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C. M. GOLD ETAL

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PRESSURE SWITCH AND APPARATUS INCORPORATING SAME

Filed June 4, 1963

2 Sheets-Sheet 1

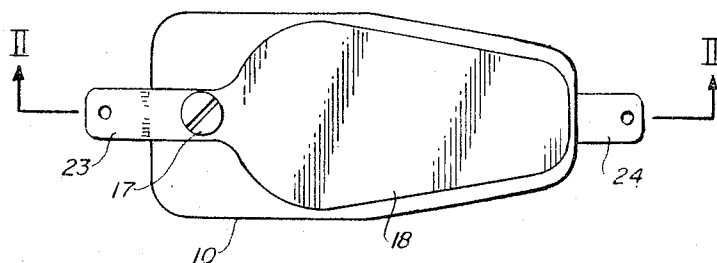


Fig. 1

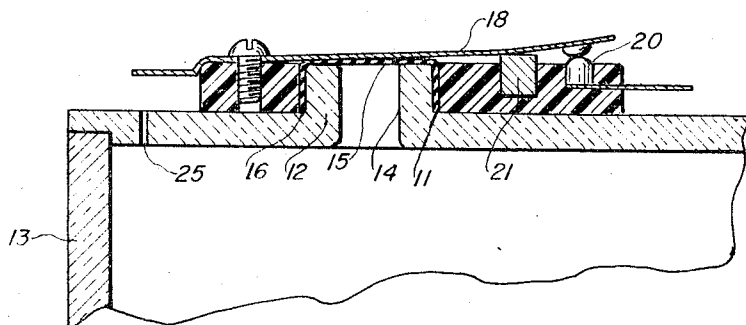


Fig. 2

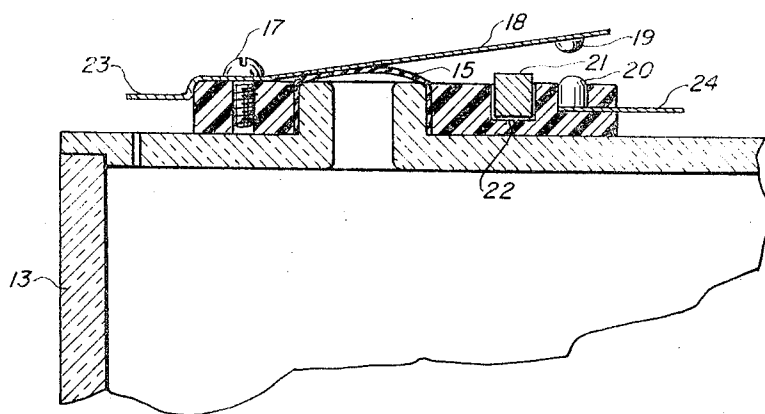


Fig. 3

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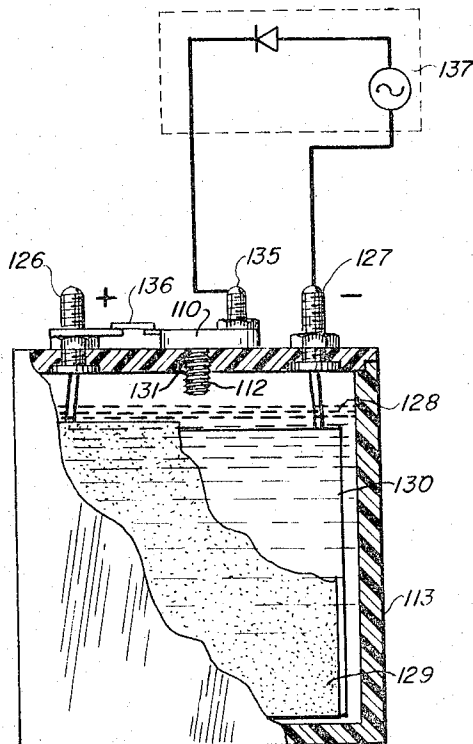


Fig. 4

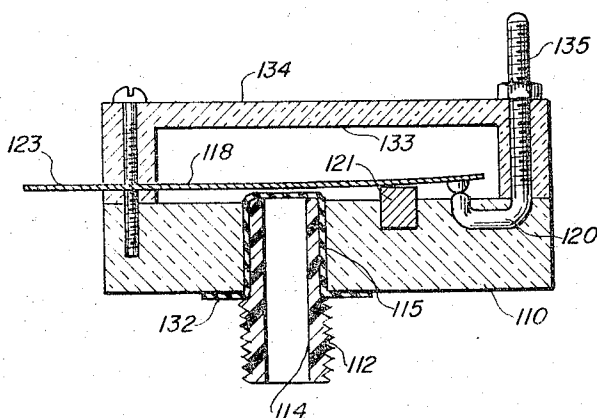


Fig. 5

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PRESSURE SWITCH AND APPARATUS INCORPORATING SAME

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Our present invention relates to improvements in switch devices and, more particularly, to pressure-responsive switches and apparatus incorporating same.

While switching devices of many kinds are known in the art and significant numbers of them have been employed as pressure-responsive circuit-control elements, certain disadvantages of these earlier switch structures have prevented their wide-spread use in situations where light pressures are encountered and in which relatively high currents may be experienced. It has been found, for example, that most slide-contacts switches were not suitable for pressure-sensing applications since a relatively slow build-up of pressure results in gradual disengagement of the contact with consequent arcing and deterioration of the contact surfaces; thus, pitting and oxidation result. It is, nevertheless, desirable that the switch contacts slide relatively in such manner as to be able to wipe away all contaminants before actually opening the circuit. Most of the efforts in switch construction were compromises between the desirability of such sliding contact and the undesirability of slow opening.

It is an object of the present invention to provide an improved switch assembly particularly suited to pressure-responsive operation wherein the aforementioned disadvantages are avoided.

A further object of our invention is to provide a pressure-sensitive switch responsive to gradual pressure built up but capable of open-circuiting substantially instantaneously without the need for complex mechanical latches, levers, springs and the like.

Yet another object of the instant invention is to provide a switch assembly for incorporation in the charging circuit of galvanic cells wherein gas evolution occurs upon excessive charging.

These objects and others which will become apparent hereinafter are attained, in accordance with the present invention, by the provision of a switch having a leaf-type resilient contact member and magnetic means cooperating therewith. While we are aware that much of the prior art has disclosed the use of permanent magnets in snap-acting switches heretofore, it must be understood that, in general, the magnets employed in these switches were designed essentially to secure a contact member temporarily in one or another position of stability. Thus it is known to provide a contact blade with a magnetically permeable mass intermediate a hinge location and its contact end and to place near this mass one or more permanent magnets in spaced relationship to form a toggle switch. One or another actuating means, mechanically linked with the blade, is then provided to displace the blade from a position in which its magnetic mass is attracted by one of the magnets into a position in which the mass is drawn against the other and vice versa. In contradistinction, the switch which is the subject of the present invention makes use of

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an entirely different principle, namely, the discovery that a magnetic element can be employed in combination with a resilient leaf contact to insure that this contact will slide along the counter contact prior to instantaneous actuation. Thus a significant aspect of the present invention resides in providing a permanent magnet close to the contact end of the resilient leaf so that the distance between the region at which this contact end engages the countercontact and the magnetic body is equal to a small fraction of the distance from the fulcrum of the leaf to the contact end, the magnetic element being disposed between the fulcrum and this end.

Advantageously the actuating member bears upon the leaf contact at a location intermediate the fulcrum and the magnetic element and, preferably, midway between these points. We have discovered that this structural arrangement of fulcrum magnetic body and contact provides the important advantage that deflection of the leaf contact will take place prior to the buildup of sufficient force to draw the leaf contact away from the magnet so that, as a consequence of the deflection the two contacts slide relatively with a wiping action preventing the accumulation of foreign matter therebetween and increase contact resistance resulting from such foreign matter. Similar sliding action, although to a lesser extent, also takes place during closing. When the actuating element exerts sufficient force in the direction opposite to the effective direction of the magnet force to exceed the restoring force of the leaf contact and the similarly directed magnetic force, the leaf contact instantaneously springs away from the countercontact and the adjacent magnet into a position in which it is straightened to its original configuration by virtue of internal restoring force out of engagement with the countercontact. As the actuating element retracts, the leaf contact is again brought into the region of the countercontact whereupon the magnet instantaneously draws the leaf into engagement with this countercontact preventing arc formation on either opening or closing of the switch.

According to a more specific feature of the present invention the leaf contact is engaged by the magnet with a minimum of frictional entrainment to insure significant deflection of the leaf. This is possible, on the one hand, to so dispose the contacts that, even in their closed condition, the magnetically permeable leaf is held out of direct engagement with the magnet but is nevertheless disposed within its magnetic field so that the aforescribed effects are achieved, while on the other hand the magnetically permeable leaf can engage the magnet but is relatively thin and has no large accumulation of the magnetizable mass in the region of the magnet so that the leaf can slide therealong to permit this deflection. This factor is significant since it has been found that the provision of magnetically permeable masses upon the leaf contact results in a substantial limitation of this sliding action and, consequently, materially reduces the wiping action between the contact members.

According to another aspect of the present invention, the actuating element is a pressure-deflectible, flexible membrane which bears directly upon the leaf contact approximately midway between its fulcrum and the magnetic body. This membrane advantageously spans an opening in the switch body via which a pressure fluid is brought to bear upon the leaf contact. According to a feature of this invention, therefore, the switch may com-

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prise an annular insulating block whereupon the leaf contact is fulcrumed in a position overlying the opening of the block while the magnetic body and countercontact are disposed diametrically opposite the fulcrum on the other side of this opening. The flexible membrane can thus be located in a gap between the wall of this opening and the periphery of a tubular member tightly fitted therein and sandwiching the diaphragm between this tube and the insulating body of the switch. This construction has many advantages. Firstly, it permits of ready replacement of the diaphragm since the press-fitted switch body can be pulled from the tube or spigot without difficulty even when high pressures are to be employed, and the diaphragm, if composed of a relatively resilient material such as neoprene, serves to seal the connection between tube and body. The tube or spigot can, according to a further feature of the invention, be integral with the casing of a galvanic cell or a part permanently associated therewith (e.g., a vent or electrolyte-inlet fitting). Alternatively, the tube may be a more or less permanent, albeit removable, part of the switch assembly which can then be threaded or otherwise fitted into an opening in a pressure vessel for actuation by the fluid pressure therein.

According to a further aspect of this invention, a switch of this character is mounted upon or within a galvanic cell or storage battery adapted to generate gases upon excessive charge. It is well-known, for example, that silver/silver oxide anodes and zinc/zinc oxide or cadmium/cadmium oxide cathodes immersed in an alkaline medium with, say, cellophanic separators form galvanic cells which can be charged satisfactorily to the capacity of the electrode material, and that continued application of charging current results in a rise of the cell potential to a level at which gas is evolved upon decomposition of the electrolyte. The evolution of hydrogen is disadvantageous as a consequence of the explosive character of this gas but its evolution and/or that of oxygen is indicative of attainment of maximum effective charge. It is thus contemplated, in accordance with the present invention, to utilize this effect to trip a circuit breaker of the character described above connected in series with the cell and a battery charger. The cell can be either totally sealed against escape of gas with the diaphragm bridging an opening in the cell wall or apertures can be provided in the casing to throttle the escape of the gas and thus permit some pressure buildup sufficient to actuate the switch at a predetermined level of gas evolution. A switch of this type is of particular utility in these storage cells since it is triggerable at low pressures and serves as a highly effective cutoff device at maximum charge.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description reference being made to the accompanying drawing in which:

FIG. 1 is a plan view of a switch assembly according to the invention;

FIG. 2 is a cross-sectional view taken along the line II—II of FIG. 1 showing the assembly mounted upon a battery casing with the leaf contact in its closed condition;

FIG. 3 is a view similar to FIG. 2 showing the switch assembly in its open condition;

FIG. 4 is an elevational view, partly in cross-section illustrating a cell casing provided with a circuit breaker according to the invention; and

FIG. 5 is a cross-sectional view of the switch assembly of this casing.

The switch shown in FIGS. 1-3 of the drawing comprises support means in the form of an insulating body 10 of synthetic resin material which is annular and formed with an opening 11 adapted to receive the tubular means or portion 12 of the cell casing 13; this tubular portion 12 forms a passage for communicating fluid pressure from the pressure-retentive casing 13 to the switch. A resilient diaphragm 15 of a deformable elastomeric material over-

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lies and blocks one end of passage 14 and is sealingly interposed between the cylindrical outer wall 16 of tube 12 and the wall of opening 11. Preferably, the diaphragm or membrane is composed of neoprene rubber and is held in place as a consequence of the force-fit of the insulating block 10 around the tubular portion 12 of the casing 13. Since the diaphragm is stretchable, a disk of neoprene, adapted to form this diaphragm, can be positioned over the tube 12 and the block 10 then forced thereover.

A screw 17 secures one extremity of a flexible and resilient leaf contact 18, preferably composed entirely of magnetically permeable material and free from localized accumulation of material of high magnetic permeability, to the block to form, at a first location along the leaf contact, a fulcrum around which this leaf contact can be bent by the distention of diaphragm 15 aligned therewith. At a second location longitudinally remote from this fulcrum and, advantageously, at its opposite extremity, the leaf contact 18 is formed with a tip 19 of a highly conductive material such as silver, copper or alloys of these metals with a refractory metal such as tungsten. A countercontact 20 is engageable by leaf contact 18 in its normally closed position, a magnetic member 21 being disposed relatively proximal to the countercontact 20 and distal from the fulcrum intermediate these locations. The magnetic member may be a permanent magnet embedded in the body 10 although it is preferred to form the latter with a recess 22 and to provide the magnet of a multiplicity of magnetic particles held in an elastomeric matrix. The magnet is thus inherently somewhat resilient so that it can be forced easily into the recess 22 and is held there under its own expansive pressure. The leaf contact 18 is provided with a terminal tab 23 while a similar tab 24 is provided for the countercontact 20 which likewise can be composed of one of the previously mentioned high-conductive metals alone or in combination with a refractory metal. The leaf contact 18 may be composed of a magnetically attractable stainless steel. It has been found to be advantageous to provide contact tips 19, 20, at least one but preferably both of which are convex in the direction of the other tip and having domed configuration. This facilitates the sliding into engagement of these tips.

When the pressure within the cell casing 13 is approximately equal to ambient atmospheric pressure, membrane 15 stretches tautly over passage 14 and, the leaf contact 18 is in the position indicated in FIG. 2, the leaf contact 18 being held against the magnet 21 with minimum sliding friction. It may be noted that the cell can be provided with valved or unvalved apertures represented schematically by the capillary openings 25 for venting and pressure equalizing purposes. These openings, which restrict the rapid efflux of gas, can be those normally present around the cell terminals (not shown in this figure but seen in FIG. 4) or specially provided venting channels. They may also be formed by constricted apertures in the diaphragm.

When, say, one of the electrodes has reached a charged state, the potential of the cell tends to rise above its gassing potential whereupon a strong gaseous evolution, resulting from decomposition of the electrolyte, takes place. The pressure within the cell builds up rapidly to flex the diaphragm 15 and bends the leaf contact 18 into substantially the dot-dash line position indicated in FIG. 2. When the moment of the force exerted upon the leaf contact 18 by the diaphragm 15 exceeds the moment exerted by the magnet 21, the leaf contact 18 springs upwardly into its position shown in FIG. 3, thereby cutting off the charging current and halting further gas evolution. Prior to the snap-action open-circuiting of the switch, leaf contact 18 slides along the countercontact 20, thereby insuring a good electric connection therebetween as previously noted. The fluid pressure within the seal is then dissipated slowly via openings 25 to permit the restoration of the leaf 18 to its original position (FIG. 2).

The thickness of the leaf member may be on the order of several mils, but it must be noted that, for best results, the distance between the magnet 21 and countercontact 20 should be equal to a small fraction of the distance between the fulcrum of leaf contact 18 and this countercontact, the diaphragm 15 bearing upon the leaf contact substantially midway between the fulcrum and the magnetic means. The switch shown in FIGS. 1-3 may, of course, be provided with a further countercontact, engageable with the leaf contact 18 in its open position (FIG. 3) for operating a signal circuit adapted to provide a visual and/or acoustical indication of the completion of the charging process.

In FIG. 4 there is shown an electric storage cell whose casing 113 is composed of a synthetic resin and is provided with positive and negative terminals 126 and 127 respectively. Casing 113 is filled with an alkaline electrolyte 128 (40% potassium hydroxide) and has a positive electrode 129 containing silver as an electrochemically effective substance. This electrode can be composed of sintered silver powder which is convertible, upon charging of the cell, to silver oxide. The negative electrode 130 can be composed of a material containing, say, zinc or cadmium. In this case, the cell casing 113 is formed with a threaded vent opening 131 into which a snap-action switch (FIG. 5) is threadedly inserted. This switch has an annular insulating support body 110 which is press-fitted onto a threaded tube 112 receivable into the vent opening 131. A resilient diaphragm 115 is interposed between tube 112 and the body 110 and closes a passage 114 communicating with the interior of the cell. Again, this diaphragm provides a hermetic seal between the insulating body 110 and the tube 112. In addition, an annular portion 132 of diaphragm 115 extends radially beyond tube 112 to seal the connection between the switch and the cell casing 113 so that the latter is rendered pressure-retentive although capillary channels can be provided as described above. The switch includes the leaf contact 118 and the countercontact 120 while a magnet 121 is disposed proximal to the countercontact. The leaf contact is, however, received within a chamber 133 formed by a cover portion 134 of insulating material through which a terminal screw 135 connected to the countercontact 120, extends. The terminal tab 123 of the leaf contact can thus be connected directly to the positive terminal 126 of the cell (FIG. 4) by a short piece of fuse wire 136, adapted to melt upon passage of excessive charging current. When it is desired to charge the cell, terminals 135 and 127 are connected to the positive and negative leads of a charging device indicated schematically at 137. As previously noted, switch contacts 118 and 120 will open upon completion of charging, whereupon the charging device 137 can be disconnected and the terminals 126, 127 connected to the load to drain the cell. While the present device makes use of a permanent magnet and such a magnet is preferred, it can be noted that an electromagnet whose coils are wound about an axis perpendicular to the leaf contact 118 can also be used. In this case it will be advisable to have this coil in circuit with the charging-current source or connected across the electrodes for unidirectional energization.

The invention as described and illustrated is believed to admit of many modifications within the ability of persons skilled in the art, all such modifications being considered within the spirit and scope of the appended claims.

We claim:

1. An electric storage cell, comprising at least one pair of electrodes of opposite polarity adapted to generate gas upon passage of an electric current between said electrodes, a fluid-pressure-retentive casing adapted to receive said electrodes, an electrolyte at least partly surrounding said electrodes within said casing, and a snap-action switch actuatable at a slow rate mounted

on said casing and connectable in a charging circuit with said electrodes for open-circuiting said electrodes upon the generation of sufficient gas thereby to elevate the fluid pressure within said casing above a predetermined level, said switch comprising: electrically nonconducting support means mounted upon said casing; an elongated resilient leaf contact secured to said support means at a first location and forming a fulcrum thereat; a countercontact mounted upon said support means and engageable by said leaf contact at a second location therealong longitudinally remote from said fulcrum, said leaf contact being magnetically permeable at least along a portion thereof intermediate said locations; magnet means on said support means intermediate said fulcrum and said countercontact and adapted to magnetically attract said permeable portion of said leaf contact for releasably holding it against said countercontact, the distance between said magnet means and said countercontact being a small fraction of the distance between said fulcrum and said countercontact, and fluid-pressure-responsive actuating means intermediate said fulcrum and said magnetic means acting directly upon said leaf contact in a sense tending to urge it opposite to the force of said magnet means.

2. An electric storage cell as defined in claim 1 wherein said actuating means includes a distensible membrane aligned with said leaf contact whereby said membrane upon distension is adapted to bear thereagainst, and means forming a passage for applying fluid pressure to said membrane to distend it.

3. An electric storage cell as defined in claim 2 wherein said support means comprises an insulating body having an opening aligned with said leaf contact, and tubular means receivable in said opening and forming a passage for applying fluid pressure to said membrane to distend it, said membrane closing said passage at one end of said tubular means and being sealingly interposed between said tubular means and said body within said opening.

4. An electric storage cell as defined in claim 3 wherein said tubular means is integral with said casing.

5. An electric storage cell as defined in claim 3 wherein said tubular means is independent of said casing and received in a bore provided therein.

6. An electric storage cell as defined in claim 3 wherein said electrolyte is an aqueous solution of an alkali-metal hydroxide and one of said electrodes contains silver as an electrochemically active substance.

7. An electric storage cell as defined in claim 3 wherein said leaf contact is composed of stainless steel.

8. An electric storage cell as defined in claim 3 wherein said membrane is composed of an elastomer.

9. In a snap-action switch actuatable at a slow rate, in combination:

electrically nonconductive support means;
an elongated resilient leaf contact secured to said support means at a first location and forming a fulcrum thereat;

a countercontact mounted upon said support means and engageable by said leaf contact at a second location therealong longitudinally remote from said fulcrum, said leaf contact being magnetically permeable at least along a portion thereof intermediate said locations;

magnet means on said support means intermediate said fulcrum and said countercontact and adapted to magnetically attract said permeable portion of said leaf contact for releasably holding it against said countercontact, the distance between said magnet means and said countercontact being a small fraction of the distance between said fulcrum and said countercontact;

and fluid-pressure-responsive actuating means intermediate said fulcrum and said magnetic means acting directly upon said leaf contact in a sense tending to

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urge it opposite to the force of said magnet means; said actuating means including a distensible membrane aligned with said leaf contact whereby said membrane upon distension is adapted to bear thereagainst, and means forming a passage for applying fluid pressure to said membrane to distend it.

10. A snap-action switch as defined in claim 9 wherein said support means comprises an insulating body having an opening aligned with said leaf contact, a tubular means receivable in said opening and forming a passage for applying said fluid pressure to said membrane to distend it, said membrane closing said passage at one end of said tubular means and being sealingly interposed between said tubular means and said body within said opening.

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10 JOHN F. COUCH, *Primary Examiner*.LLOYD Mc COLLUM, *Examiner*.S. WEINBERG, *Assistant Examiner*.