(No Model.)

3 Sheets—Sheet 1.

T. D. LOCKWOOD.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 335,708. Patented Feb. 9, 1886.

Fig. 1.

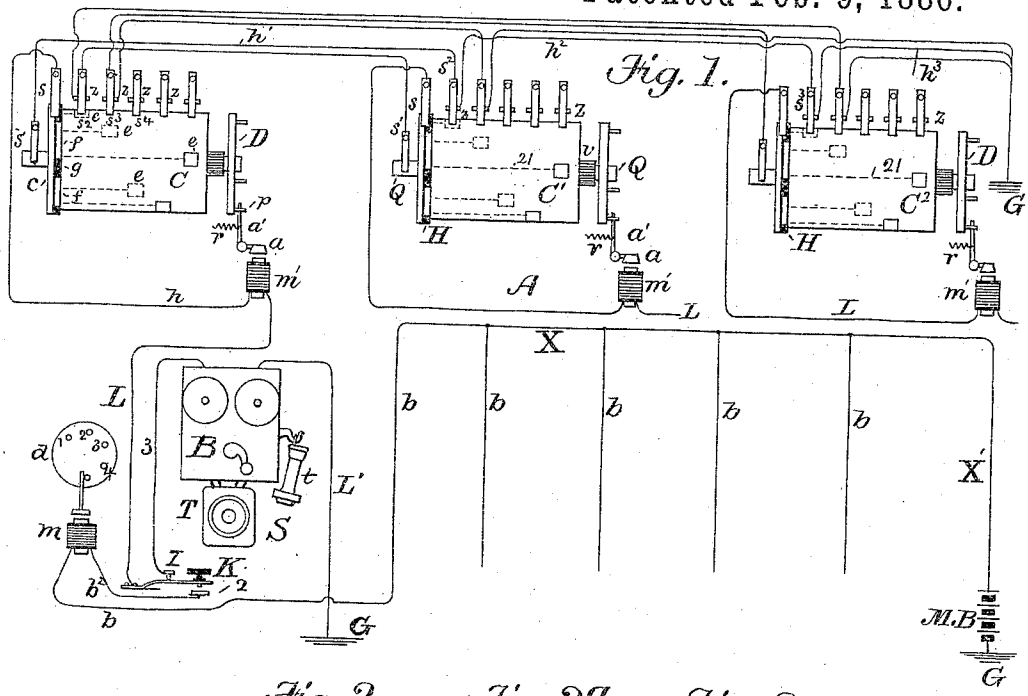


Fig. 2.

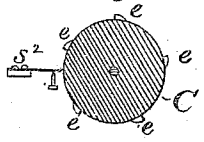


Fig. 2a.

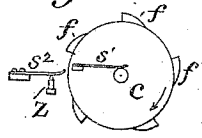


Fig. 3.

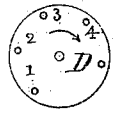
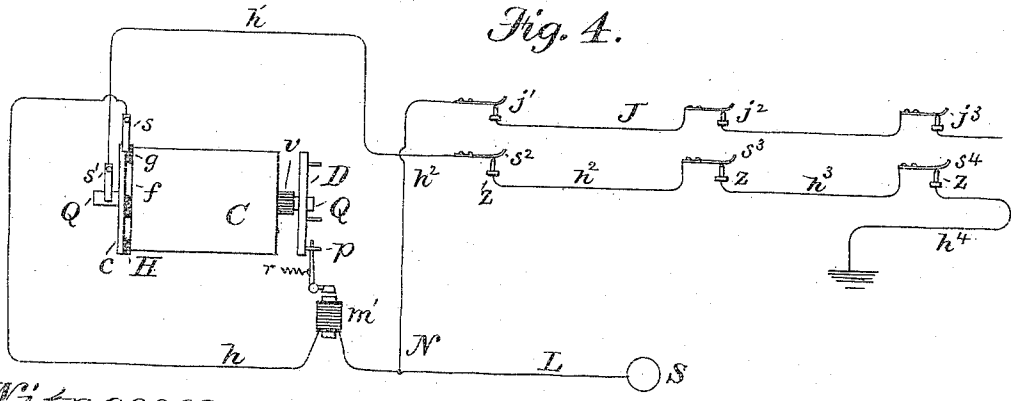


Fig. 4.



Witnesses.

Geo Willis Pierce

Geo. H. E. Fruwelot.

Inventor:

Thos D Lockwood

(No Model.)

3 Sheets—Sheet 2.

T. D. LOCKWOOD.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 335,708. Patented Feb. 9, 1886.

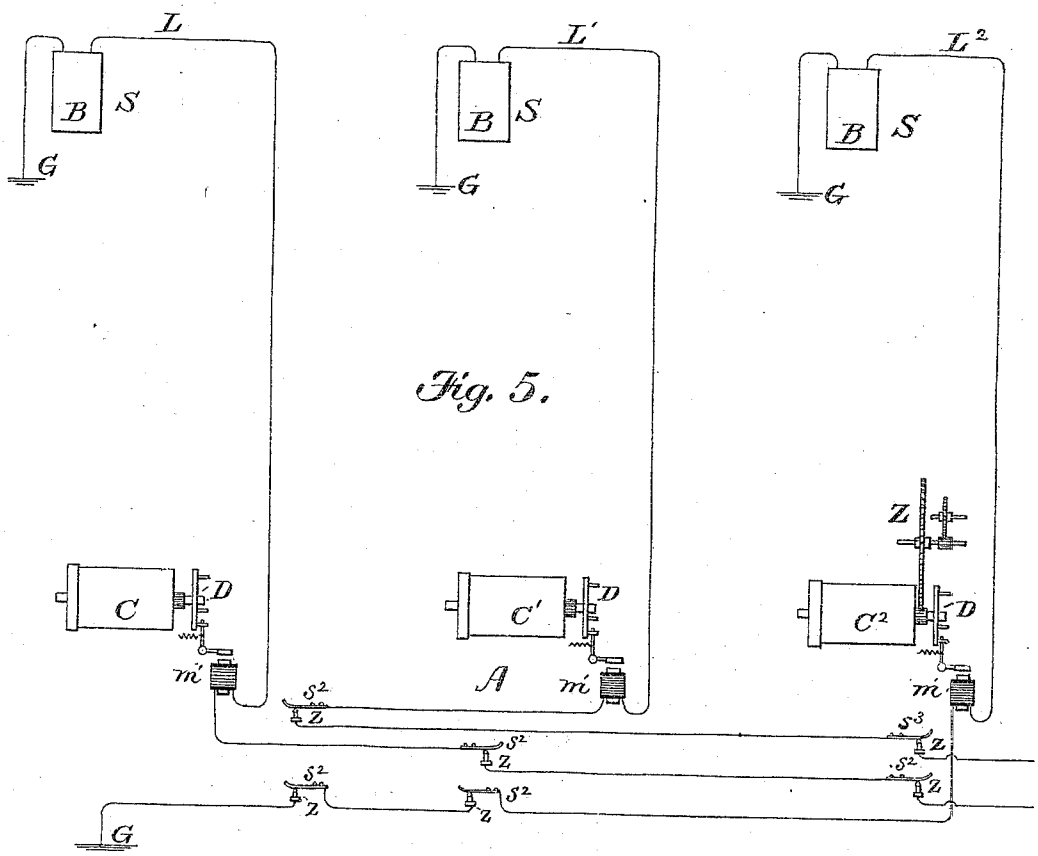


Fig. 5.

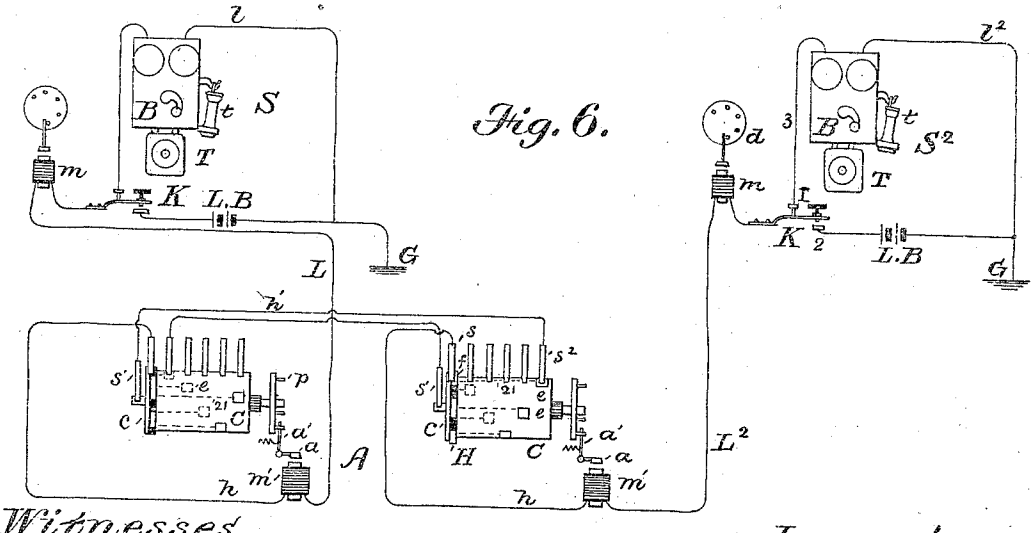


Fig. 6.

Witnesses.
Geo. Willis Pierce
Geo. H. E. Trowbot.

Inventor.
Thos D Lockwood

(No Model.) 3 Sheets—Sheet 3.

T. D. LOCKWOOD.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 335,708. Patented Feb. 9, 1886.

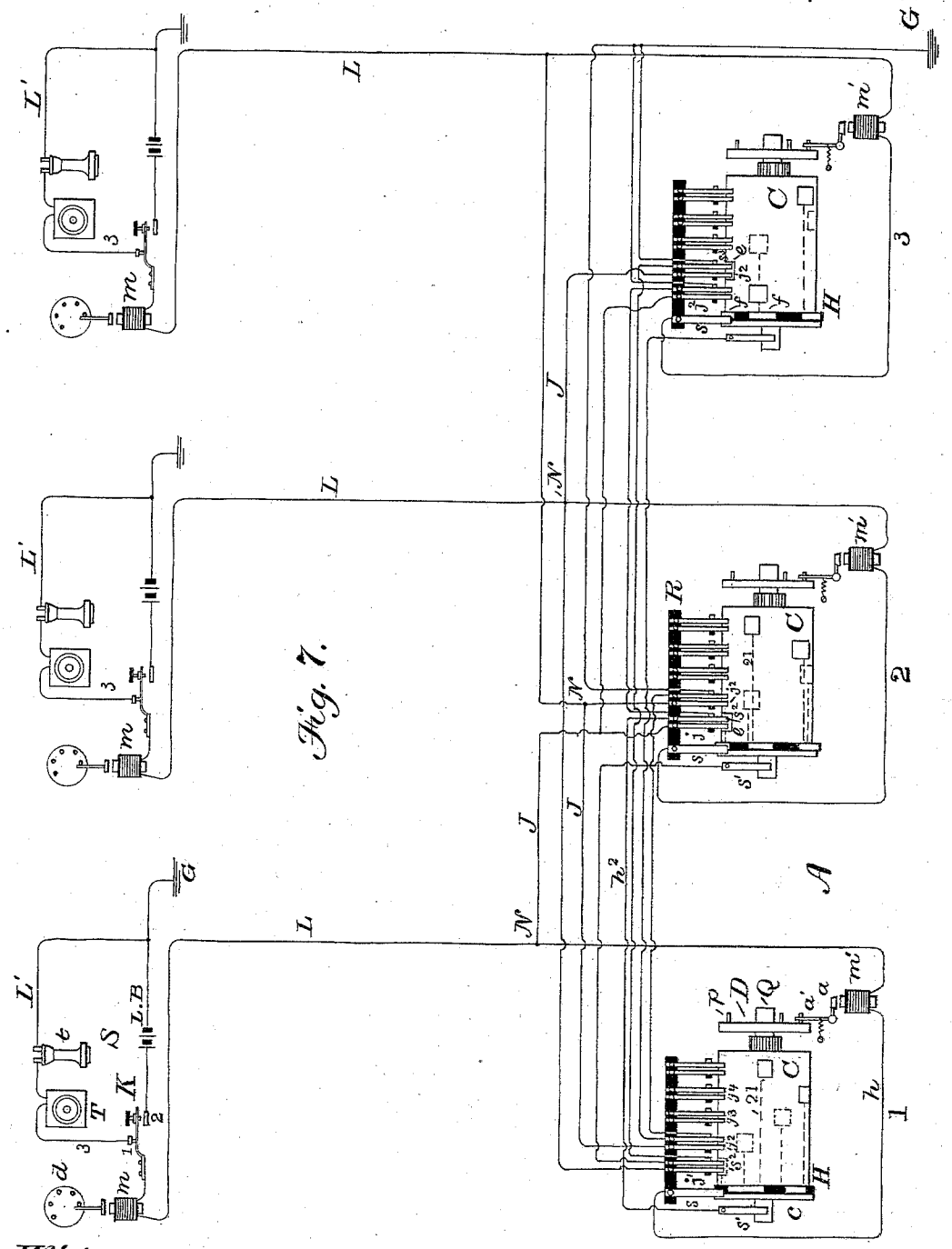


Fig. 7.

Witnesses.
Geo Willis Pierce
Geo. H. E. Trowbridge.

Inventor.
Thos D Lockwood

UNITED STATES PATENT OFFICE.

THOMAS D. LOCKWOOD, OF MALDEN, MASSACHUSETTS.

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 335,708, dated February 9, 1886.

Application filed September 26, 1885. Serial No. 178,289. (No model.)

To all whom it may concern:

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

My invention relates to central-office systems of electrical intercommunication of that class in which the several subscribers are provided with suitable mechanisms and appliances whereby they themselves may effectuate the necessary changes at the central or main office to which the several lines converge, so that the intervention or services of a central-station operator may be totally dispensed with.

The ordinary telephone-exchange system is now a well-known organization of circuits and instruments consisting of a number of line-wires, each of which connects with one or more sub-stations provided with signal sending and receiving devices and with telephones, while the entire number of said line-wires converge to or concentrate at a central station, where, by means of a suitable switch-board, an attendant connects them with or disconnects them from one another, and receives and forwards the necessary call-signals. It has been practically ascertained that it is not commercially profitable to construct and operate such exchanges in very small towns and villages, simply because the advantages of intercommunication are not sufficiently great to induce inhabitants to become subscribers at a profitable price, while the expenses contingent upon such systems are usually as high and numerous as in more populous places. Thus such places are often deprived of telephone communication altogether. My invention contemplates a remedy for this state of affairs.

I am fully aware that I am not the first to propose an automatic arrangement whereby the various lines of a subsidiary exchange may be operated both for the transmission and reception of signals, and may be readily connected with one another without the intervention of an operator at the said subsidiary exchange, apparatus aiming at that end having been described in the several patents of Theo. N. Vail, issued August 11, 1885, and numbered, respectively, 324,191 and 324,192, and elsewhere. My invention, however, aims to place in the hands of each subscriber to the system the power of placing his own line instantly in connection with the line of any other subscriber converging to the same central point, or at will with a line or lines leading from the said central point to a main central station which may be located at any distance; and, furthermore, to accomplish this with mechanism of the simplest and yet most reliable character. In like manner I purpose to provide the distant main or central station with a mechanism of similar character to that furnished to each subscriber, so that it is virtually placed on the same footing as they are—namely, that of a subscriber or contributor to the subsidiary exchange. When any subscriber has taken such action, and has disconnected his line from its original terminal and connected it with the line of any other subscriber, or with a trunk-line leading to a distant central station, he may proceed, by utilizing the ordinary telephone signaling apparatus, to call the station he desires, and after attracting the attention of the person there in charge to communicate telephonically with the said station; and he may, finally, by a repetition of his initiatory operation, at once restore the connecting mechanism to its original position and condition.

My invention, stated as briefly as is consistent with its character, comprehends (as is usual with telephone-exchange systems) a central point, from which radiate any number of electrical line-wires, these extending to the stations or offices of subscribers, at which are placed, in connection with the line-circuits, the regular telephone outfit of call-bell, signal-sending apparatus, and transmitting and receiving telephones, and, in addition to these, devices for sending a steady current to line, and an indicator actuated by an electro-magnet, which operates synchronously with a central-point mechanism, hereinafter to be described, and serves to indicate to persons at the sub-station the position of said central mechanism, and thus to guide the action of said persons. At the station to which the several line-wires converge I place a series of commutating-cylinders, one for each converging line, and each cylinder is adapted to ro-

tate by means of a suitable clock-train or motor when the said clock-work is released by an electro-magnetic controlling device, and is capable of being arrested and held at any of a number of previously-selected points and to come to unison or to the initial starting-point at the close of each revolution. The movements of these cylindrical commutators are controlled and directed, through the instrumentality of the aforesaid electro-magnet, (which is included in that main circuit to which any special cylinder belongs,) from the sub-station, where such movements are, moreover, duplicated on the indicating device, which I have already referred to. Within the range of the several rotatable cylinders are a series of contact-springs, one set in the circuit of each line, except the line which itself controls the cylinder, and the operation of each cylinder, when rotated and stopped at any particular point, is to disconnect the line-circuit with which connection is desired from its original ground-terminal, and then to connect the outward end of such broken circuit with a similar outward end of the circuit initiating the connection. The sub-station energizes the electro-magnet controlling the cylinder by sending a strong impulse of electricity from a battery or other suitable source, (a constant-current magneto-machine may be used, if preferred,) which, passing through the convolutions of the said controlling-magnet, excites the same and releases the clock-train. The sub-station operator is also possessed of the power of stopping the rotation of the cylinder at the required point, which shall leave the line connected through with the line to which it is desired to communicate, and this power is exercised by withdrawing the constant current from the line. When the cylindrical commutator is brought into position to connect its own line with any other, either sub-station may ring up the other or send call-signals at will, inasmuch as the controlling-magnet is neither adapted nor adjusted to operate with currents of rapidly-alternating direction. If one or more trunk-lines connect the central point or converging station with a distant or main station, as will generally be the case, each of the said trunks will at the point of convergence be provided with a rotatable cylinder, and will at the distant point be furnished with starting and indicating devices, and will, in short, be treated precisely as if it were one of the subscribers' lines. In addition to the foregoing, I also combine with the system of automatic circuit-changers an arrangement of circuits constituting a perfect try system, by means of which any subscriber may, after connecting his line with any other, be enabled to listen and ascertain whether that subscriber's line be already in connection with another, and to do this without injuriously affecting any such connection which already may be made, or without interfering with conversation which may be in progress. This arrangement comprises a series of twin springs and a permanent branch circuit from each line at a point external to the circuit-springs of said line, the said branch being connected with one of the twin springs at each circuit-changing cylinder. Each cylinder is adapted to bring its own line into connection with the twin spring of the desired line at the same time that it connects with the contact-spring of that line, so that from that point there are two electric paths out over the line to the desired sub-station—one through the several contacts and the other through the twin spring and branch line. Thus, even in case either of the two lines should be by any other opened by the actuation of an intermediate circuit-spring, there is still an alternative route through the permanent branch.

I have illustrated my invention by the accompanying drawings, which form a portion of this specification.

Figure 1 is a diagram indicative of a system of intercommunication constructed in accordance with my invention, the battery used by the sub-stations being located at the central point and supplied by an extra wire. Fig. 2 is a cross-sectional view of the cylindrical commutator. Fig. 2^a is an end view of the cylinder, showing the main-circuit contact-springs. Fig. 3 is a view of the detaining-plate and pins of the said cylinder. Fig. 4 shows in diagram the circuit arrangement of a single converging line. Fig. 5 is a diagram indicating in a similar way the circuits and connections of three lines. Fig. 6 shows two line-circuits actually connected together through one of the rotatable commutators, as hereinafter described; and Fig. 7 is a diagram indicating two lines connected together combined with the guard-circuits by which a third may be prevented from interference.

I will first describe in detail, referring to the drawings, that part of my invention which relates simply to the means whereby any subscriber may at will and by his own action connect his line to that of another. I provide as many rotating commutators C at the station to which the lines converge as there are lines, one commutator or circuit-changer being assigned to each line L. Any number of these subscribers' lines may converge to the same central point; and, if required, one or more of the lines so centering may in practice be a trunk-line leading to a distant exchange, and in that case the said trunk is likewise fitted with apparatus of the same character in every respect as if it were one of the ordinary short subscribers' lines.

In Figs. 1, 5, and 6, A represents the central station, and S the sub-stations.

In Figs. 1 and 5, I have shown but three lines as being sufficient to explain my principles of operation, although it is evident that any number may be similarly arranged; and in Fig. 6 two lines only are shown, these being connected through by the act of a sub-station located on line L^2.

Each of the rotatable circuit-changers con-

sists of a non-conducting cylinder, on the surface of which is arranged in suitable order a series of metal cam contact-pieces, *e*, which are let into the substance of the cylinder. At one end of the cylinder is fixed a disk, H, of non-conducting material, and a series of contact-making cams or raised points, *f*, are let into the periphery of the said disk, the cams being equal in number to the conducting-pieces let into the surface of the cylinder. Each of the cams *f* is connected by a cross-wire, 21, with a corresponding contact-piece, *e*, as shown. A second disk, *c*, made of metal, is also fixed to the cylinder outside of the non-conducting disk, and is identical in size with the said non-conducting disk, so that the peripheral lines of both are uniform and flush with one another at all points, with the exception of the raised contact-pieces of the disk H, which project outwardly from both. An axis, Q, is provided for the cylinders, and the end nearest the metal disk *c* is in electrical connection therewith, while the other end of said axis or arbor is fitted with a pinion, *v*, by which a train of clock-work, Z, is enabled to actuate the cylinder and cause it to rotate. The latter end of the axis also supports a face or detent plate, D, which has a series of stop-pins, P, projecting from its surface in number equal to the number of contact-pieces *e* on the surface of the cylinder, plus one, which serves as the unison or resting stop. The cylinder and its actuating mechanism are held normally quiescent by means of a bell-crank lever, *a'*, controlled by an armature, *a*, with which it is integral, said armature *a* being in turn under the control of an electro-magnet, *m'*, included in the main circuit, to which the cylinder which it governs belongs, the armature at this magnet being adjusted so as to be irresponsive to rapidly-alternating currents. Upon the excitation of this electro-magnet the armature is attracted and the bell-crank lever is drawn forward, releasing the pin *p* and permitting the cylinder C to rotate, which it then continues to do until the magnet releases the armature and permits the lever *a'* to fall back and to strike the first pin that reaches it. It follows, therefore, that by causing a current to flow through the line the cylinder may be started, and that by intermitting the said current at certain specific or determinate points the cylinder can be stopped at such points. At one side of each cylinder I mount a series of contact-springs, s^2 s^3 s^4, &c., all of which, when at rest, lie upon contact-points *z*. The springs are so mounted that each of the conducting-cams *e*, as it passes the end of the spring which is fixed oppositely to it, will raise the said spring s^2 from its complementary contact *z*, and will then, if the cylinder is immediately arrested, maintain the spring in its raised condition and in contact with itself, thus breaking the original path of the circuit to which the spring belongs, and diverting it to another route through the substance of the cam projection. The relative position of the cylinder, cams, circuit-spring s^2, and contact-point *z* is shown by Fig. 2^a, in which the arrow indicates the direction of rotation. A single spring, *s*, is mounted in the same way, so as to bear on the peripheral edge of the two disks *c* and H, except during the time that any of the cams or projections *f* on the edge of the inner disk is passing under the said spring, or is for the moment at rest under the said spring, in which case the spring is lifted from its original contact with the edge of the disk *c* and brought into contact with the cam contact-piece of the disk H. Another single contact-spring, *s'*, is mounted in any preferred way so as to bear upon the metallic axis Q of the cylinder. These cylinder circuit-changing apparatuses, fitted as described, comprise the whole of the instrumentalities requisite at the central point. At each sub-station the ordinary telephone outfit of call-box B, transmitter T, and receiving-telephone *t* are provided, and in addition to these a signaling-key, K, is also required, together with an indicating-dial, *d*, actuated by an ordinary clock-train, (not shown,) but adjusted to run synchronously with the cylinder-actuating clock-train at the central point or station. This indicator is controlled by an electro-magnet, *m*, which may either be included in the main-line circuit, as shown in Fig. 6, or in the normally-open local or branch circuit of a local battery, L B, (or of a magneto-machine adapted to emit continuous currents of uniform direction,) or alternatively of a main battery, M B, Fig. 1, so that it may only be introduced into the main circuit when the key is pressed and the battery-current sent to line. I will now describe the arrangement of the several circuits, and will first trace the arrangement of the main circuits. Since they are all arranged in a similar manner, it will suffice to trace one of them. Referring to Figs. 1, 4, 5, 6, and 7, the line-circuit, beginning at the ground G at the sub-station S, passes by wire L' to the call-box B and telephones T and *t*; thence by wire 3 to the upper contact, I, of the signal-key K, and from the main stem of said key through the indicator-magnet *m* to the main line L, leading to the central subsidiary exchange, A. Entering that station, it continues, *via* the controlling electro-magnet *m'* and wire *h*, to the side spring, *s*, of the commutating-cylinder C of that line. This spring normally presses upon the rim or edge of the metal disk *c*, and also upon the edge of the non-conducting disk H, which is flush therewith. The circuit is therefore thus continued through the said disk *c* to the axis Q of the cylinder, the spring *s'* bearing thereon, and by wires *h'* h^2 h^3, &c., to a succession of contact-springs, s^2 s^3 s^4, &c., leaving each spring from the anvil *z* thereof, and finally running from the fixed point *z* of the last contact-spring to the ground-terminal, as indicated in line L^2, Fig. 5, and by Fig. 7. Now, since each line passes not only through its own controlling-magnet and the disk-rim contact-spring at its

own rotatory commutator, but also through a separate contact at the commutating-cylinder of each other entering line, it follows that each line may connect itself with any other line which may be determined upon, simply by setting its cylinder in motion and stopping it at a predetermined point, where the normal circuit of the line taking the initiative is broken by means of the cam projection *f* on the rim of the non-conducting disk H, which lifts the spring *s* from the edge of the metal disk *c*, and where it is connected to the desired line by means of the corresponding cam, *e*, on the surface of the cylinder, which cam *e* is united to the projection *f* by a short wire, 21, embedded in the surface of said cylinder. The cam *e*, having lifted the spring s^2, s^3, or s^4, as the case may be, from its normal contact *z*, thus forms the connecting-point between the two lines. This condition is illustrated most clearly in Fig. 6, in which two lines are shown united together through the rotatable cylinders. It is assumed that the line L^2 at the right-hand side of the figure has connected itself with the line L on the left. The right-hand cylinder is accordingly represented as having been rotated until the spring *s* is lifted from the edge of the disk by the projection *f* and the spring s^2 at the same cylinder lifted from its normal contact by the cam *e*. This spring s^2 forms a part of the circuit of the line L, and the projection *f* and cam *e* are united by the wire 21. The two lines are thus disconnected from their original ground-terminal, and are united through the said wire 21 of the cylinder, which has initiated the connection. In like manner, if line L had taken the initiative and had rotated its cylinder, the unison would have been effected through the spring *s*, the wire 21, and the spring s^2 of that cylinder. Tracing the combined circuit, we find that it begins at the ground G at station S^2, passes *via* line l^2, magneto-machine or call-box B, and the telephones, (the latter not being of course in circuit until the receiver is removed from the hook.) wire 3, key-contact I, key K, magnet *m*, and main line L^2, to the central point, where the cylindrical commutators are located. Entering the said station, it proceeds by actuating magnet *m'* of the same line and wire *h* to the main contact-spring *s*, which, being raised, is in contact with projection *f* on the non-conducting disk H, and thence *via* wire 21, through the cylinder C, (which is also formed of non-conducting material,) to the corresponding cam or contact-piece, *e*. This being in proper position is in contact with spring s^2 of the other line, which has been lifted from its normal contact *z*, and from that spring, which is a portion of the second line, a wire, *h'*, leads to the arbor-spring *s'*, thence through the axis or arbor Q of the left-hand cylinder to the disk *c*, main contact-spring *s*, and by wire *h* through the actuating-magnet *m'* of the line L to the said line, and out to the sub-station S, where it terminates at the ground G. Each sub-station is furnished with battery-power, which can be directed to the main lines for the purpose of actuating the controlling-magnets of the rotating cylinder at the central connecting-station, whereby the said cylinders may be set in motion. This battery may optionally be provided either from a main battery located at any desired point and common to a number of sub-stations, from a local battery at each sub-station, which local battery may, if preferred, be also employed in connection with the transmitting-telephones, or by a straight-current magneto-machine, in a manner well understood.

I have illustrated the first plan in Fig. 1. M B is the main battery, one pole of which may be grounded, while the other pole is connected to a main wire, X, passing through the territory of the exchange, and extending into the sub-stations by a series of branch wires, *b*. In the drawings, although I have represented but one of the branch wires as being carried out completely, so as to show its termination, it is of course assumed that each wire terminates in a similar manner. After entering the sub-station, the wire *b* passes to one side of the indicator electro-magnet *m*, and from the said magnet by wire b^2 to the front contact or anvil, 2, of the key K, at which point it ends, being a normally-open or discontinuous branch terminal of the battery-circuit. When the key is depressed, however, the main line L is severed from its ordinary terminal and is united as long as the depression shall continue to the anvil terminating the battery branch, whereby the circuit of said battery is temporarily completed, and the current from the same directed over the main line L to the connecting-station and through the magnet-coils there, to subserve the function which I have hereinbefore specified.

The second plan is shown in Figs. 6 and 7, where the several sub-stations are each provided with their own battery L B. The same principle is involved as in the former case, one pole of the normally-open local battery being to earth, and the other ending at the anvil 2 of the key K. It may be well to note here that the dial or indicator at each sub-station has no other function or office save to rotate synchronously with the cylinder belonging to the same line, but located at the connecting-station, and thus to afford to the eye of the sub-station operator an indication or guide by which the length of time he should maintain the key depressed may be regulated. The several stop-pins on the face of each sub-station indicator may, for example, be consecutively numbered in correspondence with the pins on the cylinder stop-plate at the connecting-station. If, then, a subscriber wishes to connect his line with line 3, he will depress his key and hold the same down until the figure 2 on his dial has passed the stop-lever, and will then release it. The apparatus will continue to rotate until the next stop-pin, 3, reaches the stop-lever and is then arrested,

and as the stop-lever at the connecting-station is controlled by an electro-magnet, m', in the main circuit the same operation will be duplicated there, since the release of the key withdraws the battery-current from the line and permits the controlling-magnets to simultaneously become neutral. The cylinder at the connecting-station will therefore have stopped at the point indicated by the dial, the main line controlling it being in connection with line No. 3.

The space upon all the stop-plates between the last stop-pin and the normal stop-pins I prefer to make greater than between any other two pins, so that when any two lines are disconnected the two clock-motors will, even if one runs a little faster or slower than the other, invariably be corrected at the initial stop-pin.

In the operation of this system a sub-station operator, wishing to connect his line with that of another, first presses his key K, by this means throwing his battery-current to line, and starting simultaneously his own sub-station indicator and the rotatable cylinder at the connecting-station which represents his line. He holds the key down, watching his indicator, and as soon as the stop on the said indicator immediately preceding the stop of the line required has passed the stop-lever there- of he releases the key. The indicator and cylinder are thus simultaneously stopped, the indicator upon the stop bearing the number of the required line, and the cylinder with its main contact-spring s elevated from its normal contact with the rim of the disk c and in electric union with the projecting contact-piece f of the non-conducting disk H, this in turn being by wire 21 and cam e united to the required line-spring, (say s^2,) which in turn is lifted from its normal resting-point, z. Both lines are therefore disconnected from their original ground terminations and united to one another. Having effected this union, the next operation is to signal the required sub-station and to attract the attention of the operator there. This is effected simply by turning the crank of the call-box B, thus operating a magneto-generator inclosed therein. The alternating impulses of electricity so developed pass over the compound line and through the distant signal-bell magnet, energizing the magnet thereof and ringing the bell at the distant station. Although the indicator and cylinder actuating magnets of both lines are in the circuit, and though, therefore, the alternating pulsations must pass through them, their armatures are not affected, these being adjusted by strong retracting-springs r, so that they will not respond to rapidly-alternating currents, while at the same time they will readily respond to a steady magnetic charge produced by a protracted current of a single direction, such as a battery-current. Having called the distant sub-station, the two operators or subscribers take up their telephones and converse, and upon the conclusion of the conversation the person who initiated the same, after replacing his telephone, presses his key once more and holds it down until his indicator passes its last stop-pin, after which he releases it, suffering the indicator and the corresponding cylinder to run to unison or to its normal point of rest.

I have found in practice that another contingency must be provided for. It frequently happens that a certain sub-station desires to communicate with another sub-station which is already in telephonic communication with a third. It is essential that to avoid confusion some device be adopted whereby the first sub-station may be enabled to ascertain that fact without interrupting such conversation and without impairing the connection between the two connected lines, and whereby, also, the first sub-station is absolutely prevented from taking any action which shall tend to such impairment. The means which I have devised and adopted for this purpose I will now describe, referring to the drawings. Figs. 4 and 7 especially show this arrangement. I place side by side with the consecutive contact-springs s^2 s^3 s^4 of each line a twin or companion spring, j, which, though attached at its supported end by the same non-conducting block or support R, is not provided with any normal contact, but has its free end unattached. The several twin springs j' j^2 j^3 of each line are all united, as shown in Fig. 4, by wire J, which is attached at one end to its own main line at a point, N, thereon outside of all the connecting-station mechanism, and which constitutes a normally-open branch thereof extended parallel to the main branch through the contacts, the several springs j being sub-branches thereof. The effect of this appliance is shown in Fig. 7, in which 1 and 2 are represented as connected together for conversation by the act of line 2. Line No. 3 desires to connect with line No. 2, and has operated his cylinder accordingly. He has thus connected himself with No. 2; but it now becomes his duty, before he rings up that station, to listen and ascertain if any conversation is already passing upon the line to which he has connected his own. The connections are as already described. Lines No. 1 and No. 2 each have a branch line, J, leaving the main circuit at N and branching to the twin spring j of each of their successive contact-springs s. The cylinder C of line No. 2, having been suffered to rotate until its spring s has been united, through wire 21, with the spring s^2 of line No. 1, has connected the two lines. The cylinder-cam e, which has lifted the spring s^2 from its normal contact z, is broad enough to lift also and to make contact with the twin spring j' of the same line. It will be observed that by this device line No. 2 has effected communication with line No. 1 by two separate paths after reaching the cam e on the cylinder of No. 2—first, through spring s^2, wire h^2, axis-spring of cylinder No. 1, axis Q, disk c, main contact-spring s, wire h, and through the electro-magnet m' to

line No. 1 and the distant sub-station; and, second, through twin spring *j'* and wire J to line No. 1 at the point N direct. Though it may readily happen that the integrity of the first route may be impaired by the action of a third party, it is impossible that the second route can be interfered with. No. 3, having now connected his line with that of No. 2, proceeds to listen. If he hears no conversation, he assumes that no other line is already connected, and proceeds to ring No. 2. If, on the contrary, he hears conversation, he understands that No. 2 is already engaged, and he restores its apparatus to its normal condition. The listening-circuit which had been temporarily established I trace as follows: from line No. 3 to springs of cylinder C of that line, and *via* projection *f* on rim H, wire 21, and cam *e*, to the contact-spring s^3 and twin spring j^2 of line No. 2; thence through the said twin spring j^2 and wire J to the point N on the said line No. 2. If the line is traced over the regular route *via* contact-springs s^3 and its connecting-wires, it will be found to be open at the point where the main contact-spring *s* is lifted from the rim of the disk *c* at the cylinder of line No. 2. Thus not only is the third line enabled to listen in order to ascertain whether the other lines are or are not engaged, but the additional advantage is gained by the connected parties of a double connection cutting out one of the controlling electro-magnets and several of the intervening contacts. Moreover, we may suppose two lines, say Nos. 2 and 3, to be connected together by the action of No. 3, and that No. 1 desired to connect with No. 2. No. 1 would connect his line with No. 2 in the manner described; but as the circuit of No. 2 necessarily passes through a contact-spring at No. 1 cylinder before it passes on to the cylinder of No. 3, it is clear that as soon as No. 1 connects himself he cuts No. 3 off, destroying the connection between Nos. 2 and 3; but by the device which I have adopted this contingency is avoided.

I am aware that it is not broadly new to provide a series of lines converging to a common point or central station, each with a commutator or circuit-changer operated by clock-work and controlled by an electro-magnet, whereby any subscriber can, by operating his commutator, disconnect his own line from its ground-terminal and connect it with any other line entering said central station for telephonic communication. Therefore I do not broadly claim such arrangement as my invention. Neither do I broadly claim a cylindrical commutator or circuit-changer actuated by clock-work and controlled by an electro-magnet in an electric circuit; but

I claim—

1. A telephone-exchange system comprising a series of sub-stations, a central or connecting station, electric lines or circuits connecting the several sub-stations with the connecting-station, means, as indicated, comprising a rotatable cylindrical circuit-changer actuated by clock-work for each of the said lines, each circuit-changer being controlled by an electro-magnet in its own line-circuit, and provided with a series of conducting-cams, a series of contact-springs, each constituting a portion of another line, and each placed within the reach of one of said cams, but beyond the reach of the others, an indicator at each sub-station adapted to rotate synchronously with the cylindrical circuit-changer of its own line, and current-sending devices at each sub-station, whereby each said sub-station is enabled to operate its own circuit-changer at the connecting-station, and thereby connect its own line with any other desired line by stopping the circuit-changer at the moment when a conducting-cam is in contact with the desired line-spring, and at the same time by means of the indicator be enabled to intelligently govern the movements of said circuit-changer, substantially as hereinbefore described.

2. In a system of telephone-circuits, the combination of a main-line circuit extending between a sub-station and a central or connecting station, a central-station extension thereof passing through an electro-magnet adjusted to respond only to strong electric currents of uniform direction, and a series of successive spring-contacts, each being adapted to be controlled by one other of the lines comprising the system, an automatic connecting apparatus of the character herein described, actuated by clock-work, controlled by the electro-magnet in the said main circuit, and adapted to be operated from a distant station of the said circuit to disconnect the said circuit from its normal earth-terminal, to select any other desired circuit, and to connect the said original circuit thereto by means of the spring-contact of the second circuit, a branch circuit at the sub-station, including a battery or equivalent source of current electricity of uniform direction, an indicator included or adapted for inclusion in the main line to indicate the movements of the distant connecting apparatus, a second branch circuit, including the telephones, a polarized call-bell, and a generator of electricity adapted to develop and transmit rapidly-alternating electric currents, whereby a distant bell may be rung without affecting the intermediate controlling electro-magnets, and a key connected permanently with the main line and having its back contact connected with the bell and telephone branch, and its front contact or anvil connected with the battery branch, as and for the purposes specified.

3. An automatic telephone-exchange consisting of a series of telephone-lines extending from a series of sub-stations to a central point or connecting-station, each of the said lines being provided at the central point with a rotating cylindrical circuit-changer actuated by a clock-train or other suitable motor, and governed from the sub-stations by an electro-magnet in the main circuit, the said circuit-

changer being provided with a number of conducting-cams, and being always electrically united with the said main line, and adapted to control, by means of said conducting-cams, a contact-spring of each other line of the system and its own ground contact-spring simultaneously, whereby each sub station may at will operate its own circuit-changer to disconnect its own ground-terminal, and to connect itself with any other line, as may be desired, as herein specified.

4. An automatic telephone-exchange consisting of two or more lines or main circuits, each extending between a central or connecting station and one or more sub-stations, an automatic connecting mechanism at the central station for each line, comprising a rotatory circuit-changer in permanent electric connection with said line, actuated by a clock-motor and controlled by an electro-magnet in its own line-circuit operated from the sub-stations, and a series of spring-contacts, one for each additional circuit or line entering the central station, the rotatory circuit-changer being provided with conducting-cams, which engage successively the several contacts of the several lines, maintaining the engagement and contact with the spring representing any desired line as long as required, a normally-open branch for each line, adapted to be closed by the cam effecting the connection and shunting the electro-magnet and intermediate contacts of the line, a battery or other source of electricity supplying a current of uniform direction, and an electro-magnetic indicator at each sub-station, an alternating current-generator, and a call-bell in a separate branch circuit, also at each sub-station, and a key which when at rest connects the call-bell branch, and when depressed the battery branch, with the main line, substantially as described.

5. In an automatic telephone-exchange system, a telephone main circuit extending between a central or connecting station and one or more sub-stations, and provided at each sub-station with two branches, one including an alternating current-generator, a bell, and telephones, the other including a battery or straight-current generator, and a key or switch for connecting either branch at will with the main line, and at the central station with an extension passing through the controlling electro-magnet of a rotatory connecting apparatus, and placed in permanent electric connection with the said apparatus, and then passing successively through a series of spring-contacts, each of which is controlled by a connecting apparatus of another circuit, and also with a normally-open branch connected with the main line at a point external to the controlling-magnet, and branching to a series of twin or complementary contact-springs, one of which is fixed in close proximity to each of the main spring-contacts of the same circuit, substantially as and for the purposes described.

6. In an automatic telephone-exchange system, two or more lines or main circuits, each extending between a central or connecting station and one or more sub-stations, an automatic connecting mechanism at the central station for each line, the said mechanism being actuated by a clock train controlled by an electro-magnet in its own circuit and operated from the distant sub-station to connect the said line with any other line, as may be desired, a normally-open branch circuit for each line adapted to be closed by the act of connecting any two lines and operating to prevent interference from a third line, means, substantially as indicated, at each sub-station for directing a steady battery-current to line to operate the automatic connecting mechanism and for arresting the same at the moment when any desired line is connected, and other means, as described, for sending call-signals over the connected lines, which call-signals shall not affect the intermediate controlling-magnets.

7. The combination of two or more telephone-line circuits converging to a central station, a rotary clock-actuated cylindrical circuit-changer for each line, a series of conducting-cams on each cylinder, a controlling electro-magnet for each line adapted to respond to steady currents of one direction, a series of line contact-springs at each cylinder, one for each additional circuit, said springs resting normally on a back contact leading to ground, but each adapted to be raised therefrom by one of said cams, a contact-spring at each circuit-changer forming part of the circuit to which the latter belongs, a conducting-disk carried by the cylinder and normally in contact with said spring, said disk being also in connection with the ground, a series of conducting projections carried by said cylinder, each connected by a cross-wire with one of said cams, said projections being arranged to act successively upon said last-named spring at the same time that the corresponding cam acts upon its line-spring, and means, as specified, for stopping each circuit-changer at any desired point, whereby the operator at any station can connect his line with any desired line through a cam, cross-wire, and projection, and simultaneously disconnect each line from its normal earth-terminal, each sub-station being provided with a constant source of current electricity, a key to direct the same to the line, a magneto-generator adapted to send rapidly-alternating pulsations to line, whereby the distant bell may be rung without affecting the intermediate controlling electro-magnet, and transmitting and receiving telephones, substantially as specified.

8. The combination of a main electric circuit with a rotatory circuit-changer or commutator, having permanent electrical connection by means of contact and friction springs with the said electric circuit, and driven by a suitable motor governed as to its motion or rest by an electro-magnet included also in the said circuit, and a series of separate and independent electric circuits, each of which is con-

trolled by the said rotatory circuit-changer by means of a series of spring-contacts, one for each of the said circuits, the said springs being within range of and adapted to be engaged by a series of cams on the cylindrical surface of the rotatory circuit-changer, and to be thereby transferred from their normal contact into contact with the circuit of the electro-magnet controlling the rotatory circuit-changer, substantially as hereinbefore described, and for the purpose of uniting the said circuit with any predetermined one of the series represented by the several contact-springs.

9. The combination, substantially as hereinbefore described, of a rotatory circuit-changer or commutator having permanent electrical connection by means of contact and friction springs with an electric circuit, and driven by a suitable motor governed as to its motion or rest by an electro-magnet included in the said circuit, with a series of spring-contacts, each included in a separate electric circuit, all of the said spring-contacts being controlled by the said rotatory circuit-changer, each in its own time, by means of cams adapted to lift the said springs, the said cams being regularly arranged round the cylindrical surface of the said circuit-changer, for the purposes specified.

10. The combination, with a series of rotating cylindrical circuit-changing apparatuses, (each normally at rest and each driven by a clock-train or other suitable motor,) the said motor being controlled as to its arrest and release by an electro-magnet, with a series of electric circuits, (one for each of the said circuit-changers,) each circuit extending from one or more distant stations through the electro-magnet, and one or more spring-contacts of its own rotatory circuit-changer, and through one spring-contact at each other rotatory circuit-changer, and a normally-open branch circuit for each main circuit extending from a point on the said main circuit external to the electro-magnet and branching to a series of twin contact-springs, one of which is in close proximity to but insulated from each main-circuit contact-spring at every rotatory circuit-changer, with the exception of the one controlled over that special line, all substantially as and for the purposes described.

11. An automatic connecting device for telephone-circuits, comprising the following elements in combination: a commutating-cylinder having at one end a conducting-disk and a non-conducting disk with conducting projections on its rim, having also a series of conducting-cams ranged spirally or otherwise regularly round its surface, each cam being united by a cross-wire with one of the projections on the non-conducting disk, a face-plate at the other end of said cylinder, having a series of stop-pins equal in number to the said conducting-cams plus a unison-pin, an electro-magnet, armature, and bell-crank lever adapted to engage with the said pins and to control the movement of the cylinder, a clock-motor to actuate the said cylinder when released from the control of the said pins, a contact-spring bearing normally upon the edge or rim of the conducting-disk, but adapted to be raised therefrom by the action of the projections of the non-conducting disk, a second contact-spring bearing upon the cylinder-axis and in permanent electric connection with the said conducting-disk, a series of contact-springs, one included in each other electric circuit of the system, supported at one side of the cylinder, in the path of the cams thereof, and adapted to be engaged and held thereby, and a series of supplementary springs connected with branch circuits of the several lines, one of the said supplementary springs being placed side by side with its own main-circuit spring and in immediate proximity thereto, so as to be raised and brought into contact by and with the same cam that raises the said main-circuit spring, substantially as herein described.

12. The combination, substantially as hereinbefore described, of three or more main-line circuits, each extending at a central station through an electro-magnet controlling the movement of a rotatory circuit-changer, and through a series of spring-contacts controlled by the rotatory circuit-changer of every other line, and a branch circuit (normally open at its extremity) extending from a point on the main line outside of the electro-magnet and branching to series of twin or supplementary contact-springs, one of the said series being placed in close proximity to the main-circuit contact-spring at every rotatory circuit-changer except that of its own line, so that when any two lines are united through the said circuit-changers a double route of union will be provided, the branch circuit being caused to shunt the electro-magnet and intervening spring-contacts, whereby continuity is improved, and whereby a third sub-station line is prevented from interfering with any connection already formed.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 24th day of September, 1885.

THOS. D. LOCKWOOD.

Witnesses:
GEO. WILLIS PIERCE,
GEO. H. E. TROUVELOT.