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HIGH SPEED TIME SHARING ROTARY SWITCH

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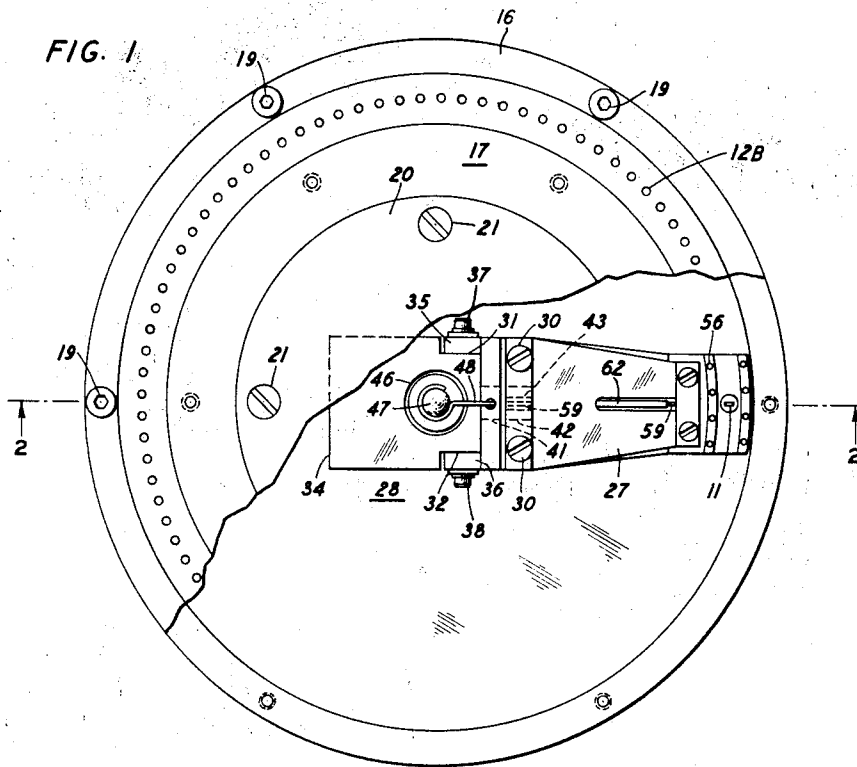
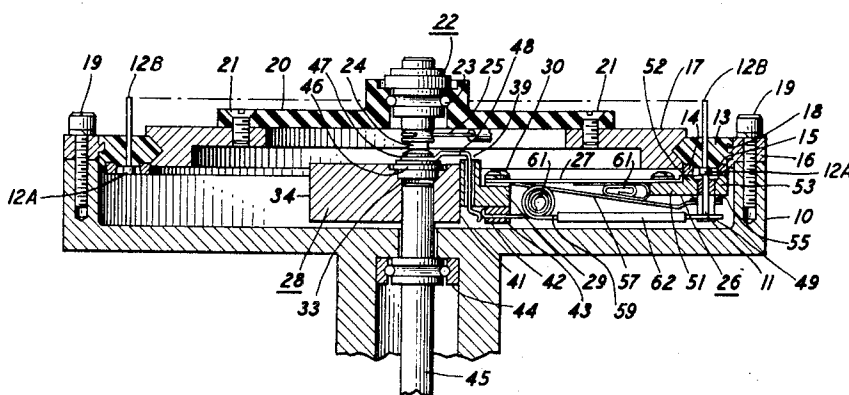


FIG. 2



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HIGH SPEED TIME SHARING ROTARY SWITCH

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9 Claims. (Cl. 260—24)

This invention relates to switches and more particularly to high speed multiple contact rotary switches adapted for successively and momentarily closing a plurality of circuits.

A number of electronic and mechanical switching devices are available for use in data distributing means which operate for long intervals of time and route large quantities of information in multiplexing systems, computers and the like. It has been found that rotary switches are the most desirable devices in such means because of their good switching reliability and low cost. These rotary switches which are of the type considered herein comprise a brush assembly that sweeps across a circular array of contacts at a high rate of speed. A common difficulty of such switches is that their switching characteristic commences to become unsatisfactory after a relatively short period of continuous operation. Investigation of the switching action of these devices indicates that misalignment between the brush assembly and the contact array contributes to the degradation of the switching characteristic. Also, burning of the contacts further reduces the performance of the switch.

A general object of the invention is to improve the performance and extend the switching life of high speed rotary switches.

Another general object of the invention is to obtain high speed rotary switches having accurate and excellent switching characteristics.

A specific object of the invention is to maintain the contact plate and the brush assembly of a high speed rotary switch in proper alignment for minimum contact wear.

Another specific object of the invention is to minimize wearing and burning of contacts employed in high speed rotary switches.

One feature of the invention involves the cooperation between a brush and an array of contacts and a plurality of associated guide rings to produce a contact plane in which the brush is guided.

Another feature of the invention is a suitably damped brush assembly having three degrees of freedom to enable the brush thereof to be in proper and continuous alignment with the contact plane for minimum contact wear.

Still another feature of the invention is a capped and trimmed contact array to reduce arcing between the brush and the stationary contacts as relative movement occurs between these members.

In an illustrative embodiment, the rotary switch comprises a circular array of fixed contacts on a plate positioned within a housing. The contacts are appropriately trimmed, and are capped with a material highly resistant to abrasion and burning. A plurality of rings are imbedded in the plate concentric with and on both sides of the contact array. The rings and contacts form a plane surface defined by rectangular coordinates X and Y with the origin of the coordinates being at the center of the contact circle. A bifurcated wiper arm is attached at one end to a rotor member driven by a drive shaft that is posi-

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tioned at the contact center. A brushholder assembly including brush or contactor and shoe members, is attached to the other end of the wiper arm and the assembly cooperates with the contact array and the ring members, respectively, as relative movement occurs between the assembly and the contact array on rotation of the drive shaft. The wiper arm is torsionally flexible to allow rocking of the assembly about the radial axis of the arm and thereby maintain the assembly in alignment with the X direction of the contact plane. Spring means anchored to the rotor bear on the brushholder assembly to allow it to rock about an axis parallel to the contact plane, perpendicular to the radial axis and passing through said assembly. The rocking action of the spring means maintains the assembly in alignment with the Y direction of the contact plane. A brush spring is secured to the rotor and biases the brush to follow the surface of the contact plane as well as to connect the brush to an external circuit. The spring means, brush spring and brush are damped by material suitably located on the brushholder assembly and the wiper arm.

These and other features of the invention will be more fully described in the following detailed specification taken in conjunction with the appended drawing, in which:

Fig. 1 is a plan view of a high speed rotary switch illustrative of this invention with parts broken away to show the brush assembly of the switch;

Fig. 2 is a sectional view taken on the line 2—2' of Fig. 1;

Fig. 3A indicates schematically the wear occurring on a brush at diametrically opposite points of a contact array where the brush and contact array are not in alignment;

Fig. 3B indicates schematically the continuous overlap between the brush and the contacts as relative movement occurs between these elements;

Fig. 4A is a perspective view of the brush assembly and the contact plate; and

Fig. 4B is a perspective view of one of the contacts employed in the contact array.

As illustrated in Figs. 1 and 2, one embodiment of this invention comprises a circular housing 10, for example, a metal casting, in which is mounted a rotatable contactor or brush 11. A circular array of stationary contacts having heads 12A and stems 12B, the stem portions only of which are visible in Fig. 1, is imbedded in a ring 13 of high dielectric strength plastic such as epoxy resin. The heads of the contacts may be slightly imbedded in the plastic to improve the contact stem stability. The contacts are of alternate small and large size (see Fig. 4A) for obtaining a particular type of switching action but may be of identical diameters in obtaining other types of switching action. Metal rings 14 and 15 (see Fig. 2) are imbedded in the ring 13 on opposite sides of and concentric with the contact circle. The surface of the rings and the contacts lie in a common plane for reasons which will become more apparent hereinafter.

The ring 13 is molded between an outer annular plate 16 and an apertured inner plate 17 which may be of aluminum or other equivalent material. An undercut tongue 18 on the inner surface of the outer plate 16 provides a dovetail joint to prevent the plastic from shrinking away from the outer plate as it hardens. The apertured inner plate is clamped tightly by the plastic as it shrinks and a V groove assures proper orientation of the plastic member and the inner plate. Pins may be inserted through the junctures of the plastic and metal rings to avoid relative rotation. The outer plate 16 is fastened to the circular housing 10 with screws 19.

An insulating plate 20 having a central bore therein is fastened to the inner plate 17 by means of fasteners 21. A flexible connector assembly 22 is keyed in the bore

of the plate 20 by pins 23. The connector assembly is of conventional design and includes the brush 24 which is connected to the exterior of the switch by the lead 25.

A brushholder assembly 26 shown in Figs. 2 and 4A cooperates with the rings and contacts of the plate assembly in a manner to be described hereinafter. The brushholder is attached to one end of a bifurcated, deflectable wiper arm 27 having its other end secured to a rotor 28 through an insulating member 29 and the screws 30. The rotor has indented sides 31 and 32 and a bore 33 offset from the rotor center to form a counterweight section 34. The member 29 is substantially step shaped and includes wing portions 35 and 36 which are secured to the indented sides 31 and 32 by fasteners 37 and 38, respectively. The member 29 also includes a vertical passageway 39 and a transverse slot 41. A metallic strip 42 having an axial passage 43 is inserted in the slot 41 and fastened to member 29 by screws (not shown). Suitably journaled in the housing 10 by anti-friction bearing 44 is a drive shaft 45 which extends part way into one end of the bore 33 of the rotor. A washer-shaped insulating member 46 having a silver button portion 47 is located at the other end of the bore. The button is contacted by the brush 24 and entwined by wire 48 which extends into passageway 39 and slot 41.

The brushholder 26 comprises the brush or contactor 11 which is of parallelepiped configuration, a slotted brush guide 49 and a guide block 51 having lands or shoes 52 and 53 and cam surfaces 54 and 55 located thereon. The block is of a plastic or equivalent material with the land portions thereof engaging the metal rings 14 and 15 in the capacity of shoes for the brush 11 which is positioned therebetween. The lands or shoes 52 and 53 include lubricating graphite means such as pencil leads 56 (see Fig. 1) for aiding the passage of the shoes over the rings 14 and 15.

To maintain the shoes and brush in contact with the metal rings and stationary contacts, respectively, leaf springs 57 and 58, having a bowed configuration, are attached at one end to insulating member 29 by screws 30 and the other end rides on the cam surfaces 54 and 55. The wiper arm and the leaf spring are insulated from each other by suitably located dielectric material. A so-called safety pin spring 59 having a coiled portion as shown applies a force to the brush 11 for feeding it through the brush guide 51. One end of the spring rests in the axial slot occurring in the guide 49 and the other end is bent over the end of axial passageway 43. The wire 48 and the spring 59 are soldered together in slot 41 to form a permanent connection for connecting the brush 11 to external circuits through the series circuit defined by elements 25, 24, 47, 48 and 59.

A damping material 61, such as rubber or equivalent, is folded and inserted between the leaf springs 57 and 58 and the wiper arm 27 and the coil of the spring 59. The material absorbs the vibration of these members as they rotate relative to the stationary contacts. A plastic sleeve 62 of nylon or like material is cemented to the safety pin spring 59 as additional vibration absorbing means. The vibration between the leaf springs 57 and 58 and the guide block 51 is further reduced by gluing sheets of the material 61 to the face of the spring engaging the cam surfaces 54 and 55 (see Fig. 4A). Inserted in the brush guide 51 is a bushing (not shown) of the material 61 such that the edges of the parallelepiped brush 11 indent the bushing to absorb by resistance the vibrations therefrom as the brush passes over the stationary contacts.

Turning now to Fig. 3A, the brush 11 of Figs. 1 and 2 is shown in positions 11¹ and 11² as it sweeps over diametrically opposite contacts 12 and 12¹ of the contact array. It will be noted that the plane A—A' passing through the contacts 12 and 12¹ is not parallel to the plane B—B' passing through the brush positions 11¹ and 11². As a consequence, the inner corner of the brush is

subject to excessive wear at position 11¹, whereas the outer corner of the brush is subject to excessive wear at position 11². In a relatively short time interval inversely proportioned to the angular velocity of the brush the unsymmetrical wear on the brush causes the outer corner thereof to lose contact at position 11¹ and similarly the inner corner thereof to lose contact at position 11². Further, the diminished area of contact between the brush and the contacts will also occur in a modified form on contacts intermediate 12 and 12¹. At one intermediate contact the leading half of the brush will make contact and at the other intermediate contact the trailing half of the brush will make contact. This effect seriously shortens the duration of contacting. The loss of contact and resultant switching degradation is undesirable and may be substantially eliminated by parallel alignment of the planes A—A' and B—B'. In such a case it is apparent that the wear on the brush at points 11¹ and 11² is symmetrical resulting in the brush being in continuous contact with the array at all points in its path of travel.

In the fabrication of rotary switches as shown in Fig. 2, it is practically impossible, as well as economically unfeasible to align the shaft 45 and the wiper arm 27 perpendicular and parallel, respectively, to the contact array 12 to the degree of accuracy required and thereby obtain minimum and uniform wear of the brush 11. In laboratory tests it has been found that high speed switches without precise alignment of these elements or the features disclosed by the present switch have a lifetime of not more than 300 hours before their switching characteristic becomes unsatisfactory.

The present invention does not require that the shaft 45 and the wiper arm 27 be precisely arranged with respect to the contact array. Instead, the wiper arm 27, leaf springs 57 and 58, and brush spring 59 cooperate with the brushholder assembly to cause the brush to wear in the plane of the contacts so that minimum and uniform wear is obtained thereby. Actually, the contacts per se do not form a continuous plane surface since they are spaced apart, but, as will be seen, the interaction between the brush and the contact array creates the appearance of a plane surface to the brush. Fig. 3B is an illustration of the desired movement of the brush with respect to the contacts. It will be noted that in all positions the brush is either positioned on a contact or engaging two adjacent contacts. Hence, it can be seen that a surface passing through the contact faces is presented to the brush at all times and this surface defines a contact plane in which the brush operates. To prevent short circuiting when the brush bridges adjacent contacts either the large or small contacts may be disconnected from external circuits.

Turning now to Fig. 4A, the movement of the wiper arm and brushholder will be described with respect to the contact plane. As an aid in guiding the brush in the contact plane the shoes 52 and 53 ride on the metal rings 14 and 15. The rings and contact surfaces are lapped to a common surface and enlarge the base for aligning the brush and contacts thereby steadying the movement of the brush in the contact plane. It should be noted that the rings and contacts of a switch need not be lapped to a flat surface but may be shaped to some other configurations, for example, a spherical surface. Obtaining a spherical surface with an accurate and constant radius of curvature would be more cumbersome and hence not preferable, but a switch so constructed would operate as satisfactorily as the present switch.

For convenience in describing the action of the brush assembly, the contact plane is defined by X and Y rectangular coordinates having their origin at the center of the contact array. These coordinates are shown in Fig. 4A. It will be seen that the brush assembly develops particular movements for each direction of the contact

plane and the combination of these movements results in the brush being continuously and properly aligned with respect to the contact plane for uniform and minimum wear of the contact and brush.

As the brush assembly 26 rotates the independent flexibility of each line of the bifurcated wiper arm 27 permits torsional flexure about its radial axis R' thereby to allow the assembly to rock about this radial axis enabling the brush to be in continuous alignment with the direction T—T' tangential to the contact array. Another way of looking at this movement of the brushholder assembly is to consider that each contact is defined by a set of rectangular coordinates translated with respect to the origin. The movement of the brushholder assembly as a result of the flexibility of the bifurcated wiper arm allows the brush to be in continuous alignment with the X direction of the contact plane. Similarly, the leaf springs 57 and 58 apply a pressure to the cam surfaces 54 and 55 to allow the brushholder assembly 26 to rock about an axis Y'—Y'' perpendicular to the radial axis R' of the wiper arm and tangential to the contact array. This freedom enables the brush to be in continuous alignment with the radial direction of the contact array. Also, the movement of the brushholder as a result of the cooperation between the leaf springs and the cam surface allows the brush to be in alignment with the Y direction of the contact array for reasons similar to those mentioned in connection with the alignment of the brush and the X direction of the contact plane.

Another, or third, degree of freedom possessed by the brush is the movement normal to the contact array. The biasing action of the spring 59 allows the brush to follow any surface variations of the contact plane.

Thus, it will be seen that as the brush assembly rotates, the wiper arm, leaf springs, cam surfaces and the brush spring cooperate to cause the brush surface and contact plane at all points along the contact array to be parallel resulting in the brush surface contacting the appropriate fixed contacts over their entire instantly facing areas. Ordinarily the switching characteristic of the present device would be excellent and accurate for the lifetime of the switch except that the materials in the switch burn and wear and degrade the switching characteristics of the device. Laboratory test of the present rotary switch, however, indicates a lifetime of 30,000 hours with routine maintenance before switching operation becomes unsatisfactory.

Regarding the burning of contacts which also reduces the switch lifetime, it will be seen that as the brush approaches the contact having a circular form, an arc takes place on the same few molecules of the brush and contact until they are worn or burned away. The arc attack then begins on another pair of points until they are eliminated. The burning process continues until the contact edge is modified by wear so that the point of the arc is distributed along a line. Unfortunately, the line is very irregular and at times permits a small amount of overlap between the contact and the brush. This overlap introduces a longer arcing period in the switching characteristic which eventually causes the operation of the switch to be undesirable. To correct this burning condition, the contacts are provided with two straight edges as shown in Fig. 4B. These edges are formed to be in alignment with a radius of the fixed contact circle. Now, as the straight edge of the brush approaches a straight edge of the contact, the two edges become parallel at the position of closure resulting in any number of points being available for the spark to jump between the brush and contacts. It is apparent, therefore, that the straight sided contact as shown in Fig. 4B divides up the spark concentration that existed at the circular contacts, thereby decreasing contact burning and extending the switching life of the switch.

The burning tendency of the contact array is further lessened by welding tungsten caps 64 on the contact

faces shown in Fig. 4B. The tungsten caps have both a high resistance to abrasion and high heat of vaporization. These characteristics of tungsten reduce the wearing and burning of the contacts and further extend and improve the switching lifetime of the switch.

It will be understood that various modifications may be made in the specific embodiments shown and described without departing from the spirit and scope of the invention.

What is claimed is:

1. A switch comprising an array of fixed contacts arranged in a circle, a contactor for sweeping over said contacts with substantially no vibration, a rotor pivoted at the axis of the contact circle and a contactor arm assembly for connecting the contactor to the rotor, said contactor arm assembly maintaining the face of said contactor in the plane of said contacts and including an arm secured at one end to the rotor, a brushholder assembly for mounting the contactor being secured to the other end of said arm, said arm being torsionally flexible to allow rocking of the brushholder assembly about the radial axis of said contactor arm assembly, spring means anchored to the rotor and bearing on the brushholder assembly to allow rocking of said brushholder assembly about an axis tangential to the contact array and perpendicular to the radial axis, and means for dampening contactor vibration and biasing the contactor with respect to the brushholder assembly and toward said contacts.

2. A switch as defined in claim 1, wherein the contacts are capped with tungsten and have at least two straight edges which cooperate with the contactor to minimize burning and arcing of the contactor.

3. A switch comprising an array of fixed contacts arranged in a circle, guide rings flanking the contact array and concentric therewith, a contactor for sweeping over said contacts, a rotor pivoted at the axis of the contact circle, and a contactor arm assembly for connecting the contactor to the rotor, said contactor arm assembly maintaining the face of said contactor in the plane of said contacts and including an arm secured at one end to the rotor, a brushholder assembly for mounting the contactor being secured to the other end of said arm, said brushholder assembly having spaced shoes that individually ride on a guide ring, said arm being torsionally flexible to allow rocking of the brushholder assembly about the radial axis of such contactor arm assembly, spring means annexed to the rotor and bearing on the brushholder assembly to allow rocking of said brushholder assembly about an axis tangential to the contact array and perpendicular to said radial axis, and means for biasing the contactor with respect to the brushholder and toward said contacts.

4. A switch as defined in claim 2 wherein the contacts and rings have their faces in the same plane and the spring means bear on cam surfaces of the brushholder assembly.

5. A switch comprising an array of fixed contacts arranged in a circle, guide rings flanking the contact array and concentric therewith, said contacts and rings having their faces in the same plane defined by X and Y rectangular coordinates with origin at the center of the contact circle, a contactor for sweeping over said contacts, a rotor pivoted at the axis of the contact circle and a contactor arm assembly for connecting the contactor to the rotor, said contactor arm assembly maintaining the face of said contactor in the plane of said contacts and including an arm secured at one end to the rotor, a brushholder assembly for mounting the contactor being secured to the other end of said arm, said brushholder assembly having shoes flanking the contactor and which individually ride on a guide ring, said arm being torsionally flexible to allow rocking of the brushholder assembly about the radial axis of said contact or arm assembly to maintain the contactor in continuous alignment with the X direction of the contact plane, spring means anchored to the

rotor and bearing on cam surfaces of the brushholder assembly to allow rocking of said block about an axis tangential to the contact array and perpendicular to said radial axis to maintain the contactor in continuous alignment with the Y direction of the contact plane, and means for biasing the contactor with respect to the brushholder assembly and toward said contacts.

6. A switch comprising an array of fixed contacts arranged in a circle, guide rings flanking the contact array and concentric therewith, said contacts and rings having their faces in the same plane defined by X and Y rectangular coordinates with origin at the center of the contact circle, a contactor for sweeping over said contacts, a rotor pivoted at the axis of the contact circle and a contactor arm assembly for connecting the contactor to the rotor, said contactor arm assembly including an arm secured at one end to the rotor and a guide block secured to the other end of the arm, a brush guide centrally located on said block for mounting the contactor, one face of said block having shoe portions thereon flanking the contactor and which individually ride on a guide ring, the opposite face of said guide block having cam surfaces thereon, said arm being torsionally flexible to allow rocking of the block about the radial axis of said contactor arm assembly to maintain the contactor in continuous alignment with the X direction of the contact plane, leaf springs anchored to the rotor and bearing on the cam surfaces to allow rocking of said block about an axis

tangential to the contact array and perpendicular to the radial axis to maintain the contactor in alignment with the Y direction of the contact plane, and means for biasing the contactor with respect to the guide block and toward the contacts.

7. A switch as defined in claim 6 wherein the biasing means for the contactor comprises a spring having a coiled portion with one end of the spring secured to the rotor and the other end thereof applying pressure on the contactor toward the contacts, and means for connecting the spring to external circuits.

8. A switch as defined in claim 7 wherein damping material is attached to end portions of the leaf springs in contact with the cam surfaces and to the spring having a coiled portion.

9. A switch as defined in claim 6 wherein the contactor arm is flexible and bifurcated.

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