May 22, 1962 R. BACCHI 3,036,167

POSITION LIMIT SWITCH

Filed Oct. 29, 1959

2 Sheets-Sheet 1

FIG_1

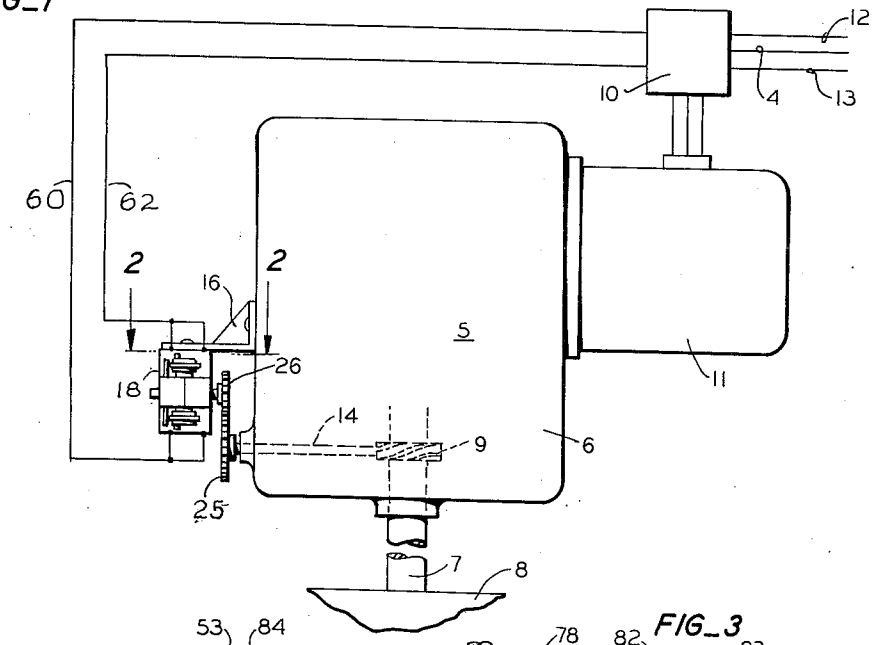

FIG_3

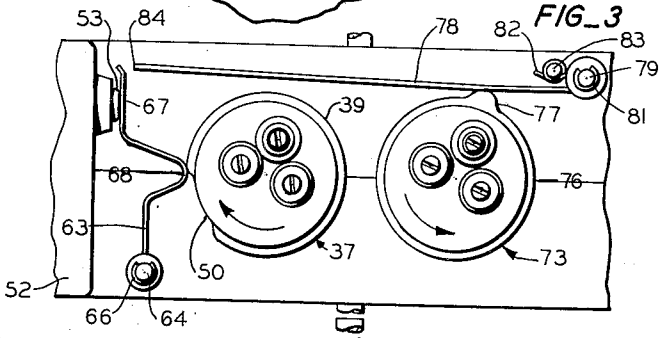

FIG_2

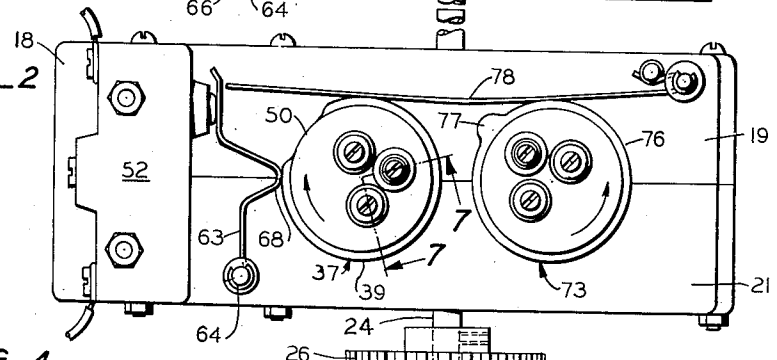

FIG_4

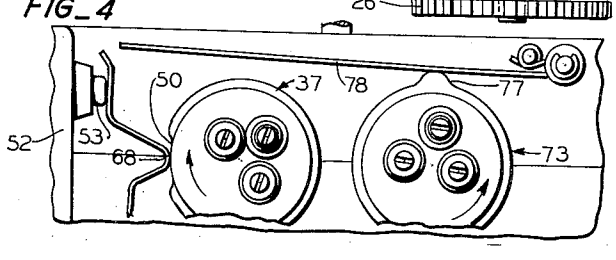

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FIG_5

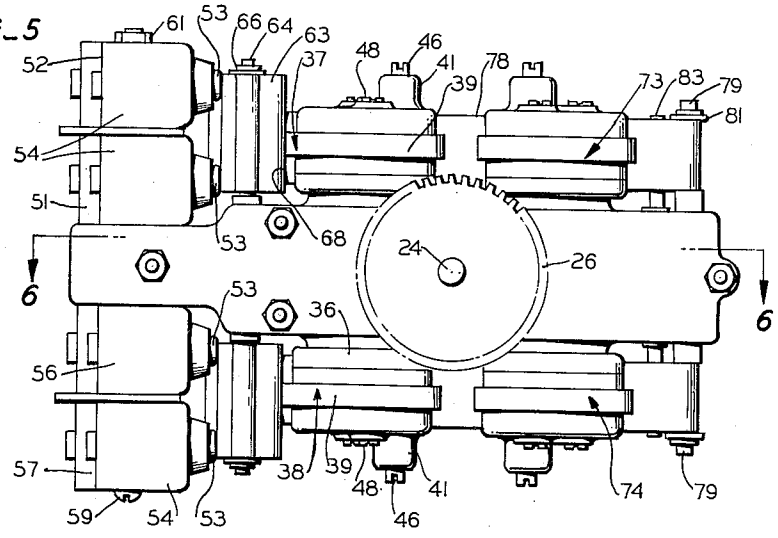

FIG_6

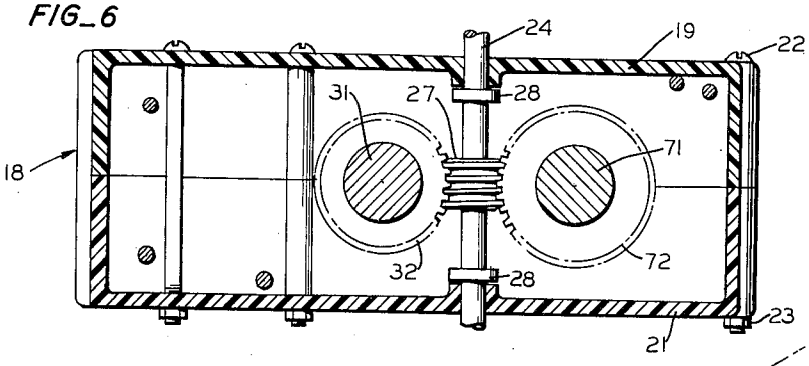

FIG_7

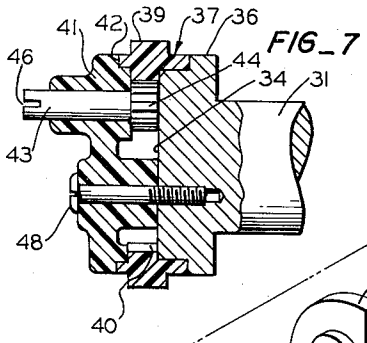

FIG_8

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POSITION LIMIT SWITCH

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4 Claims. (Cl. 200—38)

The position limit switch is useful especially with a valve actuator such as is shown in my copending application entitled Electro-Manual Operator, filed August 25, 1958, Serial No. 757,035, and assigned to the assignee hereof. In that environment, a rising stem valve is actuated by an electric motor and means are provided for stopping the motor at the opposite ends of the valve stroke. The motor, depending upon the electrical connections, is either stopped completely at the end of each stroke, is slowed down immediately before the stop and then is stopped or is automatically reversed at the end of the stroke. Various switching mechanisms accomplish the electrical changes necessary to control the motor. The present invention has to do with an actuator-controlled position limit switch suitable especially for use in the indicated environment.

An object of the invention is to provide a position limit switch which is effective to give a precise and accurate positional control of the device being actuated.

Another object of the invention is to provide a position limit switch which while giving precise control can be utilized in an environment in which there is a very great speed reduction between the electric driving motor and the device being controlled.

Another object of the invention is to provide a position limit switch that can readily be set by the user at any selected actuating positions.

Another object of the invention is to provide a position limit switch which will retain its adjustment or setting indefinitely without difficulty.

Another object of the invention is to provide a position limit switch that is effective despite adverse ambient conditions, such as vibration, shock and the like.

Another object of the invention is to provide an improved position limit switch.

Other objects, together with the foregoing, are attained in the embodiment of the invention described in the accompanying description and illustrated in the accompanying drawings, in which:

FIGURE 1 is a diagrammatic showing of the position limit switch of the invention installed in connection with a typical valve actuator having an electric motor drive.

FIGURE 2 is a side elevation of the position limit switch itself.

FIGURE 3 is a view similar to FIGURE 2, with the parts in a different position.

FIGURE 4 is a view similar to FIGURES 2 and 3, with the parts in a still different position.

FIGURE 5 is a plan of the switch as shown in FIGURE 2.

FIGURE 6 is a cross-section, the plane of which is indicated by the line 6—6 of FIGURE 5.

FIGURE 7 is a developed cross-section, the planes of which are indicated by the lines 7—7 of FIGURE 2.

FIGURE 8 is an exploded, isometric view showing the relationship of the parts especially indicated in FIGURE 7.

While the position limit switch is susceptible of use in widely different environments and under different circumstances, it has successfully been incorporated in a valve actuator 5 such as indicated in FIGURE 1 which includes a housing 6 enclosing the rising stem 7 of a valve 8. The actuator 5 includes a rotary member 9 such as an axially fixed nut engaging a threaded stem 7. By its rotation, the nut moves the valve stem. Rotation of the nut 9 is accomplished by an electric motor 11 receiving its power from mains 4, 12 and 13 through an electrical control box 10. The actuator 5 is provided with a shaft 14 emerging from the housing and rotating in unison with the operation of the motor 11 so that the position of the shaft 14 is indicative of the valve position.

The arrangement is such that the shaft 14 makes a very large number of revolutions for the complete travel of the valve stem so that the instantaneous position of the shaft 14 reflects with considerable accuracy the corresponding position of the valve 8.

Pursuant to the invention, the actuator 5 is provided with a bracket 16 carrying a base or housing 18 for the position limit switch itself. Preferably, this is a body molded of plastic in two parts, an upper portion 19 and a lower portion 21. These portions are fastened together at intervals by separate through bolts 22 and nuts 23. Suitably journalled in the body 18 is a drive shaft 24 preferably extending on opposite sides thereof so that a drive wheel 26 can be installed on either projecting end of the shaft 24 to mesh with a gear wheel 25 on the shaft 14, depending upon the particular installation. The shaft 24 is thus rotated in time with the shaft 14.

A worm gear 27 is fastened on the shaft 24 which is kept appropriately positioned within the housing 18 by collars 28 for carrying the shaft thrust. Also journalled in the housing 18 but disposed at right angles to the drive shaft 24 is a first driven shaft 31. The shaft has a relatively large diameter and within the housing carries a first driven gear 32 meshing with one side of the worm 27. The gear 32 has a set or predetermined diameter so that the shaft 24 drives the shaft 31 at a predetermined ratio. The shaft 31 carries substantially identical mechanisms on its opposite ends outside of the casing 18 so that a description of one mechanism applies equally to the other.

As especially indicated in FIGURE 7, one end of the shaft 31 after it has emerged from the casing 18 is formed to afford a relatively flat end 34 and to have a peripheral flange 36. Freely journalled on the enlarged portion of the shaft 31 is one of a pair of first cams 37 and 38 having a cam track 39 on its periphery and being provided with an internal gear 40. This is all preferably molded of plastic. The cam 37 normally freely abuts the flange 36 and so is held against axial displacement in one direction.

At the end of the shaft 31 there is provided a plate 41 preferably molded of plastic and having a peripheral shoulder 42 in abutment with the cam 37. Journalled in the plate 41 is a pinion shaft 43 at one end carrying a pinion 44 meshing with the internal gear 40. The other end of the pinion shaft 43 carries a tool engaging means 46 so that the pinion shaft 43 can readily be rotated. The plate 41 is assembled to the shaft 31 by a pair of machine screws 48 engaging threads in the enlarged end of the shaft 31.

When the machine screws 48 are in relatively loose engagement, the user by engaging a tool with the end of the pinion shaft 43 and appropriately rotating the shaft thus revolves the pinion 44. Since the plate 41 is held against rotation relative to the driven shaft 31 by the two machine screws 48, the cam 37 is necessarily rotated. This cam preferably has a contour substantially as shown in FIGURE 3 with a depression 50 interrupting the otherwise uniform cam track 39. The pinion shaft 43 can be revolved to locate the depression 50 in any desired polar position relative to the shaft 31.

After the rotary or polar adjustment is made, the machine screws 48 are suitably tightened. This clamps the cam 37 between the shoulder 42 and the flange 36 and

may also clamp the pinion 44 between the flat face 34 and the corresponding portion of the plate 41. Both the cam and the pinion may be clamped or either one may be clamped frictionally in order that the cam track 39, after adjustment, will be firmly fixed relative to the shaft 31.

Mounted on the base or housing 18 (FIGURE 5) is a pair of electrical switches 51 and 52. These switches are of a standard kind and include operating buttons 53 spring-pressed outwardly of the switch casings 54. Since the instant device is preferably symmetrical, a similar pair of switches 56 and 57 is mounted at the other side of the housing, there being provided through bolts 59 and nuts 61 to hold all of the four switches in position. While the electrical switching arrangements can be set up in various different ways, the switches 51 and 52 as well as the switches 56 and 57 serve as pilot switches acting through cables 60 and 62 to operate the controls in the control box 10 so that the motor 11 can be selectively stopped; for example, at the opposite extremes of travel of the rising stem.

It is preferred that two of the switches, for example, 51 and 52, be actuated substantially simultaneously. For that reason, there is provided a wide switch lever 63 at one side of the housing 18. This switch lever is mounted on a spindle 64 and is retained by an end lock 66 so that the lever 63 can rock about the spindle 64 in a small arc. The contour of the lever 63, which is relatively stiff, is such that one portion 67 of the lever is approximately radial with respect to the spindle 64 and affords means in abutment with the buttons 53. When the spring-pressed buttons 53 are normally urged outwardly of the casings 54, the switch lever 63 is moved in a path, in a clockwise direction in FIGURE 4, for example. When a superior force overcomes the springs in the switches 51 and 52, the lever 63 can be rocked in a counterclockwise direction.

Pursuant to the invention, there is provided means for interrelating the switch lever 63 with the cam 37. This is accomplished by making the wide lever 63 of an offset shape to provide a cam follower 68 designed to contact the cam track or surface 39. During the clockwise rotation of the cam 37, the cam track 39 normally urges the lever 63 to the left in FIGURE 3 and depresses the two buttons 53 of the switches 51 and 52. When the cam 37 has rotated sufficiently to bring the depression 50 in the vicinity of the follower 68, the spring behind the buttons 53 of the switches 51 and 52 is sufficient to rock the lever 63 into the position shown in FIGURE 4.

Since the first cams 37 and 38 are rotated through the worm 27 in time with the rotation of the motor 11, the cam 37 makes one revolution for each predetermined number of revolutions of the motor 11. After a plurality of revolutions and at a predetermined time, the switches 51 and 52 are moved from their depressed position to their projected position. Under normal circumstances, if this actuation of the switches occurred each cam revolution, it would be much too frequent for the total travel of the valve stem 7. Yet, the large amount of movement is effective to afford a fine degree of control.

In order that only a certain rotation and not every rotation of the first cam 37 (and similarly with the first cam 38 in conjunction with the switches 56 and 57) will be effective upon the switches 51 and 52, additional mechanism is provided. Mounted in the housing 18 is a second driven shaft 71 parallel to the first driven shaft 31. The shaft 71 within the housing 18 carries a second driven gear 72 meshing with the worm 27. The circumference or pitch diameter of the second driven gear 72 is different than that of the first driven gear 32 and preferably is larger so that for each complete revolution of the first driven shaft 31 there is only a partial, although nearly complete, revolution of the second driven shaft 71.

The second driven shaft 71 projects on opposite sides of the housing 18 and is provided on its exposed portions

with a pair of second cams 73 and 74. These are identical not only with each other but also with the first cams 37 and 38 except for the cam surfaces. The description of the operation of one of the second cams 73 is therefore applicable equally to the other since the opposite sides of the device are symmetrical. The contour of the second cam 73 is preferably substantially as shown in FIGURE 3 and includes a generally circular cam face 76 with a projection 77 extending therefrom.

Mounted on the housing 18 partially in the path of the projection 77 is a latch lever 78. This at one end encompasses a spindle 79 projecting from the housing 18 and is retained in position by a lock 81. One end 82 of the latch lever 78 is bent to underlie a pin 83 so that the latch lever acts as its own spring. The latch lever 78 not only lies in the path of the projection 77 but also extends over the first cam 37 and has an end 84 in proximity to the upper end 67 of the switch lever 63.

As shown in FIGURE 2, when the first and second cams are in the position illustrated, there is restraint on the switch lever 63 by the first cam 37, and there is preferably slight clearance between the switch lever and the end of the latch lever 78. When the cams have advanced to and slightly past the position shown in FIGURE 3, the latch lever 78 lifts out of the path of the switch lever 63 (FIGURE 4) and then when the depression 50 in the first cam 37 underrides the cam follower 68, there is a release of the switch buttons 53 and an actuation of the switches 51 and 52. The switches 51 and 52 are therefore actuated for this particular revolution of the first cam 37.

Since the rates of rotation of the first cam and of the second cam are different because of the different pitch diameters of the gears 32 and 72, on the next rotations, the projection 77 and the depression 50 are out of phase. That is, they are in appropriate polar positions so that the projection 77 lifts the latch lever 78 and restores it and repeatedly does so while the depression 50 of the first cam 37 is in various positions, but always away from the follower 68. Also, the depression 50 may underride the follower 68 repeatedly, but always when the projection 77 is in various positions out of contact with the latch lever 78. After a large number of revolutions, the cams are again in phase. Then the follower 68 is able to drop into the depression 50 when the latch lever 78 is lifted and to permit the spring-pressed buttons 53 of the switches 51 and 52 to be actuated.

If the cams continue to rotate in their previous directions for any reason, such as manual overriding control, the projection 77 and the depression 50 again get out of phase so that subsequent rotations of the cams do not cause switch actuation. Normally, switch actuation stops the motor which is subsequently manually reversed. Upon reverse rotation of the cams with reversal of the driving motor 11, the switch lever 63 follows a reverse movement restoring the switches 51 and 52 to their original condition and the latch lever 78 drops back into its latching position.

Normally, the ratio of the gears 32 and 72 is so chosen and the relative phasing or polar positions of the first cam 37 and second cam 73 are so chosen that it is only after a large number of revolutions of the motor 11 or of the nut 9 on the valve stem that there is an actuation of the switches 51 and 52. Similarly, and at the other end of the stroke, it is only after a large number of revolutions of the nut 9 that the cams 38 and 74 actuate the switches 56 and 57. The adjustment of the pair of first cams and of the pair of second cams can readily be altered by the user at any time simply by loosening the machine screws 48 and rotating the particular pinion shaft 43. Thus, the valve stem 7 can be automatically stopped or slowed and stopped or reversed at any point in its rising or falling movement and with any range of movement.

The switches which control the valve operation are regulated by interlocking switch levers and latch levers so that vibration and shock from surrounding mechanism

does not inadvertently cause the switches to operate. The mechanism which especially requires enclosure and may involve lubrication, such as the driving and driven gears, is located within the housing whereas the mechanism which involves adjustment is readily available from the exterior. The entire mechanism is simple and light and permits of a wide variety of control conditions with easily changed yet firm adjustments. There has thus been provided a substantially improved position limit switch.

What is claimed is:

1. A position limit switch comprising a housing, a first driven shaft passing through and projecting from said housing, a second driven shaft passing through and projecting from said housing parallel to said first driven shaft, a first gear of one diameter within said housing and on said first driven shaft, a second gear of another diameter within said housing and on said second driven shaft, a drive shaft extending into said housing, a driving gear within said housing and on said drive shaft, said driving gear meshing with said first gear and with said second gear, a first pair of cams, means for mounting said first cams on said first shaft for various polar positions thereon, a second pair of cams, means for mounting said second cams on said second shaft for various polar positions thereon, switches on said housing, a pair of switch levers pivoted on said housing in actuating position with said switches, means on one of said switch levers in engagement with one of said first cams, means on the other of said switch levers in engagement with the other of said first cams, a pair of latch levers pivoted on said housing for movement into and out of latching position with respective ones of said switch levers, and means on said latch levers respectively in engagement with said second cams.

2. A position limit switch comprising a housing, a first driven shaft mounted in said housing, a second driven shaft mounted in said housing, a first gear of one diameter on said first shaft, a second gear of another diameter on said second shaft, a drive shaft, a driving gear on said drive shaft and meshing with said first gear and said second gear, a first cam, means for mounting said first cam on said first shaft for various polar positions thereon, a second cam, means for mounting said second cam on said second shaft for various polar positions thereon, a switch on said housing, a switch lever, means for mounting said switch lever on said housing for abutment with said switch and with said first cam, a latch lever, and means for mounting said latch lever on said housing for interengagement with said switch lever and for abutment with said second cam.

3. A position limit switch comprising a base, a switch on said base, a switch lever, means for mounting said switch lever on said base for abutment with said switch, means for urging said switch lever away from said switch, a rotary first cam on said base for moving said switch lever toward said switch, a latch lever, means for mounting said latch lever on said base for movement into and out of the path of said switch lever, means for urging said latch lever into the path of said switch lever, a rotary second cam on said base for moving said latch lever out of the path of said switch lever, and means on said base for rotating said first cam and said second cam at different relative rates.

4. A position limit switch comprising a base, a switch on said base, a switch lever, means for mounting said switch lever on said base for movement in a first path between one position in actuating abutment with said switch and another position away therefrom, a rotary first cam on said base for moving said switch lever in one direction along said first path, spring means for urging said switch lever in an opposite direction, a latch lever, means for mounting said latch lever on said base for movement in a second path between one position intersecting said first path and another position away therefrom, a rotary second cam on said base for moving said latch lever in one direction along said second path, spring means for urging said latch lever in an opposite direction, and means on said base for rotating said first cam and said second cam at different relative rates.

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