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ROTARY SWITCH WITH IMPROVED CONTACT ELEMENT STRUCTURE

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FIG. 1

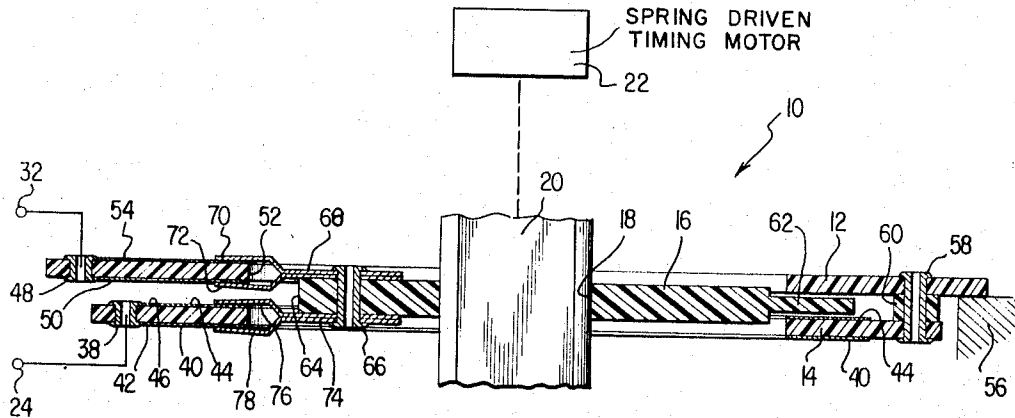
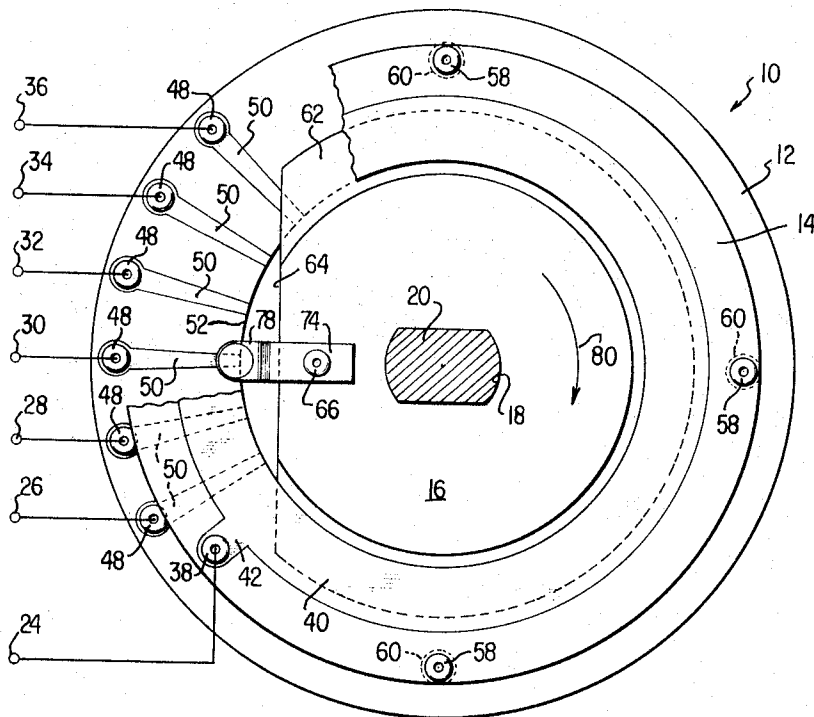


FIG. 2



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ROTARY SWITCH WITH IMPROVED CONTACT ELEMENT STRUCTURE

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10 Claims. (Cl. 200-11)

This invention relates to a rotary switch and more particularly to a shock- and vibration-insensitive switch particularly suited for aerospace applications.

As is well known, space vehicles such as missiles, rockets, satellites, and the like undergo substantial buffeting, with the result that the electrical equipment which they carry is frequently subject to very severe shocks and vibrations. This is particularly true during times of entry into and return from space as the vehicle leaves and approaches the earth. Additional shocks and vibrations are occasioned by the acceleration forces acting on these vehicles when the vehicles are being reoriented or repositioned, commonly by means of thrusting devices in the form of gas jets. Likewise, suborbital space vehicles such as weather balloons are subject to constant buffeting from air currents involving rapid acceleration with the accompanying vibration and shock to the electrical equipment.

Because of these forces many of the prior switch constructions heretofore proposed have not been able to maintain positive electrical contact at all times, but instead have chattered under the extreme environmental conditions experienced. Switch chatter is highly undesirable, in that it may result in a substantial amount of electrical noise interfering with telemetering signals to or from the vehicle, produces contact arcing and, in some cases, excessive and rapid wear of the switch contacts, and may cause partial or even complete loss of a signal or control function in the electrical equipment.

The present invention avoids the above-mentioned difficulties by providing a novel rotary-type switch wherein positive contact to the switch terminals is assured at all times, even when the switch is subjected to the most severe dynamic environmental conditions. This positive switch action is obtained through the provision of a relatively simplified, inexpensive structure that is both lightweight and of small size, making it particularly suited for aerospace operation. Because of its novel construction the switch of the present invention may be quickly and accurately moved or positioned by way of a low-output drive source, since the switch requires only a small driving torque for operation.

Important features of the present invention include a pair of parallel, spaced, annular printed circuit boards or discs on which are printed, etched, or otherwise suitably applied, substantially planar circuit elements. Positioned coaxially of the printed circuit discs is an insulated rotor carrying a pair of spring clips, each clip having a pair of spring arms engaging the opposite surfaces of the respective printed circuit disc. The printed circuits are duplicated on the top and bottom of each disc so that the resilient arms of the spring clips make contact with both circuits under static conditions, and of necessity must make contact with one or the other even under the most severe dynamic conditions. Because of the fact that the resilient clips engage both of the discs throughout 360° of rotation, the spring arms of the clips are always in proper position to engage an appropriate conductive element. In this way, problems due to contact misalignment and variations in spring tension are minimized.

It is, therefore, one object of the present invention to provide a novel electrical switch.

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Another object of the present invention is to provide a switch having increased insensitivity to shocks and vibrations.

Another object of the present invention is to provide a novel rotary switch requiring a reduced driving torque for operation.

Another object of the present invention is to provide a rotary switch which minimizes the problems of contact misalignment and spring pressure variations experienced in earlier constructions.

Another object of the present invention is to provide a relatively simplified, lightweight and inexpensive switch particularly suited for aerospace application.

These and further objects and advantages of the invention will be more apparent upon reference to the following specification, claims, and appended drawings, wherein:

FIGURE 1 is a vertical cross section through the switch of the present invention; and

FIGURE 2 is a plan view of the underside of the switch of FIGURE 1, with parts broken away to more clearly illustrate the switch elements.

Referring to the drawings, the novel switch of the present invention, generally indicated at 10, comprises a pair of stationary annular discs 12 and 14 formed of suitable insulating material such as that commonly used for making so-called printed circuit boards. Positioned coaxial with the discs 12 and 14 is a flat, generally circular rotor 16 similarly made of suitable insulating material. Rotor 16 is provided with a central aperture 18 receiving preferably with a press fit a central drive shaft 20. Aperture 18 and shaft 20, as best seen in FIGURE 2, are preferably of generally rectangular configuration so that rotation of the shaft 20 acts to rotate the rotor 16 in unison with the shaft. As illustrated in FIGURE 1, shaft 20 may be driven from a timing motor 22 of suitable construction. In aerospace applications the timing motor takes the form of a spring-driven watch or clock mechanism which acts through a conventional clock or watch escapement to drive shaft 20.

In the embodiment illustrated, switch 10 is a selector switch particularly suited for use in conjunction with the assignee's timer programmer which has a one-hour rundown time and is usable in space vehicles. In this embodiment the switch is connected through a suitable lead to an input terminal 24 and to a plurality of individually selectable output terminals 26, 28, 30, 32, 34 and 36. Input terminal 24 is connected to an eyelet 38 passing through the lower or common disc 14, which eyelet forms a solder connection to a circular common input lead 40 by way of a short printed circuit lead 42. Leads 40 and 42 are preferably in the form of copper foil and may be printed, etched, or otherwise applied as a planar conductor to the undersurface of disc 14. Conductor 40 extends completely around disc 14 adjacent its inner edge. In addition, this circuitry is repeated on the upper surface of disc 14 by way of a second identical conductor 44 similarly positioned on the upper surface of the board 14 and coupled to the eyelet 38 by way of a short lead 46. As will be apparent, conductive eyelet 38 electrically connects the annular printed circuit conductors 40 and 44 on the opposite surfaces of the lower board, which annular conductors cooperate to form the common contact for the switch.

Passing through the upper printed circuit board or annular disc 12 are a plurality of circumferentially spaced, electrically conductive eyelets 48 forming solder connections to the output terminals 26, 28, 30, 32, 34, and 36. The under surface of this upper disc 12 is provided with a plurality of spaced conductive strips or segments 50 of printed or etched copper foil, or the like, which are electrically connected to the eyelets 48 and which extend

radially inward of the board 12, terminating at its inner edge 52. This circuitry is similarly repeated on the top surface of upper board 12 in the form of identical conductive strips or segments 54 likewise each connected to one of the spaced eyelets 48. As is apparent, the cooperating lower segments 50 and upper segments 54 are electrically connected to the conductive eyelets 48 and form the output contacts for the switch. While only six output contacts are illustrated in the drawing, it will be apparent that more or less may be provided in accordance with the output requirements of the switch and that the output segments may be circumferentially spaced entirely around the upper disc 12, i.e., around its complete 360° circumference, or may be spaced around a lesser extent of the disc circumference, as desired.

Stationary annular discs 12 and 14 are mounted on a suitable support as indicated by the hatching at 56 in FIGURE 1. The boards are joined by a plurality of eyelets 58 suitably spaced around the circumference of the boards or discs and maintained in spaced parallel relation by suitable spacers such as 60 surrounding the eyelets 58. As will be noted from FIGURE 2, eyelets 58 are spaced radially outward from the circular conductive leads 40 and 44 so that they are not in electrical contact with the leads. Likewise, the segments in upper disc 12 are preferably omitted at the locations of the eyelets 58 so that these eyelets are insulated from the circuitry on both boards and act solely as joining, spacing, and supporting devices for the stationary double disc arrangement.

Rotor 16 mounted on the drive shaft 20 is of substantially circular configuration and has a reduced-thickness outer edge forming a circumferential flange 62 extending radially outwardly into the space between the upper and lower discs 12 and 14. Flange 62 is preferably slightly spaced from the discs to avoid frictional contact therewith but it helps to maintain the position and alignment of the rotor 16 with the discs, particularly during such times as the switch is subjected to shock and vibration.

Both the body of the rotor and the flange 62 are cut away on one side of the rotor to form the flat edge 64. Passing through the rotor adjacent this flat edge is a conductive eyelet 66 which secures an upper spring clip 68 to the upper surface of the rotor. Spring clip 68 is provided with spaced resilient arms 70 and 72 engaging the upper and under surfaces, respectively, of the segmented disc 12 adjacent its inner edge. A second spring clip 74 is secured by conductive rivet 66 to the underside of the rotor and carries resilient spring arms 76 and 78 engaging the upper and lower surfaces, respectively, of the continuous conductive disc 14.

In operation, rotation of the shaft 20 by the timing motor 22 causes the spring clips 68 and 74 to rotate about and wipe over the inner periphery of the two discs 12 and 14. During static environmental conditions, both spring arms 70 and 72 of the upper clip engage disc 12 and both spring arms 76 and 78 of the spring clip 74 engage the respective surfaces of the lower disc 14. Since the common circular leads 40 and 44 are continuous about lower disc 14, spring arms 76 and 78 are in continuous electrical contact with the input terminal 24.

Spring arms 70 and 72 of spring clip 68 are likewise in continuous engagement with the respective surfaces of the segmented disc 12. As this spring clip wipes over the disc, the spring arms sequentially establish electrical contact from spring clip 74, by way of conductive rivet 66, to the respective output terminals 26, 28, 30, 32, 34, and 36, to complete the circuit of the input terminal 24. This input terminal may be coupled to a suitable power supply, while the output terminals are in turn coupled to suitable load devices.

Under dynamic conditions, forces may cause one of the spring arms 70 or 72 of spring clip 68 to momentarily move away from disc 12 and one of the corresponding arms of spring clip 74 to leave the surface of disc 14. However, in each case this movement is resisted by the

other resilient arm of each clip and only acts to force the other arm more tightly against the respective disc. Thus electrical contact is firmly maintained even under the most adverse conditions of vibration and shock.

Although the switch has been described in conjunction with the continuous, one-way rotation of rotor 16, as indicated by the arrow at 80 in FIGURE 2, under the influence of a spring-operated, escapement-controlled timing motor 22, it is apparent that the selector switch may be used in conjunction with other types of drives. For example, the rotor may be stepped from one output segment to the next, it may be oscillated so as to be driven first in one direction and then in the opposite direction, or it may be manually actuated much in the manner of either a continuous or step-wise movable turret tuner so as to engage the desired output segment 50.

Similarly, the construction is not limited to use as a selector switch but may be programmed as required, by changing the printed circuitry and relocating the spring clips to produce any desired result. Terminal 24 may have its function reversed; that is, it may be an output terminal connected selectively to one of the terminals 26, 28, 30, 32, 34, or 36, which may in turn be coupled to suitable sources. For example, in telemetering applications the circumferentially spaced segments 50 may be coupled to different environmental transducers, with the output device coupling signals from these transducers to a transmitter or the like by way of terminal 24. Similarly, various ones of the segments may be grouped together for any desired programming arrangement.

It is apparent from the above that the present invention provides a relatively simplified, inexpensive, lightweight, and small-sized rotary switch particularly suited for aerospace application. In view of the light friction occasioned solely by the spring arms of the spring clips 68 and 74, the switch may be driven from small power sources, such as a spring-operated timing motor, since the switch develops only a small frictional load and may be operated by a small torque applied to the shaft 20. Under dynamic environmental conditions such as are occasioned by vibrations and shock, although one of the spring arms of each of the clips may be forced out of engagement with its respective contact, this only causes the other spring arm to even more tightly engage the corresponding surface of the disc to insure positive contact at all times with the electronic circuitry, which, as previously described, is repeated in identical form on both sides of each of the discs 12 and 14. The opposite sides of the discs are electrically coupled in an inexpensive and efficient manner by the respective conductive eyelets 38 and 48. Furthermore, since the spring clips 68 and 74 at all times have their spring arms enveloping the inner edge of both circular discs, no problems arise as to alignment of the conductive segments 50 with the respective spring arms 70 and 72, which problems are prevalent in known constructions. The circuit board always assures that the spring arms 70 and 72 are in proper alignment to engage and wipe over the segments 50.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A switch comprising electrically conductive means including a pair of spaced parallel planar surfaces of continuous electrically conductive material electrically connected together, first movable electrical contact means resiliently urged in opposite directions against said continuous surfaces, a continuous electrical insulator having

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opposite surfaces, a plurality of spaced electrically conductive elements mounted on said insulator, said spaced elements having substantially planar portions extending over said opposite surfaces of said insulator, second movable electrical contact means resiliently urged in opposite directions against the surfaces of said insulator, and means electrically coupling said first and second movable contact means together.

2. A switch comprising electrically conductive means including a pair of spaced parallel planar surfaces of continuous electrically conductive material electrically connected together, an insulated circuit board having opposite surfaces, a plurality of spaced electrically conductive elements mounted on said board, said spaced elements each having substantially planar portions on said opposite surfaces of said board, a rotor, and contact means on said rotor resiliently urged in opposite directions against said continuous surfaces and against said opposite surfaces of said circuit board.

3. A switch comprising a pair of flat annular discs, a rotor, said discs being mounted in spaced parallel relation and coaxial with the rotational axis of said rotor, one of said discs including a continuous conductive means on both sides, the other of said discs including discontinuous conductive means on both sides, and electrically conductive means carried by said rotor resiliently engaging both sides of each of said discs.

4. A switch comprising a pair of flat, annular insulating circuit boards, a continuous conductive strip mounted on both sides of one of said boards, conductive means electrically connecting the continuous strips on said one board, a plurality of spaced conductive strips on both sides of the other of said boards, said spaced strips being arranged in pairs with the strips of each pair on opposite sides of said other board, conductive means electrically coupling the strips of each pair, a rotor coaxial with said discs, and conductive means carried by said rotor resiliently engaging the opposite sides of each board.

5. A switch according to claim 4 wherein said rotor carried conductive means comprises a first pair of resilient arms engaging said one board and a second pair of resilient arms engaging said other board.

6. A switch comprising a pair of flat, annular insulating circuit boards, a continuous circular conductive strip mounted on each side of one of said boards, a conductive eyelet passing through said one board and electrically joining said circular strips, a plurality of spaced, radially extending strips on each side on the other of said boards, a plurality of conductive eyelets passing through said other board and electrically joining selected ones of said spaced strips on opposite sides of said other board, said boards being arranged in spaced parallel relation, an insulated rotor mounted for rotation coaxial with said boards, first and second spring clips mounted on opposite sides of said rotor, each clip having resilient arms engaging the opposite sides of a respective board, and conductive means passing through said rotor and electrically joining said spring clips.

7. A switch comprising a pair of flat annular stationary discs, a continuous conductive strip on both sides of one of said discs, a plurality of spaced conductive strips on both sides of the other of said discs, means electrically coupling certain strips on the opposite sides of each disc, a rotor coaxial with said discs, conductive means carried by said rotor resiliently engaging the opposite sides of each disc,

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a drive shaft coupled to said rotor, and timing motor means coupled to said drive shaft.

8. A switch comprising a pair of flat, annular insulating circuit boards, a continuous circular conductive strip mounted on each side of one of said boards, a conductive eyelet passing through said one board and electrically joining said circular strips, a plurality of spaced, radially extending strips on each side on the other of said boards, a plurality of conductive eyelets passing through said other board and electrically joining selected ones of said spaced strips on opposite sides of said other board, said boards being arranged in spaced parallel relation, an insulated rotor mounted for rotation coaxial with said boards, first and second spring clips mounted on opposite sides of said rotor, each clip having resilient arms engaging the opposite sides of a respective board, conductive means passing through said rotor and electrically joining said spring clips, a drive shaft coupled to said rotor, and spring-driven timing motor means coupled to said drive shaft for operating said rotor.

9. A switch comprising electrically conductive means including a pair of spaced parallel planar surfaces of continuous electrically conductive material, electrically connected together, electrically insulating means having a pair of spaced parallel planar surfaces of continuous electrically insulating material, a plurality of spaced electrically conductive elements mounted on each of said surfaces of insulating material, said spaced elements having substantially planar portions extending over said insulating surfaces, means for establishing external electrical connections to said electrically conductive surfaces and to at least some of said conductive elements on each of said insulating surfaces, and an electrical contact moveable with respect to said conductive and insulating means to wipe over said surfaces, said movable contact having means resiliently engaging each of said surfaces, said engaging means being resiliently urged in opposite directions against said conductive surfaces and in opposite directions against said insulating surfaces.

10. A switch according to claim 9 wherein said electrically conductive means comprises a substantially planar conductor repeated on each of two insulating surfaces, means establishing electrical connection between said conductors on said two insulating surfaces, said spaced conductive elements also each being repeated on two insulating surfaces, and means establishing electrical connection between said repeated conductive elements whereby said conductive elements are electrically connected in pairs with each member of a pair on a different one of said insulating surfaces of said insulating means.

References Cited by the Examiner

UNITED STATES PATENTS

55	1,653,313	12/1927	Sanner	200—14
	2,504,027	4/1950	Kuhlman	200—11
	2,616,994	11/1952	Luhn	200—166 X
	2,944,121	7/1960	Wasylenko	200—11
60	3,025,361	3/1962	Hartsock et al.	200—11

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