July 27, 1965 R. H. ROMNEY 3,197,579

MULTIPLE CIRCUIT ROTARY SWITCH WITH RESILIENT ANNULAR CONTACT BIASING MEANS

Filed Nov. 6, 1961

3 Sheets-Sheet 1

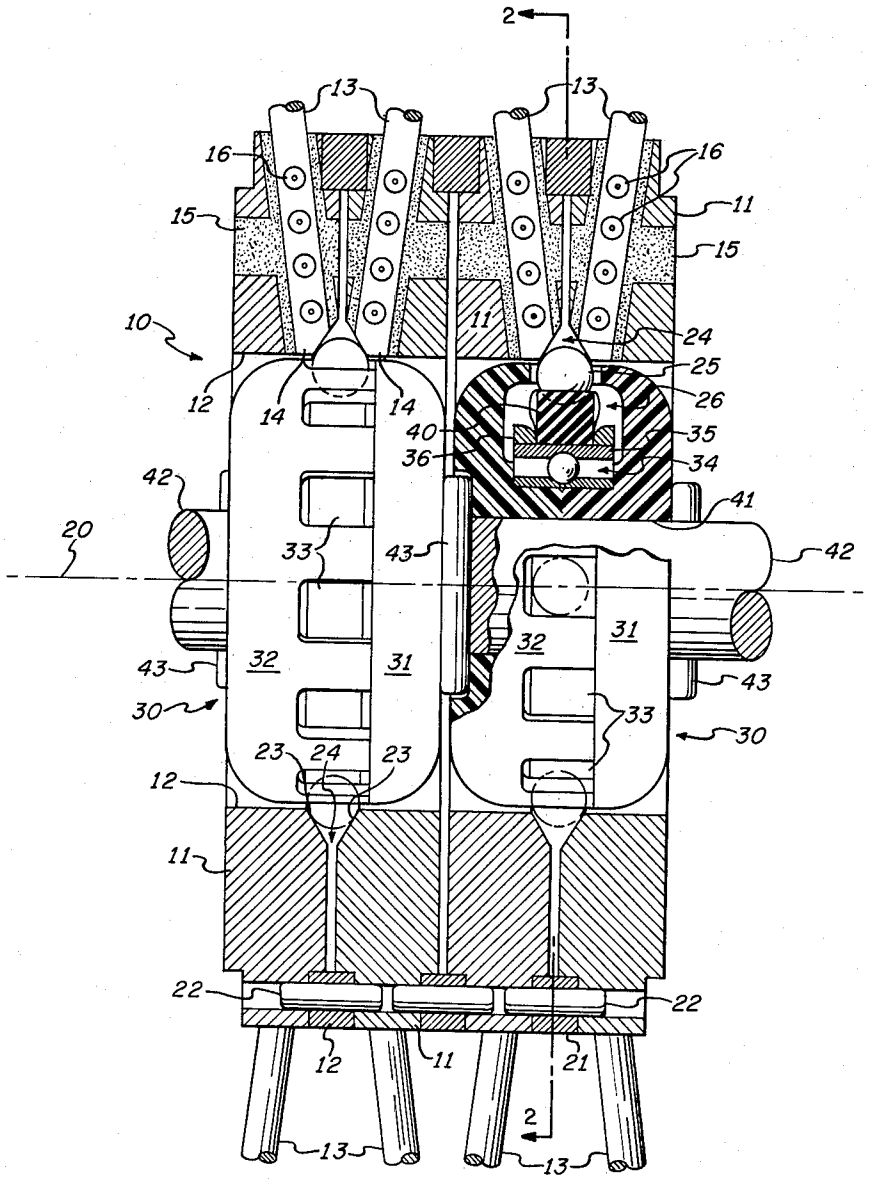


FIG.1.

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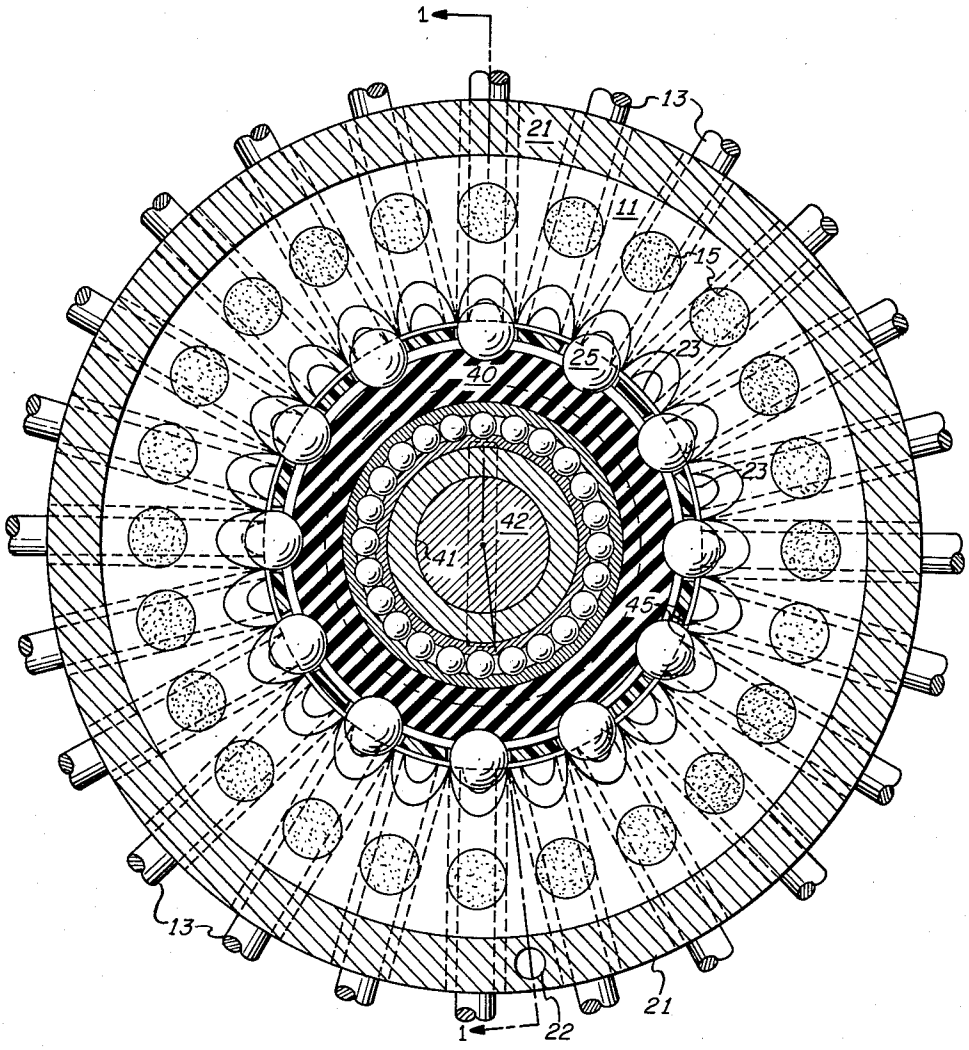


FIG. 2.

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3 Sheets-Sheet 3

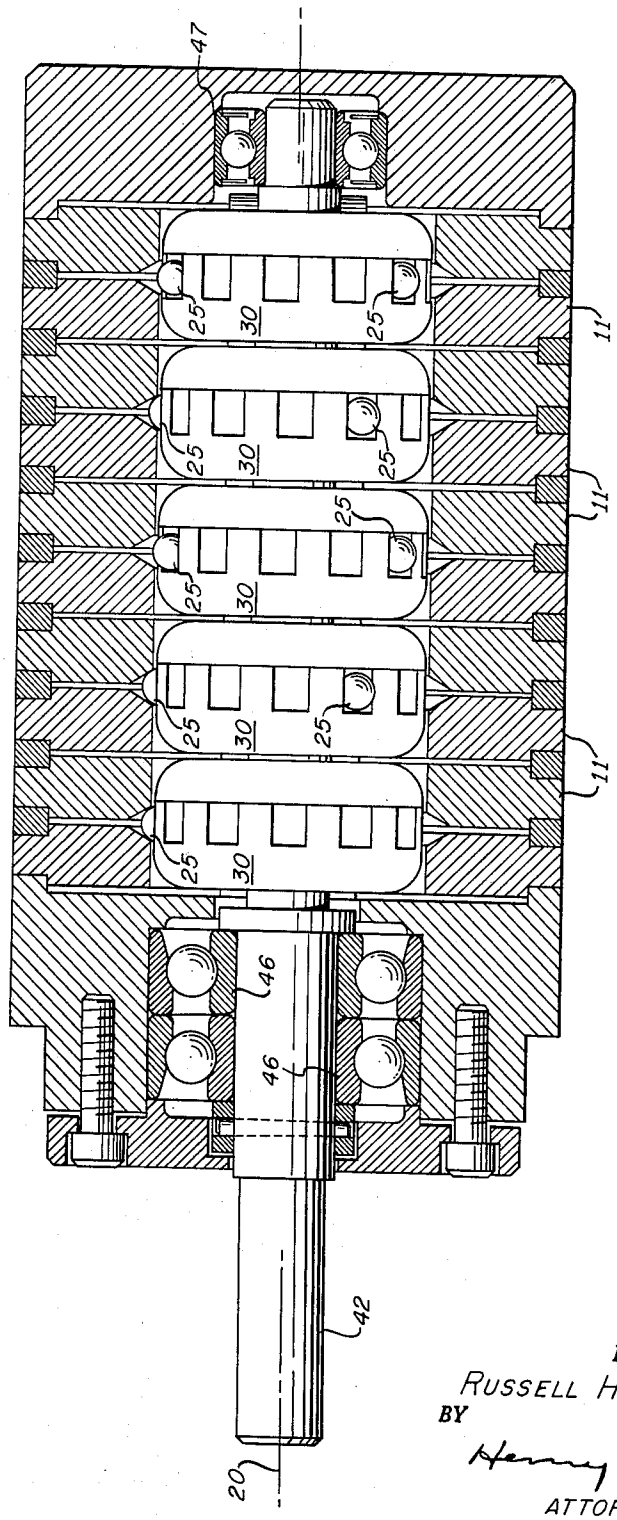


FIG. 3.

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3,197,579

MULTIPLE CIRCUIT ROTARY SWITCH WITH RESILIENT ANNULAR CONTACT BIASING MEANS

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1 Claim. (Cl. 200—11)

The present invention relates to electric switches and particularly to rotary switches of the type adapted to be miniaturized.

For many types of applications, particularly in the military and computer field, it is becoming increasingly necessary to provide a miniature rotary switch adapted to control a plurality of electrical circuits. Present day rotary switches suffer from one or more of the following defects: (1) vulnerable due to "open" construction, (2) comparatively large, (3) strain caused by harness wires sometimes causes binding of the switch, (4) incongruities between the switch mounting surfaces sometimes distort the switch thereby causing failure, (5) wiring terminals occasionally break off, (6) low-level capability is less than desired due to thermal E.M.F., (7) different switching functions require different switching wafers, (8) vulnerable to vibration and acceleration, (9) relatively vulnerable to effects of high currents and wear, and (10) relatively difficult to utilize automated wiring methods.

The rotary electric switch of the present invention overcomes the problems mentioned above and offers the following advantages: (1) adapted to be hermetically sealed, (2) suitable for miniaturizing, (3) harness strain cannot affect switch, (4) it is mounted from one end only and thus incongruities between the switch mounting surfaces cannot distort the switch, (5) wiring terminals are appreciably stronger, (6) low-level capability is excellent, (7) a variety of switching functions is available with a single form of switching wafer, (8) relatively insensitive to vibration and acceleration, (9) relatively insensitive to effect of high currents and wear, and (10) adapted to utilize automated wiring methods.

It is therefore a primary object of the present invention to provide an improved rotary electric switch having high reliability and versatility which can be miniaturized.

It is an additional object of the present invention to provide a rotary electric switch that withstands vibrations and provides continuous reliable services which is compact and relatively economical to manufacture.

The above objects are achieved by the present invention by utilizing a ball of conductive material as the switching element. The ball cooperates with adjacent extremities of a pair of conductors, the extremities of a plurality of which define a circular groove. Ball cage means are connected to a drive shaft and cause the ball to roll from one position to another in accordance with the rotation of the shaft thereby causing the ball to complete the electrical circuit through selective pairs of conductors. Circular resilient means urge the ball into contact with the extremities of the conductors for completing the electrical circuit through said pair of conductors.

Referring now to the drawings,

FIG. 1 is an enlarged side elevation partly in section of a rotary electric switch made in accordance with the present invention;

FIG. 2 is an end view taken along lines 2—2 of FIG. 1; and

FIG. 3 is an alternative embodiment of a rotary electric switch made in accordance with the present invention having a plurality of wafers and cages.

Referring to FIGS. 1 and 2, the rotary electric switch

10 consists of a pair of identical circular wafers 11 of, for example aluminum, each having a central aperture 12. Each of the wafers 11 has mounted thereon a plurality of radially extending spaced metallic conductors 13. As shown in FIG. 2, the conductors 13 are so arranged that inwardly extending spaced extremities 14 of the conductors 13 define the circular aperture 12. The conductors 13 are secured to the wafers 11 by means of a dielectric potting material 15. The conductors 13 are deformed by dimples or transverse cuts 16 to mechanically secure the conductors 13 to the potting material 15 which in turn is secured to the wafer 11.

The wafers 11 are arranged adjacent to each other but in spaced relation with their axes of symmetry coincident with a common axis 20 in order that the conductors 13 of one of the wafers 11 are disposed opposed to the conductors 13 of another of the wafers 11. The opposed wafers 11 forming a pair are held in proper alignment with each other by a steel connecting ring 21 by means of a steel pin 22. The inwardly extending spaced extremities 14 of adjacent pairs of conductors 13 are chamfered to provide cooperating sloping surfaces 23 which in cooperation with the potting material 15 define a V-shaped circular groove. One or more metallic conductive balls 25 are caused to roll in the circular groove 24 in a manner to be explained. Each of the balls 25 acts as a moving switch element which when contacting the surfaces 23 of an adjacent pair of conductors 13 completes the electrical circuit through that pair of conductors.

The conducting balls 25 are caused to roll in the groove 24 by means of a ball cage assembly 30. The ball cage assembly 30 consists of a pair of molded cage halves 31 and 32 made of dielectric material by injection molding, for example, and subsequently held together. The ball cage halves 31 and 32 cooperatively form a plurality of preferably equally spaced slots 33 for retaining and driving one or a plurality of balls 25. For example, as shown in FIGS. 1 and 2, the ball cage assembly has 12 equally spaced slots 33 adapted to receive a maximum of twelve balls 25.

Mounted within a hollow annular space 26 in the ball cage assembly 30 is a ball bearing 34 having a grooved outer race 35. In the embodiment shown, the grooved outer race 35 is made by pressing a pair of retaining rings 36 on an otherwise standard bearing 34. A resilient circular tire 40 of elastomeric insulating material, such as silicon rubber, is mounted on the outer race 35 and retained by the retaining rings 36. The resilient tire 40 supports the balls 25 and resiliently urges each of the balls 25 into contact with the conductors 13 thereby maintaining the proper contact pressure between the balls 25 and the conductors 13 while permitting the balls 25 to roll smoothly. The arrangement of the bearing 34 and the tire 40 appreciably minimizes the resistance to rolling of the balls 25.

The ball cage assembly 30 has a central aperture 41 which is adapted to receive a drive shaft 42. The ball cage assembly 30 is secured to the drive shaft 42 by means of a locating and holding pin 43. The drive shaft 42 has its longitudinal axis coincident with the common axis 20 and is mounted for rotation about said axis 20 by means not shown.

In operation, the drive shaft 42 is rotated either manually or by drive means, not shown, thereby causing the ball cage assembly 30 to rotate which in turn drives the balls 25 around the circular groove 24. As the balls 25 roll along the groove 24, they are resiliently urged radially outwardly by the tire 40. When a ball 25 contacts the spaced extremities 14 of an opposed pair of conductors 13 as shown in FIG. 1, it completes the electrical circuit through that pair of conductors 13.

It will be appreciated that although the conductors **13** have been shown in FIG. 1 disposed at an angle with respect to each other, they may be parallel. Further, any number of conductors **13** may be spaced circumferentially either equally or unequally depending upon the denired size of the switch **10** and the switching action desired. In addition, one or more balls **25** may be utilized in conjunction with a ball cage assembly **30** again depending upon the switching action desired.

The alternative embodiment of FIG. 3 provides for greater versatility and accommodates more circuits by utilizing a plurality of ball cage assemblies **30** and an even number of associated wafers **11**. The assemblies **30** are simultaneously driven by a common drive shaft **42** about the axis **20**. Axial play of the shaft **42** is prevented by a pair of preloaded bearings **46** which in conjunction with the "floating" bearing **47** support the shaft **42** for rotation about the axis **20**. In certain embodiments of the invention the number and orientation of the conducting balls **25** may obviate the need for the floating ball bearing **47** at the internal end of the shaft **42**.

As shown in FIG. 3 a great variety of switching functions are made possible by the fact that all or any of the following parameters may be varied:

(a) The number of switch wafers and ball cage assemblies and the length of the shaft.

(b) The orientation of the ball cage assemblies with respect to each other.

(c) The number of conducting balls and their positions in the various ball cage assemblies.

(d) The circuitry by which the switch is connected to its associated equipment.

(e) The type of motion applied to the shaft by the driving means.

For example, by arranging the lengths of the surface **23** as shown in FIG. 2 to be greater than the distance **45** between the conductors **13** along the circular groove **24** and displacing the ball cage assemblies **30** one from another, as shown in FIG. 3, the conductors **13** of one pair of cooperating wafers **11** act where needed as an electrical bridge between the conductors **13** of another pair of cooperating wafers **11**. By this method a circuit may be energized for 360° of rotation of the shaft **42** or any of a great variety of increments thereof, for example, when utilizing twenty-four equally spaced conductors **13** radially disposed at a 15° angle with respect to each other as shown in FIG. 2, one ball cage assembly **30** would be displaced rotationally 7½° with respect to another ball cage assembly **30**. This may be accomplished by having two grooves on each cage assembly **30**, either one of which is used to rotationally position the cage by assembly **30** engaging a holding pin **43**. The two grooves on any given cage assembly **30** are 7½° off being mutually orthogonal, while all of the holding pins **43** are coplanar. Thus, each cage assembly **30** is capable of being mounted in two different rotational modes which are mutually separated by 7½°.

By means of the above teaching a rotary electric switch is provided having very smooth action which is adaptable to miniaturizing techniques while providing extremely reliable operation under adverse operating conditions. For example, the outer dimensions of a rotary electric switch made in accordance with the embodiment

of FIG. 3 could be one inch in diameter and two inches long. As shown in FIG. 3, the switch **10** may be hermetically sealed readily.

While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than of limitation and that changes within the purview of the appended claim may be made without departing from the true scope and spirit of the invention in its broader aspects.

What is claimed is:

An electric switch comprising an even number of similarly shaped wafers having their axes of symmetry aligned with respect to a predetermined axis, each of said wafers having a plurality of radially extending spaced conductors mounted thereon, said wafers being disposed adjacent to one another to form cooperative pairs thereof, said wafers defining each cooperative pair being aligned with respect to each other to provide cooperative pairs of axially spaced conductors wherein one conductor of each cooperative pair is disposed in one of said wafers while the other cooperative conductor is disposed in the other of said wafers of a cooperative pair, each of said wafers having a central aperture defined by inwardly extending spaced extremities of said conductors, and said conductors having chamfered inwardly extending spaced extremities of cooperative pairs of conductors circularly disposed to define a circular groove, at least one ball of conductive material positionably disposed for rolling in each of said grooves for selectively contacting adjacent cooperative extremities of ones of said pairs of conductors for completing the electrical circuit through said pair of conductors, ball cage means disposed within said central aperture for rotation about said axis and cooperative with each of said pairs of conductors and having spaced slots therein adapted to receive said balls for positioning said balls with respect to said extremities of their respective conductors along said grooves, a shaft disposed within said central aperture and connected to rotate said ball cage means about said axis, each of said ball cage means having a hollow annular space coaxial with respect to said predetermined axis within which said balls protrude, and annular resilient tire means rotatably mounted on ball bearings for rotation about said predetermined axis with respect to said ball cage means within said hollow annular space for resiliently applying a radial force for urging each of said balls into contact with its respective pair of conductors.

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