

Oct. 3, 1944.

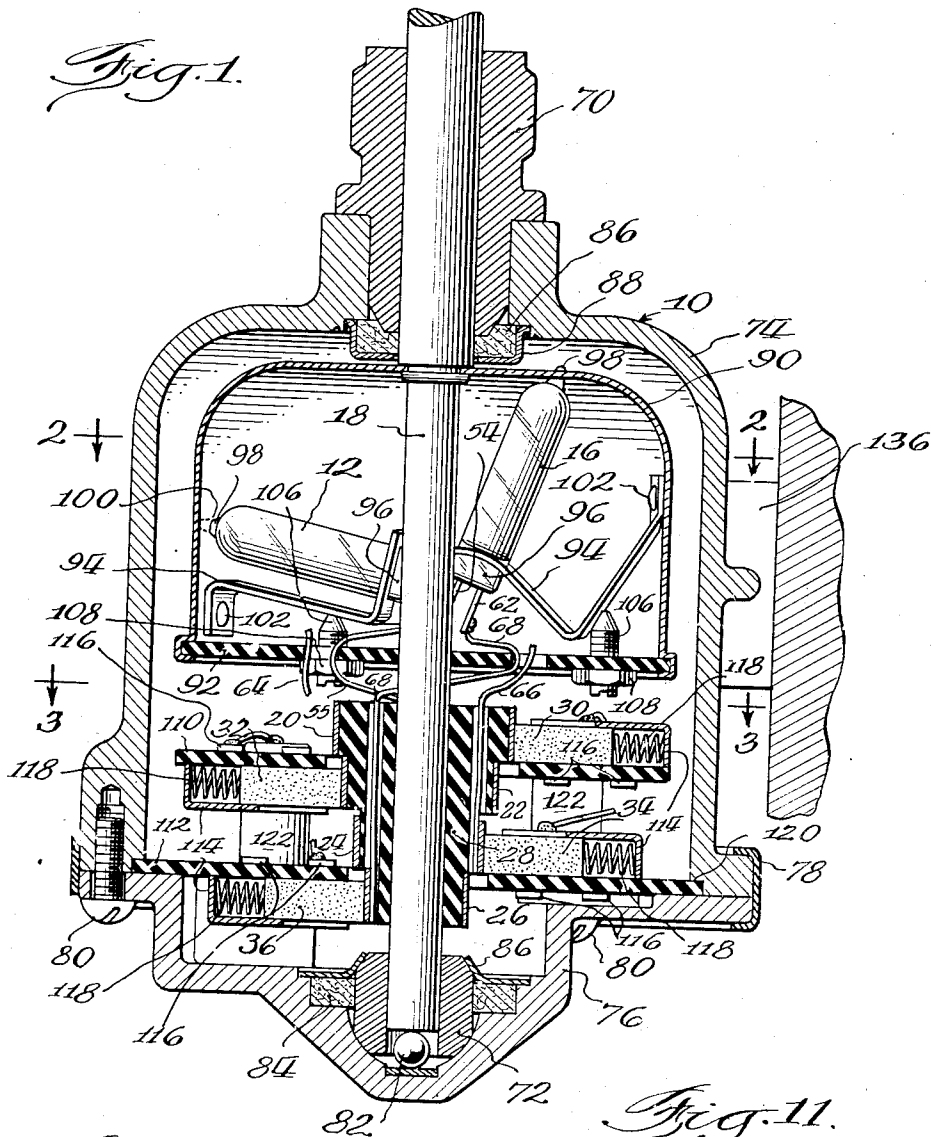
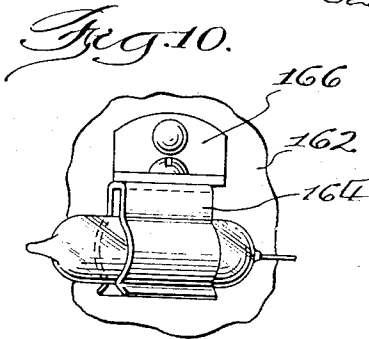
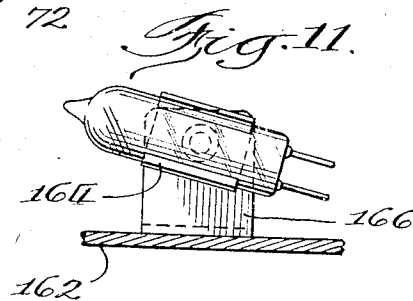
G. E. COXON

2,359,623

ELECTRIC SWITCH

Filed Nov. 22, 1940

3 Sheets-Sheet 1



Inventor:
George E. Coxon
By Williams, Brodberg & Kunkle
Attys

Oct. 3, 1944.

G. E. COXON

2,359,623

ELECTRIC SWITCH

Filed Nov. 22, 1940

3 Sheets-Sheet 2

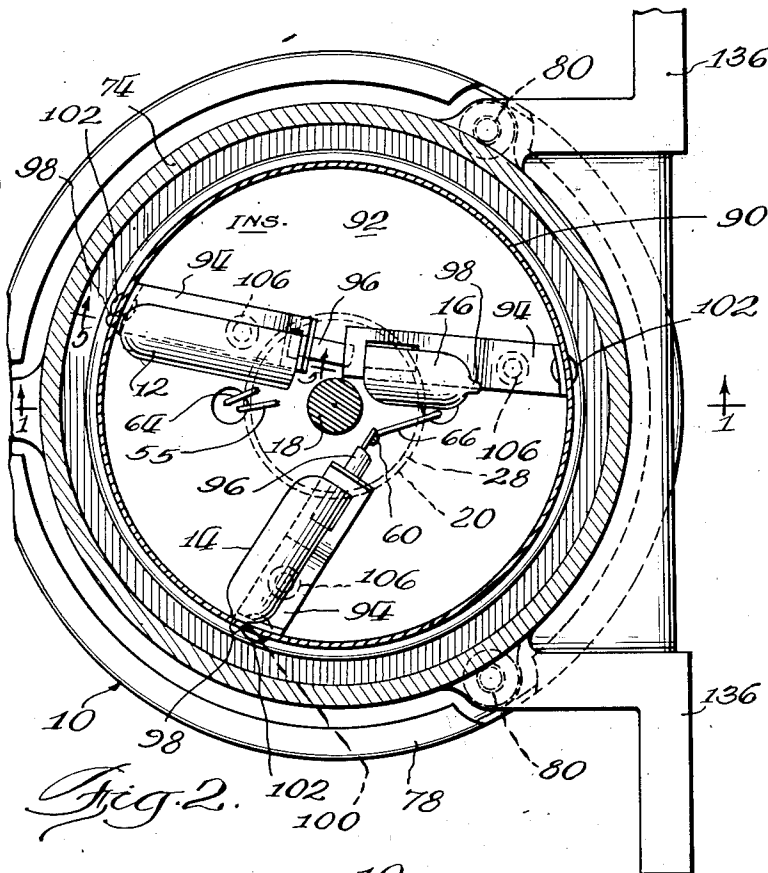


Fig. 2.

Fig. 8.

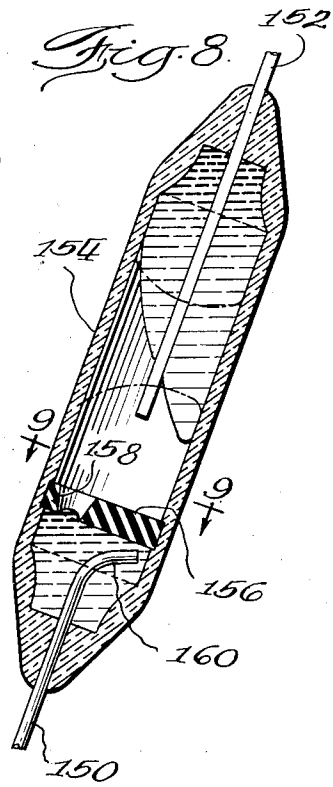
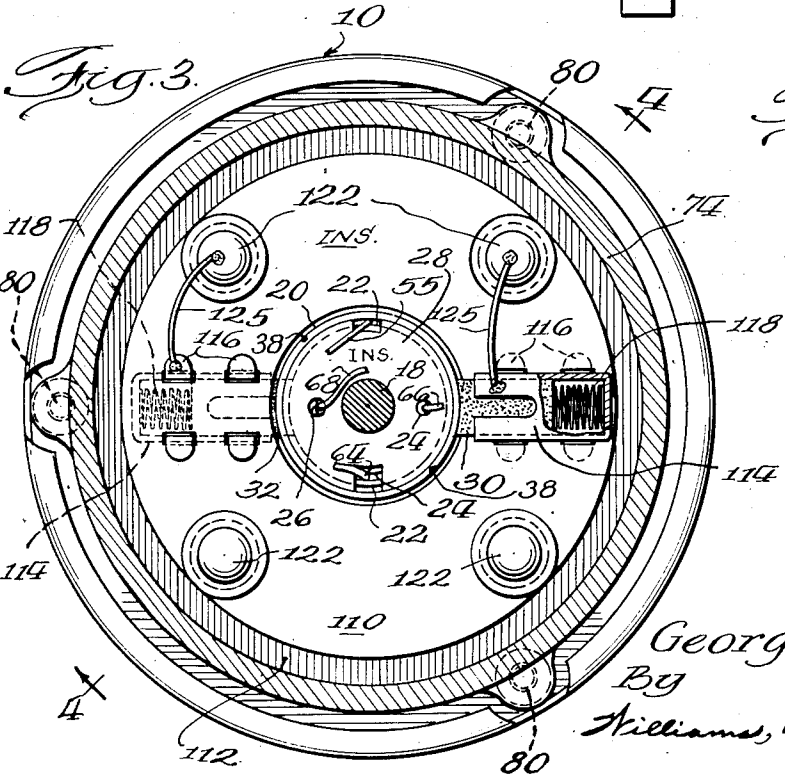
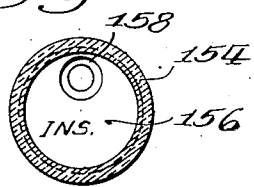


Fig. 3.

Fig. 9.



Inventor
George E. Coxon
By
Williams, Broadbent & Hinkle
Attys.

Oct. 3, 1944.

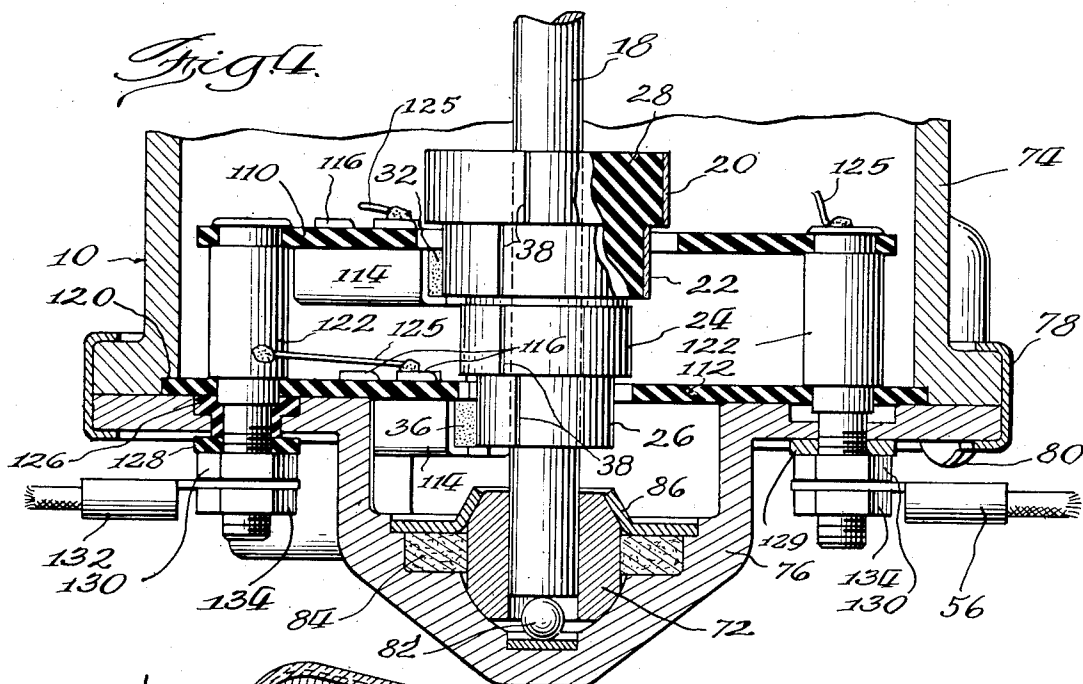
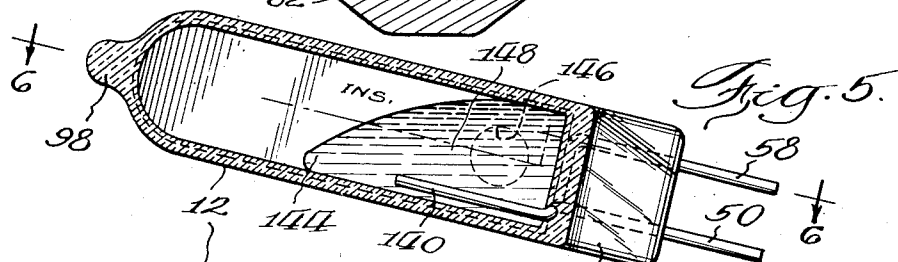
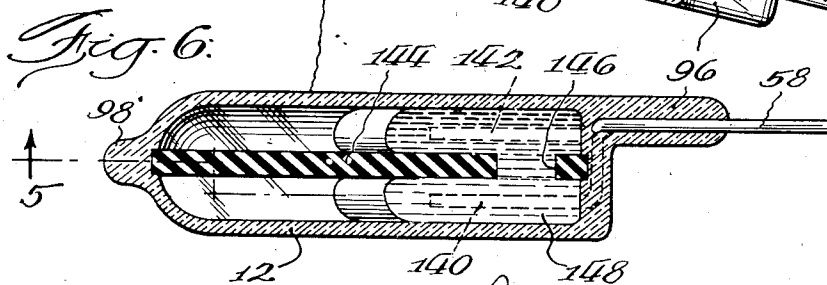
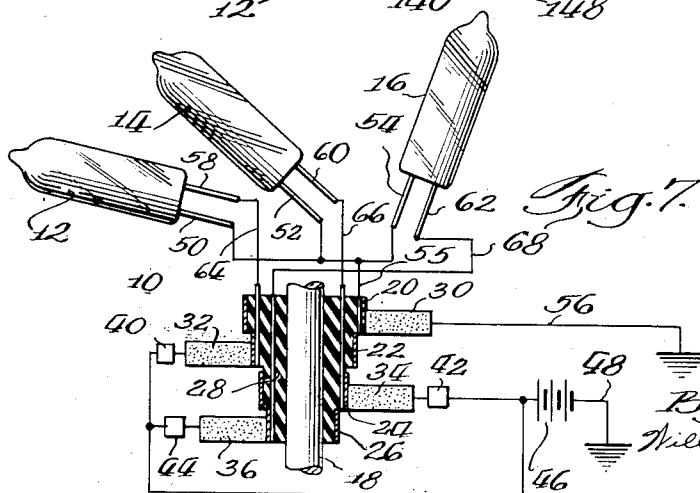
G. E. COXON

2,359,623

ELECTRIC SWITCH

Filed Nov. 22, 1940

3 Sheets-Sheet 3



Inventor

George E. Coxon

By
Williams, Bradbury & Hinkle
Phys.

UNITED STATES PATENT OFFICE

2,359,623

ELECTRIC SWITCH

George E. Coxon, Cicero, Ill., assignor to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

Application November 22, 1940, Serial No. 366,513

6 Claims. (Cl. 200—80)

The present invention relates to electric switches and more particularly to centrifugal mercury switches for use in speed responsive devices.

An object of the present invention is the provision of new and improved centrifugal mercury switches.

A further object of the present invention is the provision of new and improved centrifugal mercury switches operable to make and break electric circuits with snap action which, because of sudden operation and operation to make and break the circuits at substantially different speeds, are particularly adapted for use in speed responsive devices.

A further object of the present invention is the provision of new and improved centrifugal mercury switches for use in speed responsive devices adapted particularly for low speed systems and especially for systems where the speed of rotation is not uniform.

Other objects and advantages of the present invention will become apparent from the ensuing description, in the course of which reference is had to the accompanying drawings, in which:

Fig. 1 is a longitudinal cross-sectional view of a centrifugal mercury switch constructed according to the principles of the present invention. This view is taken along the line 1—1 of Fig. 2;

Fig. 2 is a transverse cross-sectional view of the switch shown in Fig. 1, taken along the line 2—2 of Fig. 1;

Fig. 3 is a view similar to that of Fig. 2, taken along the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary enlarged longitudinal cross-sectional view, taken along the line 4—4 of Fig. 3;

Fig. 5 is an enlarged longitudinal cross-sectional view of one of the mercury switches, the view being taken along the line 5—5 of Fig. 2;

Fig. 6 is a view similar to Fig. 5 taken in a plane located at 90° to the plane of Fig. 5, i. e., along line 6—6 of Fig. 5;

Fig. 7 is a diagrammatic representation of the circuit connections embodied in the centrifugal switch of the present invention;

Fig. 8 is a longitudinal cross-sectional view of a modified form of mercury switch;

Fig. 9 is a transverse cross-sectional view of the switch shown in Fig. 8, taken along the line 9—9 of that figure;

Fig. 10 is a fragmentary top elevation of a modified form of securing means for use with

the mercury switch illustrated in Figs. 8 and 9;

Fig. 11 is a fragmentary side elevation of the structure shown in Fig. 10.

Centrifugal mercury switches constructed in accordance with the present invention are susceptible of various uses but they are particularly applicable to speed responsive devices generally, and have been found to be extremely satisfactory in the control of automatic transmissions embodied in vehicles. A control of this nature has therefore been selected for the purpose of description of the invention and one such control is illustrated diagrammatically in Fig. 7. Reference will be had to this figure before describing in detail the mercury speed responsive switches.

The centrifugal switch of the present invention (referring now to Figs. 1 to 7, inclusive), indicated generally by reference character 10, comprises three mercury switches, 12, 14, and 16, all constructed in a novel manner hereinafter described. In order that the circuits controlled by these switches may be made and broken at different speeds, they are mounted for rotation with a drive shaft 18, and at different angles with respect to the axis of rotation of the shaft. The drive shaft is adapted to be connected by means not shown to some part of a vehicle rotating at a speed equal or proportional to the speed of the vehicle, such for instance, as the driven shaft. A plurality of spaced apart contact rings 20, 22, 24, and 26, are mounted upon an integral contact ring core 28, made of some suitable insulating material and secured to the drive shaft for rotation therewith. The contact rings have associated therewith brushes 30, 32, 34, and 36, respectively, and according to an ancillary feature of this invention each of the rings is provided with a pair of diametrically opposite small transverse grooves 38 for the purpose of keeping the brushes clean.

The nature of the circuits controlled by the switches will depend, of course, upon the purposes for which the speed responsive device is to be utilized, but, as indicated above, the circuit of Fig. 7 is to be utilized in the control of an automatic transmission. The transmission, which has not been illustrated, is assumed to be controlled by three solenoids, 40, 42 and 44, connected to brushes 32, 34 and 36, respectively, and to a suitable source of power which may be the battery 46, the other terminal of which is grounded as indicated by reference character 48. Switch electrodes or terminals 50, 52 and 54, of switches 12, 14 and 16, respectively, are connected to con-

tact ring 20 by conductor 55, which is grounded through brush 30 and a grounding conductor 56. The other electrodes, 58, 60 and 62, of switches 12, 14 and 16 are connected by conductors 64, 66 and 68 to contact rings 22, 24 and 26, respectively. The conductors extend through slots and holes formed in the contact ring core 28. In Fig. 7 the slots and holes are all illustrated as being on the same diametral section for the purpose of convenience; actually the slots and holes are spaced apart 90 degrees from each other in order better to insulate the conductors from one another.

The switches 12, 14 and 16 are partly filled with a conducting liquid, such as mercury, so that whenever the electrodes of a switch are connected by the mercury, the circuit controlled by the switch is closed to energize the solenoid controlled thereby. Inasmuch as the switches are positioned at different angular positions with respect to the drive shaft and with the electrodes at the lower ends thereof, it may be seen that the solenoids are energized when the shaft is stationary or rotating below a predetermined speed and are deenergized in sequence at different speeds as the speed of rotation increases.

In controls of the type under consideration, it is important that the switches operate suddenly and that there be a differential between the speeds at which the circuits controlled by the switches are made and broken. Otherwise, difficulties would be experienced, particularly at low speeds of rotation and especially when the speeds of rotation fluctuate, by reason of the fact that chattering of the solenoids results if the switches make and break the circuits controlled thereby upon slight variations in speed.

These difficulties are overcome by constructing the centrifugal mercury switches in the manner to be described after a brief description of the speed responsive device as a whole, which is illustrated in Figs. 1 to 4, inclusive. Referring now to these figures, it may be seen that the drive shaft 18 is mounted for rotation about a substantially vertical axis in bearings 70 and 72. The bearings in turn are mounted in a cup-shaped case 74, and a cover 76 secured thereto by a bezel 78 and a plurality of screws 80. The lower bearing 72 is an oilless self-aligning bearing and it has associated therewith a ball-bearing 82, which serves also as a thrust bearing as it abuts against the lower end of the drive shaft.

The lower bearing 72 is surrounded by an oil wick 84 held in place by a metal disc 86 which also bears against the upper end of bearing 72 and is held in place in the cover 76 into which it is pressed. The upper bearing 70 abuts against an oil wick 86 held in place by a cup 88 which is secured to the case 74 as by a press fit.

The mercury switches 12, 14 and 16 are mounted for rotation with the drive shaft 18 by means of a switch cup 90 suitably secured in inverted position on shaft 18. A plate 92 of insulating material closes the lower end of the cup, the cup and plate thus constituting a housing for the switches. In order to provide for the ready adjustment of the angular positions of the switches, the switches are mounted upon resilient clips 94 of shapes depending upon the angle at which the switches supported thereby are to be held. The axial ends of the clips are apertured to receive the reduced end portions 96 of the mercury switches, the opposite tips 98 of which are held in place by passing them through apertures 100 in the switch cup 90. The resilient clips are fas-

tened to the interior of the switch cups by suitable means, such as rivets 102.

The angular positions of the switches with respect to the drive shaft are determined by means of adjusting screws 106 threaded into plate 92 and bearing against the clips. The adjusting screws may be locked in adjusted positions by suitable means, such as the lock nuts 108.

The contact ring core 28 is mounted to rotate with the drive shaft as by a drive fit. The various contact rings are of different diameters so that they may be better insulated from one another. The brushes associated with the contact rings are secured to opposite sides of a pair of brush carriers 110 and 112 made of insulating material; the brushes 30 and 32 being secured on opposite sides of carrier 110 and brushes 34 and 36 on the opposite sides of carrier 112. The brushes are secured to the carriers by identical brush holders 114 having lugs 116 extending through suitable apertures in the carriers, as best illustrated in Fig. 3. The brushes are held in engagement with the contact rings by springs 118 located between the outer ends of the brushes 25 and the closed ends of the brush holders.

The lower brush carrier is secured in place between the cover and case, as shown in Figs. 1 and 4, by means of an internal groove 120 formed in the case 74. The upper brush carrier 110 is secured to and spaced from the lower brush carrier by four studs 122 which are connected to the various brushes by conductors 125 (see particularly Figs. 3 and 4) so that they are utilized also as terminals. The conductors 125 and the connections thereof to the studs have been illustrated somewhat diagrammatically, and it is contemplated that other forms of connections of the conductors to the brushes as well as the studs may be utilized. For instance, instead of soldering the conductors to the studs, terminals held in place by the studs may be utilized.

The studs extend through the cover (see Fig. 4) and are insulated therefrom by bushings 126 and washers 128, except for the stud to which conductor 56 is connected, which stud is grounded by metallic washer 129. The studs are secured to the cover by nuts 130 and conductors 132 are secured to the stud terminals by nuts 134. The last mentioned conductors correspond to the conductors shown in Fig. 7 leading from brushes 32, 34 and 36 to the solenoids 40, 42 and 44.

The speed responsive device as a whole is adapted to be supported upon suitable supporting structure by means of a supporting bracket 136 integrally formed with the case 74.

One form of the centrifugal mercury switch of the present invention is best illustrated in Figs. 5 and 6, to which reference is now had. These figures illustrate the construction of switch 12 but switches 14 and 16 are identical in construction. The switch comprises a generally cylindrical closed glass bulb or capsule formed with the reduced end portion 96 and tip 98, to which reference has previously been made. The reduced end portion 96 through which the electrodes 50 and 58 extend is preferably formed as a pinch seal.

In order to provide the desired sudden operation and differential between the make and break, as well as a mercury-to-mercury make and break, the electrodes 50 and 58 are provided with parallel spaced apart portions 140 and 142 extending a substantial distance within the capsule and separated by a substantially vertical partition 144 made of insulating material and provided

with a circular opening 146 near one end and above the electrode portions 140 and 142, as best illustrated in Fig. 5. The contact between the electrodes is made and broken by mercury 148, the point of make and break being in the opening since it is located above the electrodes 146.

The sudden operation is produced as a result of the surface tension of the mercury and it, as well as the differential between make and break, is controlled primarily by the thickness of the partition and the size of the opening. The location of the electrodes with respect to the opening, the distance the electrodes extend beyond the opening and the amount of mercury used also affect the operation of the switch to some extent. In general it may be stated that the greater the thickness of the partition, the greater the differential between make and break, and the larger the diameter of the opening, the less the differential. Excellent results have been obtained with a switch having the general dimensions and the various parts located as indicated when the glass enclosure is about three-eighths full of mercury. The amount of mercury, length of electrodes, and the size and location of the opening should be so correlated that a mercury-to-mercury break and make is obtained.

A modified form of centrifugal mercury switch constructed in accordance with the principles of the present invention is illustrated in Figs. 8 and 9. According to this modification, the electrodes 150 and 152 are located at the opposite ends of the glass capsule 154 and are separated by a transverse partition or disc 156 made of insulating material and provided with a tapered opening 158 located near the internal periphery of the capsule 154. It is preferable, but not necessary, that the opening be located above the electrode. In order to insure a mercury-to-mercury make and break of the switch, the end 160 of electrode 150 is bent away from the smaller diameter end of opening 158. According to this construction all or most of the mercury in the smaller of the two compartments defined by the partition remains therein when the circuit is broken, as indicated in Fig. 8. Likewise, mercury may readily flow into the smaller compartment through the tapered opening.

The switch of Figs. 8 and 9 is also filled about three-eighths full of mercury and just as in the case of the prior switch the differential between make and break is greater with partitions of greater thickness and decreases as the diameter of the opening is made larger.

Switches constructed in accordance with Figs. 8 and 9 may be readily secured to a plate 162 by means of resilient clips 164 adjustably secured to brackets 166, riveted or otherwise secured to the plate as shown in Figs. 10 and 11.

In operation, the drive shaft 18 is driven in any suitable manner at a speed equal to or proportional to the apparatus with which the speed responsive device is to be utilized. In the case of an automatic transmission for an automobile, the shaft 18 is rotated at a speed equal or proportional to the speed of rotation of the drive shaft. When the automobile is stationary, shaft 18 is stationary and as a result, no centrifugal force is present to cause the mercury to move from the axial ends of the switches to the outer ends. Consequently, the circuits controlled by the switches 12, 14 and 16 are closed and the solenoids controlled thereby are energized.

Assuming that the automobile is started and moves forward at an increasing speed, then an

increasing centrifugal force is effective upon the mercury in the switches. When the speed of rotation of shaft 18 reaches a first predetermined value, the mercury in switch 12 is first moved to open the circuit between electrodes 50 and 58, because less force is required to move the mercury from the axial to the outer end of the switch enclosure as the switch is positioned more nearly horizontal than the others. As the speed increases, the mercury in switch 14 is similarly moved from the axial to the outer end and finally as the speed reaches a still higher value, the mercury in switch 16 is effective to break the circuit between the electrodes of that switch. As a result, it may be seen that the solenoids controlled by the various switches are deenergized in sequence to effect the desired operation of the automatic transmission.

The sudden operation is produced, as hereinbefore stated, as a result of the surface tension of the mercury, and fluctuations in the speed of the automobile and of the drive shaft 18 at the critical speeds (that is, at the speeds where the switches make and break the circuits) are prevented from producing an intermittent energization of the solenoids by reason of the differential between the make and break. In the switches of the present invention the circuits are broken at a higher speed of rotation than that at which they are made, primarily as a result of the surface tension of the mercury, and for use in the control of automatic transmissions, the differential, measured in the speed of the vehicle, may be three miles per hour. For instance, one of the switches (the switch most nearly horizontal) may break the circuit at a vehicle speed of five miles per hour and make the circuit at two miles per hour, at which times the switch is rotated at the relatively low speeds of about 65 and 162.5 R. P. M.

The speeds at which the switches are effective to make and break the circuits may be simply and rapidly adjusted by means of the adjusting screws 106, which are rotatable to vary the angular positions of the switches with respect to the axis of rotation of the drive shaft 18.

It should be understood from the foregoing that the present invention is applicable not only to the control of automatic transmissions, but also to control devices in general. While two embodiments of the centrifugal mercury switches of the present invention have been described, it is contemplated that other modifications thereof may be made by those skilled in the art. Furthermore, conducting liquids other than mercury may be utilized. Consequently, the embodiments herein specifically illustrated and described are deemed merely to be illustrative.

I claim:

1. A centrifugal mercury switch rotatable about a substantially vertical axis, including in combination, a closed capsule mounted generally radially and at an angle with respect to said vertical axis such that the axial end is lower than the outer end, a pair of spaced apart electrodes extending axially of the capsule a substantial distance within the capsule, said electrodes being located in a common plane, and an apertured partition of insulating material located within said capsule and between said electrodes, said aperture being located between and above both said electrodes, and the thickness of said partition and the diameter of said aperture being proportioned to provide a sudden mercury-to-mercury break and make and a substantial differential be-

tween the speeds at which the make and break occur.

2. A centrifugal mercury switch rotatable about a substantially vertical axis, including in combination, a generally cylindrical closed capsule mounted at an angle to the axis of rotation, with the end nearest the axis of rotation lower than the opposite end, a pair of opposed electrodes disposed substantially axially of and extending within the capsule, the electrode nearest the axis being substantially shorter and spaced from the end of the opposite electrode, and an apertured partition of insulating material separating the ends of said electrodes, said partition being located substantially at right angles to the axis of the capsule and said aperture being tapered and located with the smaller diameter end facing the shorter electrode.

3. A mercury switch according to claim 2, wherein the aperture is located near the internal periphery of the capsule and the end of the shorter electrode is bent away from the opening, and the smaller diameter of the aperture is so dimensioned that the smaller of the two compartments defined by the partition is substantially filled with mercury when the circuit through the switch is broken.

4. A mercury switch according to claim 2, wherein the aperture is located near the internal periphery of the capsule and the end of the shorter electrode is bent away from the opening, the smaller diameter of the aperture is so dimensioned that the smaller of the two compartments defined by the partition is substantially filled with mercury when the circuit through the switch is broken, and the thickness of the partition and size of the aperture are proportioned to provide

a snap action mercury-to-mercury break and make and a differential between the speeds of rotation of said device at which make and break occur.

5. In apparatus of the class described, the combination including, a housing, a shaft mounted therein for rotation about a substantially vertical axis, a second housing mounted within and located co-axially with respect to said first housing and rotatable by said shaft, said last mentioned housing comprising an inverted cup-like member and a closure plate of insulating material, a mercury switch adjustably mounted within said last mentioned housing, means mounted on said plate and accessible from the outside thereof for adjusting the angular position of the switch relative to the axis of rotation of said shaft, and means associated with said shaft and first mentioned housing for completing a circuit to said switch.

6. A centrifugal mercury switch rotatable about a substantially vertical axis, including in combination, a closed capsule mounted generally radially and at an angle relative to the axis of rotation, a pair of opposed electrodes extending generally radially within said capsule from opposite ends thereof and having their inner ends spaced apart, and an apertured partition located between the electrodes, said electrodes and partition being so disposed and dimensioned that a circuit controlled by the switch is suddenly made and broken at substantially different speeds of rotation by mercury as the latter moves axially within said capsule in response to varying speeds of rotation.

GEORGE E. COXON.