

Dec. 1, 1964

E. L. LUEHRING
SWITCH WITH PLURAL ACTUATOR DEVICES HAVING IMPROVED
OVERTRAVEL TAKEUP FOR PLURAL
ELECTRICAL INTERRUPTERS

3,159,731

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3 Sheets-Sheet 1

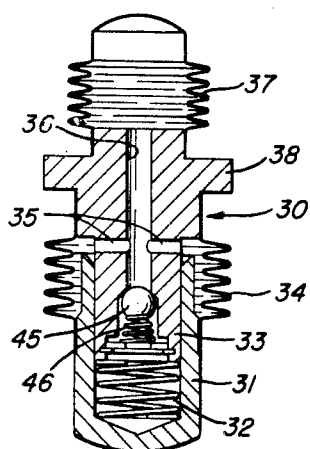


FIG. 3

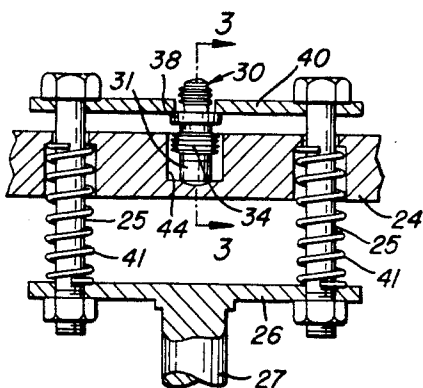


FIG. 2

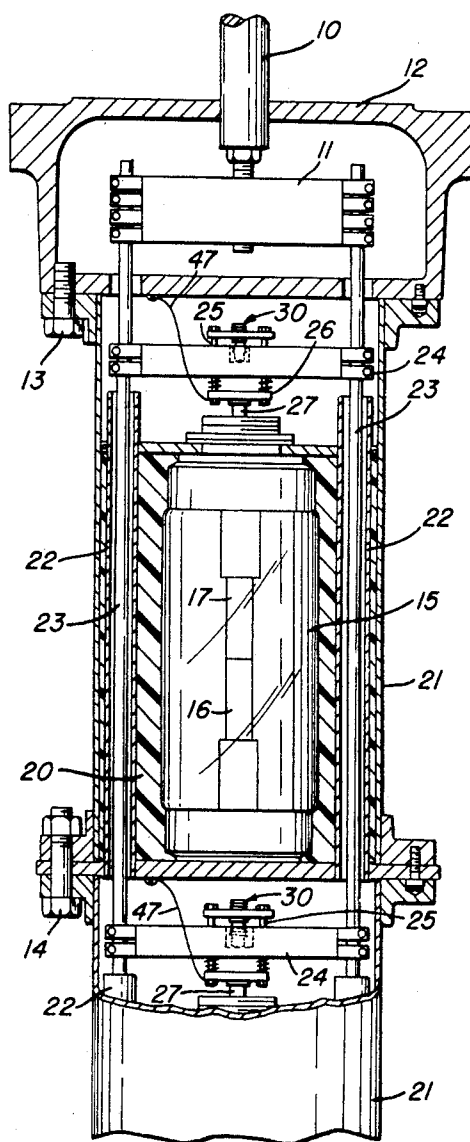


FIG. 1

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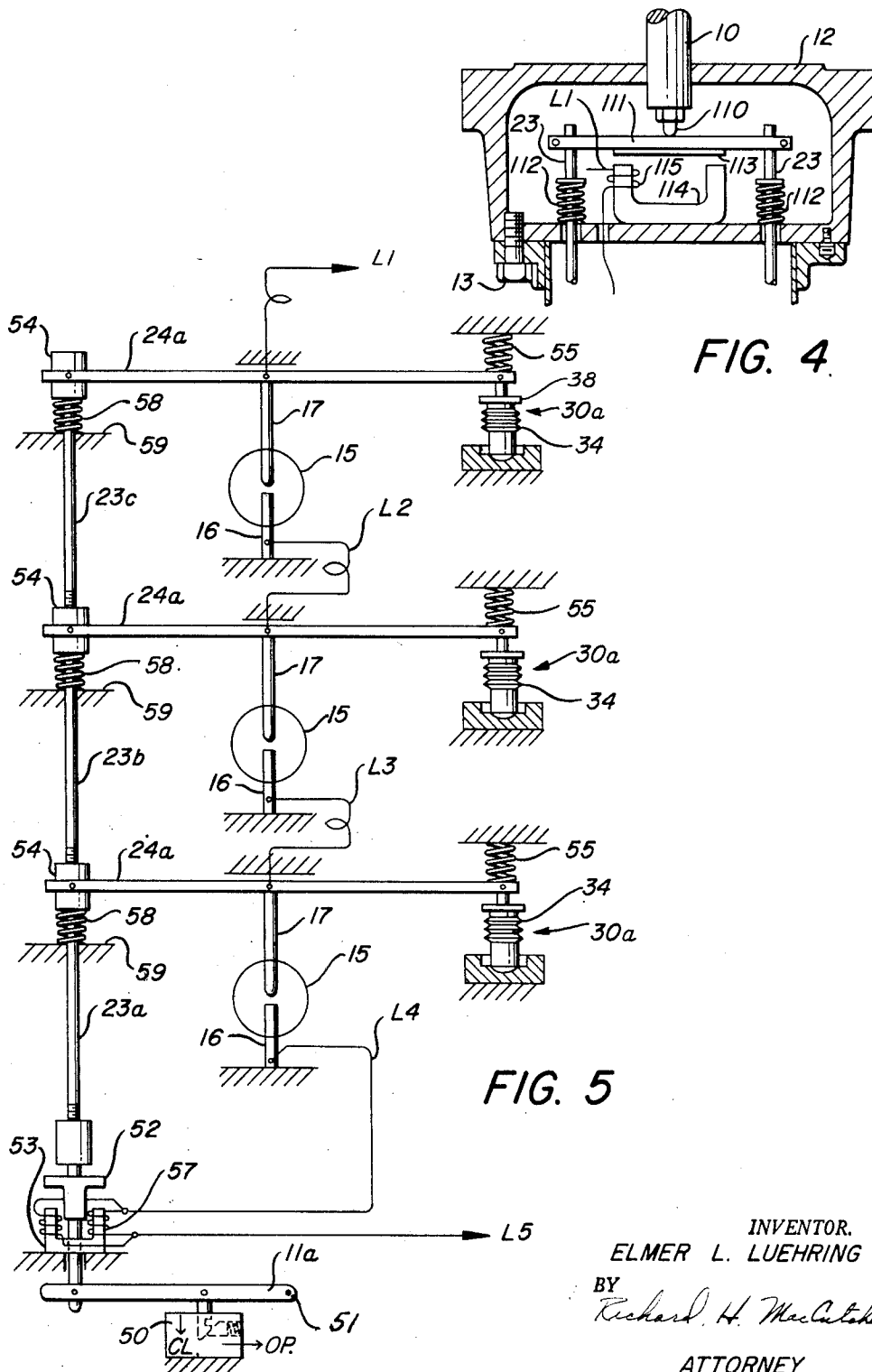
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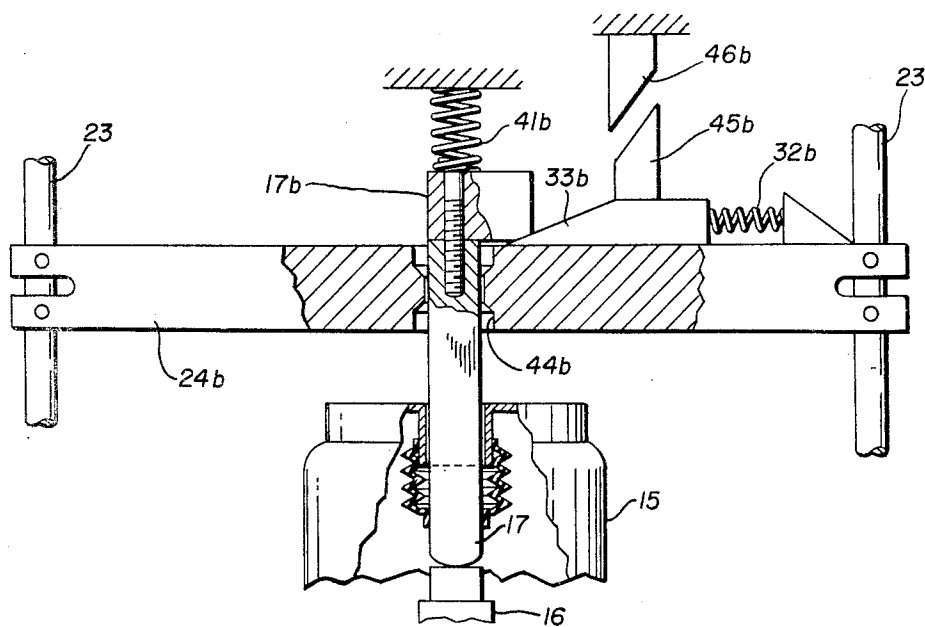
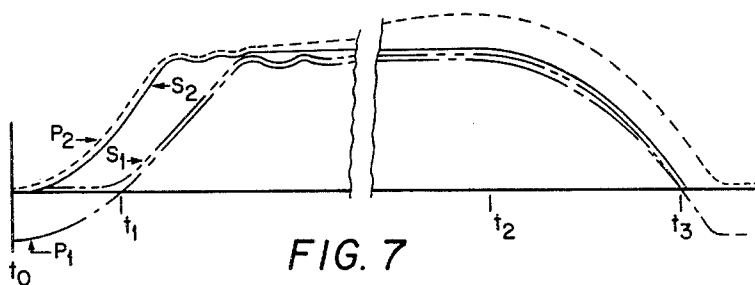
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SWITCH WITH PLURAL ACTUATOR DEVICES HAVING IMPROVED OVERTRAVEL TAKEUP FOR PLURAL ELECTRICAL INTERRUPTERS

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15 Claims. (Cl. 200-144)

This application is a continuation-in-part of my co-pending patent application Serial No. 848,092 filed October 22, 1959 (now abandoned), for Hydraulic Compensated Actuation for Tandem Vacuum Bottles and the invention has particular significance in connection with high voltage switches with tandem vacuum interrupter actuation.

High voltage switches have been extensively employed in the past, particularly in connection with outdoor switching stations for isolating sections of transmission lines and associate apparatus. Such high voltage switches are generally air-break switches provided with arcing horns as for interrupting transformer magnetizing currents. In recent years there have also been associate vacuum bottle interrupters to prevent arcing even at the arcing horns.

Present day transmission lines, transformers, capacitors, and the like, involve voltages, and charging and other currents to be interrupted, so large that as many as eight vacuum interrupters have heretofore been arranged mechanically in tandem and, usually, electrically in series. As disclosed and claimed in United States Patent 2,915,611, issued December 1, 1959, to the assignee of the present invention upon an application filed by Elmer L. Luehring and Harry E. Poe, each interrupter may have an envelope protecting against ambient, an annular housing spaced outwardly from the envelope, a cellular foam material between envelope and housing, and means such as pipes traversing the foam end for end and for accommodating mechanical operating rods which operate all the interrupters.

Although not specifically described in the above mentioned patent, compression springs (one for each unit) have been found useful in connection with such mechanism so that, on closing, after the interrupter contacts are closed the rods may undergo a certain amount of overtravel to compress such springs, so that all contacts may close with a more nearly equal contact force.

With or without such springs it is very difficult to open all interrupters with the desired degree of simultaneity in order to have maximum probability of achieving the desired voltage distribution over the interrupters, and particularly when such springs are present it would be desirable to fill up the overtravel and still retain its effect, to dispense with delicate mechanical adjustments which, to insure all units working together, are difficult to make the first time, and which, because of non-uniform part wear, are impossible to rely upon after operation for any length of time.

Further there have been difficulties associated with high current vacuum contact operation in the past because upon opening, as the contacts at first have zero pressure upon them, there is a high resistance between them causing melting and an electron path extending between the separating contacts due to thermionic emission, and this is not only destructive to the contacts but prevents effective current interruption at a predictable time.

It is an object of the present invention to provide simple and inexpensive means for overcoming the above-mentioned difficulties.

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Another object is to provide an improved mechanically initiated operating linkage for plural circuit interrupters.

A further object is to provide apparatus which will greatly improve the capabilities of the vacuum switch by eliminating the possibility of contact melting and thermionic emission caused by high current during opening.

Other objects and advantages will become apparent and the invention may be better understood from consideration of the following description taken in connection with the accompanying drawing, in which:

FIG. 1 is a side view primarily in vertical section and showing a modular encapsulated vacuum interrupter attached to the top of a like unit below and to tandem interrupter operation initiation mechanism above;

FIG. 2 is an enlarged sectional view of a portion of the apparatus of FIG. 1;

FIG. 3 is a further enlarged sectional view showing a hydraulic cylinder-piston assembly as viewed along the line 3-3 of FIG. 2;

FIG. 4 illustrates a modification;

FIG. 5 illustrates another modification;

FIG. 6 illustrates a mechanical substitute for the hydraulic unit of FIG. 3; and

FIG. 7 is a graph in which contact travel distance is plotted against time for opening and for closing operation.

Although but one interrupter unit is shown in its entirety in FIG. 1, it should be understood that a number of like units are arranged in tandem. When an initial signal is sent by some means (not shown) to actuate a normally top or bottom mounted apparatus which may comprise a toggle (not shown herein but one example of which is fully illustrated and described in U.S. Patent 2,955,181, issued October 4, 1960, and assigned to the assignee of the present invention) this operates a main pull rod 10 up or down with corresponding movement of a main drawbar 11 within a weatherproof housing 12 and fastened beneath which, as by screws 13 and bolts 14, are axially aligned successive interrupter units each of which may comprise a vacuumized glass envelope 15 having metal end caps, with separate contact rods 16, 17 extending into the envelope one from each cap and engaging the other rod inside the envelope, with means external to the envelope for preserving the vacuum of the envelope while allowing movement of the mobile rod as described, for example, in U.S. Patent 2,740,867 issued April 3, 1956, on an application filed by J. E. Jennings, and assigned to the Jennings Radio Manufacturing Corporation. Each interrupter need not necessarily be of vacuum type since the enclosed contacts might be immersed in an inert gas or in a liquid such as oil. Each of the originally enclosed interrupters, which ultimately are arranged in tandem, may be separately encapsulated in its own somewhat resilient material permanent shock-proof container comprising a cellular foam 20. Good results have been obtained using foam 20 around the envelope of each interrupter and within an annular outer housing 21.

As seen in FIG. 1, the foam 20 contains diametrically opposite vertical insulating material tubes 22 each containing an insulating material operating rod 23. Conveniently, the vertical tubes and the operating rod which they contain may be made of Bakelite. While each unit could have had its own operating rod extending only slightly more than the length of one encapsulated unit and provided with interconnecting threads (for accommodating rods of other units), with the arrangement shown in FIG. 1 the organization is otherwise and each operating

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rod 23 is presumed installed as a long unitary member at the time of final assembly. The vertical rods 23 operate a cross-bar 24 etc., one for each unit, and the cross-bar is connected to eventually operate the mobile contact rod 17 of the respective interrupter.

In accordance with the embodiment illustrated in FIGS. 1-3, each cross-bar is provided with a pair of openings which accommodate a pair of operating rods or bolts 25 which at their bottoms operate a yoke portion 26 formed integral with a rod 27 which extends to operate the movable contact rod 17 of the respective interrupter.

In between the cross-bar 24 and the rods 25 a hydraulic cylinder-piston mechanism (one for each location) as indicated generally at 30 is introduced to produce a very soft spring for expansion in one direction while acting as a substantially non-compressible member for operation in the opposite direction.

I have found that the hydraulic mechanism need only be 1½" long overall while the overall length for only three vacuum interrupters may be more than five feet long, so that it is obvious that the hydraulic mechanism as viewed in FIG. 3 is greatly enlarged over the showing of FIG. 2 and particularly over that of FIG. 1. Each hydraulic mechanism, of which there may be one for each interrupter, has a lower cylinder portion 31. Inside the cylinder is a hydraulic mechanism expander spring 32 which bears against the cylinder inside end and against a piston 33. An expansion bellows 34 joins piston to cylinder while radial vent passages 35 in communication with axial passage 36 extend through the piston to equalize pressure inside the piston with that outside the cylinder and within the expansion bellows and to provide communication with a top reservoir bellows 37 and to the cylinder 31. With the arrangements illustrated in FIGS. 1-3, the hydraulic mechanism has a flange portion 38 arranged to press upwardly against a yoke portion 40 associated with the top of the bolts 25 of FIG. 2.

Interrupter contact pressure springs as illustrated at 41 may be desirable to bias the yoke portion 26 downwardly with respect to the cross bar 24.

As will be apparent from the FIGS. 1-3, the piston 33 flange or shelf portion 38 engages the top yoke 40 around a hole which has clearance sufficient to accommodate the reservoir bellows when the parts are being assembled or disassembled, while the bottom of the cylinder 31 rests in a concave opening within an enlarged opening 44 provided in the cross bar 24 and providing a clearance sufficient to take the piston-cylinder bellows 34. The piston by-pass passage 36 terminates at the cylinder end in a ball seat accommodating a ball 45 held in place by a check valve spring 46.

A flexible electrical connection shown diagrammatically at 47 is provided between units and at top and bottom ends of the assembly.

In operation, with upward movement of the rods 23 the cross bar 24 for each unit is raised upwardly and this raises the associate cylinder 31. The parts are so designed that the hydraulic mechanism expander spring cannot rapidly compress and the hydraulic mechanism acts like a non-compressible part and raises the yoke 40, the bolts 25, and the yoke 26-27, and opens the movable contact 17 with respect to the stationary mating contact 16, and because of the direction of force upon the parts the ball 45 remains seated during this operation.

With the vacuum contacts 17-16 open, the force of the springs 41, and also air pressure acting on 17, tend to compress the hydraulic assembly and do so by fluid flow around the piston 33 which flow will be upwardly with respect to the showing in the drawing. The compression distance of the hydraulic unit establishes a margin of mechanical variation which will be adjusted for by the expansion of the hydraulic assembly after the subsequent closing operation.

On contact closing all of the units operate together, or at least within a very small fraction of a second of each

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other, and as the top mechanism 10, 11, and the rods 23 are moved downward and each cross bar 24 and cylinder 31 correspondingly moves downward and after contacts 17-16 touch, ball 45 will leave its seat and a large flow of fluid (such as oil) will occur through the piston by-pass passage of each unit and establish the expanded length of the hydraulic system at such a value as to cause perfect adjustment for the next opening operation. Thus when, due to downward force, on 10 (see FIG. 1) and on 11, 23, 24, 41 (see FIG. 2), 26 and 27, a movable contact 17 touches a contact 16 which is stationary, any further movement of 10, 11, 23, 24 will have to be taken up as overtravel, and it is, by the springs 41 but not without concomitant opening of the hydraulic device 31-38 (as the distance between 40 and 24 increases). This is accomplished by the spring 32 forcing 33 (integral with 38) away from the ball 45, as the fluid pressure above the ball overcomes the force of its seating spring 46. Those in the art will understand that extremely rapid following of a contact closing cycle by a contact opening cycle is not contemplated, and by the time contact opening is desired the hydraulics will have become static (and accommodated to the expanded position) ball 45 will be reseated, and during contact opening all the conditions (upward force on 10, 11, 23, 24 and 31) are such as to keep it seated.

With the arrangements shown in FIGS. 1 and 2, the springs 41 operate as overtravel springs (i.e., as "closing" contact pressure springs) and no opening springs are shown, the spring 32 in each hydraulic unit serving merely to reset the piston.

In FIG. 4, which is a view of the top portion of FIG. 1 but showing a modification, like parts are like numbered as before but the main rod 10 no longer functions as a "pull" rod being provided with a point 110 which merely pushes on a main "pushbar" 111, or when 10-110 are retracted (as shown in FIG. 4) allows 111 to raise up (at certain times as hereafter explained) under the influence of other forces such as "opening" springs 112 biasing the vertical rods 23 upward with respect to the stationary frame 12.

Push bar 111 has an armature portion 113 cooperating with an electromagnet 114 temporarily magnetized by a solenoid shown only diagrammatically at 115. The solenoid is energized responsive to current through a line L1 assumed in circuit with at least one of the vacuum contacts to be interrupted and is used to prevent opening of these contacts except at current values smaller than a predetermined value of instantaneous current therethrough.

FIG. 5, in which like parts are like numbered as before, schematically illustrates a preferred embodiment. A bottom mounted mechanical, electrical or hydraulic control mechanism shown in block form at 50 controls a main draw bar 11a rotatable about a fixed pivot 51 to downwardly pull or alternately release an armature portion 52 co-operating with a stationary electromagnetic yoke 53. Armature 52 is mechanically associated with a plurality of insulating material operating rods 23a, 23b, 23c, coupled end-for-end as by threaded sockets 54, although other linkage, such as a cable, might have been used instead of rods and couplings. As shown in FIG. 5 each socket operates a cross bar 24a, one for each unit, and each cross bar is tied at the opposite end to a combination of a compression spring 55 (which operates as a pressure spring to increase contact force in the contact-closed position) and a hydraulic unit 30a which can take the form of the hydraulic actuator of FIG. 3. Springs 55 may be omitted by depending on atmospheric pressure acting on the outer end of the movable contacts, if desired.

In FIG. 5 each bar 24a is everywhere somewhat free to move but a relatively stationary support is provided for it during contact opening by the momentarily "hard" hydraulic unit 30a resting on a fixed base. Considering FIG. 3 in connection with FIG. 5, after contacts 17-16 close the rod 23c can continue to pull 24a downward be-

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cause 30a can expand (in FIG. 5 just as in FIGS. 1 and 2 during closing sequence and after contacts are closed), the overtravel being taken up by spring means (contact pressure springs 55 in FIG. 5 analogous to contact pressure springs 41 in FIG. 2).

In the arrangement of FIG. 5, each evacuated glass envelope 15 contains stationary contact 16 and movable contact 17, and each cross bar 24a is connected to operate the mobile contact 17 of the respective vacuum interrupter, while leads L1, L2, L3, L4, and L5 complete the electrical connections at each end and between units, with L4 and L5 connected to coils 57 forming the solenoid on the stationary electromagnet 53.

With the arrangement shown in FIG. 5 the compression springs 58 operate, at least one for each unit, as opening springs each interposed between a fixed point (59) and the associate cross bar 24a, and operative to open the associate contacts 17-16 but only with relatively low value of current through the solenoid wound upon the yoke 53.

For closing, the arm 11a moves the armature 52 and thus the rods 23a, etc., directly.

Mechanism according to FIG. 4 or FIG. 5 considerably increases the capabilities of the vacuum switch, actually more than doubling its interrupting capacity, because it does away with zero pressure on contacts for opening until the current is low enough, for example less than 3000 amperes, so that critical contact-melting currents and thermionic emission are readily avoided.

The solenoid arrangement for delayed opening as illustrated in FIGS. 4 and 5 could not be accomplished before the introduction of a hydraulic system, such as that illustrated in FIG. 3, or an equivalent system operable by air, mechanics or electricity, since the vacuum contacts could not theretofore be opened fast enough because the pull rod and control apparatus had to go from zero velocity through a certain distance of travel without any apparent possibility of anticipation because of lack of steady state conditions. Taking FIG. 5 as an example, for contact closing a downward force is exerted on 11a, 52, 23a, b and c and each 24a and 17. An advantage of the present case claimed arrangements is that the solenoid high current lock-in is made possible thereby because the contacts are all closed (with any necessary overtravel taken up by the hydraulic units 30a) through a system which allows them to all open together. By contrast, according to the prior art, which always had to make some overtravel arrangement to accommodate wear of contacts and the like, the contacts could not open until the mechanical linkage had traversed back through the overtravel. Thus according to the prior art the well-known "opening springs" had to cause the equipment to first retravel the overtravel distance and thereafter effectuate contact opening. Because of the desirability of separating contacts in less than a millisecond when the current wave goes through zero 120 times a second, the solenoid arrangement of FIGS. 4 and 5 could not be accomplished before the introduction of a hydraulic system as in FIG. 3, or a system operable by mechanics, as in FIG. 6, or by air (which operates against a piston almost the same as does water or oil), or by a magnetic clutch or whatever is desired to be used as an equivalent of the arrangements shown in FIGS. 2 and 5 and 6.

Referring next to FIG. 6, a mechanical equivalent of the hydraulic actuator is shown. With like parts numbered as in FIG. 1 rods 23 may operate a cross bar 24b having a central hole 44b accommodating an extension of the movable contact 17 with this extension terminating in a top portion 17b. A block having a wedge 33b slides on 24b and is biased inward between 17b and 24b by a reset spring 32b. The block having wedge 33b has another wedge portion 45b co-operating with a fixed wedge 46b, while a fixed end spring 41b acts as a contact closing spring.

In analogous manner, this mechanical equivalent func-

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tions like the hydraulic assembly, rods 23 operating one or more cross bars 24b, the principal wedge 33b (FIG. 6) operating like piston member 33 (of FIG. 3), spring 32b resetting such member like expander spring 32 (of FIG. 3), while the supplemental wedges 45b, 46b take the place of the fluid flow around the piston presupposed in FIGS. 1 and 3. On the contact opening operation, bar 24b raises wedge 33b and through it 17b and contact 17 and ultimately, near full open, wedge 41b forces wedge 33b out of the way. On contact closing, as 24b drops, 17 drops (until it mates with 16), and wedge 33b flies in to establish the expanded length (of 17-24b) so as to cause perfect adjustment for the next opening operation. In the accompanying FIG. 7.

15 t_0 =time of initiation of the opening operation (old and new) and time of contact separation with the new device

t_1 =time of contact separation of the prior art

t_2 =time of initiation of closing operation (old and new)

20 t_3 =time of contact touch (old and new)

S_1 =space between interrupter contacts for prior art

S_2 =space between interrupter contacts with the new device (of FIG. 1, 5, or 6)

25 P_1 =position of rod 10 in FIG. 1 except according to prior art (e.g., without devices 30)

P_2 =position of rod 10 in FIG. 1 according to the "no slack" system of the invention which has shifted the position thereof.

30 If one refers to FIG. 7, which, for opening and closing, plots distance (of vacuum interrupter contact travel) against time (of release) he would find that for contact opening the hydraulic (or equivalent) actuator aspect of the present invention has shifted the curve over to the intersection of the zero time ordinates, whereas for contact closing the invention has left the beginning of this curve away (in time) from this point, just as it was before the invention was introduced, and, further, this aspect provides means for having all the parts work substantially together on opening without all the difficulty of fine mechanical adjustments which were previously required to be made in the factory and in the field.

35 There is thus provided apparatus of the class described capable of meeting the objects above set forth and providing means for making automatic adjustments for wear of contacts and of other operating parts.

40 While I have illustrated and described particular embodiments, various modifications may obviously be made without departing from the true spirit and scope of the invention which is intended to be defined by the appended claims taken with all reasonable equivalents.

I claim:

1. In a high voltage switch of the type having mechanically substantially permanently tandem connected electric circuit interrupters, the combination of rod means for operating the interrupters substantially in unison, a plurality of cross bars at least one for each interrupter and arranged to be operated by said rod means, and for each interrupter at least one hydraulic means for operating as a one way spring while interposed between cross bar and associate interrupter.

2. In a switch of the type having substantially tandem connected electric circuit interrupters provided with contacts, and having linkage means including a plurality of cross bars, at least one for each interrupter, arranged to be operated by said linkage means for operating the interrupters substantially in unison,

the combination of

45 a plurality of contact closing spring means, each operatively associated with a different cross bar, for exerting closing force on the associate interrupter contacts when the linkage means and cross bars are in contact closing position,

50 a plurality of one way spring means, each operatively associated with a different cross bar, for expanding

against said cross bar and against the force of the closing spring means after contact closing during the contact closing sequence and for, during contact opening sequence, at least momentarily acting as a non-compressible part.

3. The combination of claim 1 further characterized by each interrupter having a movable contact and a rod for moving said contact with said rod terminating in a yoke at a first side of the associate cross bar, fastening means extending from said rod yoke through the cross bar and slideable with respect to said cross bar, and a yoke adjacent the ends of the fastening means on the side of said cross bar opposite said first side, with the hydraulic means being mechanically interposed between one of the yokes and the cross bar.

4. The combination of claim 1 further characterized by each interrupter having a movable contact and a rod for moving said contact with said rod terminating in a yoke portion at a first side of the associate cross bar, bolt means extending from said rod yoke portion through the cross bar and slideable with respect to said cross bar, and a yoke adjacent the ends of the bolt means on the side of said cross bar opposite said first side, with the hydraulic means comprising a cylinder-piston combination mechanically interposed between said last mentioned yoke and the cross bar.

5. The combination of claim 1 further characterized by the hydraulic means, at least one for each interrupter, each comprising a cylinder portion arranged to move with the associate cross bar, a piston having one end movable within the cylinder, a hydraulic mechanism expander spring biasing the piston in a direction away from the cross bar, means connecting the piston to operate the associate interrupter, pressure fluid storage means at the end of the piston opposite the end thereof which is in the cylinder, the piston having fluid conducting passage means and a check valve associated with said passage means for permitting fluid to pass in one direction rapidly for one direction of operation while said fluid returns only slowly during operation in an opposite sense.

6. The combination of claim 1 further characterized by the hydraulic means, at least one for each interrupter, each comprising a cylinder portion arranged to move with the associate cross bar, a piston having one end movable within the cylinder and defining a chamber with respect to the cylinder, a hydraulic mechanism expander spring biasing the piston in a direction away from the cross bar, means connecting the piston to operate the associate interrupter, fluid conducting passage means leading from the chamber, and a check valve associated with said passage means for permitting fluid to pass in one direction with respect to said chamber rapidly for one direction of operation while said fluid returns only slowly during operation of piston with respect to cylinder in an opposite sense.

7. The combination of claim 1 further characterized by an electromagnet having an energizing circuit connected to be energized by current through at least one of the interrupters while said electromagnet is mechanically interposed to prevent operation of the rod means in an interrupter opening sense except with a value of interrupter current less than a predetermined value.

8. In a switch of the type having plural electric circuit interrupters each having a stationary and movable contact, a plurality of cross bars each for opening and closing one interrupter, and linkage means for operating the cross bars substantially in unison, the combination of hydraulic means one for each interrupter and for operating the respective interrupter by the respective cross bar and acting as a spring upon closing of the associated interrupter and acting substantially as a non-resilient part upon opening thereof.

9. The combination of claim 8 further characterized by a magnetic material armature movable with the linkage means and a stationary electromagnet energized responsive to current through at least one of the inter-

rupters, supervisory means arranged to pull the armature to the electromagnet and move the linkage means and thus the cross bars for closing the plural interrupters, and spring means biasing the armature away from the electromagnet for permitting the interrupters to open with release of the supervisory means for contact opening.

10. The combination of claim 9 further characterized by the supervisory means comprising an operator arranged to positively close the armature upon the electromagnet while capable of releasing the same for movement in the opposite direction under the control of other forces, the biasing spring means comprising plural springs operative one for each interrupter as opening springs while interposed each between a fixed point and the respective cross bar, second spring means comprising plural springs operative one for each interrupter as contact pressure springs, the cross bars comprising for each interrupter a cross bar having one end connected to be movable with the linkage means, an intermediate point arranged to operate the respective interrupter movable contact, and an opposite end connected to be biased in one direction by the resistance to contraction of the associate hydraulic means and in the opposite direction by the respective one of the second mentioned springs operative each as a contact pressure spring.

11. The combination of claim 10 further characterized by the hydraulic means for each interrupter comprising a cylinder portion having a closed end and a piston portion with one of said portions arranged to be stationary while the other moves with the associate cross bar, a mechanism expander means biasing the piston away from the cylinder end, the cylinder-piston combination having at least one fluid conducting passage therein, fluid storage means fluid coupled to one such passage, and a check valve associated with at least one such passage to restrict compression of the cylinder-piston combination.

12. In a high-voltage switch of the type having plural electric circuit interrupters arranged electrically in series, a plurality of cross bars at least each for opening and closing one interrupter, and linkage means for operating the cross bars substantially in unison, the combination of actuator means at least one for each interrupter for acting as a spring upon closing of the associate interrupter and to act as a non-resilient part upon opening thereof while interposed to effect the operation of the respective interrupter by the respective cross bar.

13. The combination of claim 12 further characterized by a magnetic material armature movable with the rod means and a stationary electromagnet energized responsive to current through at least one of the interrupters, supervisory means arranged to close the armature upon the electromagnet and move the rod means and thus the cross bars for closing the plural interrupters, and spring means otherwise biasing the armature away from the electromagnet for permitting the interrupters to open with release of the supervisory means for contact opening only when a current smaller than a predetermined value of interrupter current is achieved.

14. The combination of claim 13 further characterized by the supervisory means comprising an operator assembly arranged to positively close the armature upon the electromagnet while capable of releasing the same for movement in the opposite direction under the control of other forces, the spring means comprising first plural compression springs operative at least one for each interrupter as opening springs while interposed each between a fixed point and the respective cross bar, second spring means comprising second plural compression springs operative at least one for each interrupter as contact pressure springs, the cross bars comprising for each interrupter a cross bar having one end connected to movable with the rod means, an intermediate point arranged to operate the respective interrupter movable contact, and an opposite end connected to be biased in one direction by the resistance to contraction of the associate actuator means.

15. The combination of claim 14 further characterized by the actuator means for each interrupter comprising a cylinder portion having an end and a piston portion with one of said portions arranged to be stationary while the other moves with the associated cross bar, a hydraulic mechanism expander spring biasing the piston with respect to the cylinder end, a fluid conducting passage leading from the space between piston and cylinder end, pressure fluid storage means outside the piston-cylinder combination and in communication with said passage, a check valve associated with at least one passage in the piston, and spring means biasing said check valve with respect to said passage.

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