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Madland

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[54] **TACTILE FEEDBACK SWITCH MECHANISM**

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[73] Assignee: **Illinois Tool Works Inc.,** Chicago, Ill.

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[21] Appl. No.: **403,372**

[52] **U.S. Cl.** ..... **200/159 R;** 340/365 R; 197/98

[51] **Int. Cl.** **H01h 13/52**

[58] **Field of Search** ..... 200/159 R, 160; 197/98; 340/365 R

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Assistant Examiner—William J. Smith

[57] **ABSTRACT**

A feedback switch mechanism for a manually operated, nonmechanical switch for keyboards, and the like, is provided through use of a spring-loaded cam follower carrier that has a cam follower which follows a cam surface that is integrally formed on the plunger of the switch. Upon depression of the plunger, a force build-up and release occurs due to the action of a bias spring on the cam follower carrier which simulates the actuation of a mechanical switch so that the operator is assured that a data entry has been completed. The cam follower carrier is preferably a one-piece plastic member.

6 Claims, 10 Drawing Figures

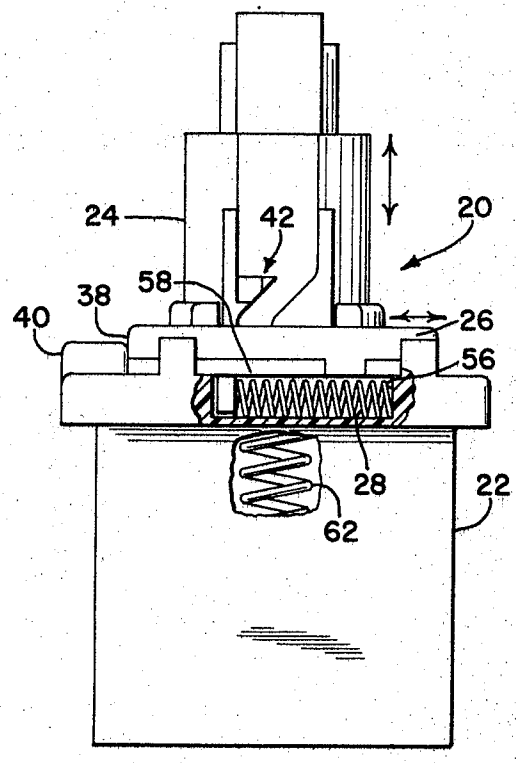


Fig. 1

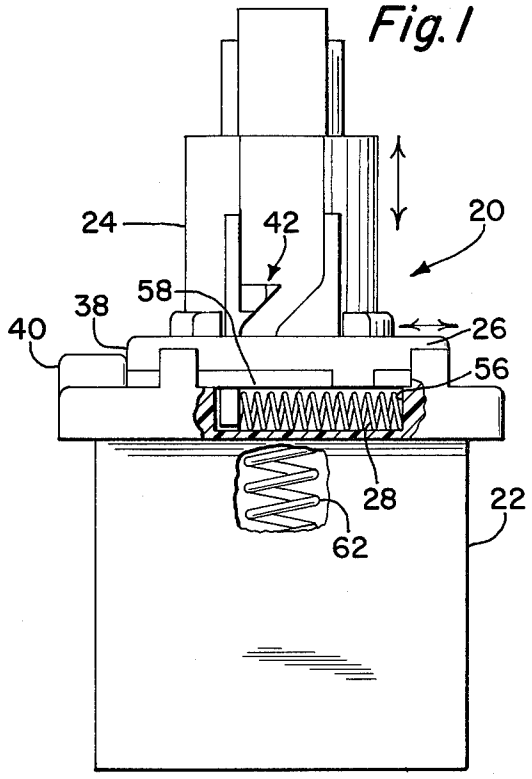


Fig. 2

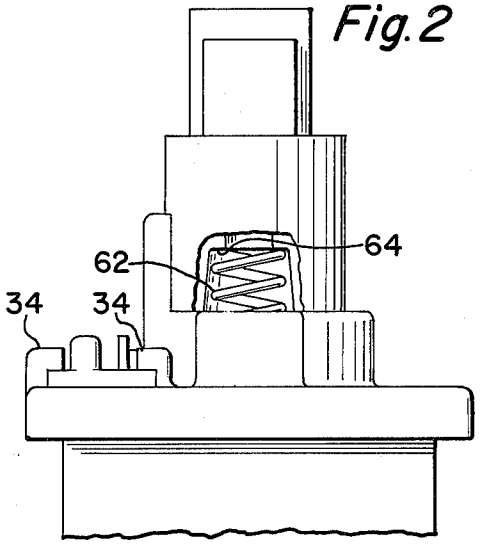


Fig. 3

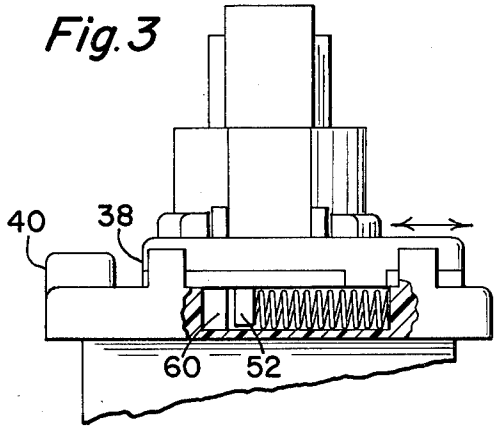
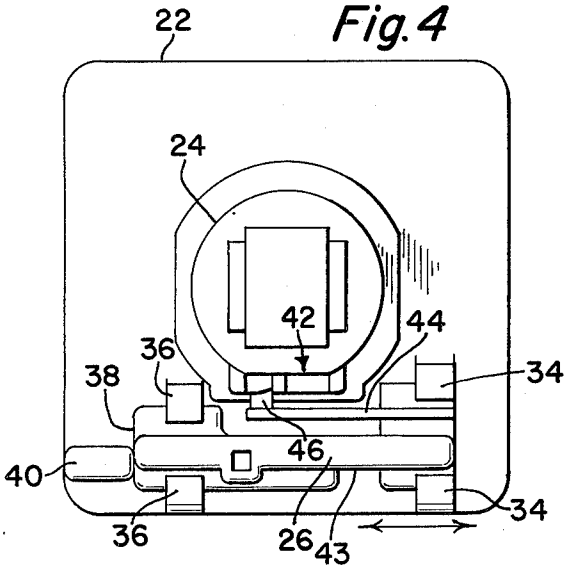


Fig. 4



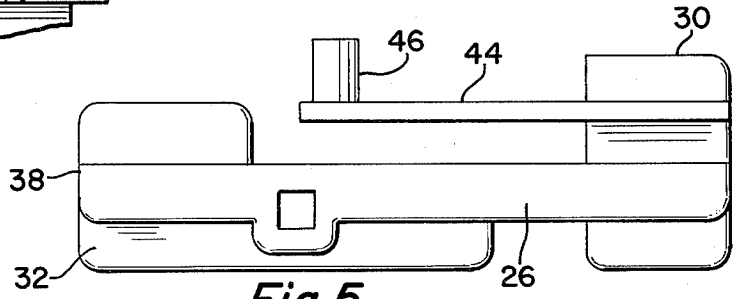


Fig. 5

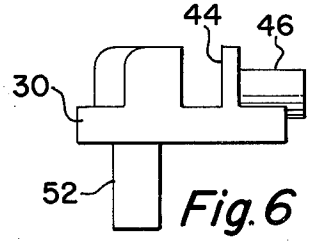


Fig. 6

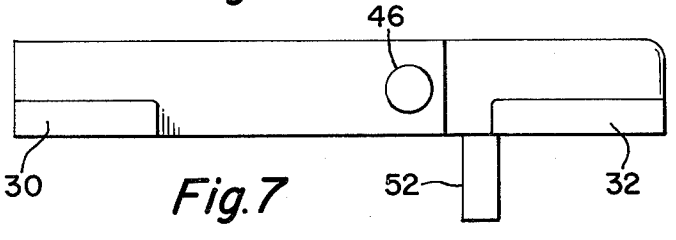


Fig. 7

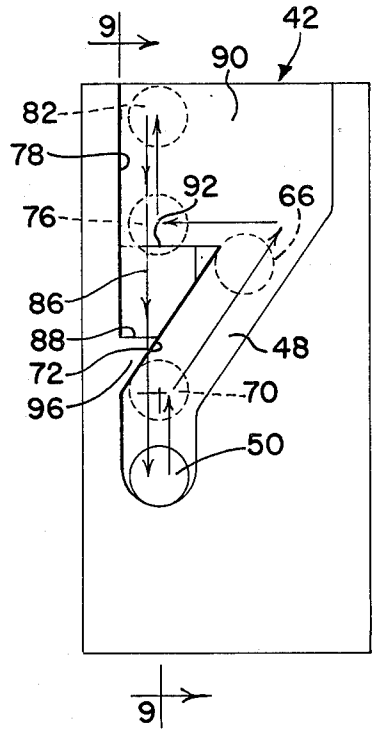


Fig. 8

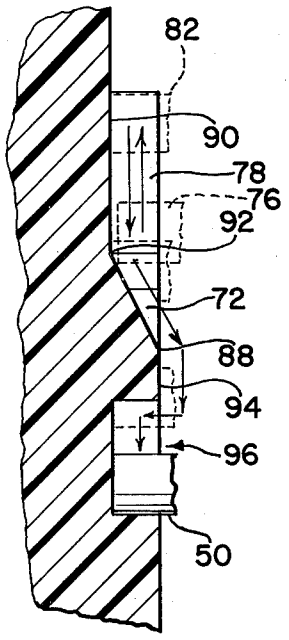


Fig. 9

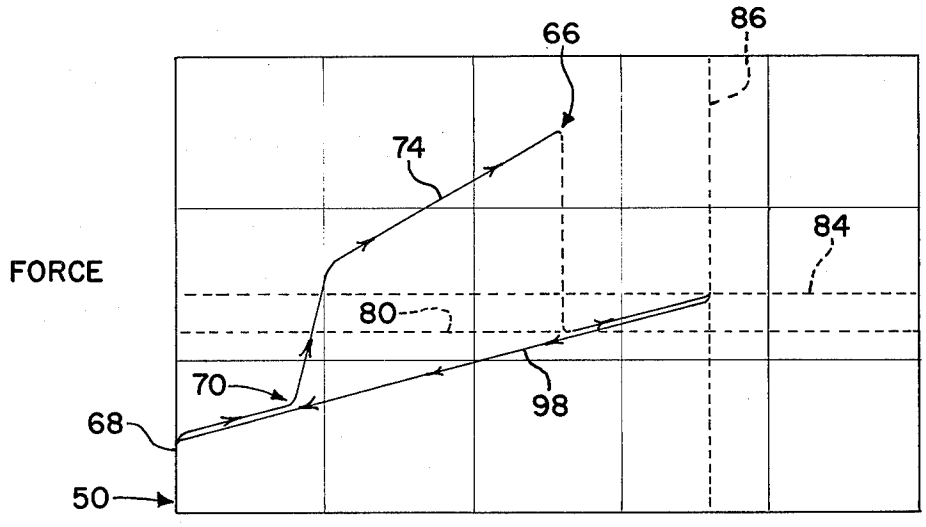


Fig. 10

TACTILE FEEDBACK SWITCH MECHANISM

BACKGROUND OF THE INVENTION

Nonmechanical switches for use in keyboards, and the like, are being utilized to an increasingly extent in modern electronics systems. One of the major reasons for this is that mechanical switches tend to become unreliable after a large number of operations, due to corrosion and pitting of the contacts and to other mechanical failures. In addition, with mechanical switches there is always the problem of contact bounce which creates noise signals that can interfere with the proper operation of the associated device. A number of types of switches including electronic, magnetic, and Hall-effect devices have been designed to provide a nonmechanical electrical switching action. One such device, with which the present invention may be employed, is shown in U.S. Pat. No. 3,638,221 issued in the name of Victor M. Bernin on Jan. 25, 1972, and assigned to the assignee of the present invention. In the switch of this patent, a saturable magnetic core and a pair of permanent magnets are employed. The permanent magnets are attached to a keystem that is depressed by the operator, which changes the state of magnetic saturation of the magnetic core, thereby determining whether or not an output signal will be produced.

While several of the nonmechanical switches, which have been developed, perform in a satisfactorily manner in many applications, they tend to be viewed unfavorably for many other applications because of the fact that the operator has no positive indication when a switch has been operated. This is due to the lack of noise or "feel" in these switches resulting from the fact that no substantial mechanical action has taken place. Consequently, even though a nonmechanical, manually operated switch may be extremely reliable in itself, the increase of operator error that results during the use of the switches tends to restrict their wide scale application.

It is, therefore, an object of the present invention to provide a spring-loaded cam follower which is integrally formed on a cam follower carrier and is actuated by a cam that is integrally formed on the actuator of a manually operated, nonmechanical switch, wherein actuation of the actuator causes a force build-up and release which simulates mechanical switch actuation to the operator.

It is an additional object of the present invention to provide a tactile feedback mechanism for keyboard switches, and the like, which require such provisions in order to reduce operator error, wherein the feedback mechanism comprises a three-dimensional cam integrally formed on the plunger of the switch, and a cam follower carrier which is removably secured to the housing of the switch and is biased by a spring that is inserted in a cavity in the housing so that the cam follower carrier is movable along a first axis and wherein the cam follower carrier has a resilient arm that carries the cam follower so that the cam follower is movable along a second axis as the plunger is released from its fully depressed position.

It is a further object of the present invention to provide a tactile feedback mechanism which may be secured to the housing of a manually operated, nonmechanical switch comprising a cam integrally formed on the plunger of the switch, a cam follower carrier, and a coiled spring inserted in a cavity in the housing for resiliently biasing the cam follower carrier along an axis of displacement normal to the axis of displacement of the plunger wherein the force vs. displacement characteristics of the switch during depression of the plunger may be predetermined by selection of the coiled spring and/or cam configuration that is used.

DESCRIPTION OF THE DRAWINGS

The present invention is shown in the following drawings in which:

FIG. **1** is a side view of the tactile feedback switch of the present invention with a partial cross-sectional showing the carrier bias spring and the plunger return spring with the plunger in its undepressed position;

FIG. **2** is an end view of the switch with the plunger in its undepressed position;

FIG. **3** is a partial side view, which is similar to the showing of FIG. **1**, but with the plunger depressed almost to the breakaway point;

FIG. **4** is a top view showing the tactile feedback mechanism in place on the switch housing;

FIG. **5** is a top view of the cam follower carrier removed from the switch housing;

FIG. **6** is an end view of the cam follower carrier;

FIG. **7** is a side view of the cam follower carrier;

FIG. **8** is a plan view of the cam portion of the switch plunger;

FIG. **9** is a side elevation of the cam portion of the plunger; and

FIG. **10** is a force vs. displacement diagram for the plunger of the switch.

TECHNICAL DESCRIPTION OF THE INVENTION

The tactile feedback switch mechanism of the present invention is applicable to manually operated, nonmechanical keyboard switches, and other types of switches, which require that stimuli be presented to the operator so that he is assured that actuation of the switch has actually occurred. The stimuli that is presented to the operator includes both mechanical "feel" and noise. "Feel" is accomplished by means of a cam on the plunger of the switch and a cam follower on a spring-loaded cam follower carrier. The loaded spring is selected to control the force build-up and force release which occurs upon depression of the switch plunger. Noise is provided by the striking of the cam follower on a portion of the housing after the breakaway point is passed.

The present invention is a relatively inexpensive addition to a nonmechanical switch, since it adds only two new components to the switch and requires modification of only the plunger and the housing of the switch. The two new components that are added are a plastic one-piece cam follower carrier and a coiled bias spring for the carrier. The plunger of the switch, which is preferably made of plastic, must be designed to include an integral cam, and the housing, which is also perferably made of plastic, includes a cavity that receives the coiled bias spring, a stop means for the cam follower carrier and retaining tabs for the carrier.

In addition to the relatively low cost of the mechanism of the present invention and its simplicity of design, the mechanism has versatility since the force vs. displacement characteristic of the plunger can be predetermined by preselection of the appropriate coiled bias spring and/or cam configuration. In addition, the mechanism is advantageous because of its linear return

characteristic, which results from the fact that the return of the plunger to its initial position after full depression is governed almost entirely by the spring characteristics of the plunger return spring.

A nonmechanical switch is shown generally by the reference numeral **20** in FIG. **1.** This switch may be of the type shown in the previously mentioned U.S. Pat. No. 3,638,221, but the particular type of switch mechanism that is employed is not of importance with respect to the present invention. The switch mechanism itself is housed in the housing **22** and it is actuated by depressing the plunger **24.** The housing **22** and the plunger **24** are preferably formed of plastic. The tactile feedback mechanism of the present invention requires the addition of only two new parts to the nonmechanical switch mechanism of the switch **20.** One of these parts is a one-piece cam follower carrier, preferably molded of plastic, that is formed as shown in FIG. **5.** The other part is the coiled bias spring **28** for the cam follower carrier **26.** The cam follower carrier **26** has a front wing **30** and a rear wing **32** which slides under the front and rear retaining tabs **34** and **36,** respectively, so that the rear end **38** of the cam follower **26** abuts against the stop member **40** that is integrally formed on the switch housing **22.** The cam follower **26** is removable from the switch housing **22** by the application of pressure on the cam follower carrier **26** so as to displace it to the right, as shown in FIG. **4** and by lifting it up when the notch **43** reaches the tabs **34.** The plunger **24** carries the integrally molded cam **42.** When the plunger is in an undepressed position, as shown in FIG. **1,** the end **38** of the cam follower carrier **26** is in abutment with the stop member **40.** The cam follower carrier **26** has a resilient arm **44** which is integrally formed on the front **30** so that it is supported in cantilever fashion and extends towards the rear wing **32.** A cam follower **46** is integrally formed on the end of the arm **44,** which is preferably of a generally circular cross-sectional shape. With the plunger **24** undepressed, the cam follower **46** rests in the cam slot **48,** as shown in FIG. **8,** at its lower most position **50.**

Extending from the bottom of the cam follower carrier **26** is a tongue **52.** The tongue **52** is utilized to receive one end of the coiled spring **28,** the other end of which engages the righthand wall **56** of the generally rectangular shaped cavity **58** that is formed in the upper portion of the housing **22.** The longitudinal axis of the coiled bias spring **28** lies along a line substantially parallel to the longitudinal axis of the elongated cam follower carrier. The left side of the cavity **58** is provided with a notch **60** of narrower dimensions than the remainder of the cavity **58** for receiving the cam follower carrier **26** when the plunger **24** is not depressed. The return spring **62** for the plunger **24** is inserted to abut the plunger wall **64** at its upper end and a portion of the housing or the switch mechanism at its lower end.

Operation of the switch mechanism of the present invention can best be understood by reference to FIGS. **8, 9** and **10.** FIG. **8** shows an enlarged view of the cam section **42,** which is integrally formed on the plunger **24.** Interaction between the cam **42** and the cam follower **46** and between the cam follower carrier **26** and the bias spring **28** determines the force build-up and release characteristics of the switch during depression of the plunger **24** to the breakaway point **66** of the cam **42.** The return spring **62** for the plunger **24** substantially determines by itself the return characteristics of the switch once the breakaway point **66** has been reached.

With the plunger **24** in its undepressed position, as shown in FIG. **1,** the cam follower **42** is initially at its lower most point **50** on the cam **42.** This point corresponds to the origin of the force vs. displacement curve of FIG. **10.** A small amount of force is initially required to produce any displacement at all due to frictional resistance and the initial loading effect of the return spring **62.** The force required to overcome the initial loading is represented by line **68** in FIG. **10.** As the force is increased and the plunger **24** is depressed, the cam follower **46** moves relative to the cam **42** so that it rides in the groove **48** of the cam **42** to the point **70.** Up to the point **70** the coiled bias spring **28** has not been compressed. As depression of the plunger continues, the cam follower **46** moves relative to the cam **42** so that it travels along the inclined wall **72.** At this time, the cam follower carrier **26** is forced to the left, as shown in FIG. **7,** by the bias spring **28** until the cam follower **46** reaches the breakaway point **66.** The position of the plunger **24** and the cam follower carrier **26** at the breakaway point **66** is shown in FIG. **3.** The amount of force needed to depress the plunger **24** during this segment of travel continually increases as a function of the spring characteristic of the bias spring **28,** as represented by the line **74** in FIG. **10.**

When the cam follower **46** is delivered past the breakaway point **66** by further depression of the plunger **24,** the cam follower **46** is abruptly delivered to the left to the point **76.** This is due to the force release effect of the spring **28** acting upon the cam follower carrier **26.** When the cam follower carrier **26** is delivered to the point **76,** the left end **38** of the carrier strikes the stop member **40** on the housing thereby providing actuation noise that may be heard by the operator.

The force vs. displacement curve of FIG. **10** shows that once the breakaway point **66** has been passed the force release of the spring **28** reduces the amount of force necessary to maintain the plunger **24** at its same level along its vertical axis of displacement. The minimum amount of force that is necessary to accomplish this is represented by the line **80** in FIG. **10.** This amount of force is not sufficient to completely "bottom" the plunger, which occurs when the cam follower **46** is delivered along the base level **90** to the point **82,** since the return spring **62** for the plunger **24** is also compressed slightly as the plunger is delivered beyond the breakaway point **66.** The minimum amount of force required to deliver the plunger to its "bottom" displacement is represented by the line **84.** The "bottom" displacement position is represented by the line **86.** Actuation of the switch normally occurs in the vicinity of the breakaway point **66** before the plunger **24** is "bottomed."

After the cam follower carrier **26** has been returned to its left most position along its horizontal axis of displacement, the cam follower **46** must be returned to its initial point **50.** To accomplish this, the cam **42** has a sloped ramp section **86** which has a rear edge **88** that is further removed from the base level **90** than is the front edge **92.** The cam follower **46** not delivered from the point **76** to the point **50** traverses the ramp section **86** and then passes over the flat portion **94** and finally goes over the dropoff into the cavity **96** where upon it

returns to its initial point **50** upon return of the plunger to its undepressed position. The arm **44,** during this time, flexes in and out along an axis of displacement that is substantially normal to the vertical axis of displacement of the plunger **24,** and also to the horizontal axis of displacement of the cam follower **26,** as represented in FIG. **4** by the arrows that are placed adjacent to the cam follower **46.** The arrows adjacent to the plunger **24** in FIG. **1** represent the notch of the plunger **24** along the vertical axis, while the arrows adjacent to the cam follower carrier **26** in FIG. **3** represent the horizontal movement of the cam follower. Upon return of the plunger **24** to its undepressed position, the return force on it is controlled substantially entirely by the return spring **62,** as represented by the line **98** in FIG. **10.**

While the present invention has been described by references to a specific embodiment, other embodiments and versions within the scope of the present invention will be apparent to those skilled in the art.

What is claimed is:

1. A manually operated electrical switch comprising a switching mechanism, a housing comprising a cavity and first and second pairs of retaining tabs, a plunger depressable along a first axis and comprising a cam, a return spring for said plunger, a unitary cam follower carrier comprising first and second spaced apart wing members, said first pair of retaining tabs being constructed to overlap said first wing member and said second pair of retaining tabs being constructed to overlap said second wing member, said cam follower carrier being displaceable with respect to said housing along a second axis that is substantially normal to said first axis and comprising a tongue which projects into said housing cavity and a resilient arm having a cam follower thereon, a coiled bias spring positioned in said cavity between said tongue and a wall of said cavity for biasing said cam carrier follower to an initial position and said cam carrier to a first point, said resilient arm being displaceable along a third axis that is substantially normal to both said first axis and second axis with said cam follower being in engagement with a first portion of said cam as said plunger is depressed to a breakaway point, said cam follower carrier being directed along said second axis against the force of said bias spring as said plunger is depressed beyond said breakaway point so that said cam follower is abruptly driven to a second point, said cam follower carrier being returned substantially to its initial position along said second axis as said plunger completes its return to its undepressed position aided by the force of said return spring with said cam follower completing its return to said first point over a second portion of said cam as a result of a deflection of said resilient arm along said third axis.

2. A switch as set forth in claim **1** wherein said resilient arm is supported in cantilever fashion.

3. A switch as set forth in claim **1** wherein said housing comprises a stop means and said cam follower carrier is driven against said stop means when said cam follower is driven to said second point so as to provide a noise indication of the operation of the switch.

4. A switch as set forth in claim **3** wherein said resilient arm is supported in cantilever fashion.

5. A switch as set forth in claim **4** wherein said resilient arm is supported from said first wing member and the portion of said cam follower carrier which strikes said stop means is adjacent said second wing member.

6. A switch as set forth in claim **5** wherein said second portion of said cam comprises a ramp which slopes upwardly from said second point to a flat portion which then drops off rapidly to a cavity defining said first point.

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