

[54] **PRESSURE ACTUABLE SWITCH
APPARATUS WITH BELLOWS AND FLUID
DAMPING MEANS**

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[51] Int. Cl. **H01h 35/34**

[58] Field of Search **200/156, 83 P, 83 C, 81 R, 200/153 J, 34, 83 T, 83 D; 92/41; 102/70 B**

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Primary Examiner—Robert K. Schaffer

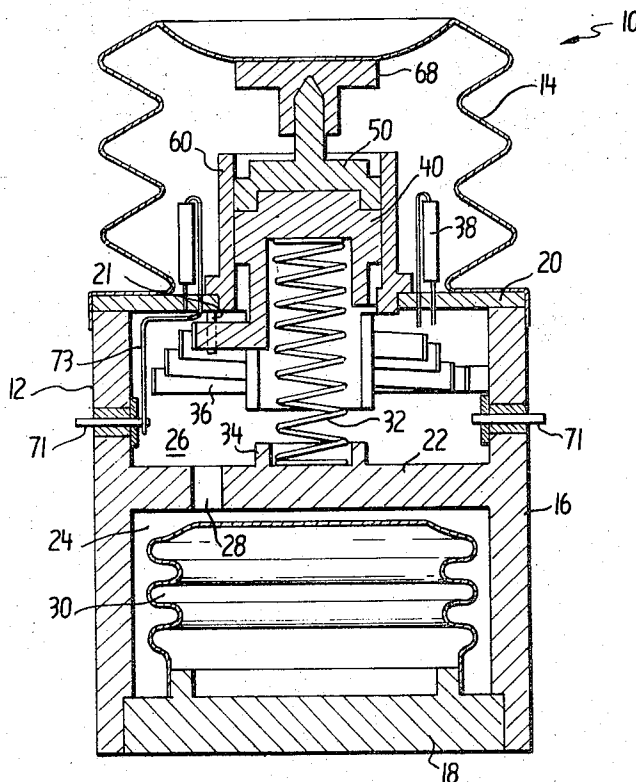
Assistant Examiner—Gerald P. Tolin

Attorney, Agent, or Firm—D. Schron

[57] **ABSTRACT**

Pressure actuatable switch apparatus is disclosed as comprising a switch mechanism, an envelope for receiving the switch mechanism therein and having a portion displaceable in response to increased external pressure, and a translating mechanism responsive to the displacement of the envelope portion for moving an arm of the switch mechanism from a first position to a second position. First and second electrical contacts are mounted within the envelope to engage electrically the arm when it is disposed respectively at the first and second positions. Illustratively, the translating mechanism includes a spline housing defining at least one spline, an actuating cam member coupled with the envelope portion for movement therewith, and a ratchet cam for moving the arm. The actuating and ratchet cams each have keys and are disposed within the spline housing so that the respective keys are channeled within the spline thereof for controlled movement as the envelope portion is displaced, to move the actuating cam to engage the ratchet cam. The actuating and ratchet cams include engaging cam surfaces, illustratively in the form of sets of mutually-engaging teeth. The key of one of the actuating and ratchet cams is displaced from the position of the other key with respect to its cam surface, whereby the displacement of the envelope portion and the actuating cam as external pressure increases, directs the ratchet cam and arm from the first to the second position. The spline housing may be provided with a plurality of splines whereby the ratchet cam may be successively moved from the first to the second to any of a plurality of positions upon repeated raising and lowering of the external pressure.

2 Claims, 16 Drawing Figures



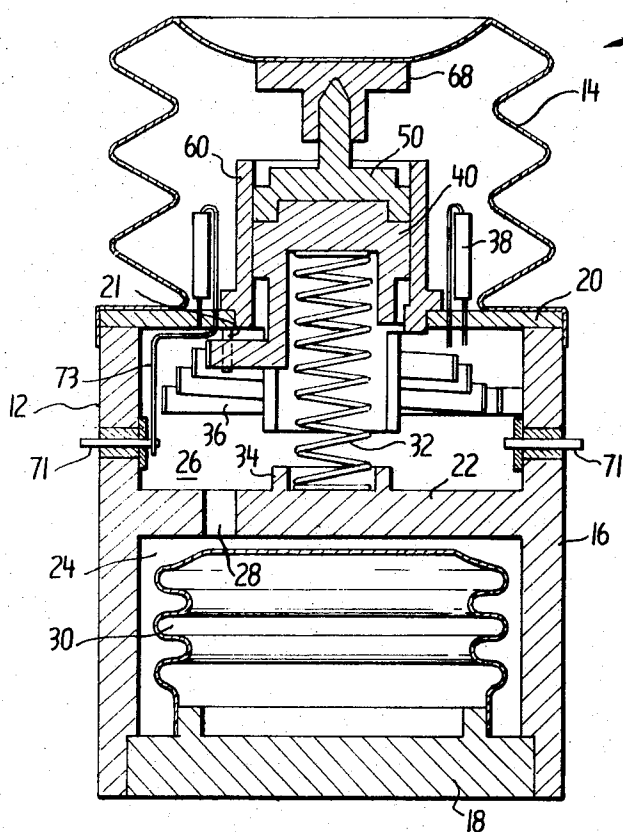


FIG. 1

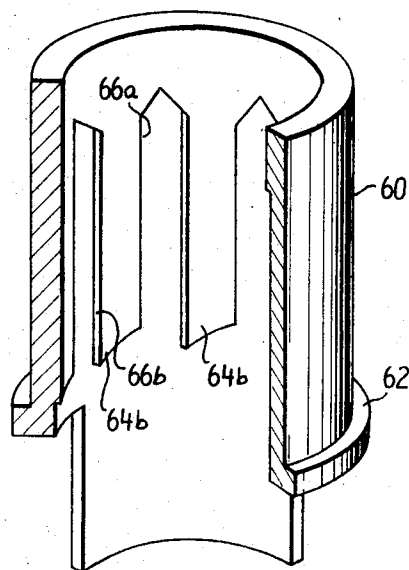


FIG. 3

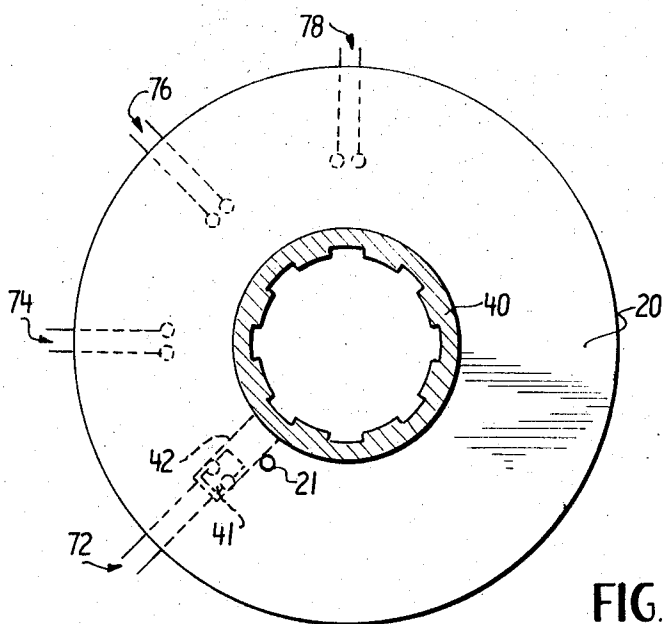
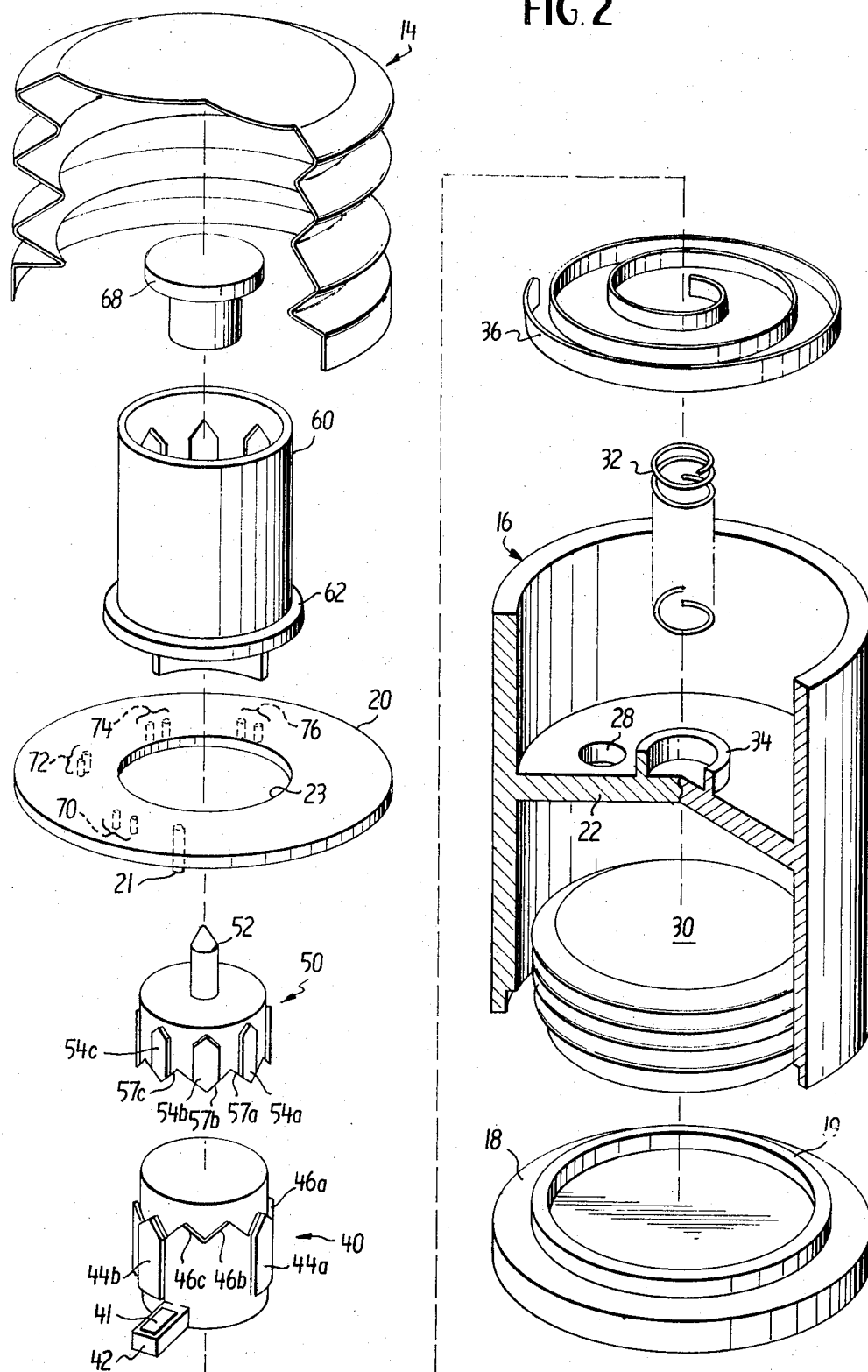


FIG. 6

FIG. 2



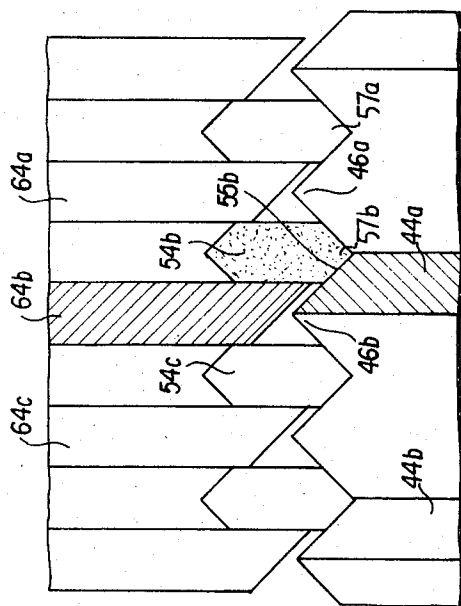


FIG. 4C

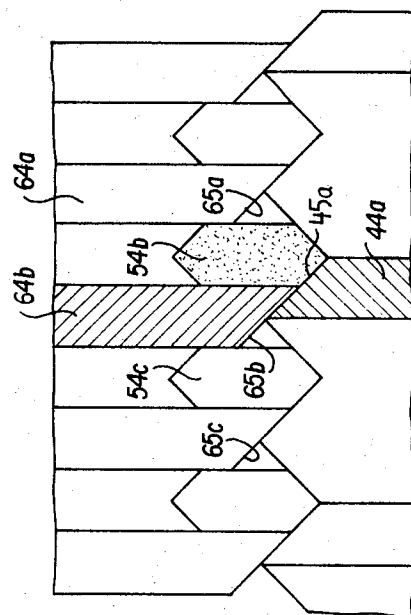


FIG. 4D

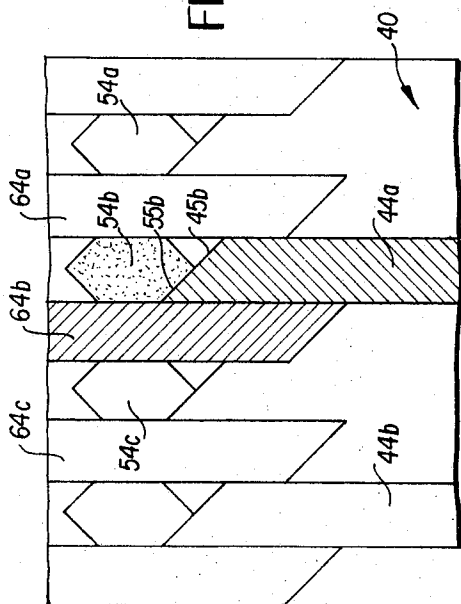


FIG. 4A

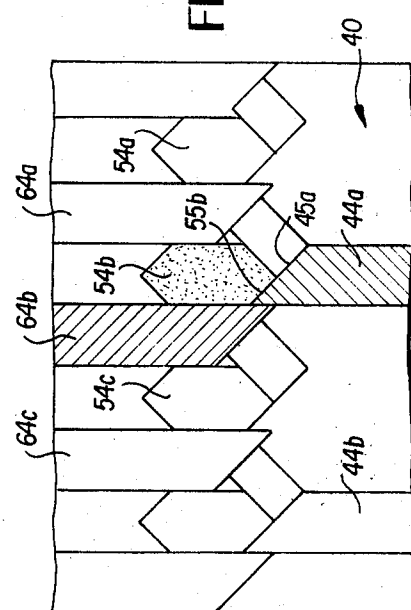


FIG. 4B

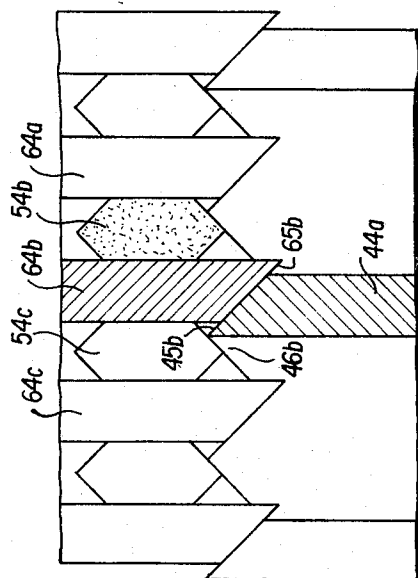


FIG. 4E

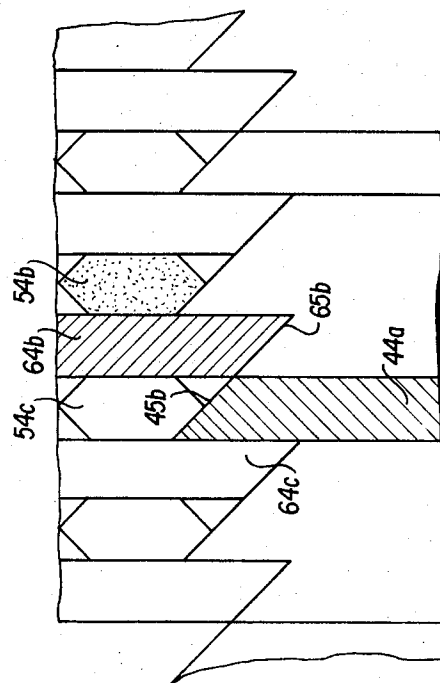


FIG. 4F

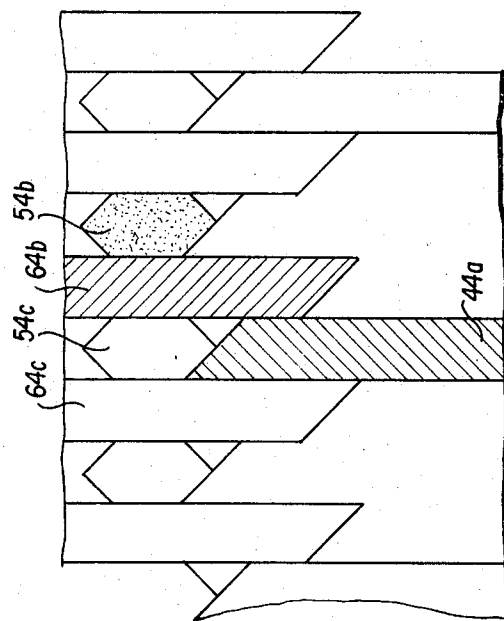


FIG. 4G

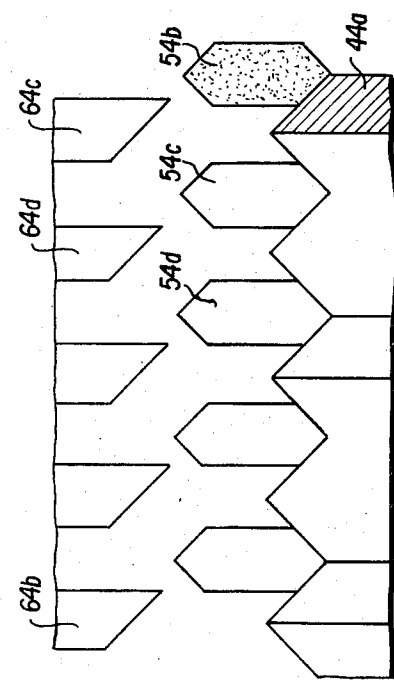


FIG. 5A

FIG. 5C

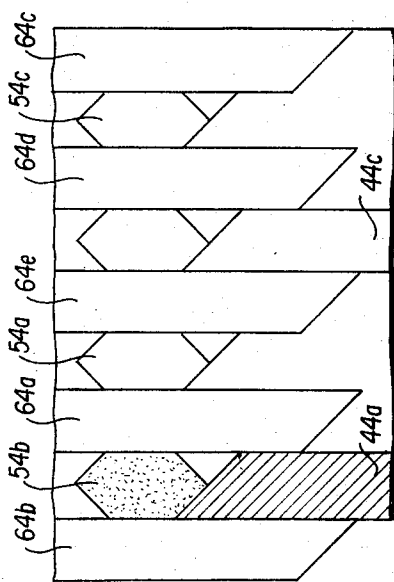
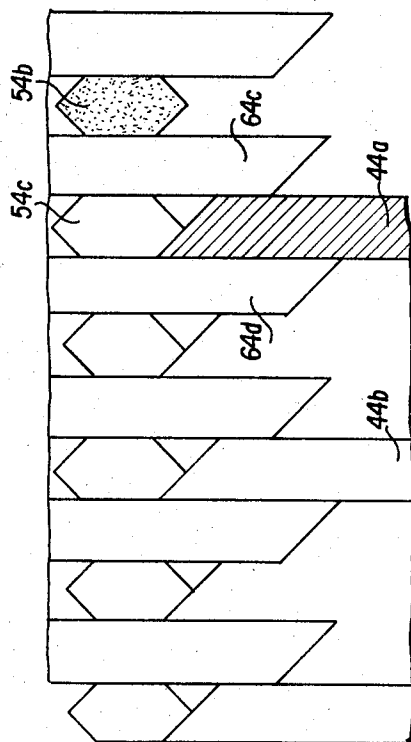
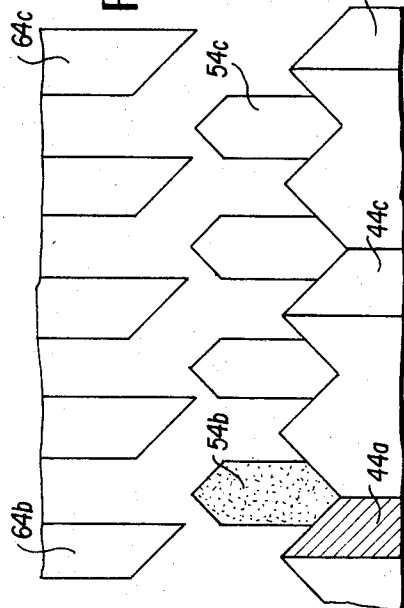


FIG. 5B

FIG. 5D



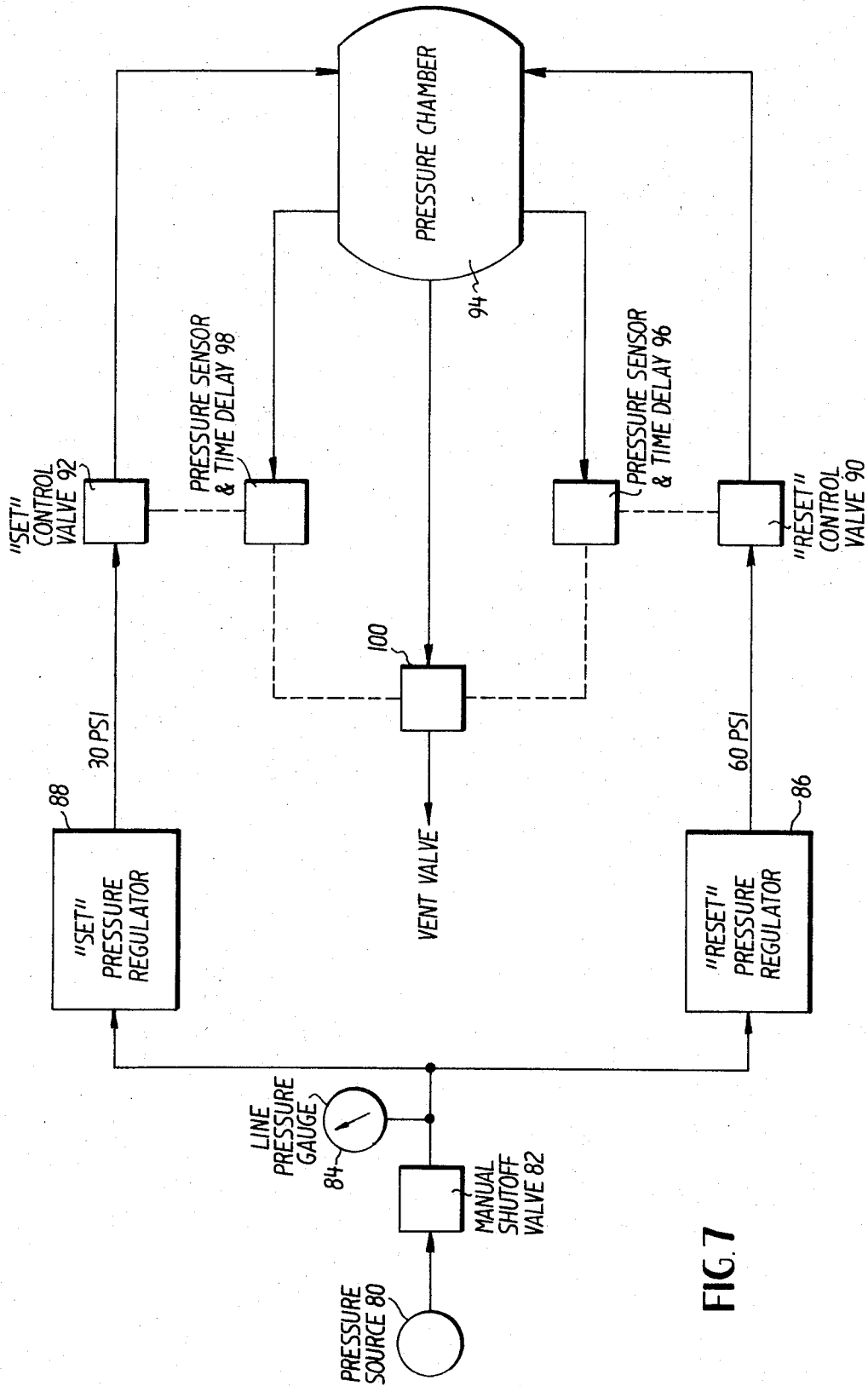


FIG. 7

PRESSURE ACTUABLE SWITCH APPARATUS WITH BELLOWS AND FLUID DAMPING MEANS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to switching apparatus and in particular to such switching apparatus actuatable in response to a change of external pressure.

2. Description of the Prior Art

There is known a class of aerially delivered weapons such as mines or bombs having a container for receiving a plurality of individual component weapons. The component weapons are released from the dispenser during the delivery or deployment. Typically, each component weapon has a separate fusing device associated therewith for controlling arming delay, detonation time, etc. Such fusing devices are preset prior to their delivery. At present, in order to set each of the plurality of the fusing devices associated with a great number of component weapons, it is necessary to manually set a switch on each of the fusing devices, prior to its loading into the dispenser. A change in the settings of the fuse devices requires the unloading of the multiple component weapons and the manual manipulation of the switches associated with each fuse device.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a fusing device capable of being set without manual manipulation whereby large numbers of such fuse devices may be set at a single time without individual attention to each of the fuse devices.

It is a further object of this invention to provide a pressure actuatable switch responsive to change in external pressure to be disposed from a first to a second switching position.

These and other objects are met in accordance with the teachings of this invention by providing a pressure actuatable switching apparatus including a hermetically sealed envelope having a portion displaceable in response to a change of external pressure, a translating mechanism responsive to such displacement of the envelope portion to move an arm from a first to a second switch position, and contacts disposed at the first and second positions for electrically engaging the aforementioned arm. In an illustrative embodiment of this invention, the translating mechanism includes an actuating cam coupled to the envelope portion and displaceable therewith, a ratchet cam biased by suitable spring means to engage the actuating cam, and a spline housing for receiving keys of the respective actuating and ratchet cams. Each of the actuating and ratchet cams has an engaging cam surface; the relative position of a key of one of the cams is displaced from the position of the other key with respect to its cam surface so that upon displacement of the actuating cam in response to an increase of external pressure to a first level, the cam surface of the actuating cam engages the cam surface of the ratchet cam to move the ratchet cam and the arm carried thereby from its first to the second switch position. At least three splines are formed within the spline housing to permit the key of the ratchet cam and therefore the ratchet cam to be "set" at the first and second switch positions.

A further aspect of this invention resides in a reset mechanism whereby upon increasing the external pres-

sure to a second level higher than the first level, the keys of the actuating and ratchet cams are both free of the splines to permit movement, i.e., rotation, of the ratchet cam to an initial or reset position under the influence of a suitable motivating means, such as a clock spring.

A further feature of this invention resides in the employment of a damping fluid within the envelope to eliminate the possible adverse effects of vibration or other rapid movement that would otherwise tend to change inadvertently the switch position of the arm.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the present invention will become more apparent by referring to the following detailed description and accompanying drawings, in which:

FIG. 1 is a cross-section view of the pressure actuatable switching apparatus in accordance with the teachings of this invention;

FIG. 2 is an assembly drawing in perspective of the components comprising the pressure actuatable switching apparatus of FIG. 1;

FIG. 3 is a perspective, cut-away view of the spline housing incorporated into the pressure actuatable switching apparatus as shown in FIGS. 1 and 2;

FIGS. 4A to 4G are linear representations of the relative position of the teeth of the actuating and ratchet cams with respect to the splines of the spline housing as the external pressure is increased to a first relatively low pressure level and then decreased therefrom;

FIGS. 5A to 5D are linear views of the relationship between the teeth of the ratchet and actuating cams with respect to the splines of the spline housing as the external pressure is increased to a second, higher level and then decreased therefrom;

FIG. 6 is a top-plan view of the ratchet cam and its arm with respect to a plurality of switch positions; and

FIG. 7 is a schematic representation of a system for establishing first and second levels of pressure within a chamber for receiving a plurality of switch actuating apparatus, as shown in FIGS. 1 and 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With regard to the drawings and in particular to FIGS. 1 and 2, there is shown a pressure actuatable switching apparatus in accordance with the teachings of this invention, comprising a hermetically sealed envelope 10 for receiving a switching mechanism therein. The envelope 10 includes an outer housing 16, a first end plate 18, and an upper or external bellows 14. The first end plate 18 is secured to one end of the outer housing 16, while the other end of the outer housing 16 is partially enclosed by a second end member 20, providing a mounting board for receiving a plurality of electrical circuit elements identified by the numeral 38. As better shown in FIG. 2, the circuit components 38 have associated therewith sets of electrical contacts 72, 74, 76 and 78 disposed at discrete, switch positions. As shown in FIG. 1, the upper bellows 14 is hermetically sealed to the outer housing 16 and receives therein a translating mechanism coupled to the external bellows 14 and displaceable therewith under a change of external pressure to permit an arm 42 carried by a ratchet cam 40 to be displaced and in particular to be rotated

from one switching position to the next as defined by the positions of the sets of contacts 72, 74, 76 and 78.

In the illustrative embodiment shown in FIG. 1, a plurality of terminals 71 are disposed about the periphery of the outer housing 16 whereby an electrical connection may be made from the exterior of the envelope 10 to a point within the envelope 10. A plurality of electrical connectors 73 serve to interconnect the terminals 71 and corresponding circuit components 38. Thus, the switch apparatus as described herein is suitable in a great number of environments where it is desired to selectively connect or switch circuits in response to a change of pressure as opposed to manual actuation by an operator.

The translating mechanism includes an annularly-shaped spline housing 60 mounted within an opening 23 of the second end member 20 and having a rim 62 disposed against the member 20. An actuating cam 50 and a ratchet cam 40 are disposed within the spline housing 60 in a manner to be more fully described. The actuating cam 50 includes a post 52 mounted axially upon the top thereof to be coupled with the upper bellows 14; in particular, the post 52 is disposed within an opening of a shaft bearing 68 secured as by gluing to a portion of the envelope and in particular to the upper bellows 14. Upon a change, and in particular an increase, in the pressure of the external atmosphere with respect to the pressure within the envelope 10, the upper bellows 14 is compressed to move the shaft bearing 68 and the actuating cam 50 in a downward position, as shown in FIGS. 1 and 2.

As more clearly shown in FIG. 3, the inner surface of the annularly-shaped spline housing 60 includes a plurality of fingers 64 for forming therebetween a series of splines 66 corresponding to the switch positions of the sets of contacts 72, 74, 76 and 78. As is more clearly shown in FIG. 2, the actuating cam 50 includes a series of keys 54a, 54b, 54c, etc. disposed about the periphery thereof, each having a diamond configuration. Further, the actuating cam 50 includes a corresponding plurality of teeth 57a, 57b, 57c, etc. whose tips are aligned with the keys 54a, 54b, 54c, etc., respectively. The ratchet cam 40 includes a plurality of keys 44a, 44b, 44c, etc. disposed about the periphery thereof, and a plurality of teeth 46a, 46b, 46c, etc. corresponding to the teeth 57a, 57b, 57c, etc. of the actuating cam 50 and configured to mesh therewith. Significantly, the keys 44 have a width of only one-half of that of the teeth 46 and are disposed as shown in FIG. 2 from the tips of the teeth 46. In a manner to be explained, the displacement of the keys 44 with respect to the teeth 46 permits the rotation of the ratchet cam 40 with respect to the spline housing 60 to facilitate the successive movement of the arm 42 to the various switch positions. As shown in FIG. 2, the arm 42 carries a circuit completing means illustratively taking the form of an electrically conductive strip 41 of a metal or a resistive film of selected impedance. Upon disposing the arm 42 at one of the switch positions, the strip 41 is permitted to engage electrically the corresponding terminal set to complete a circuit therebetween.

As shown in FIG. 1, the ratchet cam 40 is disposed flexibly by a suitable biasing means such as a spring 32 upward, as shown in FIG. 1, to engage the actuating cam 50. The spring 32 is disposed axially of the outer housing 16 and is supported at one end within an open-

ing of the ratchet cam 40 and at the other end within a ring 34 disposed upon a partition 22. The partition 22 is disposed across the interior of the outer housing 16 to divide the outer housing 16 into a first chamber 26 and a second chamber 24. An opening 28 is formed within the partition 22 to provide a limited communication between the first and second chambers 26 and 24. A damping fluid is disposed within the outer housing 10 to dampen the movement of the actuating and ratchet cams 50 and 40 to prevent inadvertent motion such as vibration or shock from moving the arm 42. In order for the external bellows 14 to be compressed, the damping fluid must be forced through the restrictive opening 28 from the first chamber 26 to the second chamber 24 whereby an internal bellows 30 is in turn compressed. The internal bellows 30 is disposed within the second chamber 24 and is mounted by a ring 19 on the first end member 18. The resulting damping action as the fluid compresses the internal bellows 30 will slow the movements of the external bellows 14 and the coupled actuating and ratchet cams 50 and 40; as a result, the switching mechanism will not be set inadvertently to the next switch position if subjected to vibration and shock impulses, as may be occasioned in the aerial delivery of weapons. The selected damping fluid should have a relatively high viscosity stability over wide temperature ranges, be chemically inert, and present a relatively high impedance between the sets of terminals 72, 73, 74 and 76 in order to avoid electrically shorting these terminals. In one illustrative embodiment of this invention, the damping fluid was a silicone fluid.

It is contemplated that the second cavity 24 and the inner bellows 30 may be eliminated and that the outer housing be partially filled with the damping fluid; the resulting pocket of air, or bubble, will serve then as an internal compression chamber to dampen the effect of external vibrations or shock upon the movement of the actuating and ratchet cams.

With regard to FIG. 6, there is shown the switching positions as defined by the sets of contacts 72, 74 and 78. In a manner to be explained below, the ratchet cam 40 is successively moved from the first to the second, to switch successively positions as the external pressure is raised to a first level with respect to the pressure within the envelope 10 and then lowered. As the ratchet cam 40 is rotated, the arm 42 and strip 41 are disposed successively from one position to the next to electrically engage the corresponding sets of contacts.

The manner of interaction between the ratchet cam 40 and the actuating cam 50 to rotate the ratchet cam 40 from one switch position to the next will now be explained with regard to FIGS. 4A to 4G, which show a linear representation of the circumference of the actuating and ratchet cams and the spline housing. In FIG. 4A, the external pressure has not yet been increased significantly with respect to the internal pressure within the envelope and the ratchet cam 40 is in one of the set positions as defined by the splines 66 formed between the fingers 64. In this discussion of the operation of the translating mechanism, the spline housing 60 and its fingers 64 remain relatively stationary. As shown in FIG. 4A, the keys 44 of the ratchet cam 40 and the keys 54 of the actuating cam 50 are confined within the splines 66 as defined by the fingers 64 of the spline housing 60. Because the keys 54 are confined by the fingers 64, the teeth of the actuating and ratchet cams

are not permitted to mesh and an open space occurs between the cams.

With respect to FIG. 4B, the external pressure is increasing whereby the external bellows 14 forces the actuating cam 50 downward so that the cam or teeth surfaces 55 of the actuating cam 50 engage the teeth or cam surfaces 45 of the ratchet cam 40 to direct the ratchet cam 40 downward. As shown in FIG. 4B, ratchet cam 40 is restrained against rotational movement as its keys 44 are held by the fingers 64 of the spline housing 60. As the pressure continues to increase to a first level, as shown in FIG. 4C, the keys 44 of the ratchet cam 40 are freed from the constraint of the fingers 64 of the spline housing 60. By the biasing force of the spring 32 (see FIG. 2), the ratchet cam 40 is disposed upwardly, whereby the teeth 46 of the ratchet cam 40 fully mesh with the teeth 57 of the actuating cam 50, to effect thereby a movement of the ratchet cam 40 to the left, as shown in FIG. 4C, and clockwise, as shown in FIG. 2. As the external pressure decreases from the first level, the force exerted upon the actuating cam 50 is reduced and the spring 32 forces the ratchet cam 40 upward, as shown in FIGS. 4C and 4D. As seen in FIG. 4D, the cam or teeth surfaces 45 of the ratchet cam 40 engage cam surfaces 65 of the fingers 64 of the spline housing 60. As the external pressure continues to be reduced, the axial force exerted by the spring 32 moves the ratchet cam 40 upward whereby the interaction of the cam surfaces 45 upon the cam surfaces 65 imparts a further movement to the ratchet cam 40 in a direction to the left as seen in FIGS. 4E and 4F. In FIG. 4F, the key 44a has been displaced one position to the left and is now confined within the spline formed by the fingers 64b and 64c of the spline housing 60.

In FIG. 4G, the ratchet cam 40 has now been translated to a second set switch position and the key 44a is now fully disposed between the fingers 64b and 64c. At this point, the external pressure has been lowered to its normal or ambient level whereby the spring 32 urges the keys 44 and 54 to their topmost positions within the splines 66 of the spline housing 60 (see FIG. 3). The translation imparted to the ratchet cam 40 may be more fully realized by comparing FIGS. 4A and 4G. In FIG. 4A, the key 44a is disposed between the fingers 64a and 64b. By increasing the pressure to the first level and then releasing the pressure to a normal level, the ratchet cam 40 is displaced to the left as seen in FIGS. 4 to the next position as seen in FIG. 4G wherein the key 44a is disposed between the fingers 64b and 64c of the spline housing 60. Due to the axial force exerted upon the ratchet cam 40 by the spring 32, the switching mechanism is now set in this switch position until the next increase and decrease in pressure.

It is apparent that the above-described pressure increase and release cycle may be performed any number of times to permit the ratchet cam 40 and its arm 42 to be rotated in a counterclockwise direction as seen in FIG. 2 to each of at least four switch positions. Though only four switch positions are illustrated in FIG. 2, it is realized that any number of switch set positions may be provided in accordance with the teachings of this invention.

Further, the pressure actuatable switching apparatus of this invention may include a reset feature whereby the arm 42 of the ratchet cam 40 is reset from any of the plurality of switch set positions as defined by the

contacts 74, 76 and 78 to its first or initial set position as defined by the set of contacts 72. As seen in FIGS. 1 and 2, a clock spring 36 is interconnected between the ratchet cam 40 and the periphery of the outer housing 16 to exert a counterclockwise force as seen in FIG. 2 upon the ratchet cam 40. Normally, the ratchet cam 40 is held in a set position because its keys 44 are confined within one of the splines 66 of the spline housing 60 to prevent the rotation of the ratchet cam 40 under the influence of the clock spring 36. When the ratchet cam 40 and the actuating cam 50 are completely released from the splines 66 of the spline housing 60 in a manner to be explained, the ratchet cam 40 is rotated by the clock spring 36 in a counterclockwise direction until the arm 42 is stopped by a post 21 mounted on the second end member 20 whereby the ratchet cam 40 and its arm 42 are disposed at the initial or first switch set position.

The operation of the reset mechanism as described above will be explained in greater detail with regard to FIGS. 5A to 5D, which show a linear representation of the relationship of the keys of the ratchet and actuating cams with respect to each other and to the fingers of the spline housing. In FIG. 5A, the ratchet cam 50 is shown disposed in a fourth position whereby its key 44a is disposed between the fingers 64a and 64b of the spline housing 60. The external pressure outside the envelope 10 is normal and the spring 32 retains the keys 44 and 54 fully within the splines 66 of the spline housing 60. In order to reset the ratchet cam 40 to its first or initial position, the external pressure is increased with respect to the pressure within the envelope 10 to a second level higher than the aforementioned first level, whereby the external bellows 14 disposes the actuating cam 50 and the ratchet cam 40 to a position as shown in FIG. 5B and the axial force of the spring 32 has been sufficiently overcome to free both the keys 54 of the actuating cam 50 and the keys 44 of the ratchet cam 40 from the fingers 64 of the spline housing 60. At this point, the clock spring 36 is permitted to rotate the ratchet cam in a counterclockwise direction as seen in FIG. 2 (or to the right, as seen in FIGS. 5A to 5D) until the arm 42 of the ratchet cam 40 abuts the stop post 21, whereby the ratchet cam 50 is disposed at its reset position, as shown in FIG. 5C. Then, the external pressure is released to a normal level, whereby the spring 32 directs the ratchet cam 40 in an upward direction as seen in FIG. 5D, and the keys 44 are fully disposed within the splines 66. When the pressure has been completely released, the ratchet cam 40 is disposed at its initial position.

If the reset mechanism as described above is omitted, the pressure actuatable switch apparatus of this invention may be continuously set in one direction until the ratchet cam 40 has been redispensed in its initial position. In this embodiment, the mechanism may be considerably simplified and the manufacturing tolerances are increased. However, if a reset mechanism including the clock spring 36 is incorporated, continuous rotation of the ratchet cam 40 is not possible. Thus, the inclusion of the reset mechanism requires that reset be performed once the switching apparatus has been set through all of its settings.

Though not shown in the drawings, a status indicator may be provided whereby suitable indicia may be disposed upon the arm 42 of the ratchet cam 40 and a portion of the envelope 10 is made transparent to permit

an operator to observe the position of the arm 42 and thereby to identify the set switch position to which the switching mechanism has been set.

With regard to FIG. 7, there is shown an illustrative system for selectively controlling the external pressure applied to a great number of switch apparatus as described above. In particular, a source 80 of relatively high pressure is applied by a manual shut-off valve 82 to each of "a set" pressure regulator 88 and a "reset" pressure regulator 86. The pressure of the source 80 is measured by a suitable gauge 84. The set pressure regulator 88 provides at its output a pressure corresponding to the first level whereby the switch apparatus disposed within a chamber 94, are set from one position, to the next, whereas the reset pressure regulator 86 provides an output of a greater pressure corresponding to the second level whereby the switching apparatus are reset to their initial positions. Illustratively, the pressure of the first level derived from the set pressure regulator 88 may be in the order of 30 PSI, and the pressure derived from the reset pressure regulator 86 of the second level may be in the order of 60 PSI. In order to reset the switch apparatus which are disposed within the pressure chamber 94, the operator manipulates the set control valve 92 to initiate an increase in pressure within the pressure chamber 94. A pressure sensor and time delay 98 coupled with the chamber 94 measures the pressure build-up within the chamber 94 and "latches" the set control valve 92 until the first level is reached. After a delay determined by the pressure sensor and time delay 98 corresponding to the damped response of the pressure actuatable switch apparatus, the vent valve 100 is opened under the control of the pressure sensor and time delay 98 to permit the pressure within the chamber 94 to be returned to a normal level. In this manner, each of the switch apparatus disposed with the chamber 94 is set or moved to its next switch set position. In a similar manner, the operator may manipulate the reset control valve 90 to introduce a pressure of the second level into the chamber 94. A pressure sensor and time delay 96 measures the pressure within the chamber 94 and latches the reset control valves 90 until a pressure of the second level is achieved. After a delay dependent upon the damping characteristics of the switch apparatus, the pressure sensor and time delay 96 releases the pressure built up within the chamber 94 to be vented through the vent valve 100. Thus, the external pressure applied to a great number of switch apparatus may be raised to the second level, whereby each of the switch apparatus is reset to its initial switch set position.

Numerous changes may be made in the above-described apparatus and the different embodiments of the invention may be made without departing from the spirit thereof; therefore, it is intended that all matter contained in the foregoing description and in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Pressure actuatable switch apparatus comprising:

- a. an envelope for receiving switch means therein and having a diaphragm portion displaceable in response to changes of external pressure with respect to that established within said envelope;

- b. first and second contacts disposed within said envelope, at first and second switch positions, respectively;
- c. said switch means comprising a switch member movable to each of said first and second switch positions;
- d. translating means for securely setting said switch member at each of said first and second positions and responsive to the displacement of said diaphragm portion to release said switch member from said first position and move said switch member to said second position, said translating means effecting the movement of said switch member from said first position to said second position in response to the increase of the external pressure from a normal pressure level to a first pressure level and the subsequent decrease of the external pressure from said first level to said normal pressure level; and
- e. reset means responsive to the increase of external pressure from said normal level to a second level greater than said first level for disposing said switch member to said first position.

2. Pressure actuatable switch apparatus comprising:

- a. an envelope for receiving switch means therein and having a diaphragm portion displaceable in response to changes of external pressure with respect to that established within said envelope;
- b. first and second contacts disposed within said envelope at first and second switch positions, respectively;
- c. said switch means comprising a switch member movable to each of said first and second switch positions;
- d. translating means for securely setting said switch member at each of said first and second positions and responsive to the displacement of said envelope portion to release said switch member from said first switch position and move said switch member to said second switch position, said translating means comprising an actuating cam coupled to said displaceable diaphragm portion for movement therewith, said actuating cam having a first cam surface, and a ratchet cam for supporting said switch member for movement therewith and having a second cam surface for engagement with said first cam surface whereby upon displacement of said actuating cam in response to a change of external pressure, said ratchet cam is moved so that said switch member is disposed from said first to said second switch position, a spline housing fixably mounted within said envelope for receiving said actuating cam and said ratchet cam, said spline housing defining at least first and second splines corresponding to said first and second switch positions, said actuating and ratchet cams each having at least one key disposable within one of said splines, and biasing means for urging said ratchet cam to engage said actuating cam against displacement of said diaphragm portion; and
- e. reset means comprising spring means for urging said ratchet cam to said first position, stop means disposed within said envelope to engage at said first switch position said switch member as it is urged by said spring means, said actuating cam and said ratchet cam being released from said spline housing in response to an increase in pressure to a level dependent upon the force exerted by said spring means upon said ratchet cam to permit movement by said spring means of said ratchet cam and said switch member to said first switch position.

* * * * *