunk line extending between the said branch exchange and a distant central station, the said line being normally grounded at the branch exchange, an annunciator or an equivalent signal-receiving instrument in circuit with said trunk line at the distant end thereof, a series of sub-station lines converging to and terminating at the branch exchange and extending therefrom to sub-stations, a series of electro-magnetic switches or circuit-changers, one for each sub-station line and included in the circuit thereof, the said switches being in each case controlled by currents in the sub-station line, and adapted to turn in one direction and connect the said sub-station line with the trunk line, removing the normal ground-terminals of both lines when a current passes over the sub-station line in one direction, and to turn reversely and disconnect the said lines, reinstating the ground-connections when a current of opposite direction traverses the sub-station line, and signal-sending apparatus at each sub-station adapted to transmit at will currents of either direction, whereby when currents of definite direction are transmitted over the sub-station line the first pulsation thereof is adapted to operate the electro-magnet switch at the branch exchange and connect the sub-station and trunk lines, and the succeeding pulsations to operate the annunciator at the central station, and whereby, when currents of opposite direction are transmitted, the said switch may be operated reversely to restore the normal conditions, substantially as hereinbefore set forth.

8. The hereinbefore-described selecting, circuit-changing, and connecting apparatus, consisting of an electro-magnet, armature, and armature-lever, supported as a whole upon a rotatable shaft, a suitable motor adapted to revolve the said shaft, the stop mechanism for said motor, and rotatable magnet comprising the grooved bed-plate, with which the curved end of the armature-lever is adapted to engage, a series of ground-springs placed in a portion of the stop-grooves, and a series of circuit-closers in another portion of the said stop-grooves, and adapted to be actuated by the lever end as it falls into the said grooves, a main line terminating in a circular contact-plate, a series of segmental plates arranged in a circle concentric with the main-line plate but insulated therefrom, each of the said segments constituting a terminal of a separate circuit or branch line, contact-springs, each constituting one of the terminals of the electro-magnet, one of which is adjusted to trail over and in contact with the circular main-line plate, the other being similarly adjusted to trail over the segmental plate, whereby the main line is successively connected through the electro-magnet with the several branch circuits or lines.

9. The combination, in a selecting and connecting apparatus at a branch exchange, of the circular metal plate provided with a unison stop-groove, a series of ground-spring stop-grooves, and a series of paired connecting stop-grooves, a series of ground-springs, and a series of circuit-closers, an electro-magnet mounted at the center of said bed-plate, and an armature and pivoted lever attached thereto, the said lever having its end bent at right angles, as shown, and being sufficiently long to rest upon the bed-plate projections between the grooves, but adapted to engage with and fall in any of the said grooves upon passing the same, and thus to actuate the ground-spring or circuit-closer of said groove, unless at that moment the armature is attracted by the electro-magnet, a suitable motor to rotate the magnet and attachments, the said motor being held normally at rest by the engagement of the lever-arm with the unison-groove, adapted to move and rotate the magnet when the lever is released from the said groove and to be stopped at any desired groove by allowing the said lever to fall therein, a continuous circular contact-plate constituting the terminal of a main line, and a circular series of segmental conducting-plates arranged concentrically with the main-line ring-plate, each of the said segments being connected electrically with a separate branch or separate circuit, and contact-springs constituting the terminals of the actuating-magnet, one of the said springs being adapted to trail constantly upon and in contact with the circular main-line plate, the other being similarly adjusted to trail over the segmental series, whereby the main line is successively connected through the actuating-magnet with the several branch lines, the several conducting-segments being so arranged with respect to the ground-springs and circuit-closers in the bed-plate grooves that at the moment the end of the rotating lever is acting upon or op-

posite any one of the ground springs or connectors, the second trailing spring is also in contact with a segment having connection with the sub-station or branch line or pair of branch lines controlled by such ground-spring or circuit-closer, for the purposes specified.

10. The combination, in a selecting and connecting apparatus at a branch exchange, of the circular metal bed-plate provided with a unison stop-groove, a series of ground-spring stop-grooves, and a series of paired connecting stop-grooves, a series of ground-springs, and a series of circuit-closers, an electro-magnet mounted at the center of said bed-plate, and an armature and pivoted lever attached thereto, the said lever having its end bent at right angles, as shown, and being sufficiently long to rest upon the bed-plate projections between the grooves, but adapted to engage with and fall in any of the said grooves upon passing the same, and thus to actuate the ground-spring or circuit-closer of said groove unless at that moment the armature is attracted by the electro-magnet, a suitable motor to rotate the magnet and attachments, the said motor being held normally at rest by the engagement of the lever-arm, with the unison-groove adapted to move and rotate the magnet when the lever is released from the said groove, and to be stopped at any desired groove by allowing the said lever to fall therein, a continuous circular contact-plate constituting the terminal of a main line, and a circular series of segmental conducting-plates arranged concentrically.

11. In a branch or subsidiary telephone-exchange, a series of converging sub-station lines terminating at such branch exchange, a polarized relay for each of the said lines having its helices and armature both included in the circuit thereof, a contact-spring normally in contact with the armature and constituting a portion of the normal ground-extension of the sub-station line, a trunk line leading from the branch exchange to a point external thereto, and extending at the branch exchange through a series of contact springs and points, one contact at each relay, so that the relay-armature when deflected from its normal position is enabled to make contact with the trunk line by means of the said contact-spring disconnecting simultaneously the ground-terminal of both lines, and a series of permanent normally-open branches extending from the trunk line and terminating in limit-screws in the rear of the trunk-line contact-spring, so that the said spring, when forced backward by the relay-armature, shall make contact therewith, whereby the succeeding main-line contacts are short-circuited and the interference of other sub-station lines prevented.

12. The combination, in an automatic auxiliary telephone-exchange apparatus, of a circular metallic bed-plate and a ground-wire connected thereto, the interior edge of said plate being cut into by any desired number of single or paired grooves, an armature-lever mounted at the center of said bed-plate on a motor, so as to rotate in a horizontal plane, the arm of said lever being of suitable length to slide over the projections between the said grooves and to fall into the said grooves, if not otherwise prevented, an electro-magnet in a main-line circuit and an armature therefor controlling the said lever and adapted to lift the lever end from the groove or to prevent it from falling therein, a continuous metal ring united permanently with the said main line, a second ring concentric with the first, but formed of segmental metal pieces insulated from one another and each connected with a separate branch circuit, and a pair of trailing springs forming the terminals of the electro-magnet and adapted to trail on the concentric rings, whereby control of the said electro-magnet is at all times maintained irrespective of its position in its circle of rotation, substantially as described.

13. The combination, in an automatic auxiliary telephone-exchange apparatus, of a circular metal bed-plate, grooved as described, and constituting, by means of an attached ground-wire, the common earth-terminal of a number of circuits, the ground-springs and circuit-closers, herein described, affixed to the under side of said bed-plate and projecting into the several grooves, the rotatable actuating-arm adapted, when brought near to a special groove and released, to fall therein and actuate the ground-spring or circuit-closing bar attached thereto, the electro-magnet controlling the same, and the concentric continuous and segmental contact-plates therefor, whereby by means of trailing-spring terminals the said electro-magnet is permanently connected with the main line and successively with all of a series of branch lines, as and for the purposes specified.

14. The combination, in an automatic auxiliary telephone-exchange apparatus, of a circular metal bed-plate, grooved as described and constituting, by means of an attached ground-wire, the common earth-terminal of a number of circuits, the ground-springs and circuit-closers, herein described, affixed to the said bed-plate within the said grooves, the rotatable actuating-arm adapted, when brought near to a special groove and released, to fall therein and actuate the ground-spring or circuit-closing bar attached thereto, the electro-magnet and motor therefor controlling the said bar, and the concentric continuous and segmental contact-plates forming the main and branch line terminals, as described, with a battery-key, and an indicating-dial adapted to run synchronously with the rotating arm, all at the distant central station, whereby the progress of the rotating arm can be there noted and its action controlled, as herein specified.

15. The combination, in a sub-station line, of a series of successive spring-contacts, each consisting of a contact-spring resting normally on a contact pin or anvil, the said pin being

connected with the next succeeding spring, as described, a polarized relay-switch, and a ground-connection, the said ground-connection being detachable and placed at a given point in an automatic apparatus operated over a main line from a distant station, and a normally-open branch wire diverging from said line at a point external to the said contacts and terminating in a metal segment placed in the said automatic apparatus at a point having a definite relation to the position of the ground-connection, whereby, when the said normal ground-connection is removed by the action of the apparatus, a new connection is simultaneously made connecting the sub-station line through the branch and segment with the main line leading to the distant station.

16. The combination, in an automatic line-connecting apparatus, of the grooved circular bed-plate connected with a ground-wire, the ground-springs or circuit-closers attached thereto and fitted below the grooves thereof, and the rotary arm adapted to rotate upon a shaft at the center of the circular bed-plate to engage with the said grooves and to operate the said ground-springs and circuit-closers, as described.

17. In combination with a main line and a series of branch lines, a rotating electro-magnet, a suitable motor therefor, an armature-lever adapted to control the said motor, a continuous metal contact ring or plate constituting the terminal of the main line, a number of segmental conducting-plates in series with but insulated from one another, arranged in circular form concentric to the continuous ring and forming terminals for an equal number of branch lines or circuits, and spring-contact terminals for the electro-magnet, adjusted to maintain frictional contact one with the continuous ring and the other with the segmental ring, whereby the said electro-magnet is maintained at all times in a circuit composed of the main line and some one of the branch lines, as herein described.

18. The combination of the electro-magnet adapted to rotate on a given center, the lever-arm actuated thereby, and the trailing contact-spring terminals therefor, with the continuous circular contact-plate constituting the terminal of a main line, the series of conducting-segments arranged in a circle concentric with the continuous plate and having their ends overlapping one another, as described, each segment being the terminal of a branch line, a ground-extension, or a pair of branch lines, and an additional conducting-segment concentric with a portion of the said segmental circle and connected to earth through a high resistance, one of the electro-magnet contact-springs being adjusted to trail over and remain in permanent contact with the main-line plate, and the other being sufficiently wide to overlap and trail over and in contact with the concentric branch line and ground-segments, whereby an earth is at all times maintained for the main line through the electro-magnet, substantially as specified.

19. The combination, in a telephone-exchange system, of a series of sub-station lines, each passing at the converging station through a series of successive spring-contacts, at each of which it is in close juxtaposition with a similar spring-contact of some other sub-station, so that each and every sub-station line of the series is brought into close contiguity through such pairs of springs with every other line of the series, substantially as and for the purposes specified.

20. The combination, in a telephone-exchange system, of a series of sub-station lines, each passing at the converging station through a series of successive spring-contacts, the said spring-contacts of the several lines being brought by pairs into close contiguity with similar contacts of every other line of the system, with an electro-magnet in a local circuit for each pair of contact-springs, and means, as indicated, actuated by such electro-magnet to lift the two contact-springs of any such pair from their original contact-anvils and into contact with one another, whereby any two lines may be electrically united, substantially as described.

21. The combination, in a telephone-exchange system, of a series of sub-station lines, each passing at the station of convergence through a series of successive spring-contacts, the said spring-contacts of the several lines being brought by pairs into close contiguity with similar contacts of every other line of the system, with an electro-magnet in a local circuit for each pair of contact-springs, an armature and armature-lever therefor, and a conducting cross-bar affixed to the end of said armature-lever and lying across and below the pair of contact-springs, so that when the said local electro-magnet is energized and its armature attracted the said cross-bar is correspondingly elevated and is enabled to raise the contact-springs of both lines from their normal contact-anvils and to connect them electrically through its own substance, whereby any two lines may be united for intercommunication, substantially as described.

22. The combination, substantially as hereinbefore described, in an auxiliary telephone-exchange, of two or more sub-station lines, each passing at the said exchange through a series of successive spring-contacts, the said spring-contacts of the several lines being brought together in close contiguity to form pairs with similar contacts of every other line of the system, an electro-magnet in a local-battery circuit for each of the said pairs, an armature, and armature-lever therefor, a metal cross-bar affixed to the end of said armature-lever and lying below and across the pair of contact-springs, and a circuit-closer in the said local circuit, whereby the said circuit may be closed, the magnet energized, and

the two lines represented by the contact-springs united through the cross-bar, for the purposes specified.

23. In an auxiliary telephone-exchange, two or more sub-station lines, each passing at the said exchange through a series of successive spring-contacts equal in number to the number of converging lines less one, the said spring-contacts of the several lines being brought together in close contiguity to form pairs with similar contact-springs of every other line in the system, an electro-magnet in a local-battery circuit for each of the said pairs, an armature and an armature-lever, and a conducting cross-bar carried by the said lever in position to lift the said pair of springs upon the energization of the electro-magnet, combined with a circuit-closer for the said local circuit, consisting of a tilting bar and contact points or cups, an automatic actuating device therefor operated by a clock-motor, and an electro-magnet in a main trunk-line circuit controlled from a distant central station, substantially as hereinbefore described.

24. In an auxiliary telephone-exchange, two or more line-circuits, each passing at the said exchange through a successive series of spring-contacts equaling in number the entire number of converging lines less one, the said contacts of the several lines being grouped in pairs, one contact of each line in close proximity with a similar one of each line, an electro-magnet, armature, armature-lever, and cross-bar for each pair of springs, the said electro-magnet being, as indicated, controlled by a normally-open local circuit, all in combination with a circuit-closer consisting of a tilting lever and contact points or cups, a rotary lever-arm adapted to strike the same and open or close the said local circuit, an electro-magnet in a main circuit, and a motor to actuate the said arm, a metallic bed-plate, with a pair of guide-grooves for each circuit-closer, and a key and a dial moving synchronously with the magnet-motor at the distant central station, whereby the movements of the rotary lever are indicated and controlled as specified, substantially as hereinbefore described.

25. The combination, in a branch telephone-exchange, of the several pairs of connecting contact-springs, whereby each line is brought into the near proximity of each other line, as described, the connecting cross-bars therefor, and their actuating electro-magnets, armatures, and armature-levers, and the local circuits and circuit-closers, with the automatic connecting and supervising apparatus herein described, comprising a rotary arm adapted to select and actuate any desired circuit-closer, an electro-magnet controlling the same, a pair of trailing terminal springs therefor, the continuous metal ring forming the main-line terminal in permanent connection with one of the said springs, a series of conducting-segments arranged as described, and equal in number to the circuit-closers, a series of connecting-wires extending from the connecting cross-bars to the said segments, so as to electrically connect each cross-bar with one of the segments, each of the said segments being so placed as to be in contact with the remaining magnet-trailing spring, while the lever-arm is operating the circuit-closer belonging thereto, whereby, when any two sub-station lines are connected together by the cross-bars a branch circuit leading to the central station is simultaneously constituted, for the purposes specified.

26. The combination of any two subscribers' lines, the connecting cross-bars therefor, the electro-magnetic operating mechanism for bringing the said cross-bar into action, the local circuit for such mechanism provided with a circuit-closer, a trunk or main line, an automatic connecting and supervising apparatus at the junction of such subscribers' lines and trunk line, controlled by an electro-magnet included in the circuit of the latter, apparatus at a distant central station, substantially as herein indicated, whereby the said automatic apparatus may be operated and controlled over the trunk line, and means, as indicated, whereby the said automatic apparatus is enabled to operate the circuit-closer and connect any desired two lines together and simultaneously establish a branch circuit from the two lines so connected through its own actuating-magnet to the trunk lines, so that the central station may send call-signals or establish telephonic communication, if desired, with the two connected lines, substantially as described.

27. The combination of the local connecting-circuit, the electro-magnet *m* included therein, the armature-lever and cross-bar therefor, all arranged as and for the purposes described, with the circuit-closer *v* and the branch listening and calling circuit leading from the cross-bar through the fulcrum-post to a contact-segment having a definite relation in position to the circuit-closer, and the automatic actuating device X, arranged to operate the circuit-closer and simultaneously to connect a main line through its own controlling-magnet to said contact-segment, substantially as specified.

28. The combination of the local circuit, the magnet *m*, the armature-lever and cross-bar therefor, the branch circuit leading from the metal cross-bar, armature-lever, and fulcrum-post to a normally-open segment adapted to be brought into connection with the main line at the moment when the local circuit is closed, and the ground branch wire connected with the limit-post N, and constituting a normal earth-terminal for the said branch circuit, for the purposes described.

29. The combination of a main line, a series of branch wires, m^5, a circular contact-plate permanently connected with the main line, a series of conducting-segments, s^5, each united by wire with one of the said branch wires, an electro-magnet permanently in contact with the main line, and adapted to rotate, so as to place itself in contact successively with the segments connected with the branch lines so

that the main line may thereby be successively extended through the said segments with the several branch lines, a series of local circuits provided with circuit-closers, a rotary lever-arm operated by the main-line electro-magnet and adapted to select and actuate any of the said circuit-closers, a series of electro-magnets, one for each of the said local circuits, each provided with and actuating connecting devices for connecting two lines together, the said devices being united through the branch wires m^5 with the conducting-segments s^5, and a ground-wire for each connecting device, all arranged as shown, and for the purposes described.

30. The combination of a series of local circuits, each including an electro-magnet and a mechanical circuit-closer, a common battery therefor, a series of sub-station lines, each having a contact-spring in proximity to a similar spring of every other such line, a series of metallic connecting devices operated by said electro-magnets, and each adapted to disconnect said contact-springs from their normal connections and to unite them to one another, a main line, an automatic rotary device controlled through said main line from a distant central station and adapted to close or open any or all of the said circuit-closers, as described, a branch circuit extending from each metallic connecting device to a contact-plate, said plate being, through the agency of the automatic rotary device, connected with the main line while the circuit-closer belonging thereto is being operated, and a ground-wire normally connected with said branch circuit while the local connecting-circuit is open, but withdrawn therefrom when said circuit is closed, all as and for the purposes specified.

31. The combination of the main line L, a series of sub-station lines, A B C, &c., a polarized-relay switch, P, whereby any of the said sub-station lines may connect themselves with said main line, the spring-contacts of such sub-station lines, and the ground-wire and ground-spring g^7 attached by a non-conducting link to the contact-spring, whereby when any contact-spring is lifted from its normal connection the said normal connection may be grounded, whereby an earth-terminal is provided for the main line in case the polarized-relay switch should be left out of its normal position.

32. A complete system of telephonic intercommunication, consisting of a central station, a branch or subsidiary central station, a trunk or main line extending between and uniting the said stations, a series of sub-station lines converging to and normally grounded at the subsidiary station, a polarized relay constituting an electro-magnetic switch for each sub-station line, having its helices and armature both included in the circuit of said line, a system of spring-contacts controlled by each relay and including the normal main-line terminal and also at each relay the normal terminal of its own line, so that the main-line terminal passes through the contacts of all the relays, whereby each sub-station line may connect itself with the main line when unoccupied, a normally-open main-line shunt-circuit round the several relay-contacts adapted to be closed and to short-circuit intervening circuits to prevent interference when the main line has been engaged by any sub-station line, a series of successive spring-contacts in each sub-station line, at each of which contacts a similar spring of one of the other lines is placed in close contiguity, a connecting metal bar for each pair of springs operating to lift said pair of springs unitedly from their normal position and to unite them to one another, thus connecting the two lines, an electro-magnet in a normally-open local circuit actuating the said metal connecting-bar by means of its armature and armature-lever to which said metal bar is attached, a circular grooved ground-plate, a series of ground-springs, one for each sub-station circuit, and a series of tilting-lever circuit-closers, one for each pair of sub-station lines, adjusted in the grooves of said ground-plate, a rotating lever centered at the center of said circular ground-plate and extending outwardly to the edge thereof, so that the end of said lever is adapted to slide over the projections of the same between the grooves and to fall into the said grooves and actuate the several ground-springs and circuit-closers, a clock-work motor actuating the said lever-arm, an electro-magnet in the main-line circuit controlling the said lever-arm and motor and determining the engagement of the said arm with any special groove, the said magnet participating in the rotation of the motor and lever-arm, concentric contact-plates, one of which is continuous and permanently connected with the main line, the other being composed of insulated segments, the said segments being each united by branch wires with the several sub-station circuits and with the connecting devices for any such pairs of circuits, trailing contact-spring terminals for the electro-magnet, one of which is adjusted to maintain permanent contact with the main-line plate, while the other traverses successively the segments or branch-line plates, whereby the main line is maintained at all times in connection through the electro-magnet with some one of the branch lines, and whereby the central station may send signals and participate in or supervise communications with any single sub-station line or any connected pair of such lines, substantially as hereinbefore specified.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 4th day of April, 1885.

THEO. N. VAIL.

Witnesses:

GEO. WILLIS PIERCE,

THOS. D. LOCKWOOD.