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[54] **LIMIT SWITCH ASSEMBLY**

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[52] **U.S. Cl.** ..... **200/47;** 310/68 B; 318/475

[51] **Int. Cl.²** **H01H 3/16**

[58] **Field of Search** ..... 200/47, 153 LA, 153 LB; 318/475; 310/68 B, 68 E, 80, 83; 192/150

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[57] **ABSTRACT**

A limit switch assembly is disclosed in this application and includes a slider member adapted to slide with axial movement of an input shaft and having at least one adjustable cam member carried thereon for cooperation with a pivoted actuator member located adjacent to and normally spaced from an electrical switch connected in a control circuit. In operation, movement of the input shaft causes corresponding movement of the slider and cam members. When the input shaft moves to its limit position, the cam member pivots the actuator member into engagement with the switch member thereby actuating the control circuit. By adjusting the cam member, the spacing between the actuator member and the switch member is adjusted whereby the limit position of the input shaft is also adjusted.

16 Claims, 5 Drawing Figures

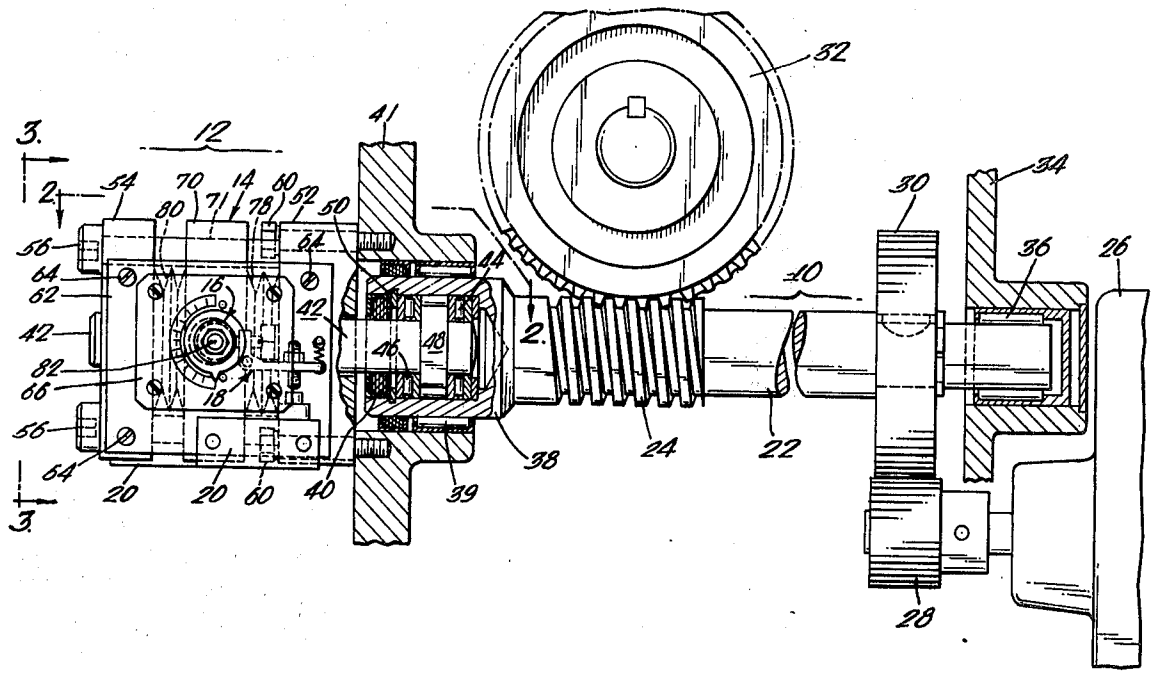


FIG. 1.

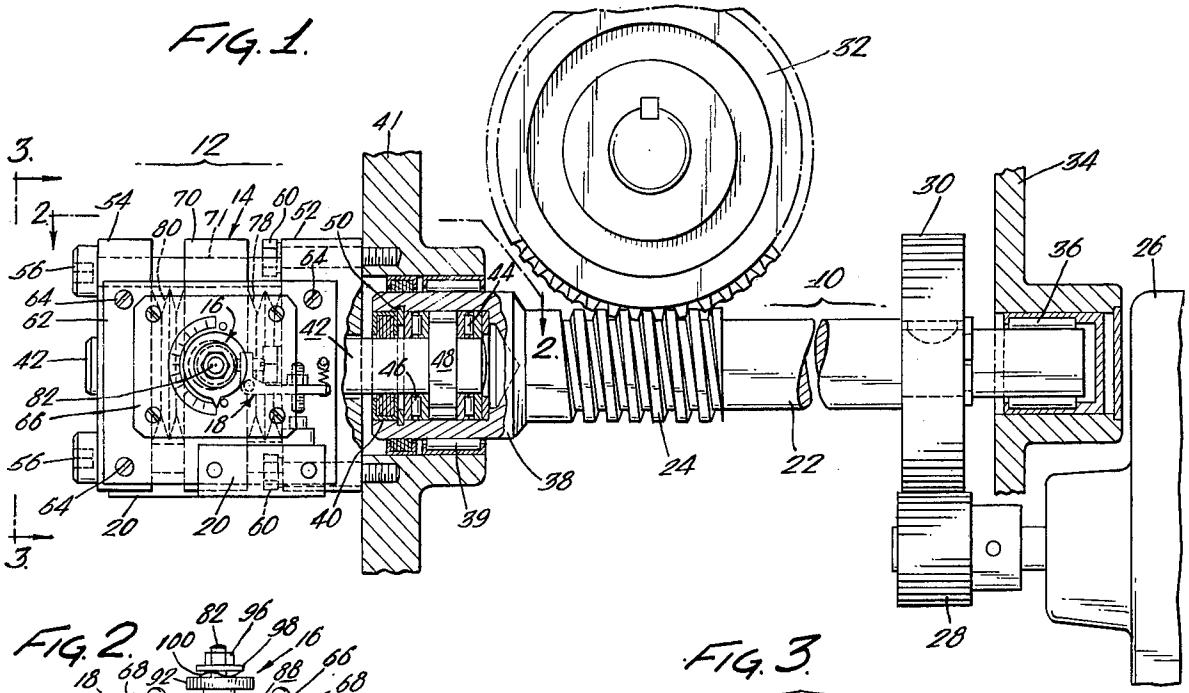


FIG. 2.

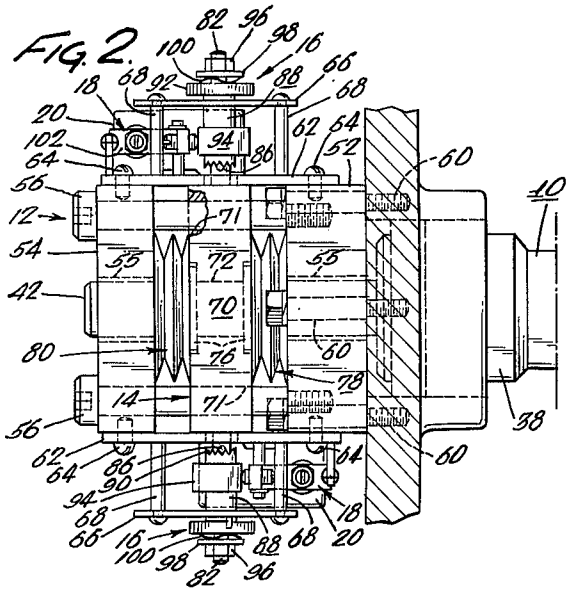


FIG. 3.

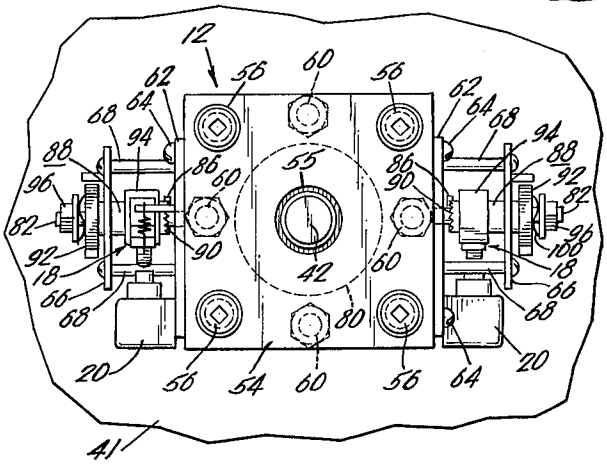


FIG. 4.

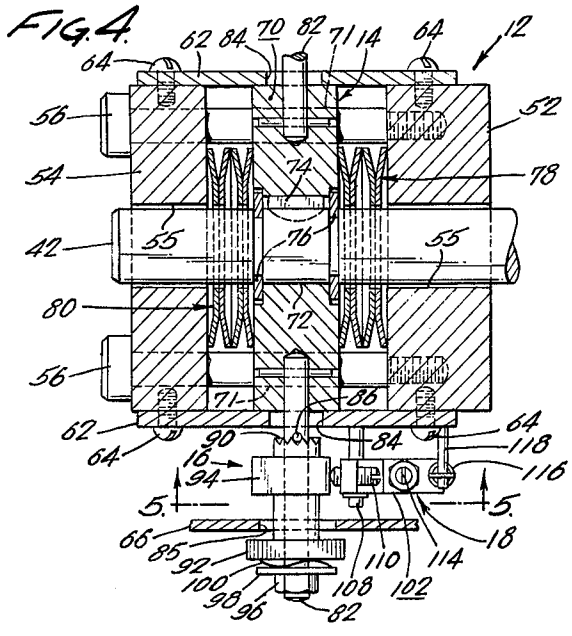
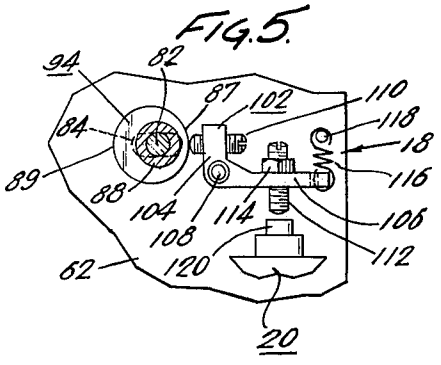


FIG. 5.



LIMIT SWITCH ASSEMBLY

This invention relates to limit switch assemblies for limiting axial movement of an input shaft, particularly a rotary drive shaft movable axially in accordance with torque developed therein.

Various mechanical devices include a movable shaft or similar member movable axially to a limited extent and which require that when the shaft has moved to its limit position, a signal, usually a stop signal to stop the movement of the shaft, should be provided. for example, a rotary drive shaft is usually driven by a motor developing a torque which is applied to an output device through the drive shaft. During application of the torque, axial thrust is developed in the shaft causing it to move in the axial direction. Of course, the movement of the shaft is proportional to the torque applied through the shaft so that a limit switch assembly sensing movement of the shaft can be used to develop a signal to stop the application of the torque when the movement of the shaft corresponds to or slightly exceeds the maximum allowable torque which can be delivered to the output device or by the motor.

Certain known limit switch assemblies usable in applications of the type noted above include arrangements for adjusting the limit position at which the signal is developed. These known limit switch assemblies, however, generally require the use of tools and, in some arrangements, the disassembly of portions of the switch assembly to make the adjustment. Obviously, situations can arise, particularly in the environment in which the devices are used, wherein the tools are not available and/or wherein the available time is limited. In those situations, adjustment of the switch assemblies is impractical and may be impossible.

Further, known limit switch assemblies that include adjusting arrangements are operative to allow adjustments whereby the maximum allowable movement of the shaft can be exceeded. Thus, a mistake on the part of the operator making the adjustment could result in damage to the shaft or its associated input and/or output devices. In the example noted above wherein the limit switch assembly is utilized to limit the torque which can be applied to the shaft, such a mistake could result in damage to a relatively expensive gear arrangement used in conjunction with the shaft or in damage to the equipment being driven by the apparatus.

Accordingly, it is an object of this invention to provide a limit switch assembly that allows for the easy adjustment of the limits of travel of an axially movable shaft.

It is another object of this invention to provide a limit switch assembly that cannot be adjusted to allow movement of the shaft beyond its maximum design limits or beyond a predetermined set limit.

It is still another object of this invention to provide a limit switch assembly that is particularly adapted for use in limiting the torque which can be developed in a rotary drive shaft.

Finally, it is an object of this invention to provide a limit switch assembly that is simple, economical, rugged and easy to use.

These and other objects of this invention are accomplished by providing a limit switch assembly including slider means movable with an input shaft member whose axial movement is to be limited. Carried on the slider means for movement therewith is cam means operatively engaged with actuator means for adjustably

spacing the distance between the actuator means and switch means connected in a circuit. In certain positions of the slider means, the cam means spaces the actuator means from the switch means and in one position of the slider means, corresponding to the limit of movement of the input shaft member, the cam means moves the actuator means into engagement with the switch means and actuates the circuit whereby an appropriate signal may be developed. The initial spacing, that is, the spacing before any movement of the shaft, between the actuator means and the switch means is adjustable by the cam means so that the limits of movement of the shaft can be adjusted.

Preferably, the switch assembly includes another set of cam means, actuator means and switch means, one set being operative to limit movement of the shaft in one direction and the other being operative to limit movement of the shaft in another direction. Further, the cam means is rotatable to vary the initial spacing between the actuator means and the switch means and is readily locked in any position or unlocked for movement from any position by easily manipulated locking means without the use of tools. The cam means further includes a cam member having a high point and a low point and is arranged so that the high point is operative to initially space the actuator means and the switch means a distance corresponding to the maximum allowable design displacement of the shaft and so that the low point is operative to allow the actuator means to engage the switch means so that no displacement of the shaft can occur.

For a better understanding of the invention, reference is made to the following description of a preferred embodiment, taken in conjunction with the figures of the accompanying drawing, in which:

FIG. **1** is a side view partially in section of a limit switch assembly in accordance with this invention operatively associated with an input shaft assembly;

FIG. **2** is a plan view of a portion of the limit switch assembly illustrated in FIG. **1** and taken generally along line **2—2** thereof;

FIG. **3** is an end view of the limit switch assembly illustrated in FIG. **1** and taken generally along line **3—3** thereof;

FIG. **4** is a view generally similar to FIG. **2** of the limit switch assembly illustrated in FIG. **1**, but with portions thereof shown in section; and

FIG. **5** is a sectional view of a portion of the limit switch assembly taken generally along line **5—5** of FIG. **4**.

Referring to FIG. **1** of the drawing, there is illustrated an embodiment of the invention particularly adapted for use as a torque limiting switch assembly, it being obvious, as noted above, that the movement of a shaft member in various other mechanical devices could be limited by an assembly in accordance with this invention. Accordingly, there is illustrated an input shaft assembly **10** operatively associated with a limit switch assembly **12**, the latter including a slider assembly **14** operatively associated with input shaft assembly **10** and on which is carried a pair of cam assemblies **16, 16**, each operatively associated with an actuator assembly **18, 18** for actuating switch assemblies **20, 20** and signaling circuits in which they are connected. As will be made clearer hereinafter, each cam means **16** is movable with slider means **14** and, accordingly, input shaft assembly **10** to limit the movement of the shaft assembly through its associated actuator assembly **18** and

switch assembly **20.**

Still referring to FIG. **1** of the drawing, input shaft assembly **10** includes an input shaft **22** formed with a worm **24** intermediate its ends and driven by a motor **26** through suitable gears **28** and **30** for changing the speed of the shaft relative to the speed of the motor. Operatively engaged with worm **24** is an output wormwheel **32** which transmits power from motor **26** to an output device (not shown). It should be noted, at this point, that motor **26** may be of any suitable type including an electrical control circuit for controlling its operation and that output wormwheel **32** may be connected to any suitable output device.

Still referring to FIG. **1,** at one end input shaft **22** is rotatably mounted in a suitable bearing assembly **36** carried on a frame member **34** which may be the wall of a housing for the input shaft assembly. At its other end, input shaft **22** includes an enlarged cylindrical portion **38** rotatably mounted in a suitable bearing assembly **39** carried on a frame member **41** which may be part of the above-noted housing. Cylindrical portion **38** is formed with a bore **40** in which is received a shaft **42** extending from slider assembly **14** of limit switch assembly **12.** Suitable bearing assemblies **44** and **46** are mounted between bore **40** and shaft **42,** are spaced apart by a radially extending flange **48** formed on a shaft **42** and are secured in place by a retaining ring **50** so that relative axial movement of the shafts is precluded. When motor **26** is operative, shaft **22** is driven about bearing assemblies **36** and **39** and also about bearing assemblies **44** and **46** and torque is applied to output wormwheel **32.** As torque is developed in shaft **22,** axial thrust is also developed which causes some axial movement of the shaft, the direction of which is dependent, of course, on the rotational direction of the shaft. If the torque developed by motor **26** exceeds a certain limit, the thrust in shaft **22** will cause its movement beyond a certain corresponding limit position which is sensed by limiting switch assembly **12** to actuate one of the signaling circuits and shut off motor **26.**

Limiting switch assembly **12** includes a housing formed by a pair of end plates **52** and **54** secured in spaced apart relationship by suitable fasteners such as stripper bolts **56** and is secured to frame member **41** in axial and radial alignment with shaft **22** by suitable fasteners **60** extending through end plate **52** and housing **41.** Each end plate **52** and **54** includes a central opening **55** through which shaft **42** extends. Completing the housing for limit switch assembly **12** are side plates **62,62** which are secured to end plates **52** and **54** by suitable fasteners **64.** Spaced from each side plate **62** and extending parallel thereto is a coverplate **66** which is secured to the side plate by suitable fastener assemblies **68** which include spacer sleeves or other suitable spacer means.

Located within the central cavity defined by the housing is the slider assembly **14** which, in addition to shaft **42,** includes a slider plate **70** slidably mounted on the smooth shank portions of stripper bolts **56.** In the preferred embodiment, slider plate **70** has openings **71** through which stripper bolts **56** extend. A central opening **72** formed through slider plate **70** receives shaft **42** and the shaft is secured to the plate by a key arrangement **74** and retaining ring arrangement **76** to preclude relative rotary and axial movement, respectively, of the shaft and the plate. A disc spring assembly **78** bears between one face of slider plate **70** and the interior face of end plate **52** and a second disc spring assembly **80** bears against the opposite face of the slider plate and the interior face of end plate **54.** Acting together the spring assemblies exert a centering force locating slider plate **70** in the interior of the housing when no external load is acting on the slider plate. However, when input shaft **22** moves axially and, in turn, causes movement of shaft **42,** the slider plate **70** is movable against the spring assemblies.

As noted previously there are two sets of cam, actuator and switch assemblies associated with the slider assembly and it is now noted that each set is the same except that one is a mirror-image of the other so that one set is operative to limit movement of shaft **22** in one direction and the other is operative to limit movement of the shaft in the other direction. Accordingly, like reference numerals will be used in the following description for like parts of the two sets.

Each cam assembly **16** includes a pin **82** extending from the side of slider plate **70** through a suitable elongated opening **84** in side plate **62,** and in opening **85** in cover plate **66** to a point adjacent the outer surface of the cover plate. Each pin **82** carries a locking pin **86** extending transverse to the longitudinal axis thereof for a purpose which will be explained hereinafter. Rotatably carried on each pin **82** is a sleeve **88** formed at one end with a series of notches **90** and at the other end with radially projecting disc member **92.** Intermediate the ends of each sleeve **88** is a cam **94** in the shape of a circular member eccentrically formed on the sleeve. Thus, each cam **94** has a point of minimum projection from sleeve **88** or low point **87** and a point of maximum projection from sleeve **88** or high point **89** spaced from the low point by **180°** along the circumference of the cam. At its free end, each pin member **82** is threaded and cooperates with a nut member **96** including an enlarged bearing surface **98** which may be in the form of a flange on the nut or a washer and which retains a spring washer **100** in engagement with disc member **92** for exerting force on sleeve **88.** If nut member **96** is tightened sufficiently, spring washer **100** retains the roots of notches **90** in engagement with locking pin **86** and precludes rotation of sleeve member **88** and cam **94** about pin member **82.** By merely loosening nut member **96,** which can normally be done by hand without the use of any tools, the force exerted by disc spring **100** can be reduced so that sleeve member **88** and cam **94** may be rotated to other desired positions.

As noted previously, each actuator assembly **18** is located adjacent a cam assembly **16** and, more particularly, each actuator assembly is mounted adjacent one of the cams **94** and includes a bellcrank **102** having a first leg **104** adjacent its associated cam member and a second leg **106** extending at a generally right angle thereto adjacent its associated switch assembly **20.** At the intersection of each of the leg members **104** and **106,** each bellcrank **102** is pivoted on a pin member **108** extending from side plate **62.** Each leg member **104** and **106** is formed with a threaded opening in which is carried suitable adjusting screws **110** and **112,** respectively. A suitable lock nut **114** may be associated with each adjusting screw **112** to secure the adjusting screw in a desired position. Biasing each bellcrank **102** to a first position out of engagement with its associated switch assembly **20** is a spring **116** connected at one end to a pin member **118** carried by side plate **62** and at its other end to a portion of leg **106.** In the first position, switch assemblies **20** have not been actuated so that the circuits in which are connected are inopera-

tive; however, when either cam **94** pivots its associated bellcrank **102** a sufficient distance, the associated adjusting screw **112** is in a second position bearing against a plunger **120** extending from its associated switch assembly **20,** the circuit in which it is connected is activated and a signal is developed which in the embodiment disclosed herein would stop motor **26.**

In operation, as motor **26** drives input shaft **22** through gears **28** and **30,** worm **24** drives wormwheel **32** and the applied torque is operative to develop axial thrust in the input shaft which causes axial movement of the shaft in one direction or the other depending on the direction in which the shaft is rotated. Axial movement of shaft **22** is dependent on the axial thrust therein which is, in turn, dependent on the torque developed therein so that the axial movement of the shaft is proportional to the torque output of motor **26.** As shaft **22** moves in the axial direction, its movement is transmitted to shaft **42** which causes movement of slider member **70** and cam assemblies **16, 16.** As cam assemblies **16, 16** move, one cam **94** moves against adjacent adjusting screw **110** pivoting its associated bell crank **102** about pin **108** and moving the associated adjusting screw **112** closer to plunger **120.** The other cam **94** is moved away from its associated adjusting screw **110** so that the associated spring **116** retains the associated bell crank **102** in its first position. Eventually, when sufficient torque is developed by motor **26,** the one cam member has pivoted its associated bell crank **102** to the second position wherein adjusting screw **112** bears on plunger **120** actuating switch assembly **20** so that the circuit in which it is connected develops a stop signal shutting off the motor. By adjusting the cams **94, 94,** the appropriate spacing between each adjusting screw **112** and its associated plunger **120** can be selected so that the stop signal is developed when the motor is developing the maximum torque allowable for the application in which the limit switch assembly is being used.

To initially adjust limit switch assembly **12,** nut members **96** are loosened and cams **94** are rotated until high points **89** bear on their associated adjusting screws **110.** Then, adjusting screws **112** are adjusted so that they bear on their associated plungers **120** and just close switch assemblies **20.** Adjusting screws **112** are now locked in position by lock nuts **114.** Rotation of cams **94, 94** to any other position allows bell crank **102** to pivot about pins **108** and moves legs **106** away from plungers **120** and, accordingly, adjusting screws **112** are moved to their first positions spaced from the plungers. When the appropriate points on cams **94** bear on adjusting screws **110,** nut members **96** are tightened to urge notches **90** into locking pins **86** and lock the cams in place. For further adjustments, nut members **96** can be loosened and the cams rotated to a new position and locked in place by tightening the nut members.

The appropriate setting of cams **94** may be readily determined by providing suitable indicia on the outer surface of disc member **92** which is correlated with the maximum allowable torque which can be applied to shaft **22.** Thus, the low point of the cam would correspond to **100%** of the allowable torque applied to shaft **22** and the high point on cam **94** would correspond to a zero setting wherein no torque would be applied to the shaft. By graduating the indicia around the 180° arcuate distance between high point **89** and low point **87** of cams **94,** according to percentage points, the correct setting of the cams can be determined, Thus, if the maximum allowable torque which can be applied to shaft **22** is divided into the desired torque limit which should be applied in the particular application of switch assembly **12,** the desird torque limit can be expressed as a percentage of maximum torque and the cams can be adjusted until the indicia indicates that the setting corresponds to the determined percentage. Thus, the cams can never be adjusted to allow an output greater than 100%, that is, greater than the maximum allowable torque which can be applied.

It should be noted, that cam assemblies **16** and their associated actuating assemblies **18** and switch assemblies **20** have been illustrated as extending from opposite sides of slider plate **70,** but that the noted assemblies could be so constructed and arranged that each extends from the same side of the slider plate. In certain embodiments of the invention the latter arrangement may be preferred since it facilitates access to the cam assemblies. The arrangement illustrated in the drawing has been specifically disclosed since it facilitates an understanding of the invention by allowing for greater clarity in the drawing. Also, it should be noted that while two cam assemblies **16,** actuating assemblies **18** and switch assemblies **20** have been described, certain applications may require that only one limit be established so that only one cam assembly, actuating assembly and switch assembly need be provided.

In view of the above, it can be seen that a limit switch assembly is disclosed which is usable for adjustably limiting movement of an input member wherein adjustments can easily be made without the use of tools. Further, it can be seen that a limit switch assembly has been disclosed wherein an adjustment to a limit greater than a maximum limit cannot inadvertently be made. Finally, it can be seen that each limit position can be adjusted independently so that limits at each end of the range can differ.

While in the foregoing there has been described a preferred embodiment of a limit switch in accordance with this invention, it should be obvious to one skilled in the art that various modifications can be made without departing from the true spirit and scope of the invention as recited in the appended claims.

I claim:

1. A limit switch assembly comprising slider means movable with axial movement of an input shaft, cam means carried by said slider means for movement therewith and actuator means located adjacent switch means and having a first position spaced from said switch means and a second position in engagement with said switch means, said cam means being engaged with said actuator means in said first and second positions thereof and being operatiave to move said actuator means from said first position to said second position when said slider means moves in one direction, whereby a limit signal is developed, said cam means further being adjustable whereby the spacing between said first and second positions of said actuator means is adjustable.

2. A limit switch assembly in accordance with claim **1** wherein said slider means includes a slider plate and spring means bearing on opposite sides thereof for locating said slider plate.

3. A limit switch assembly in accordance with claim **2** wherein said slider plate is connected to shaft means extending therefrom and adapted to be secured to said input shaft for movement therewith.

4. A limit switch assembly in accordance with claim 3 wherein said shaft means includes a shaft secured to said slider plate at one end and formed with means for securing said shaft to said input shaft at its other end.

5. A limit switch assembly in accordance with claim 1 wherein said actuator means includes spring means for biasing said actuator means to said first position and for retaining said actuator means in said first position when said slider means moves in another direction.

6. A limit switch assembly in accordance with claim 1 wherein said cam means includes a cam member rotatably mounted on said slider means and including locking means for locking said cam member in a selected position.

7. A limit switch assembly in accordance with claim 6 wherein said locking means includes a plurality of notches formed on one side of said cam member which cooperate with pin means for locking said cam member in its selected position.

8. A limit switch assembly in accordance with claim 7 including spring means biasing said notches into engagement with said pin means.

9. A limit switch assembly in accordance with claim 8 wherein said spring means includes a spring washer bearing on the other side of said cam member and adjustably retained therewith by a nut assembly.

10. A limit switch assembly in accordance with claim 1 wherein said cam means includes a pin member fixed to said slider means and projecting therefrom, a cam member rotatably mounted on said pin member and formed with a plurality of notches on the side adjacent said slider means, said pin member having a locking pin carried thereon for cooperation with said notches to lock said cam member against rotation.

11. A limit switch assembly in accordance with claim 10 including spring means bearing on another side of said cam member for biasing said notches into locking engagement with said locking pin, said spring means being adjustably retained against said cam member whereby the biasing force exerted by said spring means can be varied to allow rotation of said cam member or to lock said cam member.

12. A limit switch assembly in accordance with claim 11 wherein said spring means is adjustably retained by a nut assembly.

13. A limit switch assembly in accordance with claim 1 including second cam means carried by said slider means for movement therewith and second actuator means located adjacent second switch means, said second actuator means having a first position spaced from said second switch means and a second position in engagement with said second switch means, said second cam means being operatively engaged with said second actuator means for moving said second actuator means from said first position to said second position when said slider means moves in another direction, said second cam means further being adjustable whereby the spacing between said first and second positions of said second actuator means is adjustable.

14. A limit switch assembly in accordance with claim 1 wherein said cam means includes an arcuate cam member eccentrically mounted for rotation about a pin member and having a high point and a low point, one of said points defining a spacing between said first and second positions corresponding to the maximum limit signal which can be developed.

15. A limit switch assembly including a housing member having a slider plate slideably carried therein, said slider plate being fixed to a slideable shaft member extending therefrom and adapted to be mounted to a rotary drive shaft for axial movement therewith, spring means bearing on opposite faces of said slider plate for exerting a force locating said slider plate in said housing member, cam means mounted on said slider plate for movement toward and away from actuator means mounted adjacent switch means, said actuator means having a first position spaced from said switch means and a second position in engagement with said switch means, said cam means including a cam member rotatably mounted about a pin member extending from said slider plate along an axis adjacent said actuator means, said cam member further being formed with a plurality of notches on a first side adjacent said slider plate and cooperating with a locking pin carried on said pin member for locking said cam member against rotation when one of said notches seats on said locking pin, spring means bearing on a second side of said cam member adjacent the free end of said pin member and being retained in engagement with said second side by a nut assembly whereby the force exerted on said cam member can be varied to lock said cam member or allow rotation thereof, said actuator means including a pivoted arm member having one end adjacent said cam member and the other end adjacent said switch means, said arm member being biased to said first position, and being movable to said second position by said cam member when said slider plate moves in one direction, the spacing between said other end of said arm member and said switch means being adjustable by said cam member whereby the distance said slider plate and said drive shaft can move before said actuator means moves from said first position to said second position is also adjustable.

16. A limit switch assembly in accordance with claim 15 wherein said slider plate carries second cam means similar to the first cam means for movement toward and away from second actuator means similar to the first actuator means mounted adjacent second switch means similar to the first switch means whereby movement of said rotary drive shaft in one direction closes said first switch means and movement in the other direction closes said second switch means.

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