(No Model.) 3 Sheets—Sheet 1.

J. A. McCOY.

SYSTEM OF TELEPHONIC INTERCOMMUNICATION.

No. 367,219. Patented July 26, 1887.

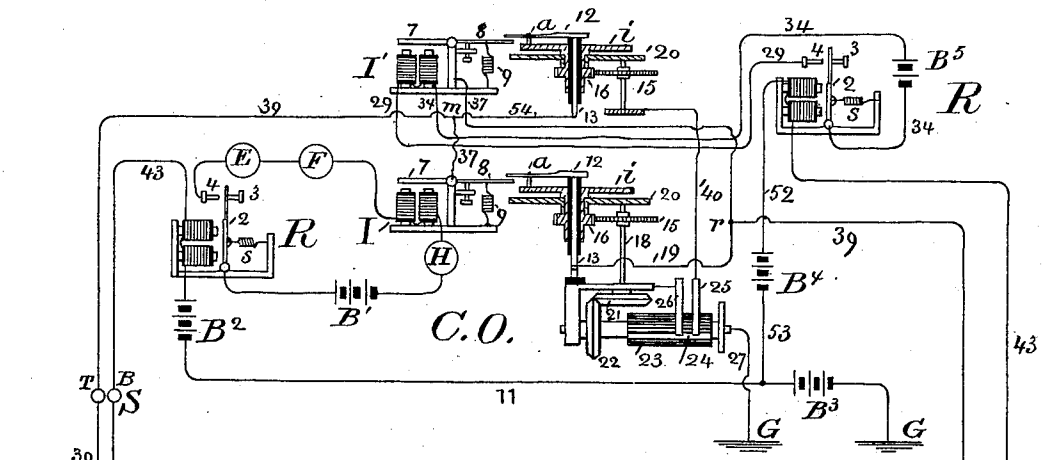
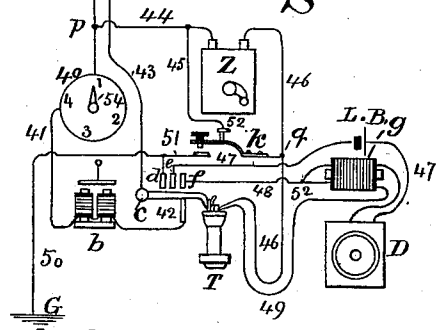


Fig. 1.



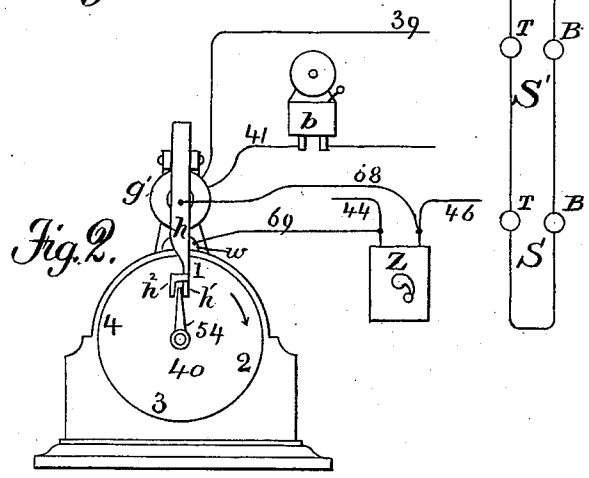


Fig. 2.

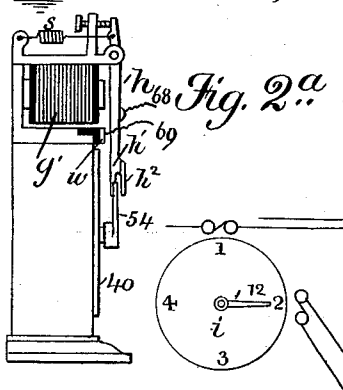


Fig. 2a.

Fig. 3.

Witnesses.
Geo. Willis Pierce.
W. M. Berthold.

Inventor.
John A. McCoy

N. PETERS, Photo-Lithographer, Washington, D. C.

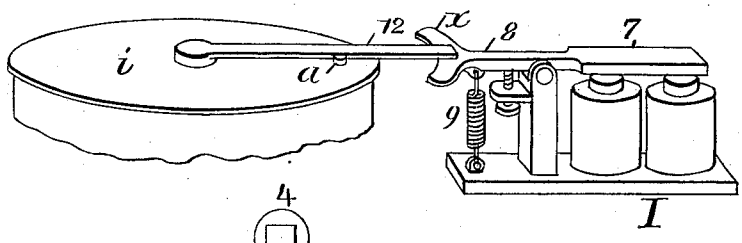
(No Model.) 3 Sheets—Sheet 2.

J. A. McCOY.

SYSTEM OF TELEPHONIC INTERCOMMUNICATION.

No. 367,219. Patented July 26, 1887.

Fig. 4.



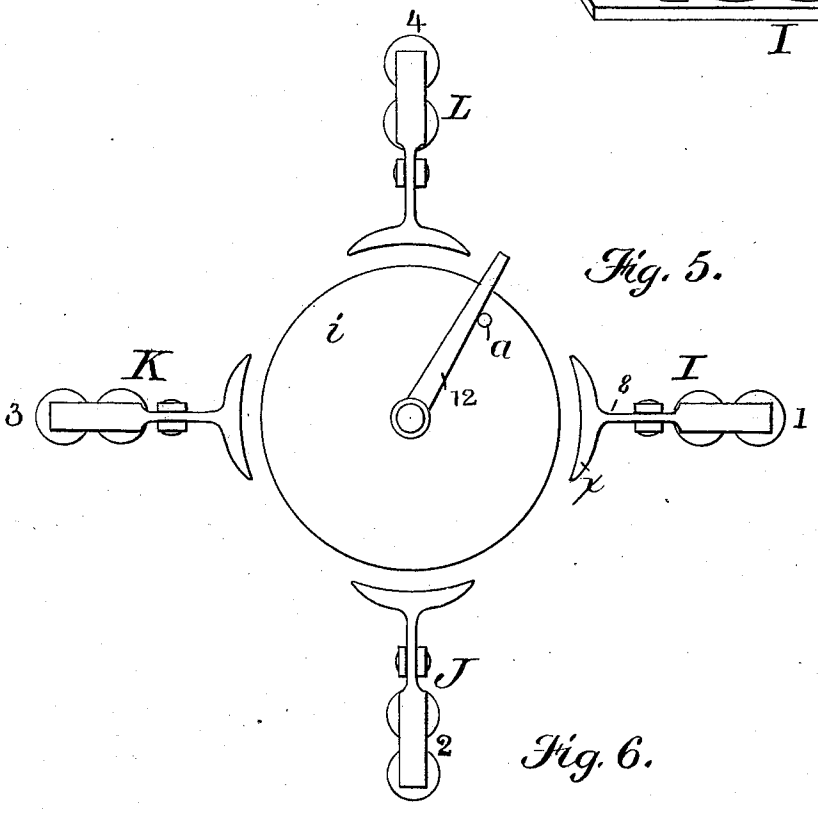
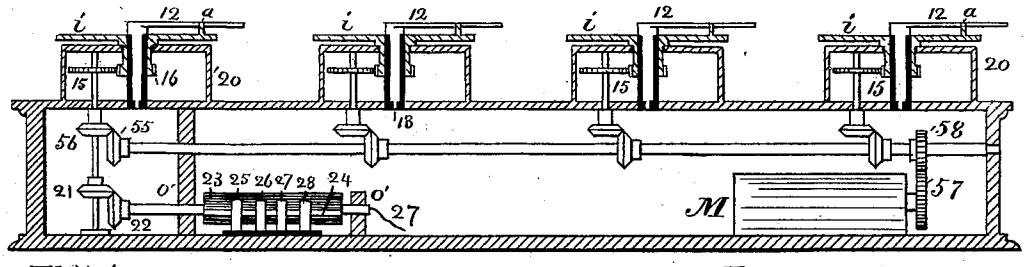


Fig. 5.

Fig. 6.



Witnesses.
Geo. Willis Pierce,
W. M. Berthold.

Inventor.
John A. McCoy,

(No Model.) 3 Sheets—Sheet 3.

J. A. McCOY.

SYSTEM OF TELEPHONIC INTERCOMMUNICATION.

No. 367,219. Patented July 26, 1887.

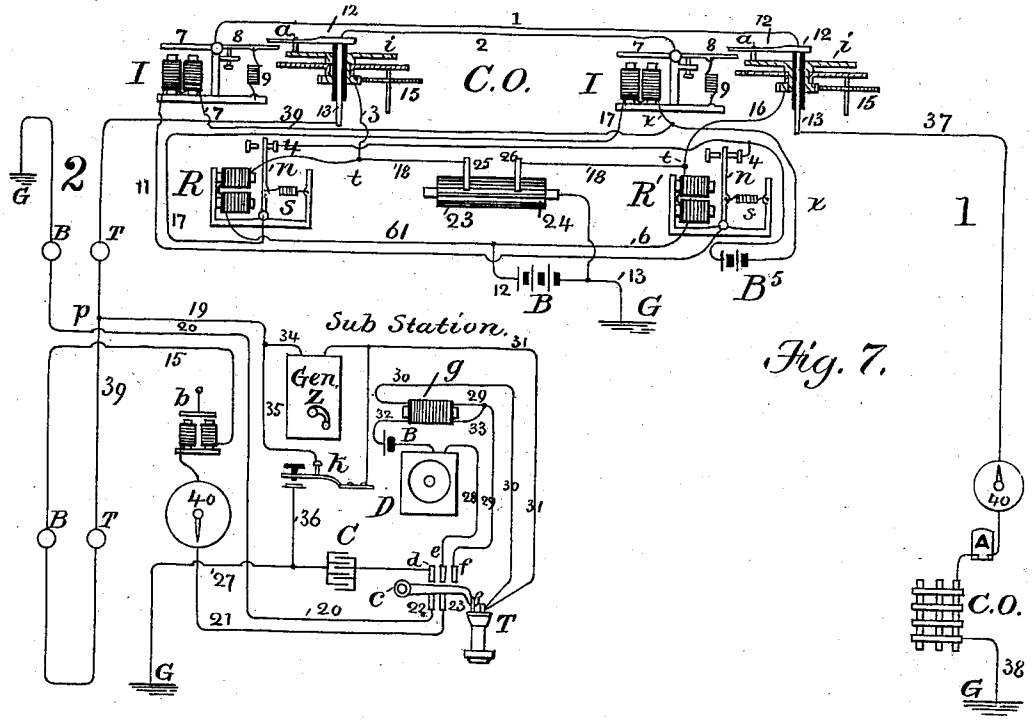


Fig. 7.

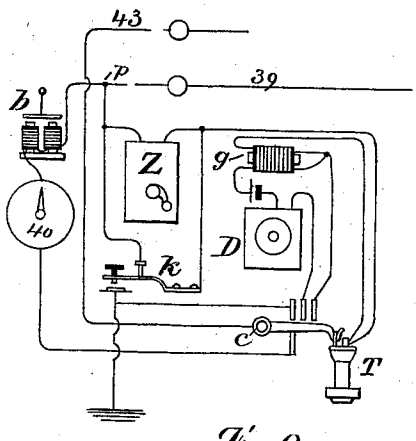


Fig. 8.

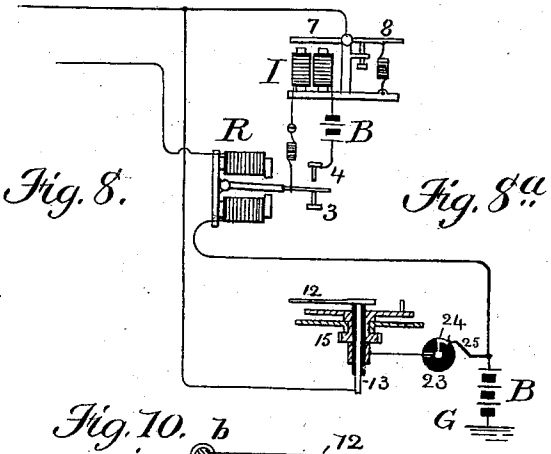


Fig. 8a.

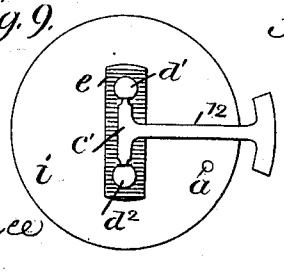


Fig. 9.

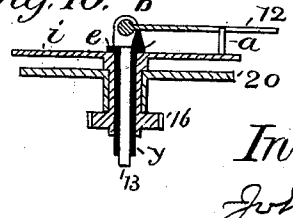


Fig. 10.

Witnesses.
Geo. Willis Pierce
W. M. Berthold.

Inventor.
John A. McCoy

UNITED STATES PATENT OFFICE.

JOHN A. McCOY, OF MEDFORD, MASSACHUSETTS.

SYSTEM OF TELEPHONIC INTERCOMMUNICATION.

SPECIFICATION forming part of Letters Patent No. 367,219, dated July 26, 1887.

Application filed January 29, 1887. Serial No. 225,862. (No model.)

To all whom it may concern:

Be it known that I, JOHN A. McCOY, of Medford, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Systems of Telephonic Intercommunication, of which the following is a specification.

My invention relates to central-office or exchange systems of intercommunication in which the speaking-telephone is generally utilized.

The ordinary telephonic "exchange" or "central office" is now a well-known institution, and has proved to be extremely useful in a large number of cities and towns. It has not, however, proved remunerative in small towns or villages, for reasons which are not here necessary to state.

The object of this invention is to furnish a system of intercommunication for such towns as are unable to sustain a regular central-station organization, whereby each and every sub-station in the system is enabled to place its own line in connection with any other line radiating from the same central point; to signal a distant sub-station over the compound line thus constituted without impairing the electrical connections thereof; to communicate orally over the same line with the said sub-station, and, finally, by the simple act of replacing his telephone, to restore the original condition of both lines. Such an organization may consist solely of a number of short or exchange lines, all converging from different points within a limited area to the same central point or station. It may, in addition to a series of such lines, include one or more trunk or inter-urban lines leading to distant central stations, or it may comprise a series of trunk lines connecting a main and central exchange with a number of outlying and subordinate exchanges. The nature and character of the problem, and of the mode in which it is solved by my invention, may be stated as follows:

Each sub station must be enabled at will, by the manipulation of its own operator, to connect its own line with any other disengaged local or trunk line in the system, and to retain such connection as long as may be necessary. Provision must be made whereby other lines or sub stations shall be prevented from interfering with or interruping the connection already formed between any two lines for through communication. The initiatory sub-station must be enabled to send call-signals to the station desired without affecting the central-station connecting appliances. Each sub-station must have the power to restore the normal connections upon the completion of a communication. Upon the establishment of such a through-line, through the operations of any sub station, it is of course also essential that the normal central-station ground terminals of both lines be disconnected. In the accomplishment of these operations by my invention I provide a central station where the mechanism and appliances required for the automatic operation of the system are located, and two or more sub-station lines may converge to this point, each line having one or more sub-stations located thereon. At each sub-station is, as usual, a call-bell and telephones, and also a dial indicating the number of the several lines composing the system. A pointer, by means of clock-work or by means of any well-known motor apparatus, rotates upon this dial, and when it passes the number of any line represented upon the dial, indicates that the apparatus at the central station is at that time in such a position that the sub-station may, by taking proper action, connect its own line with the line indicated by the pointer.

The dial mechanisms are preferably arranged to run a slight degree faster than the corresponding mechanism at the central station, and preferably, also, is arranged to stop at the end of each revolution, or at any suitable zero-point, before the said central-station mechanism has completed an equal revolution. The two mechanisms are thus maintained in unison, and by an electro-magnetic starting device, to be hereinafter described, operated by an automatic circuit-controller at the central station, the several sub-station dial mechanisms are all simultaneously started as soon as the slower central-station mechanism shall have completed its own similar revolution.

At the central station I provide a number of dials, disks, rings, or equivalent appliances, one for each line, all revolving in unison, being operated, if desired, by a common shaft and by means of a common motor. These disks are for a moment only in each revolution in connection with the earth, and constitute

the earth terminals of their several lines. Mounted upon each disk is an arm or pointer hung independently of the said disk, but normally participating in its motion by resting against a lug or pin on its surface, or within a hole or slot in its substance. This arm is connected directly with the main line, constituting, for the purpose of connecting the said line with any other line, the practical terminal thereof, and through it and the disk the said main line may be grounded. It may be, however, lifted from the disk, and when so detached its motion ceases and the line it represents is disconnected from its momentary ground terminal and electrically transferred to the lifting instrumentality. To effect this change a number of electro-magnets (one for each other line in the system) are arranged around each disk, and their armature-levers are adapted, when actuated, to engage with the rotating pointers and to lift them out of engagement with their respective disks. There is an electrical connection between the armature-lever of each of these electro-magnets and the main line which it represents, and thus by contact between the levers and the pointer lifted thereby, which represents the line desired, the two lines are brought into union for through communication; and by special instrumentalities, hereinafter to be specified, the said compound line is constituted without including any electro-magnets therein, which is decidedly advantageous. This connection is effected by means of a relay and battery, both being normally connected with the circuit, which, however, is not permanently grounded, the circuit of the battery being thus incomplete, except as herein provided, for an instant in each revolution of the several central-station disks. When a telephone is removed from its place at any sub-station, the line becomes automatically grounded at that point, closing the relay and battery circuit, and the relay becoming operative closes a local circuit, including the connecting-magnets (one at each disk) representing that line.

For the purpose of starting the sub-station dials as soon as the central station disks also have completed their revolutions, I provide a rotating cylinder with a conducting-strip throughout its length, this strip being in electrical connection with a ground-wire. Every line, after passing through its own rotating disk, terminates in a contact-spring upon this cylinder, and by means of the ground-contact strip all the lines are thus completed for an instant once in each revolution. The main-circuit battery at this moment vitalizes the releasing-magnets at the sub-stations, and the dial mechanisms at all of the said stations are simultaneously started.

The sub-station dials are marked with figures, representing the lines in the system, as already stated, and the figures at any moment indicated by the pointer at any sub-station represent the line which at that moment the connecting apparatus of such sub-station is in position to connect with. Thus when the pointers of the sub-stations on line No. 1 point to line No. 2 they indicate that the central-station disk of No. 2 line has its revolving arm in position approaching the electro-magnet armature-lever controlled by line No. 1, and that a connection between these lines may now be effected by either one. Moreover, when the pointers of line No. 1 at the sub-stations indicate No. 2, the pointers of No. 2, in like manner, indicate No. 1, and so on through the entire system.

The above is an outline of the principal features and appliances which constitute my invention, although there are many details which will be more closely described in connection with the drawings which form a part of this specification.

In the drawings, Figure 1 is a diagram of the electrical connections of one way in which my invention may be carried out. Fig. 2 shows apparatus indicating a front view of a form of sub-station dial and its electro-magnetic controller. Fig. 2^a is a side elevation of the same. Fig. 3 indicates, relatively, the arrangement at the central station of a system of four revolving disks, representing four main lines. Fig. 4 is a perspective view of a portion of the rotating disk, pointer, and connecting-magnet. Fig. 5 is a plan view of the same, showing four connecting-magnets. Fig. 6 is a view of motor mechanism, showing one way of revolving the several disks and the grounding-cylinder, and indicating that the disks and cylinder work synchronously with one another. Fig. 7 is a diagram representing a modification of my exchange system. Fig. 8 is an enlarged diagram of the sub station connections as in Fig. 1. Fig. 8^a is a modified central-station arrangement, including a polarized relay. Figs. 9 and 10 are details in elevation and plan of a modified rotating disk and pointer.

It is easy to understand that many modifications in details may be made in an invention of this character, and that the essence of my invention is in the peculiar arrangement of circuits and in the relation of the said circuits with the appliances indicated to procure the special results which are herein specified.

I will now describe the circuit arrangement shown in Fig. 1, referring to that figure, as well as to Figs. 2, 3, 4, 5, and 6.

In Fig. 1 C O represents a central station, and 1 and 2, respectively, two double-wire subscribers' lines entering the same. Of course any reasonable number of sub-station lines may be arranged in the same way, but the system can be equally well illustrated by showing but two lines, and this, for the sake of clearness, is preferable. S S′ indicate the sub-stations, at one of which the connections of the sub-station apparatus are fully traced. It will be observed that in this embodiment of my invention both ends of each sub-station line terminate at the central station. At the central station each line is provided with a relay, R, controlling a local circuit containing a number of

connecting electro-magnets, E F H I, one for each line, including its own. In the drawings one of these magnets, I, only is shown, the others being merely indicated by circles in one of the local circuits, to show that they may be connected in the same local circuit. Each line is also furnished with a rotating disk, dial, or ring, *i*, kept in rotation continuously or periodically by any suitable motor in a manner well understood by those skilled in the art, and an arm, 12, normally rotating with the said disk, but capable of being disengaged therefrom. A rotatable cylinder, 23, common to all lines and adapted to ground them once for each revolution, is also provided.

At each subs-tation is a call-bell, *b*, transmitting and receiving telephones D and T; a call-generator, Z, an indicating-dial, 40, of suitable construction, a circuit-changing press button or key, *k*, and a gravity or other telephone switch, *c*.

Each sub-station circuit when at rest may be traced, as in the case of No. 1, as follows: Beginning at the earth, G, at the central station, the circuit leads through battery B^3, line 11, battery B^2, relay-magnet R, line-wire 43, to and through as many sub-stations as may be located on the said line-wire, passing, however, at each sub-station through the telephone-switches, bell-magnet, and dial-magnet only. After extending to the most distant sub station on the line, the circuit is retraced and is branched or legged into each of the said sub-stations, the calling-generator and telephones being connected with this branch of the return-wire, which in all cases is normally (or while the telephone is in place) open.

The details of the sub-station connections and the telephone branch will be hereinafter described.

The return-wire 39, after passing and branching into all of the sub-stations, reaches the central station, and is there permanently united with the rotatable arm 12 of its own central-station disk *i*, the circuit thence continuing through the said disk (by reason of the engagement therewith of the arm 12) to the frame 20 and actuating mechanism 15 thereof, and by wire 40 to ground-spring 25. This spring rests upon a rotatory cylinder, 23, which works with and in synchronism with the disks *i*, and has a conducting-strip, 24, let into its surface longitudinally, this being electrically connected through the cylinder-bearings, or otherwise, and by wire 27 to the earth G. It is evident, therefore, that the circuit, considered as a whole, is permanently grounded at the battery end, but is open at the disk end, except for an instant during each revolution, when the terminal springs are in contact with the conducting-strip of the cylinder 23. Consequently there is no current flowing through the relay-coils R, which are normally inert. This description answers for all the lines converging to the central station.

The disk *i* may be actuated, as shown in Figs. 1 and 6, by any suitable motor, M, through intermediate spur-gear, 57 and 58, and bevel-gear 55 and 56, and may be permanently adjusted to run at a proper degree of speed by suitable speeding-gear, 15 and 16. The grounding-cylinder 23 is also preferably actuated by the same power, and is of non-conducting material, with the exception of the conducting-strip 24. It is mounted in bearings *o o'*, and the several springs 25, 26, 27, and 28 indicate the several circuit terminals.

It is of course not intended to specify any special construction or form of motor mechanism, the arrangement shown being purely illustrative, and being not material to my invention. Many plans for actuating the disks and cylinder will readily suggest themselves to persons skilled in mechanical arts. It is to be specified, however, that the essential condition of this part of my invention is that the disks and cylinder must move synchronously and isochronously with one another, and the simplest way of fulfilling this condition is to actuate them from the same motor with intervening motions or gears.

The motor mechanism may be in continual operation, so as to keep the several disks and the cylinder in continuous rotation; or, in a manner well understood, they may be arranged to come to rest at the close of each revolution, and to be tripped by an electro-magnetic disengaging device (not shown) immediately thereafter, so as to rotate in successive and periodic revolutions. In the latter case it would be necessary to furnish the motor M with a disengaging apparatus. A suitable instrument for this purpose would be that shown and described in Letters Patent issued to E. T. Gilliland, January 12, 1886, No. 334,014. For the purposes of this specification, however, I will hereinafter assume that the disks are continuously in motion.

As shown in the drawings, the arms 12, which constitute the terminals of the return or telephone wires 39, are insulated from the disk mechanism, and are mechanically independent of them—that is, the shafts 13, upon which they are supported, work loosely in the insulating-sleeve, and may be provided with a step, upon which they are sustained. Normally the arms 12 of the said shafts 13 rest upon the surface of the disks *i*, and, being engaged by the pins *a*, participate in the motion of the said disks. It is obvious that an equivalent construction would be to provide the arms 12 with downwardly-projecting pins or lugs, which, engaging with a hole or slot in the disk, would effect the same result. As an alternative way of mounting the arm 12 with respect to the disks *i*, I show the construction adopted in Figs. 9 and 10. By such a construction the upright shaft 13 is fixed in the insulating-sleeve *y*, which is loose in the hollow arbor of the motor mechanism. This sleeve is surmounted by a non-conducting plate, *e*, carrying a pair of pivot-sockets, *d'* and d^2, within which are mounted the pivot-points of a cross-bar, *c'*, of which the rotating arm 12 is an ex-

tension. The rotation of the said arm is, as in the first plan, controlled by its engagement with the pin *a*, or its equivalent. This plan is in some respects preferable, as the arm 12 can be raised without cramping its supporting-shaft.

Referring again to Fig. 1, I will now describe the means whereby one line is placed in connection with another.

At the battery end of each line, as hereinbefore described, is included a relay, R, provided with armature and lever 2, limit-stops 3 and 4 therefor, and a retracting-spring, *s*, whereby the lever is normally kept against the back limit-stop. The front limit-stop, 4, is one terminal of the circuit of a local battery, B', which includes an electro-magnet, I, for every line in the system—that is, if there be four lines in the system, in the local circuit of each line there will be four electro-magnets I, one for the disk of each line, including its own, as more clearly shown in Figs. 4 and 5—and the local circuit, including the battery B' and the several electro-magnets included therein, is controlled by the relay R through its armature-lever, which, when retracted by the spring, keeps the local circuit open, but which, when attracted to a forward position, closes the local circuit, energizing all of the magnets therein. Suppose, now, there are four disks, there will be four electro-magnets in each local circuit, and any one local circuit, beginning at its forward relay-stop, 4, may be traced through its electro-magnets near the disks of lines 1, 2, 3, and 4 successively, thence to the battery, and from the opposite pole of the battery to the metal of the armature-lever.

An armature, 7, and pivoted lever 8, (the armature being normally retracted by a suitable spring, 9,) is provided for the disk electro-magnets I, and these magnets are arranged as in Figs. 4 and 5. Thus in Fig. 5 it is assumed that the disk *i* shown is that of line No. 1. Electro-magnets I, J, K, and L are arranged at equal distances from one another around the periphery of the disk, these being controlled by and representing the respective lines Nos. 2, 3, and 4.

It will be observed that each of the levers 8 has a wide end piece, *x*. The object of this conformation is to insure that the lever when actuated shall engage the end of the arm 12 when it passes the said lever, and shall be able to lift the same, even though the arm, when the end piece, *x*, is elevated, shall have already passed the point precisely opposite the lever, or if it shall not have fully attained such opposite point. This provision might also be made by similarly broadening the end of the revolving arm, but I prefer the construction shown.

In Fig. 3 the precise arrangement of the electro-magnets with respect to the revolving disks is shown. The arms 12 in the drawings (which are shortened to allow of the introduction of the indicating-figures) show that lines Nos. 1 and 2 are reciprocally in connecting position with one another, and that lines 3 and 4 are similarly placed. If all of the disks and arms should now advance a fourth of a circle, No. 1 would be in position to connect with No. 3, and No. 3, in like manner, would reciprocally be in position to connect with No. 1, while the arms of disks Nos. 2 and 4 would be in position to be arrested only by action of the stations connected with their own lines, and do not register with any other. Upon the advance of all of the disks a second quarter of a revolution it will be seen that Nos. 1 and 4 may connect with one another, and that lines 2 and 3 are also in position for reciprocal communication, and so on. These conditions are of course variable in accordance with a variation in the number of lines in the system. Thus, when I in the local circuit of any main line becomes energized the broadened end of all of the armature-levers will fly up; but only that one which at the time the revolving-arm is passing will perform its function of raising the arm. The remaining levers will pass up above the level of their arms, and the said arms on their arrival at that point will pass under the lever ends, instead of over, as usual. One of the local circuits—that of line No. 1—with its magnet at disks 2, 3, and 4 is shown.

When the armature-levers 8 engage with the revolving arms, the latter are raised out of engagement with the pins *a* of the disks *i* and held quiescent while the disk passes on with uninterrupted motion. As the arm 12 is in permanent connection with the line and the disk and its mechanism with the ground-cylinder, the line which is represented by the said disk is thus disconnected from its intermittent ground and is brought into electrical connection with the armature-lever 8 of the controlling-magnet. This armature-lever 8 is connected by a branch wire, 37, with its own main-circuit return or telephone wire 39, and the connection thus made between the lever 8 and the arm 12 places the two lines interested in through connection.

The sub-station connections must now be described in detail, and are shown in Figs. 1 and 8.

The line leading from the central-station battery passes into the sub-station and is united to the telephone switch-bar *c*. The switch, being depressed by the weight of the telephone, makes contact with point 42, and from thence the line passes through the bell *b*, wire 41, and dial-magnet 40, out to return-line. A branch wire, 44, leads, as hereinbefore stated, to the call-generator and telephone-instruments. This extends from a point, *p*, on the return-wire to call-generator Z, and from thence, *via* wire 46, telephone T, wire 49, and secondary helix of induction-coil *g*, to switch-contact *f*. Here the telephone branch wire is normally open. It is completed to earth, when the telephone is to be used, by removing the telephone from its hook, and thus producing an electrical connection between the switch-

contacts *f* and *d* through the metal of the switch-bar *c*. The contact *d* is in connection with the ground-wire 50, and thus completes the branch to earth for as long a time as the telephone is in use, or is not in place upon the hook. The direct or bell line 43 from the central station, being permanently united with the switch-lever *c*, is also grounded under the same conditions. The primary circuit 47 of the sub-station transmitter D and local battery L B is also led through the switch by means of contacts *e* and *f*, the former connecting by wire 47 with the battery, and the latter being common to both secondary and primary helices by uniting the two at 52 in the usual way. The purpose of this is to close the primary circuit automatically when the line is in use, and to open the same again when the telephone is replaced. The generator is normally cut out of circuit by a shunt-circuit comprising a wire, 45, leading from the branch 44, external to the generator, to the back contact, 52, of a key or button, *k*. The key itself is permanently connected with the telephone-wire 46 at the point *q*.

The generator may be introduced into the circuit after the telephone is taken from its hook by pressing the key *k*, which also cuts out during the call the telephone and induction-coil.

When the line is not being used telephonically, the pointers 54 of the dials 40 are rotated by any suitable clock-train, (not shown,) and by their position indicate the periods when the sub-station operator may connect his line with any other. For instance, any sub-station on line No. 1, removing its telephone when the pointer passes figure 2, will instantly place his line in connection with line No. 2 by the operation of the controlling magnet and armature upon the revolving arm of line 2 at the central station, and this may be effected when the sub-station has not fully reached the proper figure, or when it has passed the figure for a short distance.

The sub-station dial-pointers may, if desired, be in continuous motion; but I prefer to so arrange them that they will come to a stop at the termination of a revolution and remain quiescent until a momentary electric impulse is received from the central-office battery. This I may accomplish by an apparatus similar to that shown in Fig. 2.

The clocks are adjusted to run a shade faster than the central-station mechanisms, so that they will stop before the grounding-cylinder at the central station fully completes its revolution. Thus when the said cylinder, at the completion of its rotation, brings its conducting or ground strip under the line-springs the battery-circuit is closed for a moment through the main line, and charges the dial electro-magnets *g'* at the sub-stations, which, attracting their armatures *h*, allow the detents *h'* to release the clock mechanisms, allowing the sub-station pointers to recommence their rotation.

It will be observed that there is a separate stopping-piece, h^2, also mounted on the end of the armature-lever *h*, fixed a short distance behind the first, and also, as more clearly shown in the side elevation, a sufficient distance in front of the stop *h'*, to insure that it will stand in the path of the moving pointer if the magnet is energized for a considerable time. A momentary energization—such as that occurring after every revolution—will not bring the second point into play, because the armature will be attracted but for an instant, and allow the pointer to pass between *h'* and h^2 before the latter can obstruct its path; but when the sub-station line is connected with any other for conversation the electro-magnets at any intervening stations are energized during the entire period of interconnection, and would allow the dials to move continuously were there no means of stopping them. The presence of the second stop averts this, and when the armature is thus attracted for a considerable time the second stop is brought in front of the pointers at all intermediate sub-stations, stopping them and indicating that the line is in use.

In the operation of this system, let it be supposed that a sub-station upon line No. 1 wishes to talk with a sub-station on line No. 2. He watches his dial, and when the rotating pointer reaches No. 2, or immediately in advance of or behind that point, he removes his telephone T from the hook, and the switch-lever *c*, released from the weight of the telephone, flies up, impelled in the usual way by a retracting-spring, disconnecting itself from switch-contact 42 and making contact with the upper switch-contacts, *d*, *e*, and *f*. The dial 40 and bell *b* are thus disconnected, and the main circuit is now divided into two complete circuits, one of which is used as a telephonic circuit, while the other is employed in maintaining the first.

Both sides of the double wire main line are grounded through the hook-lever *c*. The first action of the grounding of the circuit is to close the circuit of the batteries B^3 and B^2, through the relay R, *via* ground at central station, battery B^3, wire 11, battery B^2, relay R, line wire 43, switch-lever *c*, contact *d*, and wire 50, to ground at sub-station. The relay thus energized is brought into action, as hereinafter described. The other grounded circuit of the same line is from ground G at sub station, *via* wire 50, spring-contact *d*, hook-lever *c*, spring-contact *f*, wire 48, secondary of induction-coil *g*, wire 49, telephone T, wire 46, key *k*, back-contact screw, 52, wires 45 and 44, line-wire 39, rotating shaft 13, and arm 12; then by the pin *a*, disk *i*, motor-train 15, and wire 40 to terminal spring 25 and intermittent grounding-cylinder 23.

It will be noted that there is a branch connection-wire, 37, between the line-wire 39 and the lever 8 of the electro-magnet I of the same line. These two line-wires having been grounded, as described, at the sub-station, the

relay R attracts its armature 2, which closes the circuit of the local battery B′ at the point 4. The electro-magnets included in the said local circuit are thereupon energized, and the magnet I attracts its armature 7, raising its extension-lever S, which engages the disk-arm 12 of the disk of line 2, this arm being at the moment passing that part of its orbit (in correspondence with the sub-station dial of line No. 1) at which is located the controlling-magnet representing and operated by the relay of line No. 1. The arm 12 of line 2 is lifted from its engagement with the pin *a* of disk *i* and raised clear, being held quiescent and disconnected electrically, as well as mechanically, from disk *i* of line 2, and consequently from its intermittent ground contact; and as the magnet-lever S is connected by a branch, 37, with the main wire 39 of line No. 1, it is evident that the said main wire is now virtually extended through the said magnet-lever S to arm 12 of line 2, shaft 13 thereof, and *via* wire 19 to line-wire 39, through the station or stations of line 2, and back over return-wire 43 thereof, to relay R of the same line, and through wire 52, battery B^4, wire 53, and battery B^5, to earth at the central station. The obvious effect of this extension is to close the batteries B^4 and B^3 through the relays R, which, being thus energized, closes its own local circuit, including battery B^5 and magnet I′, with the result, as in line 1, that the armature-lever S thereof now becomes elevated and in turn lifts the rotating arm 12 out of engagement with its controlling disk. There are thus constituted two distinct paths between the talking-circuits of lines 1 and 2 through the central station, neither of which includes a single electro-magnet. One of these routes, beginning at the point *m* on wire 39 of the line No. 1, follows branch wire 37, lever S, arm 12 of line 2, shaft 13 thereof, wire 19, and point *r*, where it connects with the main wire 39 of line 2. The other route is from the same point, *m*, on line No. 1, *via* wire 54, shaft 13, and arm 12 of line No. 1, to lever S of the electro-magnet I′ of line No. 2, and thence *via* branch wire S7 to the junction-point *r* of line No. 2. These combinations, though requiring considerable description, of course practically occur simultaneously and in an almost infinitely brief space of time. A through line having been thus established, the sub-station S on line No. 1 rings the sub-station it desires on line No. 2 by turning the generator-crank, at the same time pressing the key *k* to introduce the generator into the line. The required station on line No. 2 responds by taking down its telephone, which act grounds both sides of line No. 2 through the hook-lever, precisely as in line No. 1. The relays at the central then maintain the union of the lines, the circuit of the main batteries being closed, and the two stations may maintain oral communication as long as desired. When conversation is concluded, each operator hangs up his telephone, and the battery-circuits being thereby opened, the arms 12 fall on their respective disks and are engaged by the pins thereof, the normal conditions being automatically resumed. When any two lines are united, it is impossible for any other line to interrupt, since the only way for one line to connect with another is through the rotating arms, which in case of a through connection rotate no longer. Since the union between any two lines is effected without the interposition of electro-magnets, the conversation transmitted is reproduced sharply and clearly.

If in all cases there were but one sub-station connected with each line, it would not be necessary to provide for the several lines an electro-magnet in the local circuit adapted to control the revolving arm of its own line. Not infrequently, however, it is required to connect a number of sub-stations upon a single line. In such cases it is necessary to provide means whereby when two stations of the same line are already communicating telephonically with one another other lines are prevented from interfering with them. This is accomplished by the extra electro-magnet. It is only necessary that the subscriber desiring to speak with another upon the same line shall operate his magneto-generator before taking the telephone from the hook. The circuit in this case will be from ground at subscriber's through the generator to the point *p*, and as the generators of all the sub stations are beyond all the bell-magnets on the line its calling-current passes through them all and to ground through relay and battery at the central station. In many cases batteries B^2 and B^4 in the ground terminal of each individual line would not be necessary, provided the main ground-battery B^3 were sufficiently large; but their use is advisable, as it is possible that all of the lines in a system might, upon occasion, be in use at the same time, in which case the drain on the battery B^3 would be heavy. By placing a portion of the battery, as shown, in each line, I divide the work and equalize the use of the battery-power. The apparatus and circuit arrangement which I have thus described show that each line has a movable terminal—*i. e.*, the rotating arm—and a number of fixed normally-open branch terminals—*i. e.*, the connecting armature-levers operated by the local circuits, all of the levers of one local circuit being united by a separate branch wire, 37, extending from the main telephone-circuit—and that an important feature of my invention consists in bringing the movable terminal of each line opposite and in position to be connected with one of the fixed terminals of the several lines successively, and in each case in also bringing the movable terminals of each of the said other and several lines at the same time similarly in position to connect with one of the fixed terminals of the first line, whereby it is provided that when any given line, say No. 1, is in position to connect with any other given line, say No. 2, No. 2 is also adapted and arranged to connect

in like manner with No. 1, the two apparatuses registering with one another, the effect in practice being that in each automatic connection of any two lines two parallel conversation-current routes are provided through the central station, the resistance being thus lowered and the integrity of the talking-circuit substantially insured. Moreover, this is brought about without the necessity of an operation tending thereto on the part of any sub-station operator, so that at the time of such connecting position occurring between any two lines the said two lines may thereupon be united by a simple act occurring at any of the sub-stations of either line.

Fig. 7 shows a modified system, in which it is not requisite to bring both ends of the line to the central station. In the figure I show two lines grounded at the distant end, instead of returning to central point, it being of course understood that a number of lines may in practice be so arranged. One or more of these may be trunk lines leading to distant stations. In the drawings, No. 1 indicates such a line, and will be equipped at the distant station with an indicating-dial similar to those in use at sub-stations, as well as with such other automatic or ordinary connecting apparatus as may be required. The automatic connecting apparatus at the central station on lines of this description is identical in character with that hereinbefore described in connection with the preceding part of my invention, but the connections and circuit arrangements differ. The apparatus at sub-stations is also the same as in the plan hereinbefore described, with the addition, as shown, of a condenser.

Referring to Fig. 7, No. 1 line, which in this case is assumed to be a trunk line leading to another central station, the circuit may be traced from the said distant station as follows: from ground G through wire 38, central-office apparatus and indicating-dial, main line 37 to rotating shaft 13 and arm 12; then through disk *i*, motor mechanism 15, and wire 16 to the relay R′; then to wires 6 and 12, to battery B and ground-wire 13, to earth at G at automatic central station. Line No. 2 may be traced from the central station to the distant ground terminal *via* ground-wire 13, battery B, wire 12, wires 61, relay R, wire 3, through mechanism 15, disk *i*, arm 12, and shaft 13, line-wire 39 to each sub-station. At each sub-station a branch, 19; from this side 39 of the circuit is conducted into the sub-station for telephonic and signal-sending purposes. After reaching the last sub-station the line doubles on itself and extends backward, looping into each sub-station and passing through the bell-magnets or call-receiving devices located thereat, and at last terminating at earth at the sub-station nearest the central station. It will be observed that in this, as in the other arrangement, there are no bell-magnets in the talking-wire. This system is a closed-battery-circuit system, and the current from the battery B, assisted, if necessary, by individual batteries, as in Fig. 1, keeps the lines normally charged. The local circuits at the central station are substantially identical in function and principle with those in Fig. 1; but they are open when the armature is attracted, and closed between the armature-levers *u* and back-stops 4 when the main circuits are opened and the armatures are retracted by their springs *s*. As shown, moreover, one local battery, B^5, is enabled to energize more than one local circuit.

Connected with each main circuit at a point, *t*, between the relay and disk mechanism of the same circuits, are branches 18, united with contact-springs 25 and 26, these resting on a rotating cylinder, 23, provided with a conducting-strip, 24, as in Fig. 1. The action in this case is therefore to short-circuit the battery through the relays and to withdraw it from the lines once in each revolution. The dial mechanism at the sub-stations must therefore, when this plan is adopted, be reversed, so that the motion of the several clocks, which, as before stated, comes to rest at the conclusion of each revolution, will be renewed by the discharging of their controlling-magnets at the instant when the main battery is short-circuited through the relays at the central station. In this arrangement, as in the preceding, a subscriber desiring to call another on his own line operates his generator while his telephone is in place on the hook. In such an event the magneto-current divides at the point *p* on the main circuit, part going over the line toward the central station and part through the bell-magnets to ground at distant end. If, however, a subscriber desires to call a station on another line, he removes, as in the former case, his telephone from its support when his pointer indicates on its dial the proper number. The direct contact to earth will in this way be broken by the lever *c* disuniting from contact-springs 22 and 23, and a circuit for talking will be established through condenser C; but when the direct ground is thus cut off no current from the main battery B can flow through the relay-coils R, and the armature *n* is retracted by spring *s* and closes on the back-stop, the local circuit, including the electro-magnet I, thereby attracting its armature and lifting the arm 12 of the desired line. This operation connects the two lines, as hereinbefore described, enabling, also, the relay of the second line to react upon the first, and thus to provide a double connection between the two lines. No. 1 then calls No. 2, and No. 2, responding, removes his telephone, and conversation is carried on. If No. 2 be a trunk line, the circuit will be direct to earth at the end thereof; but if a sub-station line, similar to No. 1, it will be through a condenser, as above explained. It is obvious that the two lines will remain connected until the battery-current is restored to the lines. When the short-circuiting springs 25 and 26 come in momentary contact with ground-plate 24 on cylinder

23, the main-battery circuit will be closed through the relay-coils and the local circuits opened. If, now, the conversation is finished and the telephones are replaced, the relays will remain closed and the normal condition is restored; but if the compound line be still in use the relays will reclose the local circuits, and through communication will be restored after a momentary interruption, which in practice will cause no inconvenience to the talking subscribers.

In Fig. 8ª I have shown that a polarized relay may readily be substituted, if desired, for the neutral relay shown in Fig. 1, the normal magnetism thereof acting in lieu of a retracting-spring when the battery-current is removed, in a well known manner. The connections are the same in every respect as in Fig. 1.

If desired, more than one sub station may be included on the same telephone or talking branch wires 44 or 19; but I prefer to provide each sub-station with a separate branch wire.

The electro-magnet of the indicator dials at sub-stations are preferably arranged to short-circuit the calling-generators when the main lines are in use, as in Figs. 2 and 2ª, by the wires 68 and 69, connected, respectively, with the indicator-armature and its front stop, *w*, and interruption of communication by sub-stations on the same circuit is thus averted.

In order that each sub-station may, if desirable, hear its own call, a buzzer may be included in the generator-circuit in the wire 51 of Fig. 1, or 36 of Fig. 7, between the generator and ground.

The principal advantages of my invention are that when any two lines are connected by means thereof no electro-magnets are included, and that the lines are thus entirely free from electro-magnetic retardation, that no complicated series of operations is necessary on the part of the sub-station operator, the operation of connecting one line with another being automatically performed by the action of the mechanism governed by the removal of the telephone from its support, and that when any two lines are so connected no interference on the part of a third line is possible.

Having now described my invention and its operation, I claim—

1. An automatic telephone exchange system comprising, substantially as hereinbefore described, two or more sub-station lines converging, for the purpose of intercommunication, to a central station, a series of conducting arms normally rotating continuously or periodically at the said central station in synchronism with one another, each constituting a terminal of one of the said lines, electro-magnetic connecting apparatus, as described, for each line, whereby the said line is enabled to stop the rotating arms of the several lines each in its own time, and thereby to selectively connect itself with any other line, and reactive reciprocal connecting devices, whereby the said other line thus connected is caused to separately stop the arm of the line initiating the connection and to connect itself thereto independent of the first connection, an indicator at each sub station indicating the proper time for connecting with any other line, and a circuit-changing device operated by removing the receiving telephone from its support and adapted to change the electrical condition of the circuit and thereupon to actuate the said central-station electro-magnetic connecting apparatus.

2. In an automatic telephone-exchange system, a series of sub-station lines converging to a central station, a series of conducting-arms normally rotating at the said central station continuously or periodically in synchronism with one another, each being a terminal of one of the said lines, a series of electro-magnets in local circuits, one local circuit for each line, and one magnet of each circuit being located within range of each arm, but differently placed for each arm, and each adapted to actuate an armature-lever electrically connected by a branch circuit with its own line and to engage a predetermined arm and thereby to stop the said arm and to connect the line represented by the said electro-magnet with the line represented by the said arm, a relay in each main-line circuit controlling the local circuit, including the connecting-magnets of its own line, and adapted to render the same operative upon a change in the electrical condition of its own line, means, as indicated, located at the several sub-stations, whereby any sub-station may ascertain which other line is at any moment in position to connect, and a circuit-controller actuated by the removal of the sub-station telephone and operating to change the electric condition of the line, and thereupon to energize the relay of said line.

3. In an automatic telephone-exchange system, two normally-open main lines, both entering the same central station for the purpose of interconnection and each extending to one or more sub-stations, a battery connected with the said lines, rotating arms at the central station, one for each line, moving in synchronism with one another and each arm practically constituting a terminal of its own line, a relay in the circuit of each main line controlling a local circuit, and an electro-magnet having an armature and armature-lever in each of the said local circuits, the said armature-lever being permanently united by a branch circuit to its own main line and extending within range of the rotating arm of the other main line, so that when actuated by its magnet it may engage the said arm and stop the same, as described, and an automatic circuit-closer at each sub-station operated by the displacement of the receiving-telephone and acting to ground the normally-open main-line circuit, whereby the relay of the line initiating the operation is energized and enabled to act through its electro-magnet and to unite the two lines together by

means of the engagement of the armature-lever of the said magnet with the rotating arm of the second line, substantially as described.

4. The combination, substantially as hereinbefore described, in a telephone-exchange system, of a series of sub-station lines converging to a central station and each extending to one or more sub-stations, each provided at the said central station with a conducting-arm normally rotated or adapted to be rotated synchronously with the arms of the other lines by a common motor mechanism, and constituting the practical terminals of their several lines; also with a relay included in the main-line circuit, together with a battery, the said main-line circuit being normally open, a series of electro-magnets in a local circuit controlled by each, and one of the said magnets in each local circuit being placed in proximity to the rotating arms of each of the said main lines, but at a relatively different point for each arm, an armature and lever for each magnet, each lever being electrically united to its own main line at a point external to the rotating arm of said line and adapted when actuated to engage with the rotating arm with which it is in proximity, to disengage the same from its motor mechanism and thereby to connect the two lines together, an indicating device at each sub-station to denote which rotating arm is at any moment passing an electro-magnet controlled by such sub station, as decribed herein, and an automatic circuit-closer at each sub-station, adapted to be brought into operation by raising the telephone from its support, whereby the act of removing the telephone at a sub-station on one of the lines is caused to close the main-battery circuit and thereupon to energize the relay of the same line, which, acting through its local electro-magnet, connects the said line with the line at the moment denoted by the indicator, disconnecting it from its motor, and thus furnishing an extended circuit for the battery-current and enabling the relay of the selected line to act reciprocally and through its electro-magnet to connect the two lines together independently, substantially as hereinbefore described.

5. In an automatic telephone-exchange system, a series of normally-open main-line circuits, each line having both of its ends terminating at the central station, a main battery and a relay included in circuit at the central station in one side of each of the said main circuits, a conducting-arm for each line rotating continuously or periodically in a horizontal plane included in circuit at the central station and united with the other side or branch of the said main circuit, a disk engaging each of the said arms and maintaining the motion thereof, a motor mechanism common to the series of disks and adapted to actuate the same synchronously with one another, a series of local circuits, one for each relay, a series of electro-magnets and armatures and armature-levers therefor in each local circuit, one of the said electro-magnets being placed in proximity to each disk and having its lever within range of the revolving arm thereof, for the purpose, when actuated, of disengaging the same from its motor and of holding the same inert as long as may be desired, a branch connection from each armature-lever to one side of its own main line at a point external to the revolving arm of said main line, an indicator-dial and pointer at each sub-station corresponding to the disks and arms of the central station and adapted to indicate by the position of the pointer the line which at any moment has its arm opposite to and adapted to be engaged by one of the electro-magnets of said sub-station line, and a circuit-closing switch at each sub-station operating by the removal of the telephone from its support and acting to connect the double-wire main line to earth and thus to divide the same temporarily into two independent circuits, one of the said circuits including the relay and battery and acting through the local magnets of said relay to maintain the continuity of the other of the said circuits, which is thus freed from electro-magnets and is adapted to serve as a talking-circuit only, substantially as hereinbefore described.

6. In an automatic telephone-exchange system, two main lines, each provided at a central station with a conducting-arm normally rotated or adapted to be rotated, and constituting, respectively, the terminal of their several lines, a relay, also included in the main-line circuit with a battery, the circuit being normally open, a connecting electro-magnet in a local circuit controlled by each relay, and each of the said magnets being mounted in proximity to the rotating arm of the opposite line, an armature and lever for each magnet united by a branch circuit to its own main line at a point external to the rotating arm of said line, and adapted, when actuated, to engage with the rotating arm of the other line to disengage the same from its motor mechanism and thereby to connect the two lines together, and an automatic circuit-closer at each sub-station brought into operation by raising the telephone from its support, whereby the act of removing the telephone at a sub-station on one of the lines is caused to close the circuit of the main battery and thereupon to energize the relay of the same line, which, acting through its local electro-magnet, connects the said line with the remaining line, thus furnishing an extended circuit for the battery-current and enabling the relay of the second line to act reciprocally and through its electro-magnet to connect the two lines together independently, substantially as herein described.

7. In an automatic telephone-exchange system, the combination of a series of main lines each extending from a central station to a number of sub-stations, and after reaching the most distant sub-station being retraced to the central station or to the sub-station nearest thereto, the bell-magnets at the several sub-stations being all included in one side of the

said main-line circuit, and the telephones and call-generators being included in normally-open branches extending into the said sub-stations from the other side of the said main-line circuit, so that the telephonic impulses from any sub station may reach the sub-station without passing through electro-magnets, with means, as indicated, at each sub-station for automatically closing the said normally-open telephone branches to earth and for simultaneously grounding the bell-magnet side of the circuit by taking the telephone from its support, and other means, as described herein, at the central station for automatically connecting the telephone side of the circuit with any other predetermined line, substantially as and for the purpose specified.

8. The combination, substantially as hereinbefore set forth, of a series of double-wire main lines converging to a central station and extending therefrom to one or more sub stations and back, the bells and indicators of each sub-station being looped from the outgoing wire and the telephones and call-sending apparatus of each sub-station being included in normally-open branches from the return-wire, a conducting-arm in constant or periodic revolution in permanent electric connection with the end of the return-line, a relay and battery connected with the end of the outgoing line, a local circuit and a series of electro-magnets therein, each adapted to engage and arrest the motion of one of the revolving arms, each local circuit being controlled by one of the said relays, and a circuit-closer at each sub-station controlled by the removal or replacement of the receiving-telephone and adapted to connect and disconnect a ground-wire to the normally-open telephone-branches, whereby both sides of the line are closed, and whereby one side of any line may be constituted a through telephone-circuit with any other line, and the other side enabled, through its relay, to maintain such telephone-circuit, substantially as described.

9. The combination, substantially as described herein, with automatically-operating line-connecting devices at a central station, of a series of sub-station indicating-dials and clock-operated pointers rotating thereon and indicating thereon the position at any given moment of the corresponding central-station-connecting device of its own line, the said pointers being adapted to come to rest upon the completion of each revolution, a main circuit extending from each sub-station to a distant central station, an electro-magnet included therein and adapted to control the said pointer mechanism and to periodically permit the said pointer to commence another revolution, and a non-conducting rotating circuit-closer at the said distant central station in said main circuit adapted to finish each revolution immediately after the sub-station pointer, and upon the conclusion of its revolution to effect a momentary change in the electrical condition of the line and to act upon the electro-magnet controlling the sub-station pointer, for the purposes specified.

10. The combination of a series of main lines converging to a central station and extending to one or more sub-stations, with a series of disks, dials, or rings, one for each line, rotating in synchronism with one another and impelled by a common motor, a series of conducting-arms, each electrically connected with one of the said main lines and normally engaged by and participating in the motion of one of the said disks, and a series of local circuits, each controlled by a relay in the circuit of one of the main lines, and each including a series of electro-magnets, one magnet of each local circuit being located near each revolving disk and provided with an armature and lever extending within range of the revolving arms and adapted, upon the energization of their magnets, to engage the said arms and to disengage them from the disks and motor mechanism, the several magnets of each circuit being, moreover, placed differently with respect to each disk and caused to correspond, as shown in Fig. 3, so that when the rotating arm of line No. 2 is in position to be engaged by an electro-magnet controlled by line No. 1 the arm of No. 1 is in like manner in position to be engaged by an electro-magnet controlled by line No. 2, and so on throughout the system, substantially as herein specified.

11. The combination, at a central telephone-station, of a series of disks, dials, or rings, each representing a main line and all maintained in synchronous rotation by a common motor, a series of revolving conducting-arms mechanically controlled by the said disks engaged thereby and revolving therewith, each arm being connected with a main line, a series of local electric circuits containing a series of electro-magnets, one electro-magnet for each local circuit being differently placed in proximity to each disk and provided with a lever attached to its armature, the said lever being adapted upon the energization of its magnet to arrest the motion of the arm revolving within its range, and a series of relays, each in the circuit of a separate main line, controlling and adapted to close the said local circuits and thus to arrest the rotating arm which at the moment may be passing any one electro magnet, substantially as described.

12. In an automatically-operated telephone-exchange, the combination of two or more double-wire main lines extending to one or more sub-stations, each line brought back on itself after passing all of its sub stations, and reciprocal automatic line-connecting devices at the central station, as described herein, whereby any main line when the telephone is removed at a sub-station is enabled to connect itself with any other selected line, and whereby any second line so connected immediately is enabled to react and to establish a second connection between itself and the first line by a parallel route, substantially as and for the purposes specified.

13. The combination, in a telephone-exchange comprising two or more lines extending to sub-stations, of rotating conducting-arms, one for each line, each arm constituting the terminal of its own line and adapted to be engaged by an electro-magnetically-actuated conducting-lever permanently connected with another line, a compound telephone-circuit extending from a sub-station upon one line to a sub station upon another line, including the rotating arms and the electro magnetically-actuated levers of both lines, a relay for each line controlling a local circuit, including electro-magnets adapted to actuate the connecting-levers and to engage and arrest the rotating arms, a maintaining-circuit including the said relay and a battery, and means at each sub-station, substantially as hereinbefore described, for establishing both of the said circuits by removing the sub-station telephone from its support, for the purposes specified.

14. The combination of a series of main lines converging to a central station and extending therefrom to a series of sub-stations, a series of synchronous rotating disks at the central station, one for each line, all operated by the same motor, a series of rotating arms constituting the line-terminals, each normally engaged by and rotating with its own disk, a series of arm arresting devices for each arm, one for each line, whereby each line is enabled to arrest the arm of its own or any other line at a predetermined point, an indicator consisting of a dial and rotating pointer at each sub-station corresponding to the arm and disk of its own line, but performing its revolution slightly faster than the said arm and disk, a stopping or unison device for the said pointer, and means, as indicated, comprising a device at the central station moving with the said rotating disks, for changing the electrical condition of the line on the completion of each revolution of the said disks to release the sub-station pointers and to permit them to start a new revolution in unison with the central-office disk, as described herein.

15. A series of telephone-lines centering at a common station and provided each with a number of fixed normally-open branch terminals, and with a constantly-movable main terminal, means for bringing the movable terminal of each line into juxtaposition with one of the normally-open branch terminals of each of the several main lines successively, and other means for electrically uniting both movable and fixed terminals of two lines at any moment in such connecting position upon a change in the electrical condition of either line and for arresting the motion of the movable terminals of both of the said lines as long as the union between them shall continue, substantially as hereinbefore described.

16. A series of telephone-lines centering at a common station and provided each with a number of fixed normally-open branch terminals and with a movable main terminal, mechanism for moving the said movable terminal of each and every line and for bringing the same into position to connect with one of the normally-open branch terminals of the several lines of the series successively, the fixed and movable terminals of the several lines being so arranged with respect to one another that when the movable terminal of a given line is in position to connect with the fixed terminal of a second line the reverse arrangement is likewise simultaneously effected, and the movable terminal of the second line is also in position to connect with one of the fixed terminals of the first, and reciprocal electro-magnetic connecting devices, as described, whereby the fixed and movable terminals of any two lines may be caused to unite with one another reciprocally for intercommunication, and whereby the movable terminals of both lines are engaged and arrested for the purpose of isolating both lines from possible interference by any other line during such intercommunication.

17. In an automatically-operated telephone-exchange, a series of main circuits extending to sub-stations, a relay in each main circuit at the central station, a rotating arm constituting the end of each main circuit, all of the said arms revolving or adapted to revolve in unison, a local circuit for each relay, each including an electro-magnet for each rotating arm, the magnets of the different circuits being differently disposed round each rotating arm and adapted, by means of levers extending into the path of said arms, to arrest the progress thereof, an indicator at each sub-station denoting the position of the said arms with reference to the electro-magnets of its own line, and an automatic circuit-closing switch operated by the removal of the telephone at each sub station, whereby, by noting the indicator and then removing the telephone, any sub-station operator is enabled to energize his own central-station local circuit and to engage the central-station rotating arm of any selected or predetermined main circuit, including his own, substantially as and for the purposes specified.

18. In an automatic exchange and at any sub-station thereof, the combination, substantially as hereinbefore set forth, of an indicating-dial automatically controlled from the central station, and a call-bell normally included in the main-line circuit, a call-generator and telephones normally included in a normally-open branch of the main circuit, extended from a point in such main circuit between the central-station end of the line and its nearest bell-magnet, and an automatic telephone-switch serving also as a telephone-support, and adapted, when in one position, to maintain the circuit through the bell and indicator, and when in the opposite position to disconnect the bell and indicator, to bring one side of the line into contact with a ground-wire direct and to close the normally-open telephone branch to earth also, thus establishing a telephone-circuit excluding the bell-magnets, for the purposes specified.

19. In a telephone sub-station apparatus

substantially of the character herein specified, the combination of the indicating-dial and pointer, the controlling-magnet and armature therefor, the call-generator, a normally-open shunt-circuit therefor, and a circuit-closer actuated by the indicator-controlling magnet when the line is being used by one sub-station to short-circuit the call-generators at the remaining stations on the same line, for the purpose of preventing interference by any sub-station during the communication.

20. The combination, in an automatically-operated telephone-exchange, of a disk rotating or capable of rotation, an arm representing the end of a main line and mechanically engaged by the said disk and normally participating in the rotation thereof, and a series of electro-magnets placed in order at different points round the said disk, each under the control of a separate and independent main-line circuit, and each adapted, if energized when the arm is passing it, to engage it, to disengage it from the disk and to thereby connect the line represented by the said arm with the line represented by the magnet operating to arrest the said arm, as shown in Fig. 5, and as described herein.

21. The combination, in an automatically-operated telephone-exchange, of a series of main lines converging to a central station and extending therefrom to one or more sub-stations, a series of rotating or rotatable conducting-arms, one for each line and each constituting a terminal of its own line, means, as described, for bringing the said conducting-arm of each line into position successively to be arrested by the electro-magnetic arresting devices controlled by each line, and also constituting a portion of the circuit thereof, placed in the path of the rotating arms and adapted, when energized, to arrest the same, said electro-magnetic devices and sub-station apparatus comprising an indicator to show the position of the several arms at any moment, and a circuit-changer operated by the removal of the telephone and acting to energize the said electro-magnetic arresting devices, whereby any sub-station upon any line is enabled to connect its own line with any other desired line simply by taking the telephone from its support when the indicator points to the number of the line desired.

22. In an automatically-operated telephone-exchange of the character herein described, the combination of a number of main-line circuits, each provided with a rotating arm, a disk and motor mechanism therefor, and a relay-battery and local circuit controlled thereby, the said local circuit including an electro-magnet and arm-arresting devices operated thereby, and the said electro-magnet being arranged at a definite point in the path of the rotating arm of its own line, and a circuit-changer at each sub station adapted to be operated by raising the telephone from its support, and thereupon, by effecting a change in the electrical condition of its own line, to energize the local circuit and electro-magnet and to arrest its own rotating arm, thus preventing other lines from interfering while any two stations of the same line are in communication with one another.

23. Two or more lines converging at a central station and extending therefrom, each to one or more sub-stations, each line being lapped back on itself, as described herein, so that all the sub station telephones may be on one side thereof and all the sub-station bell-magnets on the other, a circuit closer or changer at each sub-station actuated automatically by the act of removing the telephone from its support to change the electrical condition of the line with respect to a battery connected therewith, a rotating terminal at the central station for each line, and an electro-magnetic connecting device at the central station for each line, controlled by the sub-station circuit-changers and adapted to respond to the said electrical change effected by the operation thereof, the said devices comprising for each line a relay and local circuit, including a series of electro-magnets equal in number to the number of main lines, the whole arranged and connected substantially as herein shown and described, whereby any line is enabled upon the operation of a sub station circuit-changer to select the rotating terminal of any other line, to arrest the motion thereof, and to connect itself thereto, and when so connected to extend the same electrical condition throughout the compound line so constituted, which line is then enabled to act reciprocally, and through the operation of similar devices to engage the rotating terminal of the initiatory line, thus effecting a double connection of the two lines, substantially as specified.

24. The combination, in a telephone-exchange, of two or more lines centering in a central station, one or more sub-stations on each of the said lines, a circuit-changer at each sub-station actuated by the removal or replacement of the telephone and operating to change the electrical condition of the line, a conducting-arm at the central station for each line, kept in continuous or periodic rotation by a suitable motor common to all the said arms, each of the said arms constituting the connecting terminal of its own line, and a series of local circuits, one for each line, controlled by the sub-station circuit-changers, each of the said circuits including a series of electro-magnets provided with levers connected with branch circuits from their own line and actuated by their armatures, the several magnets in each circuit being each arranged with its lever in the path of a different one of the rotating arms, but each lever of the same local circuit being differently placed for each arm, whereby any rotating arm may be arrested by the elevation of a magnet-lever during the time the said arm is passing the said lever, and whereby the respective lines may thus be

united by the act of removal of the sub-station telephone and disunited by its replacement, substantially as described.

25. The combination, with a series of telephone-lines radiating each from one or more sub-stations to a common central station, of a series of normally-rotating conducting-arms, each connected with the end of one of the said lines, a series of conducting-levers for each line, one of each series being placed near each of the said rotating arms, and all of the levers of each series being united electrically to their respective lines at a point external to the rotating arm thereof and constituting normally-open branch circuits of the said line, a local circuit for each main line and a series of electro-magnets in each local circuit, each controlling one of the branch-circuit conducting-levers, and a relay in each main circuit actuated by a circuit-controller, also in the said main line at any station thereof and adapted to close the local circuit of its own line, whereby the local circuit of any main line may be closed from any sub-station of the said line, and an electric connection thereby effected between one of the connecting-levers of the said line and the rotating terminal of that one of the series of main lines which at the moment is passing the said lever, substantially as described.

26. The combination, with two connected double-wire telephone-lines, of a relay for each line, and connecting devices, as indicated, for each line, controlled by the relay thereof, whereby each line, by means of its relay and connecting devices permanently connected with one end thereof, is enabled to connect with the opposite end of the second line, for the purposes specified herein.

27. In a telephone-exchange system, the combination of two or more lines converging to a central station and extending therefrom each to one or more sub-stations, a relay in the circuit of each line at the central station, a rotating terminal piece for each line, local circuits, one for each line, which are automatically closed by the said relays when the telephone at any station on the said line is removed from its support, and electro-magnetic apparatus in the said local circuits adapted upon the closure thereof to engage the rotating terminal of another line and to connect the said other line with the initiatory line by a double connection independent of and excluding the relay-magnets of the several lines, substantially as and for the purposes described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 22d day of January, 1887.

JOHN A. McCOY.

Witnesses:
GEO. WILLIS PIERCE,
V. M. BERTHOLDE.