United States Patent

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[54] **ELASTIC DIAPHRAGM SWITCH**
9 Claims, 6 Drawing Figs.

[52] U.S. Cl. .... **200/83 B,** 200/83 N, 200/159 B
[51] Int. Cl. **H01l 35/34**
[50] Field of Search .... 200/83, 83.2, 83.8, 159 B

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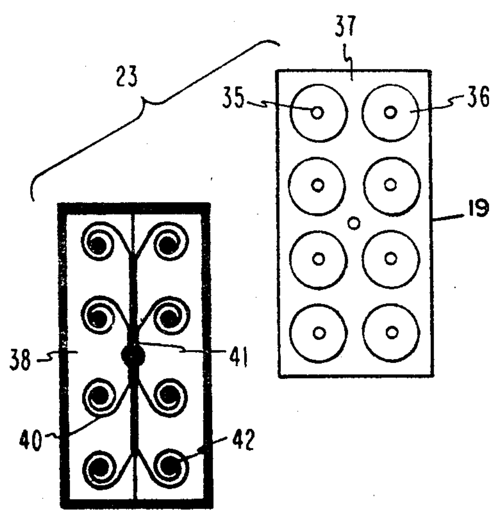
ABSTRACT: An elastic diaphragm switch has a diaphragm assembly formed as an airtight interface between a substantially rigid substrate material and a diaphragm of highly flexible film to which is adhered a copper conductive pattern designed to withstand large deflections without fatigue. This is accomplished by an extended length conductor such as a spiral conductor path extending from the diaphragm supported contact to a stationary conductor. Thus the diaphragm switch may be formed of a single thin film and activated by very low-pressure levels.



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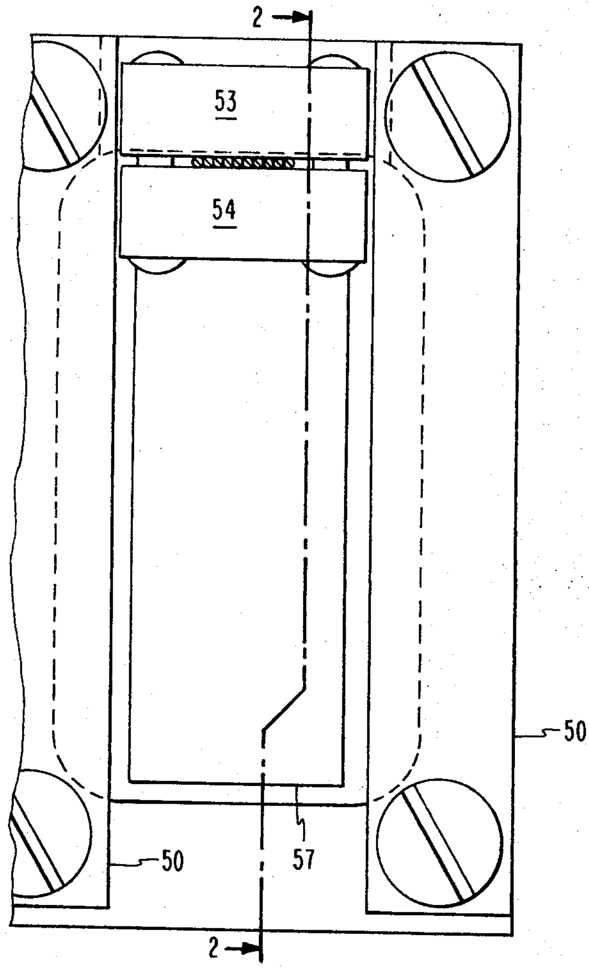

FIG. 1

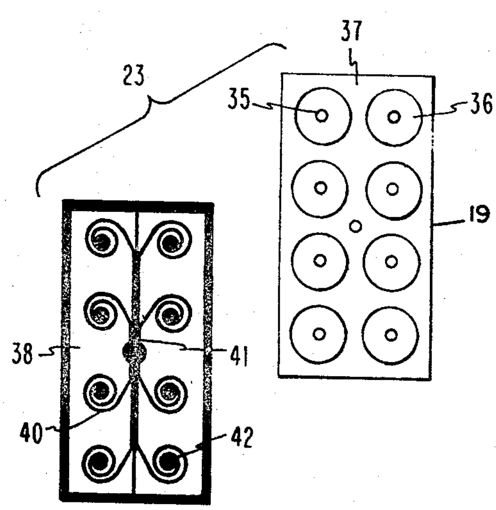

FIG. 5

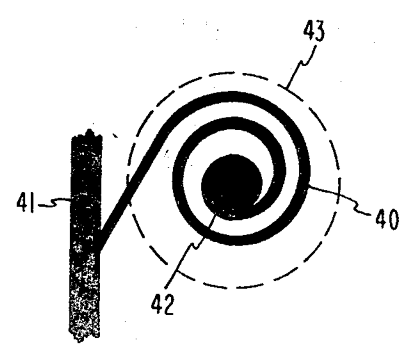

FIG. 6

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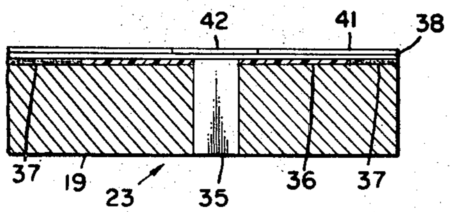

FIG. 7

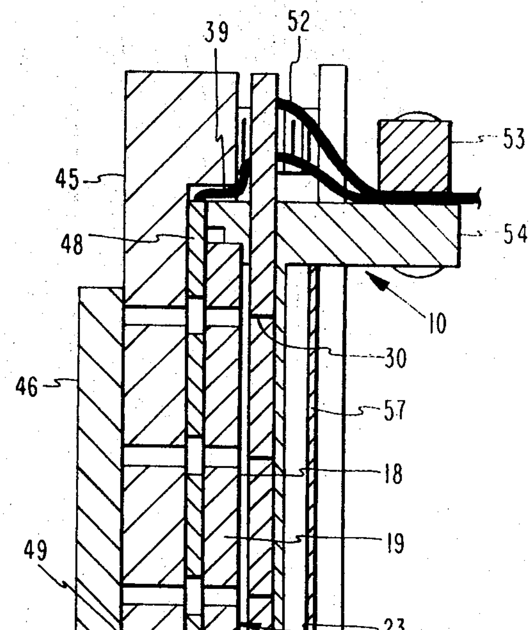
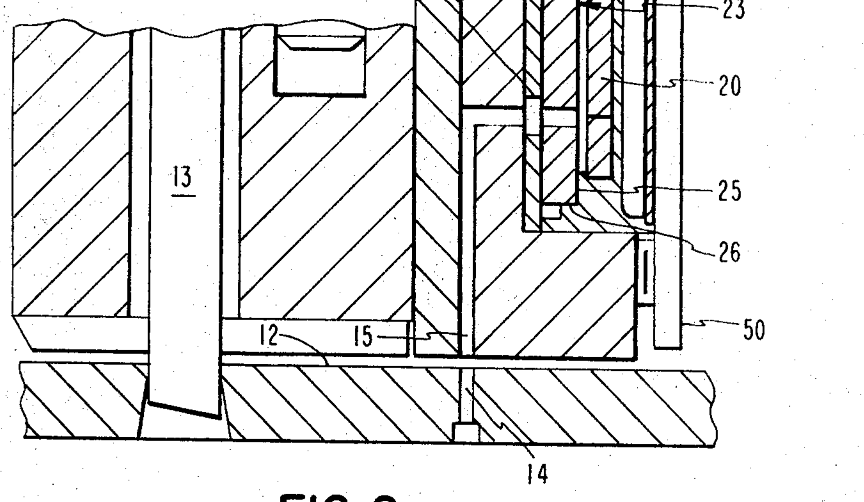

FIG. 2

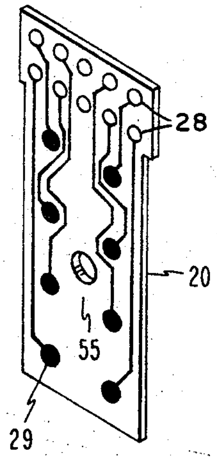

FIG. 4

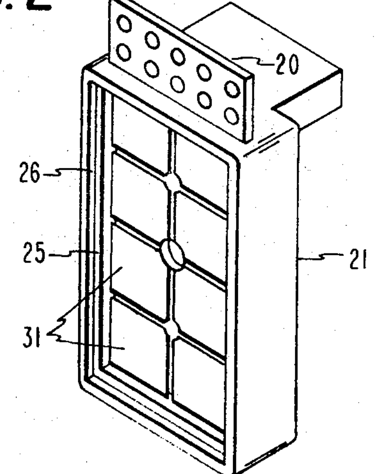

FIG. 3

ELASTIC DIAPHRAGM SWITCH

BACKGROUND OF THE INVENTION

This invention pertains to elastic diaphragm switches and more particularly to low-pressure fluid-actuated diaphragm switches.

Elastic diaphragm switches have commonly been made by adhering a layer of conductive material to a flexible substrate such as polyester film with an overlying coversheet of elastic material to further resist abrasion or permanent deformation. Multiple layers of deformable materials and the impairment of the flexibility caused by the presence of conductors increases the necessary operating pressures required and limits the density of switches that may be placed in a given space. Further the fatigue of conductors induced by the flexing action limited the effective life of the individual switches.

This invention is directed to an elastic diaphragm switch utilizing a thin film of highly flexible material formed as an airtight diaphragm. The diaphragm is deflected through such distances as 0.012 inch rather than the more typical 0.002 inch using the less flexible substrate materials such as previously utilized. To accommodate the increased deflections without fatigue, the copper conductive pattern extending from the diaphragm carried contact to a stationary lead extends in a helical pattern to thereby approach a disposition perpendicular to the radial elongation of the diaphragm material and reduce the conductor flexure per unit length to minimize the fatigue load to which the conductor is subjected. This simultaneously reduces the impairment of diaphragm flexibility caused by the adhered conductive material.

The diaphragm switch made in accordance with the present invention is high speed and economical. Using thin film polymer plastics, it has been possible to achieve response rates of 2,000 cycles per second using a 0.005 inch gap. Further, with diaphragm assembly packaging densities such as 16 per square inch, the structure can be readily fabricated at low cost by automated paging or sheeting techniques. Also, the low masses involved in the structure cause the device to be virtually shockproof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an enlarged elevation view of a document punching and verification device utilizing the elastic diaphragm switch construction of this invention.

FIG. 2 is a section view taken along line 2—2 of FIG. 1.

FIG. 3 is an isometric view of the elastic diaphragm switch housing including the stationary contact circuit board which is an insert in the molded housing.

FIG. 4 is an isometric view of the stationary contact circuit board showing the major surface opposite that visible in FIG. 3.

FIG. 5 is an exploded view of the diaphragm and substrate assembly.

FIG. 6 is a fragmentary view of the elastic diaphragm material showing the conductor pattern extending from the stationary diaphragm portion to the movable contact.

FIG. 7 is an enlarged partial section of the diaphragm assembly including the rigid substrate and flexible membrane.

DETAILED DESCRIPTION

As illustrated in FIGS. 1 and 2 in an enlarged view, the elastic diaphragm switch assembly 10 is shown as a punch checking or verifying device for a parallel punch where a card passing in parallel, row by row through the punch station along the card guide surface 12 has rows of information punched therein. Two rows subsequent to the punching operation, the card is read to verify the information entered. For each punch element 13 there is a corresponding read position where a jet of air supplied through an orifice 14 is received by a passageway 15 whenever an unpunched card surface is not present to act as a valve. When the aligned orifice 14 delivers air to the passageway 15, the elevated pressure applied at the terminal end of such passage causes the diaphragm 18 extending over a fluidtight circular interface with the board 19 to be flexed outward therefrom bringing into engagement the aligned contacts carried by the diaphragm 18 and the stationary circuit board 20.

The switch assembly 10 in the environment shown has normally closed contacts as the passages 15 are subjected to airflow from the respectively aligned orifices 14. However, a punched card guided along surface 12 and passing through the read-verify station serves as a valve intermediate the orifices and aligned passageways. Accordingly, the logic circuits associated with the device which are activated when a card is present would find the matrix to consist of normally open switches and through the read timing circuit sense when a punched hole has permitted the associated diaphragm switch contacts to be closed.

The elastic diaphragm switch assembly 10 includes a molded housing 21 which has a circuit board 20 held captive as an insert and a diaphragm assembly 23 which is received by the housing in abutting relation with shoulder 25 and is aligned by the surrounding wall surface 26.

The circuit board 20 is also shown in FIGS. 3 and 4. As seen in FIG. 4 the epoxy circuit board has a series of terminals 28 individually connected to contacts 29 which are plated through apertures 30 (shown in FIG. 2) in the circuit board to the enlarged contact surfaces 31 on the opposite surface that are disposed within the housing as seen in FIG. 3. The extended surface contacts 31 provide the stationary contacts of the elastic diaphragm switch assembly.

The diaphragm assembly 23, as shown exploded in FIG. 5, is fabricated starting with epoxy board 19 which is provided with a series of apertures 35. Surrounding each of the apertures is a coating 36 of nonstick material, such as a flurocarbon in a carrier which does not adhere to the diaphragm material, applied in a circular pattern radially outward from each of the apertures. This nonstick material is selected to prevent adhesion between the circuit board and the subsequently applied overlying elastic film. The remaining surface 37 is coated with an adhesive. Over the surface which has thus been selectively coated with nonstick material and adhesive, a film 38 of highly flexible material is applied which carries a conductive layer on the exposed surface. The conductive material is thereafter etched to form an extended helical conductor path 40 from the stationary conductor portion 41 disposed on the film portion adhered to the board and across the boundary 43 between adhered and nonadhered interfaces to the central contact 42 overlying the nonadhered interface. In the assembled condition the common circuit 40 printed on the diaphragm 38 is connected to a terminal on circuit board 20 by a conductor 39 which extends along the interface between gasket 48 and diaphragm assembly 23 and between mounting plate 45 and housing 21. As seen in FIG. 6 and FIG. 7, when fluid pressure is applied through an aperture 35 to the otherwise airtight circular interface between board 34 and diaphragm 38, the diaphragm flexes progressively from the adhesively bonded margin to the center which carries the contact 42 to correspondingly progressively flex the connecting conductor 40 thereby permitting substantial deflection of the diaphragm carried contact without a localized fatigue being sustained by the conductor. Both the flexibility of the diaphragm material and the minimum of constraint imposed by the conductor pattern permit actuation of the diaphragm by fluids subjected to very low pressure.

Diaphragm assembly 23 is shown in enlarged form. In the specific device illustrated the major dimensions of the diaphragm assembly are 1 inch by one-half inch which yields a packaging density within the matrix of 16 switches per square inch. The diaphragm 38 is a 0.001 inch polymer film carrying a circuit of ½ ounce copper which is gold plated. In the assembled condition there exists a spacing between diaphragm assembly 23 and circuit board 20 of 0.005 inch. The switches are actuated by air delivered from the aligned orifice 14 at a pressure of 1 pound per square inch.

The elastic diaphragm is shown in an assembled section view in FIG. 2 with passageways **15** leading to the diaphragm chambers formed in mounting plate **45** and completed by a closure member **46**. Continuity of the passageway between mounting plate and board apertures and the separation of individual passages therebetween is maintained by the flexible gasket **48** having a series of aligned openings **49**. The individual elastic diaphragm switch assemblies are secured to the mounting plate by straps **50** which margin each transverse side. Conductors **52** leading from the circuit board terminals are clamped between housing flange **53** and a pressure block **54** to afford strain relief.

The nonadhered circular diaphragm portions of the switch assembly deflect within the space defined by the circuit board **20**, diaphragm assembly **23** and housing **21**. To prevent the compression of air within this confined spaced from interfering with the proper operation of the switches an extended volume is achieved by the central opening **55** in the circuit board **20** and housing **21** which communicate freely with the space bounded by the housing **21** and closure plate **57**.

What we claim is:

1. A diaphragm switch assembly comprising:

a first contact carried by a substantially rigid insulating support element;

a diaphragm assembly including a flexible, electrically insulating diaphragm, supported in spaced relation to said support element;

a second contact carried by said diaphragm and aligned with said first contact;

a conductive lead adhered to the surface of said diaphragm which connects to said second contact and extends therefrom by an indirect route along at least a portion of the surface of said diaphragm subject to operational flexing; and

means for selectively varying the fluid pressure at one side of said diaphragm assembly second contact carrying portion to selectively engage and disengage said first and second contacts.

2. The diaphragm switch assembly of claim **1** wherein said diaphragm comprises an elastic film and said conductive lead comprises a metal surface portion plated on said elastic film.

3. The diaphragm switch assembly of claim **2** wherein said conductive lead is disposed in a substantially spiral configuration from said second contact along the said diaphragm surface subject to flexure.

4. The fluid-actuated switch of claim **3** wherein said lead extends from a stationary location to the diaphragm carried contact at an angle to the direction of diaphragm material elongation approaching perpendicular.

5. The diaphragm switch assembly of claim **2** wherein said elastic diaphragm material overlies a substantially rigid member;

with an adhesive bond between said diaphragm and said member defining a closed fluidtight nonadhering interface therebetween; and

passage means through said member communicating with said fluidtight interface,

said lead extending in a generally spiral path from said contact across the boundary between said adhesively bonded and nonadhesively bonded interfaces.

6. The diaphragm switch assembly of claim **2** further comprising:

a substantially rigid nonconductive board member;

a nonstick material applied to discrete areas of one major surface of said board,

said diaphragm material overlying said one major surface of said board and selectively adhered to said board at least in area portions margining said discrete area to form a fluidtight interface between said board and diaphragm material; and

passage means formed in said board member communicating with each of said fluidtight interfaces.

7. The diaphragm switch assembly of claim **6** wherein said electrical contact is adhered to said diaphragm material on the nonadhered surface centrally of said fluidtight interface and said conductive lead extends substantially spirally from said electrical contact across the boundary of said fluidtight interface.

8. A diaphragm switch assembly comprising:

a stationary first electrical contact;

a thin film elastic diaphragm;

a second electrical contact carried by said diaphragm in spaced confronting relation with respect to said first contact;

an elongated conductor adhered to the surface of said diaphragm and extending from said second electrical contact by an indirect route along the surface of said diaphragm and

means for varying the fluid pressure at one side of said diaphragm to cause deflection thereof to move said second contact into and out of engagement with said first contact.

9. The diaphragm switch assembly of claim **8** wherein said second contact and said elongated conductor comprises a conductive pattern adhered to said diaphragm and said conductor extends from said second contact in a generally spiral path.