

June 17, 1969

D. E. HUTCHINSON ET AL
ROTARY ACTUATORS

3,449,982

Filed Oct. 26, 1967

Sheet 2 of 3

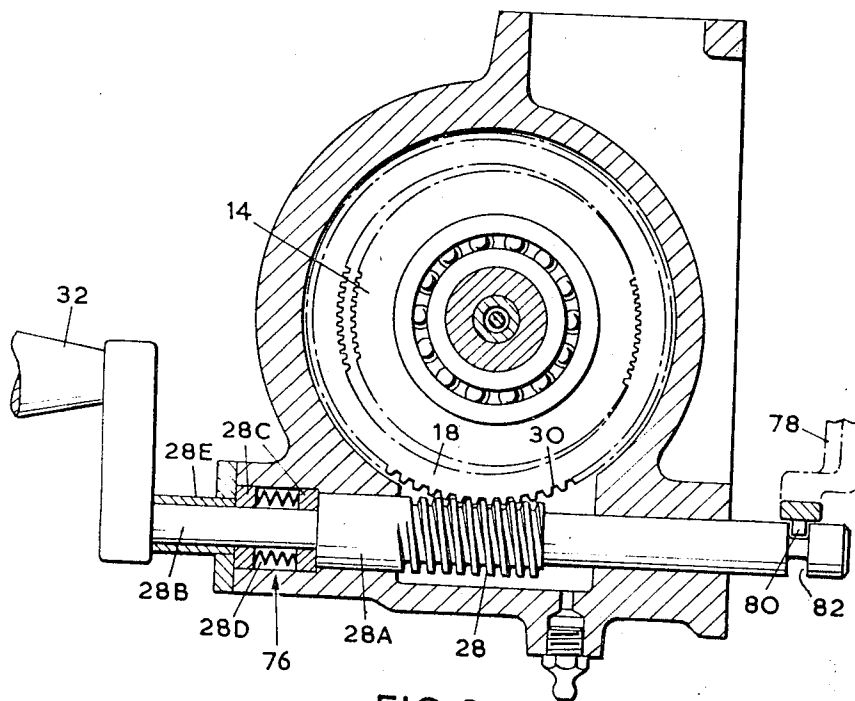


FIG. 3

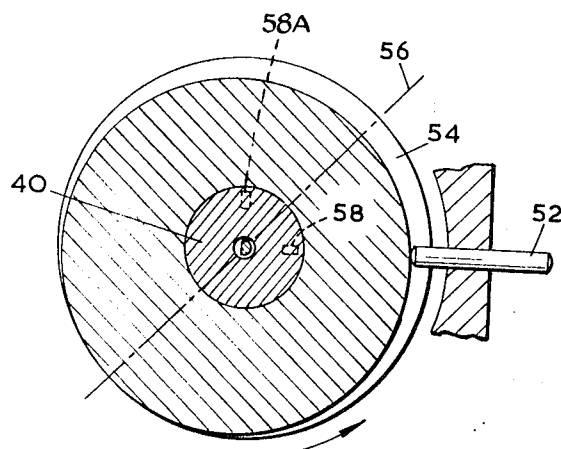


FIG. 4

June 17, 1969

D. E. HUTCHINSON ET AL

3,449,982

ROTARY ACTUATORS

Filed Oct. 26, 1967

Sheet 3 of 3

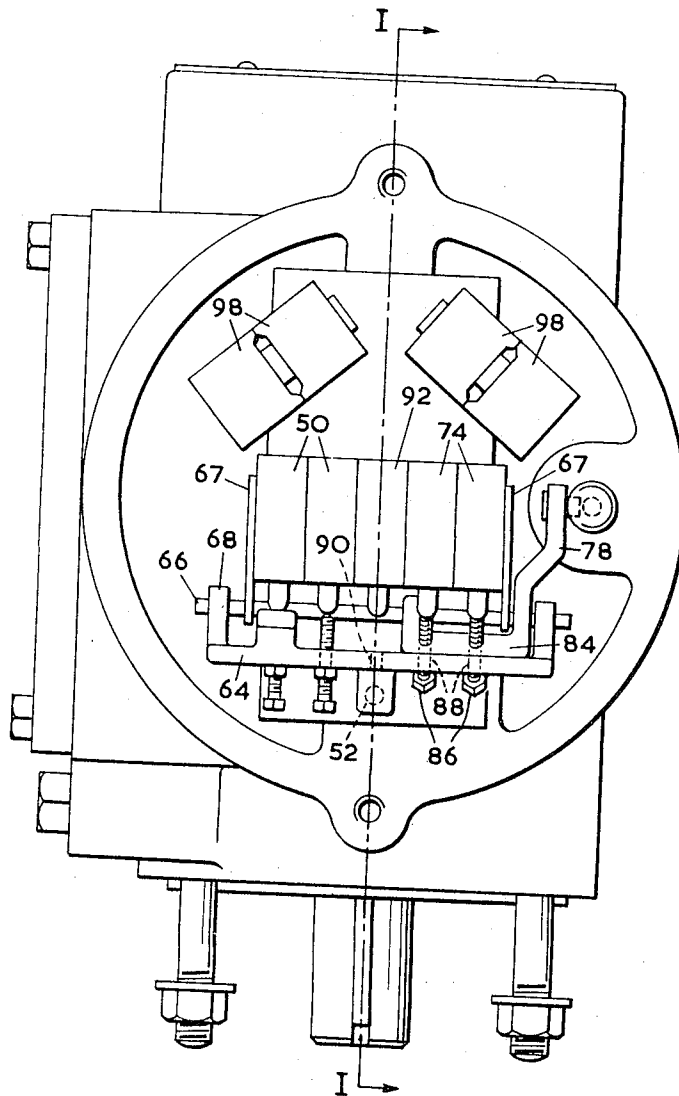


FIG. 5

1

2

3,449,982

ROTARY ACTUATORS

Desmond Ernest Hutchinson and Harry Wilkinson, Bradford, England, assignors to The English Electric Company Limited, London, England, a British company

Filed Oct. 26, 1967, Ser. No. 678,377

Claims priority, application Great Britain, Oct. 26, 1966, 47,962/66

Int. Cl. G05g 11/00; F16h 1/16; F16k 31/02

U.S. Cl. 74-626

10 Claims

ABSTRACT OF THE DISCLOSURE

This invention is concerned with a switch system for an actuator and particularly for a fractional-revolution actuator. The system includes two switch-operating members which are movable (for example pivotally) respectively in response to the position of the actuator output member and the state of a torque-sensitive member, each switch-operating member being capable of carrying switch actuators so that a user can arrange for the actuator to be controlled either by switches responsive to the output member position, or by torque-limiting switches, or by both.

This invention is concerned with switch systems for rotary actuators and particularly for fractional-revolution actuators, that is to say actuators of which the output member moves through not more than 360°.

It is sometimes desirable to have some form of switch system which operates switches at predetermined positions of the output member (which switches may be termed "position switches") or which operates torque-limiting switches to prevent overloading of the drive motor, or it may be desirable to include both position switches and torque-limiting switches. This invention is concerned with a switch system which enables a user to operate the actuator in various ways according to his needs.

According to this invention the switch system consists of a row of switches; a first switch operating member which extends along the row of switches and is arranged to carry switch actuators, the switch operating member being movable (e.g. pivotally) in response to movement of a member controlled by the output member of the actuator so that the switches can be made to operate selectively in response to the position of the output member; and a second switch-operating member which normally remains stationary but which moves (e.g. pivotally) in the event of the actuator encountering an excessive load, and which carries or can carry two switch actuators to act on two of the switches which then serve as torque-limiting switches. In other words, if a user requires torque-limiting switches and position switches then two of the switches out of the row serve as torque-limiting switches and are arranged to be operated by switch actuators on the second switch-operating member, and the remainder of the switches serve as position switches and are operated by switch actuators on the first switch-operating member; alternatively the user can arrange the system to operate without the position switches or without the torque-limiting switches, and in the last case all the switches can be used as position switches.

This invention is particularly applicable to an actuator having an input shaft which drives a double gear mounted eccentrically on the shaft (that is to say, the axis of the double gear is parallel to but spaced from the axis of the shaft). The double gear in this particular form of actuator meshes with a normally stationary annular gear member and with an output gear member;

it rolls around the annular member and by virtue of a difference between the numbers of teeth on the annular member and output member (assuming that the teeth are of the same form), it transmits a stepped-down drive to the output member. For fractional-revolution operation the gear reduction ratio of the actuator needs to be high; for this purpose the annular member and output member are formed with nearly the same number of teeth.

In the case of an actuator of the general construction just described, the annular gear member may be held normally stationary by a worm by which the actuator can be operated manually. The worm shaft in this case may be arranged to move axially, against the action of a centering spring arrangement, in the event of an excessive load being encountered by the actuator (with a consequent excessive torque on the annular member) and the worm shaft may control the second switch-operating member.

An example of an actuator according to this invention is shown in the accompanying drawings. In these drawings:

FIG. 1 is a cross-section through the actuator on the line I—I in FIG. 5;

FIG. 2 is an enlarged view of a detail taken from FIG. 1;

FIG. 3 is a section on the line III—III in FIG. 1;

FIG. 4 is a section on the line IV—IV in FIG. 1; and

FIG. 5 is an end view from the right of FIG. 1 with the end cap removed to show the inner parts.

The actuator is powered by an electric motor having a stator 2 surrounding a rotor 4 which is mounted on an actuator input shaft 6. A drive member 8 is secured to the shaft 6 and has cylindrical peripheral surfaces 10 which are eccentric with respect to the axis of the shaft, and the drive member 8 also includes a counterweight 12 to balance the eccentric force caused by the rotation of the parts around the eccentric surfaces 10.

A double gear member 14 is mounted on ball bearings 16 around the eccentric peripheral surfaces 10 of the drive member 8. During rotation of the motor, the double gear 14 rolls around a normally stationary annular member 18 and imparts a stepped-down drive to an output member 20. The output depends upon the fact that the annular member 18 and output member 20 have different numbers of inner gear teeth 22 and 24 respectively meshing with corresponding external gear teeth on the double gear member 14. The arrangement shown gives a high reduction ratio because the sets of gear teeth 22 and 24 differ only slightly in number of teeth. The ratio may, for example, be 1500:1.

The actuator is designed to impart a rotary movement of up to 90° to an output shaft 26 secured in the output member 20. The total possible movement of the output shaft 26 may however be more or less than 90°. The particular arrangement shown is intended to drive a butterfly valve or any other mechanism requiring a 90° movement.

The annular member 18 is normally held stationary by engagement of a worm 28 (see FIG. 3) with appropriate gear teeth 30 which are formed around the outer surface of the annular member 18. The worm also enables the output shaft 26 of the actuator to be driven manually by means of handle 32 mounted on the worm shaft 28A. During manual operation the motor shaft 6 remains stationary.

A visual indication of the position of the output member is provided by a marked disc 34 which is surrounded by a dial 36 (see FIG. 1). The disc 34 is driven by a spindle 38 which passes through the input shaft 6 and is secured to a centre member 40 in the output member 20.

A stiff piece of wire 42 extends across the upper face of the member 40 and its ends lie in notches in a circumferential flange 44 on the member 40 (not shown). During assembly the spindle 38 is pushed into position and the end portion 46 deflects the wire 42 which finally snaps into a recess 48 in the spindle and thus locks the spindle in position. The wire 42 bears tightly on the flat bottom surface of the recess 48 and thus transmits the necessary rotary drive from the member 40 to the spindle 38.

Position switches 50 are controlled by a mechanism including a follower rod 52 which bears on the bottom of a circular groove 54 machined eccentrically in the periphery of the output member 20, that is to say, the bottom of the groove engaged by the rod 52 follows a circular path eccentric with respect to the output member. This is shown most clearly in FIG. 4. The range of movement of the cam formed by the eccentric groove is selected to provide the greatest possible response at all positions of the output member. For that purpose the arc of the output member engaged by the follower is bisected by a diameter normal to the axis of symmetry 56. One extreme position of the output member with respect to the rod 52 is shown in FIG. 4 and the other extreme position is one in which the output member has rotated in a counter-clockwise direction through 90°. In FIG. 4 the reference numeral 58 identified a key by which the drive from the output member 20 to the output shaft 26 is transmitted; the key is shown at one limiting position, the other limiting position (after counter-clockwise rotation of the output member through 90°) being identified by the reference numeral 58A.

The follower rod 52 extends out of the casing 60 of the actuator (see FIG. 1) and bears on the lower end of a finger 62 extending from a pivot plate 64. This plate 64 is pivoted on a pin 66 which passes through turned up flanges 68 at the ends of the pivot plate. The pin 66 is supported by side plates 67. As the rod 52 moves outwards under the influence of the eccentric groove, the pivot plate is swung in an anticlockwise direction and at the extreme position of the output member (i.e. after a 90° rotation) one of the position switches 50 is opened by an adjustable set-screw 70 mounted in the pivot plate; the set-screw 70 can be adjusted, being locked in position by a locknut 72, and operates the switch by acting on a switch arm 71. During movement of the output member in the opposite direction, the other set-screw opens the second switch 50 at the end of the 90° movement. In other words, one switch is wired so as to be "normally open" and the other "normally closed." The adjustability of the set-screws enables the switch operation to be set correctly to occur precisely at the ends of the desired 90° movement or alternatively at the ends of a smaller angle of movement.

The follower rod 52 is pressed against the bottom of the groove 54 by the action of springs in the switches 50.

The actuator also includes two torque-limiting switches 74. These are operated in response to axial movement of the worm 28 against the action of a centering spring arrangement 76 (see FIG. 3). The worm shaft 28A has a reduced end portion 28B which is surrounded by two collars 28C and by a spring consisting of a stack of Belleville washers 28D. Each collar 28C bears on a shoulder in the housing of the actuator at its outer periphery and bears on a shoulder on the worm shaft at its inner periphery (the last mentioned shoulder on the worm shaft being actually on a short sleeve member 28E around the shaft). In this way, movement of the worm shaft in either direction is resisted by the Belleville washers, which may be pre-compressed so that no movement occurs until the axial force on the worm shaft has risen to a desired limiting value at which one of the torque-limiting switches stops the motor. This axial force is directly related to the torque output of the actuator. In other words, rotary movement of the annular member 18

is resisted by the worm shaft until the torque has risen to the limiting value, whereupon the worm shaft moves axially and operates one or other of the torque-limiting switches, depending upon the direction of rotation.

Axial movement of the worm shaft brings about a swinging movement of a torque-control lever 78 which has a pin 80 engaging in a circumferential groove 82 in the worm shaft 28A and which is formed integrally with a second pivot plate 84, pivotally mounted on the pin 66. The pivot plate 84 carries two adjustable set-screws 86 which act on switch arms of the switches 74 which are similar to the switch arms 71 of the switches 50.

If any user requires, for example, four position switches and no torque switches then the set-screws 86 can be taken out of the pivot plate 84 and can be screwed instead into screw-threaded holes 88 in the first pivot plate 64, in which positions they can operate on the same switch arms of the switches 74. In addition, in order to obtain a fifth position switch, a further set-screw can be screwed into a screw-threaded hole 90 to operate on a switch 92.

A further indication of the position of the output member, for example for the purpose of remote control, may be obtained through a further finger portion 94 (FIG. 1) extending from the first pivot plate 64. This finger portion 94 may be used to control a rod 96 which may, for example, be coupled to an electrical potentiometer, the rod 96 being pressed against the finger portion 94 by a spring. A potentiometer or other continuously variable electrical device can be used to indicate at a remote position the position of the actuator output member or to control further position switches.

The switches 50, 74 and 92 are connected into a control circuit via terminal blocks 98.

We claim:

1. An actuator comprising an input member; power means driving the input member; an output member; gear reduction means connected between the input and output members for driving the output member at a stepped-down speed; a row of switches; a first switch-operating member which extends along the row of switches and is adapted to carry a first set of switch-actuating devices; means moving the first switch-operating member in response to the position of the output member whereby the first-mentioned switch-actuating devices carried by the first switch-operating member operate the switches at predetermined positions of the output member; a second switch-operating member adapted to carry a second set of switch-actuating devices; and means responsive to the torque being transmitted by the actuator and coupled to the second switch-operating member for moving the second switch-operating member so that one of the second-mentioned switch-actuating devices operates one of the switches when the torque exceeds a desired limiting value.

2. An actuator according to claim 1 in which the two switch-operating members are mounted for pivotal movement about the same axis which is parallel to the row of switches.

3. An actuator according to claim 1 in which each switch-actuating device is in the form of an adjustable set screw.

4. An actuator according to claim 3 in which the switch-actuating devices of the two sets are interchangeable.

5. An actuator according to claim 3 in which each switch can be operated by a set screw carried by either switch-operating member.

6. A fractional-revolution actuator comprising an electric motor coupled to an input shaft; a double gear mounted eccentrically on the input shaft and having two sets of gear teeth; a normally-stationary annular gear member having internal gear teeth meshing with one of the sets of teeth on the double gear and having external gear teeth meshing with a worm by which the annular

5

gear member is held normally stationary, the worm being spring centered axially so as to be capable of moving axially against the spring action in the event of the annular gear member experiencing an excessive torque, the worm being furthermore connected to means whereby it can be driven manually; an output member meshing with the second set of teeth on the double gear; torque-limiting switch means operated by means responsive to axial movement of the worm for switching off the electric motor when the load on the actuator rises above a predetermined upper limit; position switch means comprising switches for operating at predetermined positions of the output member; and means for controlling the said position switch means, comprising a follower bearing against a cam surface formed on the output member of the actuator.

7. A fractional-revolution actuator according to claim 6 in which the cam surface is formed by an eccentric groove machined into the output member.

8. A fractional-revolution actuator according to claim 7 in which the follower consists of a rod lying radially with respect to the output member and bearing against the bottom of the eccentric groove.

9. A 90° actuator according to claim 7, in which the arc of the output member engaged by the follower from one extreme to the other is bisected by a diameter normal to an axis of symmetry taken with respect to the output member and its eccentric circular groove.

10. A fractional-revolution actuator comprising an electric motor coupled to an input shaft; a double gear mounted eccentrically on the input shaft and having two sets of gear teeth; a normally-stationary annular gear member having internal teeth meshing with one of the sets of teeth on the double gear and having external gear teeth meshing with a worm by which the annular gear member is held normally stationary, the worm be-

6

ing spring centered axially so as to be capable of moving axially against the spring action in the event of the annular gear member experiencing an excessive torque, the worm being furthermore connected to means whereby it can be driven manually; an output member meshing with the second set of teeth on the double gear; a cam formed around the output member; a follower bearing on the cam; a row of switches; a first switch-operating member which extends along the row of switches and is adapted to carry a first set of switch-actuating devices; means moving the first switch-operating member in response to movement of the follower whereby the first-mentioned switch actuating devices carried by the first switch-operating member operate the switches at predetermined positions of the output member; a second switch-operating member adapted to carry a second set of switch-actuating devices; and means responsive to axial movement of the worm and coupled to the second switch-operating member for moving the second switch-operating member so that one of the second-mentioned switch-actuating devices operates one of the switches when the torque exceeds a desired limiting value.

References Cited

UNITED STATES PATENTS

2,405,338	8/1946	Werner	74—675 XR
2,418,351	4/1947	Jackson	74—805 XR
2,438,545	3/1948	Davidson.	
3,339,426	9/1967	Borggräfe	74—425

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

F. D. SHOEMAKER, *Assistant Examiner.*

U.S. Cl. X.R.

74—425, 479, 675; 251—134