Feb. 27, 1968 J. A. HARPER 3,370,474

CAM OPERATED ACTUATING MECHANISM

Filed Oct. 22, 1965 2 Sheets-Sheet 1

Fig. 1

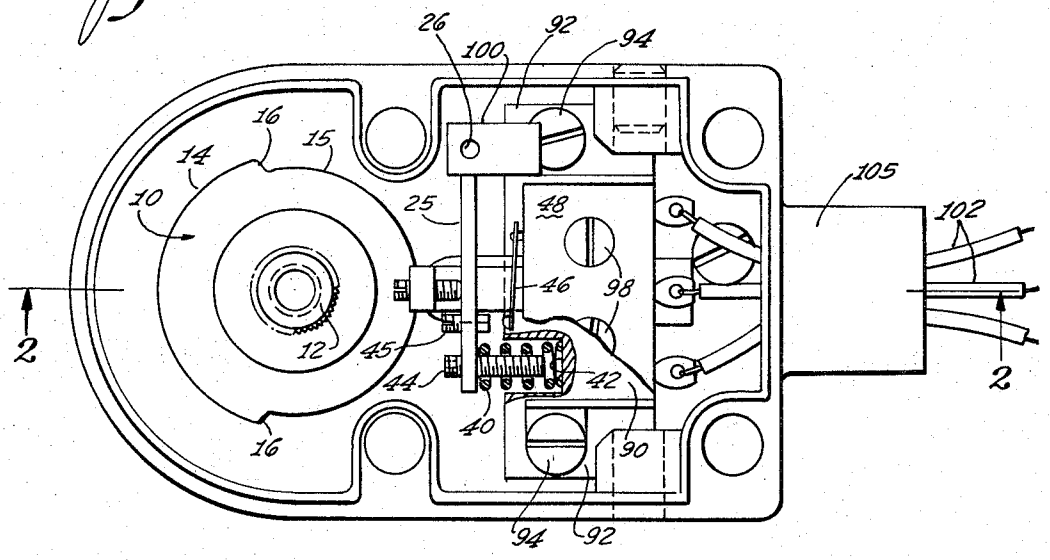


Fig. 2

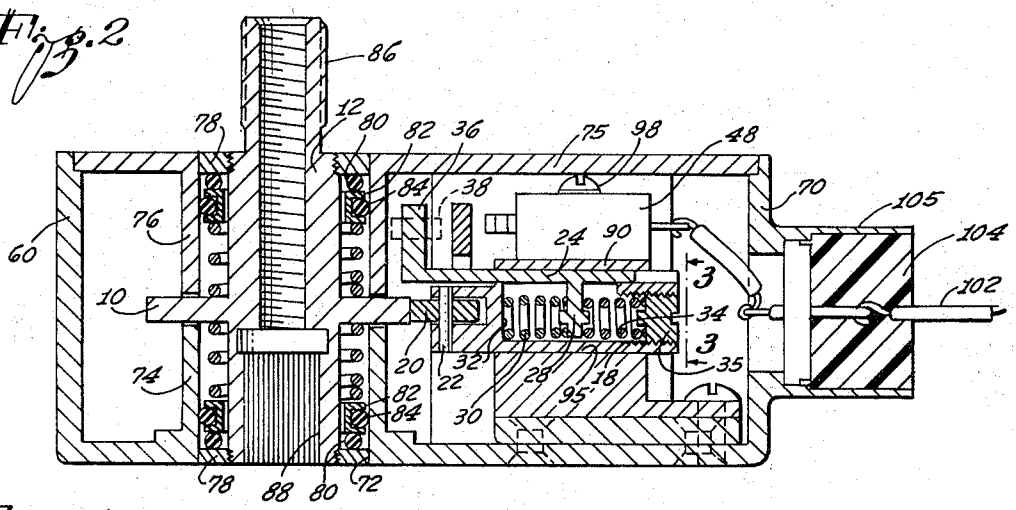


Fig. 4

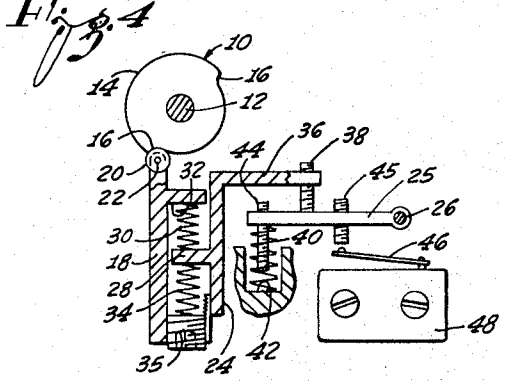
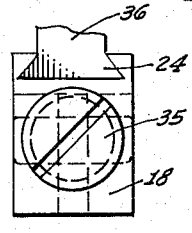


Fig. 3



INVENTOR:
Jay A. Harper

By Smyth, Roston & Pavitt

Attorneys

Feb. 27, 1968 J. A. HARPER 3,370,474

CAM OPERATED ACTUATING MECHANISM

Filed Oct. 22, 1965 2 Sheets-Sheet 2

Fig. 5

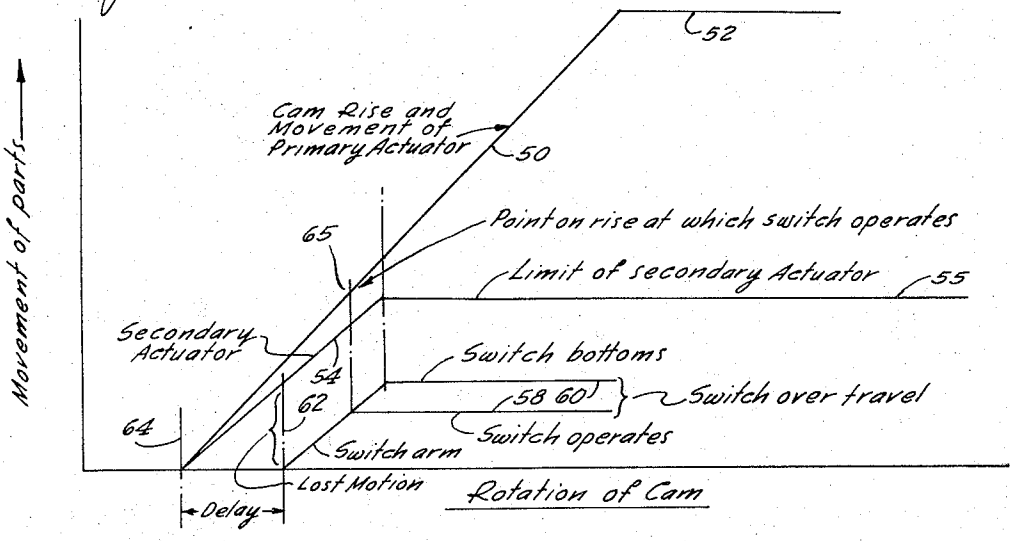
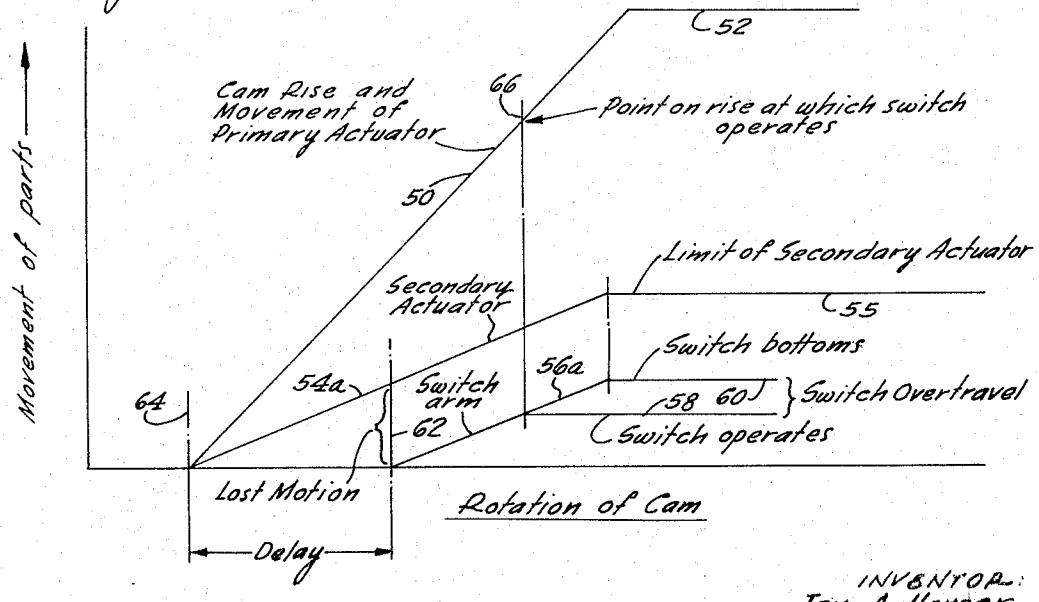


Fig. 6



INVENTOR:
Jay A. Harper

By Smyth, Roston & Pavitt
Attorneys

United States Patent Office 3,370,474
Patented Feb. 27, 1968

3,370,474

CAM OPERATED ACTUATING MECHANISM

Jay A. Harper, Gardena, Calif., assignor to Acme Machine Works, Inc., Hawthorne, Calif., a corporation of California

Filed Oct. 22, 1965, Ser. No. 500,565
14 Claims. (Cl. 74—89)

This invention relates to a mechanism in which an actuator operates a driven member at a predetermined point in the movement of the actuator with precise adjustability of the predetermined point and, more particularly, the invention relates to a mechanism driven by a cam to actuate a driven member with precise adjustability of the operation of the driven member relative to the rotary position of the cam.

Although the invention is widely applicable in various fields for various purposes, it has special utility for determining the precise point in the movement of a cam-operated actuating mechanism at which the mechanism operates a switch. The initial embodiment of the invention is employed to operate an armament switch to disarm the bombs on a military aircraft in response to lowering of the landing gear thereby to preclude detonation of the bombs when the aircraft is on the ground or when the aircraft crashes with its landing gear down. This particular embodiment of the invention will be described herein by way of example and will provide adequate guidance for those skilled in the art who may have occasion to apply the same principles to other specific purposes.

The armament switch that is used is a standard Class A hermetically sealed "close motion" switch having an operating member which is movable through .005" for switch operation and which is additionally movable through a range of .003 overtravel. If the operating member is forced to travel beyond the total range of .008" the sealing diaphragm will be damaged if not destroyed with serious consequences.

The point in the operation of the landing gear mechanism at which the armament switch operates must be determined with high reliability and once determined must be maintained over a long service period with adequate safeguard against damaging thrust against the operating member of the switch. It so happens that although large sums of money have been spent to solve this problem, no satisfactory solution has been found heretofore.

At first thought it would seem that the armament switch could be operated satisfactorily by a cam having a rise of .005 to .008" but in practice it is difficult to manufacture such cams in quantity with high accuracy and even if it were practical to produce such cams the exceedingly small cam rise makes the operating relationship between the cam and the switch too critical for dependability over an adequate service life. Only a little wear on the working parts is serious. In practice, then, the problem narrows down to how to operate a delicate sensitive switch through a maximum of .008" by means of a practical cam having a rise of many times that dimension, for example, a cam having a rise of .080".

In one prior art attempt to solve this problem, a cam with a high rise operates the sensitive switch by means of a looped leaf spring. It is a simple matter to fabricate the high rise cam in quantity and the leaf spring is a safeguard against damage to the switch. Unfortunately, however, the varying flexibility of such leaf springs makes it impossible to achieve the required precision in mass production.

The present invention meets the problem by operating the switch by means of the high rise cam in an indirect manner as follows. A primary actuator is directly operated by the cam and a secondary actuator which operates

the switch is yieldingly connected to the primary actuator is an adjustable manner. The yielding relationship between the two actuators is a safeguard to switch damage and in addition the adjustability of the yielding relationship makes it possible to vary the point on the cam rise at which operation of the switch occurs. In addition the preferred embodiment of the invention provides adjustable lost motion in the operating connection between the secondary actuator and the switch. The lost motion provides a delay and the point on the cam rise at which the operation of a switch occurs depends not only on the adjustment of the yielding connection between the two actuators but also on adjustment of the lost motion between the sec ondary actuator on the switch.

The features and advantages of the invention will be understood from the following detailed description and the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a side elevational view of the presently preferred embodiment of the invention with a side wall of the housing of the mechanism removed and with a portion of the structure broken away;

FIG. 2 is a longitudinal section along the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary elevational view as seen along the line 3—3 of FIG. 2;

FIG. 4 is a simplified diagrammatical view of the primary and secondary actuators showing how the primary actuator is related to the cam and how the secondary actuator is related to the switch;

FIG. 5 is a diagram showing the movement of the parts at different degrees of rotation of the cam; and

FIG. 6 is a diagram similar to FIG. 5 showing how an adjustment in the yielding relationship between the primary actuator and the secondary actuator shifts the point along the rise of the cam at which operation of the switch occurs.

An understanding of the invention may be approached by first considering the diagrammatical representation of the mechanism shown in FIG. 4 and the two diagrams shown in FIGS. 5 and 6.

In FIG. 4, a cam **10** mounted on a shaft **12** for operation by a landing gear control mechanism (not shown) has an outer dwell **14** and an inner dwell **15** with two shoulders or rises **16** at the opposite ends of the outer dwell. The cam **10** directly operates a longitudinally movable slide **18** which constitutes what may be termed a primary actuator, the slide being provided with a roller **20** on a cross pin **22** for cooperation with the cam.

What may be termed a secondary actuator comprises two separate members, namely a second longitudinal movable slide **24** and a lever **25** that is mounted on a fixed pivot **26**. The primary slide **18** and the secondary slide **24** are mounted in a common guideway which will be described later and the secondary slide has a central flange **28** which extends towards the primary slide. The previously mentioned yielding connection between the primary actuator and the secondary actuator comprises two springs, namely a first spring **30** under compression between the central flange **28** of the secondary slide **24** and a shoulder **32** of the primary slide **18** and a second spring **34** which acts under compression between the central flange and a first set screw **35** that is adjustably mounted on the primary slide **18**.

The second slide **24** has a laterally extending arm **36** which carries a second set screw **38** that projects towards the lever **25**. The outer end of the lever **25** is supported by a third spring **40** which is seated in a well **42** in the fixed structure of the mechanism, the spring urging the lever **25** towards the overhanging arm **36** of the secondary

slide 24. The lever 25 is provided with a third set screw 44 which extends into the well 42 to serve as a stop screw. In addition the lever 25 is provided with a fourth screw 45 which actuates the operating arm 46 of a sensitive microswitch 48 which is a Class A hermetically sealed switch.

It is apparent that the third spring 40 provides the force that urges the primary slide 18 towards the cam 10 as required for actuation of the primary slide by the cam. When the third set screw 44 is spaced from the bottom of the well 42, the secondary slide 24 takes a position of spring equilibrium at which the force of the first spring 30 is balanced by the contrary force of both the second spring 34 and the third spring 40. It is also apparent that the rate of movement of the secondary slide 24 in response to the movement of the primary slide 18 is less than the rate of movement of the primary slide 18 by the cam 10. Thus the secondary slide 24 lags behind the movement of the primary slide 18 and the degree to which the secondary slide lags may be varied by an adjustment of the first set screw 35 to change the stressing of the second spring 34. The position of the secondary slide 24 relative to the primary slide 18 is also varied by the first set screw 35. Thus the first set screw 35 serves as means for shifting the normal position of the secondary slide 24.

It is important to note that the fourth set screw 45 is spaced from the operating arm 46 of the switch 48 when the primary slide 18 is retracted into contact with the inner dwell 15 of the cam 10. This normal spacing of the fourth set screw 45 from the operating arm of the switch provides a lost motion between the secondary actuator and the switch, the magnitude of the lost motion being adjustable by the fourth set screw.

In the diagram shown in FIG. 5 the line 50 represents a shoulder or rise 16 of the cam 10 and thus represents the movement of the primary actuator or primary slide 18 by the cam. The line 50 rises to a plateau 52 which corresponds to the outer dwell 14 of the cam.

The line 54 in FIG. 5 represents the movement of the secondary actuator, i. e. the movement of the secondary slide 24 and the associated lever 25. The line 54 rises to a plateau 55 which represents the bottoming of the fourth set screw or stop screw 44 in the well 42. It is to be noted that the slope of the line 54 is less than the slope of the line 50 because the rate of movement of the secondary actuator is less than the rate of movement of the primary actuator by virtue of the described arrangement of the first, second and third springs 30, 34 and 40.

The inclined line 56 represents the movement of the switch arm 46 by the lever 25 of the secondary actuator, the line 56 being at the same slope as the line 54. When the movement of the switch arm reaches the point indicated by the horizontal line 58 the switch operates to open or close the armament circuit. The horizontal line 60 represents the limit to which the operating arm 46 may be moved without damage to the switch. Thus the two lines 58 and 60 represent the range of overtravel of the switch arm.

As heretofore stated, the movement of the operating arm to the operating point, i.e. to the extent represented by the level of the line 58 is .005" and the overtravel from the line 58 to the line 60 is .003". It is important to note that the third set screw or stop screw 44 is adjusted to bottom in the well 42 when the switch arm 46 reaches the limit position represented by line 60. Thus the third set screw or stop screw 44 provides absolute assurance that the switch will not be damaged by excess thrust on the part of the secondary actuator.

The vertical distance between the two lines 56 and 54, for example as measured along the vertical line 62, represents the magnitude of lost motion between the lever 25 and the operating arm 46 of the switch, i.e. the distance that the secondary actuator must move initially before it starts actuation of the switch arm. This lost motion measured along the vertical line 62 results in a period of delay between initiation of operation of the secondary actuator and initiation of the movement of the switch arm 46, the extent of the delay corresponding to the horizontal distance between the vertical line 62 and a vertical line 64.

FIG. 6 shows the effect of tightening the first set screw 35 to compress the second spring 34. The resulting increased spring resistance to movement of the secondary slide 24 by the first spring 30 lowers the rate at which the secondary slide moves, the lowered rate being represented by the lower slope or inclination of the line 54*a* in FIG. 6. The magnitude of the lost motion remains the same as before but it is to be noted that the decreased slope of the line 54*a* lengthens the delay that is caused by the lost motion. As a consequence, the point at which the switch operates is shifted upward along the line 50, i.e. upward on the shoulder or rise of the cam. Thus the tightening of the first set screw 35 shifts the operation of the switch from the point 65 on the slope 50 of FIG. 5 to the point 66 in FIG. 6. It is apparent that a shift in the same direction may be caused by increasing the lost motion by loosening either the second set screw 38 or the fourth set screw 45.

On the other hand, the operation of the switch may be shifted in the opposite direction from point 66 in FIG. 6 towards point 65 in FIG. 5 by loosening the set screw 35. Also the shift in the opposite direction may be accomplished by tightening either the second set screw 38 or the fourth set screw 45 to reduce the lost motion between the secondary actuator and the operating arm of the switch.

It is apparent from the foregoing that initial or gross adjustment of the point of operation of the switch relative to the rotation of the cam may be accomplished by rotational adjustment of the cam relative to the landing gear mechanism of the aircraft. Precise adjustment may then be accomplished by means of the first set screw 35 for varying the stress of the spring 34 and/or by means of the fourth set screw 45 to vary the lost motion between the secondary actuator and the operating arm 46 of the switch.

Turning now to the specific construction of the mechanism shown in FIGS. 1–3, the control mechanism for disarming bombs is enclosed by a hermetically sealed housing that is made in two sections interconnected by suitable screws (not shown). One of the housing sections comprises a side wall 67, two end walls 68 and 70, the side wall having a circular opening 72 with an integral cylinder 74 extending inward from the opening. The second section of the housing comprises a second side wall 75 which like the first side wall has an opening 72 therein with an integral cylinder 76 extending inward from the opening.

The two inwardly extending cylinders 74 and 76 are coaxial to journal the previously mentioned shaft 12 that carries the cam 10 and the inner ends of the two cylinders are spaced apart to clear the cam. In the construction shown a pair of collars 78 are threaded onto the shaft 12 to journal the shaft in the two cylinders 74 and 76 respectively.

Any suitable means may be provided to form seals around the shaft. In the construction shown, a Teflon O-ring 80 is mounted at each end of the shaft in abutment with the corresponding collar 78 and under compression between the collar and a corresponding ring member 82 that is channel-shaped in cross section to confine an O-ring 84 in sealing contact with the surrounding cylinder. Suitable coil springs 85 under compression between the cam 10 and the two ring members 82, respectively, provide the required sealing pressure against the Teflon O-rings 80. The shaft 12 is suitably adapted for connection to associated mechanism and for this purpose an end portion 86 of the shaft may protrude from one side of the

housing and the other end of the shaft may be formed with a splined socket 88.

A metal block 90 formed with opposite ears 92 is mounted on the inner end of the side wall 66 by suitable screws 94 extending through the ears and is cut away on its inner side to form a guideway 95 of rectangular cross section for the previously mentioned primary and secondary slides 18 and 24. In the construction shown, the open side of the guideway 95 is covered by a plate 96 and the previously mentioned switch 48 is mounted on the block 90 by screws 98 that extend through the plate.

The primary slide 18 is cut away to form the previously mentioned shoulder 32 for abutment by the first spring 30 and to provide space to clear the central flange 28 of the secondary slide 24. One end of the primary slide 18 is threaded to receive the first set screw 35 that abuts the second spring 34 and the other end of the primary slide is forked to carry the previously mentioned roller 20 on the cross pin 22.

As shown in FIG. 3, the secondary slide 24 is dovetailed in cross-sectional configuration to slide in a slot 99 of dovetailed cross section in the primary slide 18. The secondary slide 24 is formed with the previously mentioned arm 36 that carries the second set screw 38 for cooperation with the lever 25. The lever 25 is journalled by the previously mentioned pivot 26 on a pair of ears 100 that are integral with the block 90. As shown in FIG. 1 the well 42 that seats the third spring 40 and receives the third set screw or stop screw 44 is formed in the metal block 90. FIG. 1 shows how the lever 25 carries the fourth set screw 45 in position to actuate the operating arm 46 of the switch 48. The switch 48 is connected to external circuits by means of wires 102 that extend through a body 104 of insulating material in a tubular extension 105 of the end wall 70 of the housing.

The manner in which the described mechanism functions for its purpose may be readily understood from the foregoing description. When the landing gear is lowered, the cam 10 is rotated in one direction to bring one of the cam shoulders 16 against the follower or roller 20 carried by the primary slide 18 to operate the switch 48 in one respect and when the landing gear is subsequently raised the cam rotates in the opposite direction to return the cam shoulder 16 past the follower to operate the switch in the opposite respect. The precise point on the cam rise at which the switch operates may be varied by adjusting the first set screw 35 to change the rate of movement of the secondary slide relative to the rate of movement of the primary slide or by adjusting the second set screw 38 or the fourth set screw 45 to change the lost motion between the secondary slide and the switch arm. The range of over travel of the switch arm compensates for wear among the working parts.

My description in specific detail of the selected embodiment of the invention will suggest various changes, substitutions and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. In a mechanism of the character described, means to actuate a driven member in response to movement of a primary actuator in one direction in a given range, comprising:

a secondary actuator movable in said one direction to actuate the driven member;

first spring means coupling the two actuators to each other and acting permanently between the two actuators for movement of the secondary actuator by the primary actuator; and

second spring means to yieldingly resist movement of the secondary actuator in said one direction with the rate at which the secondary actuator moves in said one direction in response to movement of the primary actuator in the same direction depending on the relative magnitudes of the forces exerted by the two spring means,

whereby at least one of the two springs may be adjusted to cause actuation of the driven member when the primary actuator reaches a selected point in said range.

2. A combination as set forth in claim 1 in which said secondary actuator has a lost motion operating connection with the driven member for delayed response of the driven member to the secondary actuator.

3. A combination as set forth in claim 2 which includes means to adjust the magnitude of the lost motion.

4. In a mechanism of the character described, means to actuate a driven member in response to movement of a primary actuator in one direction in a given range, comprising:

a secondary actuator movable in said one direction to actuate the driven member;

first spring means acting between the two actuators to urge the secondary actuator in said one direction relative to the primary actuator;

second spring means acting between the two actuators to urge the secondary actuator in the opposite direction relative to the primray actuator whereby the two spring means yieldingly interconnect the two actuators to cause the secondary actuator to yieldingly follow the movement of the primary actuator in said one direction; and

third spring means having one end fixed with its other end acting against the secondary actuator to resist movement thereof in said one direction whereby movement of the primary actuator in said one direction causes lagging movement of the secondary actuator in said one direction,

at least one of the three spring means being adjustable to vary the degree to which the secondary actuator lags behind the primary actuator thereby to vary the point in said range at which the primary actuator causes actuation of the driven member.

5. A combination as set forth in claim 4 in which said secondary actuator has a lost motion operating connection with the driven member for delayed response of the driven member to movement of the secondary actuator.

6. A combination as set forth in claim 5 which includes means to adjust the magnitude of said lost motion.

7. A mechanism to open or close a circuit at a selected point in movement of a primary actuator in one direction with adjustability of the point and with compensation for wear of the parts of the mechanism, comprising:

a switch for said circuit, said switch having an operating member movable in one direction to a predetermined operating point to actuate the switch at the operating point and movable beyond the operating point through a predetermined range of overtravel without damage to the switch;

a secondary actuator movable in said one direction to move said operating member of the switch in its one direction;

stop means to limit the movement of the secondary driver to the end of said range of overtravel of the operating member to avoid damage to the switch;

spring means coupling the two actuators to each other and acting permanently between the two actuators to urge the secondary actuator in said one direction relative to the primary actuator; and

spring means to yieldingly resist movement of the secondary actuator in said one direction whereby the rate at which the secondary actuator moves in said one direction in response to movement of the primary actuator in the same direction depends on the relative magnitudes of the forces exerted by the two spring means,

one of said spring means being adjustable with respect to the force it exerts thereby to vary the rate of

movement of the secondary actuator relative to the rate of movement of the primary actuator to vary the point in said range at which the primary actuator causes the switch to operate.

8. A combination as set forth in claim 7 in which said secondary actuator has a lost motion operating connection with said operating member for delayed response of the operating member to the movement of the secondary actuator.

9. A combination as set forth in claim 8 which includes means to adjust the magnitude of said lost motion to vary said operating point of the operating member relative to said range of the primray actuator.

10. A mechanism to open or close a circuit at a predetermined point in the range of rotation of a rotary control member with adjustability of the point in the range and with compensation for wear of the moving parts of the mechanism, comprising:

a switch for said circuit, said switch having an operating member movable in one direction to a predetermined operating point to actuate the switch at the operating point and movable beyond the operating point through a predetermined range of overtravel without damage to the switch;

a cam operatively connected with said rotary control member, said cam having a rise;

a primary actuator movable in one direction by said rise of the cam;

a secondary actuator movable in said one direction to move said operating member of the switch in its one direction;

stop means to limit the movement of the secondary actuator to the end of said range of overtravel of the operating member to avoid damage to the switch;

first spring means acting between the two actuators to urge the secondary driver in said one direction relative to the primary actuator;

second spring means acting between the two actuators to urge the secondary actuator in the opposite direction relative to the primary actuator whereby the two spring means yieldingly interconnect the two actuators to cause the secondary actuator to yieldingly follow the movement of the primary actuator in said one direction; and

third spring means having one end fixed with its other end acting against the secondary actuator to resist movement thereof in one direction whereby movement of the primary actuator in said one direction causes lagging movement of the secondary actuator in said one direction,

at least one of the three spring means being adjustable to vary the degree to which the secondary actuator lags behind the primary driver thereby to vary the operation of the switch relative to the rise of the cam.

11. A combination as set forth in claim 10 in which said second spring means is adjustable.

12. A combination as set forth in claim 10 in which said stop means is adjustable to correlate the second actuator with the operating member of the switch.

13. A combination as set forth in claim 10 in which said secondary actuator has a lost motion connection with said operating member of the switch for delayed response of the operating member to the movement of the secondary actuator.

14. A combination as set forth in claim 13 which includes means to adjust the magnitude of said lost motion.

References Cited

UNITED STATES PATENTS

3,104,298 9/1963 Aldous ---------- 200—153.13

OTHER REFERENCES

Rothaupt: German application 1,202,862, printed Oct. 14, 1965, (K1 21c–30).

FRED C. MATTERN, JR., *Primary Examiner.*

W. S. RATLIFF, *Assistant Examiner.*