Oct. 23, 1956 J. GREENHUT 2,768,260

CONSTANT-LOAD SPRING-LOADED STATIONARY STARTING SWITCH FOR ELECTRIC MOTORS

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FIG. 1

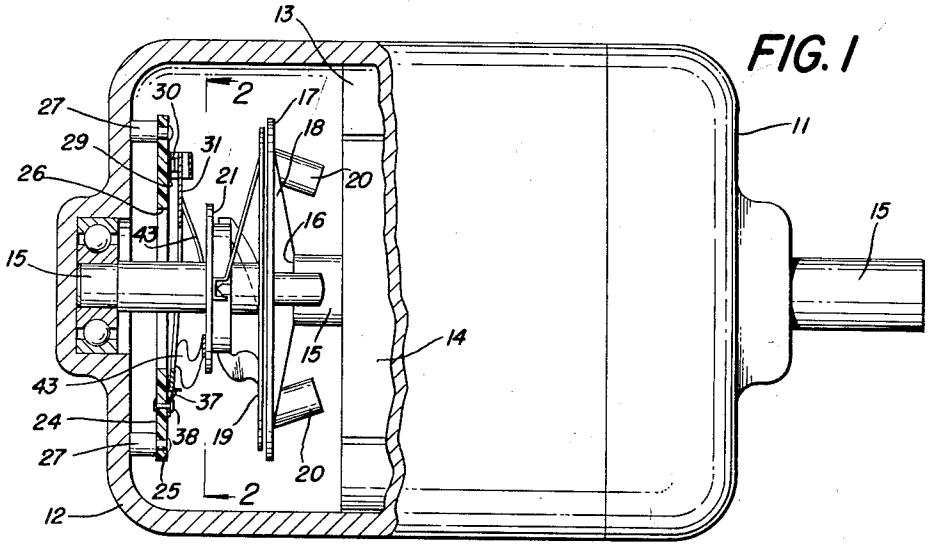


FIG. 2

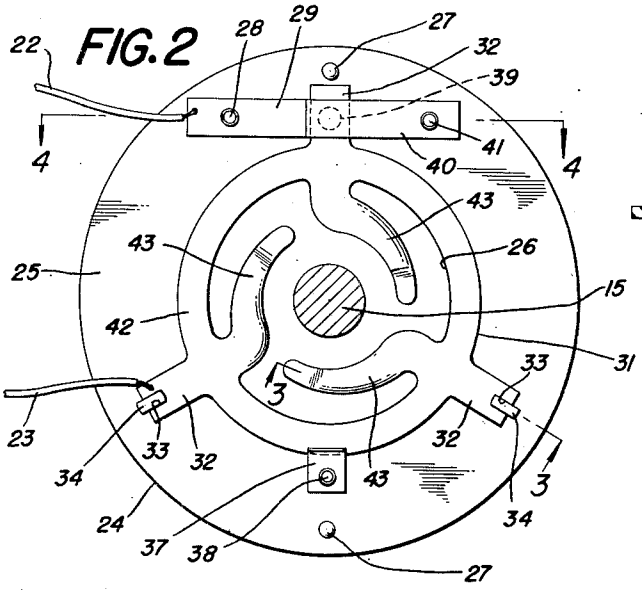


FIG. 4

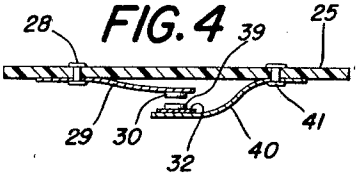
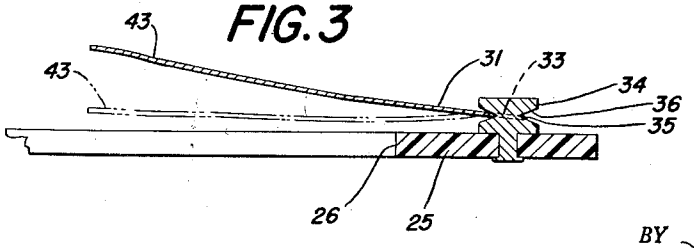


FIG. 3



INVENTOR.
JOSEPH GREENHUT

BY Isler & Dressler

ATTORNEYS

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FIG. 5

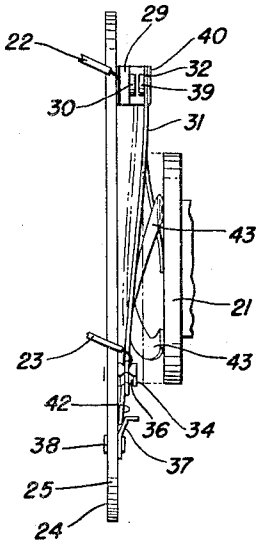


FIG. 6

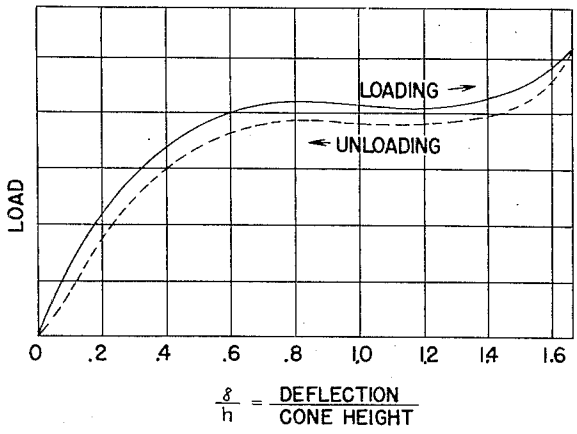


FIG. 7

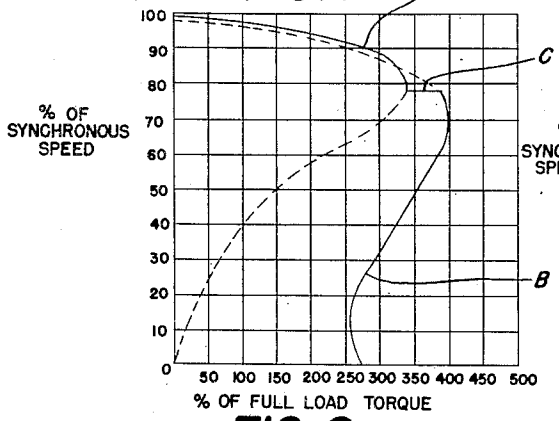


FIG. 8

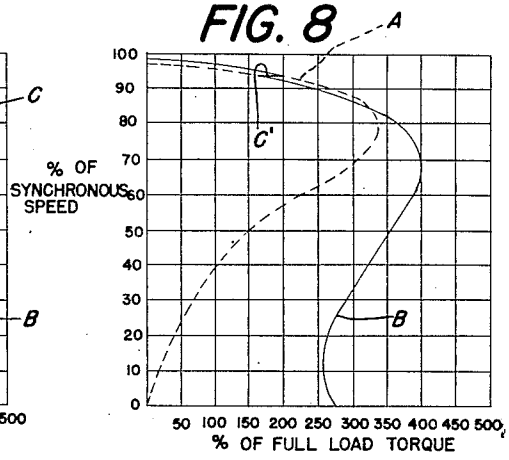


FIG. 9

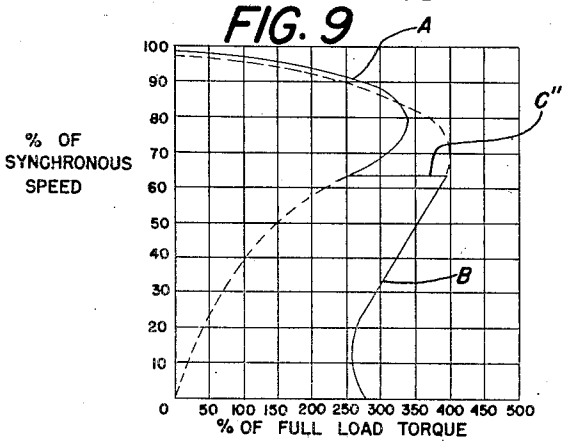
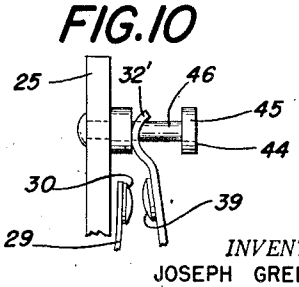


FIG. 10



INVENTOR.
JOSEPH GREENHUT

BY Lader & Aronstein

ATTORNEYS

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CONSTANT-LOAD SPRING-LOADED STATIONARY STARTING SWITCH FOR ELECTRIC MOTORS

Joseph Greenhut, University Heights, Ohio

Application April 2, 1953, Serial No. 346,372

7 Claims. (Cl. 200—80)

This invention relates to the starting switches of electrical motors and more specifically to the stationary switching element of the starting circuit of a single phase induction motor of the split-phase type.

In split-phase 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 resistance-start, reactor-start and capacitor-start split-phase motors, 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 resilient 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, relating to an improved centifugal actuating unit, for a more detailed description of such starting devices.

There are, of course, many correlated factors which must be taken into consideration in designing such switching devices for a particular motor design. Among these factors, is the tension or load characteristic on the centrifugal or rotary unit which is a resultant of the combined effect of the spring characteristics of both the stationary switch and the rotary actuating unit.

It would be expected that the operating characteristics of a starting switch would be consistent and uniform after such a switch had been developed and tested in a motor of particular design. This would be so, if all the factors upon which the switch design and motor design were based, remained constant. However, large scale production methods must allow for manufacturing tolerances which ordinarily are kept within limits which do not affect product performance.

It has been found that the cumulative effect of dimensional manufacturing tolerances in the production of electric motors is often reflected in unsatisfactory and unreliable starting switch operating characteristics. It has been established that the load characteristics on the rotary unit, specifically mentioned in the next preceding paragraph, are extremely sensitive to variations in the spacing between the stationary switch and the rotary unit, even though such dimensional variations are restricted to the range of practical manufacturing tolerances.

Thus, one of the factors, which should be fixed or constant in order to obtain uniformly consistent starting switch performance, is, instead, variable and cannot be controlled within the limits of mass production manufacturing tolerances.

It is the primary object of my invention to provide a starting switch which will, within practicable limits, be unaffected in its performance characteristics by dimensional spacing variations of the character above-descrbed.

Another object of my invention is to provide a method for constructing starting switches to obtain consistency

of performance characteristics in spite of dimensional spacing variations.

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 side elevation of an electric motor embodying the features of my invention, portions thereof being broken away to show details of the starting switch.

Fig. 2 is a plan view of the stationary switch viewed as indicated by the line 2—2 on Fig. 1.

Fig. 3 is a fragmentary transverse cross-sectional view taken as indicated by line 3—3 of Fig. 2.

Fig. 4 is a transverse cross-sectional view of the stationary switch taken on line 4—4 of Fig. 2.

Fig. 5 is a side elevation of the switch unit shown in Fig. 1.

Fig. 6 is a graph showing the load-deflection characteristics of the spring element of the stationary switch shown in Figs. 1–5.

Figs. 7, 8 and 9 are graphs showing the speed-torque curves of split phase motors under varied conditions of manufacturing tolerance, and

Fig. 10, is a fragmentary side elevation of a modified form of securement for the stationary switch illustrated in Figs. 1–5.

Referring more particularly to the drawings, I have shown in Fig. 1 a representative electric motor **11** including a motor casing or housing **12**, a stator **13**, a rotor **14** and a rotatable shaft **15**. These elements are of conventional design and form no part of the present invention.

Fixedly secured to the shaft **15**, in abutment with an annular shoulder **16** thereof, is a speed-responsive centrifugally-energizable switch actuating unit **17** which is commonly and more briefly termed the "rotary unit" or "rotary." The rotary **17** may be of conventional design and reference is made to my U. S. Patent No. 2,616,682 for a description of a form of rotary which may be utilized.

Briefly, the rotary unit **17** includes a body member or base plate **18**, a resilient toggle plate or spring **19**, a plurality of movable weights **20** secured to the toggle plate **19** and a longitudinally movable switch-engaging shoe **21**. The movement of the weights **20**, in response to centrifugal force, causes the shoe **21** to withdraw or retract from the circuit closing arm of the switch in a manner well known in the art. It is to be noted that the switch arms of the prior art starting switches are resilient or spring-pressed so that the starting circuit will be opened when the shoe **21** is retracted. The spring pressure of the stationary switch is opposed to the spring pressure of the rotary unit. The foregoing is disclosed in the above-mentioned patent.

Before proceeding with a description of the novel stationary switch structure disclosed in the drawings, reference will be made to the graphs shown in Figs. 7, 8 and 9 of the drawings for a fuller understanding of the problem here involved.

In Fig. 7 is shown the speed-torque curve of a representative high-torque spilt-phase motor. The curve A is developed for the main or running winding of the motor. The curve B is developed for the combined starting and main windings. It will be noted that the combined windings develop a much greater torque than the main winding alone until the motor attains about 85% of synchronous speed. At higher speed, the main winding develops more torque than the combined windings. This characteristic of split-lapse motors is well known and is the basis for the use of speed-responsive switches to open the starting winding circuit when a predetermined

motor speed has been attained. The line C designates the switch operating speed and represents the speed at which the switch is operative to open the starting winding circuit thus permitting the motor to run on the main winding alone. The solid lines indicate the circuits actually utilized in bringing the motor up to full speed from a position of rest.

Purely from a maximum torque standpoint, the switch operating speed should coincide with the crossover point of the curves A and B. As a matter of practice, however, the starting switches are generally designed to operate at a slightly lower speed; in this instance, at about 78% of synchronous speed. If, for any particular design of motor and starting switch, the switches would operate at the speed for which they were designed, there would be no particular problem. The fact is that identical switch assemblies, mounted in several motors of identical manufacturing design, will not operate at identical speeds.

I have found that this unexpected and unpredictable variation in switch operating speeds can generally be traced to variations in the dimensional spacing between the rotary and the stationary switch. It must be emphasized that this spacing variation does not represent faulty manufacture, but is entirely within the practicable manufacturing tolerances established.

In Fig. 8, the curves A and B of Fig. 7 have been reproduced to illustrate one of the effects on the switch operating speed as a consequence of spacing variation. In this instance, although the individual components of the motor were all within the established limits of manufacturing tolerance, the cumulative effect of minor dimensional variations resulted in a change of plus .045 inch in the spacing between the stationary and rotary units. Thus, instead of being spaced apart x inches as in Fig. 7, the switch elements were spaced x plus 0.45 inch. This increased spacing resulted in a decreased deflection of the stationary switch arm and a corresponding reduction in the pressure of force exerted by it upon the rotary. The result was that the interplay of spring pressure on the rotary was diminished and the centrifugal forces acting on the rotary had to be augmented to actuate the rotary. Therefore, as illustrated by line C' in Fig. 8, the switch operating speed increased to about 92% of synchronous speed, and the starting winding was retained in the circuit overly long.

In Fig. 9, I have again shown the curves A and B and have illustrated the circuits established as a result of a variation in spacing in the minus direction. In this instance the cumulation of tolerances resulted in a spacing of x minus .045 inch between the stationary and the rotary elements. The increased deflection of the switch arm created an undesirable and unforeseeable increase in the interplay of spring forces which resulted in the lower switch operating speed indicated by line C''. The resulting opening of the starter winding circuit at about 63% of synchronous speed caused a premature switchover to the main winding only with a torque drop of almost 150 percentage points.

Figs. 8 and 9 are thus illustrative of the adverse effects which are caused by spacing variations of the character described. To overcome this difficulty by narrowing the tolerance limits in manufacture would, if otherwise feasible, be prohibitive in cost.

My method of overcoming the difficulty involves no significant increase in cost and consists broadly in maintaining the spring pressure of the switch assembly substantially constant and independent of spacing variations of the magnitude which would result from cumulations of the manufacturing tolerances which are ordinarily used in the motor industry. An embodiment of this method is shown in Figs. 1–5 of the drawings to which further reference will now be made.

The starting winding (not shown) is connected by leads 22, 23 to a stationary switch assembly 24. The assembly 24 includes a dielectric plate or mounting panel 25 which is provided with a central aperture 26. The panel 25 is secured to the motor housing 12, interiorly thereof, by means of suitable fasteners such as rivets 27. The shaft 15 extends through the aperture 26 of the panel 25 without interference.

Secured to the plate 25, as by rivet 28, is a contact arm 29, which may be of Phosphor bronze or copper, and which is provided with a contact button 30. The lead 22 is connected to the contact arm 29.

A conical disc spring 31, having radially extending circumferentially spaced ears 32, is mounted on the panel 25 in spaced relationship thereto. Two of the ears 32 are notched as at 33 and these ears slidably engage two anchor pins 34 which are fixedly secured to the plate 25. As best seen in Fig. 3, the anchor pins 34 are each provided with a V-shaped recess 35 in which the ear 32 is received. The surfaces 36 of the notch 35 serve as bearing faces or fulcrum during the flexing movement of the spring 31 and the notches also provide adequate relief to permit the slight degree of radial movement which occurs during flexure of the spring. The marginal portion of the disc spring 31 which lies intermediate the notched ears 32 may be additionally anchored by means of a retaining clip 37 which overlies the spring, as indicated, and is secured to the panel 25 by means of a rivet 38.

The third ear 32 has a contact button 39 affixed to the underside thereof so that it overlies and is in registry with the contact button 30.

A retainer arm 40 is secured to panel 25 by rivet 41 and overlies the ear 32 to limit the outward movement thereof, as shown in Fig. 4.

The spring 31 may be stamped out of a cup-shaped disc and includes a frusto-conical ring portion 42 having integral arcuate lever arms 43 which project interiorly of the ring 42 and are substantially concentric therewith. The arms 43 also project outwardly slightly or away from the panel 25.

The lead 23 is connected to one of the notched ears 32 and the electrical circuit to the starting winding is thereby closed when the contact buttons 30 and 39 are in abutment.

As best seen in Figs. 1 and 5, the shoe 21 of the rotary 17 abuts the lever arms 43 of the stationary switch 24. It will, of course, be understood that the rotary 17 rotates with the shaft 15. In Fig. 1 the motor is shown at rest and the spring-pressed shoe 21 bears against the lever arms 43 to maintain the contact button 39 on spring 31 in abutment with the contact button 30 on arm 29. The starting circuit is thereby closed. The position of the various parts at rest is also shown in broken lines in Figs. 3 and 5.

When the motor is energized, the weights 20 swing outwardly in response to centrifugal force and at a predetermined speed cause retraction of the shoe 21 to the solid position shown in Fig. 5. The load on the spring 31 is thereby reduced and the contacts 30 and 39 separate, as shown in Fig. 4, to open the circuit to the starting winding.

The switch operating speed will remain substantially uniform irrespective of variations in the switch spacing which may occur as a result of manufacturing tolerances in individual motor assemblies of identical design. This improved result is obtained because the spring 31 is a constant-load spring and exerts a substantially uniform pressure over a relatively wide range of deflection.

In Fig. 6 this characteristic of the spring is shown graphically by the load-deflection curves. It will be noted that a substantial portion of the curve shows steadily increasing deflection at substantially constant-load. Thus the load characteristics of the spring 31 would not be materially affected by moderate dimensional spacing variations which would increase or decrease the deflection of the spring.

By incorporating a constant-load spring in a stationary switch, the switch operating speed of the rotary remains unaffected by a variation in spacing of the character heretofore described. Dimensional deviations on the order of plus or minus .045 inch, or a total of .090 inch, which have heretofore produced the undesirable characteristics illustrated in Figs. 8 and 9, have had no significant effect on switch operating speeds when the constant-load spring is embodied in the switch assembly.

In Fig. 10, I have shown a modification of the invention in which a guide pin **44**, having an enlarged head **45**, is utilized to limit the movement of the spring **31**, in lieu of the previously described retainer arm **40**. In this form of the invention, the ear **32'**, which carries contact button **39**, is notched to slidably engage the shank or stem **46** of the guide pin. The head **45** of the pin limits the movement of the ear **32'**.

The form of stationary switch shown in the drawings is exemplary of an embodiment of my invention. It may be noted at this point, that the constant-load disc spring lends itself readily to incorporation in a stationary switch and I consider its use preferable to other forms of resilient elements. In using the constant-load disc spring, it is important that the spring be elevated slightly above the surface on which it is mounted, as by the pins **34**, illustrated. This mounting permits deflection of the spring **31** beyond the abscissa point 1.0 shown on the chart in Fig. 6. If the spring is mounted flush against a flat surface, the constant-load deflection characteristics are restricted to a much narrower range than is shown in Fig. 6, and the full advantages of the constant load disc spring are not obtained.

The lever arms **43** may be varied in length and in position to suit the characteristics of the switch design or the motor design. The lever arms, of source, produce a mechanical advantage in relation to the ring portion **42** of the spring and produce an effective deflection range for the spring which is proportional to the basic deflection range of the ring portion.

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 subjoined claims.

Having thus described my invention I claim:

1. In a motor starter device of the type having a movable switch, resilient means operatively engaging said switch to maintain it in closed position, and shaft-mounted speed-responsive means engaging said resilient means to disengage said resilient means from said switch, said speed-responsive means being axially spaced from said switch within predetermined dimensional limits defining a spacing range; the improvement consisting of a resilient element engaging said switch in opposition to said resilient means and yieldably urging said switch to open position, said element being characterized by a substantially constant load factor within a range of deflection corresponding to said spacing range.

2. In a motor starter device of the type having a movable switch, resilient means operatively engaging said switch to maintain it in closed position, and shaft-mounted speed-responsive means engaging said resilient means to disengage said resilient means from said switch, said speed-responsive means being axially spaced from said switch within predetermined dimensional limits defining a spacing range; the improvement consisting of a mounting panel, a fixed contact of said switch carried by said panel, a resilient element mounted on said panel, and a movable contact of said switch carried by said resilient element, said resilient element being disposed in opposition to said resilient means to yieldably urge said switch to open position, and said element being characterized by a substantially constant load factor within a deflection range corresponding to said spacing range.

3. In a motor starter device of the type having a movable switch, resilient means operatively engaging said switch to maintain it in its closed position, and shaft-mounted speed-responsive means engaging said resilient means to disengage said resilient means from said switch, said speed-responsive means being axially spaced from said switch within predetermined dimensional limits defining a spacing range; the improvement consisting of a conical disc spring engaging said switch in opposition to said resilient means to yieldably urge said switch to open position, said spring being characterized by a substantially constant load factor within a range of deflection corresponding to said spacing range.

4. In a motor starter device of the type having a movable switch, resilient means operatively engaging said switch to maintain it in closed position, and shaft-mounted speed-responsive means engaging said resilient means to disengage said resilient means from said switch, said speed-responsive means being spaced axially from said switch within predetermined dimensional limits defining a spacing range; the improvement consisting of a mounting panel supporting said switch, and a conical disc spring carried by said mounting panel in elevated spaced relationship thereto and engaging said switch in opposition to said resilient means to yieldably urge said switch to open position, said spring being characterized by a substantially constant load factor within a range of deflection corresponding to said spacing range.

5. In a motor starter device of the type having a movable switch, resilient means operatively engaging said switch to maintain it in closed position, and a shaft-mounted speed-responsive member operatively connected to said resilient means to selectively disengage said means from said switch, said member being axially spaced from said switch within predetermined dimensional limits defining a spacing range; the improvement consisting of a conical disc spring engaging said switch in opposition to said resilient means to yieldably urge said switch to open position, said spring being characterized by a substantially constant load factor with a range of deflection corresponding to said spacing range, and force-compounding fingers integral with said spring and actuated by said resilient means engaging said spring.

6. A method of reducing variations in the operating speed of centrigually-actuated starter switches for motors resulting from manufacturing variations in the dimensional spacing between the spring-loaded stationary and spring-loaded rotary units of such switches, comprising the steps of impressing a constant substantially uniform load on the spring of said rotary unit while simultaneously deflecting the spring of said stationary unit through a dimensional range corresponding to the range of the aforesaid manufacturing variations in the dimensional spacing between the stationary and rotary units.

7. A method of reducing variations in the operating speed of centrifugally-actuated starter switches for motors resulting from variations in the dimensional spacing between the opposed spring-loaded stationary and spring-loaded rotary units of said switches, comprising the steps of impressing a load on the spring of said rotary unit, and maintaining said load uniform while deflecting the spring of said stationary unit in a deflection range corresponding to the range of the aforesaid vairations in dimensional spacing.

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