May 10, 1960 W. C. SEALEY 2,935,877

CAM OPERATED HOLDING IN SWITCH

Filed Dec. 18, 1957

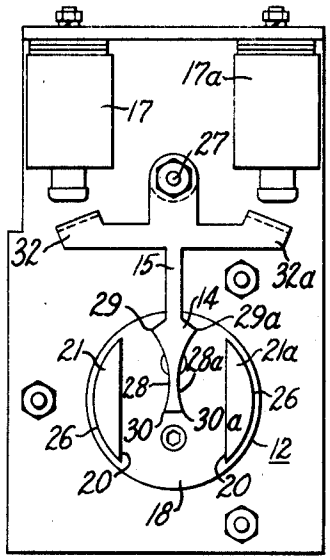


Fig. 1

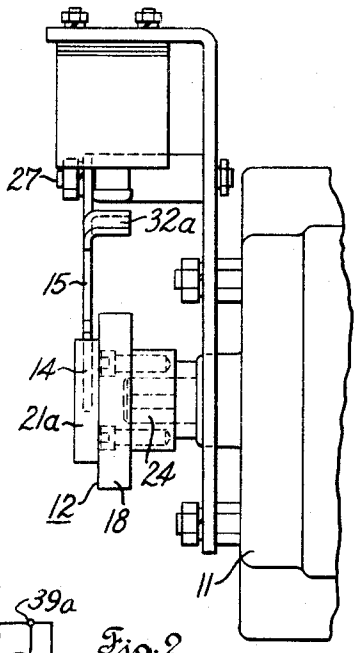


Fig. 2

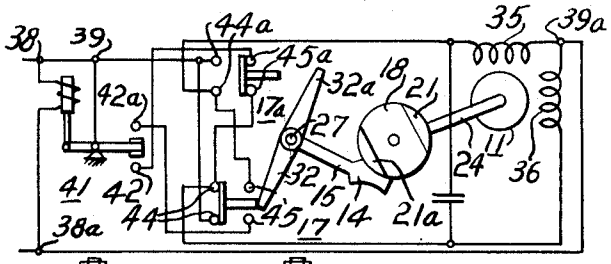


Fig. 5

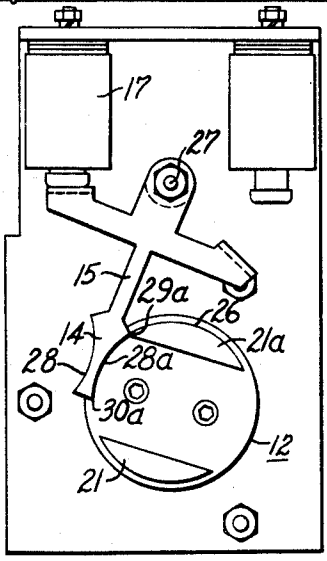


Fig. 3

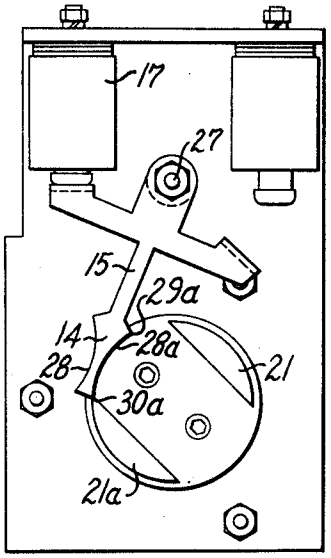


Fig. 4

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United States Patent Office 2,935,877 Patented May 10, 1960

2,935,877

CAM OPERATED HOLDING IN SWITCH

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Application December 18, 1957, Serial No. 703,636

7 Claims. (Cl. 74—54)

This invention relates in general to cam operated switches. More specifically this invention relates to a cam operated holding in switch for use with a tap changing transformer.

A holding in switch is an auxiliary switch that is provided to maintain an electric motor energized during a predetermined cycle after a primary switch has started the motor to initiate the cycle. Holding in switches are required for some tap changers for transformers. These tap changers include a plurality of stationary contacts which are connected to the taps of the transformer, a set of movable contacts which cooperate with the stationary contacts for changing the turns ratio of the transformer and a reversible motor for moving the movable contacts in a step motion between stationary contact positions. The primary switches for energizing the motor may be actuated by a means sensitive to changes in electrical conditions such that the tap changing mechanism tends to change the transformer turns ratio until the desired voltage output condition is reached. Since extraneous factors may produce the desired voltage output condition before a tap change is completed, the primary switches may open before the movable contacts have reached the next operating position. Therefore, it is often desirable to provide an auxiliary switch for keeping the motor energized until the tap change is completed.

In some tap changers of the prior art the holding in switches are operated by a moving part peculiar to the tap changer to which the switches are adapted. A more generalized method for operating the auxiliary switches is by means of a cam which may be attached to the motor or to some other rotating part of the tap changer. These cams may be directional or nondirectional. A nondirectional cam indicates only the period of motor operation during which an auxiliary switch should be held in. A directional cam indicates the period for holding in an auxiliary switch and it also indicates which of the two auxiliary switches corresponds to the direction of rotation of the motor.

Some nondirectional cams comprise a circular disk which has a recessed or a raised portion for operating a cam follower. As the cam rotates it moves the follower between a switch opening position and a switch closing position. The follower action in such a cam arrangement is substantially the same for either direction the cam rotates. If a direction response is desired, it must be obtained by separate means such as by the primary switches and cooperating relays.

A directional cam selectively operates one or the other of two auxiliary switches according to the direction of rotation of the cam and does not require a separate direction responsive means. In some known directional cams of the prior art the cam is provided with a recessed portion, and the cam follower is adapted to pivot between two switching positions. When the movable switch of the tap changer is on an operating position, the cam is in a neutral position for receiving the

follower in the recess. As the cam rotates during a tap change operation, the follower is moved out of the recess in the direction of the rotation of the cam and it closes one of the auxiliary switches. The follower rides on the outer surface of the cam and holds in the switch until the cam has rotated to a point where the follower again falls into the recessed portion and releases the switch.

These directional cams have some features which limit their use with tap changers. Usually it is desirable that the auxiliary switch be held in to energize the motor somewhat beyond a complete cycle to assure that the movable contacts of the tap changer are accurately positioned and to overcome mechanical losses between the movable contacts and the cam. Additional hold in time can be provided if the cam must travel past its neutral position to release the follower. Furthermore, it is usually desirable that the auxiliary switch close soon after the cam begins to rotate to assure that the motor will not stop shortly after the tap change has begun. Additional hold in time and quicker switch closing can be obtained to some extent with cams of the prior art by changing the relative size or position of the components. However, in designs of the prior art the requirements for additional hold in time usually conflict with the requirements for quick closing of the auxiliary switch or produce other undesirable results.

Most directional cams are easily adapted to provide some overtravel because the follower rides on the outer surface of the cam at a point spaced in the direction of cam rotation away from the neutral position of the follower. If the contact point of the follower extends beyond the recess when the cam is in the neutral position, the cam must rotate somewhat past its neutral position before the follower can reenter the recess. In directional cams of the prior art the overtravel of the cam has been increased by making the arc of the recessed portion of the cam very narrow so that the cam must travel farther beyond the neutral position before the recessed position reaches the point at which the follower will be released. Narrowing the arc of the recess provides only small increases in overtravel because the travel of the cam increases by only one half the arc by which the open sector is reduced. Furthermore, if the open sector is very narrow, the recess will not present a sufficient area to allow the follower to return fully to its neutral position when it is released. Since the distance the follower travels to release the switch is restricted in these designs, the adjustment of the switches is very critical. If the cam and the switch are misaligned so that the follower does not release the switch, the motor will continue to operate the tap changing switch without control by the electrical responsive means and will produce an undesirable voltage output condition.

The amount of overtravel of the cam can also be increased by providing more than one recess in the cam. A cam with two equally spaced recesses must travel past its neutral position by the same angle as a similar cam with only one recess but it travels only half as far from neutral to neutral. When a cam with two recesses is suitably geared to turn at half the rate of a similar cam with only one recess, it will provide twice as much overtravel as the cam with only one recess. Generally it is advantageous to provide a cam which may be geared to operate over a half revolution since most tap changing switches move through a fraction of a circle in each operation. It is easier to adapt the cam to the switch if the ratio between the cam and the switch is decreased in this way. However, a cam of the known prior art having these advantages may be unsatisfactory because the lag in closing the switch at the beginning of the cycle

is also increased by increasing the number of recesses in the cam.

Another known method for obtaining additional overtravel is by allowing the follower to extend past the point at which the follower normally contacts the cam surface. The extended portion of the follower causes the cam to rotate past the point at which the normal contact point would be released. However, the follower must back off from the switch closing position after the releasing edge of the recess travels past the normal contact point. If the follower is extended very far beyond the contact point, the switches must be adjusted within narrow limits to prevent the follower from backing off from the closing position sufficiently to release the switch and stop the motor before the follower has actually entered the recess. The follower would then reclose this auxiliary switch if on the next cycle the opposite primary switch closed to operate the motor in the reverse direction.

It is also possible to obtain increased overtravel by increasing the distance between the follower pivot point and the cam surface since the follower will then rest on the cam surface farther outside the neutral position of the recess. However, this method of providing overtravel increases the lag in closing the auxiliary switch at the beginning of a tap change.

The holding in switch of this invention overcomes the disadvantages of the prior art by calling for a cam mechanism in which the cam follower is shaped to ride on the outer surface of the cam at two spaced apart points. One point on the follower is positioned to ride on the cam surface near the normal position of the recess to provide a quick closing action of the switches, and the other point on the follower is spaced from the first point to provide overtravel. Since in this invention the hold in period depends in part on the shape of the follower, it is possible to increase the arc of the recess so that sufficient space is provided for the follower to release the switches; and consequently, the switches are easy to adjust. Since the follower can be made to close the auxiliary switch after a slight rotation of the cam, this cam mechanism may use two or more recesses to provide the advantages of more than one tap changing cycle per revolution of the cam.

Therefore, it is an object of this invention to provide a new and improved cam device for operating a holding in switch. Another object of this invention is to provide a new and improved holding in switch in which the closing and opening operations are independently adjustable.

Another object of this invention is to provide a new and improved holding in switch in which the switches are easily adjusted.

Other objects and advantages will be apparent from the following description when read with the following drawings in which:

Fig. 1 is a front view of the holding in switch of this invention;

Fig. 2 is a side view of the holding in switch of this invention;

Fig. 3 illustrates the holding in switch of this invention at one point in a holding in operation;

Fig. 4 illustrates the holding in switch of this invention at another point in the holding in operation; and

Fig. 5 illustrates a motor control circuit using the cam operated holding in switch of this invention.

The cam operated holding in switch of this invention, as shown in Figs. 1 and 2, is particularly adapted for controlling a reversible motor **11** and comprises a rotatably mounted cam **12**, a cam follower **14**, a follower arm **15** and two switches **17**, **17***a*. However, various modifications can be made in the switch of this invention to adapt it to mechanisms other than reversible motors.

The cam may consist of a circular disk **18** which is provided with one or more recessed portions **20**. Preferably, as shown, the cam consists of two segments **21**, **21***a* formed by a slot cut in the face of a circular disk. The cam is mounted on a suitable shaft **24**, which is illustrated as the shaft of a motor **11** of a tap changer, not shown, and rotates in step with the motor.

The follower **14** is adapted to ride in the recess **20** between the segments **21**, **21***a* when the movable contacts of the tap changer are on an operating position and on the outer surface **26** of a segment during a tap change operation. As illustrated the follower **14** is attached to one end of the arm **15** and the arm is pivotally mounted at **27** for swinging the follower **14** between positions. However, any suitable means for guiding the follower may be used. The follower **14** is constructed to define two spaced oppositely facing concave surfaces **28**, **28***a* complementary to the outer surface **26** of a segment. The surfaces **28**, **28***a* are made concave to provide the follower **14** with two spaced apart points for contacting the cam. One point **29** or **29***a* on each surface **28**, **28***a* is positioned in the normal position adjacent the leading edge of the cam surface **26** for initially actuating a switch **17** or **17***a*. The other point **30** or **30***a* is spaced from the actuating point **29**, **29***a* in the direction of cam rotation and rides on the outer surface **26** of a segment **21** or **21***a* until the cycle is completed at which time the follower **14** falls into the recess **20** and releases the switch. The position of these two points **29** or **29***a* and **30** or **30***a* determines the duration of the cycle. For example, either point may be positioned farther in the direction of cam rotation for increasing the amount of cam rotation required to actuate or release a switch. On the other hand either of the points may be extended contrary to the direction of rotation to decrease the amount of cam rotation required to actuate or to release a switch. Preferably the follower operating surfaces **28**, **28***a* are arcuate in shape so as to contact the circumference of the cam at points intermediate the actuating point **29**, **29***a* and the releasing point **30**, **30***a*. To this end the shape of the follower surfaces **28**, **28***a* intermediate the points **29**, **29***a* and **30**, **30***a* is defined by a circle of substantially the same radius as the cam **12** and having its center the same distance from the arm pivot **27** as the center of the cam. However, the operating surfaces **28**, **28***a* of the follower **14** may be of any suitable configuration which provides an offset in the follower to allow two spaced apart points **29**, **30** or **29***a*, **30***a* to contact the outer surface **26** of the cam **12**. The concave surfaces **28**, **28***a* of the follower may begin or terminate at the point on the cam surface **26** at which a flat follower would be tangent; and therefore, one of the points **29** or **30** may be substantially identical with corresponding point **29***a* or **30***a*. Preferably, however, the concave surface extends to either side of the tangent point.

The switches **17**, **17***a* are positioned symmetrically about the follower **14** so that one or the other of the switches is actuated when the follower rides on the outer surface of the cam and is released when the follower enters the recess. Preferably the arm **15** is provided with switch operating members **32**, **32***a* at right angles to the arm near the pivoted end of the arm. However, any suitable arrangement of levers attached to the arm **15** or the follower **14** may be used or the switch contacts may be positioned so as to be closed directly by the arm or the follower.

Fig. 5 illustrates the holding in switch of this invention in a simplified control circuit for using the motor **11** with a tap changer for a transformer. The motor **11** has a raise winding **35** and a lower winding **36** corresponding to the direction of the voltage changes of the transformer. The control circuit includes a pair of voltage terminals **38**, **38***a* that are connectable to the voltage output of the transformer, a pair of power terminals **39**, **39***a* that are connectable to a source of power for energizing the motor **11**, and a voltage sensitive relay **41** that includes a raise primary contact **42** and a lower primary contact **42***a* for connecting one or the other of the windings **35**, **36** to a power terminal **39** to initiate a tap change in response to the

voltage condition at the voltage terminals. The power terminals 39, 39*a* may be connected to the voltage output of the transformer as is indicated in the drawing. The circuit of Fig. 5 further includes the cam operated holding in switch of this invention including the two auxiliary switches 17, 17*a* that maintain the motor energized once a tap change has begun. The auxiliary lower switch 17 includes normally open auxiliary lower contacts 44 that are in parallel with the relay primary lower contact 42 and energize the motor independent of the relay when the switch 17 is actuated by the arm 32. The auxiliary lower switch 17 also includes normally closed raise interlock contacts 45 that are in series with the raise primary contact 42 and are opened by the arm 32 during a lower voltage operation of the motor to isolate the primary raise contacts 42*a* of the relay 41 from the motor. The auxiliary raise switch 17*a* is analogous to the lower auxiliary switch 17 and includes auxiliary raise contacts 44*a* and lower interlock contacts 45*a*. The circuit just described is typical of motor control circuits that are well known in the transformer art, and the circuit is not a part of this invention.

When the holding in switch of this invention is used with a tap changer for a transformer, the follower is positioned in the recess 20 of the cam 12, as shown in Fig. 1, when the movable contacts of the tap changer are on an operating position. When, for example, the primary contact 42*a* closes to operate the motor 11 in a counterclockwise or lower voltage direction. The cam 12 rotates and the leading edge of the segment 21*a* of the cam bears against the follower near the actuating point 29*a*. As the cam 12 rotates, the follower is forced out of the recess, as is shown in Fig. 3, and then rides on the outer surface 26 of the cam. As the follower reaches the position shown in Fig. 3, the left hand operating member 32 actuates its corresponding switch 17 thus closing the auxiliary lower contacts 44 and opening the raise interlock contacts 45. If the primary contact 42*a* of the tap changer motor 11 should now be opened by its electrical responsive relay 41, the tap changing motor 11 will remain energized by the auxiliary switch 17 until the tap change cycle is completed. The raise interlock contacts 45 are open and prevent the relay 41 from energizing the raise winding 35 of the motor 11 while the auxiliary switch 17 is maintaining the lower winding 36 energized. When the cam 12 has completed a cycle, the movable contacts of the tap changer should be on the next operating position. In practice the movable contacts may lag the cam because of mechanical losses between the cam and the switch or for other reasons. Because of the overtravel feature of the cam and follower of this invention, the cam continues to rotate for a period sufficient to assure that the switch is on position. When the edge of the recess 20 of the cam reaches the release point 30*a* of the follower, as shown in Fig. 4, the follower 14 reenters the recess of the cam and the auxiliary switch 17 is released by the switch actuating member 32. Because the hold in period depends in part on the shape of the follower, the recess can be made sufficiently wide so that the follower will release fully even though the recess is not in the normal position. If the primary switch is still held closed by its controls, the motor 11 will continue for a second cycle.

Although but one embodiment of this invention has been illustrated, it will be apparent to those skilled in the art that variations are possible within the scope of the appended claims.

What is claimed is:

1. An actuator for a switch controlling a motor through predetermined cycles comprising a rotatably mounted cam having an arcuately circumscribed outer surface interrupted by an inwardly extending recessed portion, a follower positioned to ride in said recess and on said outer surface according to the position of said cam, and an arm having one end attached to said follower and the other end adapted to close said switch when said follower is on said arcuate surface and to open said switch when said follower is in said recess, said follower being concave to define two spaced apart points for contacting said arcuately circumscribed surface.

2. An actuator for a switch controlling a motor through predetermined cycles comprising an element adapted to move in a circular path and having an arcuate outer surface complementary to said path, a follower positioned to ride within said circular path and on said outer surface according to the position of said element, and an arm having one end attached to said follower and the other end adapted to actuate said switch when said follower is on said arcuate surface and to release said switch when said follower rides within said path, said follower being concave to define two spaced apart points for contacting said arcuate surface.

3. An actuator for a switch controlling a motor through predetermined cycles comprising a rotatably mounted cam having an arcuate outer surface interrupted by an inwardly extending recessed portion, a follower positioned to ride in said recess and on said outer surface according to the position of said cam, means for guiding said follower between said position in said recess and said position on said arcuate surface, said follower being adapted to actuate said switch when said follower is on said arcuate surface, said follower being concave to define two spaced apart points for contacting said arcuate surface.

4. An actuator for a switch controlling a motor through predetermined cycles comprising a rotatably mounted cam having an arcuate outer surface interrupted by an inwardly extending recessed portion, a follower positioned to ride in said recess and on said outer surface according to the position of said cam, and an arm having one end attached to said follower and the other end adapted to actuate said switch when said follower is on said arcuate surface and to release said switch when said follower enters said recess, said follower being concave to contact said cam along its said arcuate surface.

5. An actuator for a switch controlling a reversible motor through predetermined cycles comprising an arm adapted at one end for moving between two switch actuating positions, a follower attached to the other end of said arm, and a rotatably mounted cam having an arcuate outer surface interrupted by an inwardly extending recessed portion, said follower being positioned to ride in said recess when said switch is intermediate said actuating positions and on said arcuate surface when said switch is in one said actuating position, said follower adapted to be moved from said recess in two directions in accordance with the direction of rotation of said cam to move said arm into one of said actuating positions, said follower having opposed concave surfaces for contacting said arcuate surface at two spaced apart points during rotation of said cam.

6. An actuator for a switch controlling a reversible motor through predetermined cycles comprising an arm pivotally mounted at one end, a switch actuating member attached to said arm and positioned to move between two switch actuating positions, a follower attached to the one end of said arm, and a rotatably mounted cam having an arcuate outer surface interrupted by an inwardly extending recessed portion, said follower being positioned to ride in said recess when said member is intermediate said actuating positions and on said arcuate surface when said member is in said actuating positions, said follower adapted to be moved from said recess in two directions in accordance with the direction of rotation of said cam to pivot said arm and move said switch actuating member into one of said actuating positions, said follower having opposed concave surfaces for contacting said arcuate surface during rotation of said cam.

7. In a transformer having a motor energizable in response to electrical conditions for operating a tap changing switch to vary the transformer voltage output, and having switch means for energizing said motor independ-

ent of said electrical conditions, a switch actuator for actuating said switch means in accordance with the position of said motor in a tap changing cycle said switch actuator comprising a rotatably mounted cam having an arcuate outer surface interrupted by an inwardly extending recessed portion, a follower positioned to ride in said recess and to ride on said outer surface according to the position of said cam, and an arm having one end attached to said follower and the other end being adapted to close said switch when said follower is on said arcuate surface and to open said switch when said follower is in said recess, said follower being concave to define spaced apart points for contacting said arcuate surface.

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