Sept. 2, 1969 N. T. WILLIAMS 3,465,109

ELECTRICAL SWITCH HAVING DEFORMABLE MOVING CONTACT ARM

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Fig. 1.

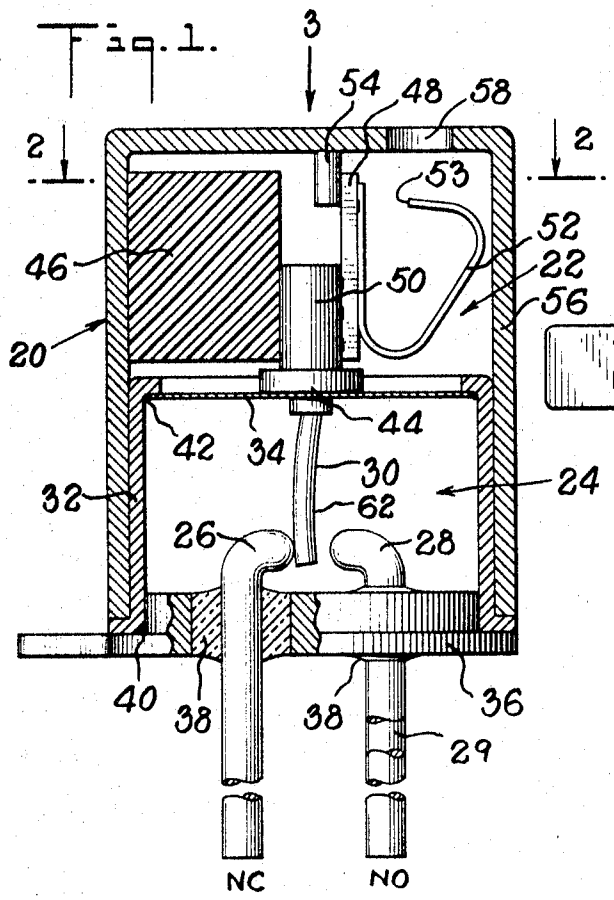
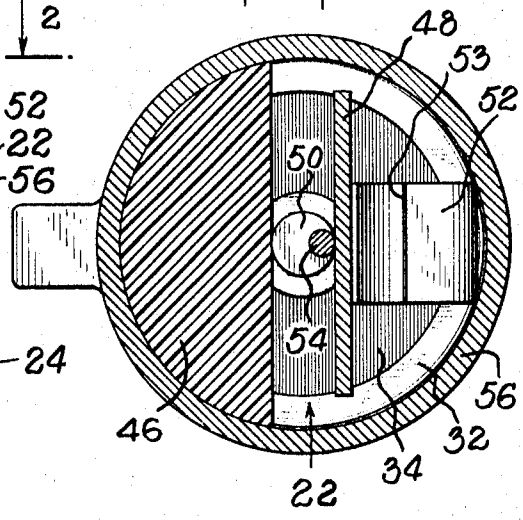


Fig. 2.



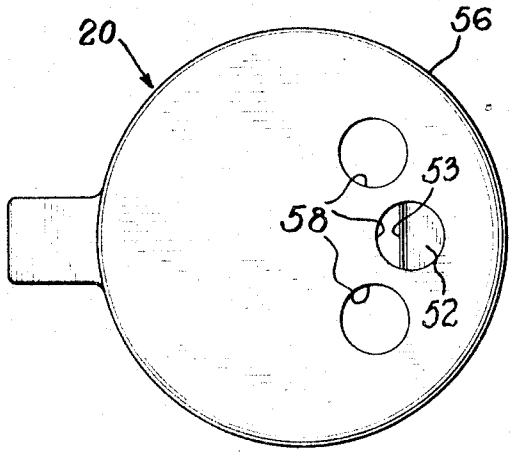


Fig. 3.

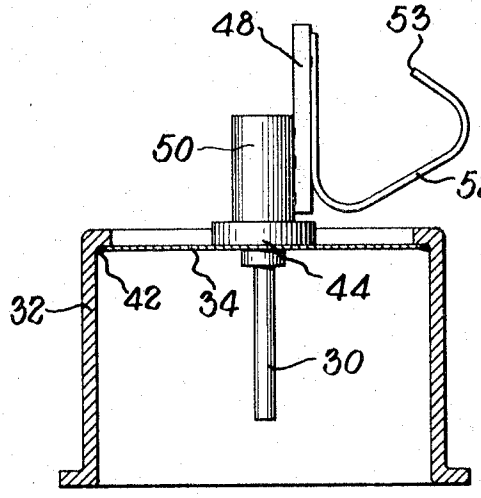


Fig. 4.

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Fig. 5.

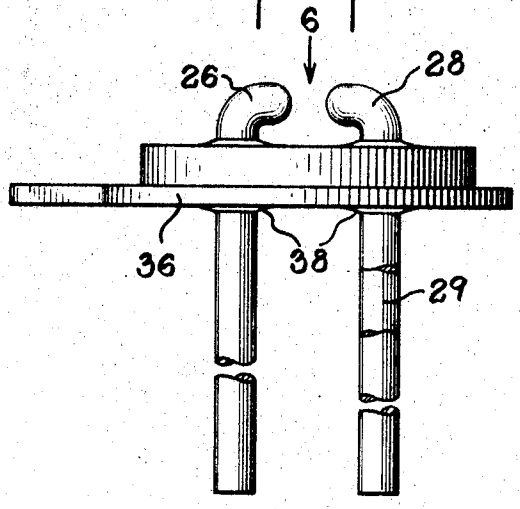

Fig. 6.

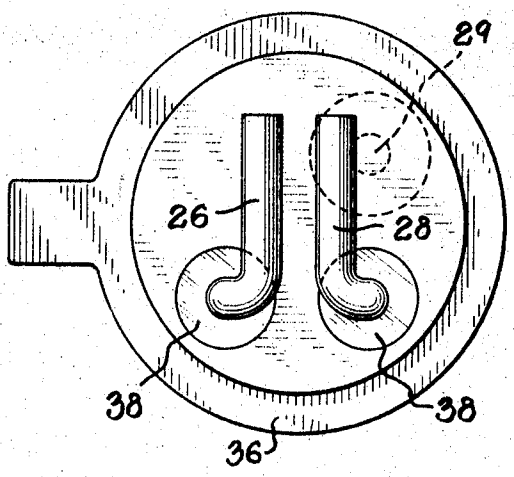

Fig. 7.

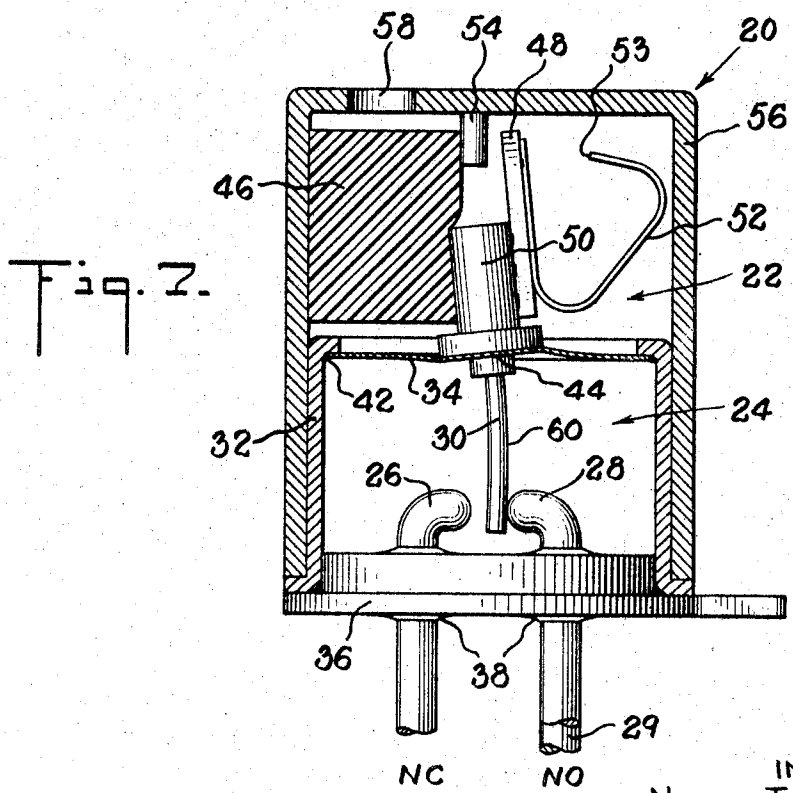

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Fig. 8.

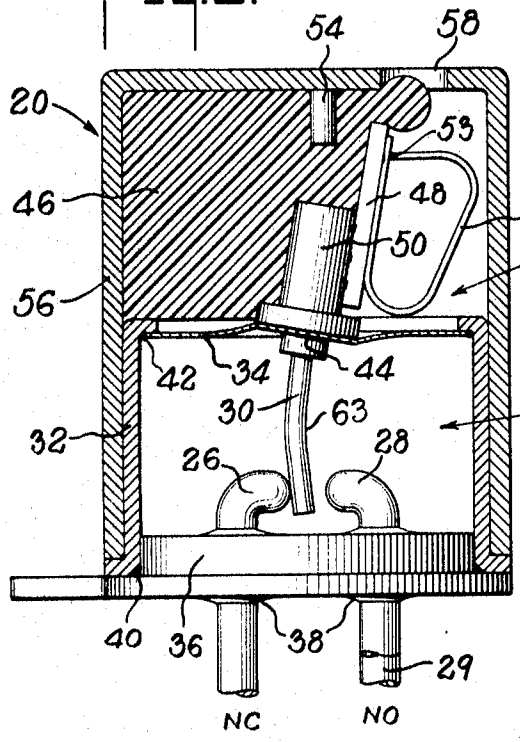
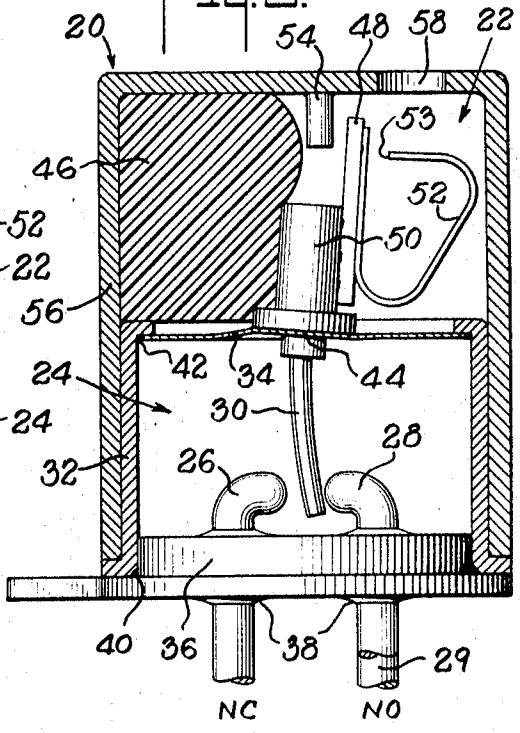


Fig. 9.



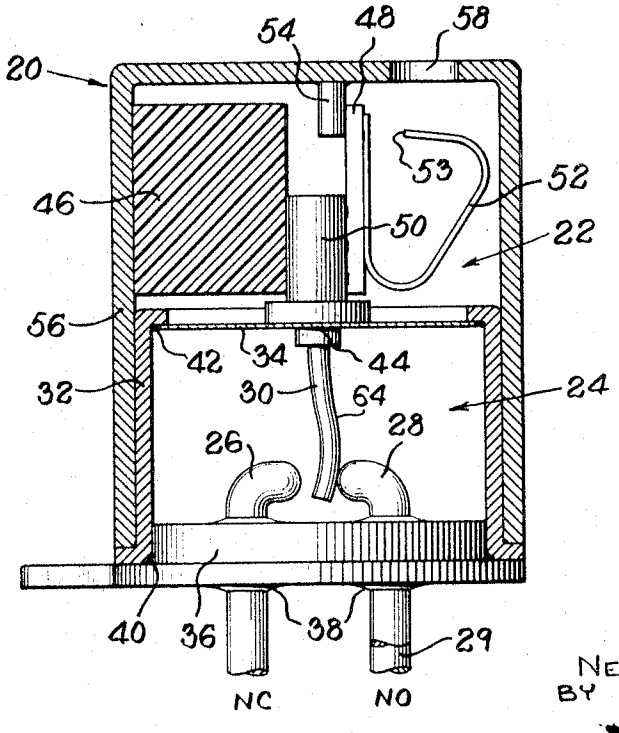


Fig. 10.

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Fig. 11.

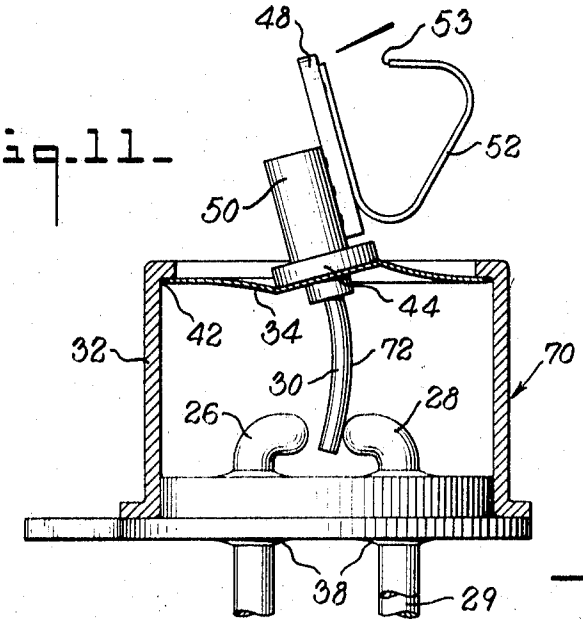


Fig. 12.

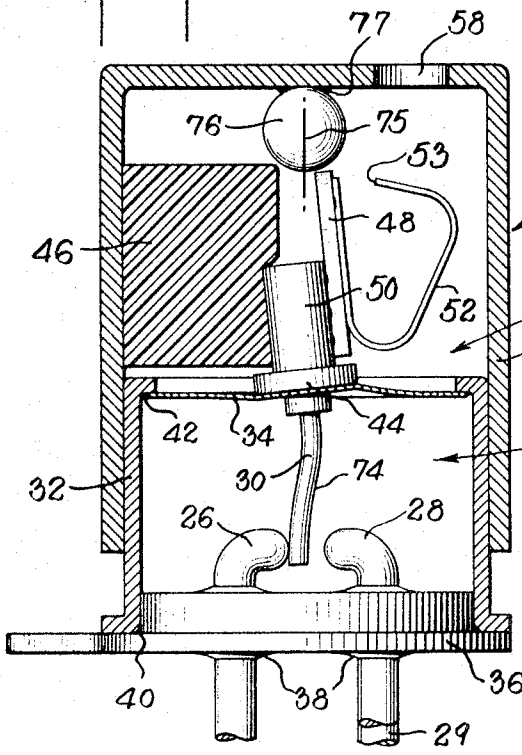
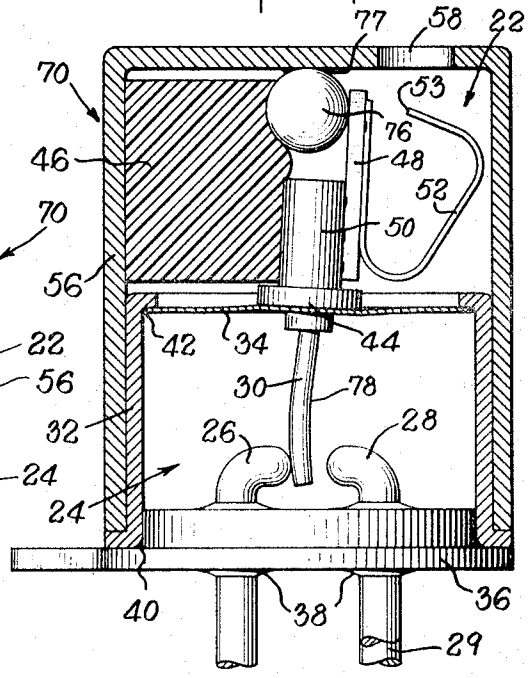


Fig. 13.



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United States Patent Office 3,465,109 Patented Sept. 2, 1969

3,465,109

ELECTRICAL SWITCH HAVING DEFORMABLE MOVING CONTACT ARM

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Int. Cl. H01h 43/24
U.S. Cl. 200—33 11 Claims

ABSTRACT OF THE DISCLOSURE

An electrical switch having at least one fixed contact, a moving contact arm and means for urging the moving contact arm into and out of contact with the fixed contact. The moving contact arm being formed of deformable, electrically conductive, material so that the moving contact arm is deformed by contact with the fixed contact and so that there is a delay before the contact between the moving contact arm and the fixed contact is broken, the delay being determined by the deformation, the elastic memory and the velocity of the moving contact arm.

The invention relates to electrical switches having a deformable, moving contact arm and in particular relates to such electrical switches wherein the moving contact arm is urged in one direction by the expansion of a block of elastomeric material which expands upon being immersed in a liquid swelling agent.

These electrical switches are generally referred to as chemically actuated switches and they have been used as delay starting devices. The liquid swelling agent most commonly used has been Freon TF, manufactured by E. I. du Pont de Nemours and Co. of Wilmington, Del., or a similar liquid which causes the elastomer which is, for example, sold as SE–555U by The General Electric Company of Schenectady, N.Y., to expand when immersed in the liquid.

When the elastomer is immersed in the liquid, the moving contact arm is urged against one of the contacts of the switch usually referred to as the normally closed (NC) contact. When the elastomer is removed from the liquid swelling agent, the liquid evaporates from the elastomer, the elastomer contracts and some resilient means, acting on the moving contact arm, urges the moving contact arm into contact with the other contact of the switch, usually referred to as the normally open (NO) contact.

These electrical switches are usually used in conjunction with other circuits which are "made ready" by the closing of the NO contact. If it is desirable to deactivate the system, the switch is immersed in the liquid swelling agent, the elastomer expands and the moving contact arm makes contact with the NC contact.

These prior art switches require that the switch be immersed in and kept in the liquid swelling agent in order to keep the moving contact arm in contact with the NC contact. As a result, it was necessary to have a liquid swelling agent available prior to connecting the switch to its associated electrical circuit.

Prior art, chemically actuated switches were not able to be hermetically sealed because all of the elements were in a single chamber into which the liquid swelling agent had to be admitted. As a consequence, the contact points became pitted and corroded, thereby reducing the operating efficiency of the switch.

It is an important object of the invention to provide an electrical switch which is actuated by the expansion and contraction of a block of elastomeric material and in which the moving contact arm is in contact with the NC contact when the switch is first manufactured.

It is a further object of the invention to provide such a switch wherein upon immersing the elastomer in a liquid swelling agent, the moving contact arm remains in contact with the NC contact and upon removing the elastomer from the liquid swelling agent, the moving contact arm moves into contact with the NO contact. Thereafter, the moving contact arm moves to contact either the NC or NO contact depending upon the expansion or contraction of the elastomeric block.

It is another important object of the invention to provide such a switch wherein the moving contact arm is deformable and has some elastic memory so that there is a delay in its "break" time.

It is a still further object of the invention to provide such a switch wherein the housing is divided into two chambers, separated from each other, and the contacts are in one chamber and the elastomer is in the other chamber.

It is a still further object of the invention to provide such a switch wherein the chamber containing the contacts is hermetically sealed.

These and other objects, advantages, features and uses will be apparent during the course of the following discussion when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is an enlarged, vertical, sectional view, partly in elevation, of an embodiment of the invention;

FIGURE 2 is a sectional view, taken along the lines 2—2 of FIGURE 1, viewed in the direction of the arrows;

FIGURE 3 is a top plan view of the invention, viewed in the direction of arrow 3 of FIGURE 1;

FIGURE 4 is a view similar to that of FIGURE 1, showing the moving contact arm, the paddle and the restoring spring;

FIGURE 5 is an elevational view showing the fixed contacts installed in the header;

FIGURE 6 is a top plan view of the fixed contacts installed in the header, viewed in the direction of arrow 6 of FIGURE 5;

FIGURE 7 is a view similar to that of FIGURE 1 showing the position of the moving contact arm against the NO contact during assembly of the switch;

FIGURE 8 is a view similar to that of FIGURE 1 showing the position of the switch elements when the elastomer block is immersed in a liquid swelling agent;

FIGURE 9 is a view similar to that of FIGURE 1 showing the position of the moving contact arm as it moves from the NC to the NO position;

FIGURE 10 is a view similar to that of FIGURE 1 showing the position of the moving contact arm against the NO contact after the elastomeric block has contracted to its original size;

FIGURE 11 is a view, similar to that of FIGURE 7 of another embodiment of the invention showing the position of the moving contact arm against the NO contact during assembly of the switch;

FIGURE 12 is a view of the embodiment of FIGURE 11 showing the outer housing being moved into position; and

FIGURE 13 is a view similar to that of FIGURE 1 of the embodiment of FIGURES 11 and 12 showing the switch ready for use.

In the drawings, wherein, for the purpose of illustration, are shown two embodiments of electrical switch of the invention, the numeral 20 designates a switch of the invention generally. Switch 20 (FIGURE 1) comprises housing 56 which is divided into an upper chamber 22 and a lower chamber 24. Lower chamber 24 is formed by cylindrical, metal housing 32 to which is affixed diaphragm 34 and header plate 36. Diaphragm 34 and header plate 36 are formed of steel or any other suitable material and are joined to housing 32 by welding, brazing

or any other method, as shown at **40** and **42**, so that chamber **24** is, preferably, hermetically sealed.

Fixed contacts **26** and **28** are typically formed by two right angle leads which are "glassed in" the header plate **36**, as shown at **38**. This type of construction is commonly referred to as a transistor header. Moving contact arm **30** is suitably mounted to diaphragm **34** at its center **44** by welding, brazing or any other suitable method. Moving contact arm **30** makes connection to the external circuit through pin **29** which is welded or otherwise affixed to header plate **36**. The electrical connection between pin **29** and contact arm **30** is made through the housings **32** and **56** and diaphragm **34** and/or the housings, stop **54**, paddle **48**, pin **50** and the diaphragm.

Moving contact arm **30** is preferably formed of deformable, electrically conductive material with low elastic memory such as pure annealed nickel or an alloy of 50% nickel and 50% iron. These materials have low elastic memories in that they do not return to their original shape when the deforming force is removed. For example, if annealed nickel is deformed .01", it will return about .001" toward its original condition. The 50% nickel 50% iron alloy will return about .002" toward its original condition when it is deformed .01". If longer initial break time is desired, the moving contact arm should be formed of material having higher elastic memory.

Upper chamber **22** is sealed from lower chamber **24** by diaphragm **34** and contains block **46** of elastomeric material such as SE–555U silicone compound rubber sold by The General Electric Company, paddle **48** which together with pin **50** serves as a lever arm or pivot means, resilient spring **52** and stop **54**. Spring **52** and pin **50** are both welded or otherwise joined to paddle **48**. Pin **50** is affixed to diaphragm **34** at hinge point **44** so that the motion of moving contact arm **30** is complementary to that of the lever arm comprised of paddle **48** and pin **50**. Spring **52** is restrained by outer housing **56** which is provided with one or more holes **58** to permit the ingress and egress of the liquid swelling agent into and out of upper chamber **22**. Spring **52** is deformed so that its edge **53** faces toward paddle **48**. When paddle **48** is urged toward spring **52** by the action of the swelling elastomer block, edge **53** serves as a stop to prevent further motion of the paddle.

Electrical switch **20** is assembled easily and simply as there are no close manufacturing tolerances due to the fact that the deformable pin, which is used as the moving contact arm, is a vital part of the combination. What is desired is a switch with hermetically sealed contacts and a switching cycle as follows:

(1) On initial assembly, with the elastomer contracted (uncharged by Freon or other liquid swelling agent)—NC.

(2) Upon expanding the elastomer by immersing it in Freon—NC.

(3) Upon removing the elastomer from Freon so it contracts—NO.

(4) Upon expanding the elastomer by reimmersing it in Freon—NC.

(5) Upon removing the elastomer from Freon so it contracts—NO etc.

The wide manufacturing tolerances are attainable since the errors in component manufacture are adjusted out by the deformable wire which is used as the moving contact arm of the switch.

Leads **26** and **28** are "glassed in" header plate **36** as shown at **38** (FIGURES 1, 5 and 6). The portions of leads **26** and **28**, which are within the chamber **24**, are parallel to each other (FIGURE 6). The spacing is any amount greater than the diameter of moving contact arm **30**.

Diaphragm **34** is brazed or otherwise affixed to housing **32** as shown at **42** (FIGURES 1 and 3). Moving contact arm **30**, which is formed of deformable, electrically conductive material with low elastic memory, is affixed to diaphragm **34** at hinge point **44** by welding or similar techniques. It can be seen that diaphragm **34** forms both a hermetic seal and a hinge point having a minimum of axial motion. The construction is such that the diaphragm is not required to supply any restoring force. Diaphragm **34** is preferably formed of cold rolled steel, stainless steel or similar material and is about .001" to .002" thick.

Before assembly, the contact portions of contacts **26** and **28** and moving contact arm **30** are gold plated to improve their electrical contact characteristics. In the assembly of the switch, certain steps insure the obtaining of proper operation and the correct initial, starting condition.

Lower chamber **24** is treated as a subassembly and a preferred procedure is to impart a backward preset to paddle **48** (as shown in FIGURE 7). This moves contact arm **30** into contact with NO contact **28** and imparts a reverse bend **60** to moving contact arm **30**. Next, the outer housing **56**, which contains elastomer block **46** and to which stop **54** is affixed, is placed over the lower subassembly (FIGURE 7) and the outer housing **56** is rotated so that stop **54** moves paddle **48** to the vertical position of FIGURE 1. In this position, contact arm **30** is moved into contact with fixed contact **26** and is deformed as shown at **62** and housings **32** and **56** are joined.

At this point in the assembly, the elastomer block **46** does not exert any force on the paddle **48**. If block **46** is in contact with paddle **48** at this time, it exerts less force on the paddle than does restoring spring **52** which is confined between the paddle and housing **56**. An additional advantage of the deformable, movable contact arm resides in the additional contact pressure obtained. This additional contact pressure results from the elastic memory of the material and it increases as the elastic memory increases.

Stop pin **54** is preferably installed through an opening in outer housing **56** but a stop may also be made by riveting it inside the housing or deforming the housing inwardly at the desired location. It is off-center so that when the outer housing is rotated during assembly, it erects paddle **48** to its vertical position. This is the condition in which the switch is sent to the user, it is uncharged with Freon and contact is in the NC position.

After the user has made the necessary circuit connections and the switch is ready for operation, it is placed in a Freon TF bath and the Freon enters the upper chamber **22** through openings **58**. This causes elastomer block **46** to expand and push paddle **48** toward the right of FIGURE 8 against the force of spring **52**. This movement causes deformable, movable contact **30** to be bent even more against contact **26**. The action of expanding or charging the rubber does not change the electrical connection from what existed at the time of initial assembly of the switch.

The motion of paddle **48** must be great enough to produce equivalent, complementary, unrestrained motion of movable, contact arm **30** by an amount greater than the effective gap between the two fixed contacts **26** and **28**. By way of illustration, but without limitation of the scope of the invention, following is an example of switch of the invention:

	Inches
Gap between fixed contacts **26** and **28**	.015
Diameter of contact arm **30**	.010
Effective gap	.005
Paddle movement at top	.015
Unrestrained movable contact movement due to paddle movement	.013

Since, in the charging or swelling operation, the movable contact arm **30** is restrained from moving by contact **26**, additional bending, as shown at **63**, occurs (FIGURE 8).

When the switch is removed from the Freon environment, the elastomeric block **46** contracts and moves out of contact with paddle **48**. Then spring **52** acts on paddle

48, as block 46 contracts, so as to move through the position of FIGURE 9 to that of FIGURE 10 so that it makes contact with NO contact 28 and assumes the configuration shown at 64. The device, to which switch 20 is connected, is now ready for operation.

If it is necessary to disable the system, immersion of the switch in Freon will expand elastomeric block 46 and cause contact arm 30 to move out of contact with fixed contact 28 and into contact with fixed contact 26.

Usually, the Freon evaporates in about fifteen minutes or so thereby imposing a delay of that period of time before the movable contact starts to transfer. The transit time between initial break and final make can be varied by changing the gap between the fixed contacts and the diameter of the movable contact arm. By forming the movable contact arm of a deformable material having a high elastic memory, it is possible to lengthen the time that the movable contact arm remains in contact with one fixed contact before breaking contact and moving toward the other fixed contact. The moving contact arm remains in contact with one of the fixed contacts for a period of time determined by its deformation, its elastic memory and its velocity before breaking contact with the fixed contact.

In FIGURES 11–13, there is shown another embodiment of electrical switch of the invention. Its operation is identical with that of the embodiment of FIGURE 1 but the assembly procedure is different because of the shape, construction and placement of the stop.

The construction of the lower chamber 24 is identical with that of the embodiment of FIGURE 1. The fixed contacts 26 and 28 are also right angle leads which are "glassed in" the header plate 36, as shown at 38. Moving contact arm 30 is suitably mounted to diaphragm 34 at its center 44. Diaphragm 34 and header plate 36 are suitably affixed to housing 32 as shown at 40 and 42. Paddle 48, spring 52 and pin 50 are of the same construction as has been described previously.

To construct the switch 70 of FIGURES 11–13, the various elements are installed in the lower chamber 24 and pin 50, paddle 48 and spring 52 are assembled as shown in FIGURE 11. A force is applied to paddle 48 and pin 50 so that pin 30 is pushed against NO contact 28 and is bent as shown at 72. Now, paddle 48, pin 50 and spring 52 are moved to the position shown in FIGURE 12. In this position, pin 30 is moved into contact with NC contact 26 and assumes the shape shown at 74.

Next, housing 56 is moved into the position of FIGURE 11 until stop 76 contacts paddle 48. As the housing 56 continues to move down until it reaches the position of FIGURE 13, stop 76 pushes paddle 48 over toward the right of the figure and pin 30 assumes the shape shown at 78. The unit is now ready for operation.

Stop 76 is preferably spherical in shape and formed of a metal such as steel. It is welded or otherwise affixed to housing 56 as shown at 77. Since it is spherical in the direction toward paddle 48, it will push paddle 48 into the position of FIGURE 13 so long as paddle 48 is preset to a position beyond the center line 75 as shown, for example, in FIGURE 12.

By way of illustration, but not by way of limitation, following is an example of the dimensions of stop 76 and its relationship to paddle 48:

Diameter of stop 76—.040" to .046"
Contact with paddle 48—.010" to .015" below top of paddle

It will be apparent that the invention is not to be limited to the embodiments set forth in the drawings and description, and that variations may be made in form and construction without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An electrical switch comprising:
at least one fixed contact;
a moving contact arm; and
means for urging the moving contact arm into and out of contact with the fixed contact;
the moving contact arm being formed of a deformable, electrically conductive, material having a low elastic memory such that when the moving contact arm is urged in a direction into contact with the fixed contact, it is deformed by such contact with the fixed contact and when it is urged out of contact with the fixed contact, it remains in contact with the fixed contact for a period of time determined by its deformation, its elastic memory and its velocity before breaking contact with the fixed contact.

2. The invention of claim 1 wherein:
there is a second fixed contact and the means for urging the moving contact arm urges the moving contact arm to a first position in contact with the first fixed contact and to a second position in contact with the second fixed contact;
the moving contact arm being deformed in one direction when it makes contact with the first fixed contact in the first position and being deformed in an opposite direction when it makes contact with the second fixed contact in the second position;
the moving contact arm maintaining contact with the first fixed contact for a period of time determined by its deformation, its elastic memory and the velocity of the urging means when being urged from the first position to the second position and maintaining contact with the second fixed contact for a period determined by its deformation, its elastic memory and the velocity of the urging means when being urged from the second position to the first position.

3. The invention of claim 2 including means connected to the moving contact arm and wherein the means for urging the moving contact arm comprises:
a block of elastomeric material which expands when immersed in a liquid swelling agent and contracts upon being removed from the liquid swelling agent;
the block of elastomeric material expanding against the pivot means to move the moving contact arm to the first position when the block of elastomeric material is immersed in the liquid swelling agent;
the block of elastomeric material contracting so as to leave contact with the pivot means when the block of elastomeric material is removed from the liquid swelling agent; and
resilient means acting on the pivot means to move the movable contact arm from the first position to the second position when the block of elastomeric material contracts so as to leave contact with the pivot means.

4. The invention of claim 2 including:
a housing;
a diaphragm dividing the housing into an upper and a lower chamber so that the chambers are sealed from each other;
the two fixed contacts and the movable contact arm being in the lower chamber;
the movable contact arm being affixed to the diaphragm, a lever arm in the upper chamber being affixed to the diaphragm at a point opposite that to which the movable contact arm is affixed such that a force applied to the lever arm causes the diaphragm to act as a hinge and move the movable contact arm in a direction complementary thereto;
a block of elastomeric material, which expands when immersed in a liquid swelling agent and contracts when removed from the liquid swelling agent, mounted in the upper chamber;
the block of elastomeric material exerting a force on the lever arm to move the movable contact arm to

a first position in contact with the first fixed contact when the block of elastomeric material expands; and

a spring mounted in the upper chamber so as to exert a force on the lever arm to move the movable contact arm to a second position in contact with the second fixed contact when the block of elastomeric material contracts.

5. The invention of claim **4** wherein the lever arm is a flat paddle and including a stop to limit the movement of the paddle when it is moved by the action of the spring.

6. The invention of claim **5** wherein the movable contact arm is in the first position on being assembled and the block of elastomeric material is not immersed in the liquid swelling agent and upon the block of elastomeric material's being immersed in the liquid agent, the movable contact arm remains in the first position.

7. The invention of claim **6** wherein the lower chamber is hermetically sealed and the upper chamber has an opening therein to facilitate ingress and egress of the liquid swelling agent.

8. The invention of claim **5** wherein the lower chamber is hermetically sealed and the upper chamber has an opening therein to facilitate ingress and egress of the liquid swelling agent.

9. The invention of claim **4** wherein the movable contact arm is in the first position on being assembled and the

block of elastomeric material is not immersed in the liquid swelling agent and upon the block of elastomeric material's being immersed in the liquid agent, the movable contact arm remains in the first position.

10. The invention of claim **9** wherein the lower chamber is hermetically sealed and the upper chamber has an opening therein to facilitate ingress and egress of the liquid swelling agent.

11. The invention of claim **4** wherein the lower chamber is hermetically sealed and the upper chamber has an opening therein to facilitate ingress and egress of the liquid swelling agent.

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H. O. JONES, Primary Examiner

U.S. Cl. X.R.

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