(No Model.) 8 Sheets—Sheet 1.

J. G. SMITH.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 550,728. Patented Dec. 3, 1895.

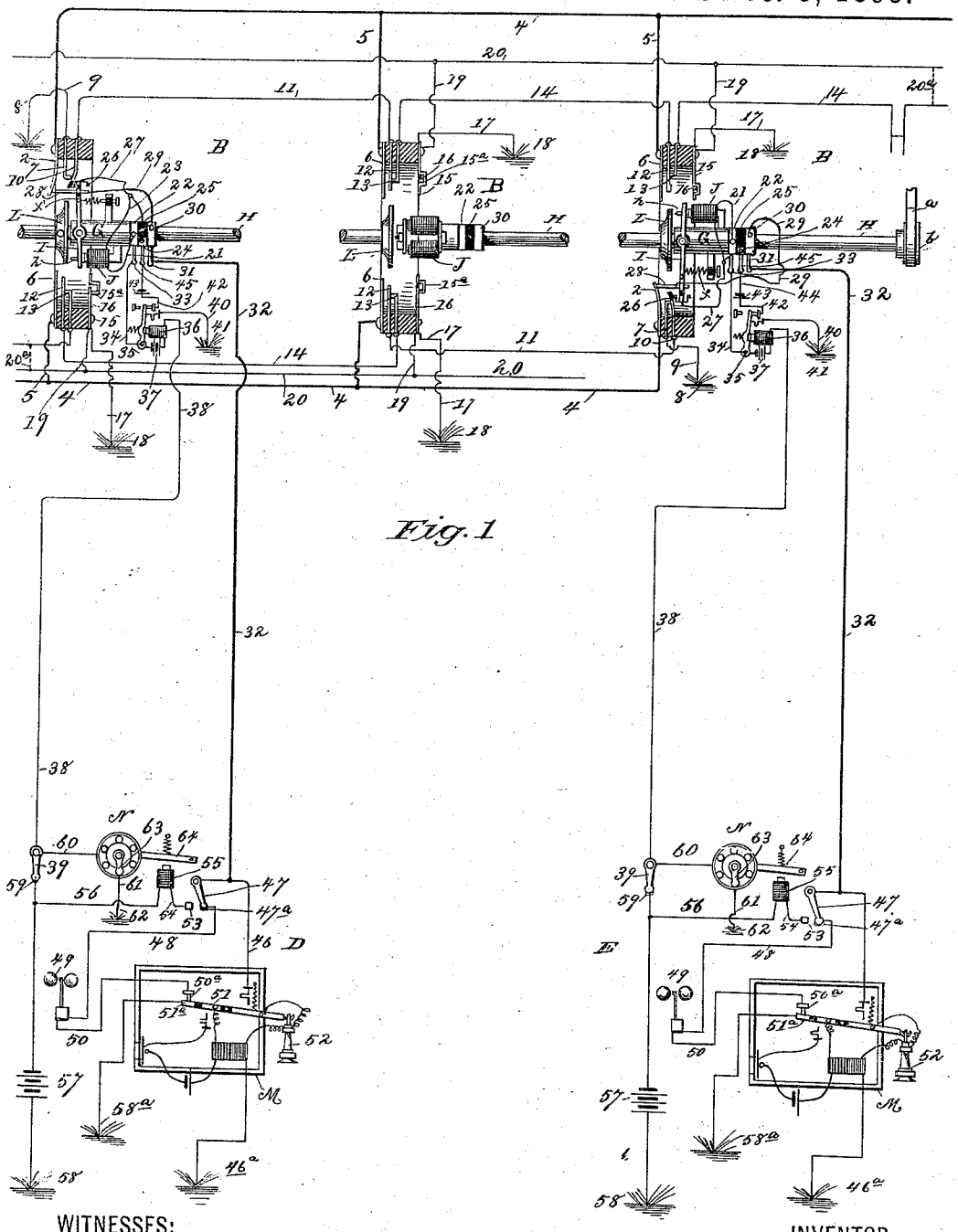

Fig. 1

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(No Model.) 8 Sheets—Sheet 2.

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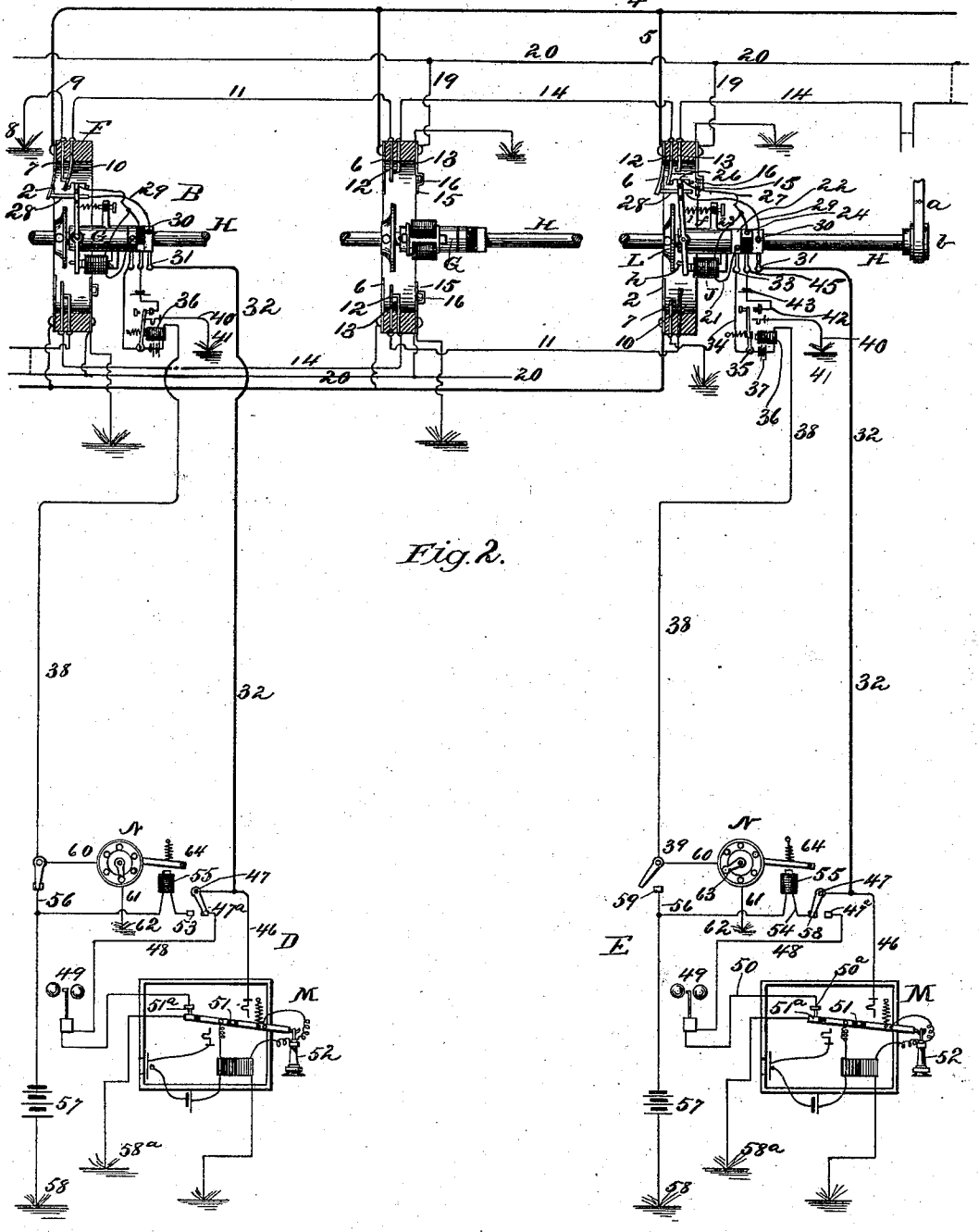

Fig. 2.

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(No Model.) 8 Sheets—Sheet 3.

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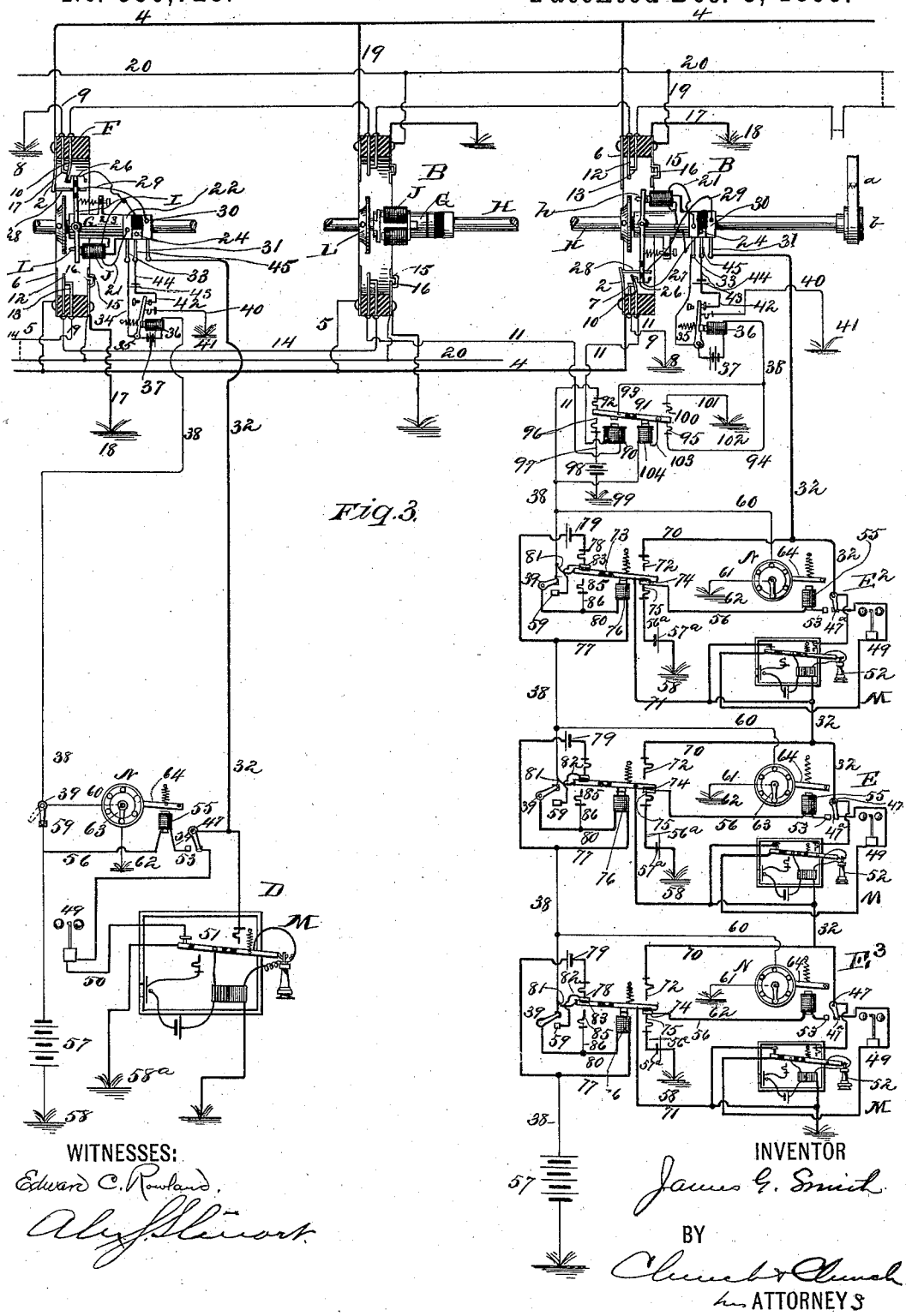

Fig. 3.

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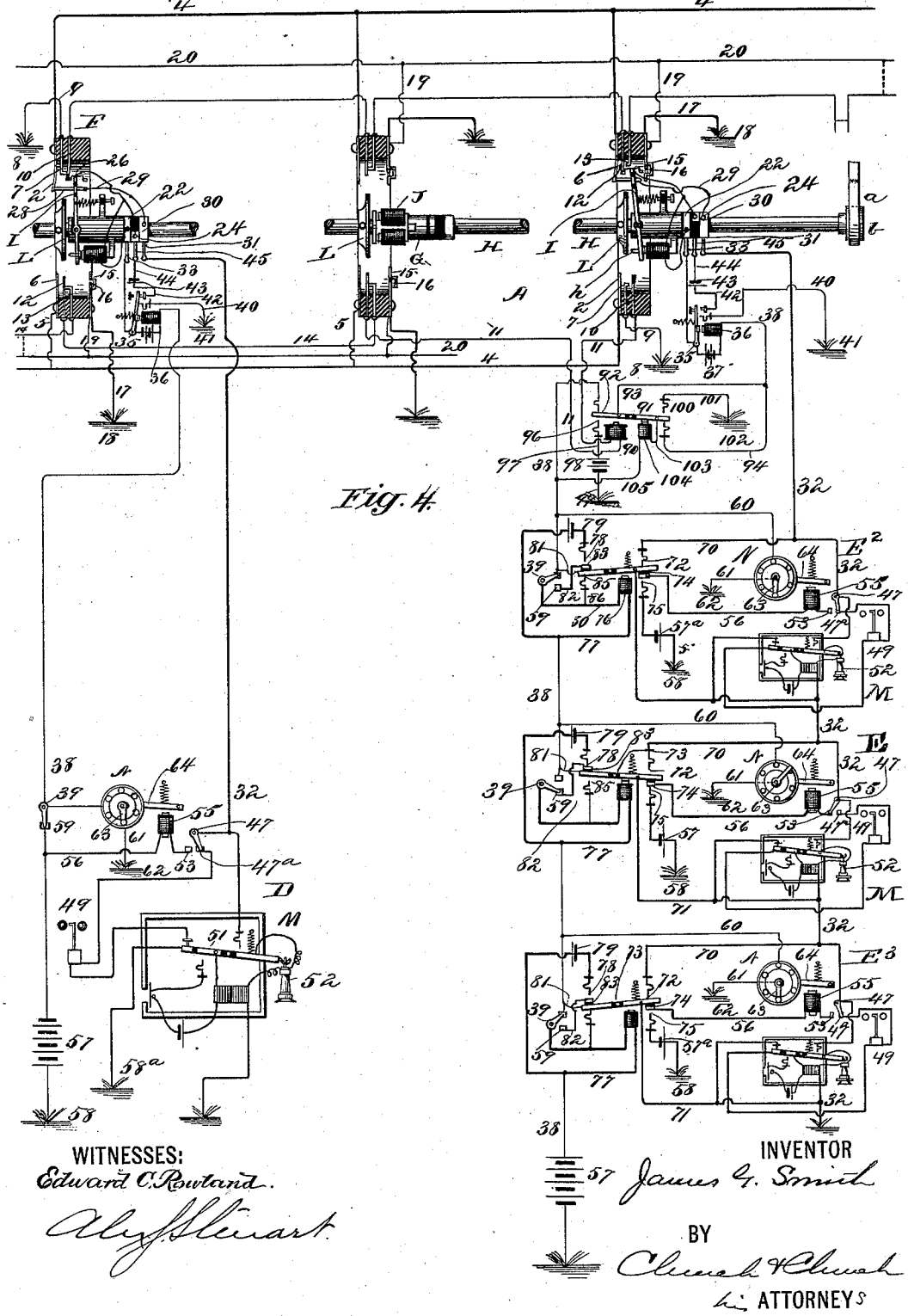

Fig. 4.

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AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

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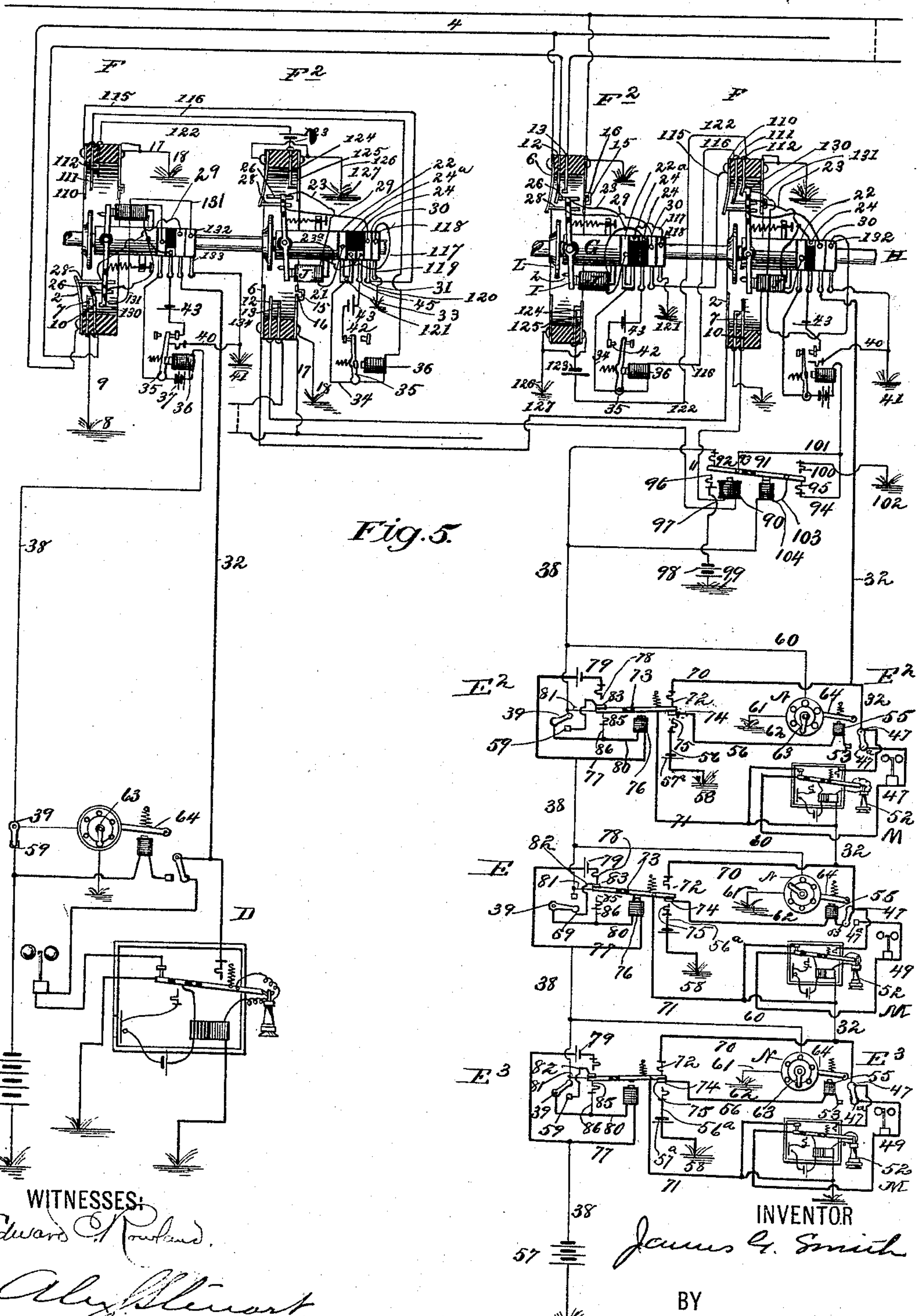

Fig. 5.

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AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 550,728. Patented Dec. 3, 1895.

Fig. 7.

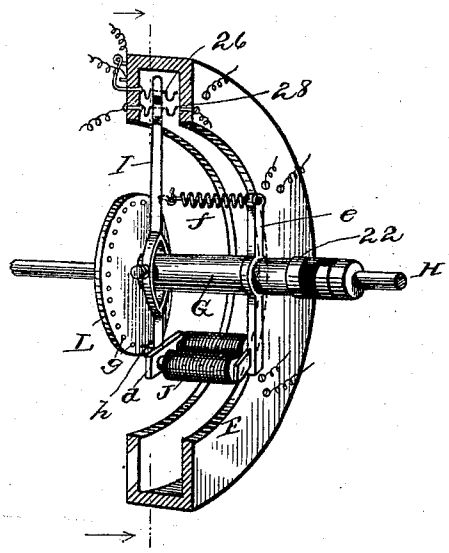


Fig. 8.

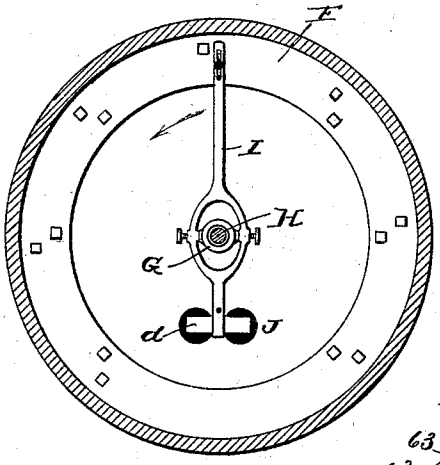


Fig. 6.

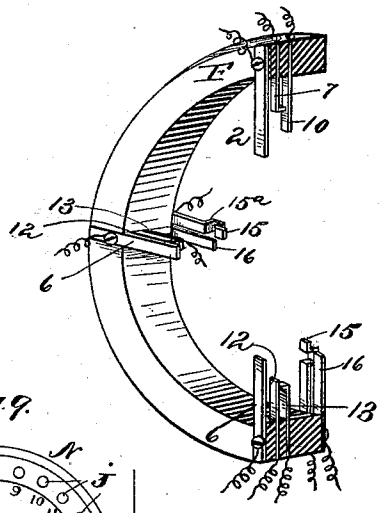
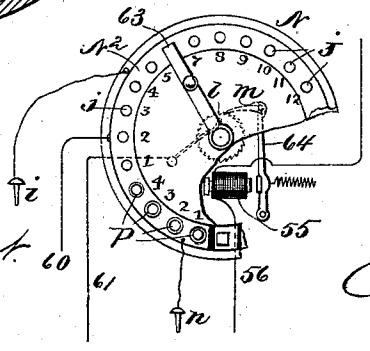


Fig. 9.



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(No Model.) 8 Sheets—Sheet 7.

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AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

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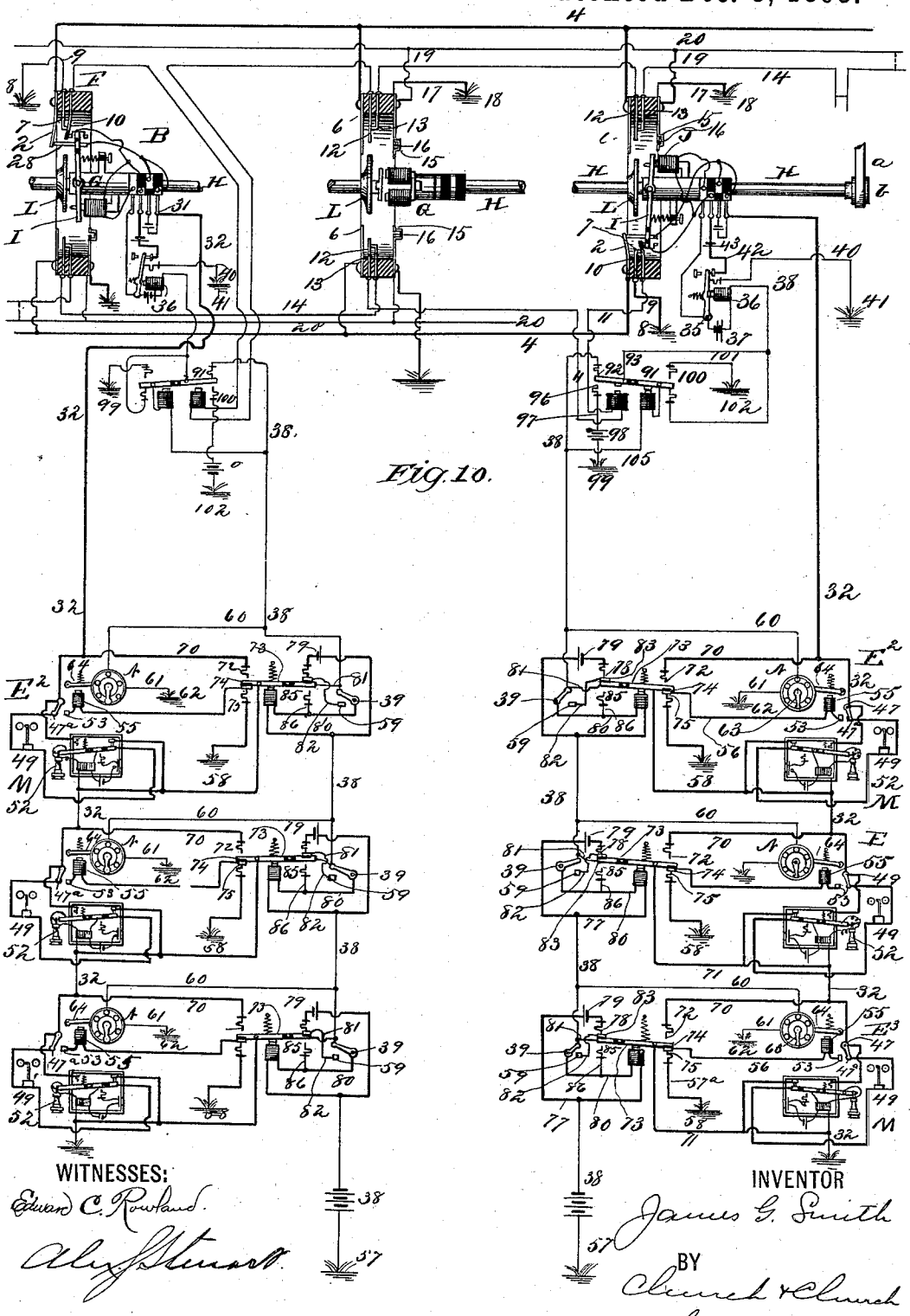

Fig. 10.

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AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

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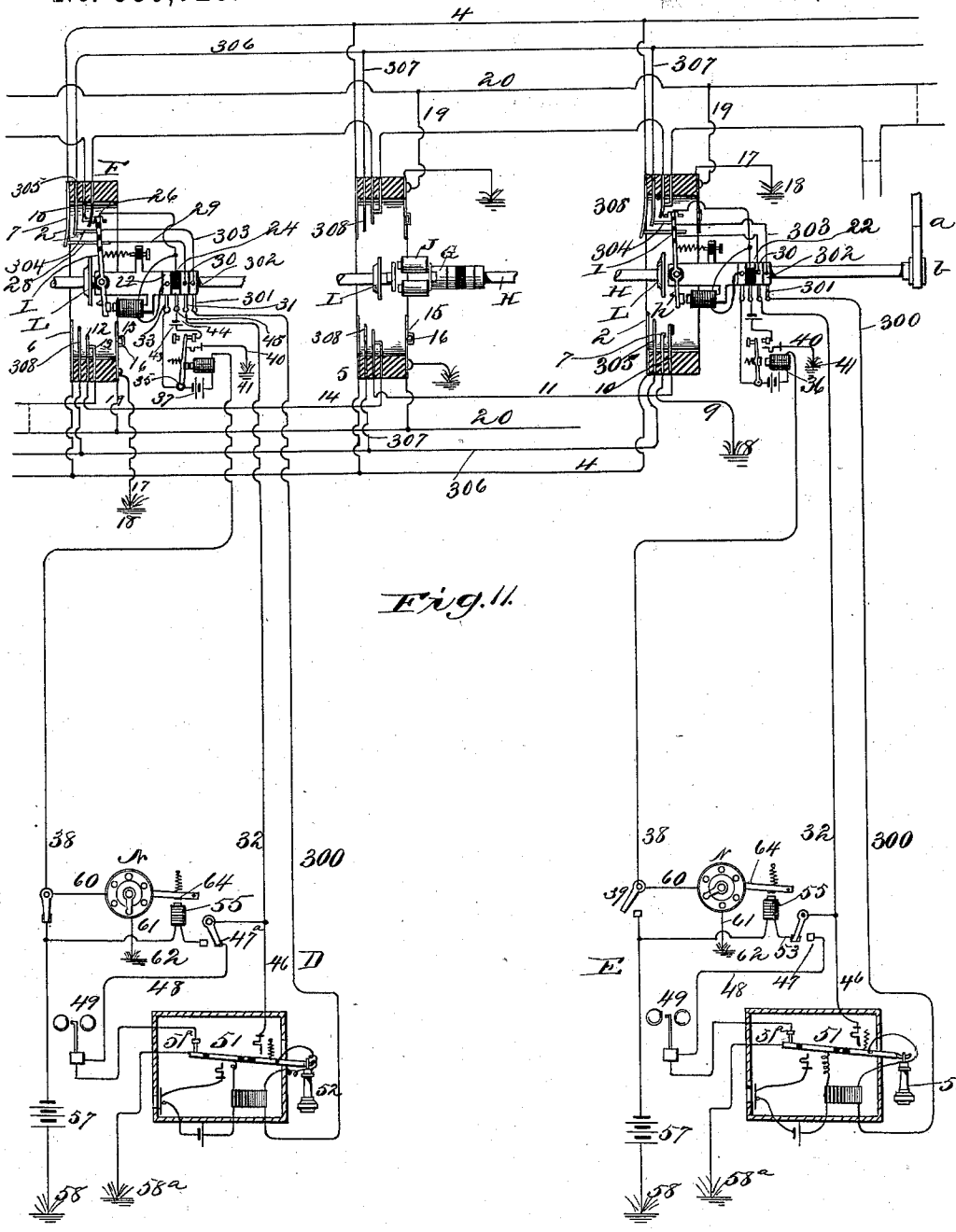

Fig. 11.

WITNESSES:

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UNITED STATES PATENT OFFICE.

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

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 550,728, dated December 3, 1895.

Application filed February 18, 1893. Serial No. 462,908. (No model.)

To all whom it may concern:

Be it known that I, JAMES G. SMITH, of New York city, county and State of New York, have invented certain new and useful Improvements in Automatic Telephone-Exchange Systems; 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 letters and figures of reference marked thereon.

This invention has for its object to provide an automatic telephone-exchange system whereby any one of an almost unlimited number of subscribers may, without the intervention of operators at the central office, but through the operation of automatic mechanism there located, establish a circuit or connection with any one of the other subscribers. In a prior patent granted to me August 23, 1892, No. 481,247, I have shown and described a system whereby communication may be established automatically between any subscriber of one exchange and any subscriber of another exchange located at a distant point, the exchanges being, for instance, located in different cities. Now the present system I have devised particularly with a view to supplying the needs of a local exchange, by which I mean an exchange located in one city, town, or at a central point, to which the local-subscribers' circuits may be run, although the two schemes may be combined to enable subscribers to reach other local subscribers or subscribers to the exchange located in the distant city.

A further object of the invention is to provide an exchange of the character stated in which when one subscriber has effected telephonic connection, or completed the circuit to another subscriber, no third subscriber can cut in or interrupt the communication.

A further object of the invention is to provide a means whereby several or any number of subscribers may be located on a single local circuit extending to the central, any one of whom may secure circuit connections with any other subscriber to the exchange and cut out all the other subscribers on his particular local circuit in such manner that no one of them can by manipulating the instrumentalities at his station interrupt or overhear the communication passing through the central office.

A further object of the invention is to provide a double series of automatic switches, controlled one from the other, or, more properly, a main and auxiliary series whereby the capacity of the system is vastly increased without enlarging the apparatus used by each subscriber, or requiring any subscriber to go through a complicated series of manipulations in order to establish the desired circuit connections.

The invention 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 the accompanying drawings, Figure 1 is a diagrammatic view showing a central-office apparatus in section with two subscribers' stations, a third central-office apparatus being shown without its subscribers' circuit in order to illustrate more clearly the manner of coupling the same, all the parts being shown in a position ready for operation. Fig. 2 is a similar view with the parts in the position they assume when a circuit is established between the two subscribers, the right-hand subscriber being the calling subscriber. Fig. 3 is a view similar to Fig. 1 with several subscribers included in one of the local circuits. Fig. 4 is a view similar to Fig. 2 with several subscribers included in one of the local circuits. Fig. 5 is a similar view showing the double or main and auxiliary system of apparatus for increasing the capacity of the system. Fig. 6 is a detail sectional perspective of one of the annular switchboards at central. Fig. 7 is a detail sectional perspective view of a central office apparatus of preferred form. Fig. 8 is a sectional view of the same, looking in the direction of the arrow. Fig. 9 is a detail elevation, partially broken away, of the dial mechanism at the subscriber's station. Fig. 10 is a view corresponding to Fig. 3, but with a series of subscribers located on each of the local circuits. Fig. 11 is a view showing contacts and wires for forming a complete metallic circuit between subscribers, this feature being omitted from the previous figures in order to prevent any possible confusion.

Similar numerals and letters of reference in

the several figures of the drawings indicate corresponding parts and circuit connections.

As in said former patented system, I now make use of a series of automatic switches at the central office and consisting in the preferred form of a series of circular or substantially circular frames or switchboards, one for each subscriber's circuit, as indicated at B in the drawings, and each having circuit connections, to be presently pointed out, either directly or indirectly with all the other frames or with auxiliary frames, as will be presently understood. A switch arm or lever is provided for each frame, adapted to establish the circuit through any of the circuit connections just mentioned, and in order to move said switch-arms a motor mechanism is provided, preferably in the form of a constantly-driven shaft or shafts passing through the frames and having means whereby the switch arm or lever may be connected therewith at the will of the calling subscriber and moved to the desired circuit-connection terminal or terminals, where it is disconnected from the shaft to establish said connections.

Referring now specially to Figs. 1 and 2, illustrating the simplest form of the present arrangement, H indicates the shaft or shafts passing through the frames B. G indicates sleeves loosely journaled on the shaft or shafts in proximity to the frames; I, the switch arms or levers pivotally connected to the sleeves at right angles to the shaft, so as to travel over the contacts on the frames; L, disks rigidly mounted on the shaft in proximity to the levers and adapted to serve as a means whereby the levers may be connected to the shaft for rotation therewith. For this purpose each of the said levers is provided with a projection or point *h*, adapted to enter one of a series of apertures in the disk when said lever is moved in one direction under the influence of its retractile spring *f* and to become disengaged from said disk when the lever is moved in the opposite direction under the influence of the electromagnet J, acting on the armature *d*, attached to the lever. Obviously, the disk may be simply roughened or have a leather or soft face for the engagement of the lever, the only essential being that when the lever is moved into contact with the disk it shall be moved by the shaft, so as to pass the circuit terminals or contact successively. In addition to the lever I and parts just mentioned each sleeve carries a commutator, whereby the circuit connections may be formed with the magnet J and with the contacts carried by the lever, as will presently appear.

Magnet J in the preferred arrangement shown is normally energized to hold the lever out of engagement with the disk by means of a local circuit and battery, as follows: from said magnet through wire 21 to complete commutator-ring 22, brush 33, wire 34, armature 35, stop and wire 42, battery 43, brush 45, small commutator-segment 24, and wire 23 to magnet J again, and this local circuit is controlled from the subscriber's station for that particular frame through the armature 35, as follows: Said armature is normally held in the position shown in Fig. 1 by the magnet 36, the circuit passing from ground 41 through wire 40 to armature 35, battery 37, magnet 36, and wire 38 to the subscriber's station, where it passes through switch 39 to battery 57 and ground at 58. The combined strength of the batteries 37 and 57 is required to completely energize the magnet 36, and if the switch 39 is thrown off of contact 59, breaking the circuit from battery 57, the armature 35 is withdrawn by its spring and the local-circuit-energizing magnet J broken, allowing the lever to engage the disk and be rotated therewith.

Around each of the frames B are arranged a series of contacts, one set for each subscriber, consisting of arms 6, 12, 13, 15, and 16 and an additional set 2 7 10, the latter set constituting what will be known as the "home" set—that is to say, the set with which the arm or lever is normally in contact or engagement when the line is not in use, as in Fig. 1. From the home contact 2 of each frame a wire 4 extends and is connected by branches 5 with one of the contacts 6 on each of the other frames to enable each of the latter to reach the home point of the frame under consideration. From home contact 7 a wire 9 leads to ground at 8. From home contact 10 a wire 11 leads to a contact 12 on the next frame, thence by contact 13, normally in contact with 12, to the wire 14, to the contact 12 on the next frame, and so on throughout the series of frames, thus making it possible by separating the contacts 12 13 at any one frame or contacts 7 and 10 at the home point to interrupt the circuit from the home contact 10 and ground at 8. The contacts 7 and 10 at the home point are normally held in contact by the lever I and separate when the lever leaves the home point, while contacts 12 13 are normally together and are separated when engaged by the lever.

All of the contacts thus far particularly described are adapted to be engaged by the lever I or contacts thereon when said lever is not in engagement with the disk, or, in other words, when said lever is held by the magnet, and mounted on each of the frames in position to be engaged by the lever or contacts thereon when the lever is in engagement with the disk and not under the influence of the magnet J are a series of contacts 15 and 16, corresponding in number to the number of sets of contacts 6 12 13 and located, respectively, substantially in line with said sets on the opposite sides of the frames in order that the lever I may engage them, as just described. Contacts 15 are preferably located slightly in advance of the contacts 16, and wires 17 connect them with ground at 18. The contacts 15 are adapted to be engaged suc-

cessively by the rear end of a movable contact 28, carried by the lever I, as said lever is being rotated with the shaft, thereby establishing a ground at 18 for a circuit passing through contacts 28, wire 29, commutator-segment 30, brush 31, and wire 32 to the subscriber's station, where it includes a step-by-step mechanism, to be presently described, and operates one step each time a ground is established at 18. Thus it will be seen that the mechanism at the subscriber's station indicates the position of the arm of the lever in its passage around the switchboard. Hence when said arm reaches the desired point indicated by the number of sets of contacts it passes, if the magnet J be energized, its further movement will be arrested, and by the shifting of said lever I the circuit will be established to the distant subscriber's station through the contact 6 in circuit with his home contact 2 as follows: The forward end of the movable contact 28 is in position to engage any one of the contacts 6 when the lever is held by the magnet, as shown at the right in Fig. 2. Hence the circuit from 32 passes from said contact 6 to wire 4, thence to the home contact 2 of the desired subscriber's central-office apparatus, through the contact 28 at the latter station, and through the circuit connections just described to the subscriber's line 32 at that point.

Obviously the calling subscriber might have provision for manually completing a circuit through the magnet J when his step-by-step mechanism indicated that the lever I had reached the desired point; but my system contemplates the automatic establishment of this circuit, as well as the cutting out of the central-office apparatus of all other subscribers, so far as the two subscribers to be put into communication are concerned, but leaving said other apparatus free to establish circuit connection with any other of the subscribers. In other words, the two subscribers after establishing their circuit have the exclusive use of that circuit without, however, interfering in any way with the circuits between other subscribers or the operation of the central-office apparatus of other subscribers to establish such other circuits. The central-office apparatus for accomplishing this result consists of a contact 26, carried by the lever I and connected through a wire 27 to the wire 23, and by the latter through the magnet J, commutator 22, brush 33, wire 34, and wire 38 to the subscriber's station. Contact 26 is adapted to engage successively with the contacts 16, and the latter are connected by wires 19 with lines 20, which I shall for convenience term "open" lines, inasmuch as they extend throughout the entire series of central-office apparatus and are connected beyond the last one to the wire 14 by a bridge or connection 20^a, the circuits respectively extending thence through the wires 14, contacts 12 13 of one set on each frame to the home-set contacts 7 10 of some one frame, and from the contact 7 by a wire 9 to ground at 8. The contact 26, in addition to engaging the contacts 16 successively, is also adapted to engage any one of the contacts 12 when held forward by the magnet J and to establish contact with 12 before breaking contact with 16. Now assume for the moment that the arm has reached the point opposite the contacts corresponding to the line 4 connecting with the home set of the desired subscriber and that this fact has, as before described, been indicated over the wire 32 to the calling-subscriber's station and a ground is at that instant established at said subscriber's station for the wire 38. The circuit will then be established from 38, through battery 37, wire 34, magnet J, wires 23 27, contacts 26 16, line 20 20^a 14, contacts 12 13 of one set of contacts in each central-office apparatus to home contacts 10 7 of the desired subscriber, and to ground at 8, thereby energizing magnet J of the calling-subscriber's apparatus and drawing the lever out of engagement with the disk, throwing contact 26 into engagement with 12, moving the latter out of engagement with 13, thereby breaking the circuit at this point and preventing any one else from reaching the subscriber which he desires, because the magnets J of the other central apparatus can only be energized at corresponding sets of contacts through the open line 20, and the circuit for this line is broken at 12 13 of the calling subscriber. The circuit through the magnet J of the calling-subscriber's apparatus is maintained, however, by the circuit established from 26 through contact 12, wires 14 11, to ground at 8 at the desired subscriber's station, as just described. Having now stopped the arm or lever I and established a circuit from the calling subscriber over wire 32, contacts 28 26, wire 4 to the desired subscriber through his home contacts 2 28 and line 32, it remains to describe the preferred form of apparatus for use at each subscriber's station where but one subscriber is placed on each circuit. The wire 32 leads to a telephone M, where it terminates in a contact which establishes the circuit when the receiver 52 is lifted from the usual lever 51, and at a proper point wire 32 is provided with a branch terminating in a switch 47, adapted to connect either with a contact 47^a, leading by wire 48 to the call-bell 49, thence by wire 50 to contacts 51^a and 50 to ground 58^a, or with a contact 53, leading by wire 54 to the magnet 55 of the step-by-step apparatus and through wire 56 to battery 57 and ground at 58. When the switch 47 is on contact 53, impulses from battery 57 over 32 and to ground at 18 as the contact 28 on lever I successively engages the contacts 15 will operate the step-by-step apparatus. The latter apparatus consists, as in said former patented apparatus, of an arm 63, adapted to be rotated (see Fig. 9) by a ratchet-wheel *l*, pawl *m*, and lever 64, operated by the magnet 55. Said arm 63 is connected by wire 61 with ground at 62 and travels above

a metal ring or dial N^2, having a series of apertures J therein and connected by wire 60 with the wire 38 above the switch 39. A pin *i* is provided for insertion in any one of the apertures *j* in the dial, and when so inserted is adapted to be engaged by the arm 63 in its passage over the dial. The result of such arrangement is that as soon as the said arm reaches the pin *i* a circuit is established from wire 38 through the dial and arm to ground at 62. Hence if the pin *i* be placed in an aperture so located that the arm 63 will reach it when the lever I of the central-office apparatus has reached the circuit leading to the home point of the desired subscriber the circuit will be established through the magnet J and the lever I will be arrested at that point, establishing the circuits as before described. If, however, the desired subscriber's line or his central-office apparatus is in use, the contacts 12 13 of some of the other apparatus will be separated on the one hand, or the contacts 7 10 will be separated on the other hand, and the circuit cannot be established through the magnet J of the calling-subscriber's switch. Hence the arm I will not be arrested, but will return to home position, and if not arrested there will continue to rotate until the desired subscriber's apparatus is in condition to permit the circuit to be established. This condition of affairs is indicated at the calling-subscriber's station by the fact that the arm 63 will not come to rest when it reaches the pin *i*.

If the circuit be established all right, as shown in Fig. 2, where E is the calling and D the receiving subscriber, and the switch 47 at the receiving-subscriber's station be on the contact 47^a, his call-bell 49 will be sounded by the battery 57, and he simply lifts his telephone from its hook to establish his circuit in the ordinary manner and answers. The switches 47, it will be noted, normally rest on contacts 47^a, and when the circuit has been established the transmitting subscriber should return his switch to this contact in order to permit the receiving subscriber to answer his call before either of the telephones is moved from its hook. The calls having been properly answered, the removing of the telephones from their hooks allows the levers 51 to rise and break the call-bell circuits at 50^a and 51^a and establish the line from 32 through the telephone to ground at 46^a in the ordinary manner. When the conversation is finished, the receiving subscriber simply hangs his telephone on the hook and the transmitting subscriber does the same, and in addition returns the arm 63 to the home position and throws the switch 39 onto contact 59, from which, it will be remembered, it was removed to demagnetize the magnet 36 and break the local circuit, normally holding the magnet J of the calling-subscriber's central-office apparatus. Returning the switch 39 to contact 59 again energizes magnet 36 by combining the batteries 37 and 57, drawing the armature 35 over. This establishes a direct short circuit to earth at 41, demagnetizing the magnet J, allowing the arm I to engage the disk, and at the same time it connects wires 34 42 of the local circuit through the armature 35, and as soon as the arm and commutator have revolved to a point where the small segment 24 rests on the brush 45 the local circuit will be established, the magnet J energized, and the movement of the lever I arrested.

The small segment 24, it will be noted, is of such size and is so located on the commutator that the brush will only rest thereon when the lever is at the home point. Hence the establishment of the circuit over 38 and energizing of magnet 36 brings the lever automatically back to the home point, from which it will not move until the magnet is again demagnetized to release the lever I.

From the foregoing it will be seen that any one subscriber in the system can by simply placing the plug *i* at his station in an aperture in his dial corresponding to the desired subscriber and manipulating the switches 39 and 47 secure circuit connection with that subscriber through the medium of the automatic switching mechanism located at the central office; and, further, by so doing he automatically cuts out all other subscribers from interfering in any way with the circuit so established; but as so far described the capacity of the exchange is limited to the number of sets of subscribers' contacts which can be placed around one switchboard, and inasmuch as it would be obviously inconvenient, if not impractical, to place a very large number—say over one or two hundred—on each board I have devised two schemes for increasing the capacity of the system, both of which may be used simultaneously, thereby making the capacity practically unlimited, or, at least, sufficient to meet the requirements of the present day, even in the largest city exchanges. The first of these schemes contemplates the location of a number of subscribers on each local circuit—say subscribers located in the immediate vicinity of each other—with means whereby any one subscriber may cut all the others out, so as to gain uninterrupted communication with the central and through it with the desired subscriber. The second contemplates the use of auxiliary switchboards or frames, practically duplicates of the boards or frames heretofore described, and which will be described with greater particularity hereinafter.

In carrying out the first idea, (see Figs. 3, 4, and 10,) and in order to permit one subscriber to use the local circuit mentioned without interference from another subscriber on said local circuit, I provide a shunt around each of such instruments at each station, which shunts are controlled by the subscriber using the local line to cut out the other subscribers on said line. For this purpose I connect a wire 70 with the line-wire 32 before the latter enters the subscriber's telephone

M and another wire 71 with the wire 32 after the latter passes from said telephone. (See Fig. 3.) The wire 70 has a contact 72 to be engaged by a centrally-pivoted lever 73, to which the wire 71 is connected, so that when 72 and 73 are in contact a shunt will be formed from 32 through 70, 72, 73, and 71, around telephone M to 32 again, thus completely shunting the telephone from the local-subscriber's circuit. In this case also the lever 73 carries a contact 74, (but insulated from it,) connected with the wire 56 from magnet 55. The wire 56 is broken at this point, a wire 56^a leading from a contact 75 to battery 57^a, the contacts 74 75, when joined, making a circuit from 56 through 56^a and 57 to ground 58. By this means when lever 73 rises the circuit 56 56^a is broken and magnet 55 thus prevented from action.

The levers 73 are operated, when a subscriber on the local circuit desires to telephone, as follows: 76 is a magnet to actuate lever 73, said magnet being connected by a wire 77 with the line 38 and passing thence to a contact 78, including a local battery 79 in the circuit. A wire 80 also leads from the magnet 76 to the switch 39, that makes and breaks contact with 38. Wires 81 also lead from 38 to each lever 73. The contact 59 connects by a wire 82 with a contact 83 on lever 73, insulated therefrom, adapted to make a contact with 78, whereby when the switch 39 of one subscriber is moved to 59 a local circuit will be formed from 39 59 through 82 83 78 79 77 to magnet 76, thence by wire 80 to 39, whereby magnet 76 of the subscriber using the telephone will be energized to hold lever 73 and prevent the shunting of his own operating instruments connected with wire 32, and whereby, also, as switch 39 is thrown the circuits through 38 to the other subscriber's magnets 76 are broken, thereby permitting the levers 73 of said subscribers to break contact at 74 75 and form contact at 72 73, thus establishing a shunt at 70 71 around each of the other subscribers' telephones on this local circuit and leaving the line solely to the subscriber at work. As the levers 73 are released, as stated, and rise to 72, they make contact at 85 with a wire 86, connecting with wire 80, whereby a circuit is established from 76 to 80 86 85 73 81 to 38, so that if the subscriber at that point should throw switch 39 to break circuit the current can pass through 86 to 38; otherwise it will pass through 39 to 38. When the calling subscriber returns the switch 39 to wire 38, circuit in line 38 will be re-established and the magnet 76 will receive current from battery 57 and thus attract lever 73 at all stations on the same local circuit, re-establishing all the original circuits. By this means any subscriber can cut out all the other subscribers on a local circuit, while his own instruments remain wholly in circuit.

In order that when the subscriber at D calls a subscriber on the local-subscribers' circuit at E, E^2, and E^3 and the device B belonging to the latter circuit shall not operate when a subscriber at E, E^2, or E^3 breaks the line at 38 39 59 while being called or answering a call, I provide the following arrangement at central office: In the circuit of wire 11 is inserted a magnet 90, (see Fig. 3), adapted to actuate a centrally-pivoted lever 91. The lever 91 is adapted to make and break electrical contact in the line 38 at 92, one part of the circuit 38 being connected to said lever at 93, as shown, whereby the circuit through 38 is normally sustained. A wire 94, connecting with wire 38 and terminating in a contact 95, normally engaging lever 91, makes an additional course for the current in 38 to insure proper action in 38.

96 is a contact in a wire 97, having battery 96 and ground 99, the contact 96 being adapted to be engaged by lever 91 when the latter is attracted by magnet 90. Now when the subscriber D calls a subscriber—say E—on the local-subscribers' wires 32 38 and the current passes over wire 11, previously described, the first action will be to energize magnet 90, which will attract lever 91 and break the circuit at 92 91 and establish it at 91 96, whereby a local circuit will be formed from 99 through 98, 97, 96, 91, 93, and 38 to magnet 36, and thence through 37, 35, and 40 to ground 41 to keep the latter energized and thus hold the lever I of subscriber E's device B at rest. By this means also when the subscriber E throws his switch 39 to shunt subscribers E^2 and E^3 from line 32 the magnet 36 will not be demagnetized. In the latter position of lever 91—that is to say, when attracted by magnet 90—the lever 91 makes contact at 100 with a wire 101, leading to ground at 102, the lever 91 also having a wire 103 leading to magnet 104, wire 105 also leading from said magnet to wire 38, as shown. Thus a circuit is established from 38 to 105 104 103 91 100 101 to ground 102, so that when switch 39 is restored to its normal position the magnet 104 will be energized to return lever 91 to its normal position to re-establish line 38 at 91 92. This is permitted when the subscriber D restores his switch 39 to energize his magnets 36 J and permit his lever I to return home and be held at rest, thereby breaking his circuit at 12 and demagnetizing magnet 90. The complete operation of this portion of my invention is as follows: Suppose subscriber D desires to call subscriber at E. He first places plug *i* in aperture *j* corresponding to the local circuit in which E is situated and throws his switch 47 on stud 53 and switch 39 off of 59 to break contact at 59. His lever I now turns, as hereinbefore described, and makes contact at 12 through circuit 14 11 with the device B of the subscriber E, thereby energizing magnet 90, at the same time establishing the circuit through line 32 with E. Lever 91 now moves to break the circuit at 92 93 and establishes it at 93 96 from 99 through 93 36 to ground at

41, thereby preventing lever I, belonging to switch B of the called subscriber E, from operating. No one of the subscribers E^2 or E^3 can now break his circuits through 36 and J. The called subscriber E now answers the call and throws his switch 39 to 59, whereupon lever 73 is operated to shunt E^2 and E^3 from the main line, as stated, leaving E free to telephone. When the subscribers have finished telephoning, they restore their switches 39, which causes the line 12 14 11 90 to be broken and permits the circuit through 38 105 104 to 102 to act upon lever 91 to restore the circuit 38 to 93 92, keeping the magnets 36 and J energized.

It will be understood that when the subscriber D has made connection with the subscribers' local circuit through E, E^2, and E^3 he gives a prearranged call for the subscriber he desires, who answers the call and throws his switch 39 to shunt the other subscribers on his local circuit. When a subscriber—say E—on the series circuit desires to connect with D for telephoning, he throws his switch 39 to break the circuit in 38, thereby shunting the other subscribers on their local circuit and starting his lever I to make connection with D, as hereinbefore specified. At this time the lever 91 does not operate.

In Fig. 10 I have shown two subscribers' circuits with a number of subscribers therein, and as the operation is just the same as has been described with reference to Figs. 3 and 4 a specific description of Fig. 10 is not deemed necessary.

The second plan for increasing the capacity of the system—*i. e.*, by the use of auxiliary switch boards or frames—I have illustrated in Fig. 5, and before entering into a detail description of this apparatus and system I will explain the plan in general terms.

Assume, for instance, that the capacity of any one frame is one hundred sets of contacts 6, 12, 13, 15, and 16 and a set of home contacts. It is obvious that the capacity of the system would be limited to one hundred subscribers, for each subscriber has to have a set of contacts on each board or frame; but suppose that each set of contacts, instead of leading to a subscriber's central-office instrument and through it to the subscribers' circuit, should lead to another frame with a capacity of one hundred sets of contacts and each of the latter sets of contacts lead to a subscriber's central-office instrument and through it to a subscriber's circuit it will at once be seen that the capacity of the system is increased just one hundred times. Thus with small frames, which will accommodate one hundred sets of contacts only, not less than ten thousand subscribers might be accommodated at one central office, any one of whom could automatically place himself in communication with any other subscriber. It will not be understood from this, however, that all the sets of contacts on the main frames must lead to auxiliary frames, for in practice it will be found that only a few auxiliary frames are usually necessary, and additional sets of contacts are placed on the main frames, corresponding to the necessary number of auxiliary frames. For instance, subscribers up to one hundred may be accommodated on the main frames and one additional set of contacts for one auxiliary frame, which will accommodate subscribers from one to two hundred, &c. Referring to said Fig. 5 of the drawings, F F indicate two frames or switchboards, as previously described, controlled from the subscribers' circuits, and F^2 F^2 indicate the auxiliary frames or switchboards, having contacts 6, 12, 13, 15, and 16 leading to other subscribers' main frames F and controlled from the subscribers' circuits only through the frames F—that is to say, the switch arms of frames F must be moved to the proper point to put the subscribers' circuits in circuit with the auxiliary or secondary frames.

Frames F differ from those heretofore described in three particulars only. First, the magnet J is double—that is to say, composed of two coils in the preferred construction. Secondly, there is an additional commutator-ring 132 provided, having a brush leading to earth at 41, and itself connected by wire 131 through the extra coil of the magnet with an extra contact 130 on the lever. Thirdly, additional sets of contacts are provided, leading to the auxiliary frames. These contacts are numbered 110, 111, and 112. No. 110 is adapted to make contact with contact 28 on the lever and leads by wire 115 to the commutator-ring 30 of the auxiliary frame, then by wire 29 to the contact 28 of that frame, and the latter is adapted to make contact with any one of the series of contacts 6 leading off to the other subscribers' frames, as heretofore pointed out. When the frames are, therefore, in the operative position, as shown at the right in Fig. 5, the circuit from 32 passes through the connections just described to the home point of the left-hand frame F, then over that subscriber's wire 32 to the subscriber's station. Contact 111, with which 26 is adapted to engage, leads by wire 116 to magnet 36 of frame F^2. Contact 112, which is adapted to be engaged by the additional contact 130 on the lever of F, leads by wire 122 through a battery 123 to home-point contact 124 of frame F^2 and through the latter to contact 125, bearing against the same, thence by wire 126 to ground at 127. Frame F^2 also differs from those first described further in that it is provided with an additional commutator-ring 118, connected through brush 119 and wire 120 with earth at 121, on the one hand, and, on the other hand, is connected through wire 117 with the additional small commutator-segment 24^a, corresponding to and located beside the commutator-segment 24, heretofore described in connection with the other frames. Brush 33 is bifurcated in frame F^2. Hence the

circuit over wire 116 from 26 of frame F is established through wire 34, brush 33, wire 117, commutator-segment 118 to earth at 121, thereby energizing magnet 36, which in this instance is energized to break the local circuit through magnet J of frame F^2 instead of being demagnetized, as in the former instance. This is secured by locating the stop 42 on the opposite side of the armature 35, as shown in said Fig. 5. The breaking of the local circuit through magnet J of frame F^2 causes it to release its lever, which at once begins to revolve, and the said magnet J is again energized through the circuit established from the subscriber's station when the arm 63 reaches the pin *i*, over wire 38, commutator 22 of frame F, and contact 26 of said frame to wires 116 34 of frame F^2, brush 33, wire 21, magnet J, wire 23, contact 26, stationary contact 16, and then 12 to the desired subscriber's central-office instrument.

It would appear from the foregoing that, having secured the manipulation of the frame F to bring its lever into engagement with the proper contacts for the frame F^2 and having started the movement of the latter, the magnet J of frame F would be demagnetized through the interruption of the circuit through the commutator-segment 24^a of frame F^2, and to guard against this I provide the magnet J of said frame F with the additional coil, and at the time when the frame F^2 is moving away from its home point a local circuit is established through the extra coil of the magnet J of frame F as follows: starting from ground 41, (frame F,) through wire 134, to commutator-segment 132, wire 131, magnet J, wire 131, additional contact 130, contact 112, wire 122, battery 123, home contacts 124 125 of frame F^2 to ground at 127, thereby keeping magnet J of frame F energized until the lever of frame F^2 again returns to home point and separates the contacts 124 125 to break the circuit, which operation will presently be described.

The subscriber's station apparatus is similar to that in my before-mentioned patented device and has an additional pin to indicate the auxiliary frame desired.

The operation is as follows: Say, for instance, that subscriber No. 214 is desired. One pin will be placed in the second hole of the first series to indicate the number of the frame desired and another pin will be placed in the fourteenth hole of the second series to indicate that the lever of the second frame is to be stopped at the fourteenth set of contacts. When the circuit 38 is broken by moving switch 39, magnet 36 of frame F releases its armature, breaking the local circuit for magnet J and starting the lever around the frame. As soon as the arm 63 reaches the first pin the circuit through 36 and said arm is established through magnet J to contact 26, thence in this instance to earth at 18, with which contact 16 is connected. As the lever is attracted by the magnet J, the contact 26 strikes contact 111 and maintains the circuit through magnet 36 of frame F^2 to ground at 121, as before stated. This energizes magnet 36 of frame F^2, breaks the local circuit through the magnet J of that frame, and starts the lever to moving. As the said lever I of frame F moves, in addition to moving contact 26 into engagement with 111 it moves contact 130 into engagement with contact 112, establishing the circuit through the second coil of magnet J of frame F, as before described, holding the lever I of this frame stationary and leaving the line 38, &c., free to control the magnet J of the frame F^2 in a manner exactly similar to that described in connection with Figs. 1 and 2—that is to say, the circuit is established through magnet J of frame F^2 when arm 63 reaches the second pin, thereby arresting the switch-arm I of frame F^2 and establishing the circuits to the central-office apparatus of the desired subscriber, as before explained, through the contacts 6 12. The circuit over which communication is had now extends from line 32, commutator 30 of frame F, contacts 28 and 110, wire 115, to commutator 30 of frame F^2, then by wire 29 to contacts 28 and 6 of this frame, and to line 4, which extends to the other subscriber's home contact 2, and if his contact 28 is in engagement therewith over the latter to his line 32, all as shown clearly in said Fig. 5, where station E is shown as having secured circuit connection with D. When the conversation is finished, D simply returns his telephone to its hook. E returns his telephone to its hook, sees that switch 47 is returned to 47^a and switch 39 returned to 59 to re-establish the circuit 38, and the arm 63 returned to normal position ready for another operation. By re-establishing the circuit 38 the magnet 36 of frame F is energized and the short circuit to earth before described established. This demagnetizes magnets 36 and J of frame F^2, allowing the lever I of this frame to return to normal or home point, where it is arrested by the completion of the local circuit through the armature 35 and commutator-segment 24. At the instant the lever I of frame F^2 reaches its home point it separates the contacts 124 125, breaking the local circuit through the second coil of magnet J of frame F and starting the lever I of this latter frame back to home point, where it is arrested by the completion of the local circuit through armature 35, magnet J, and commutator-segment 24.

It will be understood, of course, that a number of subscribers may be located on each subscriber's circuit with this form of apparatus, just as described in connection with Figs. 3, 4, and 10, and, in fact, the drawings show one of the circuits having three subscribers, as in Figs. 3 and 4.

Referring now to Fig. 11, wherein I have shown an arrangement whereby a complete metallic circuit may be established between any two stations, it will be seen that to ac-

complish this a third wire 300 is connected directly with the induction-coil of the telephone instead of the ground connection 46ª, which wire extends to the central-station apparatus, where it terminates in a brush 301, bearing on an additional commutator-ring 302, connected by wire 303 with an additional contact 304, carried by the lever I and adapted to make contact or engage contact-arm 305 when at the home point and one of the contacts 308 when attracted by the magnet J when in line with any of the other sets of contacts. From contact 305 at the home point of each frame a wire 306 extends to each of the other frames, where it is connected by branches 307 to contacts 308, adapted to engage with the movable contacts 304 of the respective frames, as just indicated. With this arrangement it will be seen at once that when a subscriber at one station has secured the movement of his switch-lever to the point desired for making the circuit connections with any other subscriber he will also complete the second or return circuit. Thus in Fig. 11 subscriber E is supposed to have called subscriber D and the second wire or return circuit will extend from his telephone over the wire 300 to the brush 301, commutator 302, wire 303, contacts 304 308, branch wire 307, wire 306 to home contact 305 of station D's central-office apparatus, thence over movable contact 304 to wire 303, commutator 302, brush 301, and wire 300 to the subscriber's station.

The arrangement of the return-wire for either of the duplicating or capacity-increasing plans heretofore described is exactly similar to that just described, and hence I have not deemed it necessary to illustrate the same, as it would call for an unnecessary duplication of the drawings.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an automatic telephone exchange system, the combination with a series of switch boards, each having a series of sets of contacts, one set for each of the other boards and an additional or home set and circuit connections between the home set of each board and one of the sets of contacts on each of the other boards, of a switch lever for each board, carrying contacts adapted to engage any set of contacts on the boards, and a subscriber's circuit for each switch; substantially as described.

2. In an automatic telephone exchange system, the combination with a series of switch boards, each having a series of sets of contacts, one set for each of the other boards, and an additional or home set, and circuit connections between the home set of each board and one of the sets of contacts on each of the other boards, of a switch lever for each board, carrying contacts adapted to engage any set of contacts on the board, a magnet controlling the movement of the lever and a subscriber's circuit for each board over which circuit the magnet is controlled, substantially as described.

3. In an automatic telephone exchange system, the combination with a series of switch boards, each having a series of sets of contacts one set for each of the other boards, and an additional or home set, and circuit connections between the home set of each board and one of the sets of contacts on each of the other boards, of a magnetically controlled switch lever for each board carrying contacts adapted to engage any set of contacts on the board, a circuit extending from said lever to the subscriber's station, and a second circuit extending from the magnet controlling the lever to the subscriber's station; substantially as described.

4. In an automatic telephone exchange system, the combination with a series of switch boards, each having a series of sets of contacts, one set for each of the other boards, and an additional or home set, and independent circuit connections between the individual contacts of the home set of each board and the individual contacts of one of the sets of contacts on each of the other boards, of a magnetically controlled switch lever for each board, carrying contacts adapted to engage any set of contacts on the board, a circuit extending from the subscriber's station to the switch lever whereby the circuit may be established from the subscriber's station to the distant board, and a second circuit extending from the subscriber's station through the controlling magnet of the switch lever and through the contacts on the lever and frame respectively, to the distant frame, whereby the circuit through the controlling magnet may be interrupted at the latter point to prevent the operation of the magnet; substantially as described.

5. In an automatic telephone exchange system, the combination with a series of switch boards each having a series of sets of contacts including separable contacts, one set for each subscriber's circuit and an additional or home set and each having circuit connections between its home set and one of the sets of contacts on each of the other frames or boards, a switch arm for engaging said contacts, an electro-magnet controlling the arm, a circuit including the magnet having a contact on the arm and a battery for energizing the said magnet, of a second series of contacts with which the arm engages when in motion and circuit connections between said last mentioned contacts and the separable contacts on the other boards whereby the circuit may be established through the magnet and whereby the circuit is prevented from being established when the separable contacts for that circuit at any of the other boards are separated; substantially as described.

6. In an automatic exchange system the combination with the series of subscribers' circuits, a series of switch boards correspond-

ing to the subscribers' circuits, a series of sets of contacts on each board, one set for each of the other boards, circuit connections between each board and its respective contacts on each of the other boards and a second series of contacts located one in proximity to each of the first mentioned sets of contacts, of a movable switch lever for engaging said second series of sets of contacts successively to establish the subscriber's circuit through any one of the said second series of contacts, an indicating mechanism at the subscriber's station operated by impulses over the circuit when established through the lever and a second series of contacts and a second subscriber's circuit including a magnet for arresting the lever when the same has moved to a predetermined point as shown by the indicator; substantially as described.

7. In an automatic exchange system the combination with the series of switch boards or frames, each having a set of contacts corresponding to each of the other boards, circuit connections between each board and its set of contacts on each of the other boards, a movable switch lever and a subscriber's circuit for each board established by the lever, of an electro magnet controlling the lever and a second subscriber's circuit extending from the subscriber's station to the distant board and including said magnet, whereby the lever may be arrested at any desired set of contacts; substantially as described.

8. In an automatic exchange system, the combination with the series of switch boards or frames each having a set of contacts corresponding to each of the other boards and an additional or home set, circuit connections between the home set of each board and its set of contacts on each of the other boards, a movable switch lever normally resting on the home contacts, and a subscriber's circuit for each board established to the distant board by the switch lever, of an electro-magnet controlling the lever, a second subscriber's circuit extending to the subscriber's station and also established to the distant board by the switch lever and including the electro magnet, whereby the lever may be arrested at any desired set of contacts and is prevented from being arrested if the said second circuit is interrupted at the distant board; substantially as described.

9. In an automatic exchange system, the combination with the series of switch boards or frames each having a set of contacts corresponding to each of the other boards and circuit connections between each board and its set of contacts on each of the other boards, a movable switch lever for each board engaging said contacts when stationary, a second series of contacts with which said lever engages when in motion, a subscriber's circuit established through said second series of contacts and a step by step mechanism at the subscriber's station included in said circuit and operated one step each time the circuit is established, of a second subscriber's circuit controlled by said step by step mechanism and established thereby when said mechanism has reached a predetermined point, and an electro-magnet controlling the switch lever included in said second series, whereby, the lever is arrested automatically at the desired point; substantially as described.

10. In an automatic exchange system, the combination with the series of switch boards or frames, each having a set of contacts corresponding to each of the other boards and independent circuit connections between each board and the individual contacts of its set of contacts on each of the other boards, a movable switch lever for each board engaging said contacts when stationary, two series of contacts with which said lever engages when in motion, arranged in pairs comprising one of each set, one of said sets being connected to earth and the other to the circuit leading to the distant frame and an electro-magnet controlling the lever adapted to be put in contact with the last named set, of two subscribers' circuits established through said contacts respectively by the lever, a step by step mechanism included in and operated by one of said circuits each time the circuit is established by the lever, the other subscriber's circuit passing through and controlled by the step by step mechanism to complete the circuit at a predetermined time and including the electro-magnet, whereby the magnet is energized to arrest the lever when the step by step machanism and lever have both reached the predetermined point; substantially as described.

11. In an automatic exchange system, the combination with a subscriber's circuit, a switch lever, a magnet controlling said lever, a battery and a local circuit including said magnet, whereby it is energized and an electro-magnetically controlled switch lever in said local circuit controlled from the subscriber's station, of a switch board or frame having a series of contacts leading to other subscribers' stations, any one of which is adapted to be connected with the first mentioned circuit by means of the switch lever; substantially as described.

12. In an automatic exchange system, the combination with the series of switch boards or frames having contacts and circuit connections leading to the other boards or frames and a subscriber's circuit for each board, of an electro-magnetically operated switch arm for each board or frame for establishing circuit connections between the subscriber's circuit and the contacts on said board or frame, a local circuit including the switch magnet and an electro-magnetically controlled switch lever in said local circuit controlled from the subscriber's station; whereby the local circuit may be broken to demagnetize the switch magnet; substantially as described.

13. In an automatic exchange system, the

combination with the series of switch boards or frames having contacts and circuit connections leading to the other boards or frames and a subscriber's circuit for each board, of an electro-magnetically operated switch arm for each board or frame for establishing circuit connections between the subscriber's circuit and the contacts on said board or frame, a local circuit including the switch magnet, and an electro-magnetically controlled switch arm in said local circuit, a second circuit leading to the subscriber's station and including the magnet for operating said local circuit switch arm, whereby the local circuit may be controlled from the subscriber's station; substantially as described.

14. In an automatic exchange system for telephony, the combination with a series of subscribers' circuits, a switch board or frame for each circuit an auxiliary switch board or frame located at the same central office and having a series of sets of contacts corresponding to the subscribers' circuits, and circuit connections between said auxiliary frame and sets of contacts on each of the other frames, whereby circuits may be established to said auxiliary frame from any one of the other frames, of a switch arm for said auxiliary frame adapted to engage any one of said sets of contacts, whereby any subscriber may be put in circuit with any of the subscribers' sets of contacts on the auxiliary frame substantially as described.

15. In an automatic exchange system, the combination with a transmitting local subscriber's circuit, a series of receiving local subscribers' circuits, and an auxiliary automatic switch actuated from the transmitting subscriber's circuit and controlling circuit connections between the said transmitting subscriber's circuit and any one of the receiving local subscribers' circuits, of an automatic switch between the auxiliary automatic switch and transmitting subscriber's circuit actuated from the transmitting subscriber's circuit and controlling circuit connections between the latter and the auxiliary switch, and a local circuit controlled by the said auxiliary switch and including the controlling magnet of the switch located between said auxiliary switch and subscriber's circuit, whereby said intermediate switch when set is held until released by the auxiliary switch; substantially as described.

16. In an automatic exchange system for telephony, the combination with main and auxiliary automatic switches, a series of contacts on the latter corresponding to subscribers' circuits, a series of receiving subscribers' circuits connected with said contacts, and a single transmitting subscriber's circuit controlling the main switch and through the same controlling the auxiliary switch, of a local circuit established by the main switch when in circuit with the auxiliary switch, to hold the main switch in set position, said local circuit passing through and controlled by the home contacts of the auxiliary switch, whereby the main switch is held until released by the auxiliary switch when the latter is in normal position; substantially as described.

17. In an automatic exchange system for telephony, the combination with main and auxiliary automatic switches, a series of subscribers' circuits having contacts on the auxiliary switch and a single subscriber's circuit controlling the main switch and passing through the same to the auxiliary switch, of a local circuit established by the main switch when in circuit with the auxiliary switch to hold the main switch in set position, contacts on the auxiliary switch controlling said local circuit, a local circuit for holding the auxiliary switch in normal position and an electro-magnetically operated switch arm in said last mentioned local circuit controlled by the said subscriber's circuit; substantially as described.

18. In an automatic exchange system for telephony, the combination with a main or transmitting automatic magnetically controlled subscriber's switch and circuit, an auxiliary or receiving subscriber's automatic magnetically controlled switch, a series of receiving subscribers' circuits connected therewith and two local circuits one for each of said switches by means of which said switches are held in normal position respectively, and electro magnetically operated switch arms in said local circuits respectively controlled from the transmitting subscriber's station with contacts and circuit connections controlled by said main and auxiliary switches for establishing connection between the transmitting and any one of the receiving subscribers' circuits; substantially as described.

19. In an automatic exchange system for telephony, the combination with a main or transmitting automatic magnetically controlled subscriber's switch and circuit, an auxiliary or receiving subscriber's automatic magnetically controlled switch, a series of receiving subscribers' circuits connected therewith and two local circuits one for each of said switches, by means of which said switches are held in normal position respectively, an electro magnetically operated switch arm in each of said local circuits controlled from the subscriber's station by currents of different power, whereby one of said arms may be operated without operating the other and contacts and circuit connections controlled by said main and auxiliary switches for establishing connection between the transmitting and any one of the receiving subscribers' circuits; substantially as described.

20. In an exchange system for telephony, in which complete metallic circuits are established between subscribers, the combination with a series of central office switch frames one for each subscriber's circuit and each having sets of independent contacts and independent circuit connections between said contacts and similar contacts of corresponding

sets on each of the other frames, of a switch lever for each frame having independent contacts adapted to engage respectively with the independent contacts on the frame, a metallic subscriber's circuit for each frame, the branches of which terminate in the contacts on the switch lever respectively and a second subscriber's circuit controlling the switch levers, substantially as described.

21. In an exchange system for telephony, in which complete metallic circuits are established between subscribers, the combination with the series of central office switch frames one for each subscriber's circuit and each having sets of independent contacts, one set for each of the other frames and an additional or home set, independent circuit connections between the independent contacts of the home set of each frame and the independent contacts of the sets corresponding to that frame on each of the other frames, of a switch lever for each frame having independent contacts adapted to engage respectively with the independent contacts on the frame, a metallic subscriber's circuit for each frame, the branches of which terminate in the contacts on the switch-lever respectively and a second circuit controlling the switch levers; substantially as described.

22. In a telephone system, the combination with a central office switching apparatus for connecting subscribers' circuits, and a subscriber's circuit including a number of subscribers' stations, of a shunt switch at each station, a normally closed shunt controlling circuit including all of said shunt switches whereby the circuit is maintained through the instruments at all the stations, a local circuit at each station including the shunt switch whereby said switch may be held in the position stated, and a manually operated switch in both said shunt controlling circuits at each station, whereby the main shunt circuit may be broken to cut out all other stations and the local circuit established to keep the instruments of that particular station in the main line; substantially as described.

23. In a telephone system, the combination with a central office switching apparatus, for connecting subscribers' circuits, and a subscriber's circuit including a number of subscribers' stations, of an electro-magnetically controlled shunt switch at each station, a normally closed shunt controlling circuit including all of said shunt switches, whereby the subscriber's circuit is normally maintained through the instruments at all the stations, a local shunt controlling circuit at each station with contacts therein moved by the said shunt switch to break the local circuit when said switch is released by the main shunt controlling circuit and a switch at each station for breaking the main and establishing the local shunt controlling circuit, whereby all the shunt switches, save that one will be operated to shunt the instruments at their stations, respectively; substantially as described.

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