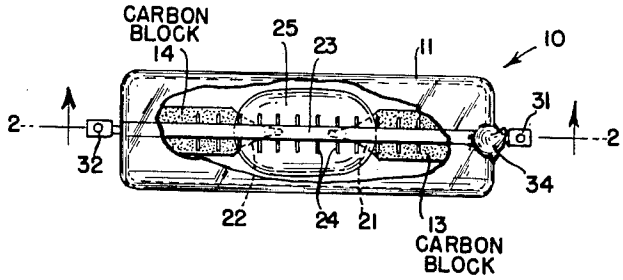
March 27, 1956 W. D. BUCKMAN 2,740,028

VARIABLE RESISTANCE DEVICES

Filed Nov. 19, 1952

FIG. 1



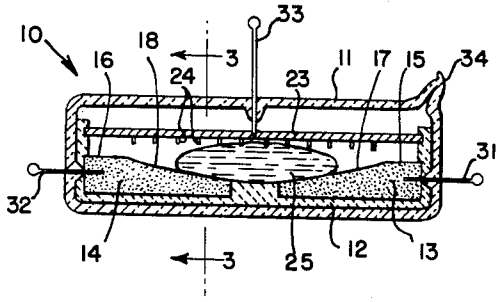


FIG. 2

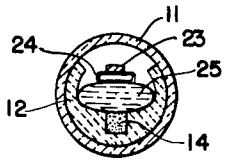


FIG. 3

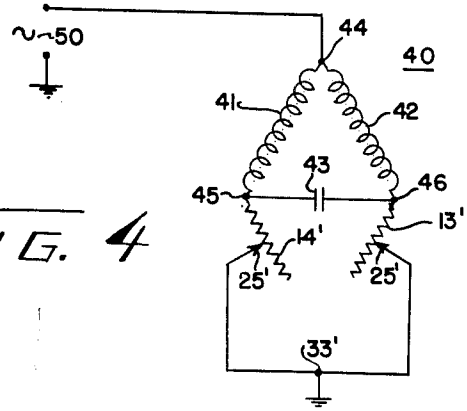


FIG. 4

INVENTOR
WILMER D. BUCKMAN

BY George H. Fisher

ATTORNEY

United States Patent Office 2,740,028
Patented Mar. 27, 1956

2,740,028

VARIABLE RESISTANCE DEVICES

Wilmer D. Buckman, Minneapolis, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Application November 19, 1952, Serial No. 321,355

5 Claims. (Cl. 201—62)

This invention pertains to variable resistance sensing devices in general and more specifically to a variable resistance sensing device whose resistance is proportional to the area of contact between a body of current conductive fluid and a resistive material, the area of contact varying in accordance to relative motion between the fluid and the material.

One object of this invention is to provide an improved variable resistance sensing device wherein a resistive material such as carbon in the form of blocks, plates, baked coatings, or the like is used as the resistance element and a current conductive fluid is used as a means to contact the carbon resistance elements.

Another object of this invention is to have in a sensing device a plurality of resistive carbon elements, portions of which are contacted by a globule body of current conductive fluid, said elements being positioned so that a tilting of the device about one or more axes will increase the area of contact between the fluid and one or more elements while at the same time decreasing one or more other areas of contact, and said elements and said fluid being associated with circuit means external of said device so that the increase and decrease of said areas results in a decrease and increase respectively of the resistance imposed by said device in said circuit means.

An additional object of the invention is to provide a switch for a device such as a torque motor that applies to said torque motor an energization which is proportional to the amount of tilting of said switch away from a normal position, said switch including resistive carbon and a current conductive fluid.

Another object of the invention is to provide a switching device of the current conductive fluid type wherein a novel combination of elements provides a sensitive and stable switching action.

A further object of this invention is to provide an improved variable resistance switch suitable for use in interrupting high inductive circuits.

It is another object of the invention to provide a variable resistance switch that minimizes arcing.

Still a further object of the invention is to provide a sensitive variable resistance device wherein the effort required to produce a change in resistance is very small.

These and other objects of this invention will become apparent from the specification together with the drawings wherein:

Figure 1 is a plan view, partly in section, of the variable resistance device,

Figure 2 is a side sectional view of the device, the view being taken along section lines 2—2 of Figure 1,

Figure 3 is a sectional view of the device taken along section lines 3—3 of Figure 2, and

Figure 4 is a schematic representation of an electric circuit employing the variable resistance device.

Referring to Figures 1, 2, and 3 a variable resistance device 10 is shown. The variable resistance device 10 is contained within an envelope or housing 11 which in the preferred embodiment is fabricated out of soft glass,

but may be made of various other materials well known by those skilled in the art. An electrical insulation material 12 such as one of the ceramics is applied in a thin layer over all of the inside of housing 11 except for the top portion of housing 11 as viewed in Figure 2. A pair of carbon block resistive elements 13 and 14, embedded in the ceramic 12, lie longitudinally along the bottom of the housing 11. The upper surfaces of the carbon blocks 13 and 14 are represented as 15 and 16 respectively and are not coated with the ceramic 12. A portion of each of surfaces 15 and 16 are tapered toward the center of the device 10 as at 17 and 18 so as to form, in the preferred embodiment of the invention, a curved depression along the longitudinal axis of the device. The tapering of the blocks 13 and 14 as at 17 and 18 results in the decreasing of the transverse cross-sectional area of the blocks 13 and 14 in the direction toward the center of device 10. Blocks 13 and 14 are further tapered along a portion of their sides as at 21 and 22, this being best shown on Figure 1. The purpose for reducing the transverse cross-sectional area of the carbon blocks 13 and 14 will become more apparent as the remainder of the device is described.

An electrode member 23 comprising a long elongated metal conducting bar is positioned within housing 11 and spaced away from the pair of carbon blocks 13 and 14 by being secured at its two ends in the ceramic lining 12. A plurality of metal damping fins or blades 24 are integral with or suitably attached to the electrode 23 and are disposed longitudinally along the electrode. The fins 24 are shown to be rectangular having their longest dimension transverse to the longitudinal axis of the electrode 23. A movable body of conducting fluid 25 herein shown as mercury is contained within the housing 11 and is in engagement with some of the fins 24 attached to the electrode 23 and to portions of the carbon blocks 13 and 14. The body of conducting fluid 25 is disposed so that it may move relative to the carbon blocks 13 and 14 from one end to the other of the device should the device be tilted or should the device be accelerated or decelerated. As the body of conducting fluid 25 is moved with respect to the carbon blocks 13 and 14, various portions, that is, exposed areas of the blocks are engaged or disengaged by the fluid. The body of conducting fluid is at all times in electrical contact with some of the fins 24 and thus is at all times in contact with the electrode member 23. A pair of in leads 31 and 32 are embedded in carbon blocks 13 and 14 respectively and project through the ceramic lining 12 and the glass housing 11 to the outside of the device and provide a means of connecting the carbon blocks to an external circuit. Another in lead 33 is electrically secured to the electrode member 23 and projects out through the glass housing 11, thus providing a means for connecting the electrode 23 to an external electrical circuit.

After all of the above mentioned elements have been assembled within the housing 11, the housing may be evacuated of air and sealed off as at 34, thus producing a hermetic seal which prevents the device from being contaminated. If desired, a gas such as hydrogen may be admitted to the housing 11, it taking the place of the evacuated air and serving the purpose of an arc suppressor.

The tapered portions 17 and 18 of the upper surfaces 15 and 16 of carbon block resistors 13 and 14 respectively are preferably curved or spherical thus forming a concave depression or basin for retaining the current conducting fluid 25. It will be appreciated that the concave depression or basin in the surface of the blocks provides stability in the operation of the device in that the current conducting fluid 25 will be definitely positioned for each position of the housing. However, it is well known by those skilled in the art that a fluid switch hav-

ing a flat surface is more sensitive to tilting than one having a rounded surface. It is further known that a fluid switch having a flat surface upon which the fluid rests is unstable in the sense that the fluid is not definitely positioned for each position of the switch envelope. The instant invention employs the concave depression or basin, above described, in order to enjoy the stability which is inherent with this type of design. Further, the instant invention has a higher degree of sensitivity in the novel selection of components, i. e., carbon resistive elements and a current conductive fluid such as mercury. It has been found that the action of the mercury on the carbon elements is analogous to the use of a "slick fill" in conventional mercury switches in that the mercury has no tendency to stick to the carbon elements and thus responds readily to any force which would tend to cause relative motion between the mercury and the carbon elements.

It will be appreciated that there is electrical continuity of varying resistance between in lead 33 and in leads 31 and 32 respectively. That is, one circuit is established from in lead 33 through electrode 23, fins 24, the conducting fluid 25, the carbon block 13, to in lead 31. A second circuit is established from in lead 33 through electrode 23, fins 24, the conducting fluid 25, the carbon block 14, to in lead 32. The amount of resistance between in leads 33 and 31 and 32 respectively depends upon the area of contact between the body of current conducting fluid 25 and the uppermost surfaces of the carbon blocks 13 and 14. In other words, if the housing 11 were tilted so that the body of fluid would move to the right as viewed in Figure 2 covering quite a large area of the carbon blocks 13, the resistance between in leads 33 and 31 would become relatively small. It will be appreciated that as the area of contact between the body of conducting fluid 25 and carbon block 13 increases, the area of contact between the fluid and carbon block 14 is proportionately decreased. Therefore it follows that as the resistance between terminals 33 and 31 decreases, the resistance between in leads 33 and 32 increases. The reverse condition of resistance change would occur when the housing 11 was tilted so that the body of fluid would move to the left as viewed in Figure 2 covering more of carbon block 14 and less of carbon block 13. In general, the amount of resistance between in lead 33 and the in leads 31 and 32 will be proportional to the area of contact between the body of current conducting fluid and the carbon block resistors 13 and 14. The resistance characteristics of the device 10 can be altered by suitable shaping of the carbon block elements 13 and 14 as at the tapered surfaces 17, 18, 21, and 22.

The resistivity of the fluid 25 is very low as compared to the resistivity of the carbon block elements 13 and 14, and therefore, it will be appreciated that substantially all of the resistance between the in leads 31 and 32 and the in lead 33 is the resistance in the carbon block elements.

Figure 4 is a schematic representation of an electric circuit wherein the subject variable resistance switch is used to control a torque motor 40 having a squirrel cage or eddy current armature (not shown), a pair of field windings 41 and 42, and a phasing condenser 43. The field windings 41 and 42 of the torque motor 40 are connected at 44 while the other ends of the windings are connected by the condenser 43 at junction points 45 and 46. Also connected to junction points 45 and 46 are variable resistances 14' and 13' respectively, each having a wiper 25' which are connected to a common point 33', which is also at ground potential. Rheostats 13' and 14' are analogous to the carbon blocks 13 and 14 as are wipers 25' analogous to the body of electric current conducting fluid 25. Point 33' is analogous to the in lead 33 of the varaible resistance device 10. When the device 10 is in a horizontal position and assuming that the carbon blocks 13 and 14 are symmetrical with one another, the amount of resistance between the in

leads 33 and 31 will be equal to the amount of resistance between the in leads 33 and 32. That condition is represented on Figure 4 when the two wipers 25' are equidistant from the junction points 45 and 46. Under these conditions and when motor 40 is energized by an alternating current 50, there would be no torque produced due to the fact that the currents flowing through the windings 41 and 42 were equal in magnitude and in phase relationship. Should the switch be tilted so that the body of fluid 25 would move to the right, as viewed in Figure 2, covering more of the surface of carbon block 13 and covering less of the surface of carbon block 14, the result would be that the wiper 25' of rheostat 13' would be repositioned closer to junction point 46 while the wiper 25' of the rheostat 14' would be repositioned further away from junction point 45 thus causing the currents flowing through the windings 41 and 42 to be different both in phase relationship and in magnitude, creates a rotating flux which in turn produces a torque of a certain direction and magnitude in the motor 40. If the device 10 were tilted in the opposite direction, the fluid 25 would move to the left and the motor 40 would have a torque developed therein opposite to the first torque.

The variable resistance device 10 is sensitive to any condition that will result in the relative movement between the body of electric current conducting fluid 25 and the carbon resistive elements 13 and 14. The relative motion between the aforementioned fluid and elements may be caused by tilting of the device or rapid acceleration or deceleration of the entire housing along the longitudinal axis thereof. The fins 24 associated with electrode 23 have in addition to their purpose of completing contact between the fluid and the electrode, the further purpose of damping the movement of the fluid 25 inside the housing 11. The damping of the fluid would be advantageous in many instances where the switch was suddenly tilted or accelerated or decelerated and overshooting of the mercury was not desired. Another means of damping the motion of the body of fluid 25 (although not shown) would be to use a fluid such as oil around the body of current conducting fluid 25. The body of current conducting fluid 25, being heavier than the oil, would remain below the oil and have its movement retarded thereby.

The variable resistance device 10 may be adapted for many applications including sensing devices and switches, one application being where it is used to interrupt high inductive circuits. One advantage here is having the current gradually decrease before the break in the circuit.

The variable resistance device 10 may also be made in multiple for one or more axes of tilting and serving one or more devices such as torque motors.

The variable resistance device is ideally applicable for use as a modulated motor operator, as opposed to an "on-off" operator, in applications where it is desired to modulate the energization to the motor in accordance to the degree of deviation of a sensing device away from a normal or neutral position.

While I have shown and described a specific embodiment of this invention, further modifications and improvements will occur to those skilled in the art. I desire it to be understood, therefore, that this invention is not limited to the particular form shown and I intend in the appended claims to cover all modifications which do not depart from the spirit and scope of this invention.

I claim as my invention:

1. A device of the class described comprising in combination, a tubular sealed envelope, insulation means lining a portion of the inside of said envelope, a pair of resistive carbon members positioned axially along the bottom of said envelope, said members being secured to said insulation means and having portions of their surfaces exposed, a conducting electrode positioned in said envelope substantially parallel to and spaced from said plates, elec-

trical connections for said plates and said electrode, a body of current conducting fluid in said envelope adapted to make contact between said electrode and various areas of said exposed surfaces of said members, said areas of contact between said fluid and said exposed surfaces varying in accordance to relative motion between said elements last named, and means damping said relative motion.

2. A device of the class described comprising in combination, a gas filled tubular sealed envelope, at least two plates of resistive material positioned in said envelope, electrode means positioned in said envelope, said electrode means being spaced from and adjacent to said plates, electrical connections for said plates and said electrode means, a body of conducting fluid in said envelope adapted to make contact between said electrode means and various portions of said plates, said portions being determined by relative motion between said body and said plates, and means including said electrode means damping said relative motion between said body and said plates.

3. A variable resistance sensing device comprising in combination, a hermetically sealed container, insulation means lining a portion of the inside of said container, first and second carbon blocks separately secured to said insulation means along the bottom of said container, electrode means positioned within said container and spaced from and substantially parallel to said blocks, a body of current conductive fluid adapted to establish electrical continuity between said electrode and portions of said blocks, and connection means separately connecting said electrode and said blocks to circuit means external of said container, the resistance between the connection means for said electrode and the connection means for said blocks being dependent upon the area of contact between said body of fluid and said blocks, said area varying in accordance to relative motion between said body of fluid and said container.

4. A device of the class described comprising, in combination, a relatively straight tubular envelope, a carbon member positioned in and along the bottom of said envelope, a conducting electrode spaced from and substantially parallel to said member, electrical connection means for said carbon member and said electrode, and a body of current conducting fluid in said envelope adapted to make contact between said envelope and said carbon member, the area of contact between said fluid and said member varying in accordance to relative motion between said elements last named.

5. A device of the class described comprising, in combination, a tubular sealed envelope, a carbon member, means including said envelope for positioning said member in and along the bottom of said envelope, an electrode spaced from and substantially parallel to said member, and a body of conducting fluid in said envelope adapted to make contact between said electrode and said carbon member, the area of contact between said fluid and said carbon member varying in accordance to relative motion between said elements last named.

References Cited in the file of this patent

UNITED STATES PATENTS

1,819,849	Stearns	Aug. 18, 1931
2,075,056	Rich	Mar. 30, 1937
2,256,833	McDonald	Sept. 23, 1941