United States Patent

Rattan

[15] **3,670,281**

[45] **June 13, 1972**

[54] **THERMALLY RESPONSIVE SWITCH AND METHOD FOR MAKING THE SAME**

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[22] Filed: **April 5, 1971**

[21] Appl. No.: **131,205**

[52] **U.S. Cl.**.....**337/112,** 337/94, 337/111, 337/374

[51] **Int. Cl.**.....**H01h 37/04,** H01h 37/52, H01h 61/06

[58] **Field of Search**.....200/166 BH; 337/94, 95, 111, 337/112, 374, 378, 379, 380, 381, 400

[56] **References Cited**

UNITED STATES PATENTS

3,230,607	1/1966	Gelzer	337/94 X
3,148,258	9/1964	Dales	337/381 X
2,745,924	5/1956	Coates	337/380 X
2,248,531	7/1941	Harris	337/112 X
1,799,651	4/1931	Siegmund	200/166 BH

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[57] **ABSTRACT**

A thermally responsive switch and method for making the same in which a base container having a cover supports a pair of contact elements, including at least one bimetallic element, and is filled with a hardenable material cured at the desired operating temperature of the switch to form an integral support base. The contact elements each have a protruding tab which cooperates with an interior wall of the base container so as to properly position the contact elements in the container after the cover has been attached, to close off the bottom of the container such that the hardenable material may be retained therein, and to cause the contact elements to pivot together at their contact ends under the force of gravity whereby the switch is accurately calibrated and the contact elements are protected during assembly.

8 Claims, 9 Drawing Figures

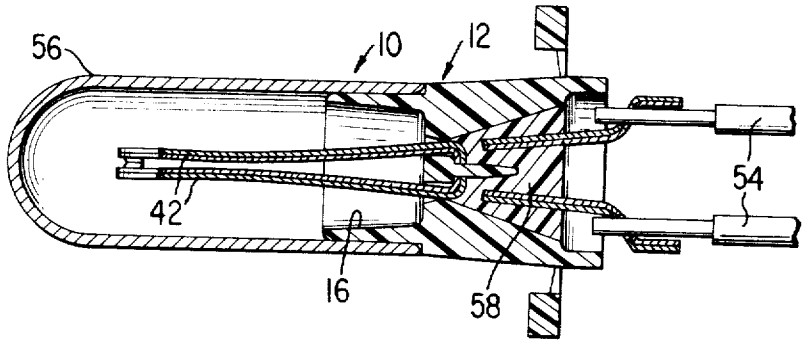


FIG. 1

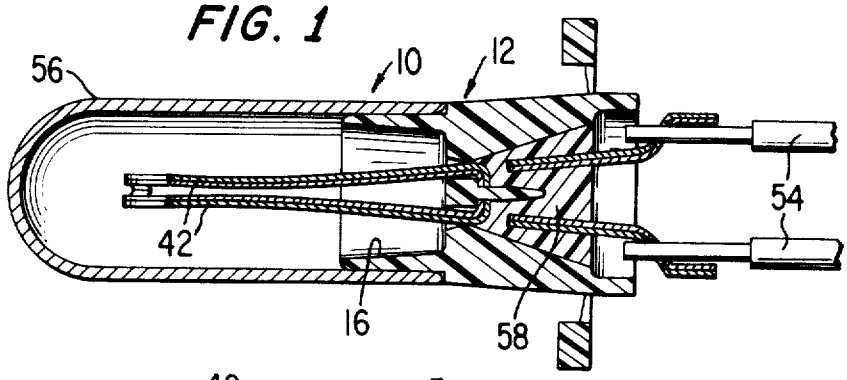
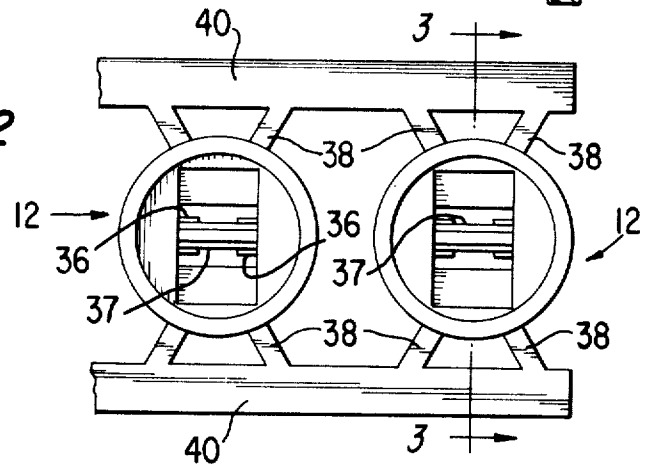


FIG. 2



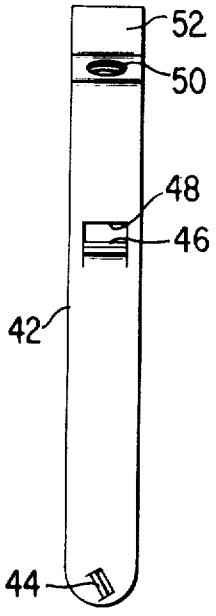


FIG. 4

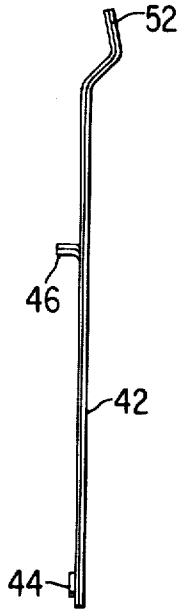
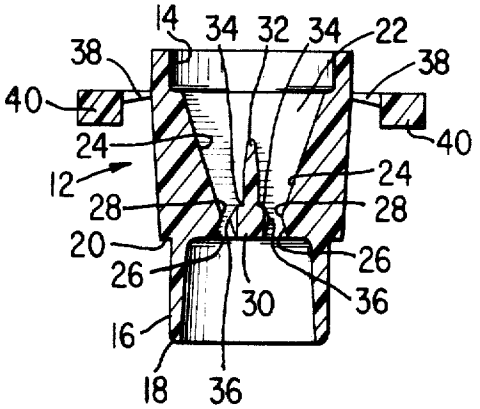


FIG. 5

FIG. 3



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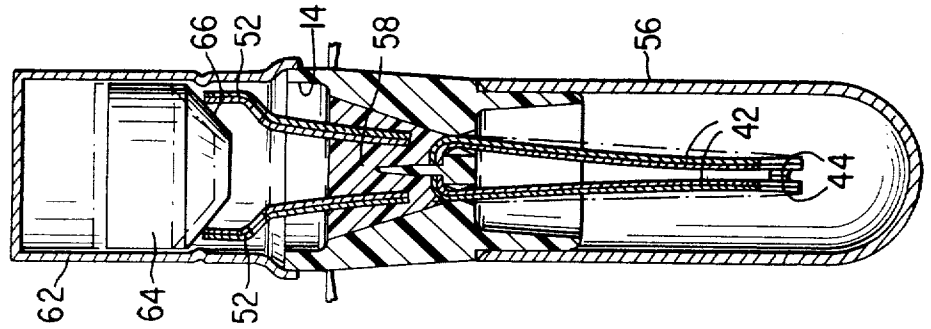

FIG. 9

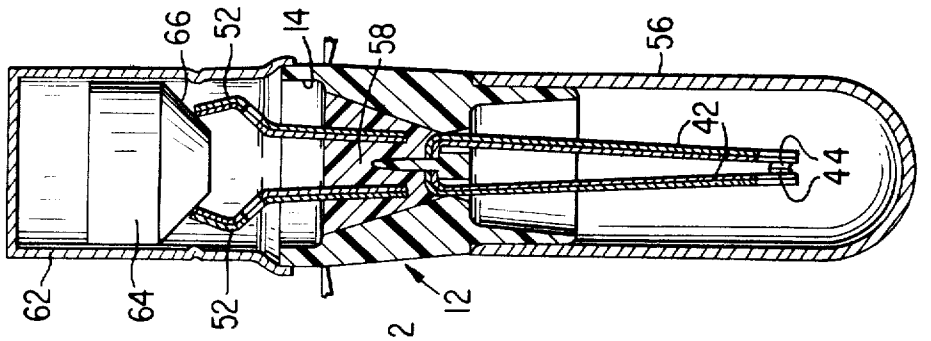

FIG. 8

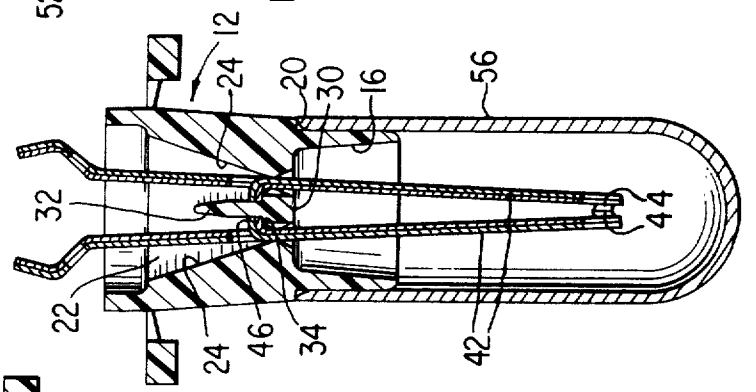

FIG. 7

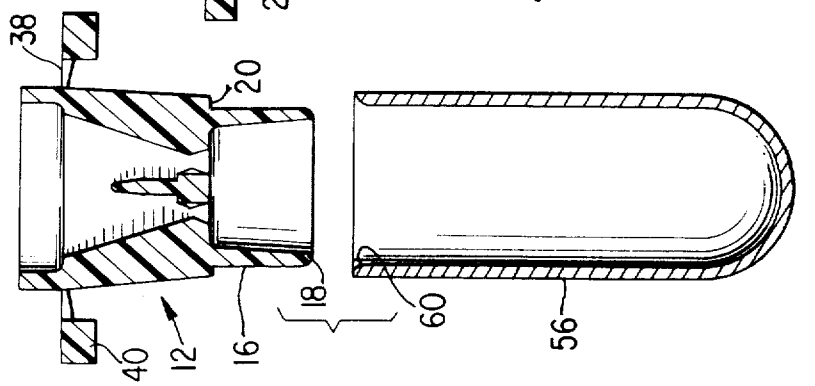

FIG. 6

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THERMALLY RESPONSIVE SWITCH AND METHOD FOR MAKING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to thermally responsive electrical switches and more particularly to an improved calibrated thermally responsive switch and method for making the same wherein the contact elements are protected during assembly.

2. Description of the Prior Art

In the design and construction of thermally responsive electrical switches, it is often desirable to provide protection for the various switch components and especially the contact elements during assembly and to reliably, yet inexpensively provide a temperature-calibrated finished product. Such criteria become extremely important when mass-production techniques are contemplated and where the completed switch is to be used in a critical circuit, such as one which is responsive to the over heating of various devices or assemblies in a major system.

The prior art, as characterized by U.S. Pat. Nos. 2,745,924, 3,148,258 and 3,230,607, is generally cognizant of electrical switches which are calibrated during manufacture. U.S. Pat. No. 2,745,924, for example, discloses a switch in which a pair of contact elements are placed in a multiple section housing with the contact ends held in a fixed position by a spacer **23** as illustrated in FIG. **8**. A base material **24** is molded about the contact elements and is cured at the operating temperature of the switch. Thereafter, spacer **23** is removed to complete the assembly. U.S. Pat. No. 3,148,258 is generally similar to the previously described patent wherein contact elements **1** and **2** are placed in a multisectioned housing and are held, by structure not shown, during the curing of a plastic mass **24**. U.S. Pat. No. 3,230,607 pertains to a switch in which a cylindrical post is axially movable by a bimetallic contact element during the curing of a thermosetting material.

While the prior art switch assemblies, as exemplified by the above, have generally served the purpose, they have proven to be disadvantageous in that the contact elements are not protected during manufacture and are often held in place during the curing cycle by a spacing member which can easily damage the contacts or bend the contact elements as it is being removed, the contact elements generally are not provided with any means for properly positioning the same during assembly, and the finished product is not accurately calibrated as it comes from the assembly line. In addition, conventional methods of making such prior art structures normally are not adaptable to high speed mass-production techniques, resulting in increased costs.

While the problems associated with the design and construction of thermally responsive switches have been recognized for a considerable period of time, an accurate, calibrated thermally responsive switch and a simple and inexpensive technique for manufacturing the same have heretofore been unavailable.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to inexpensively construct a thermally responsive switch which is calibrated during manufacture for accurate and reliable operation.

Another object of this invention is to manufacture a calibrated thermally responsive switch such that the contact elements thereof are protected from damage and/or contamination during assembly.

The present invention is summarized in a thermally responsive switch and method for making the same, the thermally responsive switch being generally characterized as including a container defining an internal passage therethrough having a dividing wall centrally formed therein, the dividing wall having a pair of shoulders at an upper surface thereof, a pair of contact elements including at least one bimetallic element, each

of the contact elements having a projecting tab mediately formed between a contacting end and a terminal end thereof, the contact elements being disposed in the container each adjacent one side of the dividing wall with the tabs facing each other, each of the tabs cooperating with a respective one of the shoulders of the dividing wall under the force of gravity to close the bottom of the container and to position and maintain the contacting ends of the elements together during assembly, and a mass of hardenable material disposed in the container surrounding at least a portion of each of the contact elements and cured at a particular temperature whereby the contact elements open at the particular temperature.

The present invention has a further object in that protruding tabs of a pair of contact elements cooperate with a wall of a base container to position the elements therein, to close the container for receiving a hardenable material, and to cause the elements to move together during assembly for precise calibration.

Another object of this invention is to construct an accurate thermally responsive switch by a simple and inexpensive method.

Some of the advantages of the present invention reside in its simplicity of construction, accuracy in operation, effectiveness in providing precise calibration, and ability to accurately position a pair of contact elements during manufacture while at the same time precluding damage to the electrical contacts resulting in a finished product of superior quality.

Other objects and advantages of the present invention will become apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view of a preferred embodiment of a thermally responsive switch according to the present invention;

FIG. **2** is a plan view of a detail of a plurality of base containers in strip form for use in making the thermally responsive switch of FIG. **1**;

FIG. **3** is a sectional view taken on line **3—3** of FIG. **2**;

FIG. **4** is a front elevational view of a detail of a bimetallic contact element of the thermally responsive switch of FIG. **1**;

FIG. **5** is a side elevational view of the contact element of FIG. **4** and

FIGS. **6–9** are elevational views partially in section illustrative of a method for making a thermally responsive switch according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1–5**, a preferred embodiment of a thermally responsive switch according to the present invention is generally designated at **10** and includes a generally cylindrical base container **12** having an annular rim or shoulder **14** formed upon an upper surface thereof. An annular wall **16** is formed upon a lower surface of container **12** and has a slightly rounded bottom outside edge **18**. As shown in FIG. **3**, wall **16** has a smaller outer diameter than that of the body of container **12** such that the bottom surface of the container forms an annular lip **20**.

A generally rectangular interior void or passage **22** is centrally formed within container **12** and has a pair of inwardly converging opposing side walls **24** extending from the upper surface to a point adjacent the bottom surface where they meet and are contiguous with another pair of inwardly converging side walls **26** extending from the bottom surface. In this manner, side walls **24** and **26** form a pair of parallel ridges **28** as can be seen in FIG. **3**. A rectangular dividing wall **30** extends transversely across passage **22** and has an upwardly protruding peaked portion **32** forming a pair of shoulders or ledges **34**. A pair of laterally protruding, linearly aligned ridges **36** are formed at the ends of each of the flat side surfaces of dividing wall **30** such that each pair of ridges defines a

notch 37 therebetween (FIG. 2). Ridges 36 are constructed to be parallel to and laterally aligned with ridges 28 of the interior passage 22 as shown in FIG. 3.

The upper end of container 12 has a pair of frangible fingers 38 radially extending from either side to a pair of outside runners 40. Fingers 38 have a tapered cross-section with the narrow end or apex attached to an upper peripheral edge of the container such that the fingers may be easily separated from the container 12 after assembly of the switch.

The container 12 may be used singly or in strip form, as illustrated in FIG. 2, depending upon the contemplated production techniques to be employed. In either case, the runners 40 facilitate rapid handling of the containers thereby reducing time and costs during assembly of the switch. It is important to note that the containers are constructed as a unitary structure and are preferably molded as such from a suitable plastic material. The unitary construction assures proper positioning of the contact elements of the switch assembly and precludes the possibility of container leakage during manufacture. In this manner, additional manufacturing steps formerly required in carefully assembling and aligning sectioned containers are effectively eliminated.

Thermally responsive switch 10 further includes a pair of identically constructed elongated flat contact elements 42. Each of the contact elements has a diagonal contact 44 formed near one end thereof by any suitable means such as by swaging with the contact face parallel to the flat surface of the element as shown in FIGS. 4 and 5. The diagonal positioning of the contacts is preferred since it permits the use of identical contact elements for lower cost while assuring positive contact in the event of slight misalignment.

At some point, generally about three-fifths of the total length of element 42 from the contact end, a protruding stop in the form of a tab 46 bent normal to the plane of the element is provided for cooperation with shoulder 34 of container 12 during assembly. The portion of the contact elements above tab 46 serves as a supporting means for the element with the aperture 48, left after tab 46 is bent, serving to rigidly lock each element in place, as will be more fully described below.

Each of the contact elements 42 further defines a centrally located hole 50 in an oblique portion joining the supporting portion and an offset terminal portion 52 of the element, as visualized in FIG. 5. Hole 50 cooperates with offset portion 52 to receive the bare end of one of a pair of lead wires 54 (FIG. 1) for the switch with offset portion 52 acting to laterally support the lead wires and to provide an increased area to which the wires may be soldered.

At least one of the contact elements 42, and preferably both, are bimetals and are inserted from the contact end down into passage 22 of container 12, one on either side of dividing wall 30, with their high expansion sides facing each other. It is noted that the contact elements may be constructed for disposition within container 12 with their low expansion sides facing each other if it is desired to have the switch contacts open upon being cooled. The contact elements are preferably gold-plated for environmental protection and to improve their electrical conductivity. In the preferred embodiment, two bimetal contact elements are disposed in opposing relation to reduce premature opening of the switch below the normal operating temperature when subjected to shock and/or vibration. Because of the opposing relationship of the bimetals, twice the contacting force is provided to maintain the switch closed at all temperatures below the operating temperature.

Prior to the insertion of contact elements 42 into container 12, the container is attached to a suitable cylindrical cover 56 (FIG. 1) with annular wall 16 so sized with respect to the inner dimensions of the cover to provide a tight press-fit attachment therebetween. Cover 56 preferably has a rounded closed end and is constructed of a metal or metal alloy since such materials exhibit good thermal conductivity characteristics. It should be understood, of course, that the cover may be made of other materials, such as plastic or glass, as desired. The active portion of each of the contact elements 42 is enclosed within the cover 56 with the space between the elements filled with air or gas. Sufficient clearance is provided in this area to permit the elements to operate over a wide temperature range without contacting the cover wall.

After the cover 56 is attached to the container 12 and the contact elements 42 have been inserted, a mass of a suitable hardenable material 58, such as epoxy resin, in its uncured, liquid or semi-liquid form is poured into the container surrounding the supportable portions of the contact elements to secure the same within the base. After curing, the container 12 and the hardenable material 58 interact to form an integral support base for the contact elements, as shown in FIG. 1. Thereafter, the frangible fingers 38 are separated from the body of container 12, and the entire assembly may be installed as is or may be sealed first, as by dip-coating with a suitable sealing or electrically insulating material (not shown).

The method of assembling and calibrating the thermally responsive switch of the present invention is illustrated in FIGS. 6–9. Initially, annular wall 16 of container 12 is press-fit into the open end of cover member 56 as shown in the exploded view of FIG. 6. It is noted that the rounded lower corner 18 of wall 16 cooperates with a rounded inner edge 60 of the cover 56 to facilitate assembly. As shown in FIG. 7, the container 12 is forced into the cover until annular lip 20 abuts the upper edge of the cover.

With the cover 56 thus in position, the interior of the switch assembly is protected and is maintained free of dust, dirt or other contaminants which in the past have undesirably affected switch operation and accuracy. The contact elements 42 are then dropped into the upright container 12 from the top as visualized in FIG. 7. It is important to note that since the cover 56 is affixed to container 12 prior to the insertion of contact elements 42, the elements are not only protected from dust and dirt but are also shielded from external contact and are thereby protected against damage during assembly.

As the contact elements are placed into container 12, the contact ends thereof engage inclined side walls 24 of passage 22 and the upwardly protruding portion 32 of dividing wall 30 which cooperate to guide the contact elements between parallel ridges 28 and 36 (FIG. 3). Clearance is provided by notches 37 for the contacts 44 which continue past the ridges to permit the elements 42 to drop down into the cover 56 until tabs 46 contact shoulders 34 of wall 30. The tabs 46 and the shoulders 34 cooperate to perform three primary functions; namely, to act as stops for properly positioning both contact elements within the cover 56 as shown in FIG. 7, to close off the bottom end of container 12, especially notches 37, for assuring retention of the uncured hardenable material therein, and to cause the contact elements to pivot together at their contact ends under the force of gravity for maintaining the contacts 44 touching without using springs, contact spacers or the like which, in the past, have proven to be unsatisfactory with respect to the accuracy of the finished product.

Referring to FIG. 8, a mass of uncured hardenable material 58 is poured into the upper end of passage 22 surrounding the supportable portions of contact elements 42 with some of the material flowing into apertures 48 (FIG. 4) of the contact elements so as to prevent the elements from becoming inadvertently pulled out of the base during or after installation of the completed switch assembly. A calibration jig, to be described below, may be used to assist the gravity produced action of tabs 46 and shoulders 34 for maintaining a predetermined light contact force between contacts 44 during the curing cycle. Such contact force may be desirable under certain conditions which might be detrimental for millivolt switching, for example.

The calibration jig preferably includes a cylindrical support sleeve 62 which is closed at its upper end and open at a flanged lower end designed to fit over annular shoulder 14 of the container 12. A generally cylindrical plug 64 is mounted within sleeve 62 for free axial movement therein with the lower end of the cylinder tapered to form a frustro-conical surface 66 adapted to engage the upper ends of the contact

elements 42. The plug 64, under its own weight, exerts an extremely small force on the contact elements tending to maintain the contact ends of elements 42 touching under a light force during the curing cycle.

FIG. 9 illustrates the position of the elements during the calibrating cycle at which time the entire assembly is subjected to head and is maintained at a desired operating temperature for the switch. The hardenable material 58 is selected to be curable at the desired operating temperatures of the switch such that as the material begins to harden, the contact element 42 will assume and maintain a flexed shape corresponding to their desired calibrated positions. Due to the action of tabs 46 and shoulders 34, with the assistance of plug 64 of the calibration jig, the contact ends of elements 42 are pivoted toward each other and, in this manner, remain touching during the calibrating cycle with plug 64 moving downwardly to accommodate the flexure of the contact elements. Due to the above construction, calibration springs, spacing members, and the like are eliminated with the contacts positioned primarily by gravity. This results in greater accuracy and assures standardization of the finished product. It is pointed out that the ridged construction of the lateral walls 24 and 26 of passage 22 allow unrestricted movement or flexure of the contact elements such that they are not subjected to stresses which would otherwise adversely affect the switch calibration. The flexure of the contact elements 42 may be seen from a comparison of FIG. 8, illustrating the assembly prior to heating, and FIG. 9, showing the assembly during the calibrating step. It is noted that during calibration, the plastic container 12 interacts with the mass of material 58 to provide a bonded integral support base for contact elements 42 which increases the durability of the completed assembly.

Following the calibrating cycle, the heat source is removed and the calibration jig is separated from the switch. Thereafter, the lead wires 54 (FIG. 1) are soldered to the terminal ends of contact elements 42, and the frangible fingers 38 are sheared off thereby removing the runners 40 from the completed switch assembly 10.

In operation, the contacts 44 of the completed switch assembly 10 will remain closed until the calibrated operating temperature is reached at which point the contact elements will assume the shape in which they were maintained during the calibration or cure cycle, with contacts 44 slightly touching. Upon being heated above this temperature, the contacts will move apart to provide an electrical open circuit. After the switch is again cooled to the calibrated temperature, the contacts will contact each other, as before, to provide an electrical closed circuit. In this manner the switch is effectively calibrated to operate at the pre-selected operating temperature at which the switch subassembly was cured.

Many of the advantages of the present invention can be seen in the above described simple method for making a thermally responsive switch, which method may be summarized as including the steps of supporting a container having an internal passage in an upright position, the passage separated by a dividing wall having a pair of shoulders at an upper surface thereof, forming a protruding tab on each of a pair of contact elements between the contact and terminal ends thereof, the pair of contact elements including at least one bimetallic element, inserting each of the contact elements downwardly into the container on either side of the dividing wall with the projecting tabs facing each other, releasing the contact elements such that the tabs cooperate with the shoulders of the dividing wall under the force of gravity to position the contact elements in the container, to close off the bottom of the container, and to cause the contact ends of the contact elements to pivot against each other, placing a mass of hardenable material into the passage of the container, and heating the filled container and the contact elements to a preselected operating temperature whereby the operating temperature of the contact elements is calibrated as the hardenable material cures.

Thus, the present invention enables the simple, rapid and inexpensive manufacture of thermally responsive switches on a mass-production basis with the contact elements shielded from damage and with each of the switches having a precise operating temperature and being durably and accurately constructed for reliable operation.

Inasmuch as the present invention is subject to many variations, modifications and changes in detail, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A thermally responsive switch comprising

a container defining an internal passage therethrough having a dividing wall centrally formed therein, said dividing wall having a pair of shoulders at an upper surface thereof,

a pair of contact elements including at least one bimetallic element, each of said contact elements having a projecting tab mediately formed between a contacting end and a terminal end thereof,

said contact elements being disposed in said passage of said container, each adjacent one side of said dividing wall with said projecting tabs facing each other, each of said tabs cooperating with a respective one of said pair of shoulders of said dividing wall under the force of gravity to close the bottom of said dividing wall under the force of gravity to close the bottom of said container and to position and maintain the contacting ends of said contact elements together during assembly, and

a mass of hardenable material disposed in said container surrounding at least a portion of each of said contact elements and cured at a particular temperature whereby said contact elements open at said particular temperature.

2. The invention as recited in claim 1 wherein each of said pair of contact elements comprises an elongated flat bimetal having a diagonally disposed contact formed on the contacting end thereof.

3. The invention as recited in claim 1 wherein said dividing wall of said container includes an upwardly directed peaked protrusion formed centrally thereon and separating said pair of shoulders.

4. The invention as recited in claim 3 wherein said dividing wall further includes a plurality of ridged projections formed at the ends of each of the lateral walls thereof, said ridges being linearly aligned.

5. The invention as recited in claim 4 wherein said internal passage of said container is defined by a pair of inwardly convergent opposing side walls peaked to form a pair of parallel ridges laterally adjacent said ridges of said dividing wall.

6. The invention as recited in claim 1 wherein said projecting tabs are formed normal to the plane of said contact elements.

7. The invention as recited in claim 6 wherein each of said projecting tabs are bent from a respective one of said contact elements to form an aperture, and wherein said mass of material is partially disposed within the apertures of said contact elements.

8. The invention as recited in claim 1 further including a hollow cover member having a closed end and an open end, said container being connected with said open end of said cover member with said contacting ends of said contact elements disposed interiorly of said cover member.

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