July 19, 1966 K. B. PRIVAL 3,261,939

ENCAPSULATED CIRCUIT CONTROLLING DEVICE

Filed Dec. 20, 1962

FIG. 1

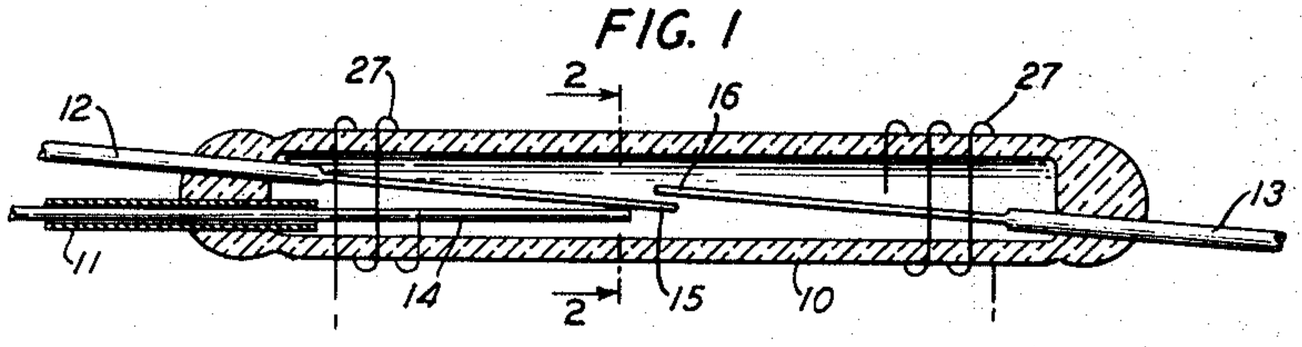


FIG. 2

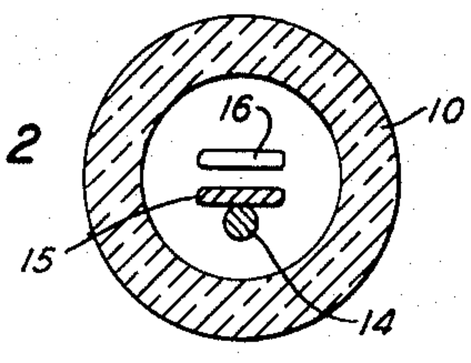


FIG. 3

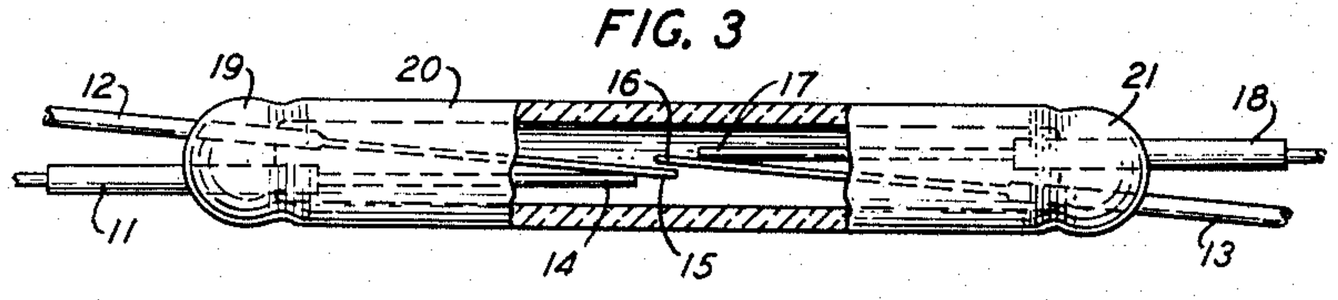


FIG. 4

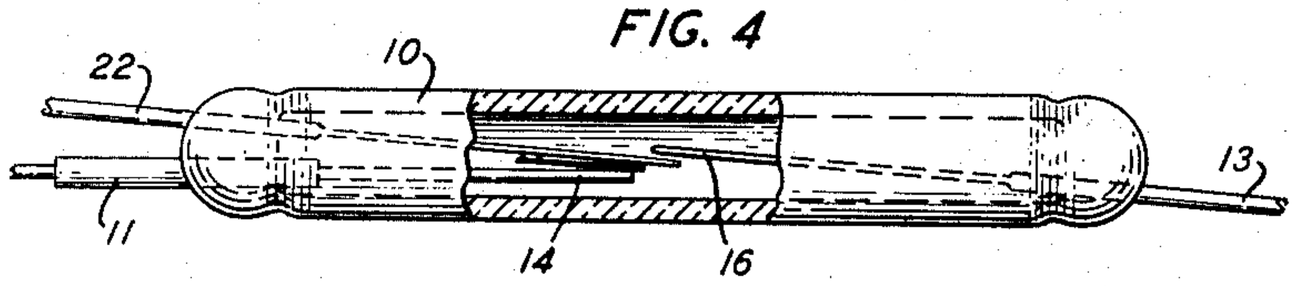
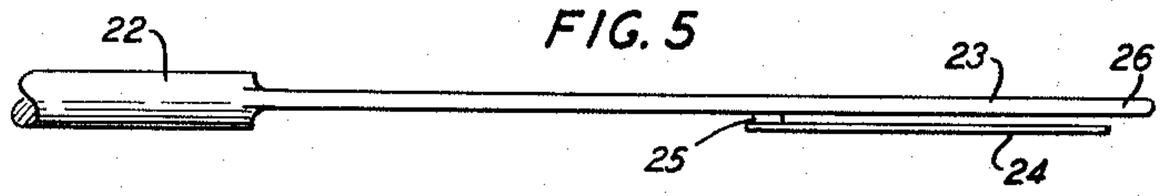


FIG. 5



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ENCAPSULATED CIRCUIT CONTROLLING DEVICE

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This invention relates to circuit controlling devices and, more specifically, to reed devices of the switch, relay, or transfer type.

In general, circuit controlling devices of the reed type comprise a plurality of conducting elements encapsulated within a sealed container; the number depending upon the design function of the device. All, or some of the elements, are usually made from materials sensitive to magnetic forces and the most usual encapsulating material is glass.

The transfer type switch presented by a substantial part of the prior art comprises three electrically conducting elements sealed in a definite geometric pattern in the extremities of an elongated glass tube. For the purpose of description, the elements can be referred to as a front contact member, back contact member, and a swinger contact member. The geometric pattern previously referred to generally comprises the sealing of the back contact contiguous to the swinger in contrast to the spaced positioning of the front contact. The individual contacts can be fixed in either end of the tube depending on the mechanical configuration desired.

The device, as described above, is in the unoperated position, that is with the swinger in electrical continuity with the back contact. The operated position is acquired by subjecting the device to an appropriate actuating force such as a magnetic force or force field. This can be accomplished by bringing the encapsulated structure into physical proximity of a permanent magnet, magnetic field, or by passing current through turns of wire that have been wound around the glass tube. If the swinger and front contact are of magnetic material or if all the contact members are of magnetic material but a preferential flux path has been established between the swinger and the front contact due to their physical design, proximity, and material, the swinger will traverse the spacing between it and the front contact. By establishing electrical continuity between the swinger and the front contact and a space or open circuit between it and the back contact, the switching or transfer function of the device will be performed. The last described situation is called the operate, operated, or transfer position.

When the actuating or magnetic force is terminated by removing the magnet or ceasing the flow of current through the turns of wire, the swinger returns to its natural, free, or unoperated position contiguous to the back contact. In order to insure the return of the swinger member to contiguity with the back contact, it is desirable to prestress, in some way, the two latter mentioned elements against each other. The prestressing creates an adequate contact force between the swinger and back contact to secure electrical continuity but because of the dimensions of the various elements, their critical spacing, and physical properties, serious problems are encountered in the manufacture of devices similar to the invention.

In particular, the physical dimensions of the electrical elements formed from magnetic material determine the limits of magnetic flux that can be generated within the elements before they become saturated. The physical dimensions further define the force necessary to deflect the swinger across the gap between it and the front contact. Therefore, the cross sections of the elements must be large enough to allow the build up of magnetic forces sufficient to attract the movable members across the air gap yet not so great that the force required to move the swinger across the space cannot be generated before the elements become magnetically saturated. The spacing between the elements is also critical because it directly affects the force necessary to close the gap between the swinger and the front contact.

In addition, if the prestressing between the swinger and the back contact is too great, there is a tendency for the back contact to follow the swinger, when it is magnetically operated, across the spacing and short circuit all three elements. If it is too little, when the magnetic biasing is released, the swinger and back contacts might have a tendency to oscillate which may result in intermittent breaks in electrical continuity called chattering. This directly affects the speed or response of the device since it is extremely difficult to accurately operate the mechanism when any of its parts are in motion.

Obtaining the proper magnitude of prestressing between the movable or swinging member and the back contact introduces further problems. If the degree of prestressing between the movable member and the back contact and the critical spacing of the elements within the envelope are attempted to be defined before they are sealed in the encapsulating material, the heating and cooling of the material may substantially alter or anneal away the desired properties and can, in some instances, introduce unwanted patterns.

The critical problem therefore arises in establishing, during the manufacturing process, the contact force between the swinger element and the back contact and the spacing of the various elements within the device once the physical dimensions of the elements have been determined.

It is an object of the invention to improve the construction and operation of these devices.

Another object is to improve the manufacturing processes and techniques involved in producing reed type devices.

A further object is to provide control and adjustment of the contact force between the various electrical elements contained within reed-type devices.

A specific object is to improve the structure of miniature encapsulated devices by providing a working access or aperture to the interior of the container.

Another specific object of the invention is to improve the operation of miniature switching devices by diminishing the deflection of a movable member required to produce an adequate degree of contact force.

In accordance with the preferred embodiment of the invention, it comprises a plurality of elements sealed within the ends of an elongated tubular container or envelope. At least one of the sealed elements is a tube or duct member through which an electrical conductor can be inserted until it comes into physical and electrical contact, on the inside of the envelope, with another of the elements that has been fixed in an envelope end. The inserted member becomes the back contact and the other element becomes the movable or swinger member. The contact force between the members can be adjusted and controlled by the depth of insertion of the back contact member. When the proper degree of contact force has been obtained, a portion of the duct or tube can be physically deformed or crimped and sealed about the wire inserted therethrough.

Such a structure provides obvious advantages. All elements of the device can be sealed within the ends of the glass container in a free or unstressed condition while the container material, glass in most instances, is hot without fear of annealing away any desired stress patterns.

The stresses or contact forces desired between the swinger and back contact members are induced through the insertion process when the container material is cold thereby alleviating the problem of annealing the sealed members.

Another advantage is the furnishing of a means of controlling and adjusting the amount of contact force by the insertion of the back contact through the tube.

A still further advantage of the device is that it can be purged of atmospheric imperfections by filling and sealing an inert gas within the glass envelope or container. The container can be filled after structural completion through the tube that contains the back contact member before it is crimped and sealed closed.

The advantages of the invention are obtained through its features one of which is the sealing within one end of an elongated glass container, along with a plurality of electrically conducting elements, of a tube through which a back contact member may be inserted and which provides access for the purposes of controlling and adjusting contact forces, spacing of elements, and through which atmospheric conditions can be defined.

Another feature is a special movable member having a leaf or auxiliary cantilever spring attached in such a way as to enhance the contact force between the member and another conductor for a given deflection of the member.

Other objects, advantages, and features will be obvious and understood from the following detailed description, when read in conjunction with the drawing, in which:

FIG. 1 is a sectional view of one embodiment of the invention;

FIG. 2 is a sectional view taken generally along line 2—2 of FIG. 1;

FIG. 3 is a sectional view of another embodiment of the invention;

FIG. 4 is a sectional view of a still further embodiment of the invention having a special swinger member; and

FIG. 5 is a plan view of the special swinger member that is incorporated in the device of FIG. 4.

In accordance with the various figures and specifically with reference to FIGS. 1 and 2, the device comprises an elongated container **10** sealed in the ends of which are a variety of elements including an apertured element or an access tube **11** and two reed members **12** and **13**. Those portions, including the ends, of the members **12** and **13** that are encapsulated within the container **10** are flattened in cross section into a ribbon or reed-type generally rectangular cross section. One dimension of the rectangle is much greater than the other dimension and the reeds, therefore, have a tendency to bend preferentially in the direction of the smaller rectangle dimension. For the purpose of disclosure, the movable member **12** will be designated as a swinger or swinger member and the member **13** will be designated as a front contact or front contact member.

The swinger **12** and the front contact **13** are held within the container **10** such that their ends **15** and **16** respectively, are in a spaced apart relationship in the unoperated position shown in FIGS. 1 and 2. The apertured element or access tube **11** is held in the end of the container **10** such that its axial line intercepts the swinger **12** near its end **15**. A back contact **14** crimped within the access tube **11** is in electrical and physical contact with the swinger end **15**.

The invention is assembled by sealing the tube **11** and the two reed members **12** and **13** in the ends of the container **10** while the container material is still hot. Because the elements are in a free position and not in a deflected or prestressed state, the heat from the container does not affect them in that it cannot anneal away any desired contact forces or stresses that are to be subsequently generated. After the container material has cooled, the back contact **14** is inserted through the access tube **11** until it contacts the swinger end **15**. It is apparent that the degree of insertion of the back contact **14** within the tube **11** determines the contact force between the back contact **14** and the swinger end **15** and the gap spacing between the swinger end **15** and the front contact end **16**. The contact force and reed spacing, can be controlled and adjusted by the amount of insertion of the back contact **14**. The contact force and spacing of the elements **12** and **13** are not subject to the annealing heat of the hot container material because they are established subsequent to the cooling of the container **10**.

After the desired amount of contact force between the swinger **15** and the back contact **14** has been established, a portion of the duct or access tube **11** may be crimped, or in some other similar manner, physically deformed and sealed around the back contact **14** to fix or making permanent the physical relationship of the elements within the container **10**. It is to be noted that the access tube **11** can further be used to defining the atmosphere inside the container **10** if a special environment, such as an inert argon atmosphere, is desired.

The invention is operated by subjecting it to an actuating force such as a magnetic force field. Such a field may be generated by passing a current through turns of wire **27** that have been wound around the container **10**. The swinger **12** and the front contact **13** are formed from material sensitive to magnetic forces. The current passing through the wire turns induces lines of magnetic flux in the two members. As a result of the magnetic force field in the air gap, the swinger end **15** is attracted away from the back contact **14** and to the front contact end **16**. Electrical continuity then exists between the swinger **12** and the front contact **13**. When the current is stopped or the magnetic field removed, the swinger **12** snaps back against the back contact **14**.

The above discussion of the magnetic operation is of a summary nature in that it is well known in the art and not part of the novelty of this invention. In conjunction with the prior art, it is also well known that the back contact can be either of magnetic or non-magnetic material without affecting the operation of the device.

FIG. 3 illustrates another embodiment of the invention in that the device shown is capable of a multiplicity of switching functions. FIG. 3 describes a device comprising an elongated container **20** having sealed in each of its ends a reed member and an access tube. In end **19** of container **20** is sealed a swinger member **12** and an access tube **11** while in end **21**, access tube **18** and front contact member **13** are sealed. Crimped or permanently fixed within the tube **11** is a back contact member **14** and within tube **18** is a second back contact member **17**. The device is assembled as previously described with relation to the switch illustrated in FIGS. 1 and 2.

The invention as shown in FIG. 3 is in an unoperated position, that is, the swinger end **15** is contiguous to the back contact member **14** and the front contact end **16** contiguous to the second back contact **17**. When the device is subjected to a magnetic force field or operated, the field attracts the swinger end **15** and the front contact end **16** to each other transferring electrical continuity from members **12** and **14**, and **16** and **17** to members **12** and **16**. Air gaps or electrical discontinuities are established between the elements **14** and **15** and between the elements **16** and **17**. The removal of the magnetic force allows the device to snap back to its previously described unoperated position. The operation of the device described above is only exemplary of a number of switching combination possibilities inherent in such a device and obvious to those skilled in the art.

FIG. 4 illustrates a further embodiment of the invention wherein the device shown in FIG. 1 is modified with the special swinger member **22** shown in FIG. 5. A leaf or auxiliary cantilever spring member **24** is fastened to the main portion or flattened section **23** of the reed on the side adjacent the back contact **14**. The leaf **24** is attached to the reed **23** at a point **25** distant from the reed end **26** and so located that when the back contact **14** is in-

serted into the tube 11, the back contact 14 comes into contiguity with with the member 24.

The spring constant of the leaf 24 is large enough to prevent the deflection of it into physical contact with the main portion 23 when the desired contact force is obtained. The incorporation of the auxiliary cantilever spring member 24 shortens the effective lever arm of the reed because when the leaf 24 is deflected by the back contact 14, the resulting force applied towards the deflection of the reed 23 is essentially, in effect, applied at the attaching point 25 and not the end 26 where the force would normally be applied. The reed lever arm has been shortened by approximately a distance equal to the difference of the reed length between its end 26 and the lever attaching point 25. The result and importance of shortening the effective reed lever arm is to supply at least an equal amount of contact force for a smaller deflection of the reed end 26 than would normally be obtained by the same deflection of the reed end 15 in the device shown in FIG. 1.

The manufacture and operation of the device shown in FIG. 4 is similar to those previously described.

Although three embodiments of the invention have been disclosed, it will be obvious to those skilled in the art that modifications too numerous to mention, some of which have been alluded to in the specification, may be made without departing from the scope of this disclosure and the appended claims.

What is claimed is:

1. A controlling device comprising a hollow container having a first contact, a movable element, and a duct member sealed within the walls of said container, said member including a deformable portion, a second contact extending through said member, said element being spaced from and overlapping said first contact, said element further comprising a reed-type main portion having a free end and an auxiliary cantilever leaf juxtaposedly secured to said main portion at a point distant from said free end, said leaf being spaced from said main portion at all times, said second contact being in physical and electrical continuity with the free end of said leaf, said leaf providing at least the same contact force between said leaf and said second contact for a smaller deflection of said main portion than would be obtained by the same deflection of said main portion by said second contact being in continuity to said main portion, because of the effective foreshortening of the lever arm of said element, said deformable portion being physically deformed about said second contact sealing the inside cavity from the outside environment of said container and, actuating means operatively influencing said element between said first and second contacts.

2. A controlling device comprising an elongated tubular container sealed on both ends having a first contact, a swinger member and a tube sealed in its ends, said tube having a deformable portion and a second contact contained therein, said swinger comprising a reed-type main portion having a free end and an auxiliary cantilever leaf juxtaposedly secured to said portion at a point distant from said free end, said leaf being spaced from said portion at all times, said second contact being in electrical continuity with the free end of said leaf, said swinger member located between said second contact and said first contact and spaced from said last named contact, and actuating means operably moving said swinger between said first and second contacts.

3. A switch device comprising a hollow container having at least one movable element and at least one tube sealed within the walls thereof, said tube further having a deformable portion and an electrical conductor sealed within, said element comprising a main portion having a free end and an auxiliary cantilever leaf juxtaposedly secured to said portion at a point distant from said end, said leaf being spaced from said portion at all times, said conductor being in physical and electrical continuity with said leaf of said element, and actuating means external to said container operatively moving said element away from said conductor and disrupting said continuity.

4. A controlling device comprising a hollow container having a plurality of movable elements and a plurality of tubes sealed within the walls thereof, said tubes having deformable portions and electrically conducting means sealed within, each of said elements further comprising a main portion having a free end and an auxiliary cantilever leaf juxtaposedly secured to said portion at a point distant from said end, said leaf being spaced from said portion at all times, said means being contiguous to said leaves of said elements and said elements being in a spaced and overlapping relationship to each other, and actuating means outside of said container operatively influencing said elements away from said means and contiguous to each other.

5. A controlling device comprising a hollow container having at least one electrically conducting element and a plurality of apertured members sealed within the walls thereof, each of said members further having deformable portions and electrically conducting means sealed therein, said element further comprising a main portion having a free end and an auxiliary cantilever leaf juxtaposedly secured to said portion at a point distant from said end, said leaf being spaced from said portion at all times, one of said conducting means contacting said leaf of said element and the other means being overlapped and spaced therefrom, and actuating means outside of said container operatively moving said element between said spaced means.

6. A controlling device comprising a hollow container having a plurality of electrically conducting means and at least one apertured element sealed within the walls thereof, said element comprising a tube having a deformable portion, one of said means being a movable member, said means being in a spaced and overlapping relationship with each other within the interior of said container, said member further comprising a main portion having a free end and an auxiliary cantilever leaf juxtaposedly secured to said main portion at a point distant from said end, said leaf being spaced from said main portion at all times, said conductor being sealed within said tube by said deformable portion of said element about said conductor, said conductor being contiguous to said leaf, and actuating means outside of said container operatively moving said member away from said conductor and into contiguity with another of said first named means.

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