June 17, 1958 L. E. WOOD 2,839,630

PRESSURE-RESPONSIVE SWITCH

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Fig. 2.

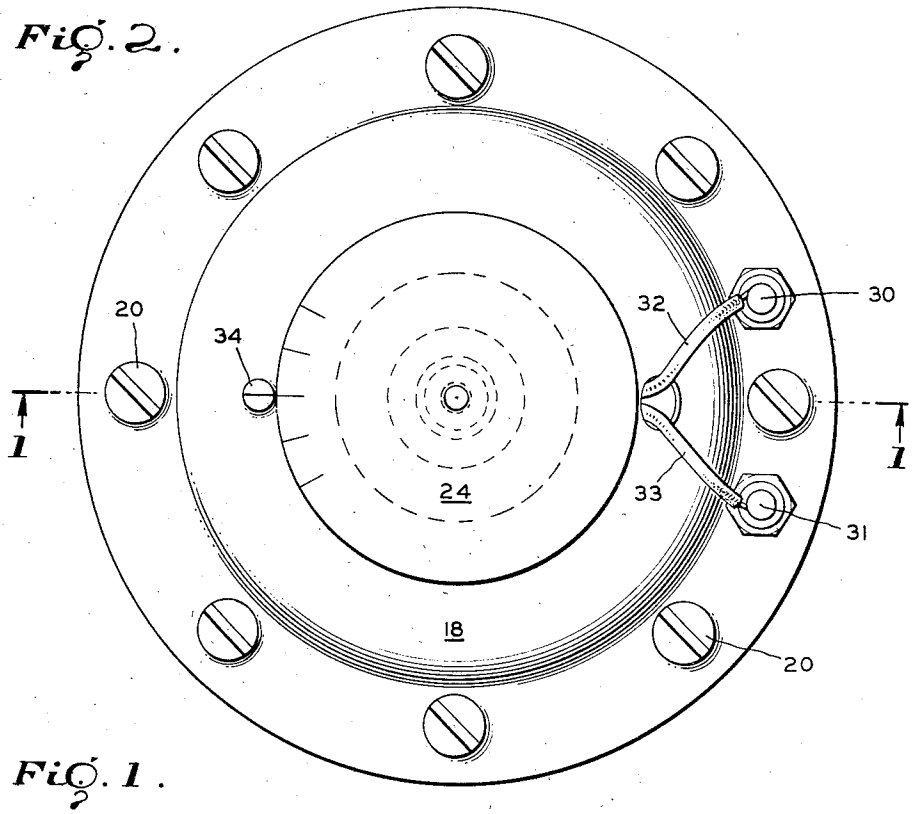
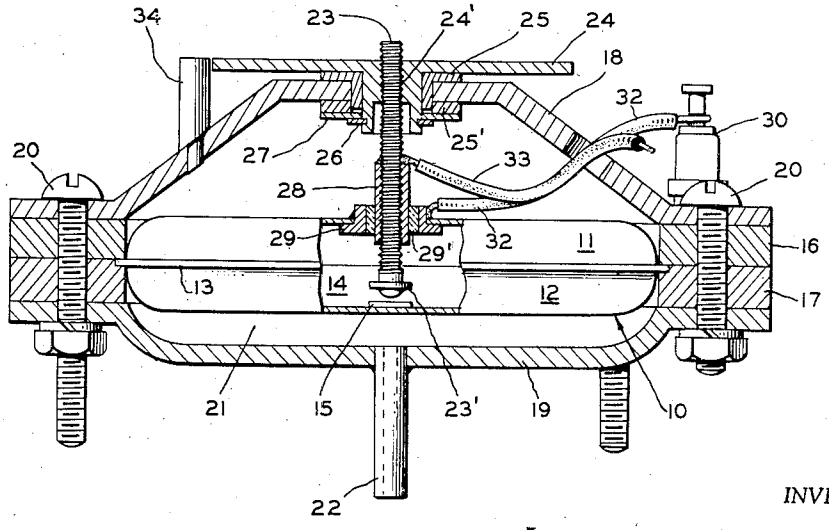


Fig. 1.



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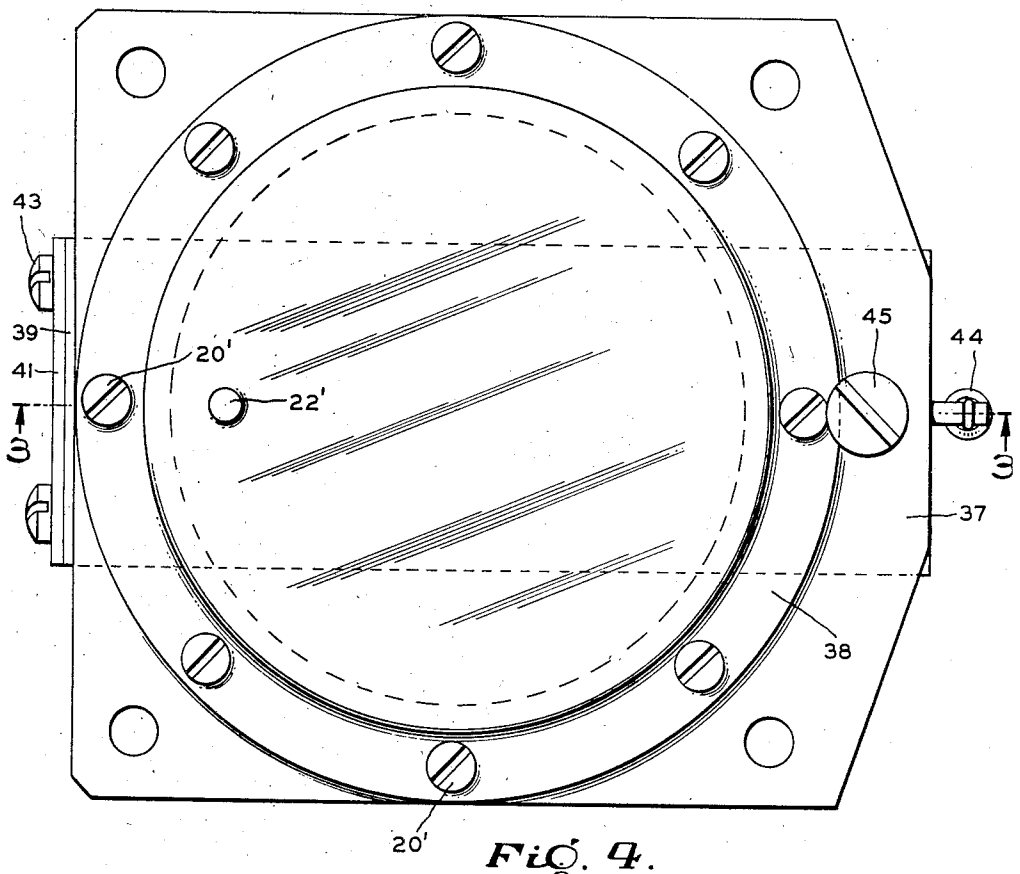
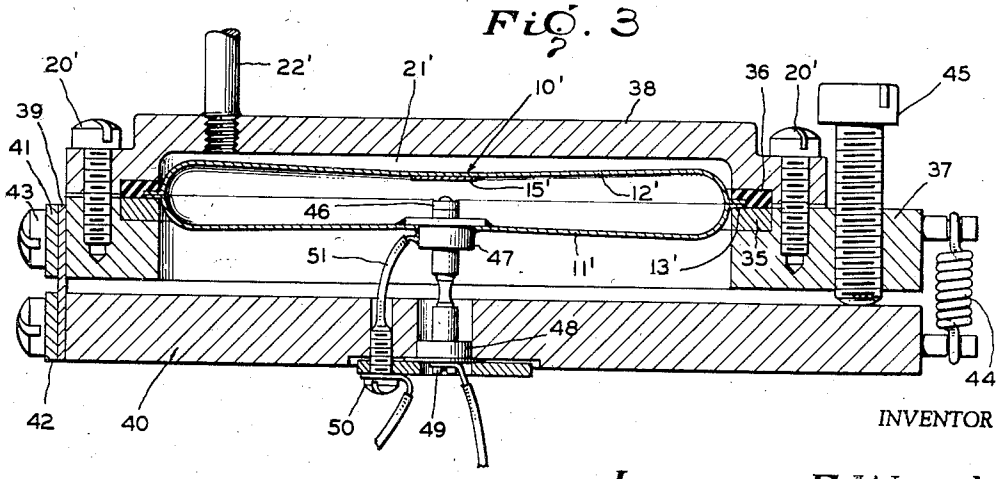


Fig. 4.

Fig. 3



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PRESSURE-RESPONSIVE SWITCH

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FIG. 5

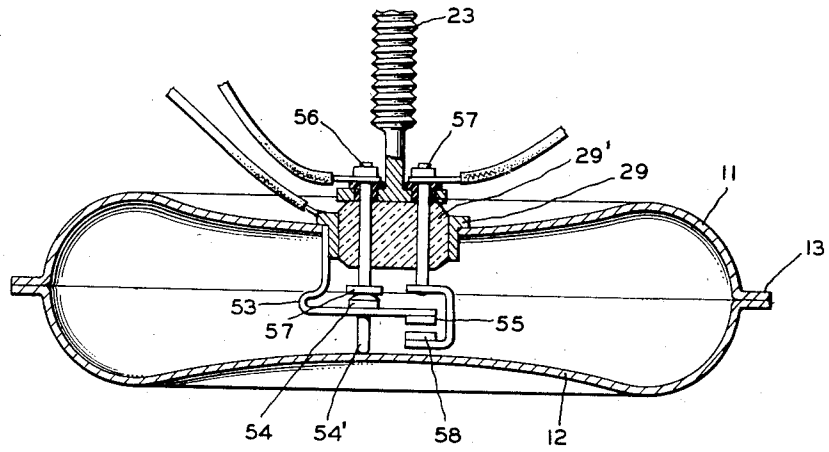
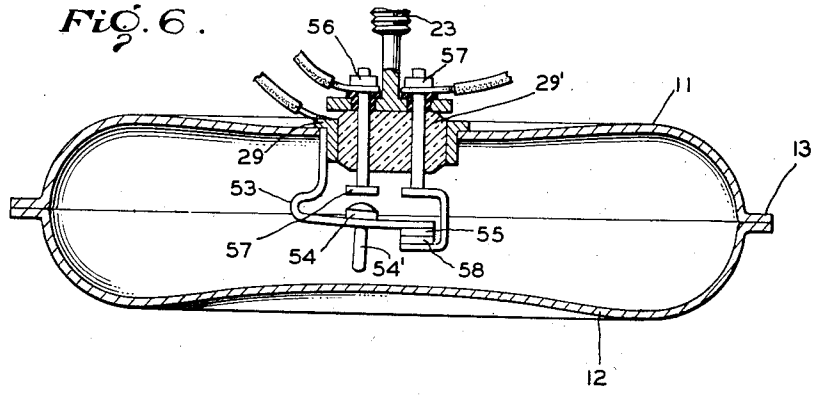


FIG. 6.



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2,839,630

PRESSURE-RESPONSIVE SWITCH

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Application June 20, 1955, Serial No. 516,461

10 Claims. (Cl. 200—83)

This invention relates to switch mechanism of that type having electrical contacts located within a hermetically sealed expansible chamber and arranged to make and/or break an electric circuit in response to changes in ambient pressure.

Pressure switches of the type with which the instant invention is particularly concerned are often required to perform with a high degree of accuracy while at the same time they must withstand severe vibrational and gravity stresses such as are encountered when the switch is carried aloft by a rocket or analogous projectile. The sensitivity and accuracy of the switch hinges on the quality of its pressure-responsive diaphragm, and the ability of the latter to withstand such stresses is lessened when it is required to support relatively heavy elements such as contact members, current-carrying connections and hermetic seals. Also, the thin highly sensitive wall of a diaphragm may be subjected to damaging stresses when it is secured to another wall of different thickness, such as a relatively thick end plate, and this same danger is present when the cell or diaphragm unit as a whole is mounted to relatively heavy supporting structure. The matter of providing adjustable internal contacts also presents a sealing problem, since any moving parts in a seal renders it more difficult to maintain an evacuated aneroid leak-proof.

An object of the present invention therefore is to provide a pressure-responsive switch utilizing an aneroid cell or capsule of the internal contact type which will remain in its preset condition and undamaged should the switch be subjected to severe vibrational and gravity stresses.

Another object is to provide a switch of the type specified having internal contacts which may be easily and accurately adjusted without damaging the aneroid seal and which will retain its preset or adjusted condition both during storage and under severe operational stresses.

Another object is to simplify the construction and assembly operations of pressure switch mechanism embodying internal contacts and pressure-sensitive diaphragms and at the same time reduce the chances of damage to the diaphragm during fabrication and assembly.

The foregoing and other objects and advantages will become apparent in view of the following description taken in conjunction with the drawings, wherein:

Figure 1 is a substantially central diametric cross-section of a pressure switch assembly in accordance with the invention; the view being taken substantially on the line 1—1 of Figure 2;

Figure 2 is a top plan view of Figure 1;

Figures 3 and 4 are views similar to Figures 1 and 2 of a modification in structure;

Figure 5 is a cross-sectional view of the pressure-responsive cell or capsule of the switch of the preceding figures, equipped with a preferred type of single pole, double throw contact arrangement; and

Figure 6 is similar to Figure 5 but showing the contacts in another position.

Referring to the drawings in detail, and first to Figures 1 and 2, an aneroid cell or capsule **10** is made up of a pair of reversely-dished thin metallic shells **11** and **12**. The shell **12**, in this instance being free to flex in response to changes in pressure, may be considered as the pressure-responsive diaphragm for the switch. The shells **11** and **12**, when joined at their meeting edges, provide a mounting flange **13** and define therebetween a chamber **14**, which may be evacuated and charged with a suitable temperature-responsive or compensating gas, or it may be simply evacuated to some predetermined degree, as conditions of use may warrant. An electrical contact element **15** is secured as by welding to the center of the diaphragm **12**; and other than the said contact, which may consist of a very light piece of conductive material, the diaphragm is free of any loading whatsoever. The capsule **10**, after having been fabricated as a separate unit, including a hermetic seal in the center of the shell **11**, is located with its flange **13** engaged between a pair of clamping rings **16** and **17**, and the said rings in turn are clamped between a pair of housing sections or walls **18** and **19**, the assembly thus provided being secured in assembled relation by means of a series of screw bolts **20**. The unit thus assembled defines a closed chamber **21** between the diaphragm **12** and housing section **19**, which may be vented to the atmosphere or a source of reference pressure by means of a small tube or conduit **22**.

The housing section **18** has a flattened central portion formed with an opening to accommodate a contact mounting and calibrating assembly, including an elongated screw **23**, having a contact **23'** on the lower or inner end thereof, the said screw being threaded through the hub portion **24'** of a calibrating dial **24**. The hub and dial are insulated from the housing section **18** by means of a flanged insulating ring or collar **25** and an insulating washer **25'**. At its lower or inner end, the hub **24'** is provided with an annular groove to receive a split retainer ring **26**, a suitable friction or bearing element in the form of a washer **27** being interposed between said ring and the insulating washer **25'**.

The intermediate portion of the screw **23** has fixed thereto an elongated terminal sleeve or bushing **28**; and the shell **11** is formed with a central opening to accommodate an hermetic insulating and bearing seal, consisting of an outer metallic flanged ring **29**, which functions as a terminal and has fixed therein insulating and sealing material **29'** such as silicon glass, the sleeve **28** being fixed in the material **29'** and also being secured around the screw **23** in air-tight relation. Thus when dial **24** is rotated, the screw **23** moves in and out (or vertically as viewed in Fig. 1) but it does not rotate, the wall of the shell **11** flexing to accommodate adjustment travel.

A pair of terminals **30** and **31** are adapted to be interposed in a suitable electric circuit, not shown, and are provided with conductors **32** and **33**, the conductor **32** being connected to the terminal bushing **28** and the conductor **33** to the terminal bushing **29**. Thus when the contact **15** engages the contact **23'**, a circuit is completed across the terminals **30** and **31**.

An index pin **34** is fixed in the upper wall **18** and coacts with suitable indicia on the calibration dial **24**, to facilitate an accurate setting of the switch mechanism.

In view of the foregoing description, the operation of the switch mechanism will be obvious. One example is where the switch is installed in an airborne device or projectile to separate the contacts **15** and **23'** at some predetermined altitude. In such case, the pressure developed in chamber **21** below a predetermined altitude would maintain the contacts closed. As altitude is gained, the

decrease in pressure permits the diaphragm 12 to expand and separate the contacts as shown in Fig. 1. Obviously the arrangement could be designed to accommodate varying types of circuitry and to open and close contacts at varying altitudes. In certain installations, a plurality of switches are hooked up in series or parallel and contact adjustment thereof controlled by suitable automatic mechanism such as synchros, which drive the adjusting dial to reset the switch as a function of certain operating parameters. Diaphragm 12 is the only pressure-sensitive element in the entire assembly, and the only part which this diaphragm carries is the contact 15, which is so small as to be negligible as far as it affects the response characteristics of the diaphragm. The only hermetic seal required is that provided in the upper shell 11, and the contact adjusting screw 23 is supported by the upper housing section 18 and does not rotate in the seal. Both shells 11 and 12 of the capsule 10 may be made of the same material and have the same thickness. This facilitates fabrication of the diaphragm assembly as a whole, since it does not require the connection of thin diaphragm walls to relatively thick metal plates, or the attachment of hermetic seals and current-carrying connections to the sensitive pressure-responsive diaphragm proper. Hence, the shell 12 may be made of one piece of metal with no perceptible loading or perforations to accommodate attachments. As a result, the capsule is reduced to the ultimate in simplicity and lightness in weight, which contributes to accurate operation under severe vibrational conditions, and it is more readily adaptable for manufacture to either linear or non-linear response specifications. In installations where one or more switches are provided with automatically-driven adjustments to open and/or close an electric circuit at predetermined altitudes, the design lends itself more readily to operation by non-linear drive mechanism. Furthermore, the design is such as to permit effective operation with an extremely small volume on the pressure-sensing side of the diaphragm 12, or in the chamber 21. Since hermetic or insulating seals are not required for the pressure-responsive element. there is practically no limitation on the size and type of seal that may be used.

Figures 3 and 4 show a modification in structure directed primarily to the housing arrangement for the pressure-responsive diaphragm, the latter being essentially similar to that shown in Figure 1. In Figure 3, parts which correspond to those shown in Figure 1 have been given similar reference numerals except that a prime (') has been added. The aneroid cell or capsule 10' has its peripheral flange 13' clamped between an insulating ring 35 and a gasket 36, carried by a frame member 37 and cover plate 38, secured to one another by screw bolts 20'. The assembly thus provided is connected at one side by means of a hinge member, in the form of a flexible plate 39, to a base member 40, the plate 39 having its opposite edges gripped between elongated washers 41 and 42 and the frame members 37 and 38 and secured by screws 43. At the side opposite the hinge plate, the frame members 37 and 40 are drawn together under tension by a loading spring 44, and an adjusting screw 45 projects through the member 37 into abutting engagement with the base 40.

The center of the shell 11' has connected thereto a contact 46 which projects through a hermetic seal and insulator similar to the seal at 29' in Fig. 1, the said seal being fixed in a terminal member 47 similar to the terminal 29 of Figure 1. At its lower or outer extremity, the contact member 46 projects through another hermetic seal and insulator 48 and terminates in a terminal screw 49. Another terminal 50 is located in and insulated from the base plate 40 and connects with terminal 47 by means of conductor 51, so that when the contact 15' engages the contact 46, a suitable electric circuit, not shown, is closed in the same manner as described in connection with the switch of Figures 1 and 2.

To adjust the contact spacing, it is only necessary to

adjust the screw 45, which may be provided with suitable calibrating means and which may be set manually or automatically as conditions may warrant.

The same advantages are inherent in the switch mechanism of Figures 3 and 4 as are inherent in the preferred form of Figures 1 and 2.

Figures 5 and 6 illustrate a preferred type of single pole, double throw contact arrangement for the pressure switches shown in the Figures 1 to 4, inclusive. In this instance, the terminal ring 29 has secured thereto a spring contact-supporting member 53 which at its free extremity terminates in a strip extending in a plane generally parallel to the diametric center line of the pressure cell and carrying contact members 54 and 55. The material of which the contact-supporting member 53 is made should be sufficiently stiff to resist vibration effects. Terminal rods 56 and 57 project through the glass seal 29' and terminate in contacts 57 and 58. The contact 54 has a downwardly projecting stem 54' adapted to be engaged by the diaphragm proper 12 at some predetermined pressure value, depending upon the switch setting. The rods 56 and 57 are connected to the screw 23 for adjustment as described in connection with Fig. 1. The conductors connected to the terminal ring 29 and rods 56 and 57 lead to suitable terminals which form part of electric circuitry, not shown, for performing the desired functions.

In operation, when the diaphragm 12 is subjected to some predetermined external pressure, for example ground level barometric pressure, it moves upwardly or inwardly and engages the stem 54' of the contact 54, causing the latter to engage contact 56, while at the same time contact 55 is moved free of contact 58. In this position, a circuit is completed across the contacts 54 and 57 and another circuit is broken across the contacts 55 and 58. Figure 6 shows the other position of the contacts when the external pressure has dropped to some predetermined value, as at high altitude, the diaphragm 12 moving clear of the stem 54' of contact 54 and permitting the flexible strip 53 to break contact between 54 and 57 and make contact between 55 and 58.

An important advantage of the contact arrangement illustrated in Figures 5 and 6 is that although the contact elements are extremely light in weight, the arrangement is such as to effectively resist loading without damage to the contact mechanism either while the switch is in storage or in use. This results from the fact that when the diaphragm 12 is subjected to a relatively high external pressure and moves the contact 54 into engagement with 57, the thrust is taken on a straight line through 54' to rod 56, which is rigidly secured to the glass seal 29'. As an example of what is meant by "loading" of the switch, assume the contacts have been adjusted to close at a high altitude and the switch mechanism is stored under ground level pressure conditions. This would place the diaphragm 12 under a relatively high pressure and jam contact 54 against 57, which might cause damage to the contacts were they arranged otherwise than as shown, and if then the upper shell were also free to function as a diaphragm, it might be deformed and thrown out of its preset or precalibrated condition.

It will be noted also that in this instance the diaphragm proper 12 is completely free of attachments such as contacts and the like.

While only two forms of the pressure switch of the instant invention have been illustrated and described, it will be obvious to those skilled in the art that other forms may be adopted and certain modifications made in the switch proper within the province of the invention as defined by the appended claims.

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

1. In a pressure-responsive switch, an aneroid cell made up of a pair of reversely dished shells connected to one another at their peripheral edges and defining an

aneroid chamber therebetween, said shells being formed of metallic sheets having substantially the same gauge thickness, one only of said shells being free to respond to changes in pressure and hence to function as a pressure-responsive diaphragm, the other of said shells being formed with an opening substantially centrally thereof, contact and terminal-supporting means projecting through said opening into the interior of said chamber, an airtight seal through which said contact-supporting means projects, housing members supporting said cell from the peripheral edge thereof and also backing up said contact and terminal-supporting means, and means for moving said contact and terminal-supporting means bodily in a contact-settling direction without imparting rotation thereto, said diaphragm being substantially free of attachments or the like tending to "load" the diaphragm.

2. In a pressure-responsive switch, an aneroid cell made up of a pair of reversely dished shells connected to one another at their peripheral edges and defining an aneroid chamber therebetween, one only of said shells being free to respond to changes in pressure and hence to function as a pressure-responsive diaphragm, the other of said shells being formed with an opening substantially centrally thereof, contact-supporting means projecting through said opening, a seal fixed in said opening and engaging said contact-supporting means in airtight relation, a housing supporting said cell from the peripheral edge thereof and also backing up said contact-supporting means, and means for moving said contact-supporting means bodily in a contact-setting direction without effecting rotation of said latter means, said diaphragm being substantially free of attachments or the like which would tend to "load" the diaphragm.

3. In a pressure-responsive switch, an aneroid cell made up of a pair of reversely dished shells connected to one another at their peripheral edges and defining an aneroid chamber therebetween, a sectional housing supporting said cell from its peripheral edge, one of said shells being provided with an opening substantially centrally thereof, a member projecting through said opening and providing a support for one or more contacts within said chamber, a seal fixed in said opening in airtight engagement with said member, said member being backed up by one of said housing sections, the other of said shells being free to move and hence function as a pressure-responsive diaphragm, means for effecting movement of said member along with said seal and the adjacent shell area in a contact-setting direction without effecting rotation of said member, said shells being made of metallic conducting material of substantially the same gauge thickness.

4. A switch as claimed in claim 3 wherein a rotatable calibrating dial is operatively connected to said member for effecting adjustment of the contacts carried thereby.

5. A pressure switch as claimed in claim 3 wherein said member is in the form of a threaded screw carrying electrical contact means on the inner end thereof adapted to be engaged by said pressure-responsive diaphragm.

6. In a pressure-responsive switch, an aneroid cell made up of a pair of reversely dished thin metallic shells connected to one another at their meeting edges and defining an aneroid chamber therebetween, one only of said shells being free to respond to changes in pressure and hence to function as a pressure-responsive diaphragm, the other of said shells being formed with an opening substantially centrally thereof, contact terminals projecting through said opening and carrying electrical contacts on the inner ends thereof within said chamber, sealing means fixed in said opening in airtight engagement with said terminals, a resilient switch member provided with contacts adapted to coact with said first-named contacts to provide a single pole, double throw contact arrangement for the switch, sectional housing supporting said aneroid cell from the peripheral edge thereof, and means for moving said contact terminals along with said seal and adjacent shell area in a direction to effect adjustment of the switch contacts.

7. A pressure switch as claimed in claim 6 wherein said resilient contact member is provided with an elongated contact element extending in substantial alignment with one of said terminals, said diaphragm when subjected to a predetermined external or ambient pressure engaging said element and exerting a straight line thrust through the latter on said one terminal.

8. In a pressure-responsive switch, an aneroid cell made up of a pair of reversely dished shells connected to one another at their meeting edges and defining an aneroid chamber therebetween, a sectional housing having a pair of sections supporting said cell from the peripheral edge thereof, one of said shells having an opening substantially centrally thereof, a contact terminal projecting through said opening and carrying contact means on the inner end thereof within said chamber, a seal fixed in said opening in airtight engagement with said terminal, a third of said housing sections engaging and backing up said terminal to thereby hold the shell carrying said terminal and seal against substantial movement in a pressure-responsive direction, the other of said shells being free to move and hence to function as a pressure-responsive diaphragm, and means for moving said pair of housing sections toward and away from said third section to adjust said contact.

9. A switch as claimed in claim 8 wherein said pair of sections are resiliently hinged to said third section.

10. In a pressure-responsive switch, an aneroid cell including a pair of reversely dished diaphragm shells connected at their peripheral edges in a manner such as to define a switch-contact and aneroid chamber therebetween, a housing for said cell including a pair of opposed rigid wall sections encompassing said cell and supporting the latter from the peripheral edge thereof, an externally-threaded terminal and contact-mounting element projected through one of said rigid wall sections and the central portion of one of said shells into said chamber and having a contact on the inner end thereof, means providing a seal between said element and the shell through which it projects and coacting means holding said element against rotation with respect to said latter shell, the other of said rigid wall sections being spaced from the other of said shells leaving said latter shell free to respond to changes in pressure and also providing in conjunction with said latter shell a chamber adapted to be vented to the atmosphere or to a reference pressure, said pressure-responsive shell bearing a contact centrally thereof adapted to coact with said first-named contact to make and break an electric circuit, and a rotatable contact-setting member in screw-threaded engagement with said terminal and contact-mounting element externally of said cell, rotation of said contact-setting member causing said latter element to move inwardly or outwardly without rotating in its seal and the shell through which said latter element projects flexing to accommodate such inward or outward movement.

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