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J. G. SMITH.

AUTOMATIC EXCHANGE SYSTEM.

No. 550,729. Patented Dec. 3, 1895.

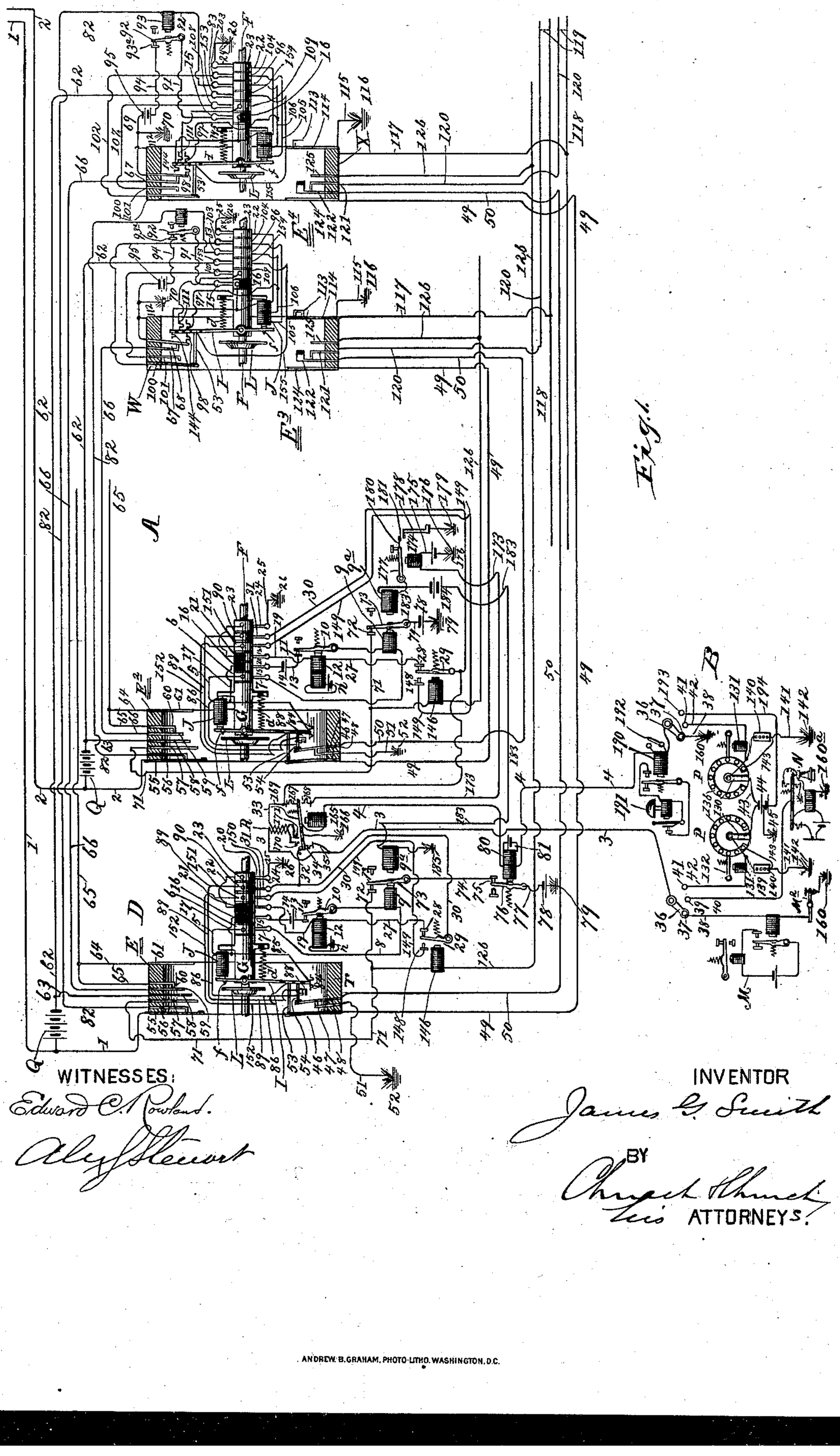

Fig. 1.

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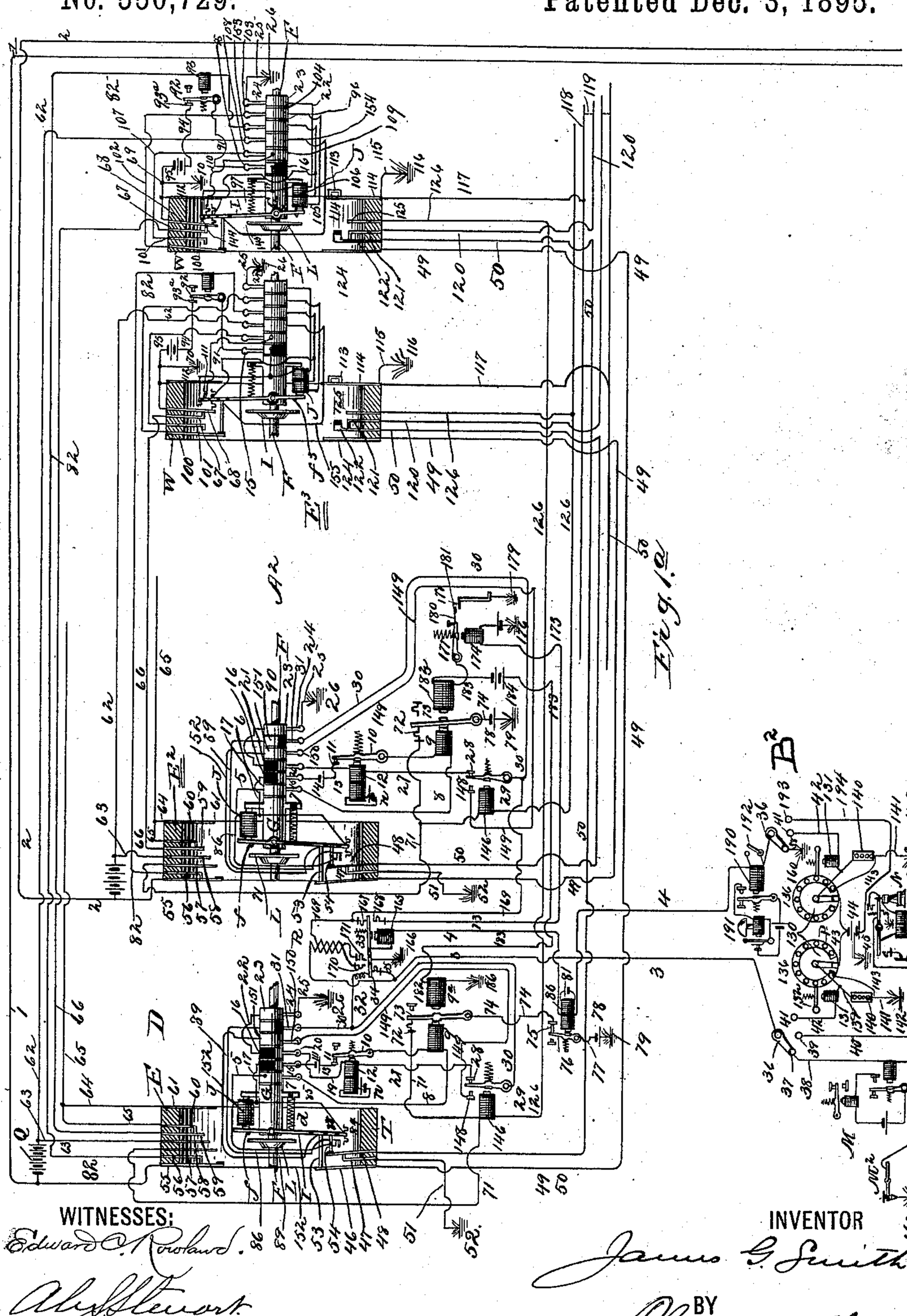

Fig. 1.

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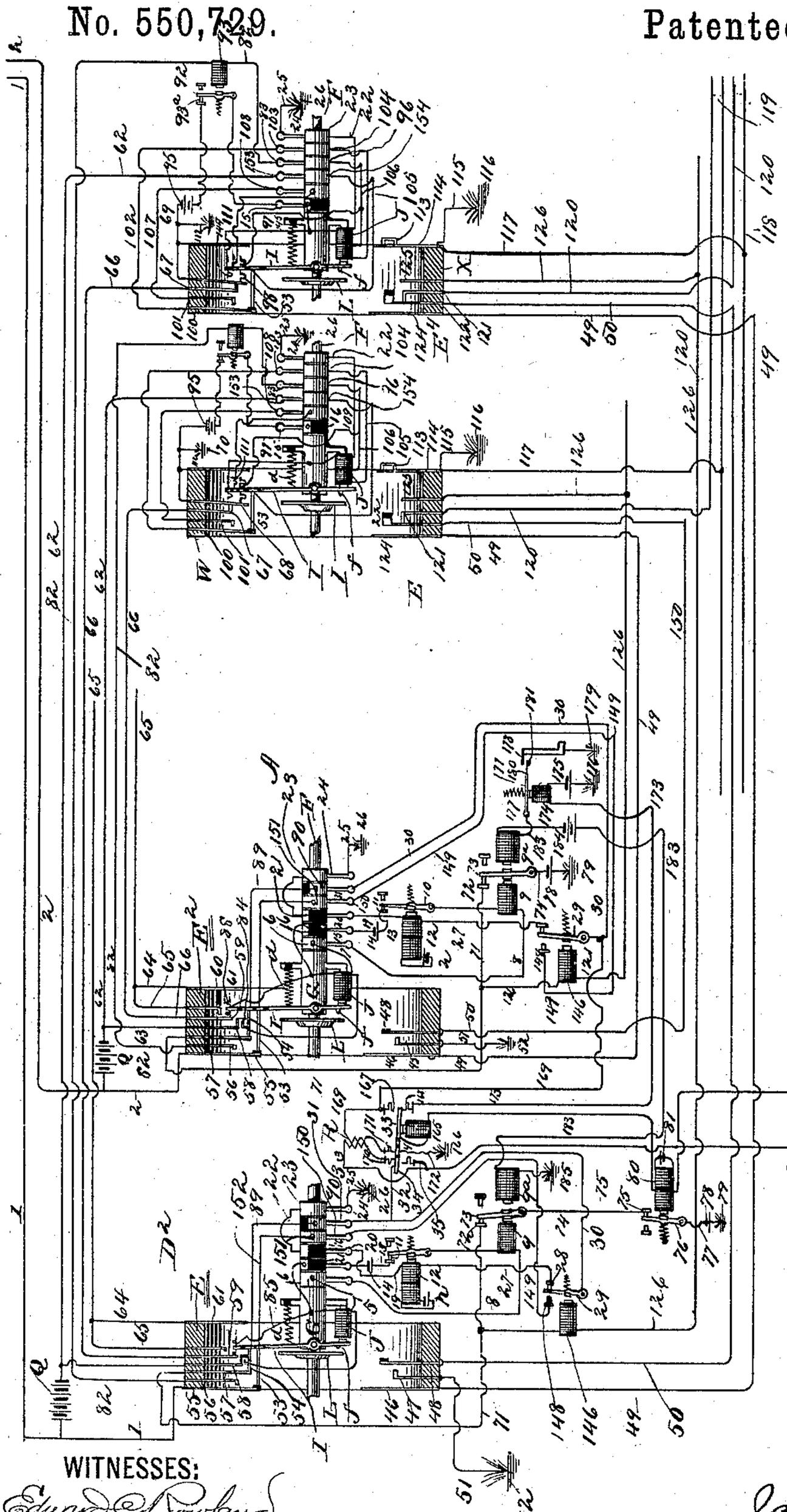

Fig. 2.

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(No Model.) 8 Sheets—Sheet 4.

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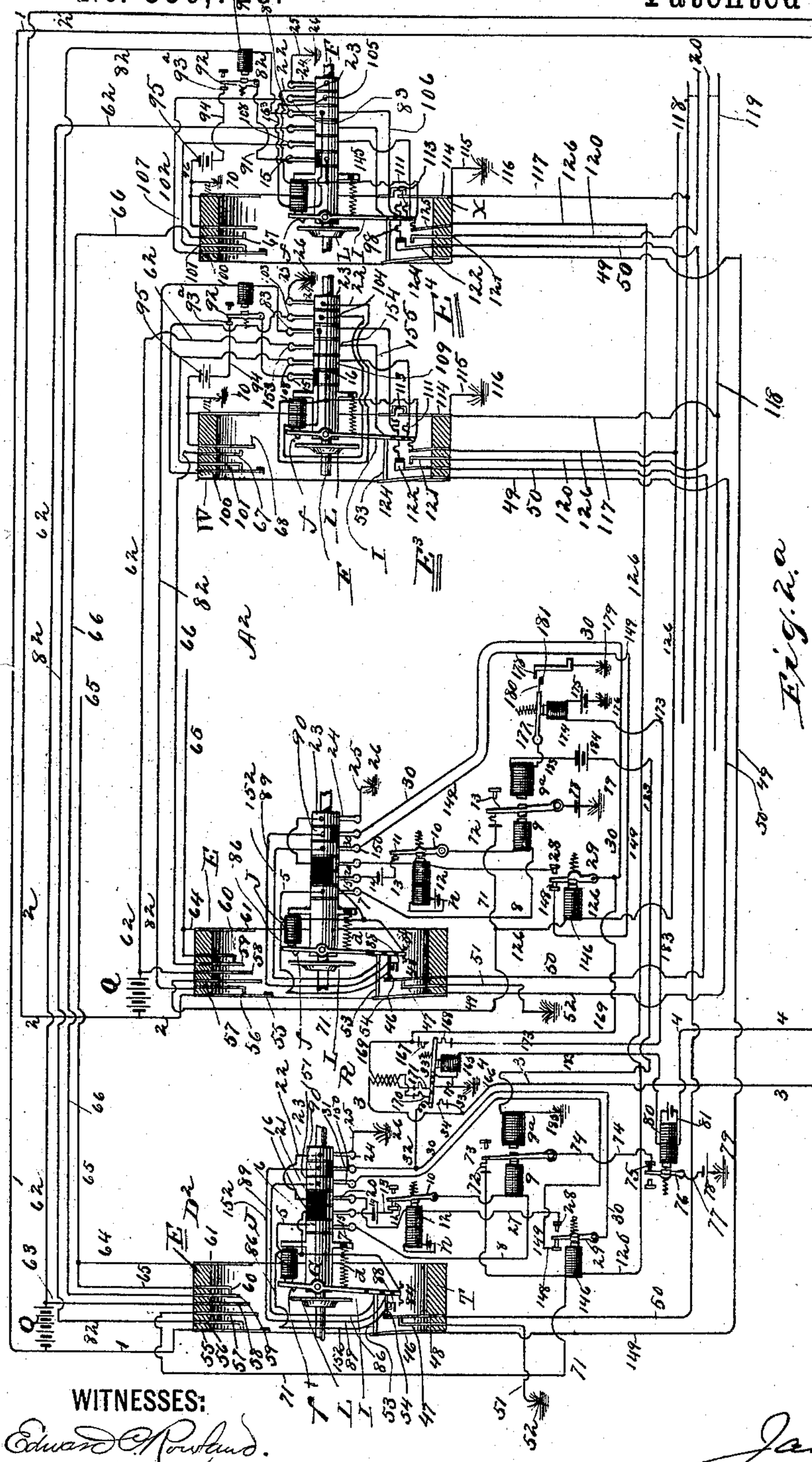

Fig. 2.

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Fig. 3.

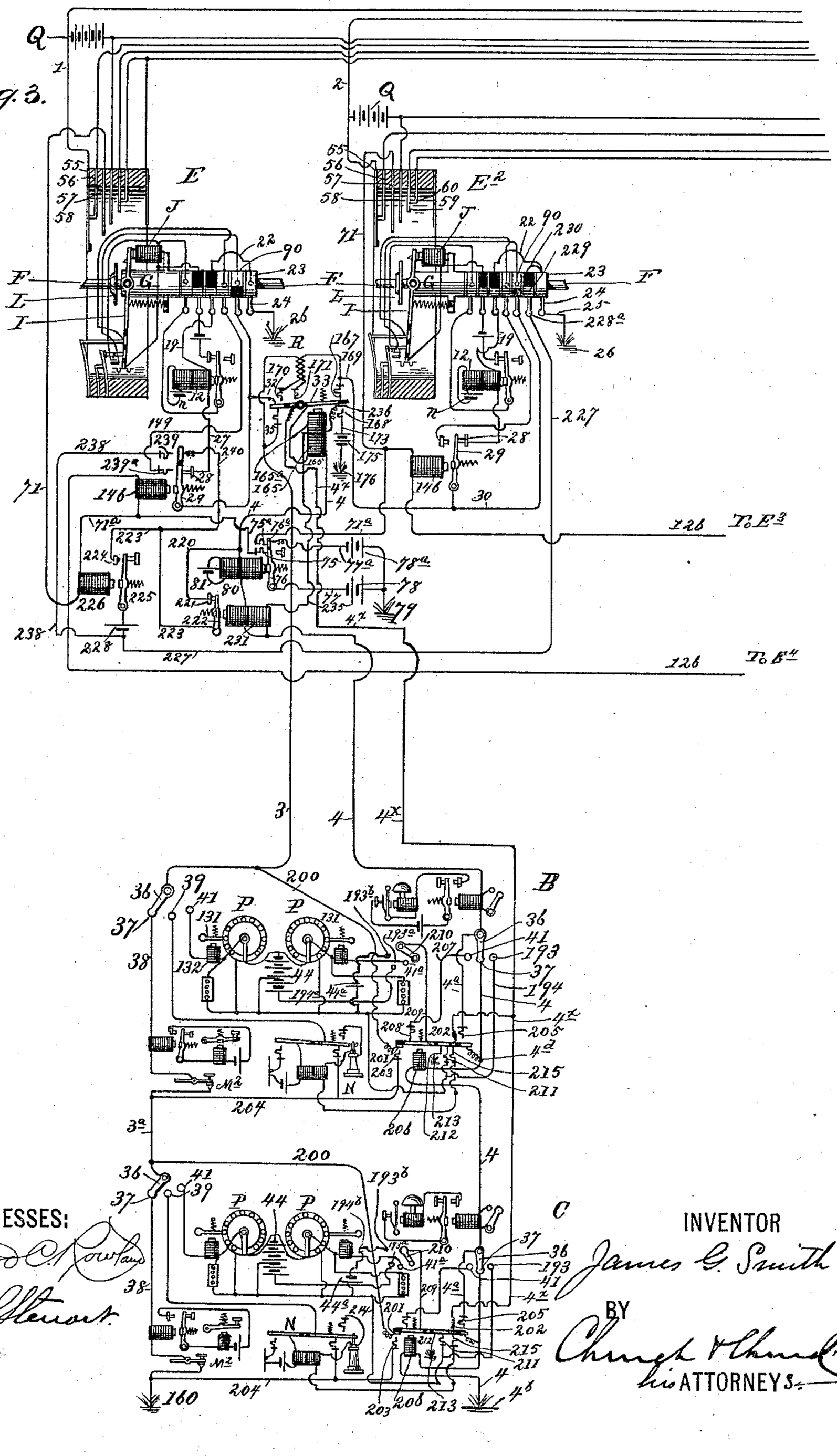

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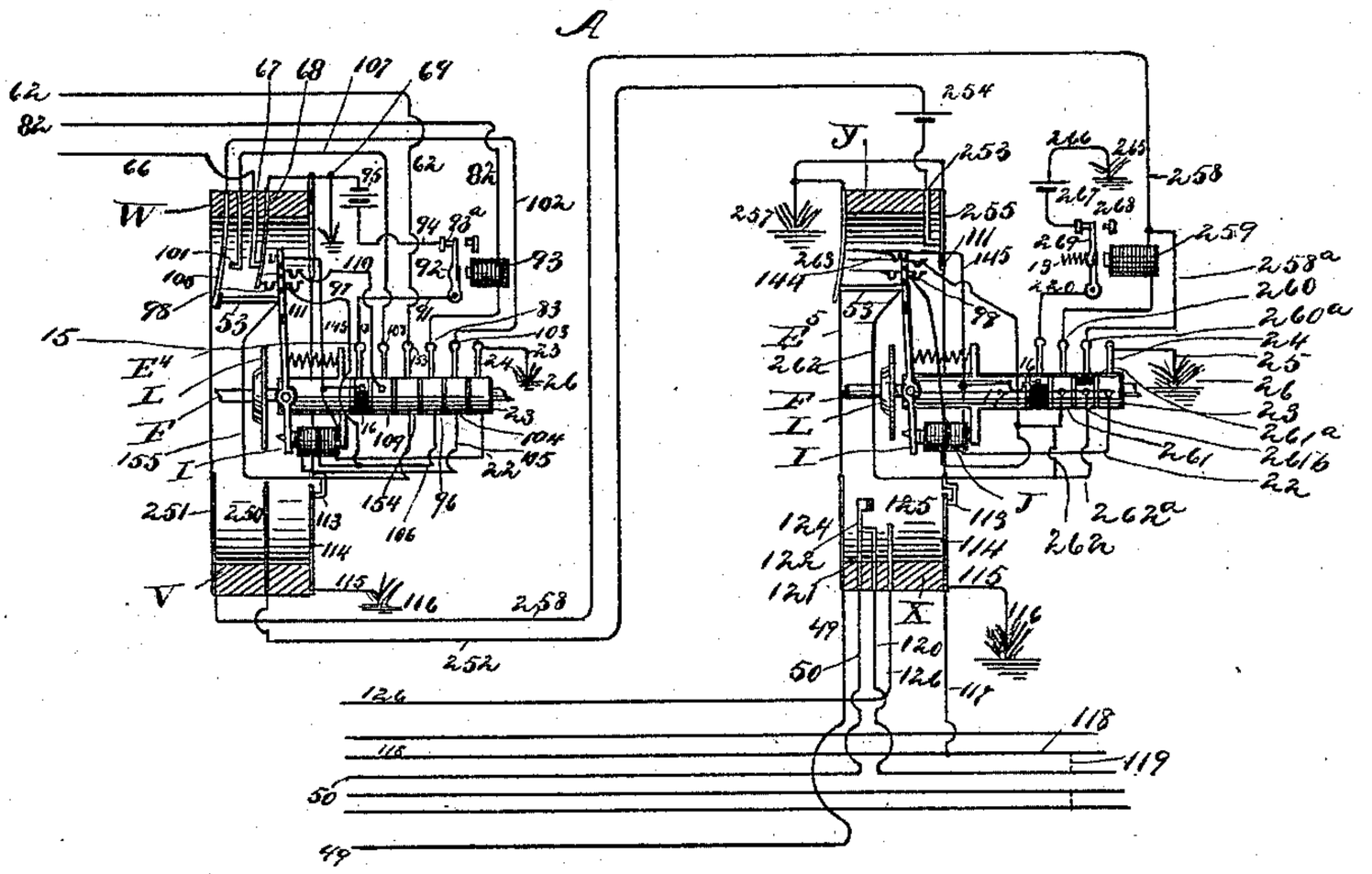
Fig. 4



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(No Model.) 8 Sheets—Sheet 7.

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AUTOMATIC EXCHANGE SYSTEM.

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FIG. 5

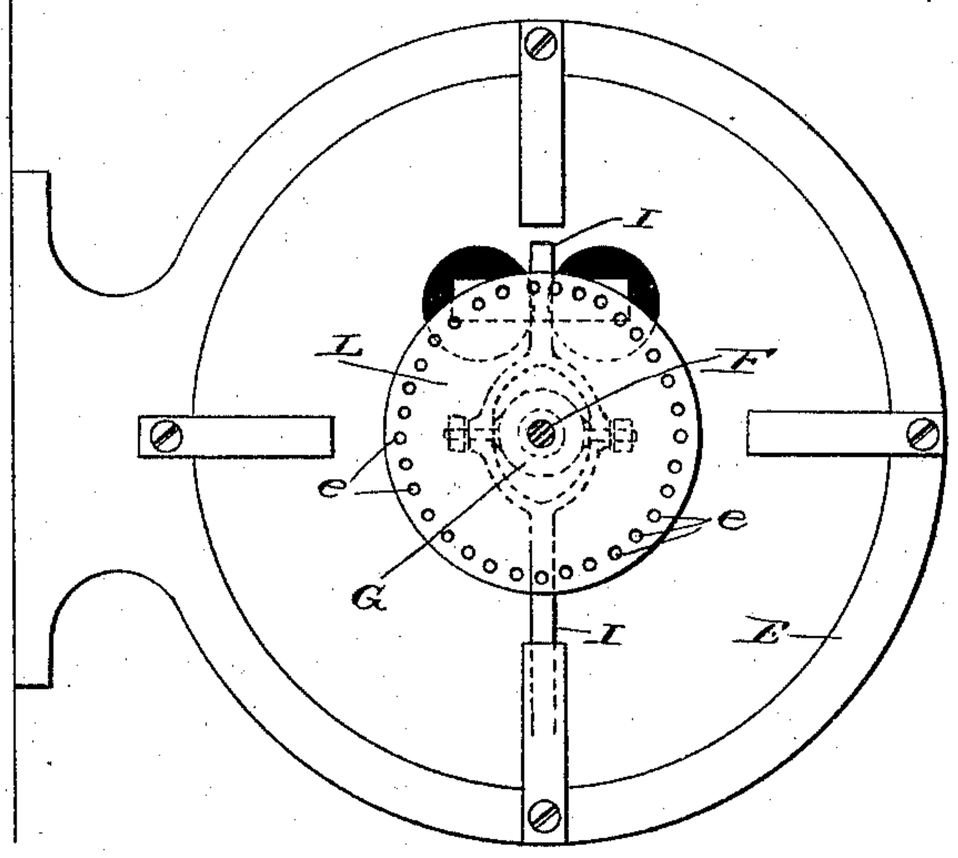


FIG. 6

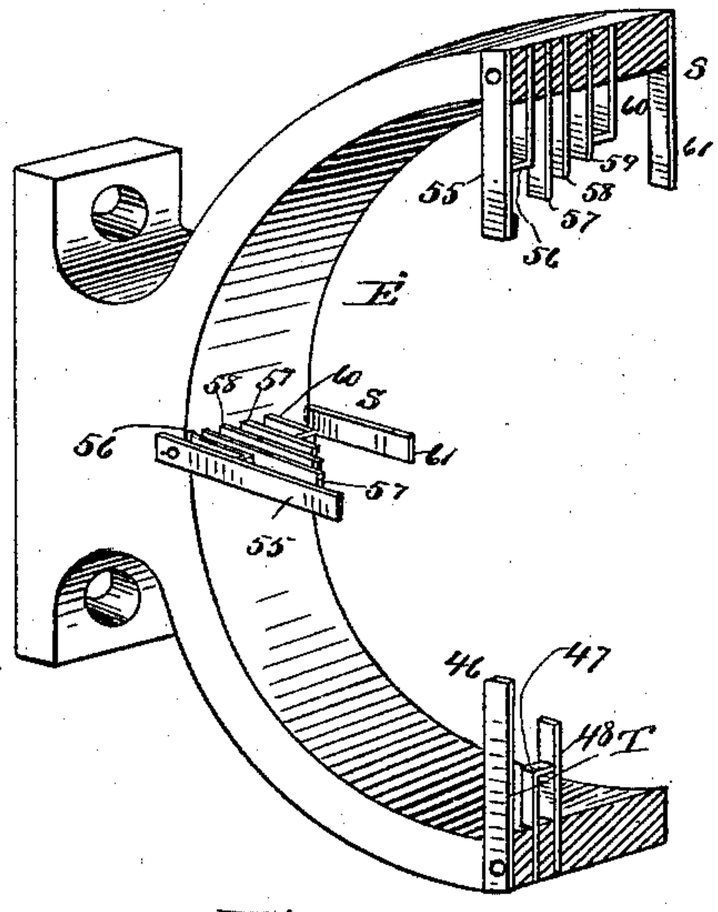


FIG. 7.

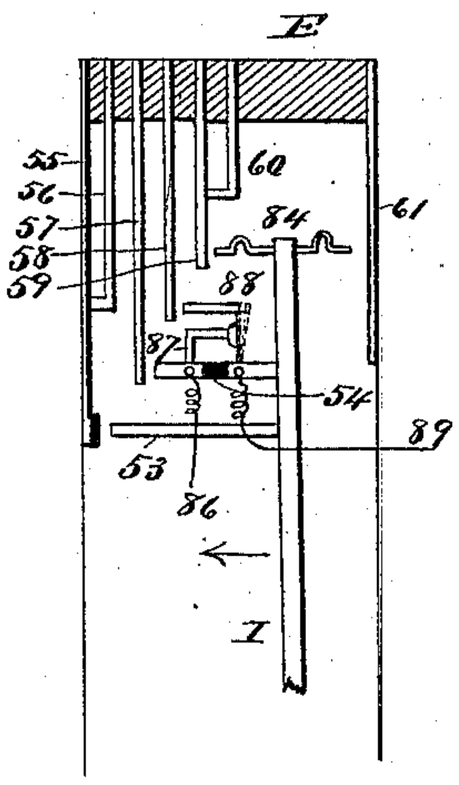
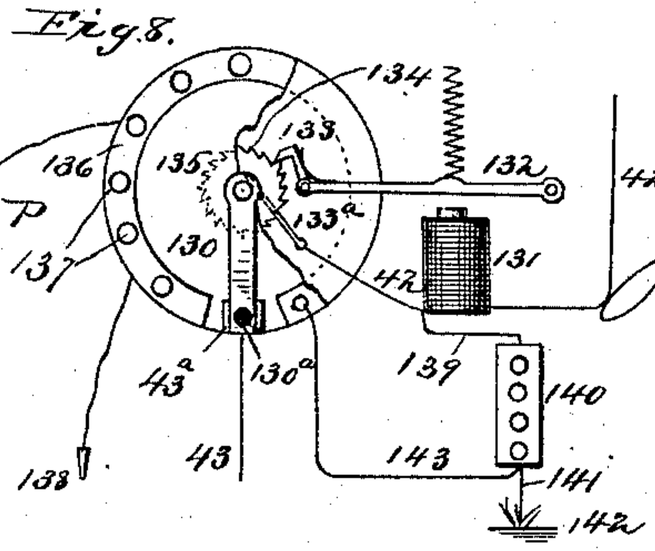


Fig. 8.



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AUTOMATIC EXCHANGE SYSTEM.

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FIG. 10

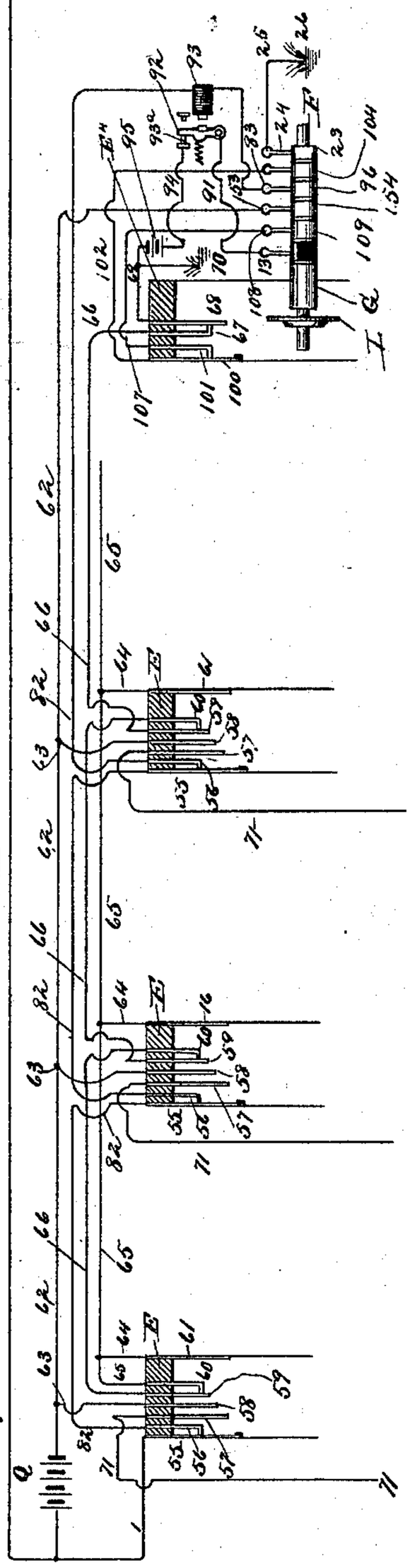
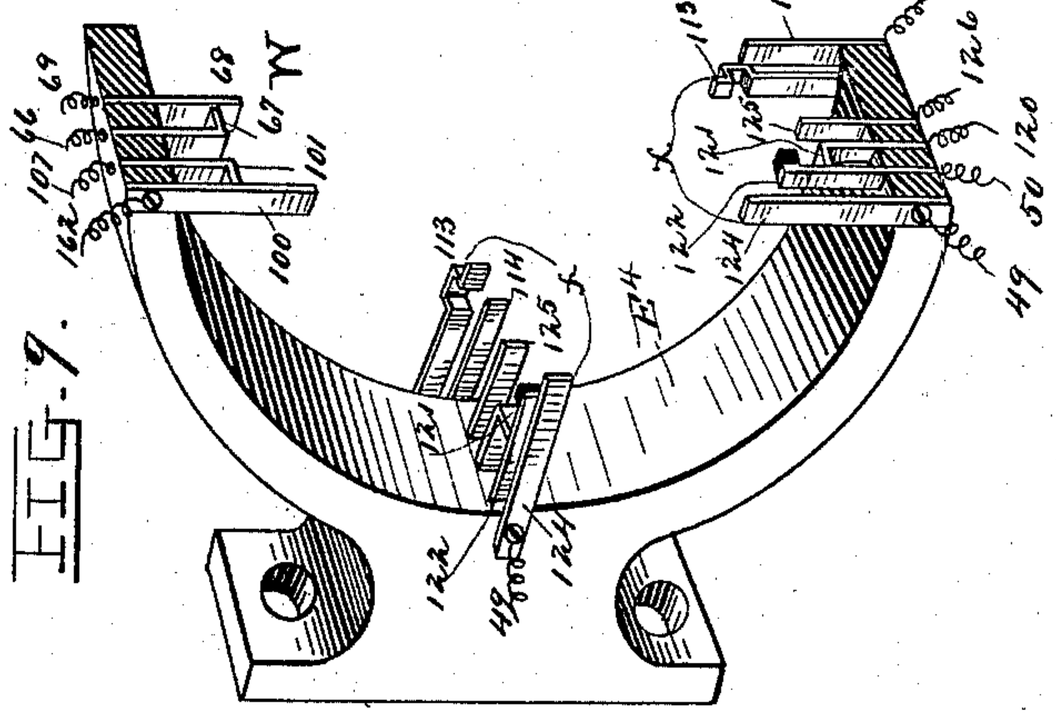


FIG. 9.



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UNITED STATES PATENT OFFICE.

JAMES G. SMITH, OF NEW YORK, N. Y.

AUTOMATIC EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 550,729, dated December 3, 1895.

Application filed February 20, 1893. Serial No. 463,086. (No model.)

To all whom it may concern:

Be it known that I, JAMES G. SMITH, of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Automatic Exchange Systems for Telephonic and Telegraphic Purposes; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming a part of this specification, and to the figures and letters of reference marked thereon.

This invention has for its object to provide an improved automatic exchange system for telephonic and telegraphic purposes, whereby any subscriber in the system may, by a simple manipulation of the instrumentalities at his station, secure circuit connections with any other subscriber and at the same time cut out all other subscribers, all through the instrumentality of automatic mechanism, in which respect the present invention is closely allied to that disclosed in my prior patent, No. 481,247, dated August 23, 1892, to which reference is hereby made for an understanding of the underlying principle of the invention.

More especially this invention has for its object to provide an effective system for long-distance telephony—that is to say, between distant cities—each of which has a telephone-exchange, any subscriber of which may automatically place himself in communication with any subscriber of the exchange in the other city.

For long-distance telephony and for some purposes in telegraphy it is very necessary to establish a complete metallic circuit between the distant points; and this invention may be said to consist, broadly, in mechanism and such an arrangement of circuits that a complete metallic circuit may be automatically selected from a number of main lines between the cities and connected with the desired subscriber, and, further, to loop to the main lines so selected through induction-coils at each end, in order to secure the advantages of an induced current over the selected metallic circuit in accordance with the well-known system in common use at this day.

The invention further consists in certain novel details of construction and combinations and arrangements of parts, all as will be now described, and pointed out particularly in the appended claims.

Referring to said drawings, Figure 1 represents the apparatus at the main office of the system at one city, as New York, as shown at A, and a sub-station at the same city, shown at B. The apparatus as shown in this figure is in the position of rest, ready for operation. Fig. 1^a shows similar apparatus at the main office in a distant city—say Boston—as shown at A^2, and a sub-station B^2 in the same city, (Boston.) The apparatus in Fig. 1^a is also shown as it appears when in a position of rest, ready for operation. Fig. 2 shows the same apparatus as Fig. 1, but with a portion of it in operated position. Fig. 2^a shows the same apparatus as Fig. 1^a, but with a portion of it in operated position. Fig. 3 shows a portion of the same apparatus at the main office as in Fig. 1, but with two sub-stations in series on the same local circuit. This figure is for the purpose of illustrating the difference in the sub-station apparatus and in the main-office apparatus used when two or more sub-stations are placed on one local circuit, as in Fig. 3. In this figure is also illustrated a modification of the releasing apparatus at central office. There is also shown a modification designed to be used when a local metallic circuit is desired between the subscriber's office and the central office in place of the single-grounded circuit. Fig. 4 shows an arrangement by which the capacity of a portion of the apparatus at a main office can be increased. The apparatus in this figure is also shown in a condition of rest. Fig. 5 is an end view of the frame at the main office that supports the sets of contact-points and also of the moving parts of the apparatus. Fig. 6 is a perspective sectional view of the same frame, showing a few of the sets of contact-points placed around the frame. The only difference in any of the frames is in the arrangement and number of contact-points. Fig. 7 is an enlarged view of one set of contact-points of the frame shown in Fig. 1 and of the lever I of said frame, with the projections and connections attached thereto. Fig. 8 is a detailed illustration of the construction of a convenient form of the dial used at each sub-station for the purpose of controlling the automatic selection of the

desired sub-station by the apparatus at the distant main office. Fig. 9 is a perspective sectional view of the frame E^4, Figs. 1, 1^a, 2, and 2^a. Fig. 10 shows the manner in which each main wire is carried to and through corresponding sets of contact-points on each subscriber's frame (to enable any subscriber at that city to select and connect to that main wire) at central office and finally to the frame E^3 or E^4 at the same central office. Wires are also shown arranged to enable one subscriber using the main wire 1 to prevent all other subscribers from connecting to said main wire.

Referring now to Fig. 1, the apparatus therein shown consists of four or more circular frames at central office, E, E^2, E^3, and E^4, preferably composed of insulating material, those marked E and E^2 being in every respect entirely alike and of any desired number, according to the number of subscribers, each subscriber having two frames, (*i. e.*, E and E^2,) they being referred to as E and E^2 simply for convenience of description, the frames E^3 and E^4 being also alike, but differing from frames E and E^2. All these frames have a mechanically-driven shaft (one shaft for all or a separate shaft for each frame) passing through, but not connected with each frame, the shaft or shafts being kept constantly rotating by electric motor, clockwork, weights, steam, hand, water, or other power.

Attached at intervals around frames E and E^2 are a series of sets of insulated contact-points (see Fig. 6) formed of metal strips, some rigid and the others flexible, all the sets on each frame being similar with the exception of one additional set, the similar sets (marked S on Fig. 6) each representing the connections to one of the main or trunk lines, and the various strips and springs so arranged as to operate jointly to form connection (by moving parts operated by the revolving shaft F) between the subscriber's office and that set's particular main line, also to reserve that line to the sub-station then using it, and also to bring into use the main batteries upon said line, as will all be more particularly described hereinafter. The dissimilar set (marked T on Fig. 6) has its strips and springs arranged differently, being the home set at which the apparatus automatically comes to a stop, with the exception, of course, of the shaft F. Each frame marked E and E^2 has a similar equipment of these sets of contact-points, and in each frame the number of such sets will correspond to the number of main or trunk wires employed in the system. The number of these pairs of frames (E and E^2) at a main office, together with the whole apparatus for each, corresponds to the number of local sub-station circuits at that end of the system, and the number of sets of contact-points upon each frame (excepting the home set) corresponds to the number of main wires employed, as aforesaid. The number of frames E^3 and E^4, however, corresponds to the number of main wires and not to the number of sub-stations, (as in the case of frames E and E^2,) and the number of sets of contact-points on each of the frames E^3 and E^4 corresponds to the number of sub-station circuits instead of to the number of main wires, as in the case of the frames E and E^2—that is to say, there is one frame E^3 or E^4 at each end of each main wire, and on each of these frames are sets of contact-points corresponding in number and connected severally to the local sub-station circuits, (all the sets being similar except one additional set,) and the said contact-points forming the sets so arranged as to operate jointly with the moving parts when operated by the revolving shaft to form connection from the main wire to that set's particular sub-station circuit.

The dissimilar set (marked W on the frames E^3 and E^4) has strips and springs arranged differently, being the home set at which the apparatus, except, of course, the shaft F, automatically comes to a stop when communication ceases and is held at rest when not in use.

Rigidly attached to shaft F, Fig. 1, and revolving with it and within (but not attached to) each of the frames E, E^2, E^3, and E^4 is a disk L, provided, preferably, with holes in its face, or having its face of such character that the point or stud *f*, hereinafter described, or its equivalent, will engage and be carried with the disk when pressed against the same. In proximity to this disk is a cylinder or sleeve G, through which the shaft F runs. Pivoted upon such cylinder or sleeve G, and insulated therefrom, is an armature-bar I, provided at one end with a stud or projection *f*, (so arranged as to engage with the holes in or the face of the rotating disk L, thereby rotating sleeve G and the attachments carried thereby,) and having at its other end projections, as shown at 53, 54, 88, and 84, insulated substantially as shown, and the extreme one 84 projecting each side of the armature-bar I; also mounted upon sleeve G are the magnet J and the retractile spring *d*, both arranged to operate armature-bar I. The projections 53, 54, 88, and 84 are of such lengths and so arranged as to engage severally with their respective series of strips and springs forming the sets of contact-points 46, 48, 55, 57, 58, 59, and 61, Fig. 1, when in operation. Also mounted upon this sleeve G are the metal commutator-strips 6, 16, 21, 151, 90, and 23, which are insulated both from the sleeve and from each other. The commutators 6, 151, and 23 pass completely around the sleeve; but 16, 21, and 90 are only segments of metallic strips, the remaining portions of these strips being composed of insulating material. Each of these commutator-strips has resting or bearing upon it, to form contact therewith, a metallic brush or flat spring. Commutators 16 and 21 have very small metallic segments, which are placed so that their respective brushes rest upon them only when the projections 53, 54,

88, and 84 of armature-bar I are at the home set of contact-points. (Shown at T.) Commutator 90 has a large metallic segment, which is so placed that its brush bears upon it only when the projections of lever I are not at home point. The brushes are shown in this figure at 7, 15, 20, 150, 31, and 24. They may be formed of metallic springs and are supported independent of sleeve G. These brushes have connections by wire, as shown—namely, brush 7 of frames E E^2 with wire 8, magnet 9, armature 10, stud 11, battery 14, brush 15, segment 16, wire 17, magnet J, wire 5, and commutator 6; brush 15 in the local circuit (to normally energize magnet J) just described; brush 20 to wire 19, leading through magnet 12 and by wire 27 to stud 28; brush 150 with wire 149 to stud 148; brush 31 to wire 30, leading to armature 29 of magnet 146. Wire 30 has a branch 32 (frame E) connected to one insulated end of armature-lever 33 of magnet 165, (there being one magnet 165 for each pair of frames E E^2,) and brush 24 with 25, leading to earth at 26.

At frame E are located several magnets, with their connections as follows: Magnet 12, which is doubly wound, one winding being constantly charged by closed circuit of battery *n*, (thus holding armature 10 normally against stud 11 to complete the local circuit of battery 14 through magnet J on sleeve G,) the other winding being connected (as previously described) between stud 28 and brush 20. Magnets 9 and 9^a are opposite each other and have a common armature 73. Magnet 9 is connected, as described, in local circuit of magnet J. Magnet 9^a is a stronger magnet than 9 and is adjusted so that at proper times it will draw armature 73 away from magnet 9, and said armature having no retractile spring will remain in the position it has last assumed until drawn by opposite magnet, when the latter is energized. Magnet 9^a is connected to ground 185 on one side and on the other to wire 183, leading to battery 184 on device E^2. The armature 73, normally held by magnet 9 against stud 72, (said stud being connected to wire 71,) forms part of the circuit of battery 78, which circuit is completed at proper times by the action of lever I, more fully described hereinafter. Magnet 146 is connected in the circuit of wire 126, with battery 78 and operates when said circuit is closed. The armature 29 of said magnet is connected normally in circuit of wire 30 and stud 28. Magnet 80 is doubly wound, one coil of which is charged constantly by the closed circuit of battery 81. This current causes armature 76 (one end of which is connected to battery 78) to rest normally against stud 75, which leads by wire 74 to armature 73, thence by wire 71 to wire 176. The other coil of said magnet 80 is connected in the circuit of wire 4, as shown.

At frame E^2 are several magnets, four of which—namely, 12, 9, 9^a, and 146—are similar in all respects to the corresponding magnets connected with frame E. Frame E^2 has, however, no magnet 80, but has a device consisting of magnet 174, its armature 177, (having a flat flexible spring 18, projecting therefrom, with insulation 181 upon its under surface,) battery 175, and standard 178. Magnet 174 is connected on one side to battery 175 and on the other side to wire 173, leading to stud 168. Armature 177 is connected at one end by wire 183 to magnet 9^a, thence to battery 184. The spring 180 of armature 177 is adjusted so that it makes no electrical connection with but snaps past standard 178 when armature 177 is attracted by magnet 174; but when 177 is retracted from magnet 174 by its spring said projection 180 will make electrical contact for a moment with 178 as it passes the same.

Between frames E and E^2, and connected thereto, as shown, is a device consisting of a magnet 165, its centrally-pivoted armature 33, (having spring-stops 167, 168, 34, 170, and 171,) and induction-coil R, with connections, as shown. Armature 33 has insulations, substantially as shown, to form connections, as hereinafter specified, and coil R may be wound in any suitable and ordinary manner.

At frames E^3 and E^4 there is also shown the shaft F, supplied with its fixed disk L and sleeve G, the latter having mounted on it, as shown, the double magnet J, having a common core, the retractile spring *d*, and the insulated armature-bar I, provided with its stud *f* at one end and its projections 53, 98, 111, and 144 at the other end, so arranged as to co-operate, when desired, with the contact-points 100, 68, 113, 114, 122, 124, and 125. The contact-point 113, however, is not directly in line with the other contact-points of the set, but is placed in advance of them, so that the projecting arm 98 will form contact with it just prior to contact being formed between 111 and 114. Also mounted upon this sleeve G, but insulated from it and from each other, are the metallic commutator-strips 16, 109, 154, 96, 104, and 23, one of which (shown in this instance at 16) is only a small segment of a metallic strip, the remainder being composed of insulation, and so arranged that the brush of this commutator bears upon it to form connection only when the projections 53, 98, 111, and 144 arrive at the set of contact-points marked W, which is the set at which they normally rest when the apparatus is not being operated. This set of contact-points W will hereinafter be referred to as the "home set." Brushes similar to those described for frame E are shown here at 15, 108, 153, 83, 103, and 24, bearing upon their respective commutator-strips. These brushes have connections by wire, as shown and as will be more fully explained hereinafter. There is also located at each of these frames E^3 and E^4 a magnet 93, connected in the circuit of wire 82, having an armature 92 connected at one end to wire 91, leading to brush 15, and the other end resting normally against

stud 93ª, which is connected by wire 94 to battery 95, and thence to earth at 70.

The apparatus at sub-station B consists, as shown in Fig. 1, of preferably two dials, which are more clearly shown in Fig. 8 and described in detail hereinafter. There is also provided, as shown in Fig. 8, a short metallic plug for insertion at the holes in each dial, so shaped that its head will project sufficiently to allow the arm 132 to pass over it, but at the same time touch it sufficiently to make electrical contact therewith. There is also provided at B, as shown in Fig. 1, a set of telegraph or other signaling instruments M of ordinary construction, telephone apparatus N, a call-bell device 191, operated by magnet 190, in circuit of wire 4, rheostats 140, switches 36, with their studs 37, 39, 41, and 193, with wire connections; also a small battery 44, all connected substantially as shown and more fully referred to hereinafter.

The main-line batteries are shown at Q on Fig. 1, representing one terminus of the system, and at Q on Fig. 1ª, representing the other terminus. Each main or trunk line is similarly equipped with batteries, and it should be understood that the system contemplates the use of a sufficient number of main and trunk lines to accommodate the business between the distant points or exchanges.

Fig. 1ª shows precisely the same instruments and connections as are shown on Fig. 1, but represents the distant end of the main lines.

On Figs. 1 and 1ª the parts are represented as at rest in normal positions.

Figs. 2 and 2ª are in all respects like Figs. 1 and 1ª, and represent the devices, &c., Fig. 2 at one terminus and Fig. 2ª at the other of the main wires between two cities, excepting that in Figs. 2 and 2ª some of the parts are represented in an operated position.

The general purpose of each device on these four figures (1, 1ª, 2, and 2ª) is as follows:

The device at frame E on Fig. 1 is used to enable subscriber B to automatically select one "idle" main wire from a number of main wires between the two cities and to connect himself thereto, and at the same time to automatically prevent any other subscriber in the same city from forming any connection with the main wires so selected by B. Any subscriber in the distant city is prevented from forming any connection with such wire by the action (the instant B's connection is formed) of the device at frame E^4 at the distant end of that wire.

The device at frame E^2 is used to enable the same subscriber B to automatically select a second idle wire from the remaining main wires (for the purpose of using a metallic circuit) between the two cities and to connect himself thereto and at the same time to automatically prevent any other subscriber in the same city from connecting himself to the said second selected wire, while the device E^3 at the distant terminal of that same wire prevents any subscriber in the distant city from forming connection with said second wire, the whole action being similar to that described in selecting the first idle wire. If subscriber B should desire but one wire for telephone or telegraph purposes, the device E^2 will not be brought into use.

The device formed of magnet 165, its armature and stops, together with induction-coil R, is used to automatically loop together the two main wires just selected into a metallic circuit through one side of the induction-coil R (at central office) and at the same time to transfer that portion of the first wire 3 which leads from central office to subscriber B to and through the other side of induction-coil R to a ground 166, for the purpose of long-distance telephoning. If it should be desired to use a metallic circuit from sub-station to central office through the local side of the induction-coil R in place of the grounded circuit just described, it could be thus formed by using a third wire from the subscriber's station to the central office connected at central to armature 33 of magnet 165 in place of ground 166, and at the same point on armature 33 as the one to which ground 166 is connected, (see Fig. 3,) and at the subscriber's station connected to the induction-coil of telephone apparatus N at the same point and in place of the connection shown from ground 160ª to that point.

By the same action of the device a local circuit is at the same instant formed (of wire 4 from subscriber's station B, to and through magnet 165, stop 168, wire 173, to and through magnet 174, battery 175, to ground 176) for the purpose of holding armature 33 of magnet 165 in the position it has just assumed and at the same time of attracting armature 177 of magnet 174. The object of this local circuit is to enable the moving parts of all the devices just mentioned to be released and returned to their normal positions after communication shall have been finished. This action of looping together automatically the two selected main wires and of forming the two local circuits just described takes place at the instant that the device E^3 at the distant end completes the selection of and connection to the distant subscriber desired. At the same instant, also, that this action takes place the device similar to the one just described (but located at the central office of the distant city) performs a precisely-similar function—namely, looping the two wires through the induction-coil R at that end and forming two local circuits between the central office at that distant end and the selected subscriber.

The devices at frames E^3 and E^4 are used to select the desired subscriber. Every main wire has one of these devices at each end. Those at one end (say New York) are operated over the main wire by the subscriber at the distant city (say Boston) to enable him to connect the main wires he has selected to the

subscriber he desires at New York. Meanwhile the devices E^3 and E^4 at the Boston end of those wires are not used. Those at the Boston end are operated by the subscriber at New York to enable him to connect the main wires he may select to the subscriber at Boston with whom he may desire to establish communication, the devices E^3 and E^4 at the New York end in this case not being operated—that is to say, to establish connection over one wire between two subscribers, the device E^4 at but one end of the main wire is used—namely, the one at the central office of the called or receiving subscriber. In case of forming a metallic circuit for telephoning it will of course be understood that two of these devices E^3 and E^4 will be used, one on the receiving subscriber's end of each main wire, as described.

The two dials at B are used to cut out the rheostats 140 by the arm of the dial touching the head of a metallic plug inserted in an aperture of the metallic plate at the hole corresponding in number to the desired subscriber at the distant city. The object of cutting out the rheostat is to increase the strength of the battery on the selected main wire at the time that the moving lever of frame E^3 at the distant end has reached the set of contacts on said frame which corresponds to the subscriber desired. The arm of the dial is moved step by step from one aperture to the next at each step by the operation of armature-lever 132 of magnet 131. This operation can be best understood by reference to Fig. 8.

The battery 44 at the subscriber's station is divided by a ground 45, one pole connected to a zero or home point, (on dial-frame,) at which the dial-arm normally rests and makes connection normally therewith. This portion of battery 44 is used when the operation of selecting a wire is begun to neutralize the normal effect of battery *n* upon magnet 12 at frames E E^2, the effect being to allow armature 10 to be retracted from stud 11 and to thus break the normally-closed local circuit through magnet J, thereby permitting arm I to revolve. The other portion of battery 44 leads by a wire 194 from the pole opposite that just described to stud 193, so that when switch 36 is thrown on stud 193, after the wire selected by said frame has been utilized as a single wire for telegraph or telephone purposes, said battery will neutralize the normal effect of battery 81 on magnet 80, thus allowing armature 76 of said magnet to be retracted from stop 75 to break circuit of wire 74 for the purpose of releasing the arm I of frame E and allowing the same to return to normal position. The purpose of this opposition in polarity of battery 44 is to avoid, when effecting the release last stated, neutralizing the normal effect of battery *n* on magnet 12 of frame E^2, as the device of E^2 is not used when subscriber B is operating a single wire for telegraph or telephone purposes.

The call-bell 191, operated by magnet 190, automatically rings at the subscribers' stations at both cities when a metallic telephone-circuit is completed and ready for operation between the two subscribers.

Fig. 3 shows, first, a modification of the system when two or more sub-stations are placed in series upon the same local circuit and the arrangements of the parts for the purpose of cutting off or shunting all other sub-stations when any one of the series is using the local circuit; second, a modification of the arrangement for releasing the levers I of frames E, E^2, E^3, and E^4 when communication has been finished to permit the same to return to their normal or "home" positions; third, a modification of the telephonic-circuit arrangement between sub-stations and their central office when a local metallic circuit is used in lieu of a grounded local circuit.

The first modification consists at the sub-stations B and C (all sub-stations on series being equipped alike) of magnet 206, its centrally-pivoted armature 202, (insulated as shown and hereinafter more particularly referred to,) said armature being limited in its action by and forming connections by means of stops 205, 208, and 203 and carrying upon one end an insulated metallic contact-point 201 with wire connection, as shown, and adapted to form contact with stop 203 when said armature 202 is attracted, thereby forming a shunt over wires 200 and 204 around the operating-instruments, as shown, (of course the operation of the parts is such, as hereinafter described, that at the station operating the instruments will not be shunted,) switch 210 with its studs and connections thereto, as shown, and a battery 44^a, connected as shown. At the central office this first modification consists of an additional commutator-strip 229 on sleeve G of frame E^2. This strip is formed of a small metallic segment, the balance being insulating material, a brush 228^a bearing upon strip 229 when lever I of E^2 is at home set, said brush being connected to wire 227, said commutator 229 being connected, as shown, by wire 230, to commutator 23 on said sleeve G, thence by brush 24 and wire 25 to ground at 26. Magnet 226 of frame E is connected on one side to wire 71 and on the other side to wire 71^a. Armature 225 of magnet 226, normally resting against its back stop, is connected to a battery 228. The front stop 224 of armature 225 is connected to wire 223. Armature 29 of magnet 146 (frame E) has an additional insulated point connected to wire 240, and has also an additional front stop 239, connected to wire 238, and so arranged that when armature 29 is attracted connection will be formed between wires 240 and 238 by an additional double magnet 231, one coil of which is connected in the circuit of wire 4 and the other coil (branching from wire 4) connected to wire 235. The armature 222 of said magnet is connected to wire 223. It rests

normally against back stop 221, which is connected to wire 220. Magnet 165 of the intermediate device is made double, the additional coil 165[a] being connected to wire 235 on one side and to an insulated contact-point 236 on the end of armature 33 on the other side.

The second modification consists of an additional insulated point 76[a] on armature 76 of magnet 80, connected to a wire 77[a], leading to a battery 78[a] and ground at 79. Insulated point 76[a] normally rests against front stop 75[a], connected by wire 71[a] to magnet 146 of frame E^2, thence by wire 126 to frame E^3. (Not shown in this figure.) Said armature 76 of magnet 80 also normally makes contact with the front stop 75, connecting by wire 71[a] to magnet 146 of frame E, thence by wire 126 to frame E^4. (Not shown.) It will be observed that this modification does away with magnets 9 and 9[a], frames E and E^2, Figs. 1, 1[a], 2, and 2[a], their armatures 73, magnet 174, its armature 177, standard 178, battery 184, and their especial wire connections.

The third modification consists of a third wire $4^{\times}$, connected at central office directly to armature 33 in place of the ground connection 166 and at the sub-station to the armature 202 at each sub-station, as shown. This modification is for the purpose of forming a local metallic circuit between the subscriber and central office through one side of induction-coil R at central and one side of induction-coil of telephone apparatus N at subscriber's station.

The apparatus represented in Fig. 4 illustrates that feature of the invention which comes into use when the number of sub-station circuits is greater than can be conveniently provided for by sets of contact-points on one frame or one set of frames E^3 or E^4—that is to say, assuming the number of sub-station circuits to be five hundred, and assuming, also, that the size of the frame E^3 or E^4 will not conveniently accommodate more than about one hundred sets of contact-points, then the apparatus here shown provides for the other four hundred or any larger number.

Frame E^4, Fig. 4, is similar to frame E^3 (or E^4) of Figs. 1, 1[a], 2, and 2[a], with the addition of one or more sets of contact-points arranged as shown at V. The object of this set or sets of contact-points (shown at V) is to enable connection to be made from the main line through the armature-bar at frame E^4 to the auxiliary switch or switches E^5. If desired, therefore, the whole or any portion of this frame E^4 can be equipped with these sets of contact-points V, each connecting with a switch E^5, so that by placing one hundred such sets V upon this frame E^4 one hundred auxiliary switches E^5 can be brought into use, each switch E^5 representing one hundred or more sub-stations, thus showing the almost unlimited capacity of the system. This auxiliary switch E^5 consists of a similar frame E^3, provided with sets of contact-points arranged, as shown at X, on frames E^3 and E^4, Figs. 1, 1[a], 2, and 2[a], corresponding in number to the number of sub-stations to be accommodated on this particular switch. It also has a set of contact-points arranged as shown at Y, representing the home set of that switch. The shaft, sleeve, disk, armature-bar, &c., are the same as in E^3; but the commutator strips and brushes, while of the same construction, are less in number, as shown.

The detail view of Fig. 8 represents the "dial" placed at each of the sub-stations, the perforations in the metallic plate being shown at 137, the electromagnet at 131, and its armature-bar at 132, the latter having a retractile spring and a ratchet-pawl 133 engaging with the ratchet-wheel 134. The number of teeth or notches in the ratchet-wheel corresponds to the number of holes in the face of the plate, and said wheel is rigidly attached to the short shaft 135, supporting the metallic arm 130, having a handle. (Shown at 130[a].) The brush 133[a] also bears upon the shaft 135. A limited number of the holes immediately succeeding the zero-point of the dial represent the several auxiliary switches at the distant city, and the remaining holes represent the number of local subscribers, from one to one hundred, located upon any of the frames E^3, E^4, or E^5 at the distant city. The handle 130[a] is employed to bring the arm around by hand to zero-point after use. There are two metal plugs 138 and 138[a], as shown, Fig. 8, adapted to be inserted in the apertures of plate 136—one to be used for the apertures representing the auxiliary frames and the other to be used for the apertures representing the fractional number from one to one hundred, of subscriber desired.

Having described the several parts, I now proceed to describe their operation.

Assuming that the operator at the station B (which is supposed to be at New York) desires to communicate by means of a long-distance telephone-circuit with station B^2 (which is supposed to be at Boston) the operation would be as follows: To select the first "idle" main wire, first, he (B) would insert the brass plug 138, Fig. 8, in the hole of his left-hand dial-plate 136, representing the number of the local circuit at Boston, upon which station B^2 is located. He would then throw switch 36 of wire 3, Fig. 1, onto stud 41, thus throwing the current of battery 44 over wire 3, its branch 35, stud 34, through one end of lever 33 to wire 32, thence by wire 30 to armature 29, back-stop 28, wire 27, to and through one coil of magnet 12, over wire 19 to brush 20, segment 21, wire 22, commutator 23, brush 24, and wire 25 to ground at 26. As the polarity of battery 44 is arranged to oppose the permanent current of battery *n* through the other coil of magnet 12, it neutralizes the effect of the latter current on magnet 12, allowing the retractile spring to draw armature 10 away from stop 11, thus breaking the local

circuit of battery 14, which has heretofore been locally energizing magnet J through wire 13, brush 15, segment 16, wire 17, magnet J, wire 5, commutator 6, brush 7, wire 8, and magnet 9 to armature 10 and stud 11. The result of thus breaking this local circuit is that the retractile spring *d* of lever I is enabled to overcome the magnet J and withdraw its end of the armature-bar I, thereby bringing forward the other end, which is provided with the stud *f*. This stud *f* then engages with one or the other of the holes in the disk L, which is rotating by the movement of the shaft F, to which it (L) is rigidly attached, and the projecting arms 53, 54, 88, and 84 at the other end of the armature-bar I leave the contact-points 46 and 48 of the home set T, and 84 engages in its rotation with the contact-points 61 successively of each set until said projection 84 arrives at the first set connected with a main wire not in use—for instance, the set S, Fig. 1. Meanwhile the sleeve G, together with the parts attached to it, revolves with said disk, removing the segmental commutator-strips 16 and 21 from contact with the brushes 15 and 20, thereby keeping the local circuit of battery 14 broken and also breaking the earth connection 26 from the circuit of battery 44. The circuit path of this battery 44, therefore, now passes by brush 31 (instead of by wire 30 and armature 29) to projection 88 (see Fig. 7) of armature-bar I, thence to 87, wire 86, magnet J, wire 85, projection 84, contact 61, (against which it is now pressing in rotation,) thence by wire 64, open wire 65, strip 60, strip 59 (which is normally in contact with strip 60), wire 66, to strip 67 on frame E^4, to strip 68, which is pressed against 67 by projection of lever I (frame E^4), whenever I is at the "home set" W, and wire 69 to ground at 70. It will be understood that the circuit can only be established when the contacts 67 and 68 are together and also when the contacts 59 and 60 of similar sets on other frames are together. Hence the apparatus automatically selects a main wire not in use. This latter circuit when so completed brings the apparatus to the position shown in Fig. 2 by energizing magnet J, which attracts the bar I and thus withdraws stud *f* from disk L again, thereby freeing it from the motion of the continuously-rotating shaft F, and the armature-bar and parts thereof stop with the projecting arms 53, 54, 88, and 84 engaged, respectively, with the contact-strips 55, 57, 58, and 59, as shown in Fig. 2. At the same time this circuit energizes magnet 131, (sub-station B,) causing dial-arm 130 to move from zero-point, on which it normally rests, thereby breaking the circuit of battery 44 at that point. The result of the new position of arm I is, first, that the connection with the earth at 70 (frame E^4) is maintained at E by the projecting arm 84 bearing against contact-point 59 instead of 61 at the same time that it presses contact-point 59 away from contact 60, thereby preventing any other sub-station from forming connection with this particular main line, (as heretofore mentioned in regard to other frames,) and it is evident that the contact-points 61 and 59 and the projecting arm 84 must be so relatively adjusted that 84 engages with contact-point 59 before leaving contact-point 61 to maintain a circuit through magnet J; but the circuit now formed through J (and which holds J energized until subscriber B has finished all communication) is different from the one just previously described through J, and is as follows: from ground 70 (frame E^4) over wire 66 (as described) to strip 59, (frame E,) projection 84, (of armature I,) wire 85, magnet J, wire 86, projection 54, strip 57, (against which 54 is now pressing,) wire 71, stud 72, armature 73, (of magnets 9 and 9^a,) by wire 74, stud 75, armature 76, wire 77, and battery 78 to ground 79; secondly, the result of this new position is that projection 53, pressing the contact-point 55 away from contact point 56, breaks the connection of the main circuit at this point from the ground 70 of frame E^4, thereby permitting the battery Q to be introduced onto the main line, as will be presently shown; thirdly, projection 88 is brought into connection with contact 58 and the main battery Q is thrown into the main-line circuit formed now as follows: from ground 142, (station B,) wire 141, rheostat 140, magnet 131, wire 42, switch 36, over wire 3, branch wire 35, wire 32 to brush 31, wire 89, projection 88, strip 58, wire 63 to battery Q and main line 1, whence it extends to the distant end of the main wire, Boston, (shown at Figs. 1^a and 2^a,) where it comes down contact-point 55 of frame E, (Boston,) up contact-point 56, thence through any number of frames E by contact points 55 and 56 on such frames, and finally to frame E^4, over wire 82, through magnet 93, brush 83, commutator-strip 96, wire 97 to projection 98 of lever I (said projection being in connection with contact-strip 68) to wire 69 and ground at 70. The result of the circuit so formed is to energize magnet 93 of frame E^4, Fig. 1^a, drawing its armature 92 away from back-stop 93^a, (with which it is normally in connection,) thus breaking the local circuit of battery 95, normally formed as follows: ground 70, battery 95, wire 94, stud 93^a, armature 92, wire 91, brush 15, segment-commuator strip 16, wire 17, to and through outer coil of magnet J, (frame E^4, Fig. 1^a,) thence by wire 22, commutator 23, brush 24, and wire 25 to ground 26, and which by energizing magnet J holds lever I of frame E^4 normally at home set W. The breaking of this circuit (at back-stop 93^a, as described) allows retractile spring *d* to draw armature-lever I so that stud *f* then engages with the disk L. This circuit is prevented from reforming by metal segment of commutator 16 passing from connection with brush 15 until the arm I again reaches rest on home-point, when this circuit is automatically re-formed. As the disk L is constantly rotating on the

mechanically-driven shaft F, the sleeve and its attachments G consequently also rotate, and the projecting arms 98 and 53, having been withdrawn from engagement with the contact-points 68 and 104 of the home set W, Fig. 1ª, the ground connection of the main line is broken at this instant, and also the connection between contacts 68 and 67 is broken, thereby preventing any other subscriber at the Boston end from selecting that particular main wire for his use, for, as has been previously shown, a subscriber to select that main wire would have to complete his circuit through ground 70 by way of wire 66 and contacts 67 and 68 (from his station B²); also, spring-contact strip 100 is permitted to form connection with contact 101 (by the removal of the pressure of projection 53 on arm I against spring-strip 100), forming two branch terminii for the main line at frame E⁴, as follows: one from wire 82 through brush 83, commutator 96, and wire 97 to projection 98. The other branching from wire 97 passes through the inner coil of magnet J, (frame E⁴,) said coil being wound with fine wire and outer coil with coarse wire, wire 105, commutator 104, brush 103, wire 102, strip 100, strip 101, wire 107, brush 108, commutator 109, and wire 110 to projection 111. This makes the virtual terminii of the wire selected at these two projections on lever I—namely, 98 and 111. As the arm I revolves with shaft F, 98 comes in contact, successively, with each bent strip 113 on frame E⁴, (strip 13 placed, as described, a little in advance of strip 114,) thus forming connection for that terminus 98 of the main wire through strip 113, and wire 115 to ground at 116. This causes closing of main-line circuit from sub-station B at New York through main battery Q at that end over main wire 1 to ground at 116, (Boston.) The effect of this last circuit is to energize magnet 131 at B,) New York,) causing the dial-arm to move one step. At the next instant projection 111 (frame E⁴, Fig. 1ª) comes in contact with strip 114 just prior, however, to contact being broken between 98 and strip 113, in order to prevent dial at B (New York) from moving a second step for the same set of contact-points at frame E⁴, (Boston,) said strip being connected by wire 117 to wire 118, loop-wire 119, (the last wire and loop extend to the corresponding sets of contact-points on every frame E³ or E⁴ for the purpose of permitting any main wire to be connected to this same Boston subscriber's circuit when said subscriber is not himself engaged over any other main wire, in which latter case the strips 49 and 48 of frame E would be separated and the ground connection for the loop broken,) wire 120, strip 121, in contact normally with spring-strip 122, thence by wire 50 to spring-strip 48, (frame E at Boston,) and thence by strip 47 to ground at 52. When the projection 111 of lever-arm I (frame E⁴ of Fig. 1ª) reaches the strip 114 of the set of contact-points on frame E⁴, corresponding and connected to the frame E of desired subscriber, the dial-arm at B (New York) will have reached and made electrical contact with the plug inserted in the hole in the metallic plate corresponding to the number of the subscriber desired. This contact between dial-arm and plug will shunt the resistance 140 at B, (New York,) thereby increasing the strength of the current of New York battery Q over the main wire sufficiently to energize the inner coil of magnet J (frame E⁴, Fig. 1ª) and cause it to attract armature-lever I, disengaging it from the rotating disk L and throwing the projections 144, 111, 98, and 53 away from 114 over against strips 125, 122, and 124, respectively, (breaking the circuit previously formed through inner coil of magnet J,) and establishing a local circuit through the outer coil of said magnet J, as will be presently described. (See Figs. 2 and 2ª.)

The results of the position now assumed by lever I at frame E⁴ at Boston are as follows: First, a local circuit is formed (frame E⁴) through the outer or coarse-wire coil of magnet J (to hold lever I in the new position) as follows: from ground 26, through brush 24, commutator 23, wire 22, coarse-wire coil of magnet J, wire 145, projection 144 of arm I, strip 125, and wire 126 (frame E⁴) to 146 at frame E, (Boston,) wire 71, stud 72, armature 73, (of magnets 9 and 9ª,) wire 74, stud 75, armature 76, (normally resting against 75,) wire 77, and battery 78 to ground 79; second, projection 98 of lever I (frame E⁴) presses against the insulated point of spring-strip 122, (see Fig. 2ª,) breaking the normal contact between strips 121 and 122, thereby preventing any other New York subscriber from making connection with the Boston subscriber selected, as previously stated; third, projection 53 (frame E⁴) makes contact with strip 124, thereby throwing the main line 1 through battery Q at the Boston end of the main wire over wire 62, brush 153, commutator-strip 154, wire 155, projection 53, strip 124, and wire 49 (all at frame E⁴) to strip 46, (frame E at Boston,) which is in normal contact with projection 53 of the last-named frame, thence by wire 152 to commutator 151, brush 150, wire 149, stud 148, armature 29, (of magnet 146,) which is now attracted by the local circuit through the coarse-wire coil of magnet J, (frame E⁴,) just described, (see Fig. 2ª,) thence by wire 30, wire 32, armature-lever 33, wire 35, and wire 3 to the sub-station B² at Boston, as shown, except that switch 36 will continue in its normal position of rest upon stud 37, unless it is desired to use the wire for telephone purposes, when 36 would be thrown onto 39.

It will be understood that the operator at B, Fig. 1, immediately after switching 36 of wire 3 upon stud 41, throws switch 36 of wire 4 upon its stud 41, whereupon the operation of selecting the second wire proceeds at the New York end in the same manner through frame E² as the operation just described

through frame E, Fig. 1, but over wire 4 from B, whereby this second wire to Boston is selected.

At Boston the operation is the same for the selection of subscriber's wire 4, B^2 at Fig. 1^a, over the second wire selected, through frame E^3, as has been previously described for the selection of subscriber B^2 through frame E^4; but the second circuit, it will be noticed, passes through magnet 165 of the intermediary device, and the consequence of the completion of this circuit to B^2 over wire 4 is that the strength of the two main batteries combined—namely, Q at New York and Q at Boston—(over wire 2) is sufficient to cause magnets 165 of the intermediate device at central offices in both cities to instantly draw their centrally-pivoted armatures 33 away from spring-studs 167 at one end and from 34 at their other end, bringing the first end into contact with spring-studs 168 and the other end into contact with the two studs 170 and 171, (which touch the armature at two points insulated from each other, the results of this action of armatures 33 (in both cities) being as follows: First, the two selected wires are looped together at each central office through one side of induction-coil R; second, the wire 3 from station B is put to ground at central office through the other side of induction-coil R by the contact of stud 171 with armature 33 and wire 172 to ground at 166; third, wire 4 (from station B and B^2) is formed into a local circuit between the sub-station and its central office, as follows: through magnet 165, lever 33, stud 168, wire 173, through magnet 174 (of frame E^2) to battery 175, and ground at 176. This causes the call-bell device at stations B and B^2 to automatically ring. Both stations then throw switch 36 of wire 3 upon stud 39, Figs. 2 and 2^a, leading by wire 40 to the telephone arrangement N. The circuit arrangement for long-distance telephoning is now complete.

It will be noticed, first, that the local circuit formed of the wire 4 through magnets 165 and 174 and battery 175 (frame E^2) not only holds armature 33 of magnet 165 of the intermediate device in position last assumed, but, also, by energizing magnet 174, it draws the armature 177 so that projection 180 will snap past metallic standard 178 without making electrical connection therewith. The object of this action is to allow for the release of the proper parts when communication shall be finished, as will be presently described; second, that the main batteries Q, (one at each end of each main wire,) while being included in the circuit of the two main wires just looped together, are arranged to oppose each other in pairs, so that their effect will be *nil*, this including of main batteries with poles opposed in a telephone-circuit being generally admitted to be beneficial; third, that when the wires are so looped no magnets are included in the entire main-line metallic circuit.

The complete arrangement for telephoning (metallic circuit) is therefore as follows: First, station B at New York, Fig. 2, and station B^2 at Boston, Fig. 2^a, have each a local circuit to central office, as follows: from ground at telephone mechanism N of subscriber's station over wire 40 to stud 39, switch 36, wire 3, through one side of induction-coil R to stop 171, armature 33, and over wire 172 to ground at 166; second, from the induction-coil R at New York there is a circuit completed through stud 170, armature-lever 33, wire 32, wire 30, brush 31, commutator 90, wire 89, projection 54, (armature I, frame E, Fig. 2,) strip 58, wire 63, battery Q, main wire I, (to Boston,) battery Q, (at Boston, Fig. 2^a,) wire 62, brush 153, commutator 154, wire 155, lever I, (frame E^4, Fig. 2^a,) projection 53, strip 124, wire 49, strip 46, (frame E, Fig. 2^a,) projection 53, wire 152, commutator 151, brush 150, wire 149, stud 148, armature 29, wire 30, branch wire 32, armature-lever 33, stud 170, one side of induction-coil R, (at Boston, Fig. 2^a,) wire 169, armature 29, (frame E^2, Fig. 2^a,) stop 148, wire 149, brush 150, commutator 151, wire 152, projection 53, (of armature-lever I, frame E^2,) strip 46, wire 49, strip 124, projection 53, armature I, (frame E^3,) wire 155, commutator 154, brush 153, wire 62, battery Q, (at Boston,) main wire 2, (to New York,) battery Q, (at New York,) wire 63, strip 58, (of frame E^2, Fig. 2,) spring projection 88, (see Fig. 7,) projection 54, wire 89, commutator 90, brush 31, wire 30, and wire 169, back to induction-coil R at New York, Fig. 2, and stud 170.

After communication between the two stations B and B^2 is finished the parts are released and return to their normal positions, as follows: At sub-stations B and B^2 the switch 36 of wire 4 is thrown off for a second or two (to break the circuit of wire 4) and then thrown on ground 160, (its normal position.) Switch 36 of wire 3 is thrown on stud 37, (its normal position.) The effect of breaking the circuit of wire 4 at New York is to release the armature 33 of magnet 165, breaking the metallic looping of the two main wires 1 and 2 and at the same time breaking the local circuit formed through wire 173 and magnet 174 of frame E^2, Fig. 2. The effect of breaking this local circuit is to allow armature 177 of said magnet 174 to be retracted, causing connection to be momentarily formed between projection 180 of said armature 177 and metallic standard 178. This forms a circuit as follows: from ground 179, standard 178, projection 180, armature 177, strong magnet 9^a, battery 184, wire 183, and magnet 9^a (frame E) to ground at 185. The latter circuit energizes both magnets 9^a of frames E and E^2, causing in both cases their armatures 73 to be drawn away from stop 72. The effect of breaking connection between 72 and 73 is to break the circuit of battery 78 (which has been energizing magnet J of frames E and E^2) and permitting armatures I of E and E^2 to engage with their respective disks L, caus-

ing them to revolve to home-point, where each will be automatically stopped and held by the local circuit of battery 14 through segment 16 bearing upon brush 15, as previously described. This circuit, which normally holds I at home-point by energizing magnet J, also energizes magnet 9, (of E and E^2,) thus bringing armature 73 back again to stop 72, ready for any new selection of main wires. The dial-arms at station B are returned by hand to zero-point.

At Boston the effect of breaking the circuit of wire 4 is to release armature 33 of magnet 165, thus breaking the metallic looping of main wires 1 and 2 at Boston and at the same time breaking circuit formed through wire 173, magnet 174, and battery 175, (frame E^2 at Boston.) The breaking of circuit of battery 175 causes armature 177 to be retracted and in so doing to form connection momentarily between projection 180 and standard 178. This latter action establishes a circuit from ground 179 through 178, 180, 177, magnet 9^a, battery 184, wire 183, and magnet 9^a (frame E) to ground at 185. This last circuit energizes magnets 9^a, which are wound and adjusted so that, combined with the proper strength of battery 174, they will overcome the attraction of magnets 9 and draw the armature 73 away from stop 72, (where it is normally held by the current of battery 14, as these two frames E and E^2 at Boston have been at rest during the entire operation.) The breaking of contact between 73 and 72 breaks the circuit of battery 78 through magnet 146, wire 126, strip 125, (of frames E^3 and E^4 at Boston,) projection 144 of lever I, (frames E^3 and E^4,) and outer coil of magnet J to ground at 26. This demagnetizes magnet J, (frames E^3 and E^4,) allowing the levers I to engage with their respective disks L and to revolve to home set, where they will be automatically held at rest, ready for the next operation by the circuit of battery 95 through segment-commutator strip 16, bearing against brush 15, thus energizing the outer coil of magnet J, as has been previously described. The release of armature 29 of magnet 146 (frame E and E^2 at Boston) allows it to be retracted against stop 28, (its normal position,) restoring circuit of wires 3 and 4, (through magnets 12,) ready for any succeeding operation that may be desired by B^2.

As a subscriber might desire to use but one wire for telegraph purposes, he would select but one wire, using for that purpose his left dial and switch, connected by wire 3 to central office. The operation would be the same as for the selection of the first wire, (metallic circuit,) with the exception that switch 36 would be placed back upon stud 37, (after the main wire was secured and connection made to the desired subscriber in Boston,) connecting wire 3 to the telegraph-instruments M. The call and answer will be made by the telegraph-instruments M at each station. It is obvious that it would be possible for him to use the telephone-instruments N over this single wire so selected and connected, and for this purpose he would throw the left-hand switch 36 upon stud 39, Boston, of course, doing the same, after first signaling and answering by the telegraph-instruments. After communication has been finished, to release this single wire the double-wound magnet 80 (having one coil permanently energized by battery 81) is utilized, as follows: Subscriber B throws his right-hand switch 36 upon stud 193, throwing the opposite pole of battery 44 to the wire 4, neutralizing the effect of battery 81 on magnet 80, but not affecting the position of armature of magnet 12, frame E^2, and thereby not starting lever I of frame E^2. The result of neutralizing the effect of battery 81 on magnet 80 is to allow armature 76 to be withdrawn from stop 75, thus breaking circuit of battery 78 which, it will be remembered, is utilized over wire 71 to energize magnet J (frame E) and to hold armature-lever I in the position it had assumed after having selected a main wire, permitting armature-lever I of frame E to engage its disk L to revolve to home-point, where it is automatically stopped and held at rest, as has been described.

At Boston B^2 throws switch 36 of wire 4 upon stud 193, which produces the same result upon magnet 80 at the central office, (Boston,) allowing armature 76 to retract and to break circuit of battery 78, which in this case has been energizing the outer coil of magnet J, frame E^4, (at Boston,) through the contact of projection 144 with strip 125 of said frame, as has been heretofore described. The result in this case of breaking circuit of battery 78 is to demagnetize the outer coil of said magnet J and to permit armature-lever I to engage the disk L, returning thereby to home-point, where it is automatically stopped and held at rest, as has been heretofore described.

Fig. 3 shows the arrangements when two or more stations are placed in series upon the same local circuit. The operation is then as follows: Supposing station C at New York desires to form a metallic telephone-circuit with some station at the distant city. He throws his left-hand switch 36 over on stud 41, as usual, the automatic selection and connection proceeding as previously described. Immediately afterward he places right-hand switch 36 upon its stud 41 and switch 210 upon the stud 41^a, thereby throwing battery 44 upon wire 4 and automatically selecting his second main wire.

The local circuit which is formed over wire 4 by the drawing of armature 33 of the intermediary mechanism against stop 168 throws current from battery 175 over wire 4, which energizes the magnet 206 of the sub-station B, drawing the lever 202 so that the contact-point 201 makes connection with contact-point 203, thus shunting all the operating-instruments at station B. At the same time the other end of armature 202 makes contact with stop 205, thereby shunting the switch 36

of said station B. These two shunts just described entirely prevent station B from interfering in any way with the operations of substation C. When C has finished communication, he throws his switch 210 off for one second and then throws the same upon stud 193ª for a second and then off altogether, and also throws his left-hand switch 36 on stud 37 and his right-hand switch 36 on its stud 37, the normal position of these two switches. The throwing off of stud 210 breaks the local circuit that was established over wire 4 and permits the armature 33 of magnet 165 to retract to its normal position. The throwing of switch 210 subsequently upon stud 193ª throws the opposite polarity of battery 44 over said wire 4, neutralizing the effect of battery 81 upon magnet 80 and allowing its armature 76 to retract, breaking the contact between the same and stop 75. The breaking of this contact between armature 76 and stop 75 breaks the circuit previously described of batteries 78 and 78ª, which have been energizing magnets J of E and E², respectively, and allows levers I of said frames to engage with their respective disks L and revolve around to home-point, where they will be automatically stopped and held at rest, as has been previously described.

If station C desires to communicate by single wire with a station in a distant city, he places his left-hand switch 36 upon the stud 41 and his right-hand switch 36 upon stud 193. The placing of left-hand switch 36 upon stud 41 throws the current of battery 44 over line 3, and the process of selecting an idle wire and the connection of the same to the substation at the distant city proceeds as previously described.

The local circuit formed over wire 71 through magnet J, &c., to hold lever I in position after the idle wire has been selected, as previously described, energizes magnet 226, which draws armature 225 and engages the same with stop 224, connected to wire 223, leading to armature 222 through the back-stop 221, against which armature 222 normally rests, and which is connected by wire 220 to wire 4. The armature 225 being connected with battery 228 and by wire 227 with brush 228ª, bearing on segment of commutator-strip 229 of frame E², said commutator-strip being connected by wire to commutator-strip 23, upon which brush 24 bears, and said brush being connected by wire 25 to earth at 26, a current from battery 228 is thrown over wire 4 and energizes magnet 206 of station B, attracting armature 202 and completing the shunts at contacts 203, 201, and 205 and armature 202. The magnet 231 is so adjusted that battery 228 will not be sufficiently strong to cause the armature 222 to be attracted away from back-stop 221. If, however, station C should, before finishing communication, desire to form a metallic telephone-circuit, he will place his right-hand switch 36 upon stud 41 and his switch 210 upon stud 41ª, thus throwing current of battery 44 upon line 4. The addition of this battery 44 to the circuit energizes magnet 231 sufficiently to draw armature 222 away from back-stop 221, battery 44 being sufficiently strong to hold it there, thus breaking the connection of ground 26 away from wire 4 and permitting the current of battery 44 to pass through magnet 12, causing the armature-lever I of frame E² to proceed, as has been previously described, to select a second main wire, and the formation of the metallic circuit will be completed through induction-coil R, as has been previously described. In this case armature 33 will be attracted by magnet 165 and will cause contact to be made between contact 236 and stop 168, completing the local circuit from ground 176 through battery 175, stop 168, contact-point 236, magnet 165ª, wire 235, and outer coil of magnet 231 to wire 4 to ground at 213. This local circuit will hold armature 33 in position last assumed, and will also hold armature 202 of station B attracted by the energizing of magnet 206 at said station B, keeping the instruments of said station shunted, while C is using the line. When C has finished communication, he throws off switch 210 for a second and then touches the same upon stud 193ª for a second, then throws right-hand switch 36 upon stud 37 (its normal position) and throws his left-hand switch 36 upon its stud 37 (its normal position) and turns by hand the arm of dials P P back to zero-point. The throwing of switch 210 off for a second breaks the circuit through magnet 165ª and allows armature 33 to retract, and the subsequent touching of switch 210 upon stud 193ª throws a current from the opposite pole of battery 44 onto line 4 through magnet 80, neutralizing the effect of battery 81 upon said magnet, permitting armature 76 to be retracted and to break contact at stops 75ª 75, thus breaking the circuit of battery 78 over wire 77 to wire 71, through magnet J of E, and also breaking the circuit of battery 78ª over wire 77ª and wires 71ª 71, magnet J, &c., of frame E², permitting armature-levers I of both said frames to engage with their respective disks L and revolve to their home points, where they will be automatically held at rest, as has been previously described.

In case a station at a distant city—say Boston—desires to communicate over a single wire with C, Fig. 3—say at New York—the shunting of station B at New York, Fig. 3, will be effected as follows: The station at Boston would make connection in the manner already described with the main wire 1, and over said wire and through the action of frame E⁴ at New York, as described, would form connection to wire 3 at New York leading to station C and through the telegraph-instruments there. The lever I of frame E⁴ makes connection, as previously described, through projection 144, contact-strip 125, over wire 126, through magnet 146, wire 71ª to stop 75, thence through armature 76 to battery 78 and ground 79.

The local circuit thus formed will energize magnet 146, as previously described. The armature of said magnet, Fig. 3, has two points of contact, one for connection with stop 239, the other for connection with stop 239ª. The connection made with the former stop forms connection from ground 26 through brush 24, commutator-strip 23, segment commutator-strip 229, brush 228ª of frame E², wire 227, wire 238, wires 240 and 223, armature 222, back-stop 221, wire 220 to wire 4. The station at Boston then signals station C by means of the telegraph-instrument. Station C answers and throws his right-hand switch 36 onto stud 41 and his switch 210 onto stud 193ᵇ, thus sending current of battery 44ª over wire to 4, to ground at 26, energizing magnet 206 of station B, attracting armature 202, and completing the shunts, as before described, at said station B; but said battery 44ª is not strong enough to draw armature 222 of magnet 231 away from back-stop 221, thus preserving the connection of wire 4 to ground 26. If, however, during the conversation the station at Boston desires to form a metallic telephone-circuit to station C at New York, he gives a prearranged signal by telegraph-instrument, whereupon station C throws the right-hand switch 36 onto stud 193, and when the shunt-circuit has been completed by the action at station B, previously described, the armature 33 of magnet 165 at New York (central) will be attracted and will complete the telephone-circuit, as heretofore described, and also the local circuit of battery 175 through magnet 165ª, wire 235, outer coil of magnet 231, drawing armature 222 away from back-stop 221, thereby breaking the ground 26 from wire 4 and permitting the current from battery 175 to flow with full strength over wire 4 through magnet 206, station B to ground at 213, station C, energizing magnet 206 at station B, which attracts armature 202, thereby completing the shunts at said station and ringing the call-bell Z at station C, notifying him that connection is completed. When communication is finished, C proceeds, as described last, for release of the parts and a return of all to their normal positions.

The object of connection of wire 235 through the outer coil of magnet 231 to wire 4 is to attract armature 222 from back-stop 221, to break the connection of wire 4 with ground at 26, and to allow the call-bell to be rung at station C for signal.

There is shown on Fig. 3 a modification of the plan for releasing the parts at frames E E² through the demagnetization of magnets J at E and E² over the circuits formed by their respective wires 71 and the demagnetization of magnets 146 when necessary to release lever I of frames E³ E⁴. This consists of the arrangement of the stops 75 and 75ª, armature 76, wires 77 and 77ª, batteries 78 and 78ª, as shown, rendering unnecessary in such case the magnets 9 9ª, armature 73, magnet 174, battery 184, wire 163, battery 175, standard 178, grounds 179 176 79 185 at frames E and E². (Shown on Figs. 1, 1ª, 2, and 2ª.)

The operation of this modification is as follows: When the opposite pole of battery 44 is thrown through switches 210 and 36 over wire 4, as previously stated, it neutralizes the effect of battery 81 upon magnet 80 and permits armature 76 to be retracted from stops 75 and 75ª, thus breaking circuits of batteries 78 78ª, that of battery 78 over wire 77 to 71 or through magnet 146 of frame E⁴, thence by wire 126 to frame E, (not shown,) and that of battery 78ª over wire 77ª, armature 76, stop 75ª, wire 71ª to wire 71 or magnet 146 of frame E², the latter being connected to wire 126 leading to frame E³ (not shown)—that is to say, the battery 78 is used not only to energize magnet 146 of frame E whenever lever I of frame E⁴ has formed connection with wire 126, but also to energize magnet J of said frame E⁴ to hold armature-lever I of said frame in that position. Consequently when the local circuit of battery 78 is broken, as described, magnet 146 of frame E and magnet J of frame E⁴ will be demagnetized, allowing the parts to return to their normal positions. Battery 78 is also used through wire 71 when lever I of frame E has formed connection with an idle wire, as described in connection with Figs. 1, 1ª, 2, and 2ª, to energize magnet J of frame E, in order to hold lever I in the position assumed in such case. Consequently the breaking of current of battery 78, as described, will cause the release of lever I, frame E, and permit the same to return to home point. It will be observed that battery 78 is never utilized for both these purposes at the same time. Battery 78ª is used precisely as battery 78 to release the parts of frames E² and E³. Armature 76 operates to break the circuit of both these batteries at the same time.

Fig. 4 shows the arrangement for extending the capacity of the system to accommodate a large number of subscribers without materially increasing the size of the frames E³ E⁴. The frame E⁴, Fig. 4, takes the place of E³ or E⁴, Fig. 1, and is precisely the same, except that it has additional sets of contact-points, arranged as shown at V, Fig. 4, and the number of such additional sets corresponds with the number of auxiliary frames E⁵ required for the number of subscribers' circuits, allowing as many sets of contact-points X on each frame E⁵ as may be deemed convenient. If there should be five hundred subscribers and it should be deemed best to connect one hundred subscribers to each frame, there would be on frame E⁴ one hundred sets of contact-points X and four sets of contact-points V, and on each of the four frames E⁵ one hundred sets of points X. The sets of contact-points V on frame E⁴ would be placed immediately after the home set W, so that the lever-arm I would first make contact with these sets V, and the dial P at the sub-station at the distant end of the line would have

four apertures in its plate immediately after the zero-point and one hundred apertures following. The frames E^4 would each have a home set of contact-points W and one hundred sets of contact-points X and four sets of contact-points V. These sets of contact-points V on frame E^4 are each composed of four strips, as shown, numbered 113 114 250 251. The strip 113 is slightly in advance of the strip 114, being similar in all respects to the same strips on other sets on said frames. The strip 250 has connection by wire, as shown, to battery 254 and thence to strip 253 on frame E^5, which strip is normally in contact with strip 255 of said frame, the latter strip having connection, as shown, to earth 257. The strip 251 on frame E^4 has connection by wire 258, as shown, Fig. 4, to magnet 259 and by wire, as shown, to brush 260, E^5, which bears upon commutator-strip 261, the latter being connected by wire 262 to projection 53 on lever I of said frame, and when said lever is at home point, as shown in Fig. 4, the said projection 53 will bear against strip 263, which has connection to ground by wire 264, as shown.

Should station at one end of the main line desire to form connection with a station at the other end, which latter station may be connected through one set of strips X on frame E^5, he would use two plugs. One plug would be placed in the aperture in the dial next after the zero-point, which would correspond to the auxiliary frame E^5 at the distant end of the line, which may have connection through one of its sets of contact-points to the subscriber desired, and he would place his second plug in the aperture of the dial-plate corresponding to the fractional number of the subscriber at the other city desired—for instance, if the subscriber's number should be 112, he would place his first plug in the first aperture in his dial-plate and the second plug in the aperture corresponding to the fractional number 12. As the arm of his dial revolves, it first touches the plug in the first aperture, which causes lever I of the frame E^4 at the distant end of the wire to come to rest opposite and to make connection to strips 250 251 of the set of contact-points V on frame E^4 in same manner as has been previously described. The connection to strip 250 will be made through projection 144 of lever I of frame E^4, and the connection to strip 251 of said set V would be made with projection 53 of said lever I.

The result of the connection of 144 with strip 250 will be a completion of a local circuit from ground 26, E^4, through brush 24, commutator-strip 23, wire 22, outer coil of double magnet J, wire 145, projection 144, strip 250, wire 252, battery 254, strip 253 of frame E^5, strip 255 of said frame, ground at 257. This local circuit will energize magnet J of frame E^4 and hold the lever I to maintain the connection just described. The connection of projection 53 to strip 251 at the set V, frame E^4, will be to carry the main wire by way of wire 62, brush 153, commutator-strip 154, wire 155, projection 53, strip 251 of frame E^4 to wire 258, through magnet 259, frame E^5, brush 260, commutator-strip 261, wire 262, projection 53, strip 263, ground at 257. This latter circuit energizes magnet 259 at frame E^5, drawing armature 269 away from back-stop 268, breaking the circuit of battery 267, which has been energizing (normally) magnet J of said frame and holding armature I in its position, as shown at home point Y. The breaking of said local circuit permits lever I to engage with its revolving disk L, whereby projections 111 98 of said lever come into contact consecutively with the strips 113 114 of the sets of contact-points around the said frame, and when the arm of the dial at the calling-station has reached the fractional number of the subscriber desired—say 12—the armature-lever I of a frame E^5 will, in the manner hereinbefore described, be brought to stop opposite to and be thrown into connection with the strips 125 124 of the set corresponding to the subscriber desired.

The releasing of the parts when communication is finished will be the same at the calling station as has been previously described, and when the called station forms the connection already described for the release the armature I of frame E^5 will engage with its revolving disk L, and when it reaches its home point Y the projection 111 will press the contact-strip 255, having an insulated point with which it engages, away from contact with strip 253, breaking the circuit previously described of battery 254 and permitting the armature-lever I of frame E^4 to engage with its revolving disk L and be carried around to home point W, where it will automatically come to rest, as has been previously described, in frames E^3 E^4 of Figs. 1, 1^a, 2, and 2^a, and the lever I of frame E^5 will be brought automatically to rest by the re-forming of the local circuit of battery 267 through brush 13, segment commutator-strip 16, wire 17, magnet J, commutator-strip 23, brush 266^a to earth 26.

Each main wire will have at each end the same number of the auxiliary frames E^5, equipped and connected in the same manner.

Having thus described my invention, what I claim as new is—

1. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a plurality of main or trunk lines, and independent automatic switches at each end of said trunk lines, independently controlled from the subscriber's station, of a loop circuit connecting the switches at each end and a local subscriber's station, and circuit connections between the same and the switches for controlling the latter, whereby a complete metallic circuit may be automatically formed between the distant stations; substantially as described.

2. In an automatic exchange system for telephonic and telegraphic purposes, the com-

bination with two series of independent main or trunk lines, and automatic switches in each of said series independently controlled from the subscriber's station, of a loop circuit connecting the switches, a local subscriber's station and circuit connections between the same and the switches for controlling the latter, whereby a metallic circuit may be established over the trunk lines; substantially as described.

3. In an automatic exchange system for telephonic and telegraphic purposes, the combination with two series of independent main or trunk lines and automatic switches in each of said series independently controlled from the subscriber's station, of a loop circuit connecting the switches, an induction coil in said loop circuit, a subscriber's station and circuit connections between the same and the switches and induction coil; substantially as described.

4. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a series of independent main or trunk lines, a transmitting subscriber's station and circuit and independent automatic switches in said main lines controlled from the transmitting subscriber's station whereby any two main lines not in use may be selected, of a receiving subscriber's station and circuit and independent automatic switches located in the main lines and controlled from the transmitting subscriber's station through said main lines for connecting said two main lines with the receiving subscriber's circuit, whereby a complete metallic circuit may be established between the distant stations; substantially as described.

5. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a series of independent main or trunk lines, a transmitting subscriber's station and circuit and independent automatic switches in said main lines controlled from the transmitting subscriber's station whereby any two main lines not in use may be selected, of a receiving subscriber's station and circuit, independent automatic switches located in the main lines and controlled from the transmitting subscriber's station through said main lines, an induction coil in the receiving subscriber's circuit and a loop including said induction coil connecting the last mentioned automatic switches; substantially as described.

6. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a series of independent main or trunk lines, a transmitting subscriber's station and circuit, an induction coil in said circuit, independent automatic switches in said main lines controlled from the transmitting subscriber's station whereby any two main lines not in use may be selected and a loop connecting said switches and including the said induction coil, of a receiving subscriber's station and circuit, independent automatic switches located in the main lines and controlled from the transmitting subscriber's station through said main lines, an induction coil in the receiving subscriber's circuit and a loop including said induction coil connecting the last mentioned automatic switches; substantially as described.

7. In an automatic exchange system for telephonic and telegraphic purposes, the combination with the main line, subscribers' stations and an automatic switch controlled from one subscriber's station to establish the circuit between the stations, of an intermediary device located between the switch and subscriber's station consisting of an induction coil and a magnetically controlled switch having its magnet included in the main line circuit and having contacts arranged to establish the main line circuit through the induction coil when said magnet is actuated by current flowing over the main line, substantially as described.

8. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a series of independent main lines subscribers' stations and an automatic switch controlled from one subscriber's station to establish the circuit between the stations of an intermediary device located between the switch and subscriber's station, consisting of an induction coil, a local circuit and a magnetically operated switch having contacts arranged to complete the main line circuit through the switch magnet and when actuated by the current over the main line, to interrupt the main line circuit through the magnet, establish the same through an induction coil and simultaneously establish the local circuit through the magnet to maintain the switch in actuated position; substantially as described.

9. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a series of independent main lines, subscribers' stations and automatic switches at each end of said main lines controlled from one station, for automatically selecting a line not in use and the desired subscriber at the distant point, of intermediary devices located between the switches and subscribers' stations at each end of the main line, consisting of induction coils, local circuits extending to the subscribers' stations, and magnetically operated switches having contacts arranged to complete the main line circuit through the switch magnet and when the latter is actuated by the circuit over the main line to interrupt the main line circuit through the magnet, establish the same through the induction coil and simultaneously establish the local circuit through the magnet to maintain the switch in actuated position; substantially as described.

10. In an automatic telephone exchange system for telephonic and telegraphic purposes, the combination with transmitting and receiving subscribers' stations and local lines

having induction coils therein, a plurality of main lines, and two switches at each end of said main lines controlled from the transmitting subscriber's station and adapted respectively to select two main lines not already in use and the desired subscriber at the distant station, of open loop lines between the switches at each end of the main line respectively, and an intermediary device located between the pairs of switches and subscriber's station at each end of the main lines, consisting of induction coils cooperating with those in the subscribers' circuits and included in the loops between the main line switches and magnetically operated switches having contacts arranged to complete the main line circuit through the switch magnets and when the latter are actuated by the current to establish the main line circuits through the loop lines and induction coils; substantially as described.

11. In a long distance telephone exchange system, the combination with a plurality of main lines and subscribers' stations at the terminals of said main lines, of open loop lines between said main lines at each end, magnetically operated switches for completing the loop lines when a complete metallic circuit is desired, and a circuit extending from said switch to the subscriber's station whereby said switch is controlled from the subscriber's station; substantially as described.

12. In an automatic exchange system, for telephonic and telegraphic purposes, the combination with the two central offices and a plurality of trunk lines between said offices, local circuits extending from said offices to subscribers' stations, automatic switches at each end of said main lines independently controlled from the subscribers' stations, of an induction coil and a magnetically operated switch device at each of said central stations, the said magnetically operated switch devices being so arranged as to operate to form a loop between the trunk lines through one wire of said induction coil, and a loop for the local subscriber's circuit through the other wire of said coil, whereby a complete metallic circuit may be automatically formed between the two central offices through one circuit of the induction coil and a complete metallic circuit may be formed from the subscriber's station through the other circuit of the induction coil simultaneously at both central stations; substantially as described.

13. In a system of long distance telephony, the combination with a plurality of main lines extending between distant main offices, induction coils at each of said main offices having one wire adapted to be included in loop circuits between the main lines to form complete metallic circuits between main offices, of complete metallic subscribers' circuits extending into each main office and adapted to be established through the other wire of the induction coil at their central office, magnetically operated switches for completing said circuits through the induction coils and automatic switches controlled from the subscribers' stations for selecting the desired subscriber at the other main office.

14. In a long distance telephone exchange system, the combination with a plurality of main lines and subscribers' stations at the terminals of the main lines, of open loop lines between said main lines, induction coils in said loop lines, magnetically operated switches for completing the loop lines through the induction coils to establish a complete metallic circuit, circuits extending from the magnetically operated switches to the subscribers' stations at the corresponding end of the main lines, whereby the switch is controlled, and circuits extending from the induction coils in the loop lines to the subscribers' stations at the corresponding end of the main lines; substantially as described.

15. In an automatic exchange system for telephonic and telegraphic purposes, the combination with the series of lines, a subscriber's station and circuit, and a magnetically controlled switch for automatically selecting any one of the lines and connecting the same with the subscriber's circuit, of a local circuit and battery for holding the switch in set position, and a magnetically operated switch in said local circuit, controlled from the subscriber's station for manipulating the local circuit to release the first mentioned switch whereby it may return to normal position; substantially as described.

16. In an automatic exchange system for telephonic and telegraphic purposes, the combination with the series of lines, a subscriber's station and circuit and a magnetically controlled switch for automatically selecting any one of the lines and connecting the same with the subscriber's circuit, of a local circuit and battery for holding the switch in set position, a second local circuit for holding the switch in normal position and magnetically operated switches in said local circuits controlled from the subscriber's station, whereby the switch may be released from either set or normal position by manipulation of the circuit from the subscriber's station; substantially as described.

17. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a transmitting subscriber's station, a main line and a series of receiving subscribers' stations, a magnetically controlled switch controlled from the receiving subscriber's station for connecting the said station with the main line and a magnetically controlled switch controlled from the transmitting subscriber's station for connecting the main line with any one of the receiving subscribers' stations, of a magnetically operated cut out switch (146) located between the receiving subscriber's station and the switch controlled therefrom, and a local circuit controlled by the switch which is controlled from the transmitting subscriber's station for operating the said cut out switch, whereby when

the transmitting subscriber completes a circuit to any one of the receiving subscribers, the circuit between that subscriber's station and the switch controlled therefrom is broken; substantially as described.

18. In an automatic exchange system for telegraphic and telephonic purposes, the combination with a transmitting subscriber's station, a series of main lines and a series of receiving subscribers' circuits, magnetically controlled switches controlled from the receiving subscribers' stations, one for each circuit for connecting any one of said stations with any one of the main lines and magnetically controlled switches, one for each main line, controlled from the transmitting subscriber's station for connecting any one of said lines with any one of the receiving subscribers' circuits, of magnetically operated cut-out switch (146) located in the receiving subscribers' circuits between the receiving subscribers' stations and switches controlled from said stations, and a local circuit including the said cut-out switch respectively controlled by the switches which are controlled over the main lines from the transmitting subscriber's station, whereby when the transmitting subscriber completes a circuit to any one receiving subscriber the circuit between that subscriber's station and the switch controlled therefrom is broken; substantially as described.

19. In an automatic exchange system for telephonic and telegraphic purposes, the combination with a transmitting subscriber's station, a series of main lines, a series of receiving subscribers' circuits and stations, magnetically controlled switches controlled from the receiving subscribers' stations for connecting any receiving subscriber's circuit with any one of the main lines, and a series of switches controlled over the main lines from the transmitting subscriber's station for connecting any one of the main lines with any receiving subscriber's circuit, of magnetically operated cut-out switches (146) one for each subscriber's circuit having contacts for establishing the circuit between the receiving subscriber's station and the switch controlled therefrom, and contacts for connecting said circuit with the main line when the first named circuit is broken and a local circuit for said cut-out switch controlled by the main line switches or those which are controlled from the transmitting subscriber's station, whereby when any one of the said main line switches has operated to select a subscriber, that subscriber's circuit to his switch is broken and the main line to him established; substantially as described.

20. In a telephone and telegraph system, the combination with the central office, a subscriber's circuit extending thereto and a series of subscribers' stations in said circuit, of a second circuit extending between subscribers' stations, and central, a magnetically operated shunt switch at each station controlled by said second circuit and operating to establish or break a shunt around the instruments at that station, a manually operated switch in said second circuit at each station and a shunt around said switch controlled by said magnetically operated shunt switch to close the shunt circuit when the switch is operated from another station whereby the operation of the shunt switch by manipulation of the manually operated switch in the second circuit is prevented; substantially as described.

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