Sept. 8, 1959 G. A. WILSON, JR 2,903,530

MANUAL TAP CHANGING SWITCH

Filed April 1, 1957 2 Sheets-Sheet 1

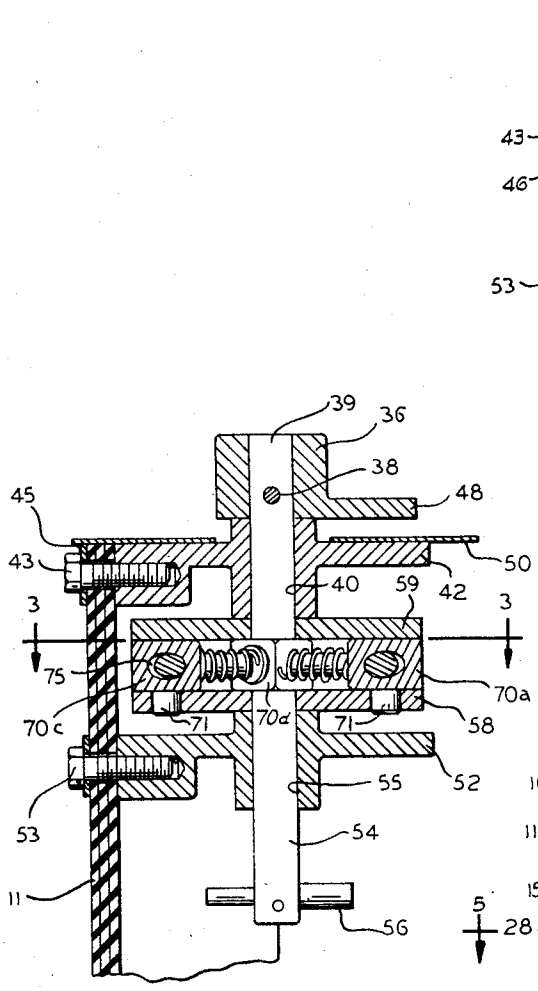

Fig. 2

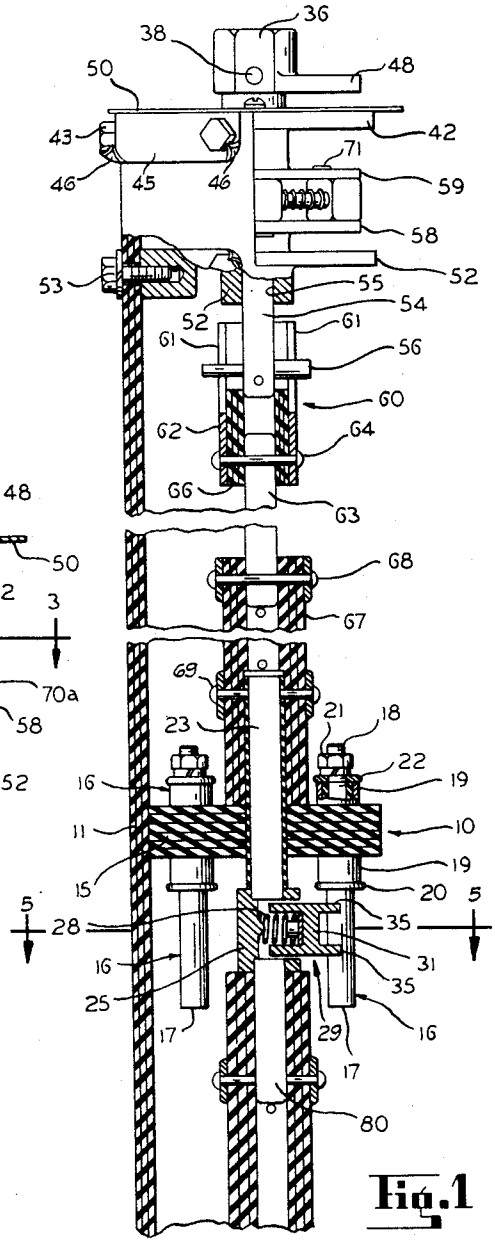

Fig. 1

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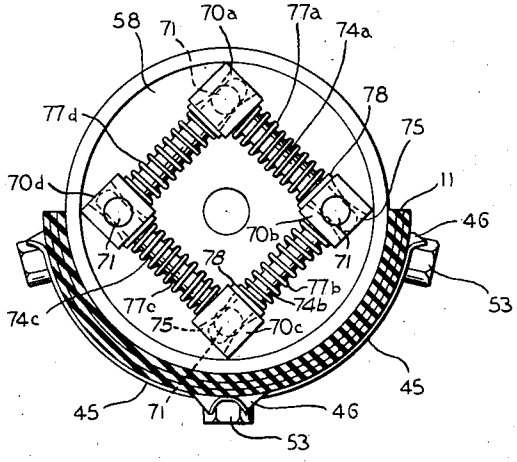

Fig. 3

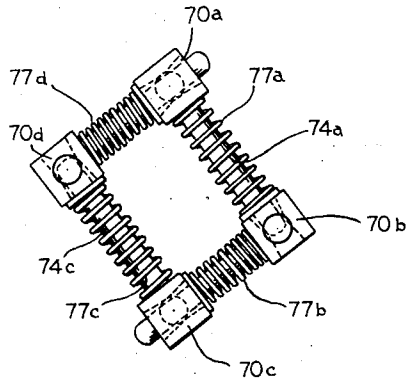

Fig. 4

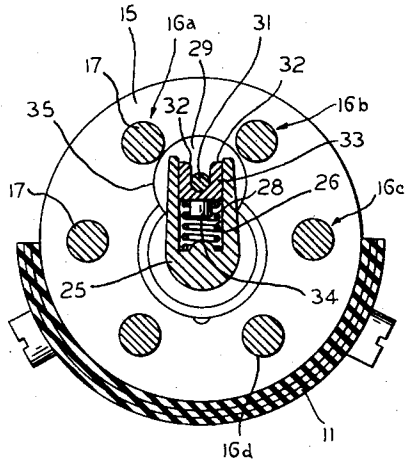

Fig. 5

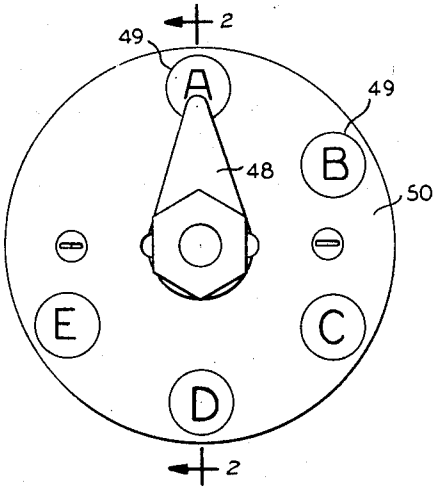

Fig. 6

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United States Patent Office 2,903,530 Patented Sept. 8, 1959

2,903,530

MANUAL TAP CHANGING SWITCH

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Application April 1, 1957, Serial No. 649,966

5 Claims. (Cl. 200—66)

This invention relates to electric switches of the multiple contact type and in particular to manually operated switch mechanisms which are adapted to adjust voltage ratios in stationary induction apparatus having windings provided with taps.

The service required of tap changing switches for stationary induction apparatus is different from that required of ordinary multiple contact electric switches in that while the latter must be capable of safely interrupting the maximum current which it is designed to carry, a tap changing switch has no current interruption rating but must carry full load current under normal conditions. Thus the problems of quick makes and breaks are relatively unimportant in manual tap changing switches, but the securing of adequate contact area and contact pressure between the relatively movable, current carrying parts is signally important. Tap changing switches are well known wherein adjacent pairs of stationary contact posts arranged in an arc are adapted to be sequentially engaged by a bridging-type movable contact carried by a rotatable contact arm and urged by relatively heavy spring means radially outward to provide the required contact pressure against the stationary contact posts. Occasionally, when moving between tap positions, this movable bridging-type contact "hangs up," i.e., remains suspended, at or near the dead center position of a stationary contact, thus undesirably keeping the electric circuit open and interrupting electrical service.

It is an object of the invention to provide a manually operated tap changing switch having means to prevent "hang up" of the movable contact.

It is a further object of the invention to provide a stored energy operating mechanism for a tap changing switch wherein the torque acting on the movable contact, resulting from the storage of energy, is insufficient to actuate the movable contact past a stationary contact until the operating means has rotated beyond the dead center of the stationary contact, thereby assuring that a turning moment will always be exerted against the movable contact when it is on dead center of a stationary contact and eliminating the possibility of the movable contact remaining suspended between taps.

These and other objects and advantages of the invention will be better understood from the following description when taken in conjunction with the accompanying drawing wherein:

Fig. 1 is a vertical sectional view through a tap changing switch embodying the invention;

Fig. 2 is a vertical sectional view taken on line 2—2 of Fig. 6;

Fig. 3 is a horizontal sectional view taken on line 3—3 of Fig. 2;

Fig. 4 is a view similar to Fig. 3 taken after rotation of the switch operating means but before the movable contact has been actuated to a new tap position;

Fig. 5 is a horizontal sectional view taken on line 5—5 of Fig. 1; and

Fig. 6 is a top view of the tap changing switch of Fig. 1.

The invention will be illustrated and described with reference to a three phase, network transformer tap changer of the vertical "in-line" type having the tap changers for the three phases positioned one above the other. However, in order to illustrate the construction in sufficient size to facilitate the understanding of the invention, the tap changer 10 for only a single phase will be illustrated and described, it being understood that the tap changers of the other phases are similar thereto. The tap changers of all three phases are housed in an arcuate-in-cross-section mounting support 11 of insulating material, and each tap changer 10 includes a circular insulating base 15 secured by screws (not shown) to the mounting support 11 and having a plurality of circumferentially spaced apart, metallic, stationary contact posts 16 extending therethrough arranged in an arc. Each stationary contact post 16 includes a metallic stud 17, preferably of copper, having a portion of reduced diameter 18 extending through base 15 surrounded by insulating collars 19 above and below the base 15. The collar 19 below base 15 is adjacent a washer 20 which is supported on a shoulder formed at the junction of the reduced diameter portion 18 and the larger diameter portion of stud 17, and a hexagonal nut 21 threadably engaging the end of reduced diameter portion 18 bears against a washer 22 which is adjacent the collar 19 above base 15 to clamp the collars 19 against the base 15 and thus rigidly secure the stationary contact post assembly 16 to the base 15. Electrical conductors (not shown) from taps on the corresponding transformer phase winding may be crimped into axial openings (not shown) in the lower end of the studs 17.

A rotatable operating shaft 23 extending axially through insulating base 15 has rigidly secured to its lower end a contact arm 25 carrying the movable contact of the tap changer switch. The contact arm 25 is U-shaped in horizontal cross section (see Fig. 5) and provides a radially extending compartment 26 adapted to receive a helical compression spring 28 for resiliently urging a movable, roller-type, bridging contact 29 against the metallic studs 17. The roller-type contact 29 is I-shaped in vertical cross section, the stem forming a spindle 31 fitting within a U-shaped-in-cross-section vertical slot 32 (see Fig. 5) in a spring seat member 33 which is slidable within compartment 26 and includes a shank portion 34 extending within compression spring 28. The upper and lower portions 35 of movable contact 29 are circular, and it will be apparent that when in the position illustrated in Fig. 5, roller contact 29 will bridge between and electrically connect contact posts 16*a* and 16*b* to provide a desired tap connection on the corresponding transformer phase winding. The contact posts 16*a* and 16*b* oppose rotation of contact arm 25 carrying movable contact 29, and when operating shaft 23 is rotated, for example in a clockwise direction, as seen in Fig. 5, the reaction of contact post 16*b* will cause radially inward movement of roller contact 29 and spring seat 33 to compress spring 28. A predetermined torque must be applied to operating shaft 23 to rotate movable contact 29 past stationary contact post 16*b*, and after movable contact 29 has rotated past the contact post dead center position, i.e., the radial line through the center of contact post 16*b* and the axis of operating shaft 23, compressed spring 28 will move the roller contact 29 with a snap action to bridge between and electrically connect contacts 16*b* and 16*c* and thus provide a desired tap connection of the transformer phase winding.

Preferably tap changer switch 10 is manually operated, after the transformer is de-energized, by engaging a wrench or other suitable tool (not shown) with a

hexagonal operating knob 36 secured by means such as a pin 38 to a rotatable drive rod 39. The drive rod 39 extends through and rotates freely within a clearance aperture 40 in a top support plate 42 secured by screws 43 to the mounting support 11. Unthreading of screws 43 is prevented by a bolt locking plate 45 having ears 46 (see Fig. 3) bent over against the flat surfaces on the hexagonal head on bolt 43 to prevent rotation thereof. A pointer 48 integral with operating knob 36 cooperates with indicia 49 on a guide plate 50 (see Fig. 6) to indicate the position to which tap changer 10 is moved.

Rotation of operating knob 36 is transmitted through the switch operating mechanism of the invention to actuate movable contact 29 between tap positions. A lower support plate 52 is secured to mounting support 11 by bolts 53 and unthreading thereof is prevented by bent-over ears 46 on a bolt locking plate 45. A vertical driven shaft 54 extending through and freely rotatable within a clearance aperture 55 in lower support plate 52 carries a transverse drive pin 56 extending through the lower end thereof and is rigidly affixed at its upper end by suitable means such as brazing to a circular driven member 58. A circular drive member 59 coaxial with and spaced axially from driven member 58 is rigidly affixed to drive shaft 39.

A pin-and-slot type coupling 60 in the means for operatively connecting driven member 58 to movable contact 29 includes transverse drive pin 56 fitting within diametrically opposed, elongated slots 61 through the sidewall of a tubular member 62 permitting relative axial movement between the tap changer movable contact and its operating means. The tubular member 62 is secured to a connecting rod 63 by a transverse pin 64 extending through the lower end of tubular member 62, through an annular spacer 66 disposed between rod 63 and the member 62, and through the upper end of rod 63. At its lower end, connecting rod 63 is operatively connected to the operating shaft 23 through a sleeve member 67 surrounding the lower end of rod 63 and secured thereto by a transverse pin 68 and also surrounding the upper end of operating shaft 23 and being secured thereto by a transverse pin 69.

Resilient stored energy means connecting driven member 58 and drive member 59 includes four box-like studs 70*a*, 70*b*, 70*c*, and 70*d* disposed between members 58 and 59 with each stud 70 normally positioned at one of the corners of a square. Diametrically opposed studs 70*a* and 70*c* comprise driven studs and are secured to driven member 58 away from the axis thereof by projections 71 integral with studs 70*a* and 70*c* fitting within suitable apertures in driven member 58. Similarly diametrically opposed drive studs 70*b* and 70*d* are secured to drive member 59 away from the axis thereof by projections 71 integral therewithin fitting within suitable apertures in drive member 59. The energy storage means for resiliently connecting drive member 59 and driven member 58 also includes spring guide means preferably in the form of four spring guide rods 74 supported by the studs 70. Each adjacent pair of drive and driven studs, for example studs 70*b* and 70*c*, support a spring guide rod 74*b* which is rigidly connected to one stud of the adjacent pair, e.g., rod 74*b* connected to stud 70*b*, and extends freely through a clearance aperture 75 in the other stud, i.e., 70*c*, so as to permit both longitudinal movement and pivoting of spring guide rod 74*b* within clearance aperture 75.

The resilient energy storage means for operating movable contact 29 also includes a helical compression spring 77 circumjacent each spring guide rod 74 bearing at one end against one drive stud, e.g., spring 77*b* bearing against stud 70*b* to which the rod 74*b* is secured, and at its opposite end against a washer 78 which is disposed against a driven stud, i.e., against the stud 70*c* through which spring guide rod 74*b* freely passes. It will be

apparent that turning of operating knob 36 clockwise when viewed from the top will, through drive rod 39, rotate drive member 59 and drive studs 70*b* and 70*d* carried thereby in a clockwise direction and compress springs 77*b* and 77*d* against driven studs 70*a* and 70*c* secured to driven member 58. Continued rotation of operating knob 36 in a clockwise direction causes spring guide rods 74 to pivot within clearance apertures 75 and to extend further through driven studs 70*c* and 70*a*, thereby further compressing springs 77*b* and 77*d* as shown in Fig. 4. The compressive loading of springs 77*b* and 77*d* exerts a turning moment against studs 70*c* and 70*a* tending to rotate driven member 58 which is resisted by the force of helical spring 28 urging roller contact 29 radially outward. As mentioned hereinbefore a predetermined torque must be exerted against contact arm 25 to move roller contact 29 radially inward sufficiently to permit rotation of contact arm 25 and movable contact 29 past stationary contact post 16*b*. The compression springs 77 are chosen so that the torque exerted on driven member 59 due to energy stored in the means resiliently connecting drive and driven members 58 and 59 upon rotation of operating knob 36 is less than said predetermined torque until drive member 59 has rotated an appreciable distance past the dead center position of stationary contact post 16*b*. It will be apparent that the operating knob 36 and the drive member 59 rigid therewith have two extreme positions of movement (i.e., the positions marked A and B on indicia plate 50) corresponding to the position occupied by movable contact 29 when it electrically connects stationary contacts 16*a* and 16*b* and the position when it bridges between stationary contacts 16*b* and 16*c*. The operating knob 36, the drive member 59, and the movable contact 29 all move through the same included angle between switch positions, and the arrangement is such that the drive member 59 operates a substantial distance, which is greater than half the angle between its two extreme positions of movement, before the movable contact 29 is actuated to a new tap position. This assures that a torque is always exerted against contact arm 25 tending to rotate it to the new tap position when the contact arm is on the dead center position of the stationary contact post, i.e., the radial line extending through the center of the contact post and the axis of rotation of the contact arm. If the drive member 59 has rotated past this dead center position before the energy stored in springs 77 is sufficient to exert this predetermined torque required to rotate contact arm 25 and movable contact 29 past stationary contact post 16, a torque will always be exerted against contact arm 25 when it is on dead center position tending to rotate it to the succeeding tap position, thus assuring that the tap changer switch cannot "hang up."

Rotation of operating knob 36 in a counterclockwise direction will rotate drive plate 59 and drive studs 70*b* and 70*d* connected thereto in a counterclockwise direction to compress springs 77*a* and 77*c* against driven studs 70*a* and 70*c* respectively, and when the turning moment exerted on driven member 58 resulting from the energy stored in compressed springs 77 is greater than this predetermined torque, the roller contact 29 is moved counterclockwise to electrically bridge between an adjacent pair of stationary contact posts 16.

It will be apparent that movement of drive member 59 a substantial distance between its extreme positions of movement before roller contact 29 is moved between tap positions assures that the movable contact arm 25 cannot "hang up" in dead center position.

The torque for operating the other phase tap changers (not shown) is transmitted through a rod 80 rigidly connected to the lower end of contact arm 25.

While the preferred form of energy storage means of the invention has been illustrated and described as including two pairs of diametrically opposed springs and

spring guide means in the form of spring guide rods extending through the springs, it will be apparent that the resilient means drivingly connecting the driven and driving members 58 and 59 can assume other forms. For example, suitable reversible drive means can utilize only two springs reacting between a pair of diametrically opposed studs 70 carried by the driving, or the driven, member and a single stud carried by the other member; the guide means for the springs can take other forms; or tension springs instead of compression springs can be utilized to provide the desired resilient connection. Thus, while only a single embodiment of the invention has been illustrated and described, it will be apparent that many modifications and variations thereof will be apparent to those skilled in the art, and consequently it is intended in the appended claims to cover all such modifications and variations as fall within the true spirit and scope of the invention.

It is claimed:

1. In combination, a contact arm movable in an arcuate path about an axis of rotation and including a movable contact carried thereby resiliently biased in a radially outward direction, a plurality of cylindrical stationary contacts arranged in a circle about said axis of rotation and adapted to be sequentially engaged in bridging relation by said movable contact and opposing movement of said arm and said movable contact about said axis, said movable contact being movable radially inward out of opposing engagement with one of said stationary contacts upon the application of a predetermined torque to said contact arm, a driven member operatively connected to said contact arm and rotatable about said axis, a rotatable driving member coaxial with and spaced axially from said driven member, a pair of diametrically opposed driven studs on said driven member positioned away from said axis and a pair of diametrically opposed driving studs on said driving member positioned away from said axis and between said driven studs, a spring guide rod between each adjacent pair of driving and driven studs and a spring circumjacent each said rod bearing at one end against a driving stud of said adjacent pair and at its opposite end against a driven stud of said adjacent pair, each rod being affixed to one stud of said adjacent pair and the other stud of said adjacent pair having a clearance aperture therethrough freely receiving said rod and permitting both longitudinal movement through and pivoting of said rod within said aperture, the arrangement being such that the torque on said driven member resulting from loading of said springs incident to rotation of said driving member is less than said predetermined torque until said driving member is moved beyond dead center of said one stationary contact, thereby preventing hangup of said movable contact on said dead center position.

2. In combination with a tap changing electrical switch having a plurality of cylindrical stationary contact posts arranged in an arc and a movable arm including a movable contact carried thereby resiliently biased radially outward and adapted to sequentially engage and electrically connect adjacent pairs of said posts, said arm being rotatable about an axis through the center of said arc in response to a predetermined torque to actuate said movable contact past one of said stationary posts and into bridging relation with said one post and a succeeding post, drive means for said movable contact including a driven member rotatable about said axis and operatively connected to said arm, a rotatable driving member coaxial with and spaced axially from said driven member, a pair of diametrically opposed driven studs on said driven member disposed away from the axis thereof, a pair of diametrically opposed driving studs on said driving member disposed away from the axis thereof and between said driven studs, a guide rod between each adjacent pair of driving and driven studs affixed to one stud of said pair, the other stud of said adjacent pair of driving and driven studs having a clearance aperture therethrough freely receiving said rod and permitting both longitudinal movement of said rod through and pivoting of said rod within said clearance aperture, and a spring circumjacent each said guide rod bearing at each end against one of said adjacent pair of driving and driven studs, said driving member rotating through the same predetermined angle as said movable contact arm between switch positions and the arrangement being such that the moment exerted against said driven member resulting from loading of said springs incident to rotation of said driving member increases until it exceeds said predetermined torque and said moment is insufficient to move said movable contact past said one contact post until said driving member is moved through an angle greater than half said predetermined angle whereby hangup of said movable contact on said one contact post is prevented.

3. In combination with a manually operable rotary type reversible electrical switch having a plurality of stationary contacts arranged in a circle, a shaft rotatable about an axis through the center of said circle, and a movable roller contact carried by said shaft and biased radially outward into bridging engagement with a pair of adjacent stationary contacts and being movable sequentially past said stationary contacts upon rotation of said shaft, said shaft being adapted in response to a predetermined torque to move said movable contact past a dead center position on one of said stationary contacts and through a predetermined angle into bridging engagement with said one stationary contact and a succeeding stationary contact, a driving member rotatable about said axis and spaced axially from said roller contact, a driven member rotatable about said axis and operatively connected to said shaft, resilient energy storing means operatively connecting said driving and driven members in both directions of rotation of said driving member, said driving member being rotated through the same predetermined angle between switch positions as said shaft and said movable contact and the arrangement being such that the torque acting on said shaft resulting from energy stored in said energy storage means incident to rotation of said driving member is less than said predetermined torque and insufficient to rotate said movable contact past said dead center position until said driving member has moved through an angle greater than half said predetermined angle, thereby preventing hangup of said movable contact on said dead center position.

4. In combination, a rotary electrical switch having a movable contact and means including a spring opposing movement of said contact between switch positions so that a predetermined torque must be exerted against said contact to actuate it between switch positions, a reversible operating mechanism for said movable contact including a rotatable driving member, a rotatable driven member coaxial with and spaced axially from said driving member and being operatively connected to said movable contact, a pair of diametrically opposed studs on said driving member disposed away from the axis thereof and a pair of diametrically opposed studs on said driven member disposed away from the axis thereof and between said studs on said driving member, four compression springs arranged in diametrically opposed pairs and each bearing at one end against one of said studs on said driving member and at the opposite end against one of said studs on said driven member, and four guide rods each extending through one of said springs and being supported adjacent its ends by one of said studs on said driving member and one of said studs on said driven member and being movable relative to one and fixed relative to the other of its supporting studs, rotation of said driving member in one direction compressing one pair of diametrically opposed springs against the studs on said driven member until

the resulting torque on said driven member is equal to said predetermined torque and rotation of said driving member in the opposite direction compressing the other diametrically opposed pair of springs against the studs on the driven member until the resulting torque on said driven member is equal to said predetermined torque.

5. In combination, a rotatable shaft, a plurality of cylindrical stationary contact posts arranged in an arc having its center coincident with the axis of said shaft, a radial contact arm on said shaft, a roller contact carried by said arm, spring means for resiliently biasing said roller contact radially outward to a first position in bridging relation with a pair of said contact posts, said contact posts opposing movement of said roller contact and said shaft being operable in response to a predetermined torque to move said roller contact to a second position on an opposite side of one of said pair of posts and in bridging relation with said one post and a succeeding post, operating means for said shaft and said roller contact including a driving member rotatable about said axis and spaced axially from said contact arm and said roller contact, said operating means also including resilient energy storage means operatively connecting said driving member and said shaft, said driving member having two positions of extreme movement corresponding to the two positions of said roller contact, the moment

for actuating said shaft available from said energy storage means upon rotation of said driving member increasing until it exceeds said predetermined torque and said moment being insufficient to move said shaft and said roller contact from said first position to said second position until said driving member has rotated a substantial distance between said two positions of extreme movement, said operating means including first spring means for actuating said shaft when said driving member is rotated in one direction and second spring means for actuating said shaft when said driving member is rotated in the opposite direction.

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