

Sept. 7, 1948.

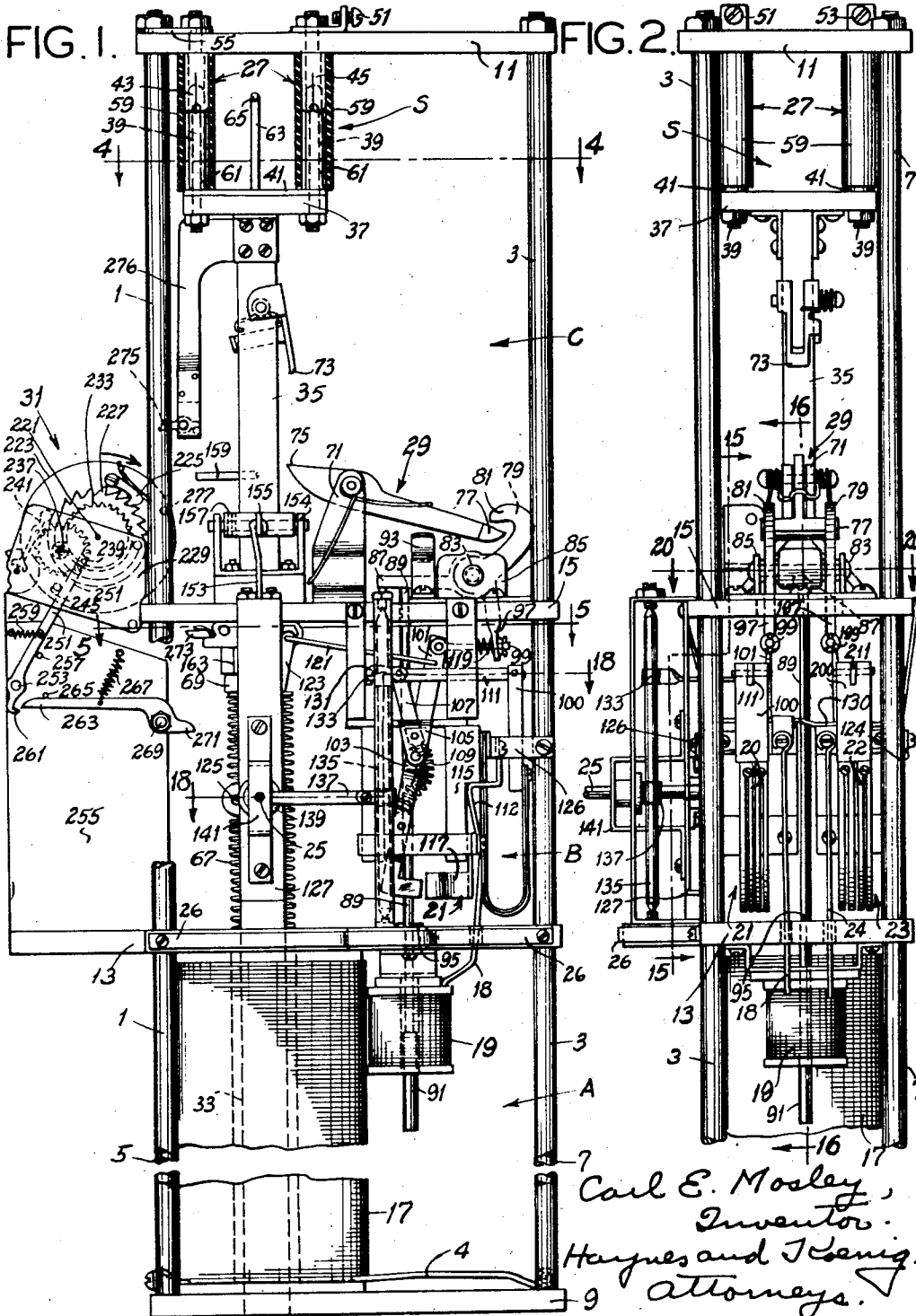
C. E. MOSLEY

2,448,615

SWITCH

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FIG. 3.

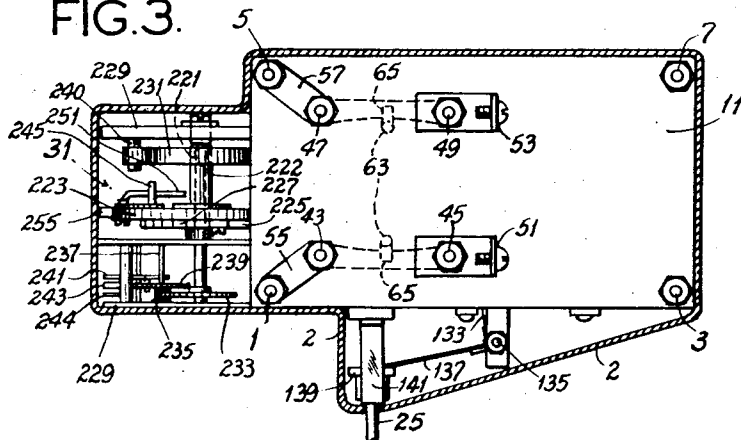


FIG. 26.

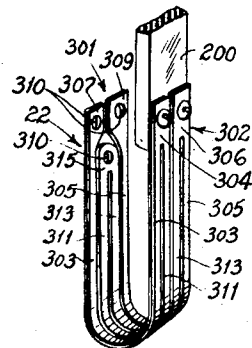


FIG. 4.

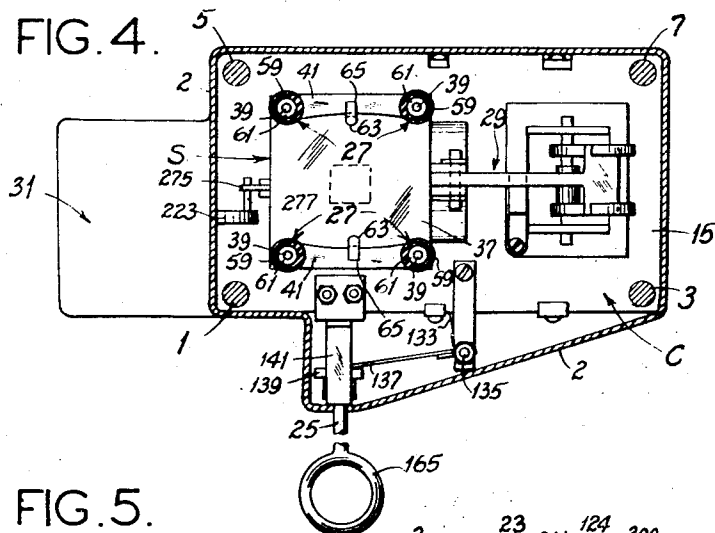


FIG. 27.

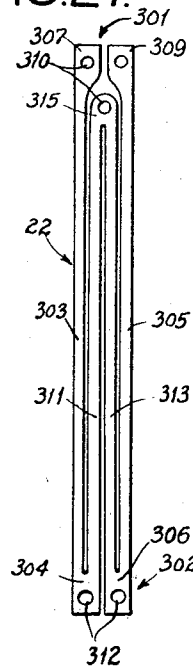
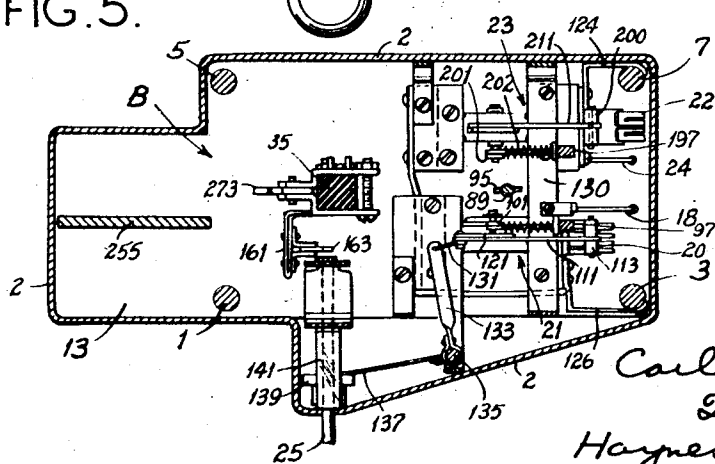


FIG. 5.



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FIG. 6.

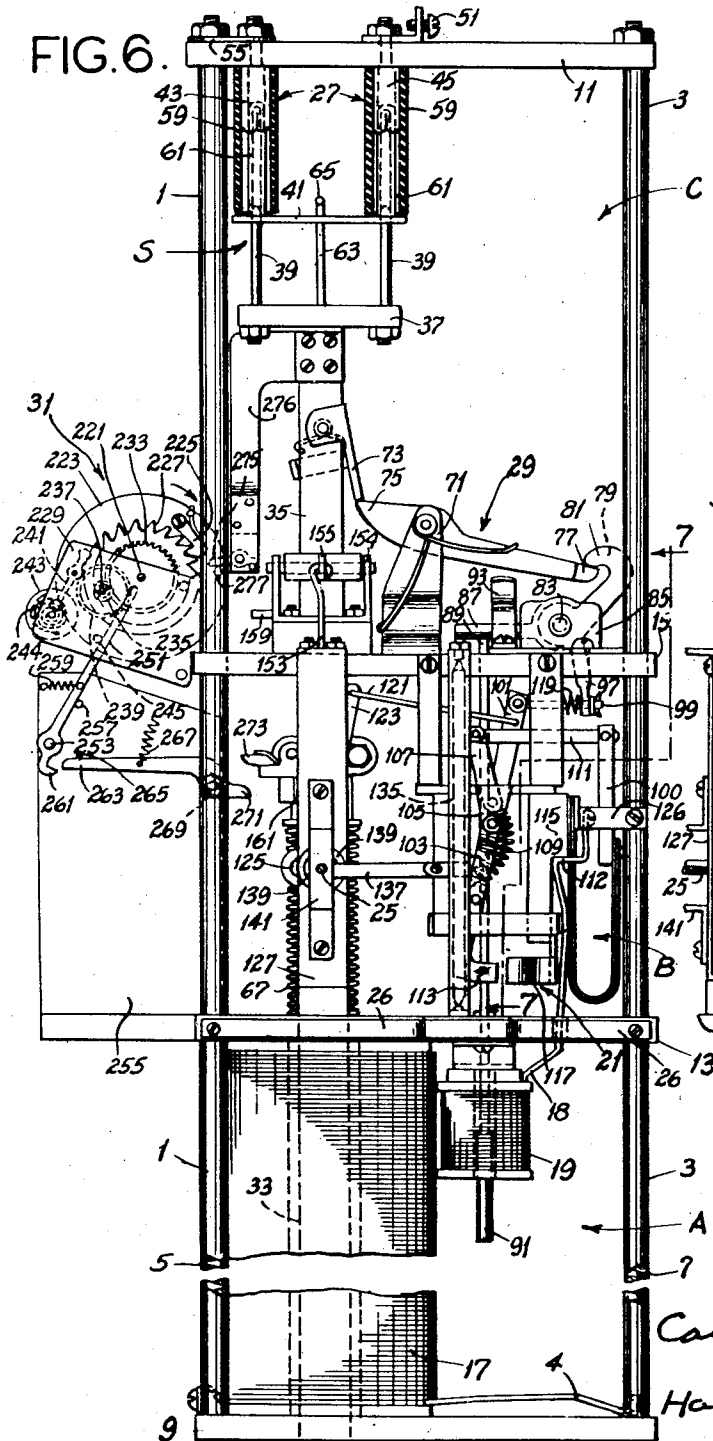
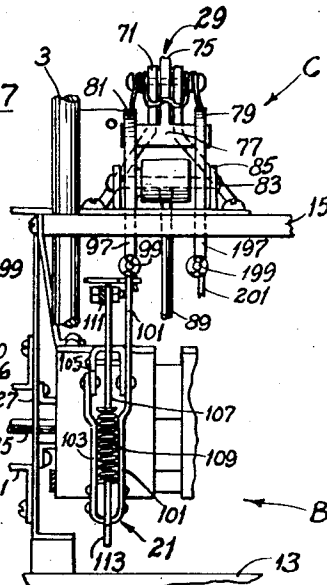


FIG. 7.



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FIG. 11.

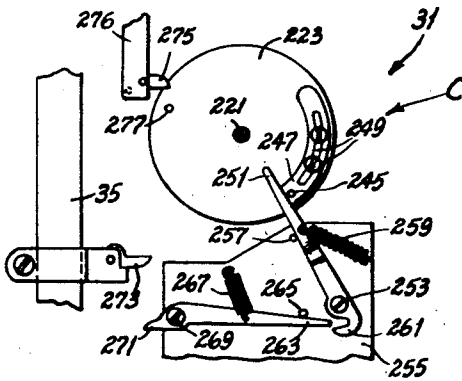


FIG. 13.

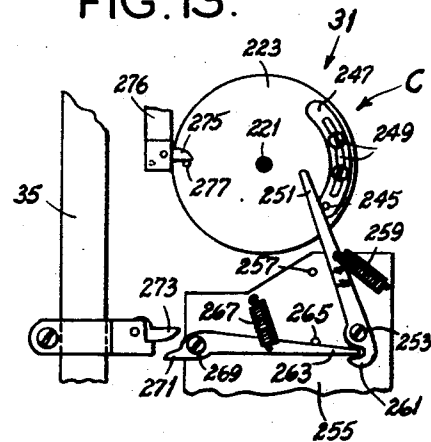


FIG. 14.

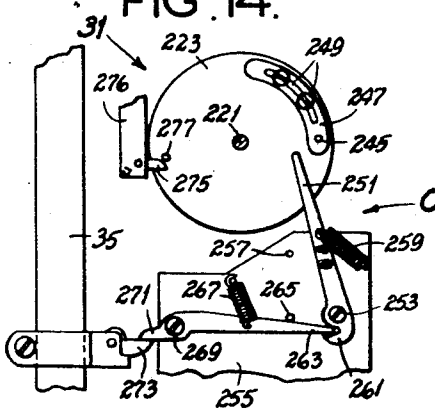


FIG. 20.

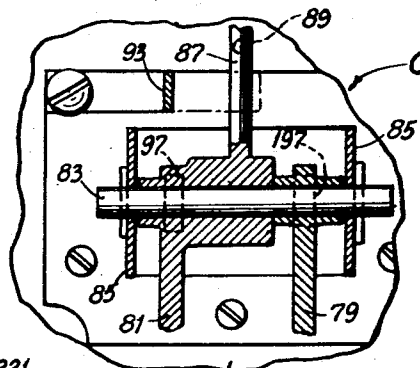
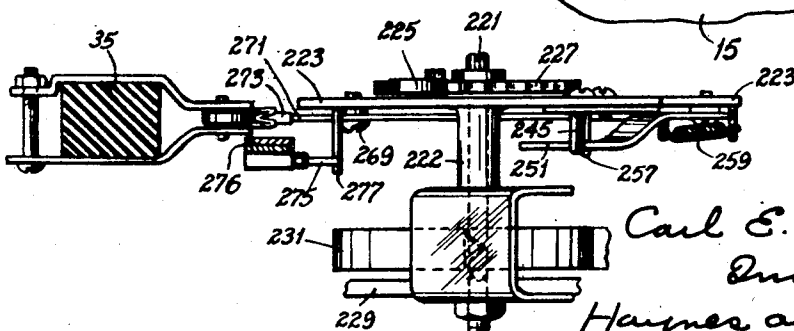


FIG. 12.



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FIG. 16.

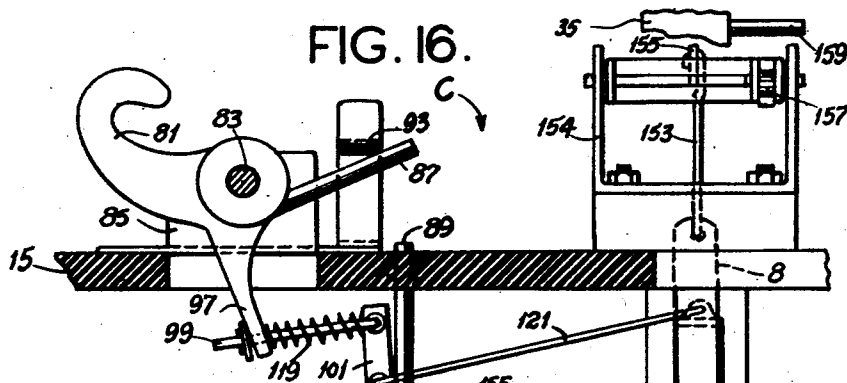


FIG. 17.

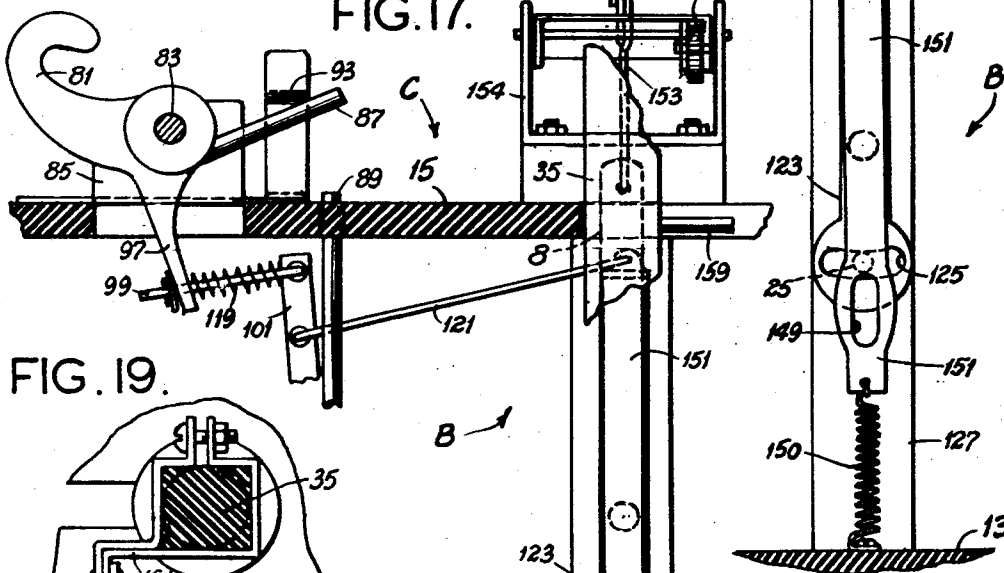
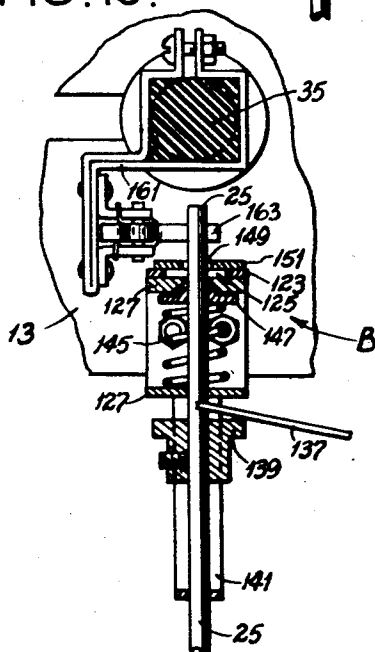


FIG. 19.



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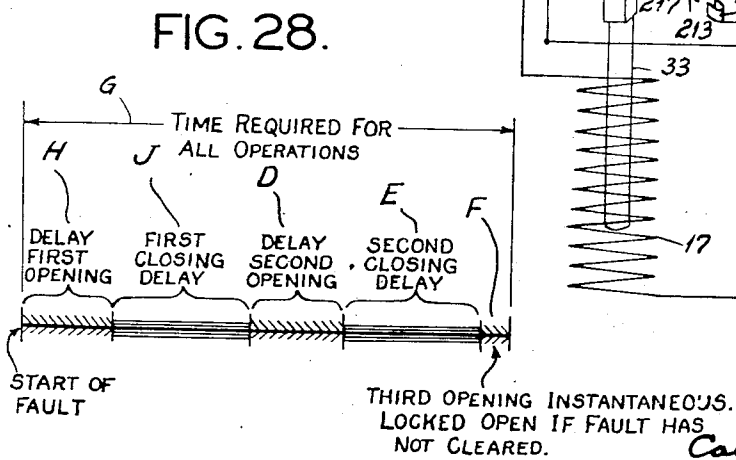
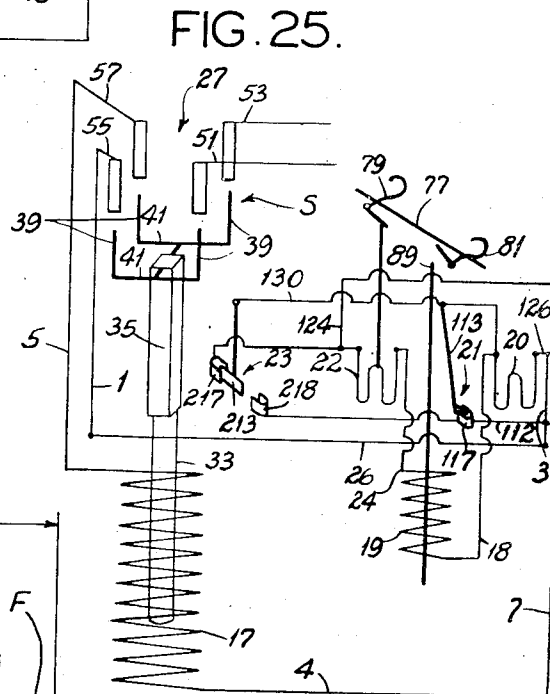
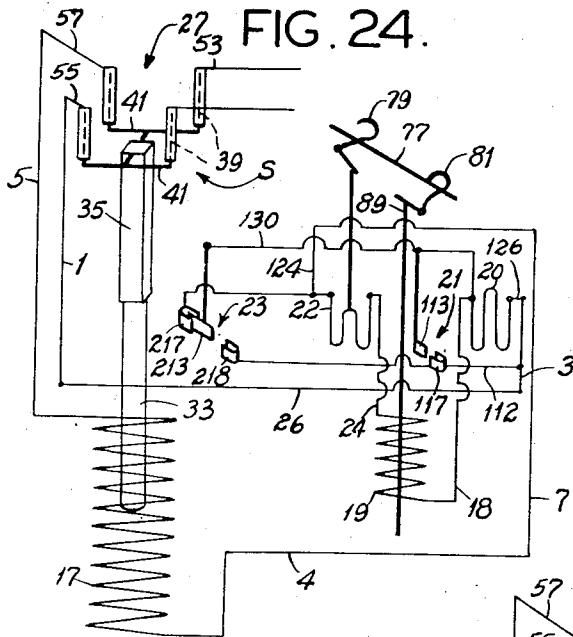
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SWITCH

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UNITED STATES PATENT OFFICE

2,448,615

SWITCH

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Application February 27, 1946, Serial No. 650,675

14 Claims. (Cl. 200—89)

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This invention relates to disconnecting switches, and more particularly to a reclosing repeater switch of that type.

Among the various objects of the invention may be noted the provision of a reclosing switch for power lines and the like which will open a line with time-current relationships corresponding closely with the time-current relationships of fuses customarily used in such lines; the provision of a switch of the class described which will repeatedly open and reclose a circuit a predetermined number of times, and then ultimately lock open; and the provision of an inexpensive multi-opening switch of this class which, without constant attention, is reliable under a wide range of operating conditions, being constructed without dashpots or similar usually unreliable time-delay means. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated,

Fig. 1 is a front elevation of my improved switch in normal closed position with its protective cover removed, parts being shown in section;

Fig. 2 is a right-side elevation of Fig. 1;

Fig. 3 is a top plan view of Fig. 1 and showing a surrounding cover;

Figs. 4 and 5 are horizontal sections taken respectively on lines 4—4 and 5—5 of Fig. 1 but showing said cover;

Fig. 6 is a view similar to Fig. 1 showing the parts in an intermediate stage of a switch-opening action;

Fig. 7 is a fragmentary vertical section taken on line 7—7 of Fig. 6;

Fig. 8 is a view similar to Fig. 1 and Fig. 6, showing the parts in a switch-open position;

Fig. 9 is a fragmentary rear elevation of parts of the device when in the Fig. 8, switch-open condition;

Fig. 10 is a modified form of over-center toggle switch;

Fig. 11 is a partial rear elevation of a time-delay mechanism shown in the Fig. 1 position;

Fig. 12 is a plan view of Fig. 11;

Fig. 13 is a view similar to Fig. 11 but showing the mechanism shown in the Fig. 6 position;

Fig. 14 is a view similar to Figs. 11 and 13 but illustrating a switch-closing, delaying action;

Fig. 15 is an enlarged vertical section taken on

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line 15—15 of Fig. 2, showing certain interlock parts in the positions of Figs. 1 and 2;

Fig. 16 is an enlarged fragmentary vertical section taken on line 16—16 of Fig. 2, the interlock parts being shown in a first moved position;

Fig. 17 is a view similar to Fig. 16, the interlock parts being shown in position to lock the switch open;

Fig. 18 is a horizontal section on line 18—18 of Figs. 1 and 15 and shows a recloser pin in normal position;

Fig. 19 is a view similar to Fig. 18 but shows the recloser pin holding the switch open;

Fig. 20 is a horizontal section taken on line 20—20 of Fig. 2;

Fig. 21 is a circuit diagram showing a normal condition;

Fig. 22 is a circuit diagram showing an initial circuit-opening phase;

Fig. 23 is a circuit diagram showing a final action in said first phase;

Fig. 24 is a circuit diagram showing a time-delayed reclosure action;

Fig. 25 is a circuit diagram showing a second reclosure action;

Fig. 26 is a perspective view of a typical thermostatic element;

Fig. 27 is a developed view of the thermostatic element of Fig. 26; and

Fig. 28 is a chart of the time-delay functions of the switch.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

There is a demand by power companies serving rural areas and the like for an inexpensive, efficient reclosing switch to handle the numerous faults occurring on electric lines in such areas. These lines are difficult to service and considerable time, trouble, and expense has been involved in their maintenance.

One requirement in a switch adapted for the above or similar conditions is repeating operations to restore service after temporary line faults for an indefinite number of times without locking out. A second requirement is a repeating or multi-break operation, for example, two openings and two reclosures with a final opening to clear permanent line faults. A third requirement is a mechanism which will provide a proper coordination of time and current upon opening, and a time-delay action upon reclosing, for each of its cycles. A fourth requirement in such a switch is a final locked-out, open-circuit condition which can easily be reset to closed position by a line-man. A fifth requirement is reliability and safety in operation.

Attempts have been made to control the time-delay action of circuit breakers for use outdoors, by dashpots and the like, but these are unreliable and require constant attention.

Solenoids, which are generally reliable, have also been used but the time-current relationships of the solenoid actions in opening switches have not coordinated satisfactorily with the time-current curves of the customary fuses employed in these power circuits. The present invention provides the proper time-current coordination by using the reliable solenoids, but without the unreliable dashpots.

Spring-controlled escapement mechanisms have been used to delay the reclosing of switches of this class but it has been necessary to wind the mechanisms at intervals. The stated attention is undesirable and has been eliminated in the present invention.

Referring now more particularly to Fig. 1, the switch comprises four corner posts 1, 3 at the front and 5, 7 at the rear. Certain of these posts serve also as electrical conductors, as will appear. The posts are supported at the bottom on an insulating plate 9, and project upwardly to a similar top insulating plate 11. Intermediate the top and bottom plates are two additional insulating guide plates 13 and 15 which, starting at the bottom, divide the switch as a whole into three levels A, B and C.

In the lower level A is located a primary solenoid 17 for opening the contacts of the switch and a secondary solenoid 19 for setting certain latches to be described later. In the intermediate zone B are located two thermostatically controlled over-centering toggle shunt switches referred to generally by the numerals 21 and 23. A reset pin 25 with associated interlocks is also located in this zone. In the upper zone C are the four contacts 27 of the main switches and a delaying lever 29 with associated parts. Located at the left in Fig. 1, outside of the posts 1 and 5, is a spring-actuated escapement mechanism 31.

A magnetic armature 33 of the solenoid 17 has an insulating extension 35 projecting up through the guide plate 15 to a rectangular supporting switch plate or crosshead 37. In the four corners of the plate 37 are bolted switch guide pins 39. Conducting bars 41 electrically connect opposite pairs of sleeves 61 loosely telescoping the pins 39 (see Fig. 4).

When the switch is in its closed position (Fig. 1), the sleeves 61 are in conductive relation to yielding tubular conducting contact sockets 43, 45, 47, 49, conduction being through lost-motion conducting sleeves 61 which frictionally telescope both the sockets 43, 45, 47, 49 and the pins 39. The purpose of the sleeves 61 will appear. The sockets 43, 45, 47, 49 are bolted to the insulating top plate 11. The sockets 45 and 49 have conducting terminals 51 and 53 associated therewith. Sockets 43 and 45 are connected to supporting posts 1 and 5, respectively, by conductors 55 and 57 (Fig. 3). The path of the incoming current from terminal 53 is as follows (see also Fig. 21): Terminal 53, socket 49, a sleeve 61, bar 41, another sleeve 61 on the same bar 41, socket 47, link 57, post 5 and down to and through large solenoid 17 to post 7 via wire 4, then to the thermostatic element 22 of the thermostatic switch 23 (see connection 124), small solenoid 19 (via wire 24), out of solenoid 19 to the thermostatic element 20 of switch 21 (via wire 18), back to post 3, (via connection 126) and then through bus bar 26 to post 1, through the link

55 to socket 43, a sleeve 61, a conducting bar 41, a second sleeve 61 on bar socket 45, and terminal 51.

Lost motion is provided in the opening action at the four contact sockets 43, 45, 47 and 49 by telescoping the sleeves 61 respectively on the pins 39. Pairs of these sleeves 61 are directly connected to the respective conducting bars 41. Each bar 41 acts as a crosshead between the respective members of a pair of sleeves 61 as well as acting as a conductor. When the main crosshead plate 37 is drawn down by the extension 35, the pins 39 will at first slide out from the sleeves 61 which temporarily remain within the sockets 43, 45, 47, 49. This continues until catches 63, fastened on the sides of the plate 37, contact and move the connecting crosshead bars 41 with them (Fig. 6). The upper ends 65 of the catches 63 are turned over to engage the bars 41 after predetermined downward movement of the catches 63. Continued movement of the plate 37 will finally withdraw the sleeves 61 from the sockets, thus opening the switch. The assemblies of sleeves 61 and connecting bars 41 will finally drop by gravity relatively to the pins 39 to the switch-open position as shown in Fig. 8. This occurs after the sleeves 61 have been completely withdrawn from the tubes and provide increased gap openings without the necessity for increased travel of the member 35 in its solenoid. It will be observed that gravity is effective for the purpose only when the switch is upright or nearly so. Clearly, if the switch were to be used in other positions, the final opening movement could be obtained by compression springs located on the respective catches 63 above the bars 41.

When the sleeves 61 are drawn down by action of the solenoid 17 (Fig. 8), the current will be broken at the four sockets 43, 45, 47, 49. The multi-break decreases the arc at any one point. Arc-suppressing insulator tubes 59, attached to each of the sockets and extending therefrom, also help quickly to extinguish any arcs. The tubes may be made, for example, of horn fiber.

The insulated extension 35 and the switch plate 37 are held in a normal elevated position (Fig. 1) by a compression spring 67. The spring surrounds the armature 33 and rests on the plate 13. The upper end of the spring bears against an adjustable collar 69 on the armature 33.

The downward movement of the armature 33 and associated parts is resisted by the delaying lever 29 pivotally mounted in a V-shaped bracket 71. The inner end 75 of the lever is engaged for the purpose by a spring-pressed pawl 73 pivotally mounted on the insulating bar 33. This arrests the downward movement because the outer end 77 of the delay lever 29 is held against rocking movement by two hooks 79 and 81 (see Fig. 6). Arrest occurs after the lost motion (above described) has occurred but before the sleeves 61 are drawn into open-circuit positions.

The hook 81 is controlled either by a thermostatic operating element 20 of a single-throw switch 21 or by the small solenoid 19. The hook 79 is controlled by a thermostatic operating element 22 of a double-throw switch 23. The linkage for the hook 81 is as follows (see Figs. 1 and 20): A pivot pin 83 is supported in a U-shaped bracket 85 mounted on the plate 15. This carries the two rotary hooks 79, 81. Integral with the hook 81 is a horizontal lever 87 which extends from the hub of the hook to a point over a lift rod 89. The latter is connected to the armature 91 of the small solenoid 19. The lift rod

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88 extends upward from the solenoid through the zone B and is guided in the plate 15 directly beneath the lever 87. A cotter pin 95 through rod 88 directly above plate 15 limits descent of rod 88. When the solenoid 19 is energized the armature and lift rod will be moved upward, raising the lever 87 and moving the hook around its pivot to an unlatched position from over the end 77 of the delaying lever (see Figs. 8, 22 and 23). A stop bracket 93 is positioned on the plate 15 to limit the upward movement of the lever 87 and hence limits rotary movement of the hook 81. Gravity returns the armature 91 and lift rod 88 when solenoid 19 is deenergized. The stop pin 95 then comes to rest on the plate 13.

The second depending lever 97 on the hook 81 reaches down into the zone B where it has a lost-motion connection (Figs. 1 and 7) with a horizontally disposed link 99 pivotally connected to the upper part of the leg 101 of the over-centering or toggle switch 21. The leg 101 extends downward and has a spaced return portion 103. The leg 101, at about its middle portion, is pivoted to a bracket 105 and the upper end of the return portion 103 is also pivoted to this bracket coaxially with the first pivot. Mounted between the legs 101 and 103 is a lever 107 providing a movable seat for the upper end of a compression spring 109. The lever 107 is pivoted to the bracket 105 at a point above the axis of the pivots for the legs 101, 103 (see Figs. 6 and 7). A link 111 pivotally connects the lever 107 with an insulated extension 100 from the free end of the U-shaped bimetallic thermostatic element 20. The other end of the thermostatic element 20 is fixed on an insulating block 115 supported from the corner posts 3 and 7.

The lower end of the compression spring 109 bears against a switch blade 113 held between the legs 101 and 103 by rivets or the like. When the thermostatic element 20 is heated, the upper free end will move to the right (Figs. 1 and 6), drawing to the right the connecting link 111 and the upper end of the lever 107. The lower end of the pivoted lever 107 and the spring bearing upon it will be moved to the left, shifting the upper spring bearing from the right side to the left side of the pivot axis for legs 101, 103. The compression of the spring 109 with a snap action shifts to the right, and into the switch contacts 117, the legs 101, 103 and switch blade 113. This closes the shunt switch 21. The upper end of the leg 101 will be moved to the left, which will rotate the hook 81 to an unlatched position clear of the end of the delaying lever 29. Thus, either the action of the solenoid 19 or heating of the element 20 moves the hook 81 from its latched to its unlatched position. During the lift of the lift rod 88, the light spring 119 allows for the lost motion between lever 97 and link 99. Thus the solenoid 19 may cause retraction to the right of hook 81, without closure of switch 21, spring 119 being ineffective when compressed to operate the switch 21 against the toggle spring 109. When the lift rod 88 descends, the spring 119 re-expands to take up the lost motion.

Also, pivotally connected to the upper end of the lever 101 is a link 121 controlling a semaphore arm 123, the lower end of which is slotted at 125 to receive an interlock pin 25. The semaphore arm 123 is pivoted to a bracket 127 mounted between the plates 13 and 15 (see Figs. 15, 16, 17, 19).

Whenever the over-centering toggle shunt switch 21 is closed (thermostatic element heated),

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the link 121 will be moved by the leg 101 to the left from its Fig. 15 position to its Fig. 16 position. This swings the upper end of the semaphore arm 123 to the left, moving the slot 125 to the right and into position to receive the interlock pin 25. The action of solenoid 19 and push rod 88 does not effect movement of the semaphore arm 123 because of the stated lost motion between parts 97 and 99.

A link 131 is fastened at its one end to the lever 107 and at its other end to a horizontal arm 133 extending from a vertical pivoted post 135 (Figs. 5 and 18). A second horizontal arm 137 extends from the pivoted post and bears against a collar 139 on the interlock pin 25. The interlock pin 25 is slidably supported in the bracket 127, its outer end being guided in an extension 141 of said bracket. It is within this extension bracket that the collar 139 is confined. The inner end of the pin 25 extends through a keeper plate 128 also fastened to the bracket 127. A hole 143 in the keeper plate 128 is beveled on the side toward the pin 25 for easy entrance. Between the keeper plate 128 and the bracket 127 a spring 145 is mounted around the pin 25 and at one end bears against the bracket 127 and at its other end acts against a collar 147 on the pin 25. This biases the pin 25 toward the hole 143, but the bias is resisted by the bell crank arm 137 bearing against the collar 139. When the pivoted post 135 is moved by the link 131 and bell crank arm 133, the pressure from arm 137 is relieved on the collar 139 and the pin 25 will pass through the keeper hole 143 and into the slot 125.

To perform the interlock functions intended, the pin 25 must also move into and through a second slot 149 in an additional slide arm 151 adjacent to the semaphore arm 123. The slide arm 151 differs from the arm 123 in that 151 is not pivotally mounted but slides vertically up and down, and also in the fact that slot 149 is in a vertical direction while that of the slot 125 is lateral, the radius of the slot 125 being struck from the pivotal center upon which the arm 123 is swung (see Figs. 15, 16, 17). The slide arm 151 is normally held down by a tension spring 150.

This slide arm 151 is supported in a lower bearing 3 attached to the bracket 127 (Fig. 18) and extends upward into the level A where it has a bearing 3 in the plate 15 (Fig. 16). A drag link 153 connects the top of the arm 151 with a rocker 155 pivoted in a bracket 154 fastened to the plate 15. On the other side of its pivot the rocker carries a spring-pressed pawl 157 positioned to be contacted by a pin 159 (Fig. 16) secured in the side of the insulated extension 35. This occurs when this extension moves down during initial opening movement of the main contacts 43, 45, 47, 49, as above described. Thus at the proper moment in the downward travel of the extension 35, provided the curved slot 125 has been moved so that the pin 25 may pass thereinto, the straight slot 149 will also be placed so that the pin may pass through it. However, lack of registry of either slot with the pin 25 locks out the latter, even though it is cleared by arm 137. Mounted on a bracket 161 encircling the insulated extension 35 is a spring-pressed pawl 163 (Fig. 19). When the extension 35 moves downward during each switch-opening cycle, the pawl 163 will pass by and below the plane of the interlock pin 25. In accordance with certain other events to be described later in the complete cycle of operations, if the interlock pin 25 has

not progressed through the three interlock elements, that is, the keeper 128, semaphore arm 123 and the vertical arm 149, the pin 25 will not be in the path of the pawl 163 and the latter may move down and up again without interference. But should the interlock pin 25 have passed through the three stated elements, it will protrude out into the path of the pawl 163 and the pawl will pass it during downward movement but will be arrested in upward movement. This will hold down the extension bar 35 and prevent the switch from reclosing at the sleeves 61 and four contact socket 43, 45, 47, 49. In other words, the switch will be locked out permanently until reset.

The above condition is a final one after a cycle of operations and requires manual reclosure by a lineman or other attendant. The reclosing is accomplished by applying a hook to a ring 165 provided on the outer end of the interlock pin 25. When this ring and interlock pin 25 are pulled out, the inner operating end of the pin 25 is withdrawn from the three interlocked elements 128, 123, 149, and from above the pawl 163. The spring 67 about the armature 33 will then return the associated parts to the switch-closed position.

The linkage associated with the hook 79 is generally similar to the hook 81, but hook 79 is not operated by rod 89 from the solenoid 16. Referring to Fig. 9 in particular, a lever 197 depends from the pivoted hook 79, similar to the lever 97. The lower end of lever 197 has a lost-motion connection with a link 199, around which is a spring 202 similar to spring 119. Link 199 is pivoted to the upper end of a leg 201 of an over-centering toggle switch 23. The leg 201 extends downwardly and has a spaced return portion 203. It is pivoted to a bracket 205. The upper end of the return portion 203 is also pivoted to this bracket 205 coaxially with the first pivot for leg 201. Mounted between the leg 201 and leg 203 is a lever 207 providing a movable seat on its inner end for a compression spring 209. The lever 207 is pivoted to the bracket 205 at a point above the axis of the pivot for the legs 201, 203. At its upper end a link 211 connects 207 with an insulated extension 200 from the free end of a second U-shaped bimetallic thermostatic element 22. The other end of this thermostatic element is fixed on an insulating block 215 supported from the corner posts 3 and 7. The lower end of the compression spring 209 bears against a switch blade 213 held between the legs 201 and 203 by rivets or the like. This switch 23 is a double-throw switch. This type of switch is used to transfer the current flowing initially through the thermostatic element 22, solenoid 19 and switch 23 (see Fig. 21 illustrating a normal circuit), to a shunt circuit wherein the thermostatic element 22 and solenoid 19 are by-passed (see Fig. 23), after a first fault has occurred. After this, only the thermostatic element 20 is in the circuit, due to a reversal of the position of switch 23. In Fig. 9, the switch 23 is shown in its moved position (thermostat 22 heated).

When the thermostatic element 22 is heated, the upper free end will move to the left (Fig. 9), drawing the connecting rod 211 and the lever 207 to the left. The lower end of the pivoted lever 207 and the spring end bearing upon it will be moved to the right, shifting the upper spring bearing from the left side of the pivot axis to the right side. Then through the compressive action of the spring 209, the legs 201 and 203 and switch blade 213 are shifted to the left with a

snap action. This transfers blade 213 from the one switch contact clip 218 to the other contact clip 217. Only the thermostatic element 22 controls hook 79 and consequently the reversing switch 23.

In Fig. 10 is shown a modified form of switch applicable to either switch 21 or 23. Instead of a metallic knife blade, the lower end of the compression spring 109 or 209 may bear on a metal element 212 riveted or otherwise held between the legs 201, 205. Encircling clips 214, bent from the element 212, tightly hold a glass capsule 216 containing a small quantity of mercury. Double leads 288 and 290 are fused into opposite ends of the capsule 216 so that various connections may be accomplished by using the four leads 288 or 290 when the capsule is tilted one way or the other. This mercury type switch has the advantage of certain non-arcing properties over other type switches and could be used equally well in the present invention.

The mechanical time-delay mechanism or escapement which is used for delaying the reclosing of the switch after each opening (except the third and last opening) will now be described (Figs. 1, 3, 6 and 8). This mechanism is referred to generally by numeral 31. It consists of a main shaft 221 on which is a relatively rotary actuator wheel 223 (see Figs. 1, 6, 11, 12, 13, 14). The wheel 223 carries on one side a spring-pressed pawl 225 engageable with a ratchet wheel 227 attached to the shaft 221. The shaft 221 is supported in front and rear frame pieces 229, the frame being in turn supported from the insulated plate 15. At one end the shaft 221 is encircled by a steel clock spring 231, the inner coil of the spring being fastened to a hub 222 of the wheel 223 while the outer end is anchored to a post 240 on the frame 229. Movement of the actuator wheel in a clockwise manner (see arrow, Figs. 1-6) is unretarded by the pawl 225 which moves over the ratchet teeth but does wind the spring 231. When the actuator wheel is allowed to move anti-clockwise, the spring will drive it and, through action of pawl 225, drive the ratchet wheel 227.

Fastened to the shaft 221 is a drive gear 233 meshing with a pinion 235 on a countershaft 237. Integral with this pinion is an escapement wheel 239. This escapement wheel is under control of pivoted escapement arm 241 which in turn is controlled by an oscillating balance wheel 243, the latter being under control of a coil spring 244. Any suitable escapement mechanism may be used at this point. The action is such that a clockwise spring-winding movement of the actuator wheel 223 is followed by a delayed-action return in its counterclockwise movement.

Referring now to the opposite side of the wheel 223 (see Figs. 11, 12, 13 and 14), there is shown an adjustably mounted pin 245. The adjustment is in the form of an arcuate strip 247 upon which the pin is mounted, the strip being held to the wheel 223 by a screw and slot combination 249. The position of the pin 245 may, within limits, be adjusted about the periphery of the wheel. The pin 245 bears against the outer free end of a pivoted trigger lever 251. The pivot is on the frame member 255 at 253. Member 255 is supported from the insulated plate 13. A stop pin 257 limits the lever movement (Fig. 11). Thus, further movement of the wheel 223 is limited by contact of the pin 245 with the lever. This prevents the clock spring 231 from unwinding completely and allows means for tensioning the clock

spring to a degree which will insure instant action of the escapement mechanism whenever the wheel 223 is allowed to return from its winding movement.

The upper end of the lever 251 will, under tension of a spring 259, follow the pin in the winding movement of the wheel 223 (counterclockwise in Figs. 11, 13, and 14). The lower end of the lever is formed as a hook 261. When the pin 245 allows the upper end of the lever 251 to move to the right under influence of the spring 259, the hook 261 engages one end of a pivoted latch 263 (see Figs. 13, 14). The latch 263 is held in position to receive the hook by a stop pin 265 and a spring 267. The latch 263 is pivoted at 269 to the frame member 255 and extends beyond in the form of a nose 271 to be contacted by a spring-pressed pawl 273. Pawl 273 is mounted on the insulated extension 35 of the armature 33. A second spring-pressed pawl 275 is mounted on an out-board bracket 276 extending from the insulated extension 35. This is the escapement winding pawl and it is positioned so as to move the wheel 223 in a winding direction when the pawl is lowered, as when the switch opens at the contact sockets 43, 45, 47, 49. A pin 277 mounted on the wheel 223 is provided for this purpose. As will be seen from Figs. 11, 13, and 14, the pawl 275 contacts the pin 277 to turn the wheel 223. Then as turning of the wheel continues, the pawl 273 will move past the nose 271 of the lever 263. Both of the pawls 273 and 275 are yielding in one direction of movement so that the parts may return to normal positions. This is likewise true of the pawls 73, 157, 163.

A housing 2, shown in section only in Figs. 3, 4 and 5, serves as weather protection. The only exposed parts are the top insulated plate 11 with its line connection screws 51 and 53, and the reset ring 165 extending from the front side of the housing (see Fig. 4).

A complete cycle of operations is as follows:

Referring to Figs. 21-25, wherein S designates the entire switch at the top of member 35, current enters from the supply line through the closed switch S and flows to the solenoid 17 as above described. It then proceeds (Fig. 21) to the thermostatic element 22, thence to the other solenoid 19 and to the thermostatic element 20. It then proceeds through closed switch S to the other side of the supply line.

When an overload occurs, a magnetic field is created in the large solenoid 17. This attracts the armature 33 and moves it downward, overcoming the compression of spring 67. The pins 29 start to withdraw from the sleeves 61, lost motion taking place before switch S is opened. Details of the sleeves 61 and lost-motion mechanism in the switch are not shown in Figs. 21-25 (but see Figs. 1, 6 and 8). The pin 159 will contact the pawl 157 and raise the slide arm 151 so that the slot 149 can admit the pin 25. The pawl 273 will approach the nose 271. Pawl 275 will contact pin 277 and through wheel 223 wind spring 231. Finally, the downward movement of the armature 33 is stopped by contact of pawl 73 with the end 75 of delaying lever 29. This occurs before switch S opens but after some lost motion has occurred therein.

The small solenoid 19 is affected by the current and its magnetic field will tend instantly to lift the armature 91 and through the rod 89 release the hook 81 from over the end 77 of the delaying lever 29 (see Fig. 22). This action of hook 89, however, does not close the switch 21 because of

the lost-motion connection between levers 97 and 99 (see spring 119, Figs. 1 and 6).

Current will continue to flow through the thermostatic element 22, which expands and after some time moves the connecting link 199 (not shown in Figs. 21-25) to reverse the switch 23, and also to move the hook 79 from above the end 77 of the delaying lever 29 (Fig. 23).

The result of the above phase of the first operation is that a time delay is created by the slowly expanding element 22, all preliminarily started switch-opening operations being halted until the hook 79 clears the end 77 of the delaying lever. This time delay is an important feature of the invention since it allows for better coordination between this switch and other fuses in the circuit. Referring to the chart Fig. 28, this time delay or duration is represented by the distance H charted on the total time line G. This duration H is dependent on two factors, (1) the size of the bimetallic element 22 and (2) the magnitude of the fault current. Obviously, no control can be exercised over the magnitude of the fault current. But the thermostatic element 22 is so designed as to have its heating and current-carrying relationship in keeping with that of the fuses in the circuit in which the present device is used. Fuses of different types have different periods of time in which they will heat, and melt to a rupture point. The element 22 in the present invention is designed to expand to an operative degree just before any rupture of the fuses in the circuit. This is what is meant by the coordination already referred to.

Continuing with the operation: When the hook 79 releases the end 77 of the delaying lever, the magnetic field in solenoid 17 continues to pull the armature 33 downward. The now free delaying lever 29 is pivoted about its center by action of the pawl 73. The turned-over upper ends 65 of the catch 63 engage the bars 41 and pull the tubes 61 clear from the sockets 43, 45, 47, 49, which opens the switch S, and hence the circuit.

The pin 159 passes from the pawl 157 and slide arm 151 drops, taking its opening 125 out of the plane of the pin 25. The pawl 273 will pass under the cam nose 271. Pawl 275 will advance the wheel 223, freeing lever 251, allowing spring 259 to pull the lever 251, so that its hook 261 engages and holds the end of lever 263 (see Figs. 14 and 23). The additional advance of the wheel 223 will further wind the spring 231 and finally the wheel 223 will have turned sufficiently to allow pawl 275 to pass the circularly moving pin 277. The downward movement of the armature 33 will finally be arrested by the compression of the spring 67. As the element 22 releases the hook 79, it also reverses the switch 23, the arm of the switch swinging with a snap action from the contact clip 218 to contact clip 217 (see Figs. 21-23).

The flow of line current is now broken. The armature of solenoid 17 cannot immediately return upward by action of spring 67 because the pawl 273 is held beneath the cam nose 271. The latch 263 associated with this cam nose is held against movement by the trigger hook 261 (Figs. 8 and 12). The armature 91 and lift rod 89 descend by gravity, allowing the hook 81 to return to a holding position above the end 77 of the delaying lever. This action is made positive by the spring 119 about the connecting link 99.

There now occurs a predetermined time delay imposed by the running down of the escapement mechanism 31 (Fig. 14). This time delay allows for the fault to clear itself from the line if this

is in the nature of events to happen. This is represented in the chart (Fig. 28) by the segment J.

As the wheel 223 returns (clockwise in Fig. 14) the pin 245, after a time, again contacts the trigger lever 251 and moves the hook 261 to the right, releasing the end of latch lever 263. The main spring 61 of solenoid 17 being stronger than that of spring 267, the pawl 273 will raise the cam nose 271 and pass it. The pawl 275 will, during upward movement, pass the pin 277. The pin 169 will pass the yielding pawl 157. The pawl 73 springs past the delaying lever nose 75 and the pins 39 will drive the tubes 61 back into the sockets 43, 45, 47, 49 thereby reclosing the switch for a second cycle. All parts have now returned to their starting positions with the exception of the thermostatic element 22 which controls the switch 23 and hook 79. Some time is necessarily required for this thermostatic element 22 to cool. This time is preferably of a greater duration than the reclosing time relay introduced by the escapement mechanism. This results in holding the hook 79 clear of the delaying lever 77 and holding the reversed position of the switch 23. Thus after the main switch has reclosed, the parts are in the position at the start of a second opening as shown in Fig. 24, wherein hook 81 has returned to a holding position, but not hook 79.

If the excessive current is still flowing after the above operations (fault not cleared during the first opening operation) the switch will perform a second series of operations as follows:

The current still enters as described before, but now the switch 23 is in reversed position (see Fig. 24) and the cooling thermostat 22 and solenoid 19 are shunted out of the circuit. The current now travels from bar 124 and contact 217 through the switch arm 201 and blade 213 via cross connection 128 to the stationary end of thermostatic element 20, then out of the element 20 to post 3 via connection 126 and thence as described before, leaving at the terminal 51.

The armature 33 will again be pulled down by energization of the large solenoid 17 and the same mechanical functions of the various parts attached to it will again take place, until the armature is stopped by the delaying lever 29. It is to be remembered that the delaying lever is now locked against movement only by the hook 81, the hook 79 still being held open by the slowly cooling element 22.

There is now a second time delay (note D in Fig. 28) imposed by the heating of the element 20 which should be of approximately the same delay as that imposed by element 22 (compare spaces H and D on chart, Fig. 28). This is another feature of the invention.

When the thermostat 20 has expanded sufficiently to release hook 81 from the delaying lever 29, the armature will continue downward as before and the switch S will again open. The lever 111 attached to insulated extension 113 of the thermostatic element 20 closes the switch 21 and, through levers 133 and 137 connected to the lever 111, releases the pressure on the collar 139 on interlock pin 25. After the pin 159 has temporarily raised and lowered the slide arm 151, the slot 149 will not be in the plane of the pin 25 and no interlock will take place at this time (Fig. 16). But the pin 25 may enter the slot 125 in the semaphore arm 123 which has been moved into receptive position through action of the connecting link 121 attached to the switch arm 101. The pin 25 has now entered the semaphore arm 123 and is ready to enter and interlock with slot 149

on the next and final operation (Figs. 17 and 19).

The pawl 273 will again spring past and under the cam nose 271 and be caught thereunder. The wheel 223 has been turned as before to wind the spring and release the lever 251 which holds the cam nose in position while the escapement allows the wheel 223 slowly to return. It may be noted here that the spring actuating the escapement is wound by the downward movement of the armature 33. No additional attention such as winding or adjusting is needed, once the circuit breaker is properly placed in the circuit.

The switch is now open on its second cycle (Fig. 25) and will be held open while the escapement is delaying the return of the wheel 223. This delay is represented by the distance E in the chart (Fig. 28). The time represented depends on the adjustment of the escapement mechanism 31. It has been determined that about 3 seconds is the proper time for this delay in reclosing. Thus distances J and E both represent 3 seconds.

Thus a second opportunity is presented for the fault or short circuit to clear itself. The main switch recloses as before and the parts will again resume their normal positions with the exception that now the second hook 81 as well as the hook 79 has not returned immediately. The thermostatic element 22 still has not cooled sufficiently and will hold the hook 79 from the delaying lever end 77 and also retain the switch arm 213 in the contact 217. It is to be remembered that this shunts out the element 22 and solenoid 19.

The thermostatic element 20 also requires a like time to cool. While it is contracting it will hold back the hook 81 from the delaying lever 29. The switch 21 will be closed and the linkage from the semaphore arm 123 remains in position to release the interlock pin 25 and allow it to extend through the slot of the semaphore arm ready to enter the slot in the vertical slide arm 151 when that arm again passes the plane of the pin 25. The now closed switch 21 is for the purpose of shunting out the element 20. It will be seen now that if the excessive current still persists upon reclosing of switch S it will be shunted from the coil 19 and element 22 (by switch 23) and from the element 20 (see Fig. 25).

The current now flows through the reclosed main switch as before, the large solenoid 17, and through post 7 and link 124 to contact 217, switch arm 213, link 130 to switch arm 113 and contact 117 which has a connection through conducting bar 112 to the link 126 to post 3. Here it leaves through link bar 26 and out of the switch as before.

Now only the large solenoid 17 is energized and it will pull the armature 33 downward as before, but the entire opening action is instantaneous. The pawl 73 will pass by the free delaying lever 29. The spring 231 will be wound as before but the escapement action 31 has no function in this cycle. The pin 259 will again raise the vertical arm 151 and interlock pin 25 will now pass into the slot (see Figs. 17, 19). The pawl 163 will spring past the protruding interlock pin 25 and be held under it, the main switch S being held open permanently. The escapement runs down to its normal position and releases the hook 261 from holding position so that pawl 273 may return past the cam nose 271 when the circuit breaker is finally reset. This third instantaneous opening of the switch is represented by the short distance F in the chart (Fig. 28).

As is clear, the locking-open action is accom-

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plished by the interlock pin 25 being so placed in the path of the pawl 163 that the armature 33 may not return automatically to reclose the main switch. These parts will remain in this condition until attended to. The element 22 will finally cool and return the hook 79 to position above the delaying lever 29. This action also returns the single-pole double-throw switch arm 213 from contact 218 to contact 217. This again places the small solenoid 19 and element 22 in the circuit.

The element 20 also cools and tends to withdraw switch arm 113 from the contact 117 to its open position but is prevented from doing so by the linkage connected to the interlock pin. It merely stands in a sprung-open position ready to act.

The pressure of the armature spring 67 to return the armature upwardly creates enough friction on the interlock in 25 (see Fig. 19) protruding through the three elements of the interlock, that is, the bracket 127, the semaphore arm 123 and vertical arm 151, to hold the pin in this position against the inherent spring action of the element 20.

After the lineman has cleared the fault he is ready to reclose the switch for another series of operations. For this purpose the pin 25, by means of ring 165, is withdrawn (see Figs. 4 and 18). This allows the armature to return the main switch S to a closed position. It also allows the now cool thermostatic element 20 to spring back, returning the single-pole single-throw switch 21 to its open position. This reconnects the element 20 into the circuit. All the parts are now in the original normal position and the circuit breaker is ready for a subsequent series of operations.

The particular form of each bimetallic electro-thermostatic element 20 and 22 is of importance and is shown in Figs. 26 and 27. These elements are similar in form. The general form is U-shaped, as indicated in Fig. 26, with the anchor end at 301 and the movable end at 302. In Fig. 27 the U-shape has been laid out into a flat development for purposes of description, but it is to be understood that the actual form is as shown in Fig. 26. Each U-shape is composed of two outside strips 303 and 305 which have terminals at 307 and 309, respectively. At their opposite ends 304 and 306, these strips 303 and 305 are conductively connected to inside strips 311 and 313. Near the terminal ends these strips 311 and 313 are connected as shown at 315. This construction provides a looped conductive structure which, when bent into the U-shape of Fig. 26, provides a cross section for flow of current which is substantially less than if the U-shape were made of a solid bimetallic ribbon. Thus the desired electrical heating may be obtained with less current than would be required for the same heating if a solid, wide ribbon were used. The heating characteristics of the thermostatic element are thus adapted to the current for which the switch is to be designed. Smaller or larger cross sections for current flow could be established by employing more or fewer of the loops 303, 305, 311 and 313 for a given width of thermostat.

The multiple loops 303, 305, 311 and 313, when bent into the U-shape of Fig. 26, provide for increased actuating force of the thermostat for a given heating because, from a mechanical viewpoint, several loops are acting in parallel, although from an electrical viewpoint the respective loops are acting in series. Thus by employ-

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ing in a U-shape several loops which are connected in series electrically but arranged in parallel mechanically, a given thermostat may be designed for any reasonable actuating force with any reasonable current-heating characteristic.

It will also be understood that more thermostatic elements, such as 20, 22; over-center toggle switches, such as 23; and solenoids, such as 19 (see Figs. 21, 22, 23, 24 and 25), in combination can be incorporated in the design to change the number and sequences of operations shown in Fig. 28.

It will be understood that each loop 303, 305, 311, 313 is composed of the usual bimetal used for such thermostatic elements. It should be understood that the cross sections of the loops 303, 305, 311, 313 are predetermined so that a normal current flowing through the circuit protected by the apparatus will not move the free ends 303 of the thermostatic element enough to cause them substantially to move any of the apparatus connected with the thermostatic elements. Only overload current is capable of this.

It should be understood that although the terminals 307, 309 are connected in a circuit, as above described, the support 115 therefor is insulating (Fig. 6), as is the support for the point 315. The holes for the supporting screws are shown at 310 in Figs. 26 and 27. Also, the member such as 200, connected at the movable end, is also insulated. The holes at this end for the supporting screws are shown at 312 in Fig. 27.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. In overload disconnecting apparatus, a line switch normally biased toward closing position, a connection in the line and controlled by said switch, said connection including a first main solenoid, a first electro-thermostatic element, a second solenoid and a second thermostatic element, a first shunt switch operated by the first thermostatic element and a second shunt switch operated by the second thermostatic element, said first shunt switch normally shunting the second thermostatic element and being adapted in response to overload heating of the first thermostatic element to connect said second thermostatic element and to shunt the first thermostatic element and the second solenoid, said second shunt switch effecting a normally open shunt around said second thermostatic element and being operative by said second thermostatic element to close said last-named shunt, overload current from the line in said connection being adapted to operate the main solenoid to apply opening force to the line switch, and said thermostatic elements being adapted in response to said overload current more slowly to operate their respective switches, a detent restraining immediate opening of the line switch in response to said force of the main solenoid, and catches temporarily restraining the detent, one of which catches is operative with time delay from the first thermostatic element and the other of which is operative instantly from said second solenoid and with time delay from said second thermostatic element.

2. In overload disconnecting apparatus, a line switch normally biased toward closing position, a connection in the line and controlled by said switch, said connection including a first main solenoid, a first time-delay electro-thermostatic element, a second solenoid and a second time-delay electro-thermostatic element connected in series, a first shunt switch operated by the first thermostatic element and a second shunt switch operated by the second thermostatic element, said first shunt switch normally shunting the second thermostatic element and being adapted in response to overload heating of the first thermostatic element to connect said second thermostatic element and to shunt the first thermostatic element and the second solenoid, said second shunt switch effecting a normally open shunt around said second thermostatic element and being operative by said second thermostatic element to close said last-named shunt, overload current from the line in said connection being adapted to operate the main solenoid to apply opening force to the line switch, and said thermostatic elements being adapted in response to said overload current more slowly to operate their respective switches, a detent restraining immediate opening of the line switch in response to said force of the main solenoid, catches temporarily restraining the detent, one of which catches is operative with time delay from the first thermostatic element and the other of which is operative instantly from said second solenoid and with time delay from said second thermostatic element, a first overload current causing said second solenoid promptly to move its connected catch from the detent and the first thermostatic element thereafter causing its connected latch more slowly to move from said detent, whereby the main solenoid may open the line switch, a time-delay mechanism, a catch controlled by said time-delay mechanism, and a latch associated with said line switch and held by said time-delay catch when the line switch is open until said time-delay mechanism releases said catch to allow time-delayed reclosing of the line switch under its reclosing bias.

3. In overload disconnecting apparatus, a line switch normally biased toward closing position, a connection in the line and controlled by said switch, said connection including a first main solenoid, a first time-delay electro-thermostatic element, a second solenoid, and a second time-delay electro-thermostatic element connected in series, a first shunt switch operated by the first thermostatic element and a second shunt switch operated by the second thermostatic element, said first shunt switch normally shunting the second thermostatic element and being adapted in response to overload heating of the first thermostatic element to connect said second thermostatic element and to shunt the first thermostatic element and the second solenoid, said second shunt switch effecting a normally open shunt around said second thermostatic element and being operative by said second thermostatic element to close said last-named shunt, overload current from the line in said connection being adapted to operate the main solenoid to apply opening force to the line switch, and said thermostatic elements being adapted in response to said overload current more slowly to operate their respective switches, a detent restraining immediate opening of the line switch in response to said force of the main solenoid, catches temporarily restraining the detent, one of which

catches is operative with time delay from the first thermostatic element and the other of which is operative instantly from said second solenoid and with time delay from said second thermostatic element, a first overload current causing said second solenoid promptly to move its connected catch from the detent and the first thermostatic element thereafter causing its connected latch more slowly to move from said detent, whereby the main solenoid may open the line switch, a time-delay mechanism, a catch controlled by said time-delay mechanism, a latch associated with said line switch and held by said time-delay catch when the line switch is open until said time-delay mechanism releases said catch to allow time-delayed reclosing of the line switch under its reclosing bias, and means whereby the time-delay mechanism is energized for time-delay action by the opening action of the line switch each time that said line switch opens.

4. In overload disconnecting apparatus, a line switch normally biased toward closing position, a connection in the line and controlled by said switch, said connection including a first main solenoid, a first time-delay electro-thermostatic element, a second solenoid and a second time-delay electro-thermostatic element connected in series, a first shunt switch operated by the first thermostatic element and a second shunt switch operated by the second thermostatic element, said first shunt switch normally shunting the second thermostatic element and being adapted in response to overload heating of the first thermostatic element to open said shunt and to shunt the first thermostatic element and the second solenoid, said second switch determining a normally open shunt around said second thermostatic element and being operative by said second thermostatic element to close said last-named shunt, overload current from the circuit and in said connection being adapted to operate the main solenoid to apply opening force to the line switch, and said thermostatic elements being adapted in response to said overload current more slowly to operate their respective switches, a detent restraining immediate opening of the line switch in response to the opening force of the main solenoid action, and catches temporarily restraining the detent, one of which catches is operative with time delay from the first thermostatic element and the other of which is instantly operative from said second solenoid and with time delay from said second thermostatic element, a first overload current causing said second solenoid promptly to move its connected latch from the detent and the first thermostatic element thereafter causing its connected latch more slowly to move from said detent, whereby the main solenoid may open the line switch, time-delay mechanism, a catch controlled by said time-delay mechanism, a latch associated with said line switch and held by said time-delay catch when the line switch is open until said time-delay mechanism releases said time-delay catch to effect a first time-delay reclosing of the line switch under its reclosing bias, said second thermostatic element upon a continuing overload current being adapted to withdraw its catch with time delay to allow said main solenoid to reopen the switch for a second time-delayed reclosure.

5. In overload disconnecting apparatus, a line switch normally biased toward closing position, a connection in the line and controlled by said switch, said connection including a first main

solenoid, a first time-delay electro-thermostatic element, a second solenoid and a second time-delay electro-thermostatic element connected in series, a first shunt switch operated by the first thermostatic element and a second shunt switch operated by the second thermostatic element, said first shunt switch normally shunting the second thermostatic element and being adapted in response to overload heating of the first thermostatic element to open said shunt and to shunt the first thermostatic element and the second solenoid, said second switch determining a normally open shunt around said second thermostatic element and being operative by said second thermostatic element to close said last-named shunt, overload current from the circuit and in said connection being adapted to operate the main solenoid to apply opening force to the line switch, and said thermostatic elements being adapted in response to said overload current more slowly to operate their respective switches, a detent restraining immediate opening of the line switch in response to the opening force of the main solenoid action, and catches temporarily restraining the detent, one of which catches is operative with time delay from the first thermostatic element and the other of which is instantly operative from said second solenoid and with time delay from said second thermostatic element, a first overload current causing said second solenoid promptly to move its connected latch from the detent and the first thermostatic element thereafter causing its connected latch more slowly to move from said detent, whereby the main solenoid may open the line switch against its bias, a time-delay mechanism, a catch controlled by said time-delay mechanism, a latch associated with said line switch and held by said time-delay catch when the line switch is open until said time-delay mechanism releases said time-delay catch to effect a first time-delay reclosing of the line switch under its reclosing bias, said second thermostatic element upon a continuing overload current being adapted to withdraw its latch with time delay to allow said main solenoid to reopen the switch for a second time-delay reclosure, a lock-out latch biased toward locked-out position, a connection with said second thermostatic element for holding said second thermostatic element, a lock-out catch movable with the line switch and engageable with said lock-out latch, first and second means responsive to overload action of said second thermostatic element and opening action of the line switch permitting said lock-out latch to move into position to be engaged by said lock-out catch of the line switch finally to hold the latter open permanently.

6. In overload disconnecting apparatus, a line switch normally biased toward closing position, a connection in the line and controlled by said switch, said connection including a first main solenoid, a first time-delay electro-thermostatic element, a second solenoid and a second time-delay electro-thermostatic element connected in series, a first shunt switch operated by the first thermostatic element and a second shunt switch operated by the second thermostatic element, said first shunt switch normally shunting the second thermostatic element and being adapted in response to overload heating of the first thermostatic element to open said shunt and to shunt the first thermostatic element and the second solenoid, said second switch determining a normally open shunt around said second thermostatic ele-

ment and being operative by said second thermostatic element to close said last-named shunt, overload current from the circuit and in said connection being adapted to operate the main solenoid to apply opening force to the line switch, and said thermostatic elements being adapted in response to said overload current more slowly to operate their respective switches, a detent restraining immediate opening of the line switch in response to the opening force of the main solenoid action, and catches temporarily restraining the detent, one of which catches is operative with time delay from the first thermostatic element and the other of which is instantly operative from said second solenoid and with time delay from said second thermostatic element, a first overload current causing said second solenoid promptly to move its connected latch from the detent and the first thermostatic element thereafter causing its connected latch more slowly to move from said detent, whereby the main solenoid may open the line switch against its bias, a time-delay mechanism, a catch controlled by said time-delay mechanism, a latch associated with said line switch and held by said time-delay catch when the line switch is open until said time-delay mechanism releases said time-delay catch to effect a first time-delay reclosing of the line switch under its reclosing bias, said second thermostatic element upon a continuing overload current being adapted to withdraw its latch with time delay to allow said main solenoid to reopen the switch for a second time-delay reclosure, a lock-out latch biased toward locked-out position, a connection with said second thermostatic element for holding said lock-out latch against its bias in normal position of said second thermostatic element, a lock-out catch movable with the line switch and engageable with said lock-out latch, first and second means responsive to overload action of said second thermostatic element and opening action of the line switch permitting said lock-out latch to move into position to be engaged by said lock-out catch of the line switch finally to hold the latter open permanently, while the time-delay mechanism runs down, means for at will manually withdrawing said lock-out latch to permit instantaneous, reclosing of the line switch in the absence of time delay from the time-delay mechanism, and means whereby the time-delay mechanism is rewound upon each opening action of the line switch.

7. In apparatus of the class described, a line switch normally biased toward closed position, a quick-action solenoid for opening said switch, a time-delay mechanism adapted to be wound by the switch upon opening, a release latch controlled to be released by said time-delay mechanism, and a catch movable with the switch and engageable with said latch to hold the switch open until release of said latch by said time-delay mechanism.

8. In apparatus of the class described, a line switch normally biased toward closed position, a quick-action solenoid responsive to overload line current for opening said switch, a detent limiting movement of the switch before it opens, an electro-thermostat responsive to overload line current, a catch for the detent operative by said thermostatic element in response to overload current to release said detent to allow complete opening movement of the switch in response to overload current in said solenoid, a time-delay mechanism adapted to be wound by the switch upon opening, a releasing latch for said switch con-

trolled to be released by said time-delay mechanism, and a catch movable with the switch and engageable with said latch to hold the switch open until release of said latch by said time-delay mechanism.

9. In apparatus of the class described, a line switch normally biased toward closed position, a quick-action solenoid responsive to overload line current for opening said switch, a detent limiting movement of the switch before it opens, an electro-thermostat responsive to overload line current, a catch for the detent operative by said thermostatic element in response to overload current to move from said detent to allow complete opening movement of the switch in response to overload current in said solenoid, a second electro-thermostat, a second catch movable by overload current in the second thermostat to move from each said detent, and switch means controlled by the thermostats determining current flow first to one thermostat exclusively and then to the other.

10. In apparatus of the class described, a line switch normally biased toward closed position, a quick-action solenoid responsive to overload line current for opening said switch, a detent limiting movement of the switch before it opens, an electro-thermostat responsive to overload line current, a catch for the detent operative by said thermostatic element in response to overload current to move from said detent to allow complete opening movement of the switch in response to overload current in said solenoid, a second electro-thermostat, a second catch movable by overload current in the second thermostat to move from said detent, and switch means controlled by the thermostats determining current flow first to one thermostat exclusively and then to the other, a time-delay mechanism adapted to be wound by the switch upon opening, a latch for said line switch controlled to be released by said time-delay mechanism, a catch movable with the switch and engageable with said latch to hold the switch open until release of said latch by said time-delay mechanism.

11. In apparatus of the class described, a line switch normally biased toward closed position, a quick-action solenoid responsive to overload line current for opening said switch, a detent limiting movement of the switch before it opens, a first electro-thermostat responsive to overload current in the line served by the switch, a catch for the detent operative by said first thermostat in response to overload current in the latter to release said detent to allow complete opening movement of the switch in response to overload current in said solenoid, a second electro-thermostat, a second catch responsive to overload current in the second thermostat to release said detent, a second solenoid responsive to current flowing through the first thermostat and adapted to remove said second catch independently of the second thermostat when the first thermostat is operative, and switch means controlled by the thermostats determining current flow first exclusively to the first thermostat and the second solenoid and then to the second thermostat exclusively.

12. In apparatus of the class described, a line switch normally biased to closed position, means responsive to overload current for suddenly applying an opening force to the switch, a detent cooperating with the switch, catches for the detent for holding it to prevent initial switch opening, solenoid means operative in response to overload current for initially clearing one catch from the

detent, a first thermostatic means operative slowly by heating in response to overload current to remove the other catch from the detent to allow a first opening action of the switch, time-delay means permitting reclosing of said switch after an interval, and second thermostatic means operative in connection with said first catch to remove it from said detent independently of operation of said catch by said second solenoid means to allow a second reopening and reclosing of the switch.

13. In apparatus of the class described, a line switch normally biased to closed position, means responsive to overload current for suddenly applying an opening force to the switch, a detent cooperating with the switch, catches for the detent for holding it to prevent initial switch opening, solenoid means operative in response to overload current for initially clearing one catch from the detent, a first thermostatic means operative slowly by heating in response to overload current to remove the other catch from the detent to allow a first opening action of the switch, time-delay means permitting reclosing of said switch after an interval, and second thermostatic means operative in connection with said first catch to remove it from said detent independently of operation of said catch by said second solenoid means to allow a second reopening and reclosing of the switch, and catch means operative upon any third movement of the switch for permanently holding the switch open.

14. In apparatus of the class described a line switch normally biased toward closed position, a solenoid subject to line current adapted to apply force to the switch to open it, a detent normally preventing opening of the switch, a catch normally holding the detent to prevent switch opening, a thermostatic element associated with the catch and responsive to overload line current to move the catch from the detent to permit opening of the switch by the solenoid in response to overload line current in the latter, a lock-out latch biased toward a lock-out position, means connecting said thermostatic element and the latch which in the normal position of the thermostatic element holds said lock-out latch against its bias and in a heated position of said element removes the hold, a movable stop means connected with the thermostatic element and adapted upon heating of the latter to be drawn into position to allow biased movement of the lock-out latch, a second movable stop means normally preventing movement of the lock-out latch to lock-out position, and means cooperating between the switch and said last-named stop means to move it to clear the lock-out latch for biased movement to the lock-out position as the switch moves to its open position.

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