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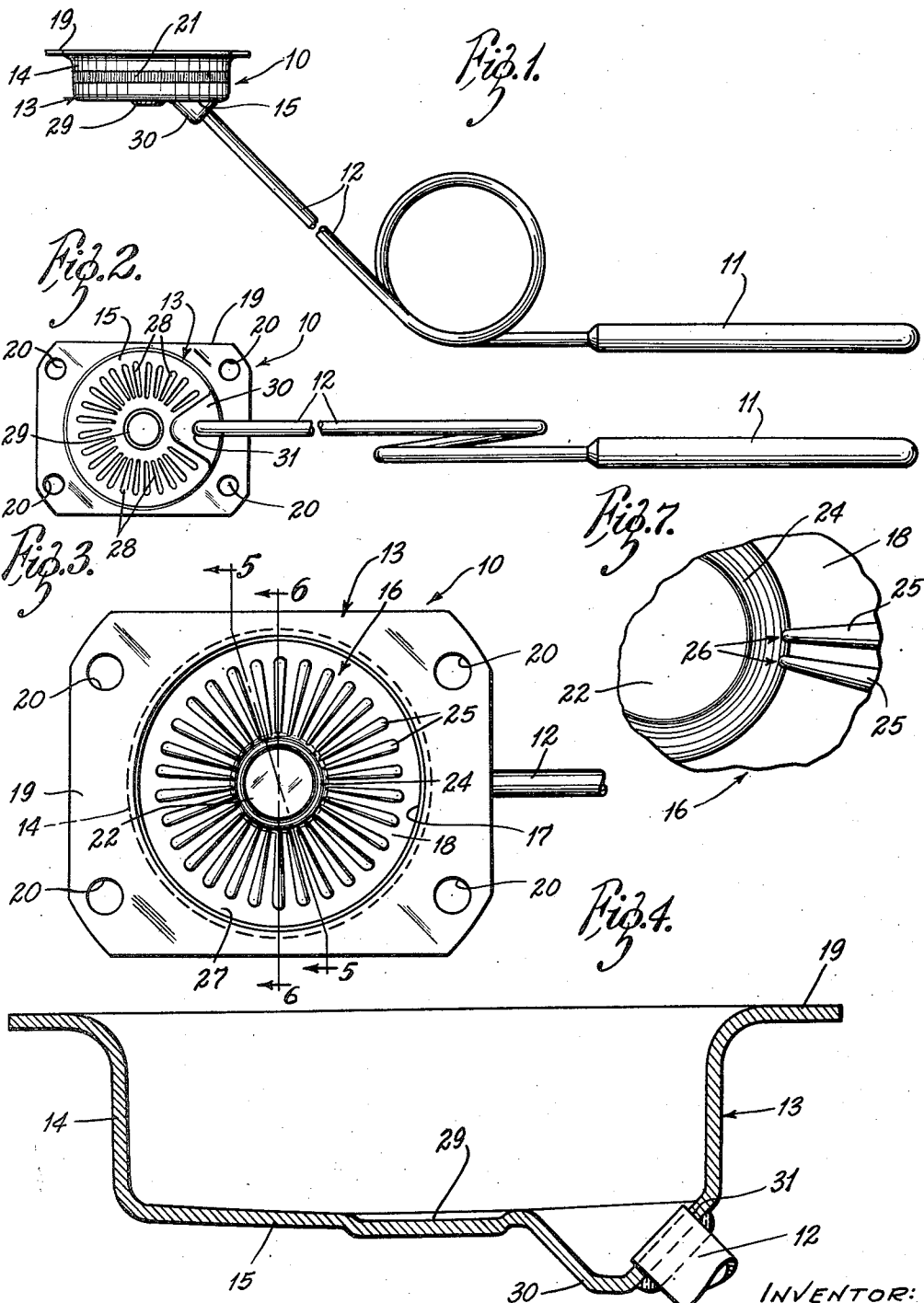
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METAL DIAPHRAGM FOR THERMOSTATIC ACTUATORS

Filed Nov. 19, 1951

2 Sheets-Sheet 1



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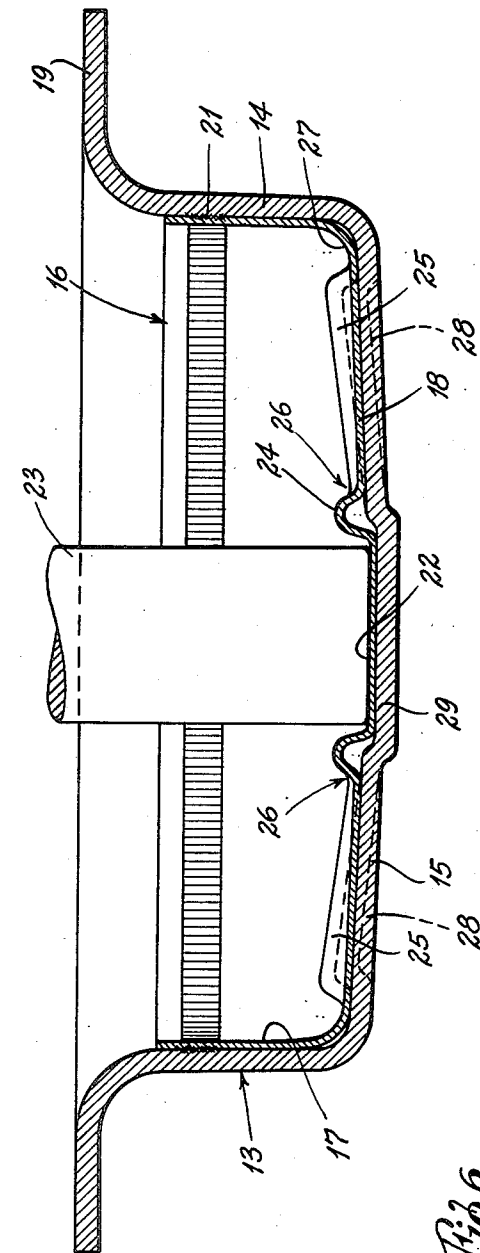


Fig. 5.

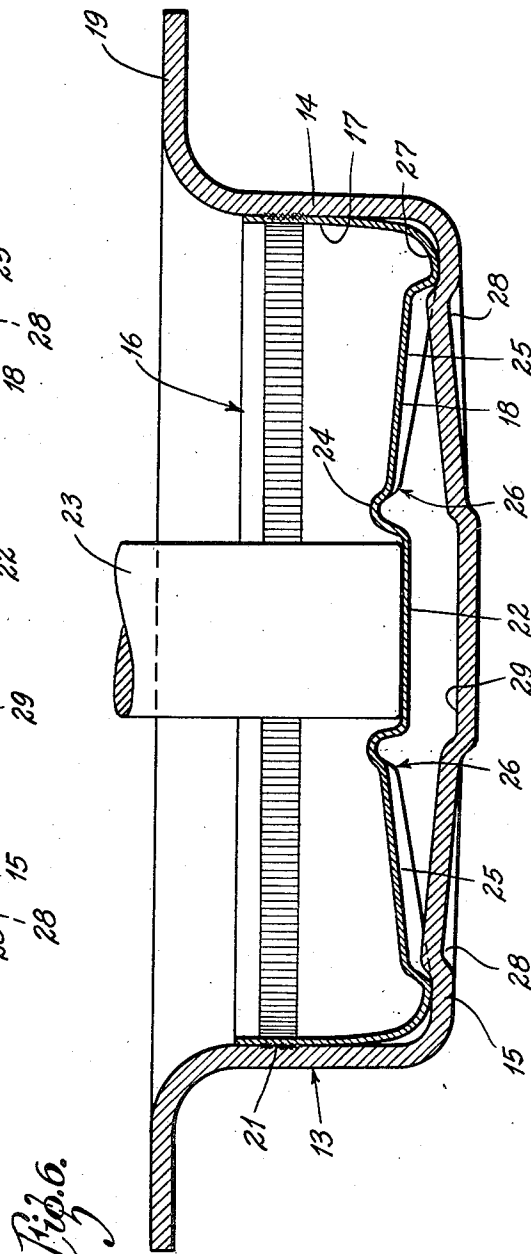


Fig. 6.

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METAL DIAPHRAGM FOR THERMOSTATIC ACTUATORS

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3 Claims. (Cl. 137—795)

This invention pertains to diaphragms and particularly to metal diaphragms adapted to use in expanding liquid-type thermostatic actuators.

It is highly desirable in these instruments that the actuating movement at the center of the diaphragm, be substantially directly proportional to the volumetric change of the liquid over the operating range of the device, so that the operative relationship between the device and a control element to be actuated thereby may be readily adjusted linearly by some simple and reliable adjusting means such as a screw, whereby the control may be accurately and conveniently set to operate at selected temperatures. It is also desirable that the movement at the center of the diaphragm be positive and unyielding under considerable load differential. This is particularly essential in the more positive acting liquid filled thermostatic actuators in which the thermal expansion of the liquid, while positive, is nevertheless relatively small and in which the consequently small diaphragm movements must therefore ordinarily be multiplied considerably for the actuation of conventional control devices.

In the patent to L. M. Persons, No. 2,203,841, issued June 11, 1940, there is disclosed a liquid filled temperature responsive actuator having an expansible element consisting of a pair of nested metal cup members sealed by the continuous welding together of their side walls. The bottom of the inner cup member, by reason of this inner cup being of much thinner stock than the outer, is adapted to flex and thereby provide movement when fluid pressure is applied between the bottoms of the cups. The bottom of the inner cup member, which basically operates as a diaphragm, is provided with an intermediate annular portion stiffened by radially extending corrugations and there is a small central cup or dome portion adapted to receive the end of an actuating member. The point of connection of the side walls of the inner and outer cups has been purposely spaced perpendicularly from the bottom walls in order to provide a more extensive portion between the stiffened portion of the diaphragm and the point of welded connection, in which the distortion normally occurring at the corner is distributed.

Applicant has discovered that greatly increased operational life, softer action, and more constant and uniform movement under considerable load differential may be achieved in a device of the character shown in the above Persons' patent by the provision of an improved diaphragm having a suitable hinged portion or flexing area between the annular stiffened portion of the diaphragm and the central portion which receives the end of a motion transmission member.

The present invention has for its primary object the provision of an improved metal diaphragm capable of providing actuating movement at its center which is linearly related to the volume change of a displacing fluid.

A further object is to provide an improved metal diaphragm having a peripheral attaching portion, a non-flexing circular central portion adapted to be engaged by a motion transmission member and a stiffened non-flexing annular portion between the central portion and the peripheral portion and which, by the provision of a flexing hinge portion between the annular stiffened portion and the provision of a flexing hinge portion the central portion and between the stiffened annular portion and the peripheral attaching portion, flexes between substan-

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tially planar and frusto-conical shapes when acted upon by fluid pressure.

Other objects and advantages will become apparent when reading the following description in connection with the accompanying drawings.

In the drawings:

Fig. 1 is a side view of a liquid filled temperature responsive actuator which incorporates an improved metal diaphragm constructed in accordance with the present invention;

Fig. 2 is a bottom view of the device shown in Fig. 1;

Fig. 3 is an enlarged top view of the expansible element of the device showing the diaphragm in open end view;

Fig. 4 is an enlarged cross-sectional view of the outer cup member of the expansible element, particularly illustrating the manner in which an included capillary tube is secured in place;

Fig. 5 is an enlarged cross-sectional view of the expansible element taken on line 5—5 of Fig. 3. This view is taken on a line passing between the radial stiffening corrugations; also, in this view, the expansible element is shown fully contracted;

Fig. 6 is an enlarged cross-sectional view of the expansible element taken on line 6—6 of Fig. 3. This view is taken on a line passing through the radial stiffening corrugations; also, in this view, the expansible element is shown in an expanded position; and

Fig. 7 is an enlarged fragmentary view near the central portion of the diaphragm showing how the radial stiffening ribs or corrugations extend into the circular corrugations surrounding the central portion.

Referring to the drawings, Figs. 1 and 2.

The illustrated temperature responsive actuator consists of an expansible chamber generally indicated at 10, a bulb 11, and a length of capillary tube 12 connecting the element and bulb. This assembly forms a closed sealed system which is filled with a thermally sensitive liquid which remains in liquid phase throughout the intended range of operation of the device. The expansible chamber 10 comprises a relatively thick-walled rigid outer cup member 13 having a side wall 14 and a bottom wall 15, and a relatively thin-walled flexible cup-shaped diaphragm 16 having a side wall 17 and a bottom wall 18. The diaphragm may be constructed of any suitable material, however, I prefer to use a stainless steel alloy of high tensile strength and in the order of thousands of an inch thick. The outer cup member 13 is provided with a flange 19 having perforations 20 therethrough to receive attaching screws. The flange 19, besides providing means for conveniently attaching the element 10 to a control casing, adds stiffness and rigidity to the element.

The cup shaped diaphragm 16 is nested within the outer cup 13 and the side wall of the diaphragm is joined to the side wall of the outer cup by a continuous seam weld as indicated at 21, thereby to provide a fluid pressure-tight seal. In the normal position, the bottom walls of the diaphragm and outer cup member are substantially contiguous, as shown in Fig. 5, and when in this position, it will be seen that the bottoms of both the diaphragm and the outer cup member are somewhat conical, the apices of the cones being opposite to the direction of movement of the bottom wall 18 of the inner cup member as it flexes toward the position shown in Fig. 6. Because of this construction, the diaphragm wall 18 in flexing, first assumes a planar shape, after which it again passes into the shape of a cone, the apex of which is opposite that of its normal position. By this design, the flexible diaphragm wall 18 is first compressed radially slightly, and is then put under a tensile strain acting radially. It will be apparent that a greater perpendicular movement at the center of the diaphragm wall 18 can be achieved by this arrangement than if the bottom wall were planar in its normal starting position, in which case all movement would increase the tension.

The diaphragm wall 18 is provided with a central, circular, flat-bottomed recess 22 adapted to receive the flat end of an actuating rod, indicated in part at 23. Surrounding the recess 22 is a circular corrugation 24 having

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rounded cross-sectional configuration and having its convex side projecting outward from the bottom of the recess. The wall 18 is further provided with radially extending corrugations 25 which provide a relatively large, flat, non-flexing annular portion lying between recess 22 and the side walls 17. The bottom of recess 22 is preferably flat so as to accommodate the flat end of an actuating rod. This arrangement is preferable over a rounded bottom recess for accommodating a rounded end actuating rod because, errors introduced by slight lateral shifting of the actuating rod during operation in the latter arrangement are thereby eliminated.

The bottom of recess 22 may also be considered as non-flexing area due to its relatively small size, the fact that in operation it is held between uniformly distributed fluid pressure and the flat end of the actuating rod, and to the stiffening effect of the annular corrugation 24 surrounding it. The central portion 22 may be further stiffened by forming it dome-shaped, or by any suitable means, if desirable, without departing from the spirit of the present invention. However, in a device of the proportions shown in the drawings, and of the preferred material and thickness disclosed hereinabove, flexing of the flat bottom of recess 22 under operation has been found to be negligible.

Inasmuch as the central area 22 and the annular area stiffened by radial corrugations 25 are non-flexing, substantially all flexing will occur in the annular corrugation connecting these areas and in the portion connecting the annular stiffened area and the fixed welded point 21. The annular corrugation 24 provides a hinge portion between the annular stiffened portion and central portion in which flexing is distributed to accommodate the changes in angular relationship between these portions as the shape of the diaphragm is changing from planar to frusto-conical shape or vice versa, thereby providing a softer action and prolonging the flexing life of the diaphragm. It will also be noted, due to the construction of this hinge portion, that while flexing may readily occur perpendicular to the direction of movement of the central portion bulging is effectively resisted. The inner ends of radial corrugations 25 are extended partially into the circular corrugation 24 as indicated at 26 in Figs. 5, 6, and 7. This is an important feature in that it eliminates what would otherwise be a critical point of local flexing.

The outer periphery of the stiffened annular portion is joined to the side wall 17 by an easy curve 27 which permits a distribution of flexing in that area occurring as the angular relationship of the bottom and side walls changes. By attaching the wall 17 of the diaphragm to the side wall 14 of the outer cup at a point 21, spaced from the bottom wall of the diaphragm, an extended portion is provided between the stiffened annular portion and the fixed periphery which is free to flex in a direction perpendicular to the movement of the center portion, thereby to accommodate the increase and decrease in diameter of the bottom wall of the diaphragm as it changes between planar and frusto-conical shape. This latter provision also permits the diaphragm to be expanded in an outward direction beyond its planar position to a considerably greater extent than it moves inwardly of this position when contracted. This flexing is shown somewhat exaggerated in Fig. 6, however, it will be seen that here also is a hinge which readily permits flexing perpendicular to the direction of movement of the center portion of the diaphragm, but effectively resists flexing in the direction of movement.

The bottom 15 of the outer cup member 13 is also provided with radial corrugations 28 and a central recess 29, which corrugations and recess are arranged to interfit with those in the bottom wall 18 of the inner cup member

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so that the bottoms of the inner and outer cup members are substantially contiguous when in fully contracted position. The outer cup member 13 is further provided with an angular hollow inlet boss 30 having a perforation 31 therein to receive one end of the capillary tube 12. The tube 12 is firmly attached by silver soldering as indicated.

It will be seen from the foregoing that upon expansion or contraction of the liquid fill, the central portion of the diaphragm wall 18 moves vertically while the annular stiffened portion moves angularly, thereby providing movement which is substantially linearly related to the volume change of the thermally sensitive liquid.

The foregoing description is intended to be illustrative and not limiting, the scope of the invention being set forth in the appended claims.

I claim:

1. A generally cup-shaped flexible metal diaphragm having a side and bottom wall, said side and bottom walls being joined by a curved portion, said bottom wall having a relatively small flat circular central portion, a relatively large flat non-flexing annular portion extending between said central portion and said joining curved portion which is stiffened by radially extending corrugations, and a circular corrugation surrounding said central portion and joining said central portion and said stiffened annular portion, and said circular corrugation having a substantially semi-circular cross-sectional configuration and having its convex surface extending inwardly of the bottom wall of the cup.

2. A generally cup-shaped flexible metal diaphragm having a side and bottom wall joined by a curved portion, said bottom wall having a relatively small shallow circular central recess adapted to receive the end of an actuating rod, a relatively large flat non-flexing annular portion extending between said recess and said joining curved portion which is stiffened by radial corrugations, and a circular corrugation surrounding said recess and joining said recess with said annular portion, said circular corrugation being semi-circular in cross-sectional configuration, and said radial corrugations being extended partially into said circular corrugation so as to stiffen the joint between said radial and circular corrugations.

3. A circular flexible metal diaphragm having a flexible peripheral portion, a relatively small flat circular central portion adapted to receive the end of an actuating rod, a relatively large flat non-flexing annular portion extending between said central portion and said peripheral portion, which annular portion is stiffened by radially extending corrugations of substantially semi-circular cross-section, and a circular corrugation surrounding said central portion and joining therewith said radially stiffened annular portion.

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