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E. J. STRAMOWSKI
SELECTIVE RECLOSING TIME MECHANISM FOR REPEATING
CIRCUIT INTERRUPTERS

2,852,638

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4 Sheets-Sheet 1

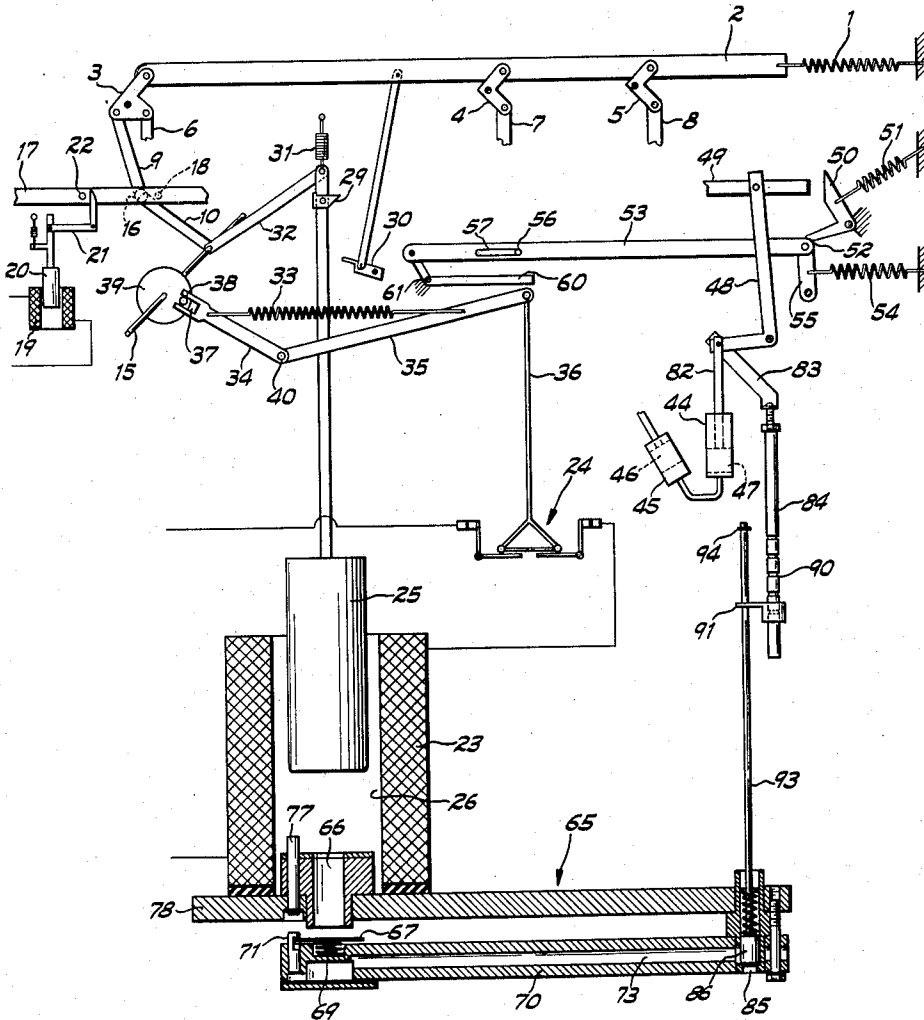


Fig. 1

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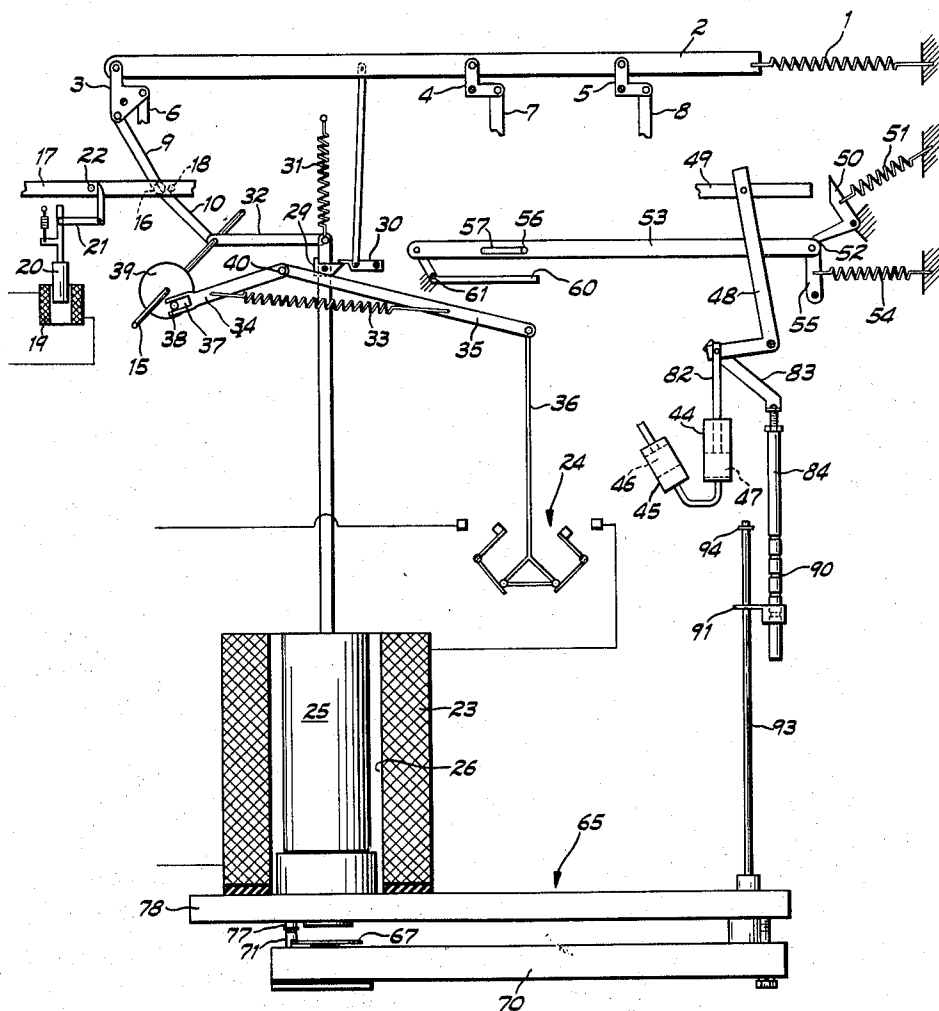


Fig. 2

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4 Sheets-Sheet 3

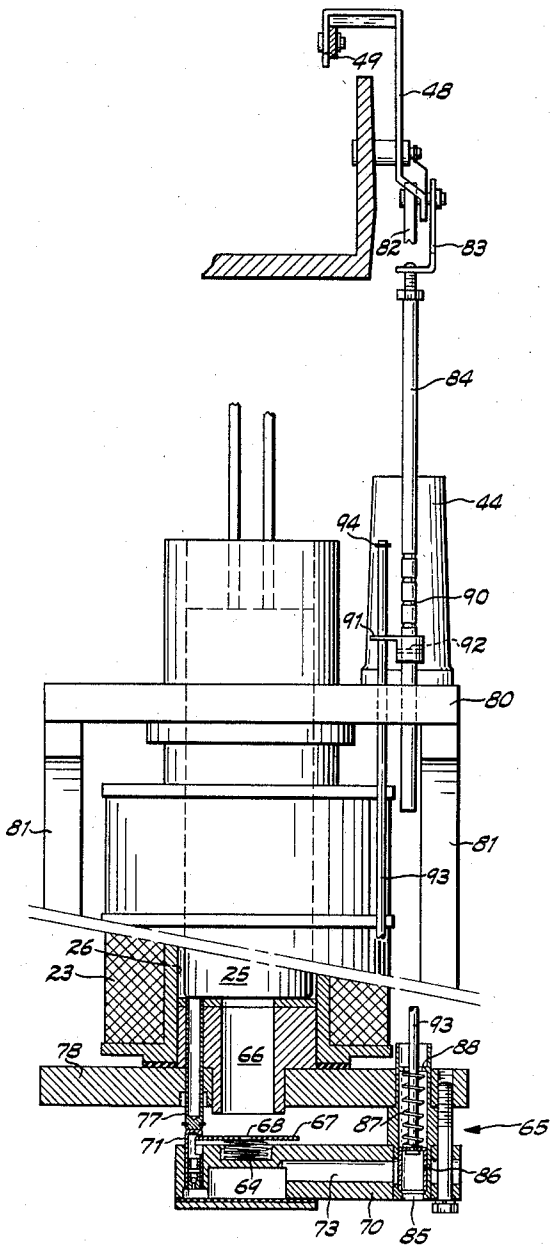


Fig. 3

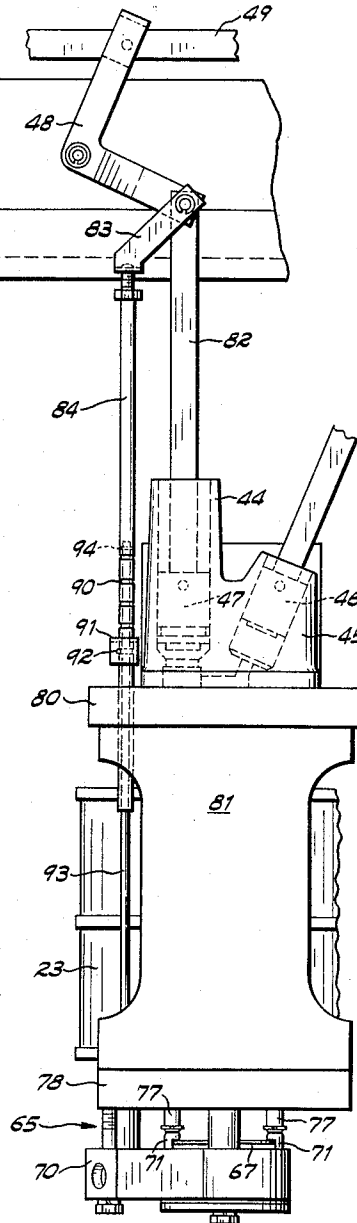


Fig. 4

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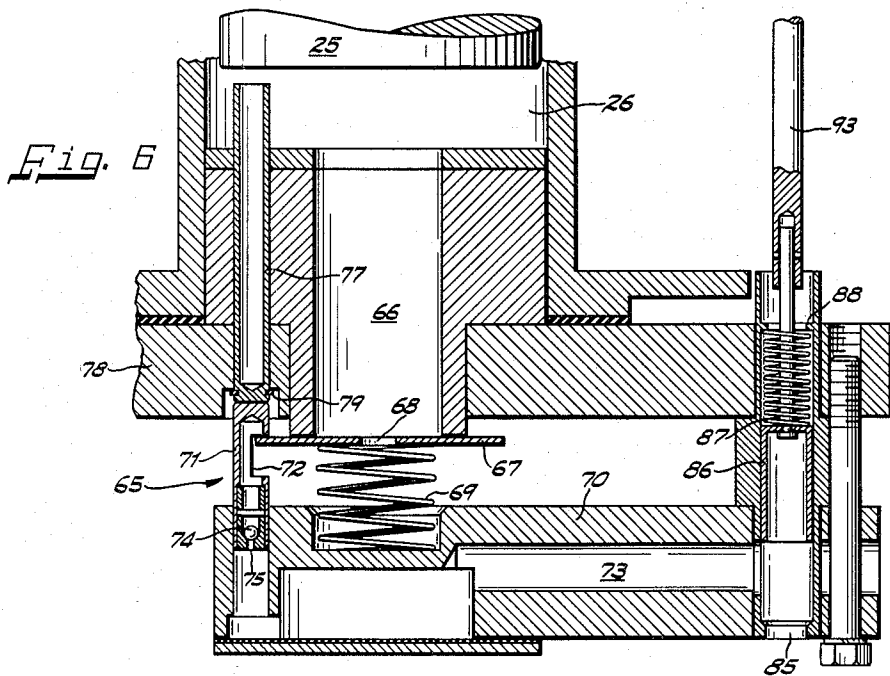
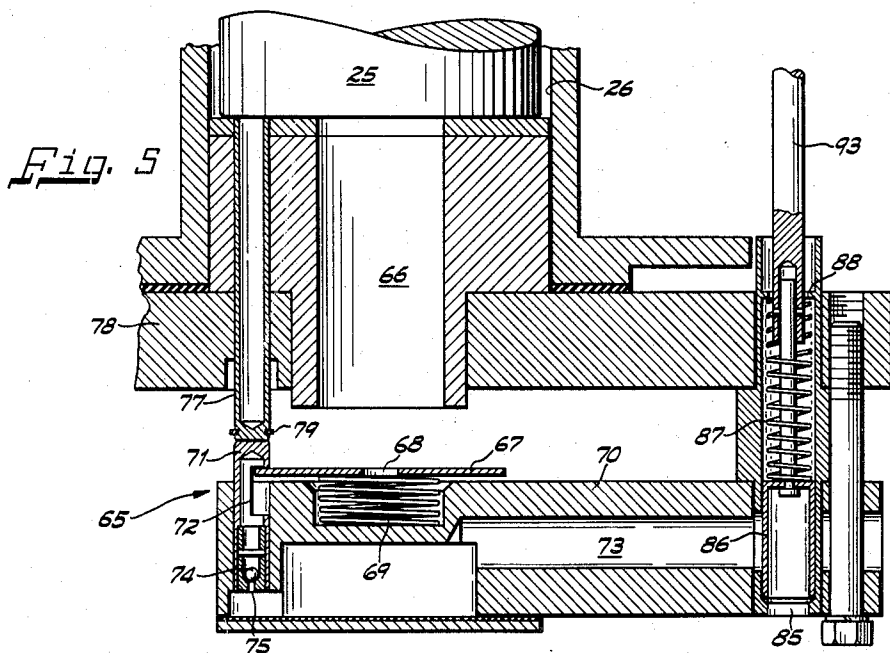
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4 Sheets-Sheet 4



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2,852,638

SELECTIVE RECLOSING TIME MECHANISM FOR REPEATING CIRCUIT INTERRUPTERS

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Application August 17, 1956, Serial No. 604,668

8 Claims. (Cl. 200--39)

This invention relates to improvements in circuit interrupters, and in particular, to that type of interrupter known as a repeating circuit recloser.

A typical, but not exclusive, form of circuit interrupter to which the present invention may be applied is illustrated in the copending application of A. Van Ryan et al., Ser. No. 379,046, filed September 8, 1953, now Patent No. 2,804,521, issued August 27, 1957, and assigned to the assignee of the instant invention.

The cited patent application illustrates in great detail a polyphase circuit interrupter adapted to execute a plurality of quickly successive fast opening operations followed by a series of slow or retarded opening operations. The length of time required for reclosing the circuit interrupter after each opening is substantially constant for all operations and is relegated largely to chance and to inherent design characteristics which impede closing through friction and uncontrolled throttling of hydraulic fluid.

In applying such circuit interrupters to distribution circuits, it is assumed that most faults on the system will be temporary and cleared during the initial fast opening operation. A certain number of faults, however, are more durable and require a longer burning time before clearing, thus accounting for the delayed opening operations. If the interrupter executes its full sequence of fast and retarded operations, indicating that the fault is permanent, the interrupter locks out and permanently de-energizes the line until the fault is repaired and the interrupter is manually reset.

The normal sequence of operations, however, is not acceptable for all installations because it is preferable on many occasions to reclose the interrupter very quickly after it has opened in response to flow of fault current. A need for rapid reclosing is exemplified where there are alternating current motors connected to the system whose line contactors drop out and de-energize the motors for every temporary fault occurring on the lines. Usually, circuit interrupters of the type here under discussion are designed to reclose in approximately two seconds or 120 cycles, a period greatly in excess of that tolerable where dropping of the line contactors is to be avoided.

The problem of having motors stop for every temporary fault such as a single stroke of lightning or the swinging together of adjacent phase wires in a wind storm is particularly annoying in areas where alternating current motors are adapted to drive irrigation pumps which supply a reservoir out of which a syphon system operates to distribute the water to various channels in the field being irrigated. Under the circumstances, the loss of pump pressure not only drops the water level in the reservoir but breaks the vacuum in a multitude of syphons and necessitates restarting all syphons by manual means before irrigation may be resumed.

Consequently, it is a general object of the present invention to overcome the above cited difficulties by providing an improved circuit interrupter which is more versatile in the respect that timing on both its opening

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and closing sequence is more fully controllable by manual discretion.

A further object of this invention is to provide an automatic reclosing circuit interrupter with mechanism which permits preselection of the number of fast interrupter reclosures and which further automatically converts to time controlled retarded or delayed reclosing after a definite number of operations, the mechanism being so designed that it does not interfere with the normal sequence of fast and retarded opening operations of the interrupter.

Other more specific objects will appear periodically throughout the course of the ensuing specification.

In general terms, the invention is characterized by a fluid immersed circuit interrupter having a set of interrupting contacts and power means for opening and closing the contacts instantaneously upon occurrence of an overload. The closing means constitute a magnet coil adapted to attract a central plunger to one position for reclosing the interrupter and to release the plunger to another position upon opening of the interrupter and simultaneously closing an auxiliary switch for re-energizing the magnet coil and repeating the closing operation. The invention contemplates very rapid movement of the plunger in closing the auxiliary switch on the first of a series of operations and later bringing mechanism into effect which retards the plunger and consequently increases the time between opening of the interrupter and reclosing the auxiliary switch for energizing the solenoid coil again.

The exemplary interrupter also includes a hydraulic pump which takes a stroke in accordance with each switch opening and closing operation and delivers a measured quantity of hydraulic fluid to an integrating cumulative piston which advances axially step-by-step in accordance with strokes of the pump. Lockout mechanism is arranged to be actuated by advancement of the integrating piston to an ultimate position, whereupon the lockout means permanently depresses the auxiliary closing solenoid switch and thereby de-energizes the reclosing mechanism.

A more detailed description of a circuit interrupter employing the invention and also of the novel selective reclosing time mechanism itself, will be made in conjunction with the following drawings in which:

Fig. 1 schematically represents the essential elements of one form of circuit interrupter embodying the reclosing time control arrangement constituting the invention, the novel subject matter being shown in this view principally in sectional rear elevation and the interrupter elements corresponding with open circuit position;

Fig. 2 shows the same elements as in Fig. 1, but with the interrupter elements corresponding with closed circuit position;

Fig. 3 is a left side elevational view of the invention with a portion thereof in section and rotated on a vertical axis to avoid an appearance of foreshortening;

Fig. 4 is a front elevational assembly view of the invention;

Fig. 5 is an enlarged sectional view showing elements of the invention as they appear when they are ineffective to retard reclosing of the circuit interrupter; and,

Fig. 6 is similar to Fig. 5, but shows the elements of the invention when they are effective to retard reclosing of the circuit interrupter.

Before proceeding with describing the novel reclosing time control mechanism in detail, the basic components of a typical circuit interrupter to which the invention may be applied will be described in connection with the schematic representation of such components in Figs. 1 and 2. It will be understood that all parts now to be described are arranged to be splashed or immersed in an

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insulating fluid ambient, such as oil, contained within a metal tank, not shown. Attention is invited to the cited figures where it is seen that the circuit interrupter is provided with an extensible main contact opening spring 1 anchored at one end and attached at the other to a rigid power bar 2 on which is carried a plurality of bell cranks 3, 4, and 5. One arm of each bell crank is attached to an insulating link 6, 7, and 8, respectively, which extend down and support the main line circuit interrupting switches, not shown. In Fig. 1, opening spring 1 is contracted and all bell cranks 3, 4 and 5 are rotated in a clockwise direction for forcing the line switch insulating links 6, 7, 8 downwardly and opening the line switches. In Fig. 2, switch opening spring 1 is extended and the bell cranks are rotated counterclockwise whereupon they lift the insulating links and close the main line switches.

When power bar 2 is shifted to the left, as in Fig. 2, in preparation for opening the line switches under the influence of opening spring 1, the power bar is held in that position by a toggle link mechanism represented schematically by a pair of collapsible links 9 and 10, the first of which is attached pivotally to the bell crank 3 and the other is pinned to a rack shaft 15. When opening spring 1 is loaded, the two links 9 and 10 are tenuously latched at their center 16 so as to act as a single rigid member extending from shaft 15 to bell crank 3. The toggle link mechanism is shown in considerable detail in the aforementioned Van Ryan application, so that, for the sake of brevity, it will not be further described herein. It is sufficient to understand, however, that the toggle link mechanism, when latched, acts as a rigid member between shaft 15 and bell crank 3 and when unlatched collapses to permit quick retraction of power bar 2 to the right under the influence of opening spring 1 to thereby open the line switches quickly. The toggle link mechanism is collapsed through control by a trip bar 17 which extends laterally adjacent the hinge latch 16 of the toggle link mechanism. Trip bar 17 is provided with a pin 18 which extends into contact relation with the latch and causes breaking of the latter when the trip bar is shifted from right to left. The trip bar is preferably spring returned.

The trip bar 17 is operated in response to overload current flowing in the lines being controlled by the interrupter. Current response is achieved through the agency of a series coil 19 adapted to attract a magnetic plunger 20 downwardly in the coil whenever an overload current of a predetermined magnitude traverses the latter. Plunger 20 is attached to a bell crank 21 having one arm extending into the path of another lateral pin 22 projecting from trip bar 17. It is evident that counterclockwise rotation of tripping bell crank 21 will strike driven pin 22 and cause the trip bar 17 to move and collapse toggle links 9 and 10 in the manner described hereinbefore, thereby releasing power bar 2 and rotating bell cranks 3, 4, 5 to open the interrupting switches.

Power for resetting the toggle link mechanism and extending opening spring 1 is derived from a large shunt solenoid closing coil 23 supplied through an auxiliary switch generally designated by the reference numeral 24, both of which are connected in series and across a pair of main power lines. When the interrupter is in closed circuit position, it will be noted in Fig. 2 that a large solenoid plunger 25 has come to rest near the bottom of shunt closing coil 23 and that it is latched in downward position through engagement of a pawl 29 by means of a plunger latch finger 30 carried on power bar 2. The arrangement of the components is preferably such that bell cranks 6, 7 and 8 will be rotated from their positions in Fig. 2 to their clockwise positions in Fig. 1, corresponding with full opening of the line switches, before latch finger 30 releases dog 29 to allow retraction of plunger 25 upwardly under the influence of a coil spring 31 which normally biases the plunger upwardly.

In Figs. 1 and 2, plunger 25 is shown as loosely fitting

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in cylinder 26 defined by the interior of coil 23. It will be understood that in the actual construction represented in Figs. 3 through 6 that plunger 25 is fairly tight in the cylinder so that no appreciable leakage can occur longitudinally of the plunger when it reciprocates.

Switch closing force and the force for loading the switch opening spring is derived simultaneously from downward reciprocation of plunger 25 and transmitted to shaft 15 through the medium of a lever 32 fixedly pinned to the shaft. Thus, by comparing Fig. 1, which shows the switch in open position and the opening spring contracted, with Fig. 2, which shows the opening spring extended and the switch closed, it will be seen that rotation of shaft 15 through downward movement of the plunger will rotate bell crank 3 at the far left counterclockwise through the rigidly connected toggle links 9, 10 and stress the opening spring 1 for the next reopening operation. Observe in Fig. 2 that when the main switches are closed, plunger 25 is in its lowermost position within shunt closing coil 23. Further observe in Fig. 1 that immediately after opening of the line switches, plunger 25 is in its uppermost position at which time auxiliary closing switch 24 is in its closed circuit position for re-energizing closing solenoid 23 and again attracting the plunger down, in which position it is normally held by latch finger 30 as described above.

Auxiliary switch 24 is arranged to close the circuit through closing solenoid 23 only after plunger 25 has reached the uppermost point in its stroke as in Fig. 1. Energization is continued during the downward stroke of plunger 25 and is discontinued by opening the auxiliary switch as in Fig. 2 when the plunger reaches the bottom of its stroke. It is therefore evident that closing solenoid 23 is normally de-energized after completion of its power stroke.

It is important to note that plunger 25 remains in its lowermost position until the line switches are fully opened as indicated by the position of bell cranks 3, 4, 5 in Fig. 1, after which plunger 25 is released for upward retraction and closure of auxiliary switch 24. It is therefore abundantly clear that the elapsed time between opening of the interrupter and closing of the auxiliary switch for the purpose of reclosing the interrupter is controlled by governing the rate of ascent of plunger 25. Further details regarding the manner in which the ascent is controlled will be set forth hereinafter.

Attention is now focused on the mechanism for opening and closing auxiliary switch 24 at the proper times, see Figs. 1 and 2. Auxiliary switch 24 is operated by an over-center mechanism comprising a spring 33 stretched between a pair of pivotally joined links 34 and 35. The longest link 35 carries at its free end a rod 36 which actuates the auxiliary switch, and the other link 34 is slotted at its end 37 for engagement with a crank pin 38 carried rigidly by a crank disc 39 affixed to shaft 15.

When the interrupter is executing its series of opening and reclosing operations prior to lockout, auxiliary switch 24 is moved between opened and closed positions with a snap action. This is accomplished by intermittently oscillating the slotted end 37 of link 34 above and below the line of action of spring 33. For example, when the interrupter is closed as in Fig. 2, the auxiliary switch 24 is open and over-center spring 33 is below the pivot point 40 interconnecting links 34 and 35. When the interrupter is open as in Fig. 1, previous rotation of rock shaft 15 has moved slotted link 34 in a clockwise direction until spring 33 has passed over the pivot connection 40 of the two links, whereupon auxiliary switch rod 36 is moved upward rapidly. Since spring 33 drives the auxiliary switch, it is seen that the latter operates independently of the speed of rotation of rock shaft 15.

As implied above, integrating mechanism is also provided for totalling the number of circuit interrupter opening and reclosing operations and for actuating a lockout mechanism which permanently holds auxiliary switch

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24 open to effect lockout of the interrupter. Referring further to Figs. 1 and 2, it will be seen that the interrupter is provided with a hydraulic pump including a cylinder 45 and a reciprocatory piston 46 the latter of which is caused to execute a single stroke each time the interrupter recloses. Means for driving the pump piston 46 by the operating mechanism of the interrupter may take a number of forms within the purview of a skilled artisan so they have been omitted for the sake of brevity and since they do not constitute an essential for understanding the instant invention. A pump driving arrangement may be seen in greater detail in the aforementioned Van Ryan et al. application.

Each stroke of pump piston 46 delivers a measured quantity of oil underneath an integrating piston 47 which moves upwardly step-by-step in a manner obvious upon inspection of Figs. 1 and 2. As the integrating piston 47 moves upwardly in steps it drives an L-shaped lever 48 which is in turn connected to a lockout bar 49. Upward advancement of integrating piston 47 causes a corresponding lateral advancement of lockout bar 49 toward a latch arm 50 biased in a clockwise direction by a tension spring 51. Latch arm 50 presses at 52 against an elongated auxiliary switch control bar 53 in opposition to another stronger tension spring 54. Auxiliary switch control bar 53 is supported on a short pivot lever 55 to which spring 54 is attached and the control bar is further guided by a fixed pin 56 residing in an elongated slot 57. When lockout lever 50 is rotated clockwise upon being struck by lockout bar 49, tension spring 54 retracts being depressed bar 53 to the right. Upon this event an additional depressing lever 60, pivotally attached to the switch depressing bar 53, swings on its fixed pivot 61 in a clockwise direction whereupon it presses on auxiliary switch carrying link 35 and holds the auxiliary switch open permanently. In order to restore electric service through the interrupter after it has been locked out in the manner just described, auxiliary switch control bar 53 must be shifted and returned to its position in Fig. 1 and lockout latch 50 reset as in that figure by manual means, not shown. This permits reclosure of auxiliary switch 24 and accordingly reclosure of the interrupter for repeating its series of opening and closing operations should another fault occur. Also during the lockout period, integrating piston 47 slowly resettles to its lowermost initial position within its cylinder 44 and prepares itself for another full series of counting operations.

The selective reclosing time mechanism constituting the invention will now be described in detail. It was stated above that controlling the rate of ascent of the solenoid plunger 25 is the principal factor involved in controlling the time lapse between tripping and reclosing of the circuit interrupter. For this purpose, the invention features the mechanism designated generally by the reference numeral 65, which can be set for a number of fast reclosing operations and which converts slow or retarded reclosing automatically by means of control derived indirectly from the integrating piston 47. The rate of plunger ascent is governed by automatically controlling an orifice 66 which places the plunger cylinder 26 in communication with the ambient fluid of the circuit interrupter. In Figs. 1-5, it will be seen that for fast reclosing a disc type of throttle valve 67 is restrained away from orifice 66 so that when plunger 25 rises it may draw oil freely through orifice 66 without any retardation of the plunger. In Fig. 6, however, throttle valve 67 has been released for movement to a position where it closes orifice 66 so that when plunger 25 rises its movement is retarded, because fluid can then only be drawn through a small central aperture 68 in the throttle valve disc 67. As is evident from the drawings, when the throttle valve 67 seats to close orifice 66 there is no other significant fluid inlet to cylinder 26 aside from the small aperture 68 in the throttle valve.

Throttle valve 67 is normally biased toward closing orifice 66 by means of a soft compression spring 69 inter-

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posed between the valve disc and a reservoir casting 70. During fast reclosing, throttle disc 67 is restrained away from orifice 66 by means of a tubular auxiliary piston 71 having a long slot 72 in its side, see Figs. 5 and 6, which normally overhangs and engages the throttle valve. Piston 71 is in turn held down in a sense by vacuum which would be created by withdrawal of the piston from a normally totally sealed reservoir chamber 73. It will be noted that slot 72 in auxiliary piston 71 is long enough to permit the full travel of throttle valve 67 from its open position in Fig. 5 to its closed position represented in Fig. 6 when the auxiliary piston is elevated from reservoir 73. Piston 71 is provided with an interior ball check valve 74 whose control direction of oil flow is such that the piston 71 may be plunged easily into reservoir 73 but the piston resists withdrawal by virtue of the ball valve 74 seating. A small hole 75 underneath the ball 74 places the interior of the reservoir 73 and the fluid ambient in the circular interrupter tank in communication through the tubular throttle valve restraining piston 71.

If left unrestrained during the extended period in which the interrupter is normally closed and in which solenoid plunger 25 is in its lowermost position as in Fig. 5, auxiliary piston 71 may tend to yield upwardly due to leakage and permit unwarranted closing of orifice 66 by throttle valve 67. To avoid this, a light weight tubular depressing rod 77 is disposed in free sliding relation within an appropriate hole in the base plate 78. When plunger 25 is down as in Fig. 5, it will be seen that depressing rod 77 is positively urged downwardly by plunger 25 to hold auxiliary piston 71 securely in its lowermost position. Depressing rod 77 is provided with a snap ring 79 which limits the upward travel of the rod 77 when it is drawn up by suction created during ascent of plunger 25.

Each time plunger 25 rises during the rapidly successive series of fast reclosing operations, depressing rod 77 is drawn upwardly as in Fig. 6. Normally however, throttle valve 67 and auxiliary piston 71 cannot yield appreciably from their position in Fig. 5 and whatever yielding might occur during the brief interval of plunger ascent will be compensated when the plunger again returns to its lowermost position and strikes depressing rod 77 so that auxiliary piston 71 is restored to its lowermost position until the latter is fully released intentionally.

Figs. 3 through 6 show an actual embodiment of the invention applied to a circuit interrupter such as that shown in the cited patent application. Referring particularly to Fig. 4, it will be observed that the selective reclosing mechanism 65 is primarily located beneath a magnetic frame which houses the shunt closing coil 23 and consists in lower magnetic base plate 78 and an upper magnetic member 80 connected together by companion parallel vertical magnetic members 81, one of which is visible in Fig. 4. The counting or integrating piston 47 is located above and integral with upper magnetic member 80. Extending from the top of integrating piston 47 is an insulating link 82 which performs the dual purpose of driving lockout bar 49 in steps for each operation of the interrupter and further lifts a link 83 which is connected to a non-metallic selector control rod 84 extending downwardly in parallelism with the insulating link 82. It will appear shortly hereinafter that the position of selector control rod 84 determines when in the sequence of reclosing operations that throttle valve disc 67 will be released for retarding ascent of plunger 25.

Means for breaking the fluid seal of the reservoir 73 and releasing auxiliary piston 71 so that throttle valve 67 may be biased upwardly to close orifice 66 after any selected reclosing operation will now be discussed. In the enlarged sectional view of Fig. 5, it will be seen that the reservoir 73 has a fluid inlet passageway 85 placing the normally closed reservoir and the fluid filled space exterior thereto in communication. During fast reclosing as in Fig. 5, fluid inlet 85 is closed by means of a

control slide valve piston 86 passing transversely across inlet 85. Under these circumstances reservoir 73 is sealed and auxiliary piston 71 is prevented from rising upwardly.

In Fig. 6 it will be observed that control slide valve 86 has been withdrawn so as to open inlet 85 and allow free admission of fluid into reservoir 73. Upon this event, biasing spring 69 forces throttle valve 67 up by virtue of the fact that auxiliary piston 71 is no longer restrained by a tendency for a vacuum to be created within the reservoir. Hence, when plunger 25 has begun its ascent as in Fig. 6, depressing rod 77 will be drawn upward until it strikes snap ring 79 and all of the fluid that can enter cylinder 26 under plunger 25 must be drawn through the small aperture 68 in the center of throttle valve disc 67. The maximum retardation of plunger 25 may be established by varying the size of aperture 68 in the original design.

Directly above control slide valve 86 there is a compression return spring 87 interposed between the top of the slide valve and an annular shoulder 88. By comparing Figs. 5 and 6 it will be seen that spring 87 has a tendency to restore the slide valve to its lowermost or closed position whenever vertically upward force is removed therefrom.

Means for establishing the position of the slide valve and accordingly determining when the retarded closing operations are to take effect will now be described. As explained earlier, each time integrating piston 47 advances upwardly one step, there is a corresponding upward advance of selector control rod 84 equal to the distance between adjacent grooves 90 in the control stem. A pick-up finger 91 is carried by the control rod and the finger may be adjusted and fixed in registry with any one of the plurality of grooves 90 by withdrawing a straight pin 92, sliding the finger to alignment with any of the grooves and replacing the pin. Pick-up finger 91 is perforated for embracing slide valve stem 93. Finger 91 is effective to pick up slide valve stem 93 and open slide valve 86 when the finger abuts a snap ring 94 adjacent the end of the stem 93. Thus it is seen that there is a lost motion connection between the selector rod 84 and valve stem 93, which lost motion is taken up by upward advancement of integrating piston 47. If it is desired that the interrupter reclose unretarded through its entire series of operations, the pick-up finger is located in registry with the lowermost of the annular grooves 90 as demonstrated in Fig. 1. If it is desired that the interrupter go into retarded closing immediately after the first opening operation thereof, finger 91 may be moved as described above to the uppermost of the annular grooves 90 whereupon the first step of integrator piston 47 will cause engagement of the pick-up finger 91 with valve control stem 93 and likewise effect lifting of the slide valve and release of vacuum within the fluid reservoir 73. Delayed reclosing time may be made to take effect at any time during the series of recloser operations prior to lockout by locating pick-up finger 91 in any one of the intermediate annular grooves 90 between the upper and lower limits.

Although the selective reclosing time mechanism constituting the invention has been described in considerable detail in connection with an interrupter wherein the reclosing time is governed by the rate of ascent of a plunger, it will be understood that the invention is broadly applicable to other hydraulic circuit interrupters involving reverse movement of the plunger.

It will be understood that the invention has little effect if any, upon the independent timing of the opening operations of the interrupter. This is so because plunger 25 may descend rapidly and unrestrained for reloading opening spring 1 and closing the main line switches, not shown, regardless of whether the throttle disc valve 67 is in the fast reclosing time position as in Fig. 5, or in the retarded reclosing position of Fig. 6. This is so because

compression spring 69, biasing throttle valve 67, is relatively soft and offers little impedance to discharge of fluid through orifice 66 when plunger 25 is descending.

Use and operation of the selective reclosing time mechanism requires no special skill. It merely involves determining whether the particular power line being protected by the interrupter installation has load connected to it which cannot tolerate loss of power even for the relatively short interval normally required for reclosing an interrupter while clearing temporary faults. If it is decided that rapid reclosures are most desirable for what are almost definitely known to be temporary faults by reason of experience showing that most faults are cleared upon the first or second openings of the interrupter, then rapid reclosing after the first and second openings will be chosen. Hence, when the interrupter is installed, the customer will set pick-up finger 91 in registry with one of the intermediate grooves 90 of control rod 84 so that a lost motion connection will be made with control valve stem 93. All subsequent procedure is then automatic.

If a temporary fault occurs which is cleared on the first opening operations of the interrupter, integrating piston 47 will advance upwardly, but insufficiently to cause pick-up of valve stem 93 so slide valve 86 will maintain fluid inlet 85 closed. Under this condition auxiliary piston 71 cannot rise and throttle valve 67 is ineffective to retard ascent of plunger 25.

If the fault does not clear during the initial opening operations, it is preferable for well known reasons that the interrupter time delay both the opening and reclosing operations. Retarded reclosing is automatically brought into action by the invention when the integrating piston has stepped sufficiently to cause engagement of slide valve stem 93 whereupon the slide valve 86 opens for admitting fluid into reservoir 73. This breaks the vacuum seal on auxiliary piston 71 and allows throttle valve 67 to rise for closing orifice 66, retarding the ascent of plunger 25 and accordingly delaying reclosing time.

If the fault is so permanent that automatic lockout of the interrupter takes place, integrating piston 47 resettles during the lockout period. This permits resettling of slide valve 86 under the influence of its return spring 87 and likewise closing reservoir 73. When the interrupter closing plunger 25 takes its first power stroke after manual resetting of the interrupter, plunger 25 will drive auxiliary piston 71 back into reservoir 73 through the agency of depressing rod 77. Depression of piston 71 will again cause it to hold throttle valve 67 away from orifice 66 so that the sequence of fast reclosures followed by retarded reclosures may be repeated if another fault occurs.

Although a preferred embodiment of the invention has been described it is to be construed as suggestive rather than limiting for the invention may be variously embodied in a number of currently used interrupter designs so its scope is to be interpreted according to the claims which follow.

It is claimed:

1. In a fluid immersed reclosing circuit interrupter including switch means, overload responsive means and means actuated thereby for opening said switch means substantially instantaneously, a switch resetting magnet means including a plunger movable to one position under magnetic influence for closing said switch means, said plunger also being movable to another position when said switch means opens, means for counting the number of plunger reciprocations, a cylinder in which said plunger reciprocates, said cylinder including a fluid orifice for admitting fluid when the plunger is moving toward said other position, normally inactive throttle valve means controlling said orifice, selective means operable by and when said counting means accumulates a predetermined number of counts to render said throttle valve means active for restricting the fluid flow only into said cylinder and to thereby determine the rate at which said plunger

may move toward its other position before commencing to reclose said switch means under magnetic influence.

2. A fluid immersed circuit interrupter including switch means, stored energy means for opening said switch means instantaneously upon occurrence of an overload, a switch means closing coil and a cylinder surrounded thereby, a plunger movable to one position in said cylinder for closing said switch means and loading said stored energy means, said plunger also being movable to another position when said switch means opens, a closing switch adapted to energize said closing coil when said plunger is in its other position and to de-energize said coil when the plunger is in its one position, means for counting said plunger reciprocations, the aforesaid cylinder including a fluid orifice for admitting fluid into said cylinder when said plunger is moving toward its other position, normally inactive throttle valve means controlling said orifice, a control valve for rendering said throttle valve means active for restricting fluid flow into said cylinder and thereby determine the rate at which said plunger may move toward its other position whereupon said closing switch may re-energize said closing coil, said control valve being selectively interengaged with said counting means and operated thereby when the counting means has executed a predetermined number of counts.

3. In a fluid immersed circuit interrupter characterized by its including switch means and being adapted to execute a plurality of rapid switch openings and closings and at least one retarded switch closing, the combination with such interrupter of a magnetic plunger movable from another position to one position for closing said switch means and returning to said other position when said switch means open, a cylinder in which said plunger reciprocates, said cylinder including a fluid orifice for admitting fluid when the plunger is moving toward its said other position, throttle valve means biased toward closing said fluid orifice, a normally closed fluid reservoir, piston means normally extending from said reservoir into engagement with said biased throttle valve and restraining the latter from closing said orifice, said piston being held in restraining position by pressure differential exterior and interior said reservoir, a control valve for opening said reservoir and equalizing the pressure differential whereupon said orifice may be closed to restrict fluid flow into said cylinder and retard said plunger.

4. The invention according to claim 3 wherein said interrupter includes means for counting the number of plunger reciprocations, and an adjustable coupling means selectively interconnecting said control valve and counting means, whereby said throttle valve may be operated to effect retarded movement of said plunger after a preselected number of counts.

5. In a fluid immersed circuit interrupter characterized by its including switch means and being adapted to execute a plurality of rapid switch openings and closings and at least one retarded switch closing, a fluid filled cylinder and a plunger therein movable in one direction to close said switch means and in another direction when said switch means opens, said cylinder having a fluid orifice, biased throttle valve means normally allowing free ingress and egress of fluid through said orifice for

unretarded movement of said plunger, a normally closed fluid reservoir, piston means extending into said reservoir and projecting into engagement with said throttle valve means, said piston means being restrained in said reservoir by normally greater fluid pressure exterior thereto, a control valve adapted to open said reservoir for equalizing its exterior and interior pressure to thereby allow release of said piston means under the bias of said throttle valve means, whereby said throttle valve means may close said cylinder orifice for retarding movement of said plunger when moving in said other direction.

6. The circuit interrupter according to claim 5 including counting means advanceable step-by-step in accordance with movements of said plunger, a lost motion coupling between said control valve and said counting means and adapted to actuate said control valve when said counting means has taken a preselected number of steps.

7. The circuit interrupter according to claim 5 including a counting piston, hydraulic pump means operable by said plunger to advance said counting piston step-by-step upon each operation of the plunger, rod means carried by said counting piston for movement therewith, a relatively adjustable lost motion connection between said rod means and control valve effective to actuate said control valve when said counting means has taken a preselected number of steps.

8. In a fluid immersed circuit interrupter characterized by its including switch means and being adapted to execute a plurality of rapid switch openings and closings and at least one retarded switch closing, a fluid filled cylinder and a plunger therein movable in one direction to close said switch means and in another direction when said switch means opens, said cylinder having a fluid orifice placing the interior and exterior thereof in communication, a throttle valve interposed in the path of said orifice and normally biased toward closing said orifice, said throttle valve normally permitting free ingress and egress of fluid through said orifice in correspondence with reciprocations of said plunger a normally closed fluid reservoir adjacent said throttle valve, auxiliary piston means extending into said reservoir and projecting normally into engagement with said throttle valve, said auxiliary piston having a passageway therethrough, a check valve in said passageway normally sealing the interior from the exterior of said reservoir and permitting free descent of said piston, switch operation counting means including a rod advanceable in steps and including groove means spaced apart a distance equal to each step, a pick-up finger selectively disposable in registry with said groove means, a control valve having stem means projecting into lost motion connection with said finger and engageable by the latter after a predetermined number of steps, whereby said control valve may be actuated to open said reservoir and allow release of said piston means under the bias of said throttle valve.

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