Feb. 1, 1966 D. C. PRIDHAM, JR., ETAL 3,233,059

VACUUM OPERATED ELECTRICAL SWITCH OR THE LIKE

Filed Aug. 22, 1962 3 Sheets-Sheet 1

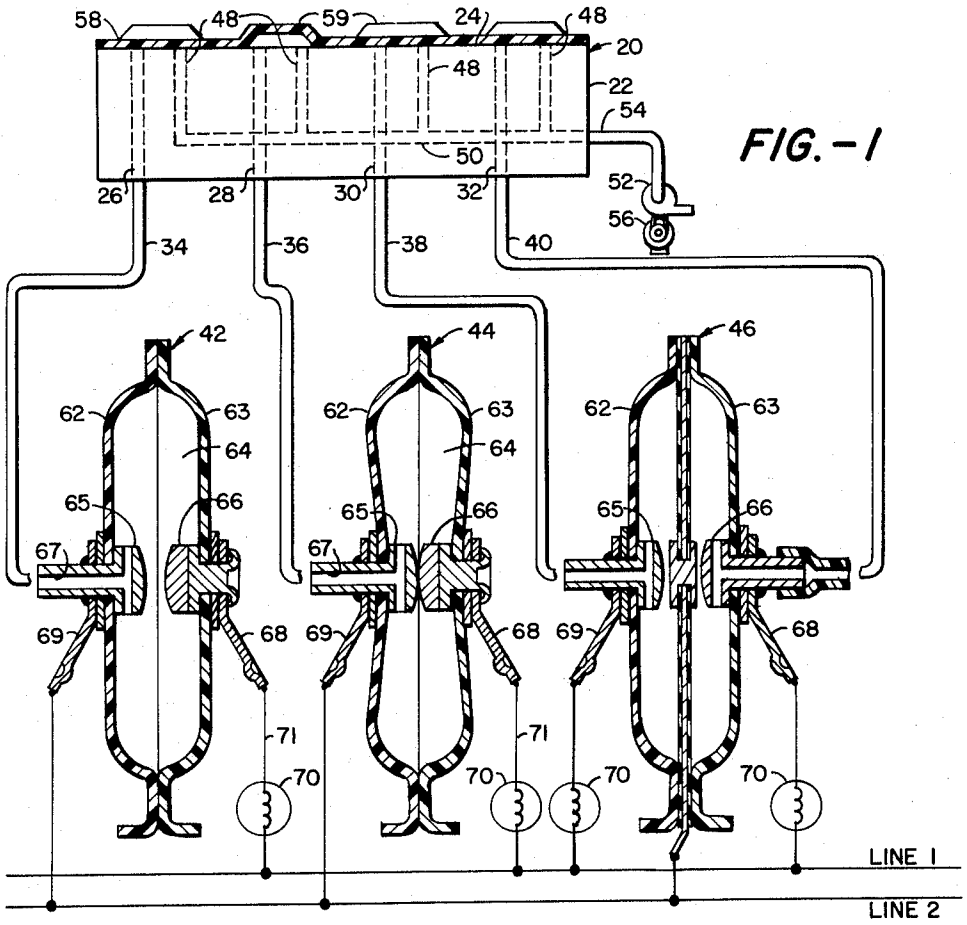

FIG.-1

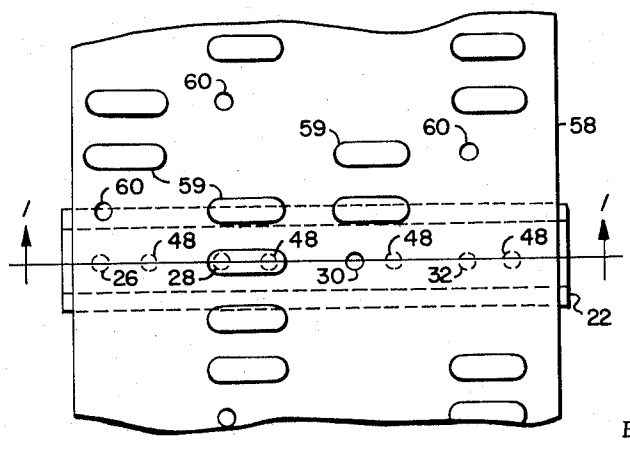

FIG.-3

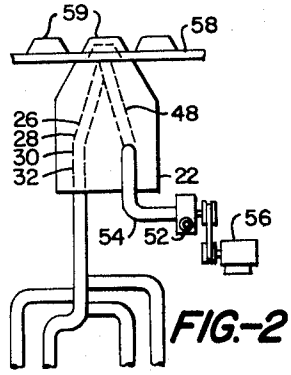

FIG.-2

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VACUUM OPERATED ELECTRICAL SWITCH OR THE LIKE

Filed Aug. 22, 1962 3 Sheets-Sheet 2

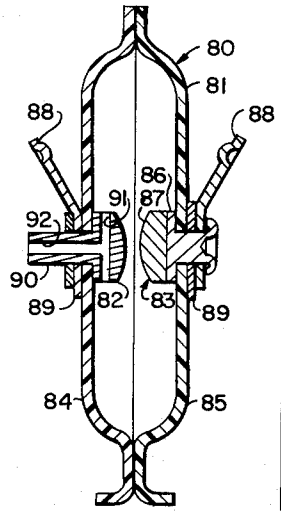

FIG.-5

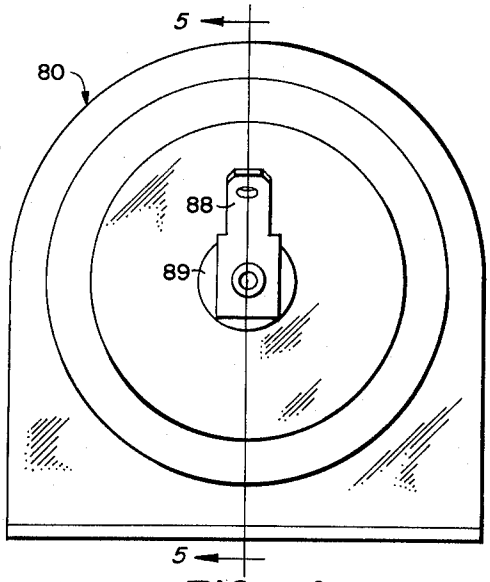

FIG.-4

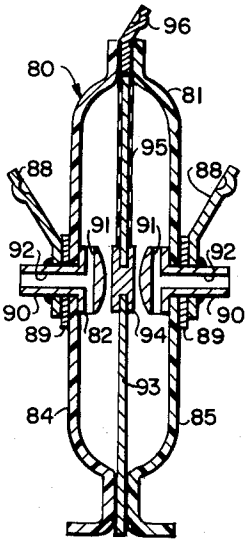

FIG.-6

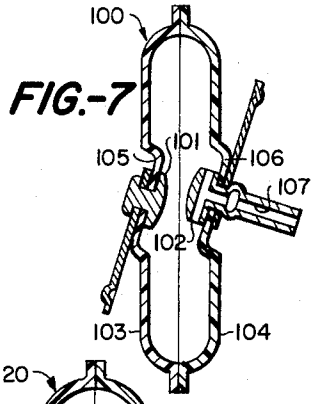

FIG.-7

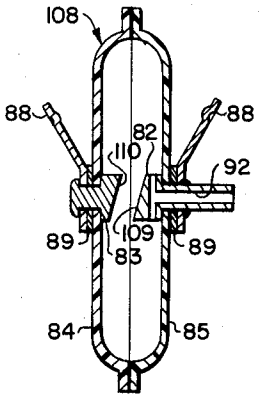

FIG.-8

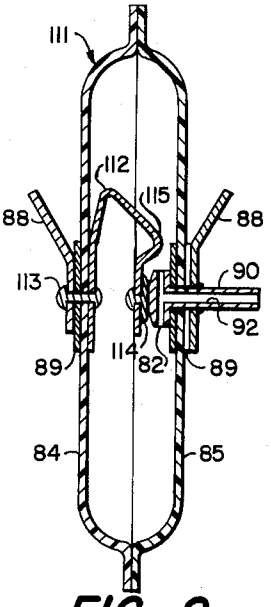

FIG.-9

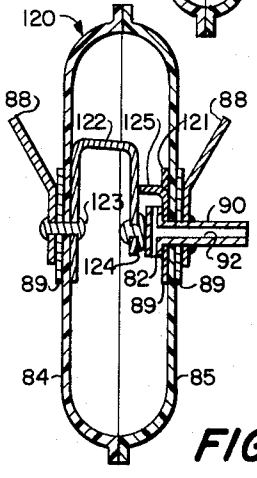

FIG.-10

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VACUUM OPERATED ELECTRICAL SWITCH OR THE LIKE

Filed Aug. 22, 1962 3 Sheets-Sheet 3

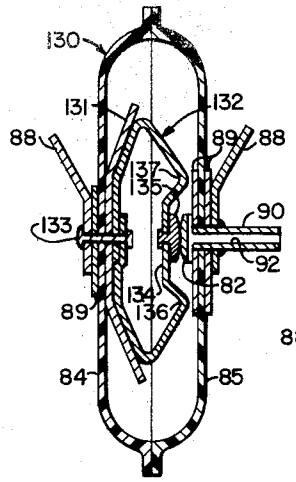
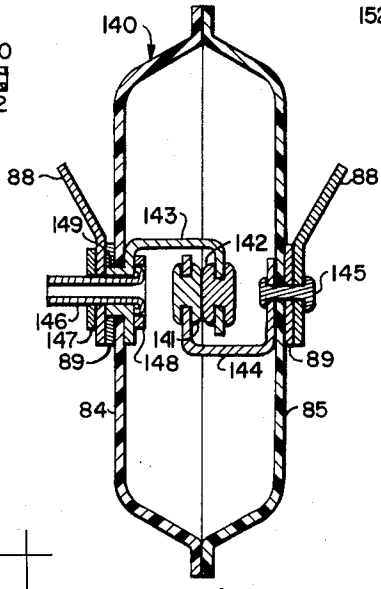


FIG.-11

FIG.-12



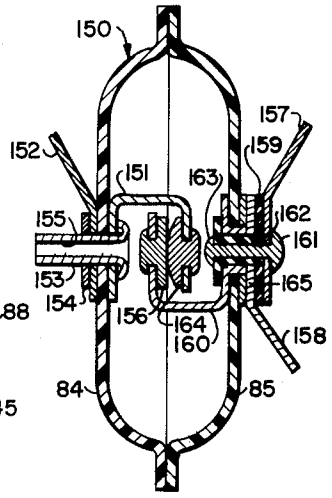


FIG.-13

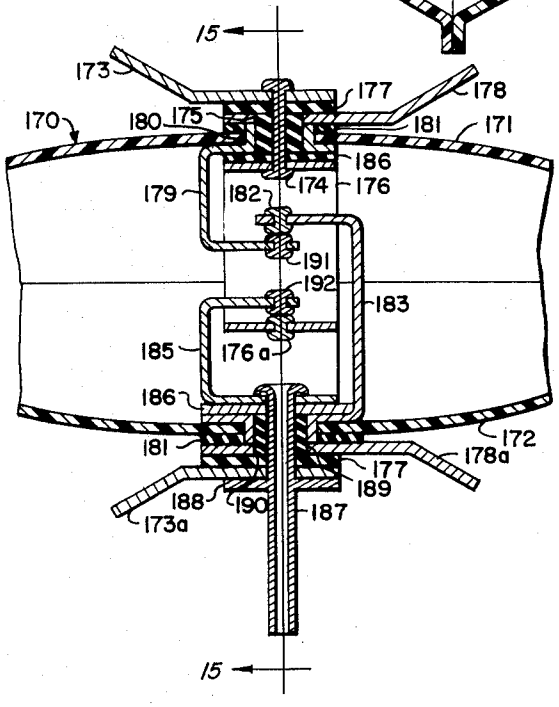


FIG.-14

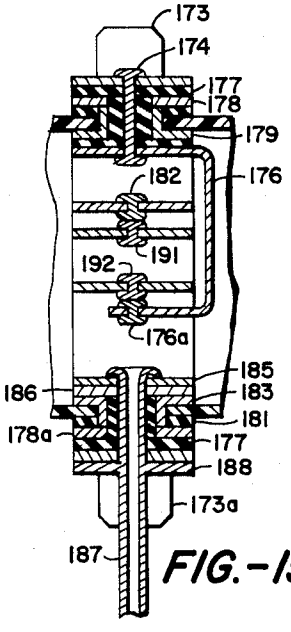


FIG.-15

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United States Patent Office 3,233,059 Patented Feb. 1, 1966

3,233,059

VACUUM OPERATED ELECTRICAL SWITCH OR THE LIKE

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Filed Aug. 22, 1962, Ser. No. 218,693
7 Claims. (Cl. 200—83)

This invention relates to pressure operated electrical switches and has for its primary object to provide a switch having a minimum number of parts.

In some commercial appliances, such as in domestic washing machines, dishwashers, driers and other operating devices which require control elements, a concerted effort is constantly being made to eliminate the number of parts for each operating component. It is therefore desirable to provide components in which each part performs a multitude of functions, thus eliminating the number of parts and reduce the total cost of the component.

Currently, the state of the art switches perform rather simple functions but require a multitude of parts to operate these functions. The present invention is operable on a very few parts and functions best under the influence of a vacuum source or a pressure source to actuate the switch elements. While the vacuum operated switches of this invention can be utilized for any desired purpose, it is found that the subject invention is particularly useful in connection with vacuum program controls and the like. It is particularly advantageous for the switches used in this sort of system to be operable on rather small variations in pressure to operate effectively by a relatively small vacuum pump.

It is a further object, of the invention, to provide a switch in which the foregoing functional characteristics are obtained by a simple compact and sturdy switch unit in which the components are held to a minimum number and may be quickly and easily assembled at a low manufacturing cost.

The foregoing objects are accomplished, according to the present teaching, by the provision of a switch employing a pressure sensitive unit in the form of a pair of diaphragms joined together to form a housing having two or more electrical contacts therein. The relative position of the contact elements for the switch may be varied in position to effect the particular variety of switching being desired.

Other objects of this invention will appear in the following description and appended claims, reference being to the accompanying drawings forming a part of the specification wherein like reference characters designate a corresponding parts in the several views.

FIGURE 1 is a schematic view illustrating various embodiments of the switches of the present invention used in combination with a vacuum program control system.

FIGURE 2 is a fragmentary side view of the structure illustrated in FIGURE 1.

FIGURE 3 is a plan view of the structure illustrated in FIGURE 1.

FIGURE 4 is a side elevation of one embodiment of the present invention.

FIGURE 5 is a sectional view looking into the open side of the switch in the direction of arrows 5—5 of FIGURE 4.

FIGURE 6 is a sectional view through the switch and its associated mechanism of another embodiment of the present invention.

FIGURE 7 is a cross sectional view of yet another embodiment of the present invention and associated mechanism.

FIGURE 8 is a sectional view through the switch and associated mechanism of an alternate construction of the embodiment illustrated in FIGURE 7.

FIGURE 9 is a sectional view through the switch and its associated mechanism of another embodiment of the present invention best suited as a normally closed switch.

FIGURE 10 is a sectional view through the switch and its associated mechanism of another embodiment of the present invention best suited as a normally closed switch.

FIGURE 11 is a sectional view through the switch and its associated mechanism of another embodiment of the present invention best suited as a normally closed switch.

FIGURE 12 is a sectional view through the switch and its associated mechanism of yet another embodiment of the present invention as used for a normally closed switch.

FIGURE 13 is a sectional view through a switch and its associated mechanism for an alternative arrangement for a normally closed switch according to the present invention.

FIGURE 14 is a sectional view through a switch and its associated mechanism of yet another embodiment of the present invention.

FIGURE 15 is a sectional view looking into the open side of the switch in the direction of arrows 15—15 of the switch illustrated in FIGURE 14.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and being carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring now to FIGURES 1, 2, and 3, an improved system using the present invention is generally indicated by the reference numeral **20** and comprises a reading head or block **22** having an upper surface **24** interrupted by plurality of switch passages **26**, **28**, **30** and **32** respectively interconnected to conduits **34**, **36**, **38**, and **40** leading to a vacuum operated switch **42**, **44**, and **46** constructed according to the present invention.

The reading surface **24** of the reading head **22** is also interrupted by a plurality of vacuum passages **48** respectively disposed in spaced aligned alternating relation with the switch passages **26–32**. The suction or vacuum passages **48** being interconnected to a common suction manifold passage **50** interconnected to the inlet side of a relatively small vacuum pump **52** by a conduit **54**. The vacuum pump **52** can be operated by a suitable electric motor **56** as desired.

A thin flexible sheet or card **58** is adapted to pass over the reading surface **24** of the reading head **22** in any suitable manner and has a plurality of indentations or blisters **59** formed therein which are adapted to successively and in any desired pattern span the spacing between a suction passage **48** and one of the switch passages **26–32**. This arrangement connects the vacuum source with one of the interior of the switches **42–46** to close the contacts thereof and operate suitable apparatus. As illustrates this condition. Switch **44** is shown in the closed source.

When it is desired to break the vacuum in one of the switch constructions, the program sheet **58** has apertures **60** formed therein which are adapted to pass over the switch passages in any desired relations so that air can be drawn into particular switch to break the flow of electrical current therethrough.

As illustrated in FIGURE 1, the switch construction comprises a pair of flexible diaphragms **62**, **63** secured together to define a compartment or closure **64** and carrying switch contacts **65**, **66** disposed within the closure

and mounted on the diaphragms. The switch contacts 65, 66 are normally being held out of electrical contact when the closure is at atmospheric pressure and switch 42 illustrates this condition. Switch 44 is shown in the closed position with the contacts engaged.

The switch contact 66 of the switch 42 is interconnected to Line 1 of a suitable power source by a terminal 68. The switch contact 65 having a terminal 69 is interconnected to Line 2 of the electrical power source by a lead. An electrically operated device 70, disposed in lead 71, is actuated when the switch contacts 65 and 66 engage each other. Lines 1 and 2 are connected to a power source (not shown).

In operation, the program sheet 58 has a blister 59 bridging the gap between the passages 28 and 48 so that air can be expelled from the closure 64 to cause the diaphragms 62, 63 to be flexed toward each other, carrying the switch contacts 65, 66 into engagement. This engagement causes the device 70 to be placed across Line 1 and Line 2 to be operated thereby.

When the aperture 60, program sheet 58 subsequently comes into register with the passage 28, the vacuum condition in the closure 64 is broken and air enters switch 44 permitting the natural resiliency of the diaphragms 62, 63 to return to their natural position. The contacts 65, 66 are disengaged thereby deenergizing the device 70. Therefore, it can be seen that the switch construction operates in a relatively simple manner to make and break electrical connections.

Another embodiment of the present invention is illustrated in FIGURE 1, as switch 46, wherein like parts are indicated by like reference numerals and the general and detailed description of the like parts of the switch construction apply to the switches 42 and 44. A third contact 72 mounted on divider 73 allows the switch to be operated in two directions. This embodiment will be hereinafter described in full.

Referring now to FIGURE 4 and 5 where one embodiment of the present invention is illustrated thereon, the switch structure 80 consists of a housing 81 and electrical contacts 82, 83, mounted on each side of the housing in juxtaposition, and a means for flexing the housing.

The housing 81 composed of a pair of identically shaped circular disc diaphragms 84, 85 are joined at their periphery to form an airtight closure. The particular shape of the diaphragms is not limited to the circular form as illustrated in FIGURE 4 and 5, but rather extend to any form of diaphragm which may flex.

Materials suitable for the diaphragms are preferably of plastic varieties such as polycarbonate, which is preferred since it has self extinguishing and high temperature properties. Other plastics which may also be used for the diaphragms are polyethylene, polypropylene, fabric reinforced with polyester resin, acetal resin, et cetera. Sheet metals may also be used for the diaphragms but the contacts must be insulated from the diaphragm or an insulation must be inserted between the two halves of the diaphragms to prevent short circuits.

Plastic diaphragms must be attached at their periphery by some suitable joining process such as heat sealing, solvent welding or the like. Metal diaphragms may be attached by plastic cements, welding, soldering, brazing and the like. In any event, the diaphragms must be joined together to form an airtight seal.

Referring now in particular to FIGURE 5, the contact 83 illustrated is composed of two materials, namely, a base 86 and a contact or head portion 87. It is conventional to use material such as silver or good electrical conductors for the head portion and a cheaper metal for the base to decrease the cost of the unit. The contact has a nose portion that extends through the diaphragm 85 which is crimped over or swaged into intimate contact with the lug or electrical terminal 88. Sufficient pressure must be placed upon the swaging operation in order to make the contact and diaphragm airtight. Disc 89 is interposed between the diaphragm 85 and the lug or terminal 88 for stiffening the assembly and preventing local stresses.

The second contact 82 is positioned opposite the first contact 83 and has a similar silver or other good electrical conductor attached to the base. The leg 90 of the second contact 82 extends through the diaphragm 84 and has a lug or terminal 88 mounted thereon with a disc 89 interposed between the terminal 88 and the diaphragm 84. A portion of the contact leg 90 is swaged or turned over the terminal for mechanical fastening purposes.

A means for flexing the diaphragm must be provided so that the contacts can engage each other and pass electrical current from one terminal to another. One manner of flexing the diaphragms is to provide a vent for evacuating the air between the diaphragms, and in the present embodiment this vent is provided by having a passageway 92 coaxially positioned on the contact leg 90 interconnected with the transverse opening 91. A vacuum line can be connected to the contact leg 92 to thereby evacuate the switch, flex the diaphragms, and cause the contacts to engage. The position of this vacuum vent is only illustrative and any vent may be positioned on any portion of the switch for evacuation purposes.

FIGURE 6 illustrates another embodiment of the present invention in which a single pole, double throw switch is illustrated. This embodiment has the same arrangement of the contacts on the two diaphragms as illustarted in FIGURES 4 and 5.

An additional diaphragm 93 or support means is interposed between the two diaphragms 84, 85, and has a contact 94 mounted thereon in a conventional manner. The middle support or diaphragm 93 has a wire 95, or printed circuit, or other conductive means sandwiched or disposed in the interior of the diaphragm 93 and attached to the contact 94 and terminal 96. The diaphragms may be flexed individually by applying a vacuum at the contact 90, 90 separately, or a vacuum may be applied to both diaphragms concurrently to make the contacts at all three terminals simultaneously. The central supported diaphragm may be either solid or flexible, depending upon the arrangement and the size of the switch.

Referring now to FIGURES 7 and 8, there is illustrated two embodiments of the present invention which provide contact elements having a wiping action. The switch 100 illustrated in FIGURE 7 has contacts 101, 102 positioned opposite each other and attached in a manner illustrated and described with relation to the switch in FIGURES 4 and 5. The diaphragms 103, 104 are flexible in nature and attached at the periphery, however, the central portion 105, 106 respectively are inclined with relation to the remainder of the diaphragm, thereby canting each contact.

As the switch, illustrated in FIGURE 7 is actuated by applying a vacuum to the contact passageway 107, the diaphragms 103, 104 flex, causing the contacts 101, 102, to engage each other. As the contacts are moved into greater engagement, there is a slight lateral movement of the contacts which prevents a weld from forming and tends to clean the contact faces of any material caused by the arcing of the contacts.

Referring now to FIGURE 8, the switch 108 is another embodiment of the switch illustrated in FIGURE 7 and has a similar wiping action effected by the contacts. In this embodiment, the entire switch 108 is very similar to the switch 80 illustrated in FIGURES 4 and 5. The contacts 82, 83, have angular faces 109, 110, respectively such that as the diaphragms are flexed toward each other, the contacts will have a slight lateral movement thereby giving a wiping action similar to the operation described in relation to the switch 100 illustrated in FIGURE 7.

The embodiments illustrated in FIGURES 9, 10, and 11 of the present invention relate generally to normally closed contacts which are opened upon an operation of a diaphragm flexing means.

Referring now to FIGURE 9, the switch **111** comprises a pair of diaphragms **84**, **85** fixedly attached to each other at their periphery and having a contact, and terminal arrangement similar to that illustrated in FIGURE 5. A looped shaped arm **112** is fixedly attached to the diaphragm **84** by a rivet **113** passing through the stiffner **89** and terminal **88**. This arm **112** has a contact **114** mounted at its extremity which is in engagement with the contact **82**. Arm **112** also has a curved portion **115** which is in spaced relation with the disc **89** and acts to pivot the contacts **82**, **114**, out of engagement upon movement of the diaphragms **84**, **85** toward each other. Arm **112** is prevented from short circuiting the switch **111** since its curved portion **115** contacts an insulator disc **89** that prevents such short circuiting.

In operation, it may be seen that as the diaphragms **84**, **85** are flexed toward each other, by delivering a vacuum to the interior of the switch **111**, such that the curved portion **115** of arm **112** contacts the disc **89**, tending to pivot the contact **114** from contact **82**. Further movement of the diaphragms **84**, **85** toward each other, moves the contacts **82**, **114** further out of engagement.

The embodiment illustrated in FIGURE 10 is somewhat similar to the embodiment illustrated in FIGURE 9. Switch **120** has a pair of diaphragms **84**, **85** attached at their periphery and having a contact **82** passing through pivot bar **121**, diaphragm **85**, stiffener disc **89**, and terminal **88**.

A U-shaped spring arm **122** is attached to diaphragm **84** by a rivet **123** passing therethrough and stiffener disc **89** and terminal **88** positioned on the opposite side of the diaphragm. Contact **124** mounted at the end of the spring arm **122** is normally in engagement with the contact **82**. An upstanding post **125** from the pivot bar **121** is in spaced relation with the spring arm **122** and operates in a similar manner to the switch construction of FIGURE 7. Movement, of the diaphragms **84**, **85** toward each other, forces the arm **122** to contact and pivot on post **125** to thereby disengage contacts **82** and **124**.

Another embodiment, of the present invention, relating to a normally closed switch **130** is illustrated in FIGURE 9. Diaphragms **84**, **85** are attached at their periphery and have a contact **82** passing through insulated discs **89** and terminal **88**.

Attached to the diaphragm **84** by rivet **133** are a terminal **88**, insulated disc **89**, a rigid backing plate **131**, and a looped shaped spring arm **132**. Arm **132** has a depressed portion **134** in its central area having a contact **135** mounted thereon which is in engagement with contact **82**. This depressed portion **134** leaves downwardly, projecting curved portions **136**, **137** which are in spaced relation with the insulated disc **89**. Therefore it may be seen that movement of the diaphragms **84**, **85** toward each other, forces the curved portions **136**, **137** of the spring arm **132** to engage the disc **89** thereby tending to force the contacts **135**, **82** out of the engagement. The rigid backing plate **131** constantly forces the spring arm **132** downwardly, tending to keep its conformed shape and prevents deflection of the upper portion of the spring arm **132** during the switch actuation.

Referring now to FIGURES 12, 13, 14 and 15, there are illustrated several more embodiments of the present invention relating generally to normally closed switch constructions.

The switch **140** illustrated in FIGURE 12 comprises a pair of diaphragms **84**, **85** sealed at their periphery and having two contacts **141**, **142** normally in the closed position. Terminal **88**, insulated disc **89**, and a contact arm **144** positioned within the switch are held thereto by a rivet **145** being staked on both sides of the diaphragm **85**.

Nipple **146** having an outwardly extending flange **147** retains the terminal **88** and insulated disc **89**, contact

arm **143**, and overtravel stop **148** against the diaphragm **84**. Nipple **146** has a passageway therethrough for communication of a vacuum into the interior of the switch for flexing the diaphragm toward each other. Contact arm **143** has a downwardly extending shoulder **149** which is electrically contacting the lug or terminal **88**. Electrical contact **141** mounted at the extremity of the arm **143** is in electrical engagement with contact **142**.

In operation, the diaphragms **84**, **85** are flexed toward each other until the contacts **141**, **142** are disengaged. The overtravel stop **148** prevents the contact **141** from engaging the nipple **146** and short circuiting the switch.

Referring now to FIGURE 13, another embodiment is illustrated of the present invention as applied to normally closed switch **150**. This embodiment has a similarity to the embodiment illustrated in FIGURE 12 but has an additional terminal on one diaphragm to provide a single pole double throw arrangement.

The switch **150** has a pair of diaphragms **84**, **85** sealed at their periphery and a contact arm **151** and terminal **152** being mounted on diaphragm **84** by a hollow nipple **153** having a lateral flange **154** contacting terminal **152** and a staked portion engaging the contact arm **151**. The passageway **155** through the nipple **153** provides an access port for evacuating the interior of the switch. The contact **156** is suitably mounted on the extremity of the contact arm **151**.

On diaphragm **85**, there is mounted a pair of terminals **151**, **158** separated by an insulating disc **159** and a contact arm **160** in electrical engagement with the lower terminal **158**. An elongated contact **161** is staked on the upper terminal **157** and extends through an insulating nipple **162** terminating in a head portion **163** in juxtaposition and spaced relation with the contact **164** mounted on arm **151**. Contact arm **160** has a shoulder **165** which is in engagement with the terminal **158** and has thereon an electrical contact **156** which is in engagement with the contact **164**, therefore forming electrical continuity between terminal **152** and terminal **158**.

In operation, evacuation of the central portion of the switch causes the contacts **156** and **164** to disengage and thereafter contact **164** engages contact head **163** to provide electrical connection between terminal **152** and terminal **157**.

Referring now to FIGURES 14 and 15, another embodiment of the present invention is adapted to a double pole-double throw switch **170** in which two terminals are positioned on each of the diaphragms.

A pair of diaphragms **171**, **172** are sealed at their periphery and each diaphragm has two contact arms respectively which are individually in contact with their respective terminals. Specifically, on diaphragm **171** there is mounted a terminal **173** having an elongated contact **174** staked at both sides and extending through an insulated nipple **175** and engaging a contact arm **176** having contact **176***a* mounted thereon. An insulating disc **177** separates terminal **173** from terminal **178**. A second contact arm **179** has a shoulder **180** which is in electrical contact with terminal **178**. The second insulating disc **181** separates the terminal **178** from the diaphragm **171**. Contact **182** extends through the extremities of the contact arm **183** so that contact can be made on either side of the arm. Insulated disc **186** separates arm **176** from arm **179**.

A similar arrangement having two contact arms **183**, **185** in electrical contact with two terminals **173***a*, **178***a* respectively, is mounted on diaphragm **172**.

The hollow nipple **187** has a peripheral flange **188** supporting the terminal **173**, extends through the diaphragm **172** and is staked on the contact arm **185**. An insulating tubing **189** prevents contact between the nipple **187** and contact arm **183**. Terminal **178** is insulated by a pair of insulating discs **177**, **181** positioned on opposite sides thereof and is in engagement with the shoulder **190** of the contact arm **183**. The contact arms **183**, **185** both

have contacts which extend therethrough and are able to make electrical engagement on either side thereof.

In operation, as illustrated terminal **173** is electrically connected with terminal **173***a*. Once the central portion of the switch **170** is evacuated, the diaphragms **171**, **172** flex toward each other until contact **191** engages contact **192**. In this second position, terminal **178** is in electrical contact with terminal **178***a*.

From the various embodiments with this present invention, which are shown and described, it may be seen that a plurality of terminals may be placed on either side of the diaphragms with a multitude of switching arrangements positioned within the switch construction, which will all be within the spirit of the invention. It is also possible to construct the switch with the contacts normally closed and operate the switch by using a pressure source. These embodiments are only illustrative and the various modifications of the switch arrangements and terminal arrangements may be made without departing from the scope and the spirit of this invention as defined in the appended claims.

We claim:

1. A switch comprising: a pair of disc shaped circular diaphragms attached to each other at their periphery to form a hollow housing, a first contact attached to one of said diaphragms, a second contact attached to the other of said diaphragms such that it is positioned opposite to said first contact, said contacts extending within said housing and having contact faces facing each other, a nipple attached to one of said contacts, said nipple and contact having a passageway therethrough and terminating in spaced relation with said contact face and within said closed housing whereby source of pressure may be attached to said nipple to evacuate the housing and flex the diaphragms toward each other and vary the spacial relation of the contacts with relation to each other.

2. A switch comprising: a pair of thin cup shaped circular diaphragms attached to each other at their periphery to form a hollow housing, a first contact attached to one of said diaphragms, a second contact attached to the other of said diaphragms such that it is positioned opposite to said first contact, said contacts extending within said housing, said contacts each having a face portion, said contacts positioned within the housing such that their faces are at an angle less than 180° to the diaphragms, and a means for evacuating said housing for flexing the diaphragms to alter the position of the contacts in relation of each other whereby the engagement or disengagement of the switch gives a wiping contact, said means for evacuating said housing including a passageway through one of said contacts, terminating in spaced relation with said contact face thereof and within said hollow housing.

3. A switch comprising: a pair of flexible thin cup-shaped diaphragms attached to each other to form a hollow closed housing, said diaphragms each having an angular portion thereon making an angle of less than 180° relative to the respective diaphragm, a first contact attached to one of said diaphragms within said angular portion, a second contact attached to the other of said diaphragms such that it is positioned opposite said first contact and positioned within said angular portion, said contacts each having a face portion, said contacts mounted on said diaphragms angular portions so that said contacts are positioned at an angle relative to the remainder of the diaphragms whereby the engagement of the contacts gives a wiping action, and a means for evacuating said housing for flexing the diaphragms to alter the position of the contacts in relation to each other, said means for evacuating said housing including a passageway through one of said contacts, terminating in spaced relation with said contact face thereof and within said hollow housing.

4. A diaphragm switch comprising: a pair of flexible thin cup-shaped diaphragms attached to each other to form a hollow closed housing, a first electrical contact attached to one of said diaphragms, a second contact attached to the other of said diaphragms such that it is positioned opposite to said first contact, said contacts having a face portion positioned at an angle less than 180° relative to the diaphragm, whereby the engagement of the contacts gives a wiping action, and a means for evacuating said housing for flexing the diaphragms to alter the position of the contacts in relation to each other, said means for evacuating said housing including a passageway through one of said contacts, terminating in spaced relation with said contact face thereof and within said hollow housing.

5. A switch comprising:
- a pair of non-metallic flexible diaphragms attached at their peripheries forming a hollow housing,
- a pair of contacts mounted one each on said diaphragms and having faces thereon which are engageable with each other,
- one of each contacts having a passage therethrough, and terminating in spaced relation with said contact face and within said closed housing,
- whereby upon engagement of said contacts by applying a vacuum to said contact passageway that said passageway is not covered when said contact face is engaged.

6. A switch as defined in claim 5 in which said passageway is in the shape of a T.

7. A switch comprising:
- a pair of non-metallic flexible diaphragms attached at their peripheries and forming a hollow housing,
- a pair of contacts mounted one each on said diaphragms and having faces thereon which are engageable with each other,
- one of said contacts having a passage therethrough and terminating in spaced relation with said contact face and within said closed housing,
- a nipple mounted to said contact having a passageway therethrough and said passageway passing through said nipple,
- a pair of electrical terminals attached one each to said contacts and extending exteriorly of said closed housing,
- whereby upon engagement of said contacts by the application of a vacuum to said nipple passageway, said contact faces may engage without closing off the vacuum passage, and electrical energy may pass from one terminal to the other.

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