

F. A. LUNDQUIST & J. J. BROWNRIGG.

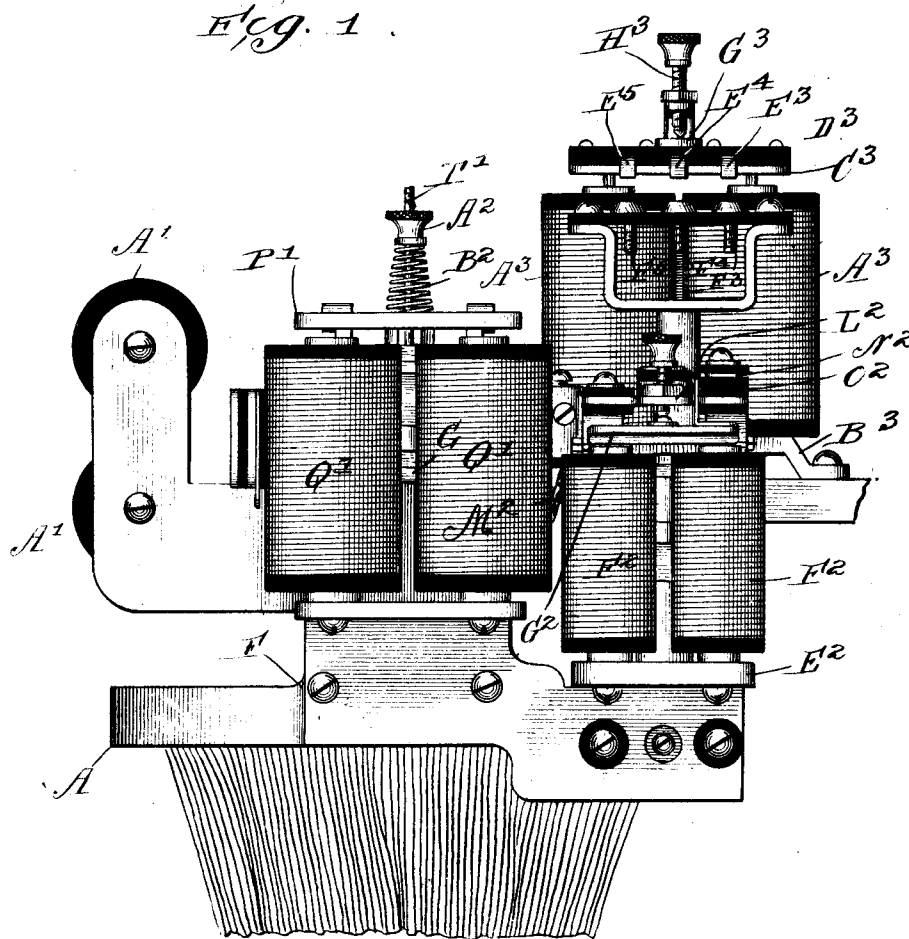
CENTRAL STATION SWITCHING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS.

APPLICATION FILED MAY 19, 1903.

1,128,701.

Patented Feb. 16, 1915.

8 SHEETS—SHEET 1.



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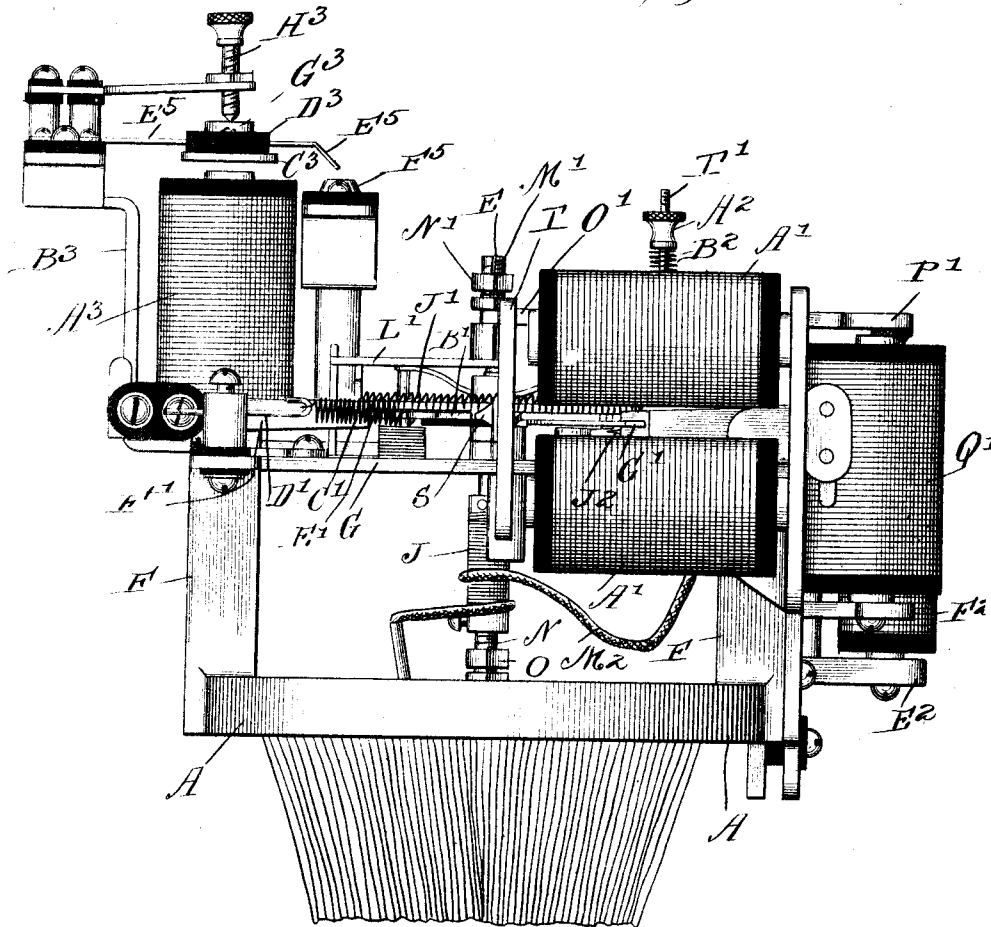
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8 SHEETS—SHEET 2.

Fig. 2



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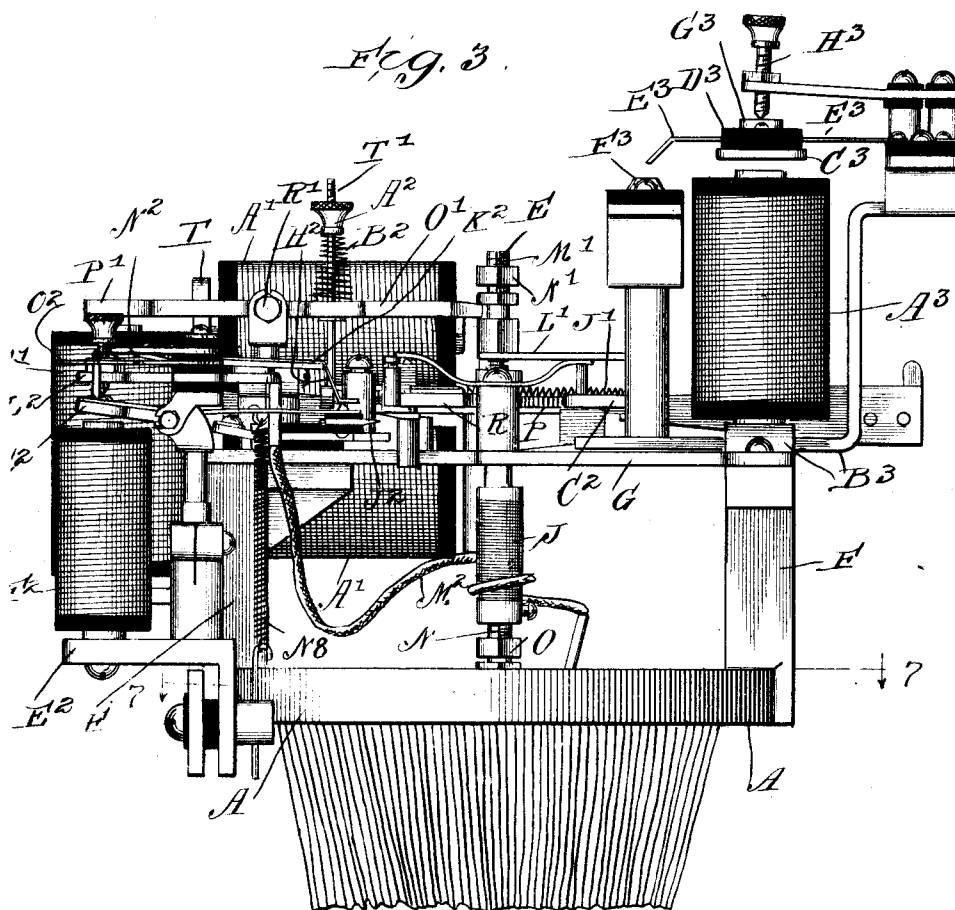
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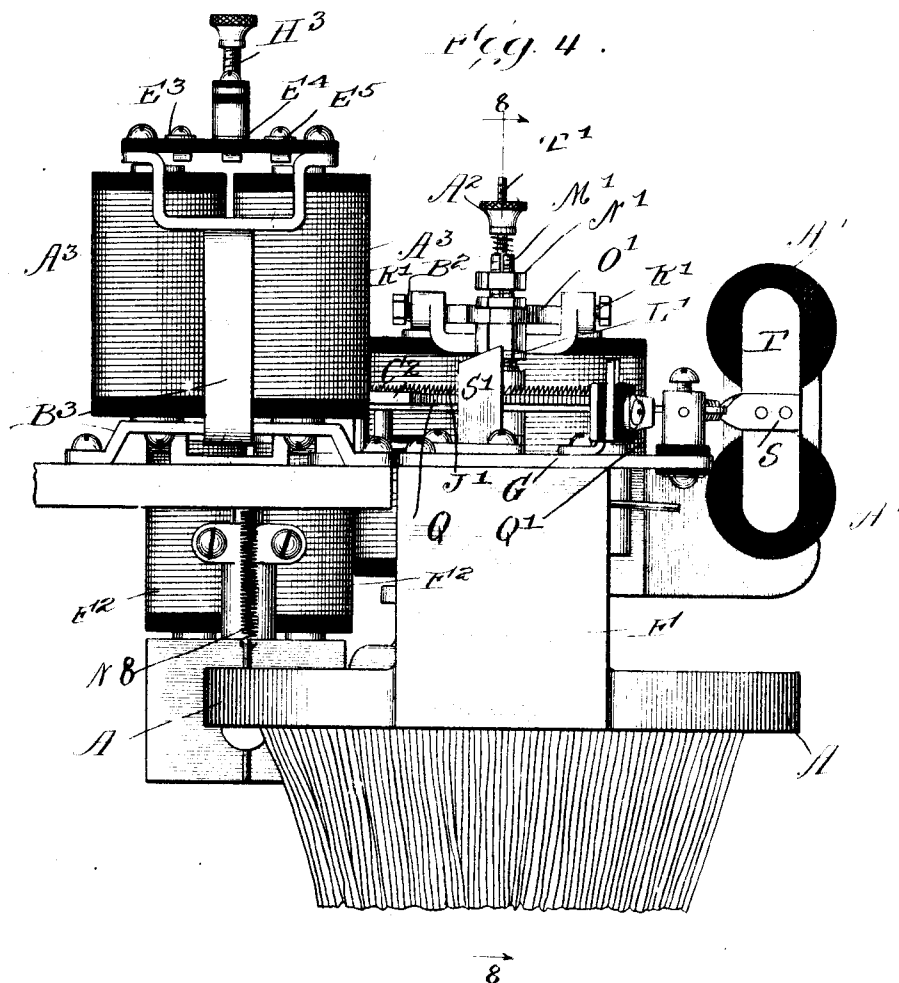
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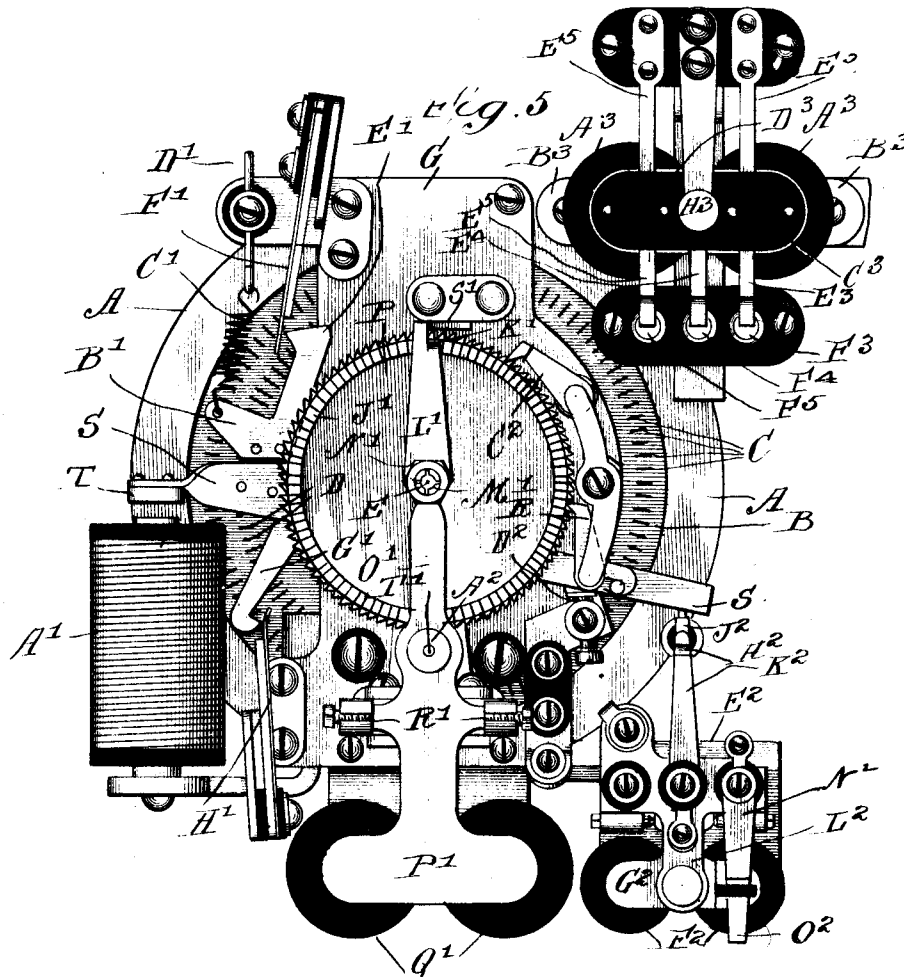


Fig. 9.

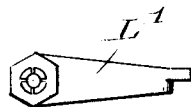
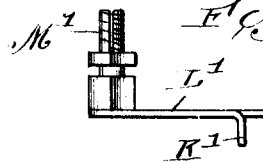


Fig. 10.



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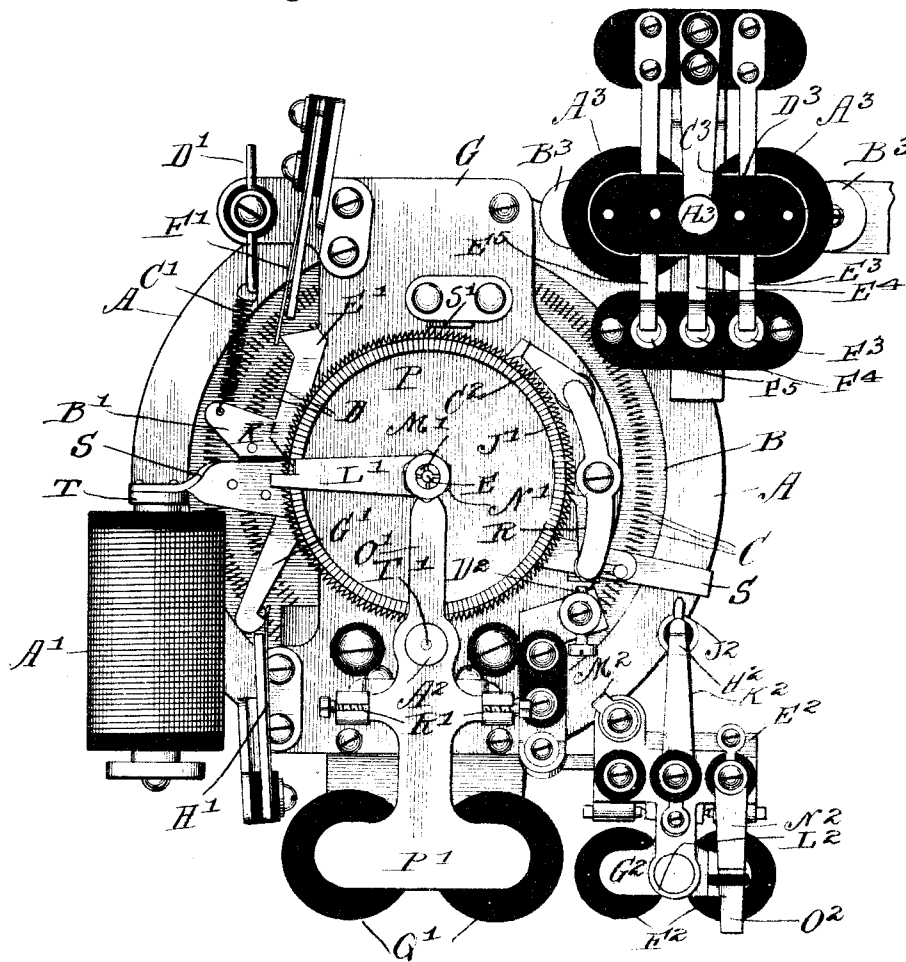
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8 SHEETS—SHEET 6.

Fig. 6.



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Fig. 8

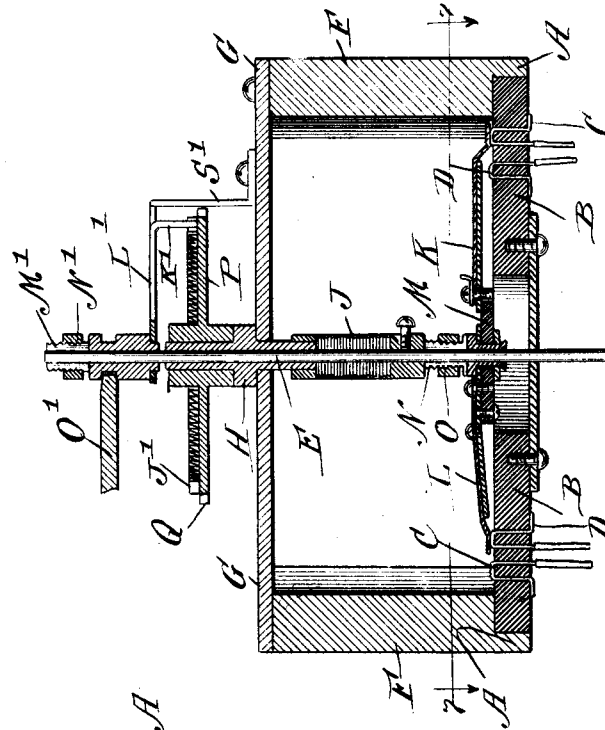
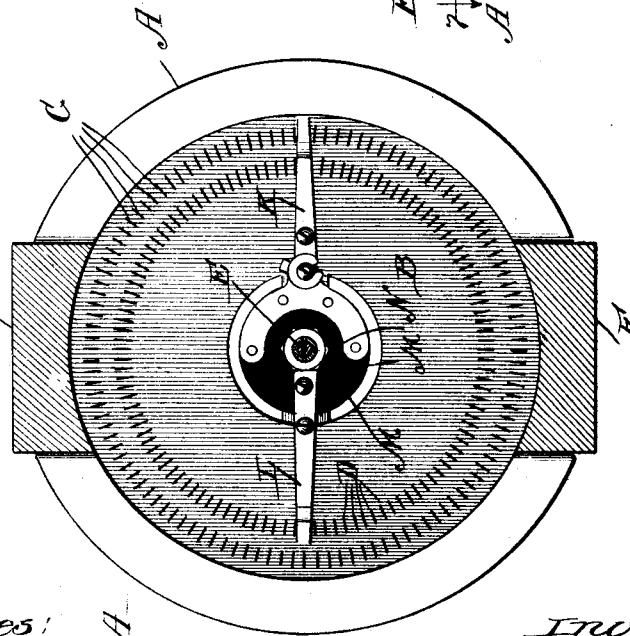


Fig. 7



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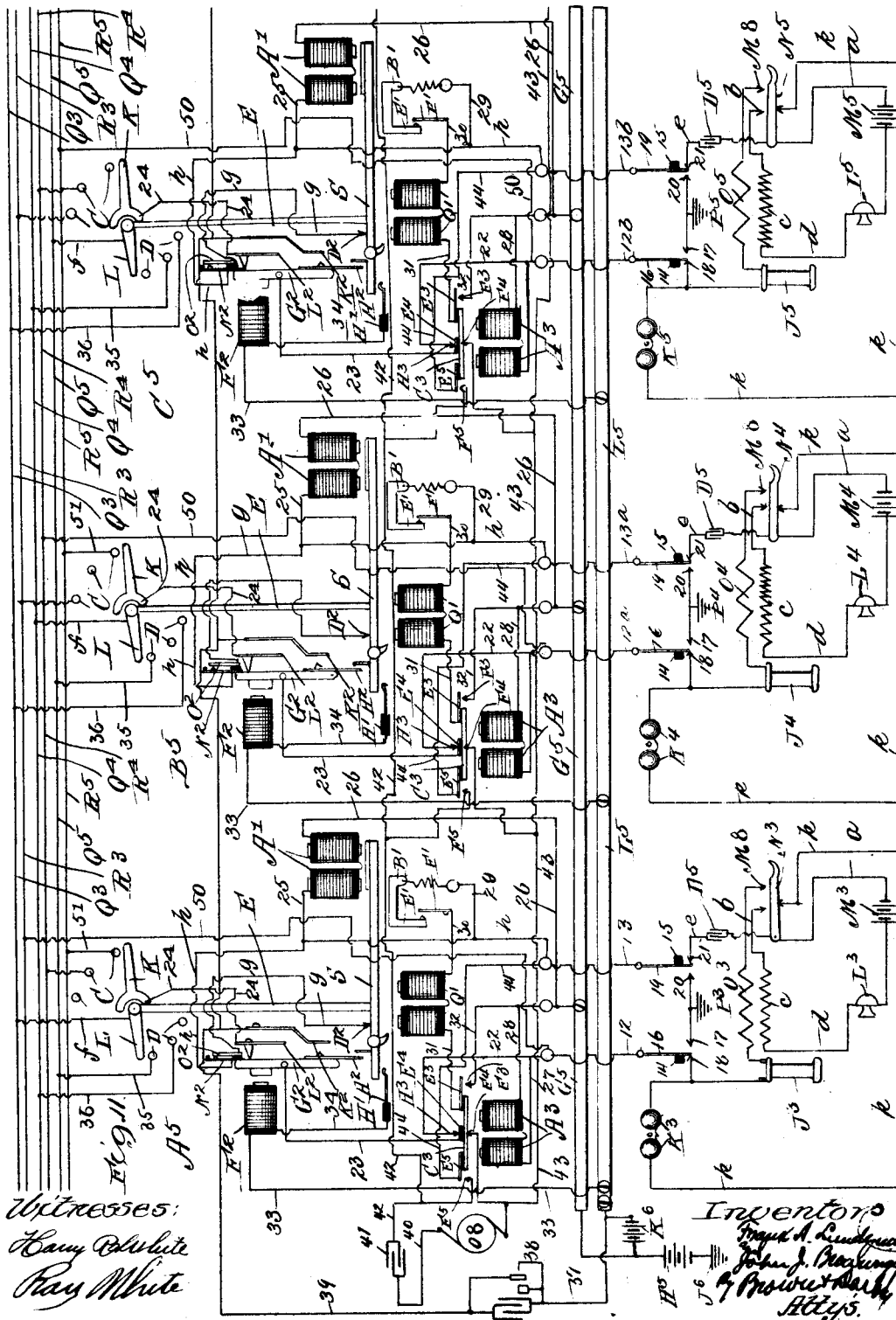
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UNITED STATES PATENT OFFICE.

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CENTRAL-STATION SWITCHING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS.

1,128,701.

Specification of Letters Patent.

Patented Feb. 16, 1915.

Application filed May 19, 1903. Serial No. 157,798.

To all whom it may concern:

Be it known that we, FRANK A. LUNDQUIST and JOHN J. BROWNRIGG, citizens of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a new and useful Central-Station Switching Apparatus for Automatic Telephone Systems, of which the following is a specification.

10 This invention relates to central station switching apparatus for automatic telephone systems.

The object of the invention is to simplify and improve the construction of switching apparatus at the central station for automatic telephone systems and to render the same efficient in operation.

A further object of the invention is to provide a call bell at each subscriber's station, all the call bells being operated from a main generator at the central station.

A further object of the invention is to provide means whereby when a called subscriber's line is busy, the calling subscriber receives a "busy" signal, which does not disturb the called subscriber.

Other objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location and arrangement of parts, all as will be more fully hereinafter set forth, as shown in the accompanying drawings, and finally pointed out in the appended claims.

35 Referring to the accompanying drawings, and to the various views and reference signs appearing thereon,—Figure 1 is a view in front elevation of a central station switching apparatus, embodying the principles of our invention. Fig. 2 is a view in side elevation, looking from the left of Fig. 1. Fig. 3 is a view similar to Fig. 2, looking from the right-hand side of Fig. 1. Fig. 4 is a rear elevation. Fig. 5 is a top plan view showing the parts in the normal positions thereof. Fig. 6 is a view similar to Fig. 5, showing the parts in actuated positions. Fig. 7 is a view in horizontal section on the line 7—7, Fig. 3, looking in the direction of the arrows. Fig. 8 is a broken detail view in section on the line 8—8, Fig. 4, looking in the direction of the arrows. Fig. 9 is a detached detail view in plan of the contact operating latch. Fig. 10 is

a similar view in side elevation of the construction shown in Fig. 9. Fig. 11 is a view in diagram illustrating the application of the principles of our invention.

The same part is designated by the same reference sign wherever it occurs throughout the several views.

In automatic telephone systems as ordinarily installed circuit connections between the circuit wires of subscribers have been completed through a common conductor at the central station. The result of such circuit connection is to throw the entire system out of balance; that is, the pressure on one side of the telephone instruments is greater than the pressure on the other side. This is objectionable, for the reason that it frequently produces inductive cross-talk on adjacent lines. Another objection to this method of central station connection employing a common bus wire or conductor at the central station is that in the case of service wires or conductors of any considerable length the connection of such wires to the common conductor at the central station results, in effect, in grounding such conductor, thereby producing the same ill effects of an unbalanced system.

It is one of the special purposes of our present invention to avoid this objection, and we accomplish this result by providing true metallic circuit conditions in which the total resistance in each of the legs of the metallic circuit is the same, thereby producing a balanced condition of the circuit, and preventing the inductive cross talk which has been common heretofore in automatic telephone systems. In accomplishing this result we avoid the use of spools in series in the line circuits, and in place thereof we employ spools of high resistance bridged directly across the talking and ringing circuit of the line wires. These spools of high resistance bridged directly across the line wires necessitate the use of a higher voltage of current for the proper operation of the system, but they produce a balanced condition in the line circuit, which prevents inductional cross-talk, and also enables us to operate over lines of greater length. Moreover, in the operation of telephone systems employing low voltage of operating current, a current of high amperage is necessary. This is objectionable, for the reason

that the difficulty of maintaining a proper amperage is increased on account of leakage, and any fall of the amperage below the proper point results in a failure of the apparatus to properly operate.

Another feature of our invention is the employment of a central station generator for the signal device at the various subscribers' stations employed in the system. The use of a generator at each subscriber's station of sufficient capacity to ring all the telephone call bells on the same line adds materially to the cost of an installation. We avoid this objection by employing a central station generator for the entire system, thus dispensing with a separate generator at each subscriber's station, thereby materially reducing the cost of installation, and thus permitting an increased number of subscribers to be supplied by each circuit, the number of subscribers on each line being limited only by the capacity of the central station generator.

In securing a balanced condition in a complete metallic circuit in accordance with the principles of our invention, we employ two pairs of spools or coils of high resistance as a bridge across the two line wires, said spools of high resistance being arranged in series with each other, and a connection is made at a point between the two pairs of spools to one side of a battery or other source of current, the other side of such battery or source of current being grounded. This arrangement enables us to dispense with the third or common return or field wire, and this is a most important consideration as it results in greater economy in installation of the system.

In carrying out our invention, we bring the two wires of each subscriber's line to the automatic switch at the central station, and arrange the terminal of one of the wires of each subscriber's line in one system of contact points over which operates a contact arm, and the terminal of the other line wire of each subscriber's line in another system of contact points, over which operates a co-operating contact arm. A convenient arrangement for carrying out this system is to arrange one series of contacts in a circle and the other system of line wire terminal contacts in a concentric circle, and we mount the respective co-operating contact arms upon a rotatable shaft, said arms being conveniently arranged to extend diametrically opposite each other and radially from such shaft, and we provide a magnet controlled ratchet mechanism for imparting a step-by-step rotation to the shaft carrying such arms, and a magnet controlled release mechanism for returning or restoring the contact arms to initial or normal position. The magnet spools which operate the ratchet mechanism of each switch mech-

anism at the central station constitute one of the pair of high resistance coils employed in the bridge across the subscriber's line wire, as above indicated. Of course, it is to be understood that a switching apparatus at central station as illustrated in the accompanying drawings, and as will be hereinafter more fully described in its details of mechanical construction and arrangement, is employed for each subscriber to the system. One of the line wires of the subscriber is led to one of the contact arms of the switch apparatus corresponding to that subscriber's line, and the other line wire of the subscriber is led to the other contact arm, and the various pairs of contacts over which said contact arms operate are in electrical connection with the respective automatic switch at central station of the other subscribers to the system. The release of the ratchet mechanism is effected by the energization of the magnet spools, the circuit of which is controlled by the joint or coincident closing of the circuit of the actuating magnet and of a relay magnet, hereinafter to be more particularly described; the relay magnet spools and the ratchet operating magnet spools employed in connection with each switch system comprising the two pairs of bridging spools across the line wire of the subscriber. Each switching apparatus is equipped with a magnet which controls the "busy" test.

Generally, the foregoing explains the principles of operation of our invention, and while we have shown and will now describe one specific construction and arrangement of apparatus for carrying the principles of our invention into practical operation, we do not desire to be limited or restricted to the exact and specific details of construction and arrangement shown.

We will now describe a construction and arrangement of an automatic switch device at central station embodying the principles of our invention, which we have found simple in construction and arrangement and efficient for the purposes desired.

Reference sign A designates a base, which in the form illustrated comprises a metallic ring, suitably counterbored on the under edge thereof, as most clearly indicated in Fig. 8, to receive an insulating disk, B, in or through which are received the co-operating pairs of terminal contacts, indicated at C, D; C designating the outer ring of contacts, and D the inner ring of contacts. Each insulating disk B contains one pair of contacts for each subscriber to the system, one member of each pair forming one of the outer circular series of contacts, and the other forming one of the inner series of contacts, and each co-operating pair of contacts at each switch is connected electrically with the line wire of the corresponding sub-

scriber's line and also to the corresponding pair of terminal contacts at each of the other switches.

E designates a rock-shaft, suitably journaled centrally with respect to ring A and insulating disk B.

Rising from the base ring A, are standards or uprights F, forming supports for the operating parts of the ratchet mechanism, by which rotative movement is imparted to the ratchet mechanism through which shaft E is actuated, and also affording convenient means for attaching the switch mechanism to a baseboard or other convenient support at the central station. Suitably supported upon the uprights F is a plate G, carrying centrally thereof a bearing, H (see Fig. 8), for shaft E. A spring J, is arranged to oppose the rotative movement of shaft E, and normally exerts its tension in a direction to return or restore said shaft to initial position when said shaft has been rotarily displaced. Suitably connected to rotate with shaft E, are conductor-arms K, L, the conductor arm K operating over the series of contacts C contained in the outer circle or ring of contacts, and the contact arm L operating over and in cooperation with the series of contacts D, forming the inner ring. The contact arm L is in electrical connection with shaft E, and through said shaft with the plate G, uprights F, base ring A, and the ratchet mechanism operating arm or armature presently to be referred to, these parts constituting what we will call the mass or base of the switch. The contact arm K, coöperating with the outer series or circle of contacts C, is suitably insulated from shaft E, as by means of an insulating disk M, mounted upon to rotate with said shaft. A convenient arrangement is shown for mounting the contact arm L upon to rotate with shaft E, wherein said arm is carried by an externally threaded split and slightly tapering sleeve N, adapted to be slipped upon shaft E and to be clamped thereto by means of a nut O, as most clearly shown in Fig. 8. Loosely sleeved upon shaft E, is a ratchet disk P. This ratchet disk is provided with peripheral ratchet teeth, indicated at Q, with which coöperates a spring pawl R, carried upon an arm S, suitably pivoted upon the plate G, and connected to the armature T of the operating magnet spools A'. A plate B', connected to but insulated from arm S, has connected thereto a retractile spring C', the tension of which may be adjusted in any suitable manner, as, for instance, by the rod D', said spring operating to retract the armature T, as soon as the circuit of magnet spools A' is opened. When the armature T is attracted by the energization of magnet spools A', an extension E' of plate B' makes contact with a contact strip F', suitably in-

ulated and connected up in circuit in a manner and for a purpose to be more fully described hereinafter. The arm S is provided with an extension or finger G', in electrical connection therewith, which when said armature is attracted by the energization of the magnet spools A', completes contact with contact point H', in a manner and for a purpose presently to be more fully described. The ratchet disk P is provided with crown ratchet teeth, indicated at J', upon the upper or peripheral edge thereof, with which engages a tooth or pawl K', down-turned from an engaging trip arm L', suitably fastened upon shaft E. This engaging trip arm may be mounted upon the shaft in any suitable or convenient manner. We have shown said arm mounted upon the shaft in a manner similar to the mounting above described for contact arm L, namely, by means of an exteriorly threaded split sleeve M' (see Fig. 10), adapted to be slipped over shaft E and clamped thereon by means of a nut N', (see Fig. 8). In this manner the parts may be readily and quickly assembled and made up in quantity without regard to the nicety of machine work, besides affording an efficient engaging or clamping relation between the shaft and the hub carrying the engaging trip arm. Engaged in a groove in the hub by means of which the engaging trip arm L' is secured to the shaft E, is the end of an armature lever O', of the armature P' of magnet spools Q'. The magnet spools Q' we designate the release magnets. The armature lever O' is pivotally mounted upon a trunnion at R', so that when the release magnet spools Q' are energized, thereby attracting the armature P', the free end of armature lever O' is raised thereby through the engagement of the free end of said armature lever in the groove in the sleeve or hub of arm L', said sleeve is raised, thereby raising the shaft E, and with it the contact arms K and L, and hence carrying the depending tooth K' of engaging trip arm L' out of engaging relation with respect to the crown teeth J' of disk P, and hence releasing the shaft, thereby returning or restoring the shaft to initial or normal position under the influence of tension or retracting spring J. A suitable stop S' may serve to arrest the engaging trip arm L' when the shaft E arrives at its initial position. Any suitable adjustable tension may be provided for returning or restoring the armature P' and armature O' to their initial positions. We have shown a simple arrangement, wherein a threaded rod T' is arranged to pass freely through said armature lever, and interposed between a thumb nut A², threaded upon said rod and said lever, is a coiled spring B², the tension of which is exerted in a direction to return or restore said armature lever to initial position.

tion as soon as the circuit of the release magnet spools Q' is broken. If desired, a locking detent or pawl C^2 , may be arranged to engage the peripheral teeth of ratchet plate or disk P , to prevent reverse movement thereof. The ratchet pawl operating lever S is arranged to make electrical contact, as at D^2 , (see Figs. 5 and 6) when said actuating lever is returned or restored to initial position. The purpose and operation of this contact will be explained more fully hereinafter in connection with the circuit diagram, presently to be more fully explained.

Suitably mounted upon but insulated from the base ring or frame supporting plate connected thereto is a frame E^2 , upon which are mounted magnet spools F^2 , which control the busy test circuits. The pivoted armature G^2 of the busy test magnets F^2 is provided with an arm or extension H^2 , carrying an insulated finger J^2 at the free end thereof, arranged to cooperate with the free end of ratchet actuating lever S , so that said armature is prevented from being attracted by the energization of the busy test magnets F^2 , except when the ratchet operating magnets A' are energized. In other words, the insulating finger J^2 is arranged to extend underneath the free end of ratchet operating lever S , when the latter is in its normal retracted position, so that when said lever is in such position the energization of magnets F^2 will be prevented from attracting the armature G^2 , by reason of the finger J^2 engaging the under side of lever S . When, however, lever S has been actuated by the attraction of armature T , said lever is carried from engaging relation with respect to the insulated finger J^2 , and when in this position the armature lever or extension H^2 is free to be rocked, and the armature G^2 is free to be attracted when the circuit of the busy test magnets F^2 is completed. If, when the armature G^2 is attracted and the extension H^2 is held in raised position, the armature T is released, the arm S again swings into the path of arm H^2 , and serves as a support therefor to prevent the latter from returning or being restored to initial or normal position until after arm S has again been moved or actuated. In its raised position the extension H^2 makes electrical contact with a contact spring K^2 , which places said contact spring K^2 in electrical connection with the frame E^2 , and when the armature G^2 is released or restored to normal position, said armature makes electrical contact with a back-stop L^2 , the latter being insulated from auxiliary base E^2 , and being in suitable electrical connection with the insulated wiper contact arm K , as, for instance, by means of the flexible cord or connection M^2 . Also, when armature lever G^2 is in retracted or normal position, circuit is closed between insulated

contact strips N^2 , O^2 , (see Fig. 3) for a purpose and in a manner presently to be more fully explained in connection with the diagram.

Associated with the switch devices, as above described, is a relay magnet, comprising the spools A^3 , mounted upon a frame B^3 , suitably insulated from the frame of the other mechanism of the switch. The armature C^3 of the relay magnet is carried by an insulating block D^3 , suitably supported upon spring arms E^3 , E^4 , E^5 , which form contacts cooperating with contact points F^3 , F^4 , F^5 , respectively, suitably supported and insulated from each other. The armature supporting insulating block D^3 carries a metallic washer G^3 , which is in electrical connection with the central supporting conductor contact spring E^4 , and said washer is arranged to make electrical contact with an insulated and adjustable back-stop H^3 , when the armature C^3 is retracted to initial or normal position. The spools of the relay magnets constitute one of the pair of bridging spools of the subscribers' line wires, the coils of said spools being connected on one side to one of the subscribers' line wires and on the other side to battery and also to the battery side of the pair of coils A' which constitute the other pair of bridging spools.

Having now explained the mechanical construction of a central station switch embodying the principles of our invention, we will now explain the arrangement of circuit connections and the electrical operation thereof, particular reference being had to the diagram Fig. 11, in which we have shown the circuit connections for three central station switches, corresponding to the lines of three independent subscribers. Referring to this diagram, J^3 , J^4 , J^5 , designate the telephone receiver at the three subscribers' stations illustrated; K^3 , K^4 , K^5 , the call bells; L^3 , L^4 , L^5 , the transmitters; M^3 , M^4 , M^5 , the local batteries; N^3 , N^4 , N^5 , the receiver hooks; these parts, together with the induction coils indicated at O^3 , O^4 , O^5 , being of the usual or any well known construction and arrangement, adapted when the receiver is removed from the hook to complete the local battery circuits as follows: from one side of the local battery, through wire a , to the receiver hook, wire b , the primary c of the induction coil, wire d , and the transmitter back to battery. We have described this circuit in connection with only one of the subscribers lines, but the same description would apply to all. 12 , 13 , 12^a , 13^a , and 12^b , 13^b , designate respectively the line wires of the respective subscribers. At each subscriber's station is arranged suitable means for throwing one or the other or both of the line wires to ground and for breaking the circuit of one or the other or

both of the line wires with the apparatus at the subscriber's station. Many specifically different constructions and arrangements may be employed for accomplishing these results, and as the specific construction and arrangement of such apparatus does not form part of the present invention, we have merely indicated diagrammatically suitable and operative means for accomplishing the desired result, wherein at each station is employed a pair of push-buttons, indicated at 14, 15.

We will describe the arrangement for only one of the subscribers, the arrangement being identical at each subscriber's station.

The push-button 14 controls the contact of a contact spring 16 with one or the other of contacts 17, 18. The contact 17 is in electrical connection with the ground, as at P²; the push-button 15 controls a contact spring 19, which coöperates with contact points 20, 21; the contact 20 being in electrical connection with the ground at P³. The contact 21 is in electrical connection through wire *e* with the receiver hook N³, and the contact 18 is in electrical connection with the circuit of bell K³, and of receiver J³. As above indicated, these parts are merely diagrammatically indicated.

Q², R³, designate the bank wires for the switch corresponding to one subscriber's station, Q¹, R⁴, the bank wires for the switch corresponding to another subscriber's station, and Q⁵, R⁵, the bank wires corresponding to the other subscriber's station. The wire Q³ is connected through conductor *f* with the base or mass of the corresponding subscriber's central station switch, which is designated generally by reference sign A⁵, the mass including shaft E and operating arm S, to the insulated contact D², through wire *g*, contact O², thence to contact N², when the circuit between O² and N² is closed, that is, when the circuit of the busy test armature is in its normal position; thence by wire *h* to line wire 13, thence through spring 19, contact 21, wire *e*, condenser D⁵, receiver hook N³, wire *k*, bell K³, contact 18, spring 16, wire 12, wire 22, to contact H² of the relay magnet, thence to the middle spring E⁴, wire 23, thence to the base of the busy test magnet frame through the mass thereof to the armature G² thereof, only the armature being illustrated in the diagrammatic view; thence to contact strip L², assuming the armature to be in its normal retracted position; thence through wire 24 to insulated wiper K.

In tracing the foregoing circuit we have disregarded the circuits of the bridging spools, and we have assumed that the contact wipers or arms L and K are in their normal positions, that is, said wipers or contact arms are not in contact with any of the contacts carried by the insulating disk B.

The circuits of the bridging magnet spools will now be described. From wire *h*, the wire 25 is tapped, which leads through the spools A¹, which are the operating magnets as above described, thence through wire 26 to the bus bar G⁵, which is a common battery strip at the central station; thence to one side of the main battery H⁵, the other side of said battery being connected to ground as at J⁶. Similarly, the relay magnet coils A³, are included in a circuit comprising a wire 27 tapped from wire 22, whence such circuit is completed through the spools A³, wire 28 to the bus bar G⁵, and to the battery H⁵, thence to ground.

The circuit of the release magnet spools Q¹ is traced as follows: From the operating circuit wire *h*, through wire 29, insulated plate B¹, and extension E¹ to contact strip F¹, wire 30, magnet spools Q¹, wire 31, contact spring E³, contact F³, thence through wire 32, to the battery bus bar G⁵, to battery H⁵, thence to ground at J⁶. It will be observed that this circuit is normally open between extension E¹ and strip F¹. It is normally open between contact strip E³ and contact F³. Consequently, in order to close the circuit of said release magnet spools Q¹, it is necessary to close the circuits thereof at both points through the energization of both the operating magnet spools A¹ and the relay magnet spools A³.

We will now trace the circuit of the busy test magnet F². From one side of battery K⁶, to busy buzz bus wire or conductor L⁵, thence through wire 33, busy magnet F², through wire 34, to contact H¹, which contact is normally open but is closed, to the ratchet operating lever S, when the operating magnet A¹ is energized, thence from ratchet operating lever S, rod E, and the mass to contact arm or wiper L. This circuit, of course, is not completed until the contact arm or wiper L has been actuated from its normal or retracted position, so as to be brought into electrical connection with a contact of the series of contacts D, but this circuit is completed coincidentally with the making of contact between contact L and a contact of the inner series of contacts D. We will suppose that contact L has been brought into electrical contact with the first contact D. Thence the busy test magnet circuit will be completed from contact arm or wiper L, through contact D and wire 35, to wire Q⁵, which is the bank wire, which is common to contact D at all of the switches B⁵, C⁵, etc., but this circuit will be completed from bank wire Q⁵ only at that particular switch, the mass of which is in electrical connection with said bank wire. Suppose, in the case illustrated, this occurs at the switch indicated generally by reference sign C⁵, then said circuit will be completed through wire 130.

f, the shaft E, arm S, contact D², wire g, contacts O², N², wire h, through the operating spools A' at station C⁵, wire 26, to main battery bus-bar G⁵, to the other side of battery K⁵. This circuit, of course, it will be understood is completed at each step imparted to contact arm L, this busy test circuit being completed successively through the various switches. For instance, when the wiper on contact arm L is brought into contact with the first contact D, the circuit above traced is completed through that particular switch, the mass of which is in electrical connection with the corresponding bank wire. When the wiper arm L is advanced to the next contact, this busy test circuit is completed through that particular switch the mass of which is in electrical connection with that particular bank wire, and so on. Each of the pair of spools A' is of a definite and fixed resistance. In practice, we employ, say, 600 ohms resistance in each pair of spools. The actuation of armature G² of the busy test magnet when the magnet F² is employed is opposed by a spring N², (see Figs. 3 and 4) the tension of which is so adjusted that said armature will not be attracted when the current traversing the circuit of the busy test magnet is required to overcome the 600 ohms resistance, above noted. When, however, say for instance, station B⁶ has called station C⁵, or said stations are in communication with each other, then the switch arm or wiper L of station B⁶ is in electrical contact with the first of the series of contacts D. In that event, when station A⁵ seeks to call C⁵ the circuit of the busy test magnet F² will be divided, part going through wire 35 at station B⁵, thence through switch arm or wiper L at that station, which under the condition assumed is in contact with the first of the series of contacts D; thence through the shaft E, ratchet actuating arm S, and the mass at station B⁶, back stop D², and on as above described, traversing the same path at B⁶ as has been described above with reference to the path at switch C⁵, thence back to the battery bus-bar G⁵, to the other side of battery K⁵, and the other path of said circuit traversing the same circuit as above described with reference to the switch at C⁵, back to battery bus-bar G⁵, and to battery K⁵. This results in dividing the circuit of the busy test magnet at station A⁵ into two parts or branches, each containing 600 ohms resistance, namely, each branch circuit including therein the coils of the actuating magnets A' at the two respective stations B⁵, C⁵. The result of this is to reduce the available resistance in this circuit to 300 ohms, and when the resistance of this circuit is so reduced, the tension of spring N² will be overcome, allowing the armature of the busy test magnet F² at the calling

station A⁵ to be attracted. As above described, this armature will not be attracted until the ratchet actuating arm S has been moved out of the way or path of the finger J² of the armature arm. When the ratchet operating lever S has been moved out of the path of this finger, the armature G² of the busy test magnet will be permitted to rock and thereafter the release of the ratchet actuating arm S will cause said lever to form a support for the finger J², thereby holding the busy test magnet armature G² in attracted position. The attraction of this armature opens the circuit between contact L² and armature G², thus opening the circuit on one side of the line. The same movement also breaks the circuit between contact strips O² and N², thereby opening the other side of the line. This movement also closes the following circuit: from one side of battery K⁶, to battery bus-bar L⁶, wire 37, buzzer 38, wire 39, to contact strip K², contact strip H², armature G², wire 28, contact strip E⁴, back-stop H², wire 22, relay magnet A³, wire 28, bus-bar G⁵, to the other side of the battery K⁵. This completes the metallic circuit for the buzzer. The disturbance created by this buzzer is thrown back through the receiver at the station making the call through a circuit tapped from wire 22, as follows: wire 12, strip 16, contact 18, receiver J³, the secondary of the induction coil, contact M³, receiver hook N³, which under the conditions named is raised, the receiver J³ having been removed from such hook; thence through condenser D⁵, wire e, contact 21, strip 19, wire 13, wire h, wire 25, magnet A', wire 26, to battery bus-bar G⁵, to the other side of the battery K⁵. This gives the subscriber at station A⁵, who is attempting to make a call, the busy or buzzing sound in his receiver, notifying him that the line he is seeking to call is busy.

We have in the foregoing description referred to the presence of a condenser D⁵ in the local circuit connections of each telephone. One purpose of these condensers is to prevent the circuit of the busy test magnet from being completed as it would otherwise be through the telephone at each subscriber's station, thereby preventing the current of the busy test from finding the desired resistance in its path.

We will now describe the central station generator for the ringing circuits of the entire system, which in connection with an automatic telephone system we regard as novel and important.

Reference sign O⁵ designates the central station ringing generator common to the entire system. This generator may be of any convenient type or form. One side of this generator is connected through wire 40, condenser 41, and wire 42, which is a bank wire, that is, is common to all of the central

station switches. At each switch this wire 42 is tapped off or is in electrical connection with contact point F⁵ of the relay. From the other side of the generator O⁵ leads a conductor 43, which is a common bank wire conductor common to all of the switches, and at each switch this common conductor is tapped off or is in electrical connection with the central contact F⁴ of the relay. Thus when the circuit of relay magnet A³ at any switch, say, for instance, switch A⁵, is completed, the armature C³ of said magnet is attracted, thereby completing circuit connection between contact point F⁵ and contact strip E⁵, also completing electrical connection between contact strip E⁴ and contact F⁴, and breaking electrical connection between contact H³ and strip E⁴. The breaking of electrical connection between the last two contacts prevents the ringing circuit from being completed through the telephone of the subscriber making the call. We will now trace the generator circuit through the switch A⁵, assuming the relay magnets A³ to have been energized. This circuit is completed from the generator O⁵, through wire 40, condenser 41, wire 42, to contact F⁵, strip E⁵, wire 44, wire h, contact strips N², O², wire g, contact D², ratchet armature lever S, shaft E, and the base of contact wiper or arm L, thence to the particular line in connection with which the wiper arm L has been actuated, thence to the switch corresponding to the subscriber being called, thence back to the contact arm or wiper K of the calling subscriber, wire 24, strip L², armature G², wire 23, strip E⁴, contact F⁴, to the opposite side of the generator.

Having now described the mechanical construction and arrangement of the switching apparatus, and having also traced the various circuits involved in the electrical operation of the apparatus, we will now explain the operation of making and receiving a call, assuming that the apparatus at each station is at normal.

Now suppose the subscriber corresponding to switch A⁵ desires to call the subscriber of switch C⁵. The first operation is to remove the receiver J³ at station corresponding to switch A⁵ from the receiver hook, thereby breaking connection between the receiver hook N³ and the local signal bell circuit K³ of the calling station and also completing the local receiver circuit and also the local transmitter circuit at the calling station. The circuit from the ground at P³ to the line wire 13 is then made and broken a given number of times corresponding to the number of the station to be called; for instance, if the station of switch C⁵ is the station to be called, the circuit connection from line wire 13 to ground at P³ is made and broken once, station of switch C⁵ being the station corresponding to number

one of the system. As above explained, the making and breaking of this circuit may be effected in any suitable or convenient manner; and as we have explained, we have merely shown an illustrative make and break device for accomplishing this result and comprising the push-button 15, spring 19, and contact 20, this merely for the purpose of illustrating the operation of the apparatus. We will now trace the circuit thus made and broken: from ground at P³, through contact 20, spring 19, wire 13, wire h, wire 25, magnet A¹, wire 26, battery bus-bar G⁵, battery H⁵, to ground at J⁵. The single completion of the circuit of the magnets A¹ imparts a single actuation to armature and ratchet operating lever S, thereby imparting one step of rotative movement to the ratchet disk P, hence rotatively displacing shaft E, and with it the conductor or wiper arms L and K, so as to bring said wiper arms into coöperative and contacting relation with respect to the coöperating pairs of contacts C D, constituting the first pair from normal on the disk B of switch A⁵. This places the telephone at station corresponding with switch A⁵ in electrical communication with the telephone of station C⁵.

The next step is for the subscriber at station A⁵ to ring the signal bell at station C⁵. This is accomplished by completing the circuit between line 12 and the ground at the calling station, that is, at station A⁵. The completion of this circuit may be effected in any convenient manner. As illustrative of an operative arrangement, the subscriber at A⁵ pushes button 14, thereby bringing contact strip 16 into electrical connection with contact 17. Thereupon the ringing circuit is completed, as follows: from ground at P³, contact 17, strip 16, wire 12, wire 27, relay magnet A³, wire 28, battery bus-bar G⁵, battery H⁵, to ground at J⁵. The completion of this circuit energizes the relay magnet A³, causing the armature C³ thereof to be attracted, thereby completing the ringing circuit from the central station generator O⁵, as follows: through wire 40, condenser 41, wire 42, contact F⁵, strip E⁵, wire 44, wire h, contacts N², O², wire g, contact D², lever S, shaft E, and mass or base, contact arm or wiper L, the first of the contacts D, wire 35, wire Q⁵, wire f at switch C⁵, shaft E, armature S, and mass, as above explained at switch C⁵, through contact D², wire g, strip O², strip N², wire h, wire 13, strip 19, contact 21, conductor e, condenser D⁵, receiver hook N⁵, wire k at station C⁵, bell K⁵ at station C⁵, contact 18, spring 16, wire 12, wire 50, to bank wire R⁵, then back to the calling station or switch A⁵, to wire 51, contact arm or wiper K, wire 24, strip L², armature G², of the busy test magnet, wire 23, spring E⁴, which under the conditions mentioned has been drawn down by the energization of

relay A³ at switch A⁵, thence to contact F⁴, to the opposite side of the generator.

It will be observed that at the called station the return circuit above traced includes
 5 a wire 50 direct from the telephone instrument to the return bank wire, thus cutting out the apparatus of the switch. A similar return connection is arranged at each of the switches. This effects a ringing or signal
 10 at station C⁵ from station A⁵. Suppose, however, the station at C⁵ is already busy; then upon completion of line 13 to ground at P² at station A⁵, the subscriber at station A⁵ making the call will receive in his receiver
 15 the busy buzz, assuming that station C⁵ has been called or is in communication with the subscriber at station B⁵. Under the conditions mentioned the contact arms or wipers L K at switch B⁵ have been stepped
 20 up one step so as to bring the switching apparatus corresponding to station B⁵ into electrical communication with the switching apparatus corresponding to station C⁵. Under these conditions the busy magnet circuit F² of the calling station A⁵, which we
 25 have hereinabove traced, will find two branches, one through the actuating magnet coils A' at switch B⁵, and the other through the actuating coils A' at switch C⁵, and as the resistance of each pair of these magnet coils is 600 ohms the total effective resistance
 30 in the external circuit of the busy magnet F² of switch A⁵, will be 300 ohms, and hence the tension of retractile spring N², opposing the attraction of armature G², of the busy test magnet F² at station B⁵, is overcome,
 35 permitting said armature to be attracted by said magnet and hence breaking circuit connection between strips L² and said armature G², and also between strip O² and N² at switch A⁵. The opening of these circuits
 40 opens both sides of the line of the calling subscriber A⁵, as above explained, and gives the calling subscriber the busy buzz signal, through the following circuit: from one side
 45 of battery K², to bus-bar L², wire 27, buzzer 38, wire 39, contact strip K², contact spring H², armature G², wire 23, spring 14, contact H², wire 22, where it divides, part finding
 50 a metallic circuit through wire 27, spools A², wire 28, bus-bar G², back to the other side of battery K². The disturbance created in this circuit by buzzer 38 finds a path
 55 from wire 22 to wire 12, spring 16, contact 18, receiver J², the secondary of the induction coil, contact M², receiver hook N², condenser D², wire 2, contact 31, spring 19,
 60 wire 13, wire 4, actuating magnet coils A', wire 25, to bus-bar 10, to the other side of the battery, thus inducing in the calling subscriber that the line is busy. Assuming, however, that the subscriber's line wire at the station corresponding to switch C⁵ is not in use, then

communication is established and the conversation is carried on through the following talking circuit: from the telephone at the station corresponding to switch A⁵, through
 line wire 12, wire 22, contact H², strip E²,
 70 wire 23, armature G², strip L², wire 24, contact arm or wiper K, wire 51, wire R², wire 50 at station C⁵, wire 12⁵, spring 16, thence through the telephone at the station corresponding to switch C⁵, to line wire 13⁵,
 75 wire 4, strips N², O², wire 9, contact D², armature S, shaft E, and mass, contact arm or wiper L, wire 7, return bank wire Q⁵, to wire 35, the first of the contacts D at switch A⁵, contact arm or wiper L, shaft E, armature S, and mass, to contact D², wire 9,
 80 contact strips O² N², wire 4, to wire 13, thence through the telephone at the station of the calling subscriber. After communication has been completed, the parts may be returned to normal in any simple or convenient manner, as, for instance, and in the arrangement illustrated as an operative embodiment of our invention, by simultaneously completing circuit from line wires 12
 85 and 13 at the calling station to ground at P².

The result of closing ground wire 13 to ground at P² is to close the circuit of magnet coils A' to battery and ground, thereby closing contact between contact extension
 90 E' and spring F', and the result of closing line wire 12 to ground at P² is to close the circuit of relay magnet coils A⁵ through line wire 28, the bus-bar and battery to ground, thereby completing circuit between strips
 95 E² and contact F². Under these conditions the circuit of release magnet Q' is completed as follows: from ground at P², through wire 13, wire 4, wire 29, plate B', contact E', spring F', wire 30, magnet
 100 spools Q', wire 31, spring B², contact F², wire 32, battery strip G², H², to ground at J'. The closing of this release magnet circuit results in an actuation of armature lever P' (not shown in the diagram), and
 105 consequent actuation of arm O', and the raising of shaft E and its associated parts, thereby carrying catchet finger K' out of engaging relation with the teeth J' of disk P, and hence permitting the retractile J
 110 to return shaft E and its associated parts to normal position. The breaking of the release magnet circuit releases the armature P' thereof and operating arm O', and permitting the shaft E and associated parts to
 120 be again lowered into normal position and ready to be again actuated.

From the foregoing description it will be seen that we provide a simple and efficient
 125 automatically-switch system, wherein is embodied a single central station generator and calling circuits of the entire system, wherein we secure the benefits and advantages of a completely balanced metallic circuit condition, thereby avoiding the objec-
 130

tion of inductive cross-talk, wherein we are enabled to secure an efficient return busy buzz or test at a calling station in case a called station is already in operation or is busy, and wherein we provide a system capable of being applied to lines of long distance, it being evident that the principles of our invention may be carried out to a system of indefinite capacity, depending merely upon the capacity of the central station calling generator.

In the application of this invention to party lines, one or more telephones may be bridged across the line wires 12, 13 or 12^a, 13^a, or 12^b, 13^b.

It is obvious that many variations and changes in the details of construction and arrangement would readily occur to persons skilled in the art and still fall within the spirit and scope of our invention. We do not desire, therefore, to be limited or restricted to the exact details shown and described. But

Having now set forth the object and nature of our invention, and a construction embodying the principles thereof, what we claim as new and useful and of our own invention, and desire to secure by Letters Patent of the United States, is:

1. In a telephone system, a central station, subscribers' lines terminating thereat, a switch for connecting said lines, a busy test magnet associated with said switch, resistance coils associated with said lines, means whereby when a connection is completed from one subscriber's line to another a resistance coil is included in the circuit of said busy test magnet to prevent actuation thereof, and means whereby when the called line is busy the circuit of the busy test magnet is divided into two branches each including a resistance coil whereby the effective resistance in the circuit of the magnet is reduced and said magnet is actuated.

2. In an automatic telephone system, a central source of ringing current, a switching mechanism corresponding to each subscriber's station and including a busy test magnet, a resistance coil at each switching mechanism, means whereby when one subscriber completes the calling circuit to another subscriber's station the coil of the called subscriber is included in the circuit of said busy test magnet to prevent actuation of such magnet, and means whereby in case the called subscriber's line is already busy the circuit of said busy test magnet is divided into two branches, each including a coil, thereby reducing the effective resistance in the circuit of the busy test magnet of the calling subscriber's switching mechanism and hence actuating the latter.

3. In an automatic telephone system, a central source of ringing current, a switch-

ing mechanism corresponding to each subscriber and controllable from the subscribers' stations, each switching mechanism including a busy test magnet and a resistance coil, means for completing the calling circuit between the switching mechanism of each subscriber to the switching mechanism of each of the other subscribers to the system, said means operating to include the resistance coil of the called subscriber in circuit with the busy test magnet of the calling subscriber, thereby preventing operation of such busy test magnet, and means whereby when the called subscriber's line is busy the circuit of the busy test magnet of the calling subscriber is divided, each part thereof including a coil of each of the two subscribers in communication with each other, thereby reducing the total effective resistance in the circuit of the busy test magnet of the calling subscriber to permit the latter to operate to give a busy test signal to the calling subscriber.

4. In an automatic telephone system, a plurality of subscribers' stations, a busy buzzer for said stations and an automatic exchange having operating magnets, a bus bar of raised electric potential at the exchange, a second bus bar of higher electric potential, means for bridging said bus bars through the busy buzzer to any subscriber's station, and means for grounding said first named bus bar through either line wire of any desired subscriber, said grounding establishing circuits through the operating magnets of the exchange for the said subscriber.

5. In an automatic telephone system, a plurality of subscribers' stations, a busy buzzer for said stations and an automatic exchange having operating magnets, a bus bar of raised electric potential at the exchange, a second bus bar of higher electric potential, means for bridging said bus bars through the busy buzzer to any subscriber's station, means for grounding said first named bus bar through either line wire of any desired subscriber, said grounding establishing circuits through the operating magnets of the exchange for the said subscriber, and means whereby the simultaneous energization of said magnets actuates a return of the exchange apparatus to normal condition.

6. In an automatic telephone system, a switching mechanism corresponding to each subscriber and controlled from the subscribers' stations, each switching mechanism including a busy test magnet and a resistance coil, means for completing the calling circuit between the switching mechanism of each subscriber and the switching mechanism of each of the other subscribers of the system, said means operating to include the

resistance coil of the called subscriber in
circuit with the busy test magnet of the call-
ing subscriber, whereby the busy test mag-
net will not receive operating current, and
5 means whereby when the called subscriber's
line is busy the resistance coils of the two
subscribers in communication with each
other are placed in parallel connection with
the busy test magnet of the calling sub-
10 scribe, whereby the said busy magnet will

receive operating current to give a busy test
signal to the calling subscriber.

In witness whereof, we have hereunto set
our hands this 12th day of May 1903, in the
presence of the subscribing witnesses.

FRANK A. LUNDQUIST.
JOHN J. BROWNRIGG.

Witnesses:

CHAS. H. SEEM,
S. E. DARBY.