

Aug. 24, 1965

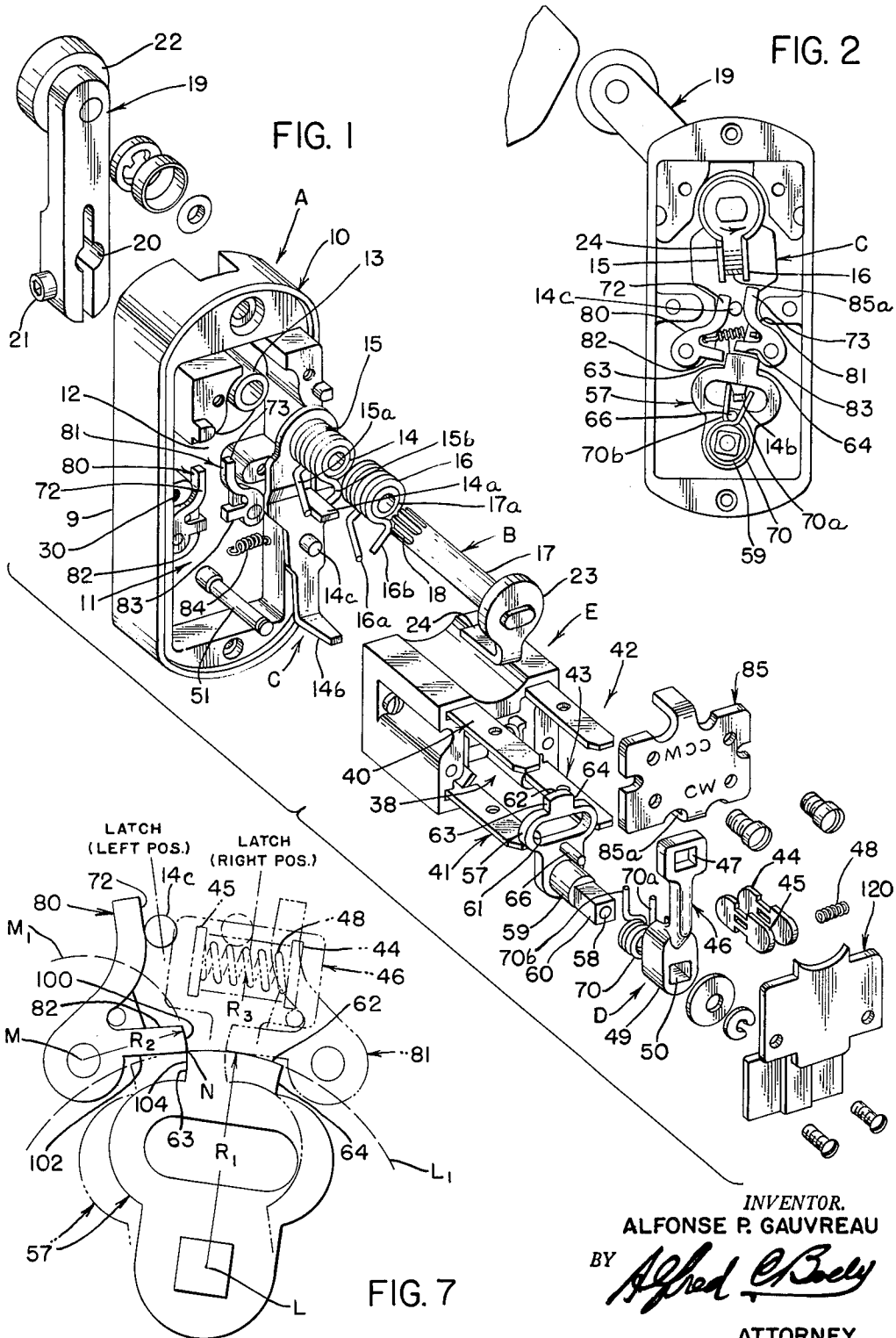
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3,202,001

LIMIT SWITCH

Filed Sept. 11, 1961

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

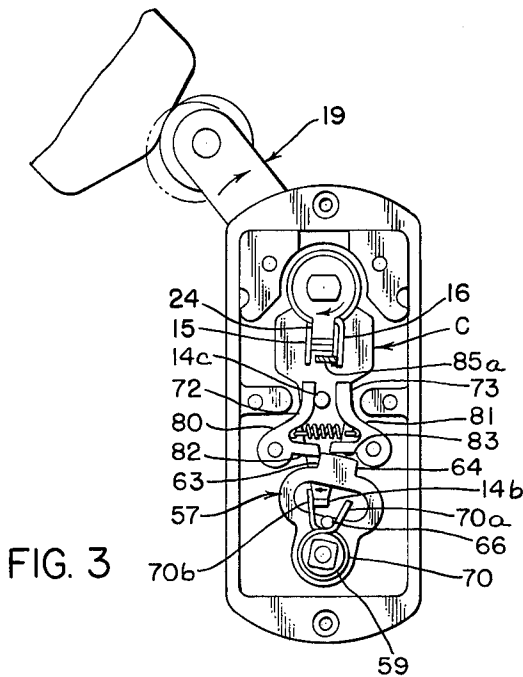


FIG. 3

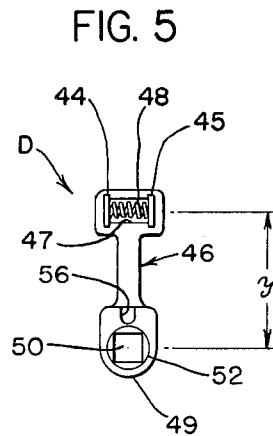


FIG. 5

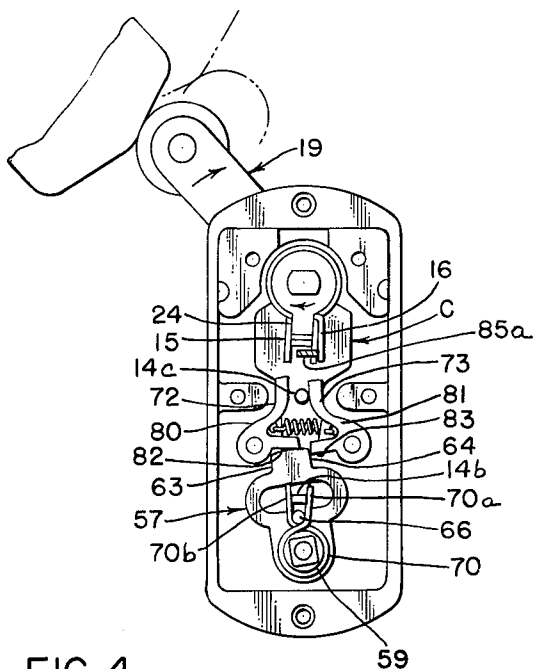


FIG. 4

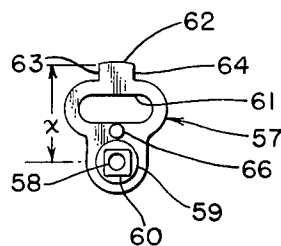


FIG. 6

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LIMIT SWITCH

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4 Claims. (Cl. 74-97)

This invention pertains to the art of electrical switches and more particularly to a snap action type switch often-times known as a limit switch.

The present invention is an improvement on the limit switch disclosed in the copending application Serial No 27,238, filed May 3, 1960, of Robert B. Denison, now United States Letters Patent No. 3,097,271. In that application, there is disclosed a snap action type of switch comprising a pivoted contact carrier which is repeatedly snapped between two contact positions. This pivoted contact carrier is secured to a latch member having a pair of protruding shoulders which coast with one of a pair of latching dogs to secure the latch member in one of the two positions. A pivotally mounted actuator arm is provided with a free end and an intermediate portion, and the free end is connected to the latch member through a torsion spring so initial movement of the actuator arm loads the torsion spring. On further movement of the actuator arm, the intermediate portion contacts the latching dog and shifts the dog from engagement with the shoulder which releases the energy stored in the torsion spring and snaps the latch member into the second contact position. Since the movable contact is carried by the latch member, the movable contact is also snapped into this second position.

Switches of this type have presented the problem of providing a durable, small, snap-action mechanism which allows millions of operating cycles without mechanical or electrical failure. The operation of the switch by pivoting the actuator arms must be accomplished with a minimum torque. The torque required to operate a limit switch such as that described in the copending application depends upon the internal frictional forces which must be overcome and the mechanical advantage of the operating members. The frictional forces are determined by the pressures between the various sliding surfaces within the switch. In a limit switch of the type disclosed in the copending application, the primary frictional force occurs between the latching dog and the protruding shoulder of the latch member during sliding disengagement of the dog.

This invention relates to an improved limit switch wherein the pressure between the latching dog and the shoulder is substantially reduced to decrease the frictional force which must be overcome to disengage these members during operation of the switch. The invention is also directed toward an improved relationship of the peripheral shape of and the relative movement between the latching dog and the shoulder which substantially improves the disengaging action between these members.

In accordance with the present invention, a limit switch is provided wherein the dog engaging shoulders of the pivoting latch member are substantially spaced from the pivotal axis of the latch member to provide a shoulder lever arm substantially equal to the spacing of movable contacts on the contact carrier from the pivotal axis of the carrier.

In accordance with another aspect of the present invention, a limit switch is provided wherein an arc defined by the movement of the latch engaging end of the latching dogs and an arc defined by the movement of the shoulders intersect at substantially right angles so the radii of these arcs at the intersection are perpendicular.

Further in accordance with the present invention, the portion of the latch member between the dog engaging

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shoulders is arcuate and has a center of curvature substantially at the pivotal axis of the latch member.

Further in accordance with the present invention, a limit switch is provided wherein the shoulder engaging leg of the latching dog has an arcuate end surface with a center of curvature at the pivotal axis of the dog and the shoulder has a coinciding arcuate surface so the surfaces of the shoulder and the leg match when these members are in blocking relationship.

In accordance with another aspect of the present invention, the pivotally mounted latch member is provided with a pair of shoulders radially spaced from the pivotal axis of the latch member, and the terminal end of the actuator arm contacts the torsion spring between the pivotal axis of the latch member and the shoulders.

Further in accordance with this invention, the latching dogs are pivotally mounted at a point transversely spaced from and directly opposite to the shoulders. Each of the latching dogs is essentially a lever comprised of a blocking leg extending generally perpendicularly toward the surface of the shoulder and a cam arm having a length substantially equal to the length of the blocking leg and having a generally flat surface extending substantially parallel to the shoulder. A bumper on the intermediate portion of the actuator arm contacts the flat surface of the cam arm to disengage the blocking leg from the shoulder by a short sliding movement of the blocking leg along the surface of the shoulder.

The primary object of this invention is the provision of an improved limit switch which will not fail mechanically or electrically when operated over a great number of switching cycles.

A further object of the present invention is the provision of a limit switch which has a snap action mechanism that requires a minimum number of operating parts and that may be produced and assembled at a substantially reduced cost.

A still further object of the present invention is the provision of an improved limit switch having a snap action mechanism which greatly reduces the friction forces between the separate elements comprising the snap action mechanism.

Another object of the present invention is to provide an improved snap action mechanism for a switch having a means for storing energy and a means for releasing the stored energy which mechanism exerts a substantially lesser force on the means for releasing the energy.

A further object of the present invention is the provision of a limit switch having a snap action mechanism comprised of a pivotally mounted latching dog having a cam arm and a blocking leg wherein the curvilinear movement of the cam arm is nearly equal to the curvilinear movement of the blocking leg.

Another object of this invention is the provision of a limit switch having a snap action mechanism comprised of a pivotally mounted latching dog having a blocking leg which coacts with a shoulder of a biased latch member so that movement of the blocking leg is coincidental to the surface of the shoulder.

Another object of the present invention is the provision of a limit switch having snap action mechanism comprised of a pivotally mounted latching dog having a blocking leg which coacts with the shoulder of a biased latch member so that movement of the blocking leg does not move the shoulder.

Still another object of this invention is the provision of a limit switch having a snap action mechanism operated by a pivoting actuator arm having a terminal end that stores energy in the snap action mechanism and an intermediate end which releases the snap action mechanism to produce the snapping action in either direction which

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terminal end moves through a substantially greater arc than the intermediate portion.

Another object of the present invention is to provide a limit switch having a snap action mechanism comprised of a pivotally mounted latching dog having a blocking leg which coacts with the shoulder of a biased latch member so that movement of the latch member and the blocking leg define arc intersecting at a point where the radii of the arcs are perpendicular.

Another object of the present invention is to provide a limit switch having a snap action mechanism comprised of a pivotally mounted latching dog having a blocking leg which coacts with the shoulder of a biased latch member wherein the end of the blocking leg has a curved surface defined by its swinging movement and the shoulder has a coinciding surface that matches the surface of the blocking leg when these members are engaged.

The invention may take physical form in certain parts and arrangements of parts, a preferred embodiment of which will be described in detail in the specification and illustrated in the accompanying drawing which forms a part hereof and wherein:

FIG. 1 is an exploded perspective view of a switch illustrating a preferred embodiment of the invention;

FIG. 2 is a view showing the operating mechanism of the switch just prior to being actuated;

FIG. 3 is a similar view showing the switch operating mechanism midway through its actuation;

FIG. 4 is a similar view showing the switch operating mechanism at the end of its actuation;

FIG. 5 is an elevational view of the movable contact carrier in the switch;

FIG. 6 is an elevated view of the portion of the switch operating mechanism to which the movable contact carrier is detachably coupled; and

FIG. 7 is a layout view of the latching legs and latch member showing the geometry of these members.

Referring now to the drawings wherein the showings are for the purposes of illustrating a preferred embodiment of the invention only, and not for the purposes of limiting same, the figures show a housing A supporting: an operating assembly B, an actuator arm C pivoted by the operating assembly B through an over-travel spring arrangement; a movable contact carrier D in turn pivoted by the actuator arm C through an energy storing spring arrangement and latched in either of two positions by a latching arrangement; and a fixed contact carrier E. The operation and arrangement of these parts correspond to the like parts found in the copending application Serial No. 27,238, filed May 3, 1960, by Robert B. Denison, now United States Letters Patent No. 3,097,271.

Referring now to FIG. 1, the housing A is generally formed in two parts and includes a first housing member 10 having side walls 9 and a base wall 12 defining a generally rectangular chamber 11 which is closed by a second housing member (not shown) to completely enclose the switch operating mechanism to be described. The operating assembly B includes generally an operating shaft 17 rotatably supported in a sleeve bearing 13 mounted on the base wall 12. This shaft has a knurled portion 18 on its outer end which is disposed beyond the housing wall 12 outside the housing 10.

An operating lever 19 is bifurcated at one end and presents a cylindrical opening 20 which receives the knurled outer end 18 of the operating shaft 17. A suitable locking screw 21 is provided on the operating lever 19 for clamping it tightly to the operating shaft 17. At its opposite end, the operating lever carries a roller 22.

The actuator arm C is generally elongated and has a sleeve 14 rigidly affixed thereto at one end which sleeve rotatably supports the actuator arm C on the bearing 13 inside the housing chamber 11 adjacent to the base wall 12. Surrounding the sleeve 14 an operating spring 15 is loosely mounted. This spring 15, in the embodiment shown, is in the form of a helical wire torsion spring, the ends of which cross and then extend radially outwardly

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to provide spaced end legs 15a, 15b. An offset lug 14a formed integral with the actuator arm C extends between these offset legs 15a, 15b. With this arrangement, it will be appreciated that a sideward force on either of the spring end legs 15a, 15b away from the other spring end leg exerts a similar force through the spring 15 to the lug 14a and then to actuator arm C.

A return spring 16 is rotatably mounted on the outside of a sleeve 17a on the shaft 17 just axially outwardly from the operating spring 15. This return spring is also a helical wire torsion spring, the ends of which cross and then extend radially outwardly to provide spaced end legs 16a, 16b.

At its inner end, the operating shaft 17 carries a head 23 formed with a lug 24 extending parallel to the shaft 17 in spaced relation thereto. This lug 24 extends between the end leg 16a, 16b on the return spring 16 and between the end legs 15a, 15b of the operating spring 15. Thus when the operating shaft 17 is turned initially in either direction, such turning movement is imparted to the actuator arm C through the coupling provided by the operating spring 15. However, when the actuating arm C reaches the limits of its movements as will appear, the operating shaft 17 may continue to turn through flexing of the spring 15 while at the same time exerting a turning force on the actuator arm C.

The actuator arm C extends longitudinally toward the opposite end of the recess 11 between a pair of shoulders 30 integral with the base wall 12 and under the contact carrier assembly E which rests on and is fastened to the shoulders 30. The details of contact carrier assembly E need not be discussed since they form no part of the present invention and they are described in detail in the above identified copending application. Basically the assembly E is provided with an access opening 33 and carries spaced terminals 40-43.

The movable contact carrier D includes a pair of movable contacts 44, 45 mounted by spring 48 in opening 47 of contact carrier arm 46 which extends through opening 33. The arrangement is such that in one angular position of the arm 46 the contact 44 bridges the fixed contacts 40 and 41 while the contact 45 is spaced from the fixed contacts 42 and 43 at the opposite side of the contact block 31. In the opposite angular position of the arm 46, the contact position is reversed.

At its pivotal mounted end, the arm 46 is formed within a large, oblong portion 49 having a square opening 50 therethrough. At its inner face, this hub portion 49 is formed with a circular recess 52 (FIG. 5) which extends around the square opening 50 and is generally concentric therewith. Also, at the edge of hub 49 toward the free end of the contact carrier, there is formed a recess 56 which has an inner end substantially semi-circular and which has relatively straight opposite sides.

The arm 46 forms one part of a two-piece assembly, the other part being a latch member designated in its entirety by the reference numeral 57 in FIGS. 1 and 6. This latch member 57 has a circular opening 58 therethrough which receives the fixed pivot pin 51. At its outer end away from the housing wall 12, the latch member 57 presents an outwardly protruding angular hub 59 which extends toward the hub portion 49 on the contact carrier 46. This hub 59 terminates in a square shaft 60 which extends into square opening 50 of the contact carrier arm 46 to securely couple the two pieces 57 and 46 together. The hub 59 is so dimensioned to extend into the recess 52. As the arm 46 is positioned over the latch member 57, a pin or projection 66 formed integrally on the upper surface of latch member 57 extends into recess 56. This pin 66 extends generally parallel to hub 59 and is spaced slightly therefrom. Preferably, the pin is circular in cross section.

A helically wound spring 70 (FIGS. 1, 2-4) encircles the hub 59 on latch member 57. The recess 52 slides over hub 59 to allow slight axial separation of the two-

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piece assembly without allowing spring 70 to enter the space caused by shaft 60. The opposite ends of the spring 70 cross and then extend outwardly to provide protruding legs 70a, 70b which are disposed on opposite sides of the pin 66.

The snap action limit switch as so far described is substantially the same as the limit switch of the copending application; the structure to be discussed hereinafter relates to an improvement over that limit switch.

The first improvement of the present limit switch is the provision of a means for reducing the force of shoulders 63, 64 by increasing the distance of the shoulders from the pivot pin 51. The means may be accomplished in various ways; however, in a preferred embodiment, an elongated central opening 61 is provided within the body of latch member 57. The latch member has an outwardly extending peripheral portion 62 supporting the oppositely facing shoulders 63, 64 which define the ends of the peripheral portion and have surfaces generally parallel to one another and symmetric with respect to the latch member. The terminal end of actuator arm C is disposed a short distance from pin 66 and an integral generally perpendicularly extending lug 14b of the actuator arm C protrudes upwardly from the back of latch member 57 through central opening 61 and extends through protruding legs 70a, 70b of spring 70. With this arrangement, when the actuator arm is pivoted in one direction or the other, the latch member 57 is pivoted about pin 51 in an opposite direction. Pivotal movement of the latch member causes a corresponding movement of arm 46 to establish the desired electrical circuit. The actuator arm C contacts the spring 70 at a point substantially below the shoulders 63, 64 which allows the shoulders to be spaced a substantial distance from the pivotal axis of the latch member 57, the spacing being represented by x in FIG. 6. By spacing the shoulders away from the axis of the latch member, the force on the shoulders is decreased.

The force on the shoulders is caused by the torque on the spring 70 and the compressive force exerted on contact springs 43. The force of the compression of springs 43 acts on the shoulders through the distance y shown in FIG. 5 and the distance x . By making the distance x substantially equal or, as in practice where the space in the switch is limited, only slightly less than distance y , the force on the shoulder is decreased. In prior switches the ratio of x to y was approximately 1:5, which caused a magnification of the contact spring force and the torque force of spring 70 on the shoulders 63, 64. This correspondingly increased the torque required to activate the switch and increased the wear of the cam members.

The second improvement of the present limit switch over the limit switch disclosed in the copending application is the construction and actuation of latching dogs 80 and 81 which are pivotally supported at their central portion on pins extending from the housing 12. The latching dogs are transversely spaced from the latched member 57 and are provided with blocking legs 82 and 83 respectively which are adapted to coast with shoulders 63 and 64 to block the movement of latch member 57 in either direction. Coil spring 84 is connected under tension between the latching dogs to bias blocking legs 82, 83 into engagement with the shoulders of the latch member. Actuation of the latching dogs is accomplished by movement of a pair of cam arms 72, 73. The actuator arm C carries a perpendicularly extending pin or other bumper means 14c which coacts with the inwardly facing surfaces of cam arms 72, 73 to move the respective latching dogs out of engagement with the shoulders to allow movement of the latch member 57 in either direction. The bumper 14c is spaced a substantial distance from lug 14b so that arcuate movement of bumper 14c is less than arcuate movement of lug 14b. By this arrangement, the lug 14b may swing a distance sufficient to properly bias spring 70 without requiring the same movement of bumper 14c.

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The blocking legs 82, 84 have contoured ends to coact with the surfaces of the shoulders so that when the blocking leg engages the shoulder, the surfaces of the engaging members substantially coincide. On subsequent pivoting of the latching dog by pin 14c coacting with the flat surfaces of either cam arm, the blocking leg slides in an arcuate path along the surface of the shoulder. The latch member is not forced rearwardly, nor is it allowed to advance forwardly during this disengaging movement of the blocking leg. This feature substantially decreases the wear between the blocking leg and the shoulder and does not dissipate energy by moving or allowing movement of the latch member. The length of the blocking leg is not substantially less than the length of the cam arm between the pivot point and the point of contact of pin 14c. Therefore, the lever arm of the blocking leg is approximately equal to the lever arm of the cam arm. This results in nearly the same curvilinear movement of the blocking leg and the cam arm to reduce the outward transverse movement of the latching dogs. As the pin 14c progresses along the flat surface of the cam arm, the lever arm through which pin 14c operates is progressively altered; therefore, the mechanical advantage changes slightly on movement of the latching dog. The flat cam surfaces of the cam arms are substantially perpendicular to the blocking legs and are offset transversely from the pivot point of the latching dogs. The force to slide the blocking leg is determined by the frictional force between the shoulder and the blocking leg, which force varies as the force between these members; therefore, the decrease in the lever arm of the shoulder decreases the force necessary to disengage the blocking leg.

In operation of this mechanism, as so far explained, the switch is shown in an initial position in FIG. 2 whereby fixed contacts 42 and 43 are closed by the movable contact 45. As the operating lever 19 is moved clockwise, lug 14b of the actuator arm C exerts a force on spring leg 70b. Thus the spring 70 tends to rotate the latch member 57 counterclockwise by leg 70a which exerts force on pin 66. The latch member cannot pivot because it is blocked by leg 82 of dog 80 contacting with shoulder 63 (see FIG. 3). As the actuator arm C continues movement against the resiliency of spring 70, increased energy is stored within the spring. Still further movement of the actuator arm causes the bumper or pin 14c to ride along the flat surface of cam arm 72 to pivot the dog 80 counterclockwise. This disengages blocking leg 82 from shoulder 63. (See FIG. 3.) When the latch member 57 is released from the blocking leg, the energy stored within the spring 70 snaps the latch member 57 and the contact carrier 46 to bring movable contact 44 into engagement with fixed contacts 40 and 41. This is shown in FIG. 4. The same operation takes place when the operating lever 19 is moved in the opposite direction. Thus, the limit switch has a snap action in either direction. The inside surface of the cam arms 72 and 73 is contoured so that bumper or pin 14c acts smoothly on the cam arm to pivot the latch dogs.

Having thus described the general operation of the limit switch, the relative movement between and the peripheral shapes of the latch member 57 and the latching dogs 80, 81 will be hereinafter described in detail. Referring to FIG. 7, the latch member 57 is pivotally mounted on axis L, and the peripheral portion 62 has a contour defined by radius R_1 which radius also defines arc L_1 . Arc L_1 is the path of movement of the outermost portions of dog engaging shoulders 63, 64. The swinging dogs 80 and 81 are identical and have the same relationship with the latch member 57. Therefore, a detailed description will be given of only the latching dog 80. The blocking leg 82 has a tip surface 100 defined by a radius R_2 extending from the pivotal axis M of the dog 80. This radius R_2 defines an arc M_1 which arc represents the arcuate path of surface 100. The lowermost surface of leg 82 lies along a radius line from axis M to arc M_1 . The arcs L_1

and M_1 intersect at N. Axes L and M are spaced from one another so that arcs L_1 and M_1 intersect at right angles, which means that radius lines from the axes to point N form a right angle and the tangents through point N are perpendicular. Since surface 102 lies on one of these radius lines and the uppermost portion of shoulder 63 also lies on one of these radius lines, these points are disengaged along the tangents of the respective arcs. By so arranging the arcs L_1 and M_1 , there is no "hooking" action between the disengaging members. This assures that the latch member 57 is not allowed to pivot toward the dog 80, nor is it forced away from dog 80 by rotation of the dog. If the disengagement were at an obtuse angle, that is, surface 102 forming an angle greater than 90° with the radius line of arc L_1 to point N, the latching arrangement would not be accurate since there would be some engagement of the portion 62 after disengagement. If this surface were relieved to prevent this contact of surface 62 with the leg 82, the strength of the outermost corner of shoulder 63 would be reduced. If the disengagement were at an acute angle, that is, the surface 102 form at less than 90° with a radius line of arc L_1 to point N, there would be a tendency to break off the outermost corner of shoulder 63, since the force on the shoulder at this point would not be perpendicular to the surface.

As was mentioned before, surface 100 lies on the arcuate path M_1 defined by radius R_2 . This allows disengagement of the dog from the shoulder 63 without movement of the latch member 57. To increase the bearing area of surface 100 with shoulder 63, the shoulder is provided with an arcuate transverse surface 104 which coincides with arc M_1 when blocking dog 80 is in engagement with the latch member 52. By providing the arcuate surface 104, the contacting surfaces 100 and 104 coincide so that the maximum bearing surface is provided between these surfaces. This decreases the wear of the slidably engageable surfaces.

As shown in FIG. 7, the latch dog 57 is in the right hand position and is angularly disposed with respect to the centerline of the switch. When latch dog 81 engages latch member 57, the latch member is in the left position and the general geometry of the engagement between the latch member and dog 81 is identical to the geometry between the latch member and dog 80. Because of this similarity, no detailed discussion of dog 81 and its engagement with shoulder 64 is necessary and this is disclosed in dotted lines in FIG. 7.

The upper portion of contact carrier 46 is disclosed in FIG. 5. The radius R_3 discloses the distance from axis L to the center of contact spring 48. Force exerted on the shoulders 63, 64 by compression of the contact spring is determined by the relationship of R_3 to R_1 which correspond to the distances y and x of FIGS. 5 and 6. By this arrangement, the torque necessary to actuate the switch is greatly reduced from the torque necessary to operate prior limit switches of the type described herein.

Referring again to FIG. 1, other structural features are disclosed which form no part of the present invention and which are described in detail in the copending application. These features include a reversing plate 85 having depending lugs 85a which coast with spring 16 to determine the initial bias on actuator arm C and a retaining plate 20 which is mounted onto housing 10 to close the switch assembly.

From the foregoing description taken in conjunction with the accompanying drawing, it will be apparent that the preferred embodiment is particularly well suited for the accomplishment of the stated objects of this invention. However, while there has been described in detail herein and illustrated in the accompanying drawing a specific, presently preferred embodiment of this invention, it is to be understood that various modifications, omissions and refinements which depart from the disclosed embodiment may be adopted without departing from the spirit and scope of this invention.

Having thus described my invention, I claim:

1. In a limit switch, an actuator arm pivotally mounted on a first axis and having a terminal end and an intermediate portion, a latch member pivotally mounted on a second axis, a torsion spring connecting said terminal end to said latch member, a shoulder on said latch member, a latching dog engageable with said shoulder, and a bumper on said intermediate portion, said bumper engageable with said latching dog to move said dog from engagement with said shoulder, the improvement comprising: said latch member having an opening between said shoulder and said second axis, said actuator arm adjacent a first surface of said member and said torsion spring adjacent an opposite surface of said member, said terminal end extending through said opening to connect with said torsion spring.

2. In a limit switch, an actuator arm pivotally mounted on a first axis, a latch member pivotally mounted on a second axis, a torsion spring connecting said arm to said latch member, a shoulder on said latch member, a latching dog engageable with said shoulder to block movement of said latch member, said dog pivotally mounted on a third axis, and means for disengaging said dog from said shoulder after energy has been stored in said torsion spring to shift said latch member, the improvement comprising: the dog having a leg with an outer tip extending toward said shoulder and adapted to engage said shoulder, said shoulder having an outermost portion which is last to disengage from said leg tip, movement of said tip defining a first arc about said third axis, movement of said outermost portion defining a second arc about said second axis, said first and second arcs intersecting, and the tangents to each of said arcs being substantially perpendicular at the arc intersection, said leg having a lower surface defined by a radius of said first arc, and a shoulder engaging surface defined by said first arc, and said shoulder having a lateral surface, said lateral surface defined by an arc having a radius equal to the radius of said first arc and a center of curvature coinciding with said third axis when said dog engages said shoulder.

3. The improvement as defined in claim 2 wherein said latch member has a peripheral portion forming said engaging shoulder, said portion being defined by said second arc.

4. In a limit switch, an actuator arm pivotally mounted on a first axis, a latch member pivotally mounted on a second axis, a torsion spring connecting said arm to said latch member, a shoulder on said latch member, a latching dog engageable with said shoulder to block movement of said latch member, said dog pivotally mounted on a third axis, and means for disengaging said dog from said shoulder after energy has been stored in said torsion spring to shift said latch member, the improvement comprising: the dog having a leg with an outer tip extending toward said shoulder and adapted to engage said shoulder, said shoulder having an outermost portion which is last to disengage from said leg tip, movement of said tip defining a first arc about said third axis, movement of said outermost portion defining a second arc about said second axis, said first and second arcs intersecting, and the tangents to each of said arcs being substantially perpendicular at the arc intersection, said shoulder having a lateral surface, said lateral surface defined by an arc having a radius equal to the radius of said first arc and the center of curvature coinciding with said third axis when said dog engages said shoulder.

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ROBERT K. SCHAEFER, *Examiner*.