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CONSTANT-LOAD SPRING-LOADED ELECTRICAL SWITCH

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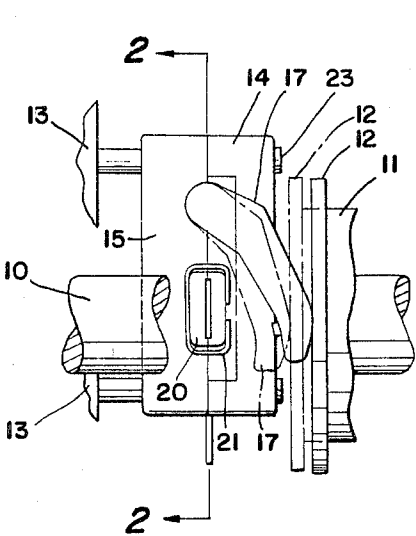


Fig. 1

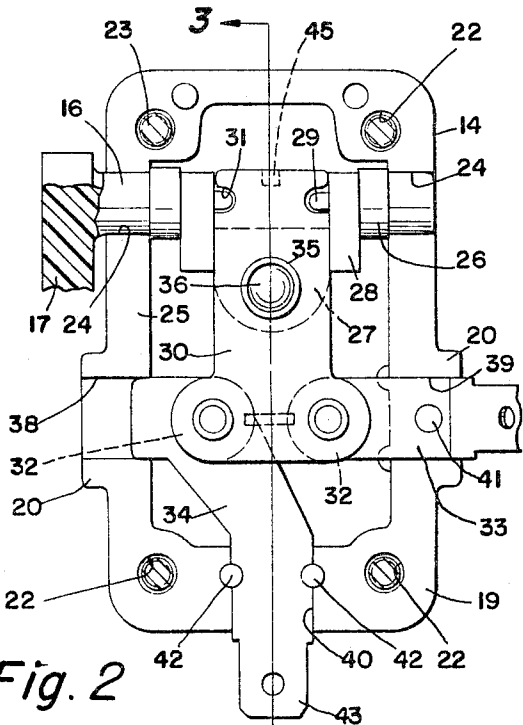


Fig. 2

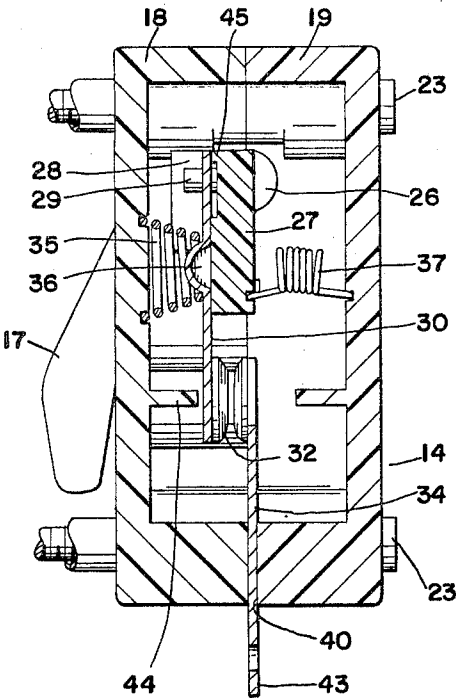


Fig. 3

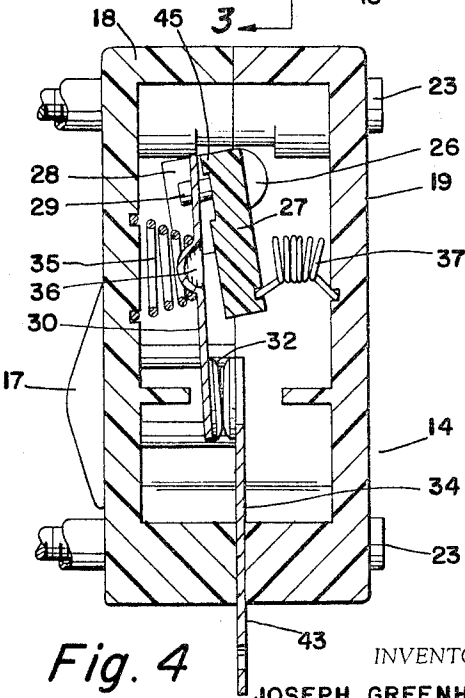


Fig. 4

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CONSTANT-LOAD SPRING-LOADED ELECTRICAL SWITCH

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9 Claims. (Cl. 200—166)

This invention relates to an electrical switch designed for use in circuits where the consistency or uniformity of the switch-opening and closing characteristics are critical. Although the utility of the switch which is the subject of the present invention is not limited to the environment of electrical motors, that environment may be considered typical of the switch-actuating conditions which create the problems which the present invention is designed to overcome. Therefore, the utility of the switch will be described in terms of its use as a switching device for the starting winding of a split phase motor.

In split phase electrical motors it is necessary to provide an auxiliary or starting winding which will produce the necessary torque characteristics to cause initial rotation of the rotor and will also bring the rotor up to a speed at which the torque developed by the main winding alone is great enough to overcome the load on the motor. In the motor design, a switching device is employed which maintains the starting winding in the main winding circuit until the rotor has reached a predetermined speed. Such switching devices may be of various forms and designs and generally provide for a yieldable stationary switch or contact mechanism which is actuated by a spring-loaded speed-responsive centrifugal device. Reference is made to my United States Patent No. 2,616,682 entitled, "Centrifugal Speed Responsive Device With Spring Support," granted November 4, 1952, for a more detailed description of such starting devices.

In such devices, the centrifugal device or "rotary" is designed to have snap action retractive movement at a predetermined speed of rotation to allow opening of a normally open starting winding circuit switch. This switch is commonly referred to as the "stationary" switch and its actuating movement is in resilient opposition to the movement of the rotary.

Although a great deal of research and development has gone into the design of rotary units to obtain improved characteristics of uniform operation, it is evident that, with mass production techniques, such predetermined consistency of operation of the rotary can be and is often negated by a non-uniform or variable load which the stationary switch places upon the rotary device. Such variation of load commonly results from the cumulation of manufacturing tolerances in assembly which in one production motor may cause the stationary switch to be assembled at a significantly greater distance from the rotary than is the case in another production motor where the manufacturing tolerances have by chance been cumulated in the opposite direction. It is not uncommon in the manufacture of fractional horsepower electrical motors, that the manufacturing tolerances which bear upon the positional relationship between the stationary switch and the centrifugal device, are on the order of plus or minus .045 inch. In some circumstances, the range of manufacturing tolerances approaches plus or minus .090 inch.

In addition to the foregoing positional variations resulting from manufacturing tolerances, the conventional leaf spring design of stationary switches introduces an inherent variation in load on the centrifugal device, particularly when there is a condition of over-travel of the rotary unit after the switch contacts have closed. Some of these characteristics of the conventional stationary switch can be minimized by the use of very weak, low

pressure leaf springs in the stationary switch, so as to reduce the critical significance of such loading variations as may occur. However, this solution to the problem of load variation, creates another problem in switch-opening movement. When the contact-opening forces of the leaf springs are of sufficiently low value to overcome the first problem, these forces are not great enough to break the "welds" which occasionally occur between the switch contacts.

Additionally, in such low force stationary switches, the contact-opening action is sluggish and the contact-closing forces are overly great, due to their direct relationship to the actuation of the rotary, thereby creating undue wear upon the contact surfaces.

It is a primary object of my invention to provide a stationary switch which will impose and maintain a constant load on a switch-actuating device within a significantly broad range of positional relationships.

Another object of my invention is to provide a switch of the character described in which a relatively strong contact-opening force is utilized and is available for breaking "welds" which may occur between the contact faces.

A further object of my invention is to provide a switch of the character described in which the contact-closing forces are substantially uniform and independent of the applied switch-closing force of the actuating device or its extent of travel.

Still another object of my invention is to provide a switch of the character described embodying a positive wiping action of the opposed contact faces.

Other objects and advantages of my invention will be apparent during the course of the following description.

In the accompanying drawings, forming a part of this specification, and in which like numerals are employed to designate like parts throughout the same,

FIG. 1 is a view in side elevation of a switch embodying the features of my invention, showing its association with a rotary element of an electric motor.

FIG. 2 is a cross-sectional view taken as indicated on line 2—2 of FIG. 1.

FIG. 3 is a cross-sectional view, taken as indicated on line 3—3 of FIG. 2, and showing the switch in open position.

FIG. 4 is a cross-sectional view comparable to FIG. 3, but showing the switch in closed position.

Referring more particularly to FIG. 1 of the drawings, I have shown a fragmentary portion of an electric motor to illustrate an environment in which the switch of my invention can be utilized. A motor shaft 10 has affixed thereto for axial rotation therewith a centrifugal speed-responsive device which may be the type of switch-actuating device described in my aforesaid patent or may be any conventional device of comparable function. The rotary 11 carries a collar or shoe 12 which has limited longitudinal movement relatively to the shaft 10 in response to predetermined conditions of rotary speed of the centrifugal device 11. If, for example, the rotary has a predetermined cut-out speed of 1600 r.p.m., the shoe 12 will be retracted by the action of the centrifugal device to the switch-opening position shown in solid lines, when the shaft speed of the motor reaches 1600 r.p.m. or greater. When the motor is at rest or when it has not yet attained the cut-out speed, the shoe 12 will be in its projected or switch-closing position, shown in phantom outline in FIG. 1.

A switching device 14 for the starting windings of the motor is secured to the motor housing 13 in any suitable manner in a predetermined positional relationship to the shoe 12, so as to have operative engagement therewith. The switch 14 is of the enclosed type, so as to protect its working parts from dust and other foreign matter to which

it might become exposed. However, as the description proceeds, it will be apparent that the principles of the invention apply as well to a switch which is not necessarily of the enclosed type.

In the switch device shown in the drawings, a housing 15 is provided in which is journaled the shaft 16 of a lever arm 17 which extends exteriorly of the housing 15 and abuts the actuating shoe 12 of the centrifugal device. The housing 15 consists of two assembled halves 18 and 19 which, for convenience in manufacture, may be of identical configuration thereby permitting the switch to be assembled for either left hand or right hand operation, as desired. The housing parts 18 and 19 are preferably made by the injection molding of synthetic resins. Each half of the housing 15 is provided with a pair of oppositely disposed projections 20 which, in assembly, provide an external boss on each side of the housing for receiving a spring clip 21 for retaining the housing parts 18 and 19 in assembled relationship. Transversely extending openings 22 extend through the housing 15 and serve to accommodate mounting bolts 23 or the like by means of which the switch 14 can be secured to the motor housing 13. It will be apparent that the fasteners 23 could also be utilized to retain the housing parts 18 and 19 in assembled relationship in lieu of the spring clip 21 or other means such as adhesive joiner could be used for retaining the housing halves in assembled relationship.

As previously indicated, the shaft 16 is journaled for rotation in aligned openings 24 provided in the wall 25 of the housing 15. Longitudinally spaced portions of enlarged diameter serve as retaining collars 26 on the shaft 16 adjacent to the inner faces of the wall 25. Centrally of the shaft 16 is a support surface or table 27 having a pair of upstanding spaced retaining walls 28 each of which has a projection or boss 29 extending in an inboard direction therefrom. The support surface 27 is adapted to accommodate a contact plate 30 which is provided with a pair of peripheral recesses or notches 31 through which the bosses 29 project. The opposite end of the contact plate 30 carries a pair of electrical contacts 32 on the underside thereof, one of which is adapted to make electrical contact with a contact arm 33 and the other of which is adapted to make electrical contact with a contact arm 34. It will be understood that the number of contacts is merely exemplary and that the principle of operation of my switch will apply equally to a single contact device as well as to a multiple contact device.

The contact plate 30 is not secured to the support table 27 but merely rests thereupon and is yieldably retained against displacement by a low pressure coil spring 35, one end of which is anchored to the wall 25 of the housing 15 and the other end of which is centered on a dimpled portion 36 of the plate 30.

The compression spring 35 resiliently maintains the contact plate 30 in planar abutment with the surface of the underlying table 27 and thereby also urges the table into a downward rotative movement. This movement is opposed by a constant force spring 37 which has one end thereof anchored to the housing wall 25 and the other end bearing against the underside of the table 27 in opposition to the spring 35. The spring 37 is of the type commonly called "constant tension" and has the characteristic feature of maintaining a substantially uniform load or force over a broad range of deflection.

As previously indicated, the constant tension spring 37 is designed to apply a substantially greater pressure or force to the underside of the table 27 than is applied by the conical coil spring 35 to the contact plate 30. This ratio of forces may be on the order of 2:1, but preferably is in the range of 4:1 to 8:1, this being somewhat dependent upon the number of contacts, and the minimum contact closing force of the spring 35. Accordingly, in those instances where the spring 35 may have a very low force value, the spring 37 may have a force providing a ratio of 8:1, but where circumstances require that spring

35 have somewhat higher pressure values than the force of the spring 37 may necessarily have to be a lower multiple of the force of spring 35 in order to accomplish the objectives of the invention. By way of example, the spring 35 may have a contact closing force of one ounce whereas the spring 37 may have a counter-force of six ounces for a 6:1 ratio. If design requirements make it necessary for the spring 35 to have a contact closing force of one and one-half ounces, then the spring 37 might be designed for a force of seven and one-half ounces for a 5:1 ratio; or if spring 35 is designed or required to provide two ounces of force, then spring 37 might be designed for eight ounces of force to provide a 4:1 ratio. Those skilled in the art will recognize and be able to evaluate the various factors which must be considered and compromised in the design of a switch of the type herein described.

Although any suitable means can be utilized for securing the contact arms 33 and 34 in desired position within the body of the switch, I have found it expedient and economical in manufacture to provide each of the housing parts 18 and 19 with arm-receiving recesses 38, 39 and 40 and with appropriate integral dowels, such as 41 and 42 which permit the contact arms 33 and 34 to be accurately positioned and clamped between the housing halves 18 and 19. Each contact arm is provided with an external terminal portion 43 for connecting the switch into the appropriate electrical circuit which, in the instant disclosure, would be the starting winding circuit of an electrical motor.

Referring more particularly to FIGS. 3 and 4 of the drawing, the operation of the switch 14 will now be described. FIG. 3 shows the position of the parts when the switch actuating member or lever arm 17 is in the solid line position of FIG. 1. In this position the rotary element 11 has attained operating speed and the shoe 12 is in retracted position as shown in solid lines in FIG. 1. The lever arm 17 maintains contact or abutment with the surface of the shoe 12 and maintains a constant force thereon represented by the lever fraction of the net resultant of the opposed forces of the springs 35 and 37. The spring 35 maintains the contact plate 30 in abutment with the upper surface of the table 27, but the opposing action of the spring 37, as limited by the position of the lever arm 17, positions the contact plate 30 so as to maintain the contacts in open position. The gap between the contacts on plate 30 and the contacts on the contact arms 33 and 34 in fully open position will ordinarily be on the order of .030 inch. An upstanding abutment 44 is provided on the wall of the housing 14 in the path of opening movement of the contact plate 30 to establish the upper limit of opening movement of that plate.

In FIG. 4 the switch parts are shown in the position they assume when the motor is at rest or below established operating speed and the shoe 12 of the centrifugal device 11 has snapped into the forward position shown in phantom outline in FIG. 1. In this forward position of the actuating shoe 12, the switch-actuating element or lever arm 17 is depressed causing axial rotation of the shaft 16 and corresponding contact-closing rotation of the support table 27 in opposition to the spring 37. During the initial portion of this movement, the spring 35 maintains the contact plate 30 in abutment with the table 27 and the contact plate moves or rotates therewith. However, as soon as the electrical contacts of the plate 30 engage the contacts on the arms 33 and 34, further rotary movement of the floating contact plate 30 is arrested while movement of the table 27 continues with the end of the contact plate 30 resting upon a portion 45 of the table which serves as a fulcrum for the plate 30 during the continued movement. During this lost motion movement between the table 27 and the contact plate 30, the projections 29 act as drivers and engage the notches 31 in the contact plate to give the contact plate a linear com-

ponent of forward movement in response to the arcuate movement of the drivers 29.

It will be noted that during the movement of the lever arm 17 from the open position of FIG. 3 to the position where the electrical contacts are in abutment, the force exerted by the lever arm 17 against the shoe 12 of the centrifugal device remains uniform and constant as there is only an insignificant change in the deflection of the spring 35 between these two positions. Moreover, as the lever arm travels beyond the position in which the contacts have closed the circuit, the constant force spring 37 maintains a uniform pressure of the lever arm against the shoe 12. This force is only slightly greater than the net effect of the spring forces on the lever arm when the switch is in open position and results from the elimination of the counter-effect of the force of the spring 35 on the lever arm 17. However, even this force is not entirely eliminated because the spring 35 still exerts some force on the lever 17 through the engagement of the contact plate 30 with the fulcrum 45. Due to these factors, and more importantly due to the relative weakness of the spring 35 compared to the spring 37, the change in force on the lever arm 17 between the open and closed position of the switch is so slight as to be of no practical significance in its effect on the operation of the rotary device 11.

Inasmuch as the overtravel of the lever arm 17 beyond the contact-closing position is independent of the contact plate 30, it is apparent that, within practical limits, positional variations between the switch and the rotary 11 which may result from manufacturing tolerances, will have no effect in changing the force exerted by the lever arm 17 on the shoe 12 and will therefore not cause any variation in the operating characteristics of the rotary device 11.

It will be understood that when the electric motor is at rest, the switch parts are in the relative position shown in FIG. 4 of the drawings, so that when the motor is energized the circuit to the starting winding is closed. When the motor reaches the predetermined operating speed at which the shoe 12 of the rotary device is retracted, the switch parts will assume the open circuit position shown in FIG. 3. During this movement from closed contact to open contact position, the spring 37 exerts the contact-opening force and, since it is relatively strong, it is effective to break any weld that may have occurred in the normal operation of the contacts. During the opening movement, the drivers 29 act upon the contact plate 30 for a reversal of the linear movement previously described, so that there is a wiping action between the electrical contacts both in the opening and closing movements of the switch. This wiping action serves to keep the surfaces of the electrical contacts clean and smooth, as well as assisting in the breaking of any welds between the contact faces. The contact-closing force is determined by the spring 35 and is independent of the extent of travel of the lever arm 17 or of the force exerted on that lever arm by the shoe 12.

Thus, by using a floating contact plate which has a lost motion connection to the lever arm 17, biasing that contact plate with a relatively weak spring to obtain a predetermined contact-closing force, and biasing the lever arm and the support table for the contact plate with a constant force spring of relatively substantially greater strength in opposition to the contact-closing spring, I have attained the objectives of the invention. It will also be noted that neither of the springs nor any components of the actuating lever 17 are current-carrying circuit elements of the switch. This has advantages in eliminating any requirement that these components be made of electro-conductive materials and, further, avoids any change in the temper of the springs which might result from current-induced heating.

It is to be understood that the form of my invention, herewith shown and described, is to be taken as a preferred example of the same, and that various changes in

the shape, size and arrangement of parts may be resorted to, without departing from the spirit of my invention, or the scope of the subjected claims.

Having thus described my invention, I claim:

1. In an electrical switch, the combination of contact elements mounted for relative movement into and out of circuit-closing relationship, first spring means bearing upon and urging one of said contact elements toward circuit-closing position, second spring means bearing upon and urging said one contact element toward circuit-opening position in opposition to said first spring means, one of said spring means exerting a force upon said one contact element less than one-half the force exerted by the other of said spring means, and movable switch-operating means operatively interposed between said first and second spring means for selectively disengaging said spring means from opposition to each other.

2. In an electrical switch, the combination of a movably mounted first electrical contact element, a second electrical contact element, said first contact element being movable into circuit-closing engagement with said second contact element, first spring means bearing upon and exerting a contact-closing force on said first contact element, second spring means of greater force than said first spring means bearing upon and exerting an opposing contact-opening force on said first contact element, and movably mounted means engaging said second spring means for selectively withdrawing and isolating said second spring means from opposition to said first spring means, whereby to cause circuit-closing movement of said first contact element.

3. A combination as defined in claim 2, wherein said last-named means comprises a movable member abutting a portion of said first contact element and interposed between said second spring and said first contact element, a lost motion connection between said member and said first contact element, and means for moving said member in a contact-closing direction in opposition to said second spring beyond the contact-closing position of said first contact element.

4. A combination as defined in claim 2, wherein the contact-closing force of said first spring on said first contact element is less than one-half the contact-opening force of said second spring on said first contact element.

5. In an electrical switch, the combination of a movable electrical contact element, a fixed electrical contact element disposed in the path of movement of said movable contact element, a pivotally movable support abutting said movable contact element and having a lost-motion connection therewith, first spring means bearing upon and exerting a contact-closing force upon said movable contact element to bring said contact elements into circuit-closing position, second spring means bearing upon and exerting a greater contact-opening force on said movable support in opposition to said first spring means, and means for moving said support to a position out of opposition to said first spring means, whereby to cause circuit-closing movement of said movable electrical contact element.

6. A combination as defined in claim 5, wherein said movable contact element is biased by said first spring into said abutment with said movable support, said movable contact element moves pivotally with said support to contact-closing position, and means are provided on said support and engaging said movable contact element for imparting rectilinear movement to said contact element in response to pivotal movement of said support beyond said contact-closing position of said movable contact element.

7. A combination as defined in claim 5, wherein said second spring means is characterized by the ability to exert a substantially uniform force over its operative range of deflection.

8. A combination as defined in claim 5, wherein said second spring means has a force from four to eight times greater than the force of said first spring means.

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9. In a stationary starting-winding switch for an electrical motor having a rotary speed-responsive switch-actuating member engageable with said device and movable into and out of circuit-closing position in response to the operation of said device, a contact-support member carried by said switch-actuating member and movable therewith, a movable contact element, first spring means biasing said contact element into abutting relationship with said support member, second spring means engaging said support member in opposition to said first spring means, a second contact element disposed in the path of movement of said movable contact element, said first spring means urging said contact elements into circuit-closing position, said support member being movable beyond the circuit-closing position of said movable con-

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tact element to withdraw and isolate said second spring means from opposition to said first spring means, and said second spring means having a constant force characteristic greater than the force of said first spring means, whereby to maintain a uniform force upon said switch-actuating member after said switch-actuating member has been moved by said device beyond said circuit-closing position of said contact elements.

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