To all whom it may concern:

Be it known that I, FRANK A. LUNDQUIST, a citizen of the United States of America, and a resident of the city of New York, county of Kings, and State of New York, have invented certain new and useful Improvements in Automatic Telephone-Exchanges, of which the following is a specification.

My invention relates to automatic telephone exchanges, and has for its object improvements in the construction and operation of such exchanges.

In the present application the trunk selecting switches are in the front of drops which are operated by gravity and which slide down rods or wires used both as guides and as electrical conductors. The switches are arranged in rows and are normally supported in an elevated position. The trunk terminals are shafts supported one above another in the path of falling switches. When a falling switch engages one of these shafts it makes electrical connection thereto and at the same time pushes it out of the path so that it will not be engaged by a second falling switch.

The drawings hereunto annexed are diagrammatic in character. Those which appear to represent structure are not to be construed as representing actual structure, but rather as representing so much of the general characteristics of structure as will enable the operation to be understood.

In the said drawings—

Figure 1 represents three primary switches in three positions, and the shafts with which they make connection;

Figs. 2 and 3 are rear and top views, respectively, of one of the switches;

Figs. 4 and 5 are side and rear views, respectively, of a secondary switch;

Fig. 6 is an enlarged view showing the electrical connection which a drop makes to a trunk terminal;

Fig. 7 is a plan of a trunk terminal; and

Fig. 8 is a diagram of so much of the exchange as is necessary to illustrate the manner of operating.

The drop D is preferably made of some insulating material, such as wood fiber, and is arranged to slide vertically on guide wires 35 and 65. Pivoted to the drop D is a contact arm 38 normally held in the position shown on the upper drop in Fig. 1. A wire or ribbon 116 is connected to one branch of the arm 38, and extends to a spool 127 loosely mounted upon a constantly running shaft 125.

In its upper position the drop D is supported by an arm 38 (Figs. 1 and 8) on armature 33 of magnet R. When the magnet R operates it withdraws the support and the drop falls. A certain amount of friction is provided in the form of a contact spring 36 engaging the guide wires 35. To illustrate the action here involved it will be assumed that the drop weighs eight ounces, and that the friction between 35 and 36 accounts for four ounces. Under these conditions the drop would fall with a force of four ounces. On the other hand, to lift the drop after it had fallen would require a pull equal to the weight plus the four ounces of friction, or twelve ounces in all. A spring 200 and a set screw 201 (or equivalent devices) are used for determining the normal position of an arm 38. When the pull on the wire 116 is considerably less than the weight of the drop, the arm 38 will be held in its normal position. When the pull is considerably more than the weight of the drop the spring 200 will be deflected and the arm 38 will take the position shown in the lower part of Fig. 1.

Supported in brackets 202 are shafts 67 which are bent into crank form as shown in Fig. 7. On the crank-pin parts of each shaft are insulated pieces 39 which are connected together by wires 203 so that all of the insulated parts on one shaft form a conductor. Any convenient stops (such as 204, Fig. 7) may be used to limit the inward movement of the crank parts.

The shafts 67 are supported one above another and are normally held, by any convenient means, so that the insulated parts 39 will be in position to be engaged by the lower end of arm 38 when drop D falls. The effect of such engagement is to swing the shaft 67 on its pivots so that it will be out of the path of another falling drop, and also to move the arm 38 so as to complete certain electrical connections. The shafts 67 rep-
resent trunks leading to secondary switches, and usually there would be ten such shafts in front of a bank of primary switches. Any convenient number of primary switches, as one hundred, would be in front of each bank of shafts, and each switch, when dropped, would engage the first idle one of said shafts. Several primary switches are assumed to be in front of each crank part of shafts 67, and each shaft is assumed to be long enough to provide connections for the one hundred, more or less, primary switches in a bank. Contact strips 118 are back of each crank part and are made into a continuous conductor by wires 205.

The spools 127 are loosely supported on shaft 125 which is continuously running in a direction to wind up wire 116 and lift drop D when the spool is driven by the shaft. A clutch member 129 (Fig. 8) and spring 125 provide means for driving the spool, and an arm 121 provides means for disengaging the clutch. The operations involved will be described hereinafter.

The slight friction between the spool 127 and the running shaft 125 is sufficient to keep the wire 116 taut, but the pull is not enough to influence the position of arm 38 or to prevent the fall of drop D when arm 23 is removed. When, however, the clutch is thrown into operation, the strain necessary to lift the weight of the drop and to overcome the friction between 35 and 36 will move the arm 38 on its pivot so that said arm and parts carried thereby will clear any released shafts 67 which may be above the particular trunk which the drop selected in falling.

From the foregoing it will be obvious that the primary switches are trunk selecting switches which are moved by gravity to perform the trunk selecting act, and that this act consists in mechanically moving the trunk terminal from an idle to a non-idle or busy position. Also, that in selecting an idle trunk and in moving it from an idle position, the falling switch comes to a stop and makes certain electrical connections. The apparatus described is simply that considered most convenient for the purpose, and the drawings are largely diagrammatic. Some parts not shown in Figs. 1, 2 and 3 appear diagrammatically in Fig. 8, and will be described in connection with the operation of the exchange.

A secondary switch is shown in Figs. 4 and 5, and in the central part of Fig. 8. It consists of a similar drop D guided on wires 41 and 50. In this case the contact arm 44 is controlled by an arm T, which is controlled in turn by projections S on shaft S. The elevating wire 47 is insulated from the arm 44, and similar insulation is used on the primary switches between arm 38 and wire 116.

The drops D are arranged in banks along side of each other, and associated with each drop D is a shaft S rotated by action of a magnet E. On the shaft S is a pin 206 which, when shaft S is in its normal position, is located under the latch 207 and serves to hold drop D in elevated position. When, however, the magnet E turns shaft S one step, pin 206 is moved from under latch 207 and drop D is permitted to fall.

In front of the primary switches D there is placed one group of about ten shafts 67. In front of the secondary switches there is a plurality of groups of similar shafts 71, the groups being placed one above another in the same vertical plane. In other words, the bank of shafts 71 in front of the drops D consists of about one hundred shafts one above another instead of about ten shafts as shown in Fig. 1 for shafts 67. The division of this vertically long bank into groups is an electrical division made by grouping the conductors extending from the projections S, S, etc., on the shaft S, arranged spirally and in groups 100, 100, 100, 100, and so on spacing to the teeth on the ratchet wheel which moves the shaft. Thus, when the shaft S has been moved one step to release the drop D so that it may fall, the uppermost projection S lies in the path of the arm T and is engaged thereby to move said arm T to push contact arm 44 outward. If, however, the shaft S should be moved two steps instead of only one, then the arm T would pass the first projection S and engage the second projection S. If the shaft should be moved three steps, then the drop D would pass the first two projections and the arm T would engage the third one. And so on.

The contact arm 44 is normally held in such a position that, when the drop D falls, said contact arm 44 will not engage any contact shaft 71 unless the arm T previously engages a projection to force said arm 44 outward. The projections S, S, etc., correspond to the electrical divisions of the shaft 71. Thus, the uppermost projection S corresponds, in position and length, to the uppermost group of shafts 71; the second projection S similarly corresponds to the second group of shaft; and so on. It will be evident that the shaft S with its projections is a group selector, the size of any group being determined by the vertical length of the corresponding projection S, S, etc.

In Fig. 8 one local station is shown at the upper left hand corner of the drawing, and at the lower left hand corner is one connector switch. These may be of any proved construction. Associated with the connector switch, and at the left of the drawing, are shown bank wires, each pair of which extends to the normal connections of a different primary switch. The arrange-
ment and connections of the bank wires are those ordinarily used.

At the upper central part of Fig. 8 is shown one primary switch, together with its associated parts. Directly below the primary switch are shown one secondary switch and its associated devices. The main characteristics of these parts and devices will be apparent from the following description of the operation.

To call, the calling subscriber presses his key A, whereupon a current flows from ground at his station to local station. At the upper central part of Fig. 8 is shown one primary switch, together with its associated parts. Directly below the primary switch are shown one secondary switch and its associated devices. The main characteristics of these parts and devices will be apparent from the following description of the operation.

In falling, the arm 38 of drop D engages the first shaft 67 which is in its normal position, and forces that shaft inward on its pivot so that it will be out of the path of another falling drop D. At the same time arm 38 on the drop is forced outward so that its outer end engages the segment 39 on shaft 67. Simultaneously, the spring 66 engages the shaft 67 and the guide wire 65. In moving away from normal position, the drop D permits contacts 79-80, 85-86 and 87-91 to open, and the contacts 101-102 to close. The new position of the drop D extends the electrical connections of the local station to an idle one of the secondary switches represented by the drop D. The calling subscriber, to select the desired group, then presses his key A a required number of times to operate R as before and close contacts 52 and 53, whereupon a current flows from battery Y-30-31-32-33-34-guide wire 35-36-37-38-39-40-guide wire 41-42-43-44-45-46-47-48-49-E-50-51-52-53-54-Y. The first impulse through E rotates shaft S to release drop D so that it may fall, and to bring the first projection S' in the path of the arm T. The second impulse moves the shaft S a step farther and brings S' into the path of T. The second impulse moves the arm T out of that path. If there is only one impulse through E then the arm T will engage S' and push arm 44 on D outward so that it will engage the first idle shaft 71 in the first group of shafts, and through that shaft be connected to the first idle connector in the first group of connectors. If there are two impulses through E, then drop D will pass the first group of shafts 71 and engage the first idle one in the second group by reason of arm T engaging S'. If there are three impulses through E the connection will be to the first idle shaft in the third group, and so on.

It will be observed that if there are many impulses through E, the drop D will fall a long distance. Under the action of gravity the speed of a falling body increases rapidly, and to keep the variations of falling speed within manageable limits, the armature E' carries a link E having a head F adapted to engage the wire 47 so as to check the falling speed of drop D each time F operates. When drop D engages an idle shaft 71 electrical connections are extended to an idle connector, and are broken between 44 and 45.

To operate the selected connector, A is first operated a required number of times, whereupon current flows from ground at local station to 9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-R-25-26-27-28-29-Z-ground at central office. The operation of the magnet R moves the holder 23 to release the drop D which belongs to the calling subscriber.

Directly below the primary switch are shown one secondary switch, local station. At the upper central part of Fig. 8 is shown one primary switch, together with its associated parts. Directly below the primary switch are shown one secondary switch and its associated devices. The main characteristics of these parts and devices will be apparent from the following description of the operation.

To signal the called subscriber, the calling subscriber presses the key B, whereupon a current flows — ground at calling station — 62-63-64-guide wire 65-66-67-68-guide wire 69-70-71-72-J-57-Z-ground. The action of magnet J connects the generator G to the calling line and the ringing circuit is: — G-73-74-75-76-77-selected contact point and bank wire to contact spring 79 which is closed for the called station which has its drop D in normal position — 80-81-82-ringer — 83-hook 84-85-86-85-86 — closed with drop in normal position-bank wire to wiper 87-88-89-90-G. The magnets R and F of the called station are bridged on this circuit. As they are liable to be effected by the ringing current and the operation of R would release the drop D of the called subscriber, a ground connection is provided at the generator G so as to provide a battery circuit for F to break the connections for R at contact springs 26-27. This circuit is: — ground at G-90-89-88-87-bank wire to 86-85-91-92-F-93-28-29-Z-ground.

5. To restore the connector and the drops to their normal position keys A and B are simultaneously pressed, and at the same time the hook is depressed by hanging the receiver upon it. The contacts closed are normally controlled in an automatic manner by the descent of the receiver hook, but are here assumed to be manually performed. When the hook rises by reason of the removal of the receiver it (the hook) causes its pin 104 to catch on the lever 103, and when the hook descends it pulls down the lever to cause it to push contact 98 against contact 99. Receiver hooks which will operate in this way are shown in my Patents No. 606,764, issued July 3, 1899, and No. 747,197, issued Dec. 13, 1903.


The action of magnet F and R is to close the circuit for magnet F as follows:—Z—29—28—27—109—110—111—112—113—114—115—116—117—118—119—F—119—120—Z.

The operations of magnets F and F' release the hooks on their armature levers from the pins on the levers 121 and 122 so as to permit the springs 123 and 124 on shafts 125 and 126 to push winding drums 127 and 128 to the right into connection with the projecting pins 129 and 130. As the shafts are continuously running, the engagement between pins and drums serves to drive these drums to elevate drops D and D' to their normal positions. When these drops arrive at their upper positions, suitable projections thereon engage levers 121 and 122 to cause them to again force the drums 127 and 128 to the left and out of engagement with their driving pins.


Magnet C closes the circuit for C, as previously described, and magnet J moves the pin of hook 131 in front of the tail on pawl 132 so that when C' attracts its armature 133 the pawl 132 will strike the tail of holding pawl 134 and release the connector switch.

When magnet F' operated, as before described, to release lever 122, its armature released holding pawl 208 from the ratchet wheel on shaft S so that spring 209 could return said shaft to its normal position.

What I claim is:

1. In a telephone exchange, a drop movable from normal position by gravity, a guide for directing the fall of the drop, a stop in the path of the drop, and means by which an engagement of the drop with the stop serves to complete an electric circuit through the guide.

2. In a telephone exchange, a drop normally supported in an elevated position and movable therefrom by gravity, a contact arm pivoted upon the drop, and drop elevating mechanism connected to the arm and acting to move it on its pivot when lifting the drop.

3. In a telephone exchange, a series of drops movable from normal position by gravity, independent guides for the different drops, a less number of common stopping devices for the drops, means by which a falling drop is arrested by a non-busy stop, and means by which such engagement serves to complete a circuit through the engaged stop and the guide for the falling drop.

4. In a telephone exchange, a drop movable from normal position by gravity, electrical conductors serving as guides for said drop, insulated contact makers carried by said drop, contact pieces located in the path of the contact makers when said drop is moved by gravity, and means by which electrical connections are extended from said contact pieces to said conductors when said contact makers engage said pieces.

5. In a telephone exchange, a drop, an electrical conductor serving as a guide for said drop, a contact maker insulatedly supported on said drop, a series of contact pieces in the path of the contact maker when said drop falls, and means by which upon engagement between the contact maker and a contact piece both contact maker and contact piece will be moved from normal position and the falling movement of the drop will be arrested, said operations serving to extend electrical connections from the engaged contact piece to the conducting guide.

6. In a telephone exchange, a drop representing a subscriber and movable from normal position by gravity, insulated guides for directing the fall of the drop, means by which a drop upon falling makes an electrical connection to one of said guides, other devices operated by impulses sent over said electrical connection, and means by which the operation of said other devices establishes a talking circuit for the subscriber through the guides for his drop.

7. In a telephone exchange, a drop, an arm carried by the drop and normally held in a mid-position thereon, a series of contact pieces in the path of the arm when the drop...
falls, means by which engagement between said arm and a contact piece will move both from their normal positions, drop elevating devices, and means by which the drop elevating devices will act to move the arm in opposite direction and beyond its normal position.

8. In a telephone exchange, a drop having a contact device movable thereon, guides for said drop, there being a predetermined amount of frictional resistance between said drop and its guides, elevating devices for said drop for returning it to normal position after it has fallen, and means by which the friction between the drop and guides serves to modify the position of said contact device when said elevating devices lift said drop.

9. In a telephone exchange, a drop normally supported in an elevated position, a series of groups of electrical contacts adjacent to the path of said drop when it falls, a contact arm mounted upon the drop and movable with respect thereto, a group selecting device, and means by which upon operating said group selecting device to select a desired group of electrical contacts the drop will be released so that it will fall and in falling will engage the group selector to force said arm into engagement with an electrical contact in the selected group.

10. In a telephone exchange, a vertical series of contacts divided into groups, a drop having a falling path adjacent to said contacts, a contact maker carried by and movable on said drop, a group selector arranged to be adjusted for the selection of any desired group of contacts, means by which upon adjusting said selector for a desired group the drop will be released so that it may fall from its normal position and in falling will engage a predetermined part of the selector, and means by which such engagement will force the contact maker outward into engagement with a contact in the selected group.

11. In a telephone exchange, a vertical series of contacts divided into groups, a contact maker movable by gravity in a path adjacent to said contacts, a group selector having projections corresponding to the groups of contacts, means for adjusting said selector for the selection of a desired projection, and connections by which upon the falling of said contact maker engagement with the selected projection will cause said contact maker to engage a contact in the corresponding group.

12. In a telephone exchange, a vertical series of contacts, a contact maker movable by gravity in a path adjacent to said contacts, means for moving the contact maker to engagement with some contact in a selected part of the series of contacts, and means for periodically checking the rate of fall of said contact maker in any drop thereof.

13. In a telephone exchange, the combination with a series of contacts, and a contact maker movable by gravity to connection with some contact in the series, of means for checking the acceleration due to gravity so that the actual rate of fall will approximate uniformity.

14. In a telephone exchange, the combination with a series of vertically disposed contacts of a contact maker guided to fall by gravity adjacent to but free from said contacts, and means for projecting said contact maker laterally at any predetermined point in its fall so as to cause it to engage a contact at a desired part of the series of contacts.

15. In a telephone exchange, the combination with a series of vertically disposed contacts, a contact maker guided to fall by gravity adjacent to said contacts but free therefrom, and means for selectively projecting the contact maker laterally at a desired point in its fall to engage a contact therein, of means for checking the normal acceleration of the falling body.

16. In a telephone exchange, a series of contact pieces serving as electrical terminals, a carrier movable in a path adjacent to said contact pieces, an arm mounted upon said carrier and having a normal position on the carrier such that it will not engage a contact piece when the carrier is being moved, and selective devices for moving said arm from its normal position at a desired part of the carrier movement so as to cause engagement between said arm and a contact piece in a desired part of the series of contact pieces.

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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents. Washington, D. C."