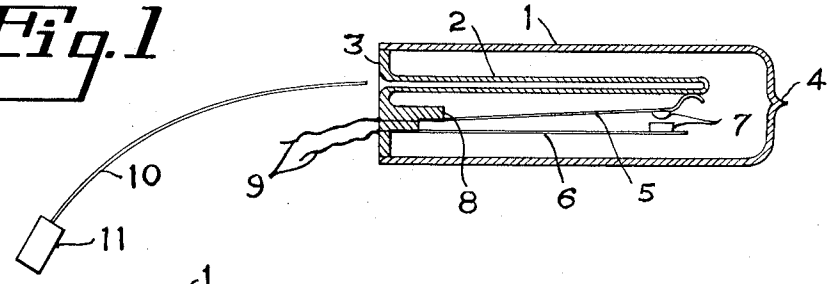
Nov. 29, 1955 C. BOSCH 2,725,445

HERMETICALLY SEALED APPARATUS

Filed April 8, 1952 2 Sheets-Sheet 1

Fig. 1



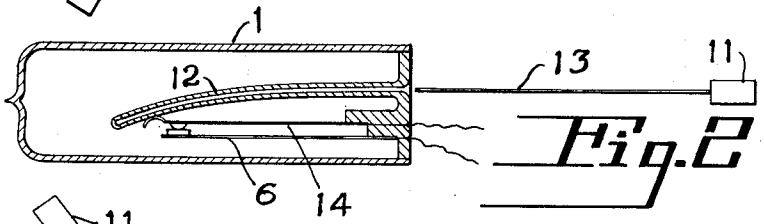


Fig. 2

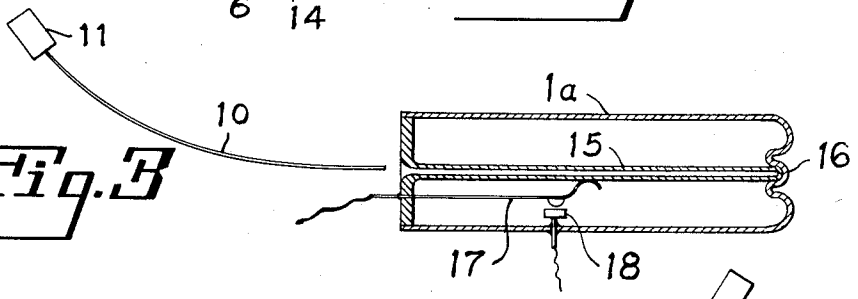


Fig. 3

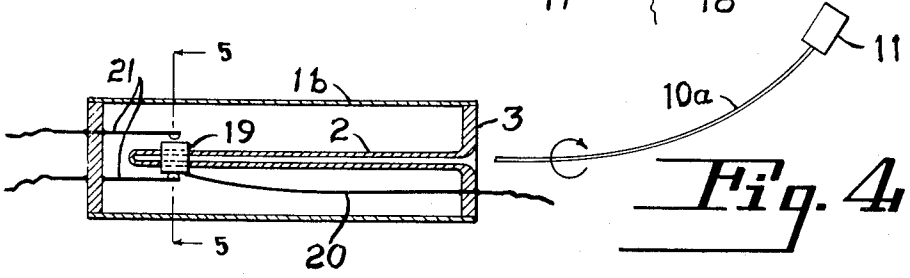
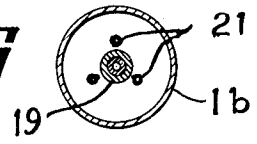


Fig. 4

Fig. 5



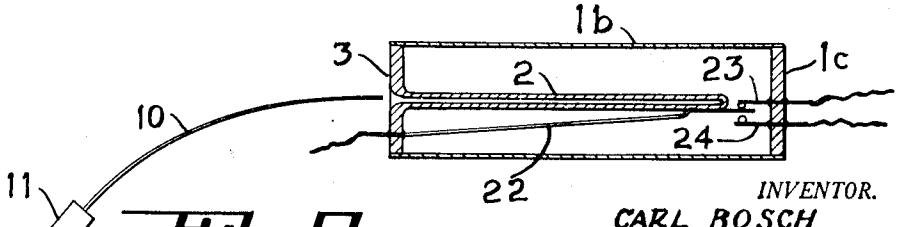


Fig. 6

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HERMETICALLY SEALED APPARATUS

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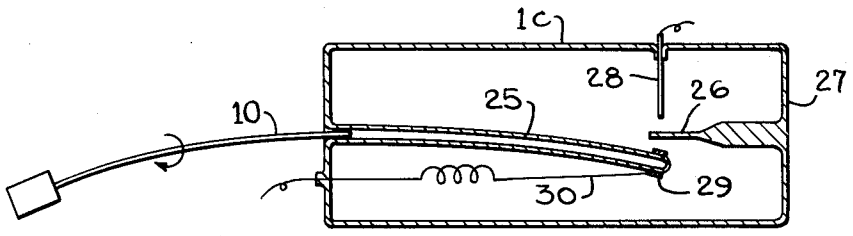

Fig. 7

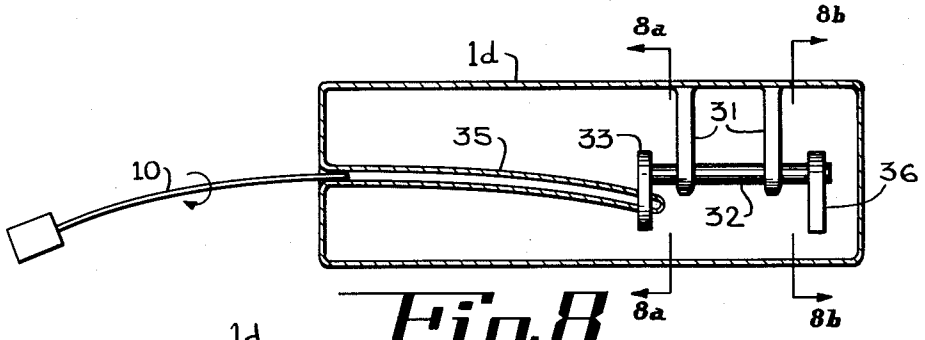

Fig. 8

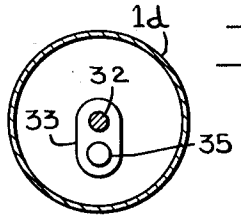

Fig. 8a

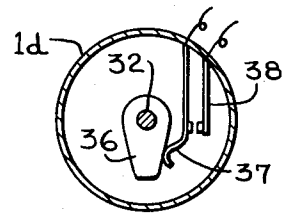

Fig. 8b

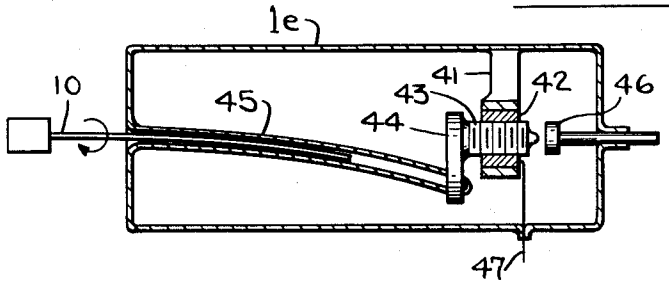

Fig. 9

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HERMETICALLY SEALED APPARATUS

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Application April 8, 1952, Serial No. 281,235

13 Claims. (Cl. 200—144)

This invention relates to hermetically sealed apparatus and more particularly to means for operating an electrical switch or for adjusting the position of a member which is enclosed in an hermetically sealed envelope.

A primary object of the invention is to provide an hermetically sealed envelope for electrical or other apparatus in combination with means for varying space relations between different elements of the apparatus contained within the envelope, such means being operable from outside the envelope in a purely mechanical manner.

In carrying out my invention the use of electromagnetic actuating means is avoided and, furthermore, it is not necessary to tilt the envelope in the manner required for the operation of a mercury switch, for example.

Another object is to provide means whereby a part within such an envelope may be translated.

A further object is to provide means whereby a part within such an envelope may be rotated.

Other objects will become apparent from the following description taken in connection with the attached drawings showing several illustrative embodiments of the invention and wherein:

Fig. 1 shows a typical embodiment of my invention, the view being taken in longitudinal cross-section through the axis of a tubular envelope which contains a capillary tube coacting with a movable element which may take the form of a switch contact. A second switch contact is also shown, and outside of the tube is shown a slender bent rod which can be inserted within the capillary tube in order to actuate the switch.

Fig. 2 is another cross-sectional view similar to Fig. 1, but differing from the same in that the capillary tube is shown bent and the actuator rod is substantially straight before being inserted within the capillary tube.

Fig. 3 shows a modified form which involves the provision of rigid supports for both ends of the capillary tube.

Fig. 4 shows another modification wherein there is a metallic collar surrounding the free end of the capillary tube, and contact elements surround this collar. The actuator rod, being round, can be rotated within the capillary tube so as to lean it and its collar into contacting engagement with none or any selected one of the surrounding contact elements.

Fig. 5 shows a transverse cross-section on the plane 5—5 of Fig. 4, looking toward the left end of the envelope.

Fig. 6 shows still another modification in which the contact elements are arranged to serve as a single-pole double-throw switch.

Fig. 7 shows a further modified form somewhat similar to the form of Fig. 4 showing means to prevent closing of the contact due to shock or vibration.

Fig. 8 shows another form including a rotary element actuated from the outside of the envelope.

Fig. 8*a* is a cross-section on the line 8*a*—8*a* of Fig. 8.

Fig. 8*b* is a cross-section on the line 8*b*—8*b* of Fig. 8, and Fig. 9 shows another form, including a rotary screw-threaded member actuated from the outside of the envelope.

Referring first to Fig. 1, the envelope 1 therein shown may be made of glass or other material suitable for its impervious characteristics so that, if desired, the interior may be highly evacuated, or may be filled with a suitable gas at any practical gas pressure. Within the envelope is a slender capillary tube 2 which is closed at the inner end and is, at its other end, open to the outer atmosphere where it is integrally joined to a wall portion 3 of the envelope. The showing of the transverse diameter of the capillary tube is to be understood merely to be of suggestive proportions. Actually the tube is usually very slender in order to give it a certain degree of flexibility so that its free end may be moved sufficiently to operate a member within the envelope such as to effect make and break relations between a movable contact element 5 and a stationary contact element 6.

The contact elements 5 and 6 may be conveniently constructed with contact points 7 and may be mounted in any suitable manner, as by being fastened to certain ledge portions 8 of the wall 3, the latter being part of the wall portion of the envelope. The envelope, in fact, comprises, preferably, the two portions 1 and 3 which are fused or welded together after assembling with the tube 2 and with the contact elements 5 and 6. After fusing or welding or otherwise joining these parts to form an effective hermetic seal, the interior of the envelope may be connected to a vacuum pump at the tip end 4, the envelope evacuated to a desired low gas pressure and optionally filled with an inert gas, then sealed off, as is conventionally done in the manufacture of electronic tubes.

The wall portion 3 may be considered to correspond substantially with a so-called "press" which forms an element of a conventional vacuum tube or incandescent lamp. Through the wall of this press wires are inserted while the glass is kept close to the fusing point. Well-known practices of insuring against gas leakage around the wires 9 where they enter the envelope are, of course, to be followed according to tube or lamp manufacturing techniques which constitute no part of the instant invention.

In order to deflect the capillary tube 2 and to cause it to move the contact spring 5 so as to bring the contact points 7 of this spring and the contact spring 6 into a make relationship, I employ an operator 10 such as a slender wire, rod, or strip (hereinafter termed wire) for insertion in the capillary tube 2. The wire is curved when free from stress. When inserted into the straight tube 2, however, with the bowed side upward, the internal stress developed in the wire 10 produces a downward deflection of the closed end of the tube 2 so as to obtain mutual contact between the contact points 7. The switch members are, therefore, subject to a change of their make-break relationship under control from outside of the envelope, the member 10 being used as an actuator. At the outer end of the wire 10 any convenient knob 11 may be used for manipulation. It is apparent that if the actuator is to be automatically controlled, means (not shown) may be mechanically coupled to the wire 10 for such control.

According to the embodiment shown in Fig. 2, the capillary tube 12, replacing tube 2 of Fig. 1, has a certain initial curvature of its axis and its closed end leans against a movable contact 14. The two contacts 14 and 6 are shown as standing normally in a make relationship. A normally substantially straight rod or wire 13 has sufficient stiffness so that when inserted in the tube 12 the latter is caused to be straightened to a certain extent, thereby breaking contact between the contact members 6 and 14. If desired, however, the bent actuator wire 10, shown in Fig. 1, may be used with its convex side held

downwardly, so as to exert the necessary straightening effect on the tube **12**.

In Fig. 3 I have shown a modification of my invention wherein both ends of the capillary tube **15** are mounted in fixed relation to the envelope **1***a*. The open end of the capillary tube **15** is fused or welded to an end wall portion of the envelope **1***a* in a manner similar to that shown in Figs. 1 and 2. The closed end of the tube **15** rests in a cup-shaped portion **16** of the envelope. The tube **15**, when flexed, has the maximum degree of deflection at a point midway between its two ends. At this point, therefore, I preferably engage the tube and a movable contact element **17** for conjoint actuation under control of the actuator member **10** when the latter is inserted within the tube **15**. A stationary contact **18** is disposed in make relation with respect to contact **17** when the tube **15** is flexed. Removal of the actuator member **10** allows the tube **15** to resume its normally straight formation and to open contact between the members **17** and **18**.

The modification shown in Figs. 4 and 5 is one wherein the envelope **1***b* encloses a selector switch comprising a movable contact member **19** surrounded by a plurality of selectable contacts **21**. The member **19** is mounted on the closed free end of the capillary tube **2** and is preferably formed as a collar or ring. It is shown electrically connected by a wire **20** to any suitable terminal.

When the curved actuator wire **10** is inserted within the capillary tube **2** (Fig. 4) stresses are applied thereto such as to lean the contact member **19** in any desired direction, according to the direction in which the wire was originally bent. Hence, by turning the knob **11** and the wire **10** any desired connection may be made between the contact member **19** and one of the surrounding contact members **21**, providing a rotary selector switch.

Fig. 6 shows a simplification of the structure of Fig. 4. Only two contact members **23** and **24** are provided in make-break relation to the movable contact member **22** which is carried by the closed end of the capillary tube **2**. The deflection of the tube **2** is accomplished in the same manner, but it is not essential that the rod or wire actuator **10** be round in this case, since it does not have to be rotated. It could be square or flat if desired. The combination of contact members **22**, **23** and **24** and of parts essential to the make-up of a practical switch gives this form of my invention the characteristics of a single-pole double-throw switch.

Fig. 7 shows a form of construction similar to that of Fig. 4, means being provided to prevent accidental closing of the switch contacts. In this form, the capillary tube **25** is normally bowed to one side. When the normally bowed actuating rod or wire **10** is inserted therein and then rotated, the end of the tube may be caused to move in a circular path around the baffle **26** which is preferably formed integrally with the end wall **27** of the envelope. Fused into the side wall of the envelope **1***c* is a contact **28**. Surrounding the free end of the capillary tube is a contact ring **29** of conductive material from which leads a conductor **30** extending through the envelope as shown.

It will be seen that as the actuator wire **10** is rotated the contact ring **29** may be swung around the baffle plate **26** into engagement with the contact **28**. It will be noted, however, that accidental engagement of the contacts cannot be effected by the application of shock forces to the apparatus.

Figs. 8, 8*a* and 8*b* show another form of construction in which a member within the envelope may be caused to rotate. The envelope **1***d* is provided with one or more bearing struts **31** within which are journaled the rotary shaft **32**, one end of which is provided with an arm **33** having an opening within which is received the free end of the capillary tube **35**. The other end of shaft **32** is provided with suitable means for actuating any desired element such as an arm **36**. In the form shown, this may be caused to engage a flexible switch contact **37** fused through the envelope **1***d* which is in engageable relation with a contact finger **38** similarly mounted.

Fig. 9 shows another arrangement for providing rotary motion. The envelope **1***e* carries a strut **41** which may be made of glass and is shown as provided with an internally threaded bushing **42**, within which is received the threaded shaft **43**, on the end of which is an arm **44** formed with an opening in which is received the free end of the capillary tube **45**. It will be seen that if the initially bowed actuator wire **10** is rotated, the end of the capillary tube **45** will be correspondingly rotated. Due to the threaded connection, the shaft **43** will be thereby moved axially for any desired purpose. Thus, in the form shown, it may be caused to engage the contact **46**. A suitable conductor **47** leads from the bushing **42** through the wall of the envelope.

It will be noted that in all of these illustrative forms there is a flexible capillary tube, preferably of glass, located within an envelope, having one end closed and the other open, with the open end attached to the envelope, and that there is an actuator, such as a wire, which is inserted into said tube from the outside and has a sliding motion relative to the tube, either of translation or of rotation. Also that said sliding motion relative to the tube causes the tube to flex and thereby operate a member hermetically sealed within the envelope.

While various forms shown above contemplate the closing or opening of switch contacts, it is, of course, to be understood that the invention is not to be limited thereto, as the means shown may be used to provide a translatory or rotary motion within an hermetically sealed envelope for any purpose. Thus, it may be used to actuate or adjust electrodes such as gas discharge tube electrodes or any other parts, as well as switch contacts. It is also to be noted that the actuating "wire" need not be of circular cross-section but may be of polygonal cross-section. Thus, the wire **10** of Figs. 1, 3 and 6 and wire **13** of Fig. 2 may well be of rectangular cross-section.

It will be noted that the constructions shown and described will serve admirably to accomplish the objects stated above. It is to be understood, however, that the constructions disclosed above are intended merely as illustrative of the invention and not as limiting as various modifications therein may be made without departing from the invention as defined by a proper interpretation of the claims which follow.

I claim:

1. In a device of the character described, an hermetically sealed envelope, at least one movable member mounted within said envelope, a flexible capillary tube one portion of said tube being adjacent to said member, said tube having a closed end within said envelope and an open end communicating with the outer atmosphere and affixed to and forming a portion of said envelope, and actuator means adapted to flex said capillary tube to effect movement of said movable member, said means being constituted as a wire capable of being inserted within said tube and slidable therein in such a manner as to flex said tube between the end of the tube and the part forming a portion of the envelope to cause said tube to move said movable member, said tube being substantially straight and said wire being normally bowed so that when inserted within the tube it causes a bending of said tube.

2. In a device of the character described, an hermetically sealed envelope, at least one movable member mounted within said envelope, a flexible capillary tube one portion of said tube being adjacent to said member, said tube having a closed end within said envelope and an open end communicating with the outer atmosphere and affixed to and forming a portion of said envelope, and actuator means adapted to flex said capillary tube to effect movement of said movable member, said means being constituted as a wire capable of being inserted within said tube and slidable therein in such a manner as to flex said tube between the end of the tube and the part

forming a portion of the envelope to cause said tube to move said movable member, the longitudinal axis of said tube being curved and that of said wire is relatively straight.

3. In a device of the character described, an hermetically sealed envelope, at least one movable member mounted within said envelope, a flexible capillary tube one portion of said tube being adjacent to said member, said tube having a closed end within said envelope and an open end communicating with the outer atmosphere and affixed to and forming a portion of said envelope, and actuator means adapted to flex said capillary tube to effect movement of said movable member, said means being constituted as a wire capable of being inserted within said tube and slidable therein in such a manner as to flex said tube between the end of the tube and the part forming a portion of the envelope to cause said tube to move said movable member, said envelope being formed at one end as a socket for holding the closed end of said tube in fixed relation thereto, the portion of said tube which is adjacent to said movable member being at a point substantially equidistant from the two ends of the tube.

4. In an electrical switch, an evacuated hermetically sealed envelope and a plurality of contact members mounted in make-and-break relation with respect to a centrally disposed movable contact member, a capillary tube having a closed movable end adjacent which it provides support for a movable contact member and an open end which is attached to said envelope, said open end forming a rigid portion of the envelope, and actuator means for effecting contact selectively between said movable contact member and any desired one of the first said contact members, said means being constituted as a wire capable of being inserted within said tube and slidable therein in such a manner as to flex said tube to change the make-break relations between said contact members, said actuator means possesses a conformation which enables it to lean the capillary tube in different directions when rotated within the same.

5. In an electrical switch, an evacuated hermetically sealed envelope and a plurality of contact members mounted in make-and-break relation with respect to a centrally disposed movable contact member, a capillary tube having a closed movable end adjacent which it provides support for a movable contact member and an open end which is attached to said envelope, said open end forming a rigid portion of the envelope, and actuator means for effecting contact selectively between said movable contact member and any desired one of the first said contact members, said means being constituted as a wire capable of being inserted within said tube and slidable therein in such a manner as to flex said tube to change the make-break relations between said contact members, said actuator means being operable to cause a make contact between said movable contact and any selected one of the first said contact members, the latter being disposed in surrounding relation to said capillary tube.

6. An electrical switch comprising a movable contact member and at least one other contact member having make-break relation thereto, an envelope enclosing and hermetically sealing the ambient space about said members, conically rotatable; and a flexible capillary tube of impervious material closed at one end and open to the outer atmosphere at the other end forming part of the envelope, said tube extending freely inwardly with respect to the envelope and having its open end rigidly affixed, fused or welded to a wall portion of said envelope, said tube having its closed end and said movable contact mechanically coupled for conjoint movement therewith, and actuator means for effecting said conjoint movement thereby to make and to break contact between said members, said means being constituted as a wire insertible within said tube and of sufficient stiffness so that when it is slid relative to said tube it will cause flexing of the tube to the extent needed for changing said make-break relation.

7. In a device of the character described, an hermetically sealed envelope, relatively movable conductive members mounted in spaced relation within said envelope, a capillary tube one portion of which is adjacent to one of said members, said tube having a closed end movable within said envelope in a conical manner and an open end communicating with the outer atmosphere and affixed to a portion of said envelope, and actuator means for the tube for effecting relative motion between said members, said means being constituted as a wire capable of being inserted within said tube and capable of flexing and rotating said tube to change the relation between said members, when slid relative to said tube.

8. The combination according to claim 7 wherein said wire possesses a "set" normally out of axial alignment such that when slid within said tube it exerts a lateral pressure thereon in one direction to distort the same.

9. The combination according to claim 7 wherein said tube is substantially straight and said wire is normally bowed so that when slid within the tube it causes a bending of said tube.

10. The combination according to claim 7 wherein the longitudinal axis of said tube is curved and that of said wire is relatively straight.

11. The combination according to claim 7 wherein said envelope is formed at one end as a socket for holding the closed end of said tube in fixed relation thereto, and the tube is flexible between its ends, the portion of said tube which is adjacent to one of said members being at a point substantially equidistant from the two ends of the tube.

12. In a device of the character described, an hermetically sealed envelope, at least one movable member mounted within said envelope, a flexible capillary tube one portion of said tube being adjacent to said member, said tube having a closed end within said envelope and an open end communicating with the outer atmosphere and affixed to and forming a portion of said envelope, and actuator means adapted to flex said capillary tube to effect movement of said movable member, said means being constituted as a wire capable of being inserted within said tube and slidable therein in such a manner as to flex said tube between the end of the tube and the part forming a portion of the envelope to cause said tube to move said movable member, said movable member has threads engaging threads in a member carried by the envelope, and the capillary tube is connected for rotating said member.

13. Hermetically sealed switch apparatus comprising an evacuated envelope having an integral capillary member extending into the envelope whereby the terminal part inside the envelope is sealed but the terminal part integral with the envelope is open to the atmosphere, a movable contact member for the capillary member, and at least one other contact member having make-break contact relation with the movable contact member, said contact members being contained in the envelope, insertible freely movable actuator means for the capillary member adapted to flex the capillary member to actuate the make-break relation while the portion of the capillary integral with the envelope is relatively rigid of the envelope but permissive of rotation of the member about the integral portion as an axis of rotation.

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