Nov. 3, 1959 M. RIGERT 2,911,494

ELECTROMAGNETICALLY ACTUATED SWITCH CONSTRUCTION

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Fig. 1

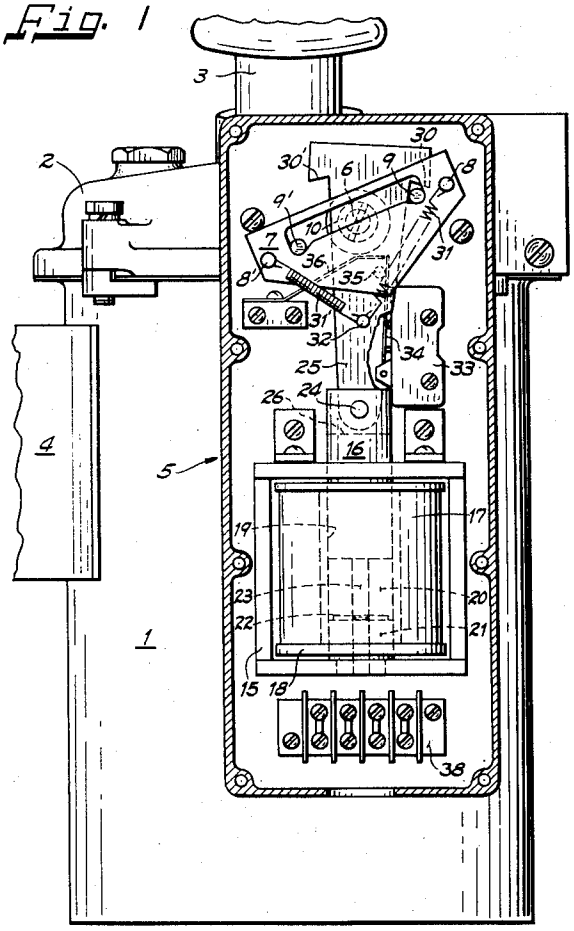


Fig. 2

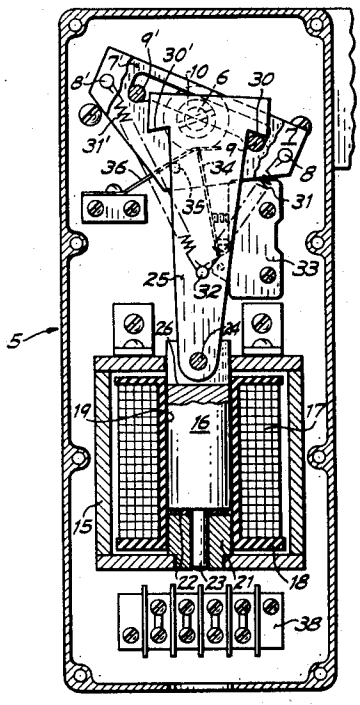


Fig. 3

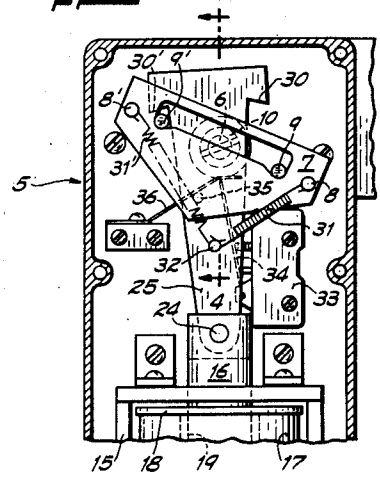
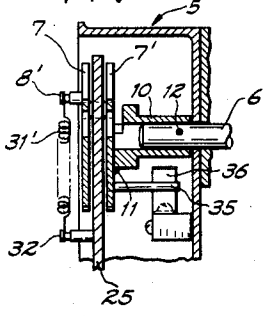


Fig. 4



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ELECTROMAGNETICALLY ACTUATED SWITCH CONSTRUCTION

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Fig. 7

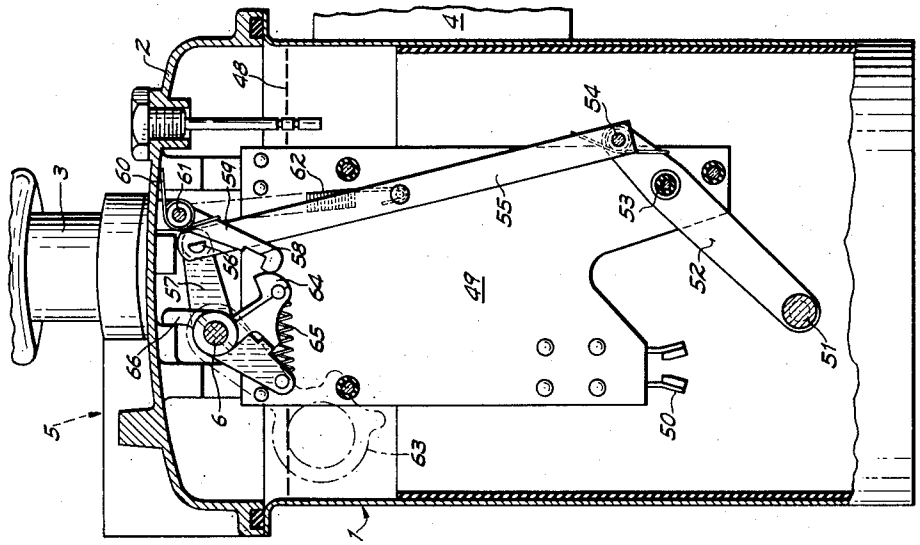


Fig. 6

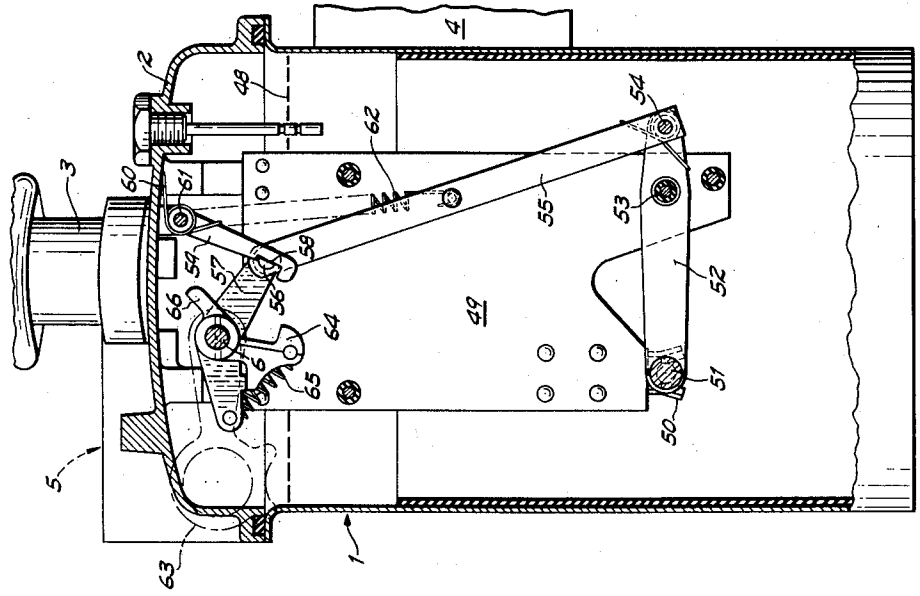
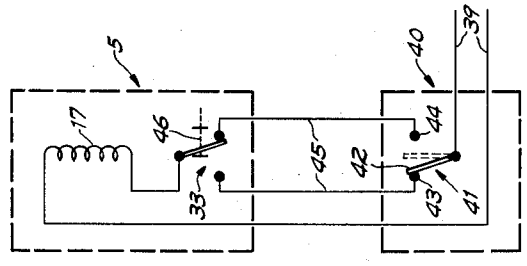


Fig. 5



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ELECTROMAGNETICALLY ACTUATED SWITCH CONSTRUCTION

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5 Claims. (Cl. 200—87)

This invention generally relates to electric switches, and particularly, to an electromagnetic switch actuator that allows both manual and automatic operation of a switch.

Objects of this invention are to provide a novel, simple and inexpensive automatic switch operator: that uses but one solenoid for driving an associated line switch open and closed; that responds without time delay after receiving a control signal; that minimizes lost motion; that requires the motivating solenoid plunger to travel only a short distance while executing a power stroke to the end that its air gap may be small and its initial driving force large, which conditions lead to low total energy consumption, and particularly, to low inrush current.

A further object is to provide an improved electromagnetic switch actuator that enables manual and automatic operation of the switch without one operating means burdening or mutually interfering with the other.

A general object of this invention is to provide a new and improved automatic switch. More specific objects will appear from time to time throughout the course of the ensuing specification.

The switch construction constituting the subject of this invention is generally applicable where it is desired to control a power line by manual operation of the switch or by automatic operation from a remote position in response to a suitable control signal. One example of automatic operation is found where the switch is applied to control a street lighting circuit and the actuator is caused to respond to a signal received from a photosensitive device, for example. A more common application, however, is in the control of power factor corrective capacitor banks where a number of such switches operate simultaneously to connect and disconnect capacitor groups in each phase in response to line power factor. In capacitor switching installations using prior art magnetically operated switches, the inrush currents of the individual switch operators totals such a great amount that the available control power must be inordinately great and protective fuses in the control circuit must be enlarged to cope with inrush current at the expense of adequate protection under steady state conditions. This is one of the disadvantages which the present invention overcomes.

In general terms the new switch actuator comprises an electromagnet and armature plunger which executes a power stroke when moving in one direction under magnetic influence and which is returned to its original position under the influence of a return spring. Consecutive strokes of the plunger alternately close and open the switch through the agency of a T-link which engages a switch operating lever and transfers from one arm of the lever to another after each successive operation. The springs for effecting transfer of the T-link on the switch also return the plunger to its original position. A limit switch is provided for deenergizing the electromagnet at the end of its power stroke and for maintaining it deenergized until the next control signal is applied to the actuator.

The switch to which the actuator is applied may take many forms, but the one here chosen for illustration is of the type that is enclosed in an oil-filled tank and which includes line contacts that are spring-biased open but latched closed.

An embodiment of the invention will now be discussed in greater detail in reference to the drawings, in which:

Fig. 1 is an elevational view of an oil switch on which is mounted the switch actuator of the invention, the latter being shown in inactive condition and prepared to open the switch;

Fig. 2 shows the actuator of Fig. 1 as it appears at the end of an opening stroke;

Fig. 3 is a fragmentary view of the actuator corresponding with Fig. 1, but showing it prepared to close the oil switch;

Fig. 4 is a partial sectional view taken on a line corresponding with 4—4 in Fig. 3;

Fig. 5 is a wiring diagram of the switch actuator and a control station;

Fig. 6 is a vertical sectional view taken through the oil switch having its line contacts in closed position after the switch has been rotated 180° with reference to Fig. 1; and,

Fig. 7 illustrates the switch of Fig. 6 in open position.

Refer now to Fig. 1 which shows a switch tank 1 provided with a cover 2 upon which is supported a line bushing 3. In a single phase switch there are in fact two such bushings 3, one for leading current in and the other out of the tank. The tank is provided with a mounting bracket 4 for supporting it above ground level on a power pole, a metallic structure, or other suitable means, not shown.

On tank 1 there is fastened by any suitable means, an actuator housing 5 into which extends an operating shaft 6 of the oil switch, see particularly Fig. 4. It will be understood that rocking of shaft 6 through a limited angle in one direction will close the oil switch as in Fig. 6 and rocking it in an opposite direction will open the switch as in Fig. 7.

For rocking switch shaft 6 by means of the actuator, there is fastened to the shaft a double-armed lever comprising a pair of parallel, generally triangular congruent plates 7 and 7'. The plates 7 and 7' may be secured in spaced parallelism with each other by means such as shouldered anchor pins 8 and lug pins 9 which span the space between the plates. These pins may be welded or peened in order to secure them.

The rear plate 7' of double-armed lever has one end of a coupling sleeve 10 welded onto it at 11. The other end of sleeve 10 is pinned at 12 to switch shaft 6. It is thus seen that lever assembly 7 and 7' is directly connected to the switch shaft 6 for the purpose of rocking the latter in opposite angular directions.

The motivating force for double-armed lever 7, 7' is derived from an electromagnetic operator comprising a magnetic frame 15, a plunger 16 and a coil 17. The magnetic frame may be laminated but it is here shown as being made of solid iron for simplicity. Coil 17 is wound on an insulating spool 18 that has a central bore 19 in which the magnetic armature or plunger 16 may reciprocate. As viewed in Fig. 1, plunger 16 is in a first or uppermost position, corresponding with coil 17 being deenergized, and with an air gap 20 underneath and between it and a magnetic guide plug 21. Impact between the plunger 16 and plug 21 may be absorbed by a resilient washer 22, as seen in Figs. 1 and 2. Axial movement of plunger 16 is guided and aligned by a guide pin 23 extending from the bottom of the plunger through an appropriate hole in guide plug 21.

Pivotally attached on a pivot pin 24 near the upper end of plunger 16 is a link 25 having generally a T-shaped

configuration. It will be evident from viewing Fig. 2 particularly that the upper end of plunger **16** is suitably slotted at **26** for accommodating the lower pivot end of the T-link so that the latter may swing through a limited angle in a plane lying normal to the axis of pivot pin **24**. As explained earlier, double-armed lever plates **7**, **7'** are congruent and spaced. This is for the purpose of admitting between them the upper portion of T-link **25** as is clearly evident in Fig. 4 and in Fig. 2 where the front plate **7** constituting the double-armed lever is broken away.

The upper or head end of the T-link is provided with oppositely extending bevelled shoulders **30**, **30'** which are adapted to engage lug pins **9**, **9'** and thereby drive double-armed lever assembly **7**, **7'** when plunger **16** descends under magnetic influence.

In Fig. 1, where the actuator is shown deenergized, it will be seen that shoulder **30** of the T-link is engaged with the right lug pin **9** of the double-armed lever assembly **7**, **7'**. When the plunger **16** is attracted downwardly as in Fig. 2, it is seen that T-link **25** rotates lever **7**, **7'** through a clockwise angle. In order to transfer T-link **25** so that its shoulder **30** disengages lug pin **9** and so that its other shoulder **30'** engages lug pin **9'**, there is provided a pair of angularly disposed springs **31** and **31'** whose common ends are attached to a pin **32** on T-link **25** and whose remotely opposite ends diverge and are attached near opposite extremities of the double-armed lever assembly **7**, **7'** by means of anchor pins **8**. Springs **31**, **31'** serve the double purpose of retracting plunger **16** after a power stroke and of transferring the T-link as just explained. Thus, it may be seen that when the T-link has been moved downwardly from its Fig. 1 to its Fig. 2 position for opening the oil switch, spring **31'** which was relaxed in Fig. 1 becomes extended as in Fig. 2 so that when coil **17** is deenergized, spring **31'** will retract link **25** and plunger **16** upwardly and cause shoulder **30'** of the link to engage with the lug pin **9'**, thereby terminating in a condition represented by Fig. 3.

It will be understood, of course, that the next successive energization of coil **17** causes double-armed lever **7**, **7'** to rotate counterclockwise from its Fig. 3 position and to again be restored to its Fig. 1 position corresponding with closing of the line switch.

In order to deenergize solenoid coil **17** and cut off its control signal, the actuator is provided with a single pole, double throw, limit switch **33**. Limit switch **33** is provided with an operating arm **34**, see Fig. 1, which is spring-biased in a counterclockwise direction from the position in which it appears in that figure. Referring further to Figs. 1 and 4 it will be seen that the back plate **7'** of the double-armed lever carries an axially extending limit switch pin **35** which drives limit switch arm **34** in opposition to its biasing spring when the line switch is closed as in Fig. 1. When coil **17** is energized to effect an opening power stroke of the actuator as has taken place in Fig. 2, it will be seen that limit switch pin **35** has swung clockwise and clear of arm **34**. The limit switch **33** does not operate nor does its arm **34** change position until the end of the plunger stroke following movement of the plunger **16** from its Fig. 1 to its Fig. 2 position because the limit switch arm **34** is restrained temporarily by a leaf spring **36** whose end bears against the limit switch arm in Fig. 1. When pin **35** has oscillated from its Fig. 1 to its Fig. 2 position, which corresponds with the end of the plunger's power stroke, it strikes leaf spring **36** and allows limit switch arm **34** to swing under and be held by it as is clearly evident in Fig. 2.

In Fig. 3 it will be seen that the actuator is prepared for its next switch closing power stroke, and that limit switch pin **35** may swing counterclockwise through a limited angle before it strikes limit switch arm **34** to transfer the latter back to its Fig. 1 position. Thus the full power of the electromagnet coil **17** is applied to plunger **16** when either opening or closing the oil switch and the coil is finally deenergized by the limit switch **33** when the operation is completed.

Although a connecting terminal block **38** is shown in Figs. 1 and 2, the wiring has been omitted for it may be understood by referring to the schematic circuit diagram of Fig. 5. In this figure is seen a pair of control voltage lines **39** feeding into a control station **40** housing a single pole, double throw, control switch **41**. The movable contact arm **42** of the control switch is adapted to contact one of the control switch terminals **43** or **44** whenever it is placed in such position for operating the actuator and to return to a neutral center between terminals **43** and **44** thereafter. Jumper wires **45** connect control switch **41** with the stationary terminals of limit switch **33**. Schematically, the movable contact arm of the limit switch is serially connected with the solenoid coil **17** which is connected to one side of the control voltage source by means of a wire **39**. In Fig. 5 the pin **35**, leaf spring **36**, and lever **7** which control limit switch **33** are represented by a broken lined symbol identified by the reference numeral **46**. Switch **41** is only exemplary for it may be replaced by a contact making voltmeter, for example, or any momentarily contacting switch. However, in conjunction with an oil switch that can be operated manually, as will appear below, it is preferable that arm **42** return to a neutral, switch open position in order to avoid closing the solenoid **17** circuit when the limit switch **33** shifts contacts as a result of lever **7** rocking during manual operation.

The electrical functions of the circuit in Fig. 5 are similar to a three-way switch circuit. For example, if switch arm **42** in the control station is transferred from its shown position to one of contact with stationary contact **44**, power will be delivered through the closed limit switch **33** and through solenoid coil **17**. By means which have already been described, when solenoid coil **17** has moved plunger **16** to the end of its stroke, the limit switch **33** will be transferred to contact its other stationary terminal and thereby open the circuit to the solenoid while at the same time preparing it for its next successive operation. When control switch **41** is momentarily transferred back to its Fig. 5 position, of course, limit switch **33** will execute a converse motion and be restored to the position in which it is shown.

One form of line switch which may be operated by the switch actuator described above is shown in some detail in Figs. 6 and 7 as an oil switch housed in metal tank **1** which is filled with oil to the level indicated by the dashed line **48**. The switch construction includes a pair of insulating plates **49** one of which is shown, but which is in parallelism with another and supports a pair of stationary contacts **50** that are adapted to be bridged for closing a circuit by a conductive bridging bar **51**. Bridging bar **51** is mounted on an insulating lever **52** that pivots on a pin **53** spanning between adjacent insulating plates **49**. Lever **52** is connected by a pin **54** to a long, upwardly extending, insulating link **55**. The upper end of insulating link **55** is provided with a shaft whose end **56**, extending toward the observer, is round on one side and flat on the other and whose midsection effects a pivotal connection between the insulating link **55** and a rocker arm **57** that is loosely journalled on main shaft **6**. As viewed in Fig. 6, flattened portion **56** is engaged with a notch **58** on a latching arm **59** that is spring-biased in a clockwise direction by a torsion spring **60** surrounding its stationary pivot pin **61**. By this means switch link **55** and lever **52** are restrained in their switch closed position of Fig. 6 in opposition to an opening spring **62** that connects to link **55** at one end and is anchored at its upper end at any suitable place on tank cover **2**. In Fig. 7 it will be seen that link **55** is unlatched and the switch opened under the contracting influence of opening spring **62**.

In Figs. 6 and 7 may be seen, in phantom outline, a

manual operating handle 63 that is pinned to and swings with switch shaft 6. Actually the handle is affixed to the end of the shaft that is nearest the observer and it would not appear in these sectional views. Shaft 6 may be rotated by manipulating operating handle 63 or by the influence of the actuator described above with an effect to be described in the next paragraph.

Inside the switch tank 1, shaft 6 carries a short arm 64 that is pinned on the shaft. It may be seen in Fig. 6 that loosely journalled rocker lever 57 is connected to arm 64 through the agency of a short coil spring 65 which holds arm 64 and lever 57 in abutment. When shaft 6 is rotated from its Fig. 6 position, either by the actuator or by pulling operating handle 63 downwardly, coil spring 65 is stressed while short arm 64 turns counterclockwise until it strikes latch arm 59 as in Fig. 7 and allows the release of flattened shaft 56 and consequent opening of the switch contacts 50, 51. During this opening movement and before the latch is disengaged, spring 65 is loaded and thereby serves to assist opening spring 62 in quickly accelerating the switch parts to open position. To limit opening movement, short arm 64 is provided with a stop extension 66 that strikes a suitable abutment on the tank cover 2 as may be seen in Fig. 7. As explained above, the switch of Figs. 6 and 7 operates similarly whether shaft 6 is operated by the electromagnetic actuator or by the manual handle 63. Under all circumstances, the manual handle 63 serves to indicate the position of the switch contact arm 52.

When the oil switch is operated manually, the double armed lever assembly 7, 7′ of the actuator oscillates through the angle that may be seen by comparing Figs. 1 and 2, and the T-link 25 is transferred between alternate lug pins 9, 9′ in a manner similar to what happens if the switch were operated by the actuator. Likewise, the limit switch 33 is actuated to a new position by pin 35 regardless of how the switch is operated so that it is always prepared for the next response to a control signal.

In summary, a single solenoid electromagnetic switch actuator has been described that is characterized by small lost motion as a result of the T-link 25 being engaged with lugs 9 or 9′ whenever an operating stroke of plunger 16 is about to be commenced. Further, the air gap 20 beneath the solenoid plunger 16 may be made relatively small by virtue of its whole travel being effective to rock double-armed lever assembly 7, 7′ and operate the oil switch in the absence of lost motion. Because of the small permissible air gap, the flux leakage of the solenoid operator is low, even at the beginning of the plunger stroke, and accordingly, inrush current is minimized.

Having disclosed a preferred embodiment of the invention, many obvious embodiments will now appear to those versed in the art. Therefore, it is to be understood that the specific details of construction disclosed are for illustration, not limitation, except as made necessary by the scope of the appended claims.

It is claimed:

1. A switch actuator including an armature electromagnetically attractable from a first position to a second position, switch shaft means adapted to be driven in alternate angular directions by successive operations of the armature, lever means operatively coupled with said shaft and having arms extending to opposite sides of the shaft axis, link means pivotally attached at one end to said armature and releasably engaged without lost motion at its other end with one of said lever arms when said armature is in first position and while moving to second position under magnetic influence, and spring means connecting said lever and said link means for biasing said link means from engagement with one lever arm into engagement with the other lever arm when the magnetic influence on the armature is relieved and also for biasing said armature toward said first position.

2. A switch construction comprising separable switch contacts, opening spring means biasing said switch contacts toward separation, latch means operatively engaged with one contact to hold the same unseparated in opposition to the opening spring means, a switch operating shaft coupled to said one switch contact for closing the switch when rotated in one direction against the bias of said opening spring, latch release lever means carried on said shaft for releasing said latch when the shaft is rotated in another direction, an electromagnetic switch actuator including a double-armed lever affixed on said operating shaft, lug means on said double-armed lever at opposite sides of its rotational axis, a generally T-shaped link means disposed between said lug means, a reciprocating magnetic plunger to which said link is pivotally attached, a pair of springs having their common ends connected to said T-shaped link means and their other ends respectively connected to said double-armed lever at opposite sides of its rotational axis, a solenoid coil for attracting said plunger when energized, whereby said link means will drive said double-armed lever in one direction and load one of said pair of spring means, said solenoid coil when deenergized allowing said one spring to transfer said link means to a new position on said double-armed lever and to return said plunger to its original position.

3. A switch actuator including a solenoid coil and a magnetic plunger that is movable between unattracted and attracted positions, a switch operating member adapted to be driven to alternate angular positions by successive attractions of said plunger, a double arm lever attached to the switch shaft means for swinging in a plane substantially normal to the axis thereof, link means pivotally attached to said plunger for swinging movement to opposite sides of the plunger axis, lug means on each lever arm alternately releasably engageable with said link means for rotating the lever means when said plunger is attracted, transfer spring means connected between said lever and said link means for biasing the latter at an angle with respect to the plunger axis and into engagement with one of said lug means when the solenoid coil is energized and for retracting said link means into engagement with the other of said lug means when said plunger returns to its unattracted position, said transfer spring means also biasing said plunger toward its unattracted position whereby said plunger will return to its unattracted position when said solenoid coil is de-energized.

4. A switch actuator including switch shaft means rotatable in opposite directions between switch open and switch closed positions, a normally de-energized solenoid coil and a magnetic plunger therein, a double arm lever attached to said switch shaft means for swinging in a plane normal to the axis thereof, lug means on said double arm lever at opposite sides of its rotational axis, a generally T shaped link means disposed between said lug means and having one end pivotally attached to said plunger, a pair of springs having their common ends connected to said T shaped link means and their other ends respectively connected to said double armed lever at opposite sides of its rotational axis, said link means driving said double armed lever in one direction and loading one of said pair of spring means when the plunger is attracted upon the energization of said solenoid coil, said one spring transferring said link means to a new position on said double arm lever and returning said plunger to its original position when said solenoid coil is de-energized.

5. A switch construction comprising separable switch contacts, opening spring means biasing said contacts toward separation, latch means operatively engaging one of said contacts to hold the same unseparated in opposition to the opening spring means, a switch operating member coupled to said contacts for closing said switch when operated in one direction against the bias of said opening spring, latch release means coupled to said member for releasing said latch when said switch operating

member is operated in a second direction, an electromagnetic switch actuator including a doubled armed lever affixed to said operating member, lug means on said double arm lever at opposite sides of its rotational axis, a generally T-shaped link means disposed between said lug means, a reciprocating magnetic plunger to which said link is pivotally attached, a solenoid coil for attracting said plunger when energized, opposite portions of said T-shaped link being alternately releasably engageable with said lug means for rotating said lever in opposite directions in response to movements of said plunger in one direction and transfer spring means connected between said lever and said link means for biasing the latter at an angle with respect to the plunger axis and into engagement with one lug means when said

solenoid coil is energized and for retracting said link means into engagement with the other lug means upon the de-energization of said solenoid means, said transfer spring means also returning said plunger to its initial position when said solenoid coil is de-energized.

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