United States Patent [19]

Schantz

[11] **3,874,052**

[45] **Apr. 1, 1975**

[54] **METHOD OF FORMING AND INSTALLING PRESSURE RESPONSIVE DIAPHRAGMS**

[76] Inventor: **Spencer C. Schantz,** 16608 W. Roger Dr., New Berlin, Wis. 53153

[22] Filed: **Oct. 1, 1973**

[21] Appl. No.: **402,519**

[52] **U.S. Cl.**..... **29/157 R,** 264/92, 200/83 WM, 92/98 R, 92/103 SD

[51] **Int. Cl.**..... **B23p 15/00**

[58] **Field of Search**..... 29/157 R, 421; 264/92; 200/83 WM, 83 J, 83 R; 92/98 R, 103 SD

[56] **References Cited**

UNITED STATES PATENTS

945,992	1/1910	Stevens	200/83 J
2,545,857	3/1951	Perkins et al.	92/98 R
2,912,536	11/1959	Hoch	200/83 R
3,302,269	2/1967	Cooper et al.	200/83 R
3,488,414	1/1970	Naples	264/92
3,801,402	4/1974	Suter	264/92

Primary Examiner—C. W. Lanham
Assistant Examiner—Dan C. Crane
Attorney, Agent, or Firm—Arthur L. Morsell, Jr.

[57] **ABSTRACT**

A cavity of predetermined shape is formed in the lower housing member of a pressure responsive device and a fluid duct is drilled through a housing wall to communicate with the cavity. A thermoplastic diaphragm sheet, either directly or in the form of a sheet clamped to a ring, is clamped over the cavity and a relatively light vacuum is applied to the fluid duct to urge the diaphragm sheet toward the bottom of the cavity. The diaphragm sheet is heated by a stream of hot air so that it will be drawn by the vacuum against the bottom of the cavity to permanently assume the shape of the cavity. A piston is then placed within the cavity on top of the diaphragm and an upper housing containing a member to be actuated by piston movement is attached to the lower housing member.

12 Claims, 9 Drawing Figures

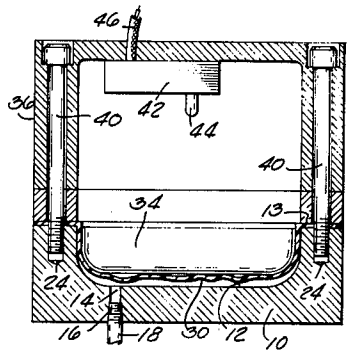


Fig. 1

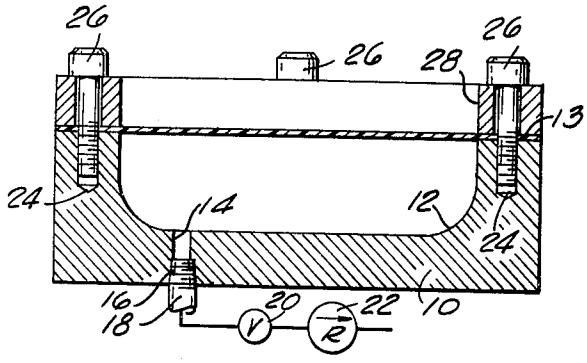
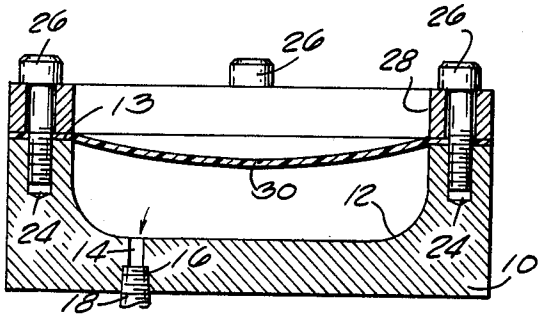


Fig. 2



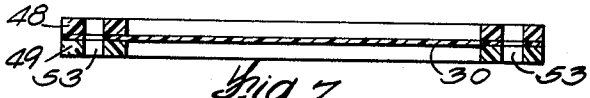


Fig. 7

Fig. 9

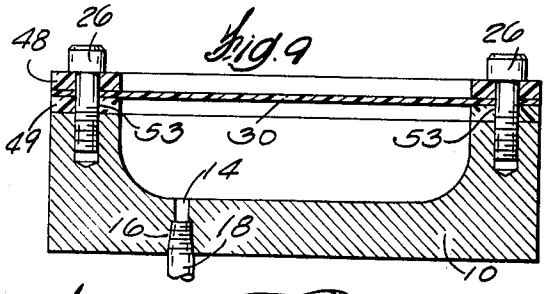


Fig. 8

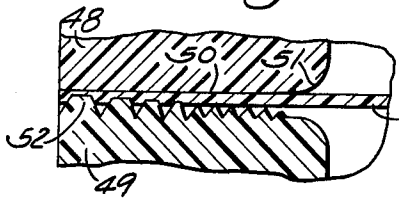


Fig. 3

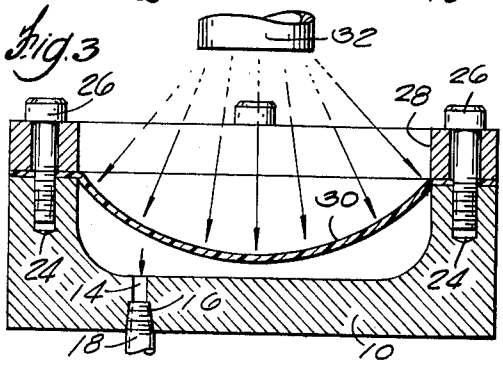


Fig. 4

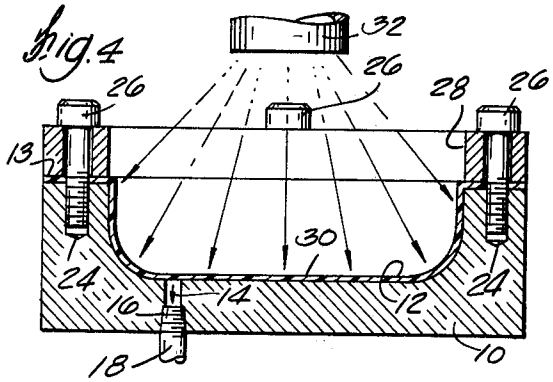


Fig. 5

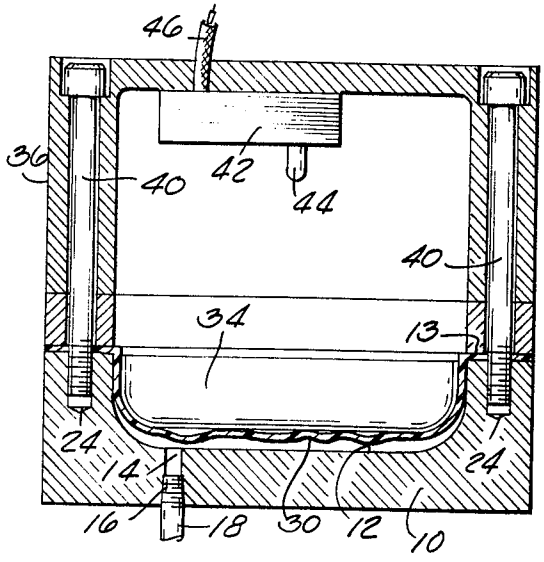
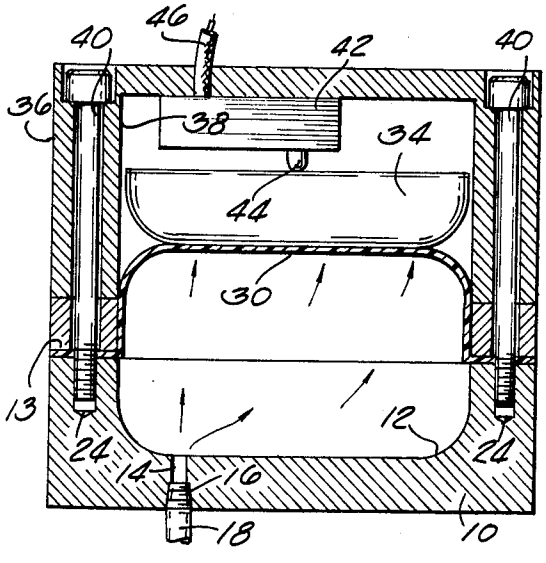


Fig. 6



METHOD OF FORMING AND INSTALLING PRESSURE RESPONSIVE DIAPHRAGMS

BACKGROUND OF THE INVENTION

This invention relates to pressure responsive diaphragms, and is particularly useful in connection with diaphragms of the type used in pressure responsive switches for automatic washers to terminate the flow of water into the wash tub after a desired water level has been reached in the tub. In such pressure responsive switches, the wash tub is coupled via a fluid duct to a cavity beneath a flexible diaphragm, the latter supporting a piston on its upper side. As the level of water in the wash tub rises, the water pressure on the lower side of the diaphragm increases, and this lifts the piston. When the desired level of water has been reached in the wash tub, the piston operates the actuating arm of a switch, the latter being wired in a manner to cause termination of the water input to the wash tub, and to initiate the next step in the cycle of the washing machine.

This invention is particularly concerned with fabrication of very thin diaphragms of extreme sensitivity and with their installation in a pressure responsive device. In the past, diaphragms for pressure responsive switches of the type above described have been made of molded rubber. However, rubber diaphragms are relatively expensive and tend to lose their resiliency with age. Accordingly, there is a need for an inexpensive diaphragm which maintains its resiliency for a relatively long period of time, which has no memory, and which can flex without fatigue.

It is a general object of this invention to provide a method of fabricating a relatively large area, extremely thin diaphragm of the type which it was impractical to mold with prior molding methods, the improved method providing a diaphragm of extreme sensitivity, which is long-wearing, and which can flex repeatedly without fatigue.

SUMMARY OF THE INVENTION

In accordance with the method of this invention, a cavity of predetermined shape is formed in a lower switch housing member and a fluid duct is drilled through a housing wall into communication with the cavity. A thermoplastic diaphragm sheet is either directly clamped or otherwise supported over the cavity, and a relatively light vacuum is applied to the fluid duct to urge the diaphragm sheet toward the bottom of the cavity. The diaphragm sheet is heated by suitable heating means so that it will be drawn by the vacuum against the bottom of the cavity and will assume the shape of the cavity. In one embodiment of the invention, a piston is then placed within the cavity on top of the diaphragm and an upper housing member, which has a cavity with a switch therewithin, is attached to the lower housing member.

A general object of the invention is, therefore, to provide an improved method of forming and installing pressure responsive diaphragms wherein the diaphragm is shaped from a flat piece of thermoplastic material by use of a cavity of predetermined shape in one of the parts of the final assembly, said method providing for a simple and inexpensive method of manufacture and one in which the fit of the diaphragm on the parts is insured.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertical cross-sectional view showing a lower housing member attached to a vacuum pump and having a sheet of thermoplastic diaphragm material clamped over a cavity therein;

FIG. **2** is a cross-sectional view similar to FIG. **1** showing the shape assumed by the thermoplastic diaphragm sheet under the influence of a light vacuum;

FIG. **3** is a cross-sectional view similar to FIG. **2** showing hot air applied to the upper surface of the thermoplastic diaphragm sheet;

FIG. **4** is a cross-sectional view similar to FIG. **3** showing the final shape of the thermoplastic diaphragm sheet under the combined influence of the vacuum and the hot air;

FIG. **5** is a vertical sectional view showing a piston on top of the shaped diaphragm sheet, and showing an upper housing member clamped to the lower housing member, the upper housing member containing an electric switch, and the diaphragm being under the influence of a small amount of pressure;

FIG. **6** is a sectional view similar to FIG. **5** showing the piston in its uppermost position actuating the electric switch;

FIG. **7** is a vertical sectional view through a pair of clamping rings showing how the diaphragm sheet may be pre-supported if desired;

FIG. **8** is an enlarged sectional view showing a portion of the clamping rings and of the diaphragm which is clamped by heat and pressure between the two rings; and

FIG. **9** is a view similar to FIG. **1** showing the pre-supported diaphragm sheet in position over the lower housing member of a switch.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The method of this invention is applicable to the production of any pressure-responsive device of a type which requires a housing member with a cavity contoured in accordance with a predetermined shape for a diaphragm to fit over the cavity. FIG. **1** shows a lower housing member **10** which has a generally cylindrical cavity **12** therewithin and a fluid duct **14** that communicates into cavity **12** and is screw threaded at **16** to receive a threaded fluid coupling **18.** Fluid coupling **18** is coupled by means of a suitable hose to an air valve **20,** and the latter is coupled by a suitable hose to a vacuum pump **22.** The cavity **12** is contoured in accordance with a predetermined shape for a diaphragm which will be described hereinafter and which has a marginal portion **13** which surrounds the cavity **12.** Threaded openings **24** are provided in the top peripheral edge of lower housing member **10** for receiving machine screws **26** which hold a clamping ring **28** in place on top of housing member **10.**

This invention is concerned with the method of shaping a diaphragm to the contour of recess **12** and with the installation of the diaphragm over recess **12.** As a first step in the method, a thermoplastic diaphragm sheet **30** is placed over recess **12** between lower housing member **10** and clamping ring **28** as shown in FIG. **1.** Thermoplastic diaphragm sheet **30** may be polyethylene or polypropylene or any other suitable thermoplastic diaphragm film material. The thickness of thermoplastic diaphragm sheet **30** is preferably in the range

of 0.001 inches to 0.060 inches. In this particular embodiment of the invention, thickness is usually less than 0.010 inches. A thickness of 0.003 works very well.

After the thermoplastic diaphragm sheet **30** has been placed between lower housing member **10** and clamping ring **28**, it is clamped in place around the periphery **13** of cavity **12** by machine screws **26**. Next, a light vacuum is applied to fluid duct **14** by vacuum pump **22** to cause the thermoplastic diaphragm sheet **30** to bow downwardly as indicated in FIG. **2**. The vacuum is not sufficient in itself to cause diaphragm sheet **30** to conform to the contour of cavity **12**, but rather provides a force which urges diaphragm sheet **30** toward cavity **12**. As long as the diaphragm sheet **30** is at room temperature, it resists the force of the vacuum and remains in the slightly bowed condition shown in FIG. **2**.

As the next step of the method of this invention, the thermoplastic diaphragm sheet **30** is heated by suitable heating means such as a stream of hot air issuing from the nozzle **32** of a hair dryer or other suitable source of heated air. It should be understood, however, that other forms of heat may be used. The heat is applied to soften thermoplastic diaphragm **30** so that it will yield to the force of the vacuum and adopt the shape of recess **12** as shown in FIGS. **3** and **4**.

After the thermoplastic diaphragm **30** has fully conformed to the shape of recess **12**, the heating nozzle **32** is removed and the diaphragm **30** is allowed to cool. Thereafter, a piston **34** is placed on top of the diaphragm **30**, and an upper housing member **36**, having a generally cylindrical cavity **38**, is clamped on top of lower housing member **10** by means of machine screws **40**. The diameter of the cavity **38** in upper housing member **36** matches the diameter of the cavity **12** in lower housing member **10**. The diameter of piston **34** is smaller than the diameter of lower cavity **12** by an amount equal to twice the thickness of diaphragm sheet **30** to provide clearance for diaphragm sheet **30** when piston **34** is within cavity **12** as shown in FIG. **5**.

A device to be actuated, such as an electric switch **42**, having a downwardly depending actuating arm **44**, is attached to the top of upper housing member **36** within cavity **38** in such position that actuating arm **44** will be operated when piston **34** is forced upwardly a sufficient distance, as shown in FIG. **6**.

Electrical conductors **46** are coupled from the switch **42** to a suitable circuit (not shown) which is to be controlled by switch **42**, e.g. to the control circuit of an automatic washer or the like. Electric switch **42** may be either normally open or normally closed or it may be a multiple contact switch having both normally open and normally closed contacts. Fluid coupling **18** is connected by means of a suitable hose to a source of fluid pressure which is to be monitored and controlled, e.g. to the wash tub of an automatic washer. When the water level in the wash tub is low, the fluid pressure on the bottom side of diaphragm **30** will be low and the piston **34** will be near the bottom of cavity **12** as shown in FIG. **5**. As the water level in the tub rises, the piston **34** is lifted by the increase in pressure on diaphragm **30** until it enters the upper cavity **38**. When the water in the tub reaches a predetermined full level, piston **34** will be raised to a level which operates actuating arm **44** as shown in FIG. **6**. This either opens or closes the contacts of switch **42**, depending on whether it is normally opened or normally closed, and the electrical signal thus generated is conveyed via conductors **46** to the washing machine control circuit to terminate the flow of water into the wash tub.

In the modification of FIGS. **7**, **8** and **9**, the diaphragm sheet **30**, instead of being clamped directly over the cavity of a housing member of a switch as in FIG. **1**, is first clamped in sheet form between two rings **48** and **49** of thermoplastic material. It is preferred that the upper ring **48** have its clamping surface flat as at **50** in FIG. **8** with the annular edge on a radius as at **51**, and that the lower clamping ring **49** have teeth **52** of diminishing height inwardly, the outermost teeth being relatively blunt on the top with the bluntness diminishing inwardly as the height decreases. The sheet is clamped tightly enough to avoid creases in its suspended portion. Heat and pressure are employed, preferably by use of ultrasonic energy, to weld the margins of the diaphragm sheet between the clamping faces of the rings **48** and **49** so that the latter are fused to the sheet. With this form of the invention it is easier to handle the very thin diaphragm sheets and the entire ring assembly of FIG. **7**, which includes bolt holes **53**, is bolted over the lower housing portion **110**, said lower housing portion being of decreased height, as compared to the housing of FIG. **1**, by the amount of the thickness of the ring **49**, so that the diaphragm sheet **30** is the same distance from the bottom of the cavity in FIG. **9** as it is in FIG. **1**. Thereafter the procedure is the same as heretofore described in connection with FIGS. **2** through **6**.

It should be understood, however, that the pressure responsive switch described above is not limited to use in connection with automatic washers, but can be utilized in any application where an electrical signal is to be generated in response to a predetermined fluid pressure, which can be either a gas pressure or a liquid pressure. It should also be understood that the pressure responsive piston **34** could be used to perform other types of mechanical work than operating a switch actuating arm. In general terms, this invention is concerned with a method of forming and installing pressure responsive diaphragms and is not limited by the functions that the diaphragm may perform after it has been installed.

It will be apparent to those skilled in the art that the above-described pressure responsive device can be designed to be actuated for any desired level of pressure. This is accomplished by selecting the proper weight for piston **34** and the proper dimensions for upper cavity **38**. If necessary, a suitable spring may be added, bearing against the top of piston **34**, to increase the pressure level at which the electric switch **42** is actuated. These and similar modifications of the disclosed structure will be apparent to those skilled in the art. Also, the step of heating the diaphragm **30** may be performed before the step of applying the vacuum to the fluid duct **14**. As long as the diaphragm **30** is heated concurrently with the application of the vacuum, it does not matter whether the initial application of heat precedes or follows the initial application of the vacuum.

What I claim is:

1. In a method of manufacturing a pressure responsive device which includes a shaped actuating diaphragm of thin material, the steps of:

a. fabricating a housing member for the pressure responsive device with a cavity of predetermined contour in accordance with a desired diaphragm shape for the pressure responsive device and with a marginal portion surrounding said cavity;

b. providing a duct in said housing member communicating with said cavity;

c. covering said cavity with a diaphragm formed of a flat sheet of thin thermoplastic material;

d. clamping a marginal portion of said diaphragm over said marginal portion of said housing around said cavity;

e. applying a relatively light vacuum to said duct to draw said diaphragm toward the bottom of said cavity;

f. heating said diaphragm to enable it to be drawn by said vacuum against the walls of said cavity to permanently assume said predetermined shape of the cavity;

g. allowing the diaphragm to cool while in said predetermined shape;

h. fabricating a second housing member having a second marginal portion surrounding a cavity, said second cavity having approximately the same outline as said cavity of the first-mentioned housing member; and

i. then clamping the marginal portion of said second housing to the marginal portion of the first housing, with said cavities in alignment with each other and while the shaped diaphragm remains clamped over the margin of the first housing portion.

2. A method of manufacturing a pressure responsive device as claimed in claim **1** in which the diaphragm material is a thermoplastic film having a thickness less than .010 of an inch.

3. A method of manufacturing a pressure responsive device as claimed in claim **1** in which the margin of the diaphragm is first welded between the clamping faces of two rings which fit the marginal portion of the first housing, and in which the rings are secured over the marginal portion of the first housing member around its cavity.

4. A method as claimed in claim **3** in which the second housing member is clamped over the rings which have the diaphragm welded thereto.

5. A method as claimed in claim **3** in which the rings between which the diaphragm is welded are formed of thermoplastic material.

6. A method as claimed in claim **5** which includes the step of forming teeth on one of the two rings between which the diaphragm is positioned, and applying heat and pressure to cause the rings, including the teeth, to be fused to the diaphragm.

7. A method as claimed in claim **5** in which the teeth are so formed as to extend approximately parallel with the marginal edges of the diaphragm sheet, and in which the teeth are formed so that they decrease in height inwardly.

8. In a method of manufacturing a pressure responsive device which includes a shaped diaphragm of thin material, the steps of:

a. fabricating a mold with a cavity of predetermined contour in accordance with a desired diaphragm shape;

b. providing a duct in said mold communicating with said cavity;

c. fabricating clamping means having marginal clamping areas;

d. clamping the margin of a diaphragm formed of a cool sheet of thin thermoplastic material having a thickness less than 0.010 of an inch by the use of said clamping means while said clamping means is over the margin of said mold and while the mold is cool;

e. applying a relatively light vacuum to said duct to draw said diaphragm toward the bottom of said cavity;

f. heating said diaphragm while the vacuum is being applied to enable it to be drawn by said vacuum against the walls of said cavity to permanently assume said predetermined shape of the cavity;

g. allowing the diaphragm to cool while in said predetermined shape; and

h. assembling the diaphragm in the pressure responsive device while its margins are in clamped condition, and with the clamping means becoming part of the pressure responsive device.

9. A method of manufacturing a pressure responsive device as defined in claim **8** in which the clamping means comprises at least one ring of thermoplastic material, and in which heat and pressure are employed to weld the diaphragm to said ring so that the ring is permanently fused to the diaphragm material.

10. A method of manufacturing a pressure responsive device as defined in claim **9** in which the clamping means comprises two rings of thermoplastic material, and in which the diaphragm is welded between said two rings.

11. A method of manufacturing a pressure responsive device as defined in claim **10** which includes the step of forming teeth on one of said rings.

12. A method of manufacturing a pressure responsive device as defined in claim **11** in which the teeth are formed so that they decrease in height inwardly.

* * * * *