This invention relates to improved vacuum operated electrical switches and the like.

While the vacuum operated switches of this invention can be used for any desired purpose, it is found that the same are particularly useful in connection with vacuum program controls and the like.

For example, the switch constructions of this invention do not require a large volume of air to be introduced into or removed from the vacuum chambers thereof to operate the same. Consequently, the vacuum program system may be efficiently operated by a relatively small vacuum pump.

Further, the vacuum operated switches of this invention are adapted to be made from a relatively few basic parts in a non-time consuming manner whereby the same parts can be utilized to form different switch constructions for different purposes.

Accordingly, it is an object of this invention to provide an improved vacuum operated switch or the like having one or more of the novel features of this invention set forth above and hereinafter shown and described.

Other objects, uses, and advantages of this invention will be apparent upon a reading of this description which proceeds with reference to the accompanying drawings forming a part thereof and wherein:

FIGURE 1 is a schematic view illustrating various embodiments of the vacuum operated switches of this invention in connection with a vacuum program control system, the cross-sectional views of the switch constructions of this invention merely being schematic and not true cross-sectional views.

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

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

FIGURE 4 is a side view of one of the vacuum operated switches of this invention.

FIGURE 5 is an exploded perspective view of the various parts of the switch of FIGURE 4.

FIGURE 6 is a side view of another vacuum operated switch of this invention.

FIGURE 7 is an exploded perspective view of the various switch parts forming the switch construction illustrated in FIGURE 6.

FIGURE 8 is a side view of another vacuum operated switch of this invention.

FIGURE 9 is an exploded perspective view illustrating the various parts forming the switch construction of FIGURE 8.

FIGURE 10 is a side view of another vacuum operated switch of this invention.

FIGURE 11 is a cross-sectional view of the switch structure illustrated in FIGURE 10 and is taken on line 11—11 thereof.

While the various features of this invention are hereinafter described as being particularly adaptable for forming vacuum operated electrical switches for use with a vacuum program control system, it is to be understood that the various features of this invention can be utilized singly or in various combinations thereof to provide other constructions as desired.

Therefore, this invention is not to be limited to only the embodiments illustrated in the drawings, because the drawings are merely utilized to illustrate one of the wide variety of uses of this invention.

Referring now to FIGURE 1, an improved system of this invention is generally indicated by the reference numeral 20 and comprises a reading head or block 21 having an upper surface 22 interrupted by a plurality of switch passages 23, 24, 25, 26 and 27 respectively interconnected to conduits 28, 29, 30, 31 and 32 leading to vacuum operated switch constructions 33, 34, and 35 of this invention in a manner hereinafter described.

The top or reading surface 22 of the reading head 21 is also interrupted by a plurality of vacuum passages 36 respectively disposed in spaced, aligned, alternating relation with the switch passages 23—27 as illustrated in FIGURES 1 and 3, the suction or vacuum passage 36 being interconnected to a common suction manifold passage 37 interconnected to the inlet side of a relatively small vacuum pump 38 by a conduit 39.

The vacuum pump 38 can be operated by a suitable electric motor 40, as desired.

A thin, flexible sheet or card 41 is adapted to pass over the reading surface 22 of the reading head 21 in any suitable manner and has a plurality of indentations or blisters 42 formed therein which are adapted to successively and in any desired pattern span the spacing between a suction passage 36 and one of the switch passages 23—27 to interconnect the vacuum source 36 with one of the operating chambers of the switch constructions 33, 34 or 35 to close the switch contacts thereof and operate suitable apparatus in a manner hereinafter described.

When it is desired to break the vacuum in one of the operating chambers of one of the switch constructions 33, 34 or 35, the program sheet 41 has apertures 43 formed therein which are adapted to pass over the switch passages 23—27 in any desired relation so that air can be drawn into the operating chamber of the particular switch constructions 33, 34, 35 to break the flow of electrical current therethrough in a manner hereinafter described.

As illustrated in FIGURE 1, the switch construction 33 comprises a pair of electrically insulating rigid casing members or means 44 and 45 secured together in a manner hereinafter described to define a compartment 46 separated into two chambers 47 and 48 by a flexible diaphragm 49 disposed in the compartment 46 and carrying a switch contact 50 disposed in the chamber 47.

The casing member 44 carries a switch contact 51 disposed in the chamber 47 and cooperate with the switch contact 50, the switch contact 50 normally being held out of electrical contact with the switch contact 51 by diaphragm 49 when the chamber 47 is at atmospheric pressure.

The chamber 47 of the switch construction 33 is interconnected to the conduit 28 by a passage means 52 formed in the casing member 44.

The switch contact 50 of the switch construction 33 is interconnected to line L-1 of a suitable power source by a terminal 53.

The switch contact 51 of the switch construction 33
is interconnected to a terminal 54 which is adapted to be interconnected to the other line L-2 of the electrical power source by a lead 55, the lead 55 having an electrically operated device 56 disposed therein which is to be actuated when the switch contacts 50 and 51 engage each other.

When it is desired to operate or energize the power element 57 of the device 56, the program sheet 41 has a blister 42 thereof bridge the gap between the passages 36 and 23 so that air can be expelled from the chamber 47 of the switch construction 33 to cause the diaphragm 49 to recede to the right and carry the switch contact 50 into engagement with the switch contact 51 so that the power element 57 is placed across the lines L-1 and L-2 to be energized and operate the device 56.

When an aperture 43 of the program sheet 41 subsequently comes into register with the passage 23, the vacuum condition in the chamber 47 is broken and air is adapted to enter the chamber 47 and permit the natural resiliency of the diaphragm 49 to return to the position illustrated in FIGURE 1 whereby electrical connection between the contacts 50 and 51 is broken to deenergize the power element 57 of the device 56.  

Therefore, it can be seen that the switch construction 33 operates in a relatively simple manner to make and break electrical connection to the power element 57 of the device 56, the particular details of the switch construction 33 being hereinafter described.  

As illustrated in FIGURE 1, the switch construction 33 of this invention is formed from a plurality of parts similar to the switch construction 33 whereby like parts are indicated by like reference numerals and the general and detailed description of the like parts of the switch construction 33 apply to the switch construction 34.  

In particular, the switch construction 34 comprises a pair of like casings 48 and 49 secured together in a manner hereinafter described to define a compartment 58 between.  

A flexible diaphragm 49 is disposed in the compartment 58 and divides the same into two chambers 59 and 60 respectively interconnected to the conductors 29 and 30 by passage means 52 formed in the casing members 44.

The diaphragm 49 of the switch construction 34 carries a pair of switch contacts 50 on opposed sides thereof and respectively disposed in the chambers 59 and 60, the switch contacts 50 being interconnected to the line L-1 of the electrical power source by a contact means 53.

The casing members 44 of the switch construction 34 respectively carry switch contacts 51 respectively disposed in the chambers 59 and 60 and interconnected respectively to power elements 61 and 62 of an electrically operated device 63 by terminals 54.

The diaphragm 49 of the switch construction 34 is normally disposed in the position illustrated in FIGURE 1 when normal atmospheric conditions exist in the chambers 59 and 60 thereof whereby the switch contacts 50 of the diaphragm 49 are disposed out of electrical contact with the switch contacts 51 of the casing members 44.

When it is desired to operate the power element 61 of the device 63, a blister 42 of the program sheet 41 bridges the passages 24 and 36 of the reading head 21 whereby a vacuum condition is imposed in the chamber 59 and causes the diaphragm 49 to move to the left and make electrical contact between the left hand switch contacts 50 and 51 so that the power element 61 is placed across the power lines L-1 and L-2.

When it is desired to operate the power element 61 of the device 63, an aperture 43 of the program sheet 41 bridges the passages 24 and 36 of the reading head 21 so that air can return to the chamber 59 of the switch construction 34 whereby the natural resiliency of the diaphragm 49 returns the same to the position illustrated in FIGURE 1 to break electrical contact between the left hand switch contacts 50 and 51.

When it is desired to operate the power element 62 of the device 63, a blister 42 of the program sheet 41 bridges the passages 25 and 36 of the reading head 21 to impose a vacuum condition on the chamber 60 whereby the diaphragm 49 moves to the right and makes electrical contact between the right hand contacts 50 and 51 of the switch construction 34 to place the power element 62 across the power lines L-1 and L-2.

Termination of the operation of the power element 62 of the device 63 is caused by an aperture 43 of the program sheet 41 registering with the passage 25 so that air can return to the chamber 60 and permit the natural resiliency of the diaphragm 49 to return the same to the position illustrated in FIGURE 1.

Therefore, it can be seen that the switch construction 34 of this invention is readily adaptable to operate two different power elements of a device or two power elements of two separate devices as desired in various sequence of operation, the switch construction 34 being formed from parts very similar to the switch construction 33 as will be apparent hereinafter.

As illustrated in FIGURE 1, the switch construction 35 of this invention is adapted to be formed of a plurality of parts similar to the switch construction 33 and 34 whereby like parts thereof are indicated by like reference numerals and the general and detailed description of such like parts also relates to the switch construction 35.

The switch construction 35, as illustrated in FIGURE 1, comprises a pair of like casings 48 and 49 members 44 disposed on opposite sides of and secured to a casing means 45 in an aligned relation whereby the left hand casing member 44 cooperates with the casing member 45 to define a compartment 64 therebetween and the right hand casing member 44 cooperates with the casing member 45 to define a compartment 65 therebetween.

A pair of like flexible diaphragms 49 are respectively disposed in the compartments 64 and 65 of the switch construction 35 and respectively divide the compartments 64 and 65 into four chambers 66, 67, 68, and 69, the chambers 66 and 69 being respectively interconnected to the conductors 31 and 32 by passage means 52 respectively formed in the casing members 44.

The diaphragms 49 respectively carry switch contacts 50 respectively disposed in the chambers 66 and 69, the switch contacts 50 being respectively interconnected to the power terminal 53.

The casing members 44 respectively carry switch contacts 51 respectively disposed in the chambers 66 and 69 and respectively electrically interconnected to power elements 70 and 71 of an electrically operated device 72 by terminals 54.

When it is desired to operate the power element 70 of the device 72, a blister 42 of the program sheet 41 bridges the passages 26 and 36 of the reading head 22 to impose a vacuum condition in the chamber 66 whereby the left hand diaphragm 49 moves to the left to make electrical connection between left hand contacts 50 and 51 to place the power element 70 across the power lines L-1 and L-2.

When it is desired to terminate operation of the power element 70 of the device 72, an aperture 43 of the program sheet 41 registers with the passage 26 of the reading head 22 so that air can return to the chamber 66 of the switch construction 35 and the natural resiliency of the diaphragm 49 will return the left hand switch contact 50 to the position illustrated in FIGURE 1.

When it is desired to operate the power element 71 of the device 72, regardless of whether the power element 70 thereof is operating or not, a blister 42 of the program sheet 41 bridges the passages 27 and 36 to impose a vacuum condition in the chamber 69 so that the right hand diaphragm 49 will move to the right to make electrical contact between the right hand switch contacts 50 and 51 and place the power element 71 across the power lines L-1 and L-2.

When it is desired to terminate operation of the power
element 71, an aperture 43 of the program sheet 41 registers with the passage 27 so that air can return to the chamber 69 of the switch construction 35 and permit the natural resiliency of the right hand diaphragm 49 to move the right hand switch contact 50 away from the right hand switch contact 51.

Therefore, it can be seen that the switch construction 35 of this invention is adapted to alternately or simultaneously operate two different power elements of a particular device or to simultaneously or alternately operate power elements of two separate devices as desired.

Further, the switch construction 35 of this invention is adapted to be made of various parts which are also utilized to form other switch constructions of this invention.

Accordingly, the various switch constructions of this invention can be formed in a relatively simple and rapid manner in a manner hereinafter described to provide vacuum operated switches for particular applications thereof without requiring a large number of different parts for different switch constructions.

The particular details of the switch parts of the switch construction 33 of this invention will now be described and reference is made to FIGURES 4 and 5 of the drawings, the particular details of the switch parts for the switch construction 33 also applying for like parts of the switch constructions 34 and 35.

As illustrated in FIGURE 5, each casing member or member 44 of this invention comprises an integrally molded mass of rigid electrically insulating material, such as general purpose phenolic or the like, having opposed flat surfaces 73 and 74 and diametrically opposed ears or lugs 75 respectively provided with apertures 76 passing therethrough.

The side 73 of each casing member 44 is provided with a plurality of concentrically disposed and stepped bores 77, 78, 79, 80 and 81 respectively defining annular shoulders 82, 83, 84, 85 and 86 with the bore or aperture 81 extending completely through the casing member 44.

The annular shoulder 82 of each casing member 44 is interrupted by an elongated slot 87 and another slot 88 at right angles to the slot 87 and interconnected thereto for a purpose hereinafter described.

The passage means 52 of each casing member 44 includes a tubular extension 89 extending outwardly from the end of casing means 44 and being adapted to be interconnected to a conduit means or the like, the passage means 52 passing through the tubular extension and interrupting the annular shoulder 84 whereby the passage means 52 terminates at the bore 79 as illustrated in FIGURE 5.

As illustrated in FIGURE 7, the other side 74 of each casing member 44 is provided with a centrally disposed raised projection 90 interrupted by a recess 91 to provide a terminal supporting surface 92 interrupted by the bore or aperture 81 previously described.

The side 74 of each casing member 44 is provided with another outwardly extending projection means 93 adjacent the outer periphery thereof, the projection means 93 being interrupted by a recess 94 to define a terminal supporting surface 95 utilized for a purpose hereinafter described.

While it has been stated that the casing members 44 of this invention can be formed into the configuration illustrated in the drawings by a molding process, it is to be understood that the same can also be formed by machining operations or combined molding and machining operations as desired.

As illustrated in FIGURE 5, each casing means 45 of this invention has opposed flat surfaces 96 and 97 and is provided with outwardly extending ears or lugs 98 having apertures 99 passing therethrough and adapted to register with the apertures 76 in the casing members 44, the casing members 45 being formed by molding or machining a rigid electrically insulating material, such as general purpose phenolic or the like.

The opposed surfaces 96 and 97 of each casing member 45 are interrupted by bores 100 which respectively define substantially annular shoulders 101 and central circular portions 102.

Each flexible diaphragm 49 can comprise 0.002 inch thick beryllium and copper alloy or the like and has a plurality of concentrically disposed corrugations 103 to render the same substantially resilient or flexible to produce the operations of the switch constructions 33-35 as previously described.

Each diaphragm 49 has an outwardly extending portion 104 suitably stepped at 105 to be spot welded to the terminal 53 formed of brass or the like, the terminal 53 having outwardly directed tangs adapted to be received in the slot 87 of the casing member while the remainder of the terminal 53 is received in the slot 88 thereof as illustrated in FIGURE 4.

When forming the switch constructions 33 and 35, the switch contact 50 is projection welded on the operating side of the diaphragm 49, the switch contact 50 comprising stainless steel or the like covered with fine silver or the like.

Since the diaphragm 49 is itself formed of electrical conductive material, the diaphragm 49 provides the electrical connection between the terminal 53 and the switch contact 50.

The diaphragm 49 is so constructed and arranged that the same is adapted to be sandwiched between the annular shoulders 82 and 101 of the casing members 44 and 45 when forming the switch construction 33 of this invention whereby the diaphragm 49 will be secured to the casing members 44 and 45 when the casing members 44 and 45 are secured together by brass hollow eyelets 107 or the like having flanged ends 108 and passing through the aligned apertures 76 and 99 of the casing members 44 and 45, the eyelets 107 having the free end 109 thereof subsequently flanged by a spinning operation or the like to secure the casing members 44 and 45 together.

The terminal 54 of each casing means 44 is adapted to be formed of brazed or the like and has an inner end 110 adapted to be interlocked in the recess 91 of the projection means 90 of the respective casing member 44 in the manner illustrated in FIGURE 6, while the other end 112 thereof is interlocked in the recess 94 of the projection means 93 and extends beyond the casing member 44 in the manner illustrated in FIGURE 4, the inner end 110 of the terminal 54 having an aperture 112 aligned with the bore or aperture 81 in the casing member 44 for a purpose hereinafter described.

The switch contact 51 carried by each casing member 44 is adapted to secure the respective terminal 54 thereto in a manner now to be described.

Each switch contact 51 can be formed of stainless steel or the like covered with fine silver or the like and comprises a contact button 113 adapted to be received in the bore 90 of the casing member 44 and has a projection means 114 adapted to pass through the bore 81 in the casing means 44 and the aperture 112 in the respective terminal 54 and be peened over in the manner illustrated in FIGURE 1 to not only secure the switch contact 51 to the casing 44 but also the terminal 54 thereto, the switch contact 51 sandwiching a gasket 115 between the annular shoulder 86 of the casing member 44 and the button 113 of the contact 51 to fluid seal the aperture 81 in the casing member 44 from the operating chamber of the particular switch construction 33-35.

While the gasket 115 can be formed of any suitable material, the embodiment thereof illustrated in the drawings comprises 0.010 inch thick neoprene or the like.

After the terminal 54 and the switch contact 51 have been secured to the casing member 44 in the manner previously described, the casing members 44 and 45 are adapted to be secured together by sandwiching the diaphragm 49 therebetween, a gasket 116 being disposed be-
between the diaphragm 49 and the casing member 44 and engaging the annular shoulder 83 of the casing means 44 to fluid seal the operating chamber of the particular switch construction 33–35.

While the gasket 116 can be formed of any suitable material, the embodiment thereof illustrated in the drawings comprises 0.010 thick neoprene or the like. Therefore, it can be seen that the switch construction 33 of this invention can be formed in a relatively simple and relatively rapid manner to provide an improved vacuum operated switch which requires a minimum amount of air to be drawn into or expelled from the operating chamber thereof to effect the desired switching action, the embodiment of the switch construction 33 illustrated in the drawings only having a clearance of approximately 0.015 of an inch between the switch contacts 50 and 51 when the switch construction 33 is disposed in the position illustrated in FIGURE 1.

While the switch construction 33 is illustrated as not having gasket means between the diaphragm 49 and the casing means 44 thereof, it is to be understood that the casing means 44 could be provided with a suitable bore to receive a gasket 116 in substantially the same manner that the casing means 44 receives such gasket 116 if desired. When it is desired to form the switch construction 34 of this invention, it can be seen from FIGURES 6 and 7 that the casing members 44 are disposed in substantially the same manner and when assembled together by the hollow eyelets 107 in the manner previously described the diaphragm 49 compresses gaskets 116 between the casing members 44 to respectively seal the operating chambers 59 and 60 thereof while the terminals 54 project from the respective casing means 44 approximately ninety degrees out of phase with each other, while the tubular means 89 of the passage means 52 of the casing member 44 are also disposed approximately ninety degrees out of phase with each other.

As illustrated in FIGURES 8 and 9, the switch construction 35 can be formed of the parts of the switch constructions 33 and 34 in such a manner that the terminals 54 are disposed ninety degrees out of phase with each other in the same manner that the tubular extensions 89 of the casing means 44 are disposed ninety degrees out of phase with each other.

While the switch construction 35 is illustrated without having gasket means 116 between the diaphragms 49 and the central casing member 45, it is to be understood that the casing means 45 can be modified to accept such gaskets 116 if desired. Therefore, it can be seen that the switch constructions 33–35 of this invention can all be formed in substantially the same manner and from the same subassemblies in a relatively simple manner so that a desired number of switch constructions can be formed from a relatively small number of different parts to provide switch constructions for different applications.

As illustrated in FIGURES 10 and 11, another switch construction of this invention is generally indicated by the reference numeral 117 and comprises a pair of like casing members 118 formed in a manner similar to the casing means 44 previously described, except that the casing members 118 have the outer surfaces 119 thereof provided with recesses 120 complementary to the ends 110 of the respective terminals 54 rather than having projections 90 and 93 previously described.

Further, the inner surfaces 121 of the casing members 118 are respectively interrupted by bores 122, 123, 124 and 125 to respectively define annular shoulders 126, 127 and 128, with the bore 125 passing through the respective casing member 118 to receive the switch contact 51 previously described and assembled thereto in the manner previously described, the switch contact 51 sandwiching a gasket 115 against the casing member 118 to seal the bore 125 and being utilized to secure the terminal 54 to the casing member 118.

The diaphragm 49 separates the compartment 130 of the casing means 118 into two operating chambers 131 and 132 respectively interconnected to the exterior by passage means 133 extending through tubular extensions 134 projecting out of the sides of the casing members 118. However, it has been found by having the tubular extensions 89 of the switch construction 33–35 extending out of the ends of the respective casing members 44 rather than out of the sides thereof in the manner illustrated in FIGURE 11, a plurality of switch constructions can be disposed closely adjacent each other in stacked relation to provide a more compact arrangement than would be provided by a plurality of switch constructions 117 of this invention.

The diaphragm 49 of the switch construction 117 is assembled to the casing members 118 in the manner previously described and sealed thereto by the gaskets 116 in the manner previously described.

While the switch construction 117 is illustrated as operating in substantially the same manner as the switch construction 34 previously described, it is to be understood that the same can be made into substantially the same type of operating switch 33 or 35 as desired by merely providing a pressure pad similar to the casing member 45 previously described.

While the diaphragms 49 of the switch constructions 33–35 and 117 of this invention are illustrated as not being snap acting, it is to be understood that the diaphragms 49 could be made snap acting, as desired.

Accordingly, it can be seen that various switch constructions are provided by this invention which are adapted to be actuated by a simple vacuum operation to operate various power devices in various sequences or patterns as desired.

While the form of the invention now preferred has been disclosed as required by the statutes, other forms may be used, all coming within the scope of the claims which follow.

What is claimed is:

1. A vacuum operated switch comprising three electrically insulting rigid casing means arranged in aligned relation and defining a compartment between each pair of adjacent casing means, a pair of flexible diaphragms respectively disposed between each pair of adjacent casing means and dividing said compartments into four chambers, said diaphragms respectively being electrically conductive and carrying switch contacts respectively disposed in two of said chambers, each diaphragm having an outwardly extending peripheral projection, said casing means having passage means respectively leading to said two chambers and being adapted to be interconnected to a vacuum source, said casing means carrying switch contacts respectively disposed in said two chambers, and terminal means electrically and respectively interconnected to said switch contacts and being adapted to be connected to leads exteriorly of said casing means, two of said terminal means being respectively secured to said projections of said diaphragms at points intermediate the inner and outer surfaces of said casing means by overlapping said peripheral portions and having fastening means directly fastening said overlapping portions together.

2. A vacuum operated switch as set forth in claim 1 wherein at least two of said casing means respectively have slot means respectively receiving said two terminal means to prevent movement of said diaphragms and said two terminal means relative to said casing means.

3. A vacuum operated switch as set forth in claim 2 wherein said two terminal means respectively have opposed outwardly directed tangs respectively received in said slot means.

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