

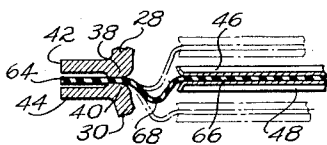
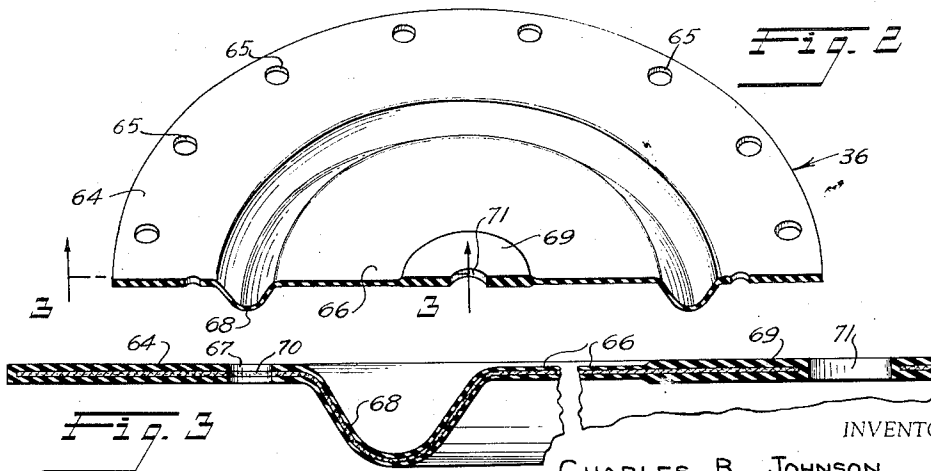
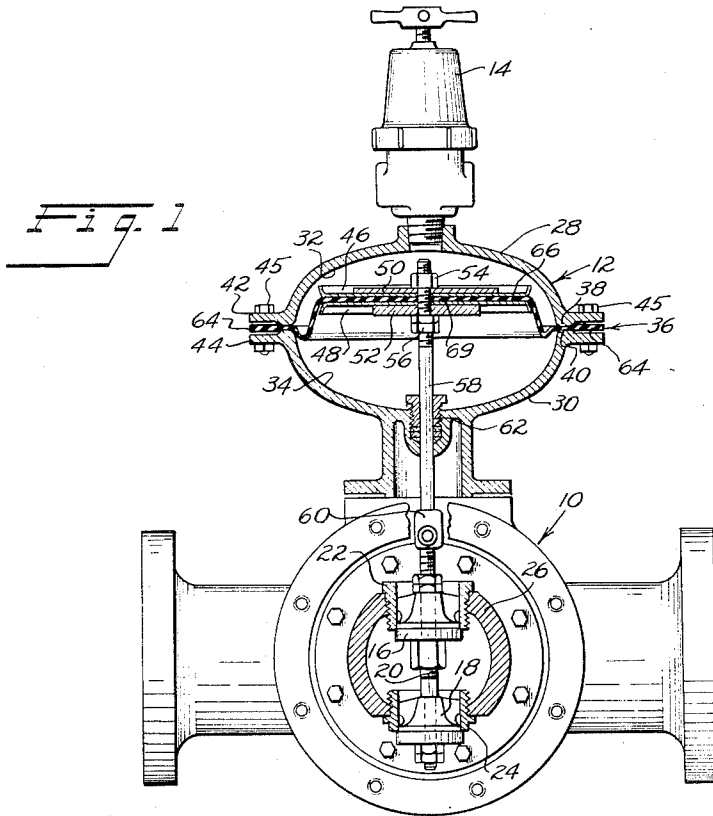
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FLEXIBLE DIAPHRAGM HAVING A TROUGH

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1

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FLEXIBLE DIAPHRAGM HAVING A TROUGH

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The present invention relates in general to improve-
ments in pressure regulating devices and more specific-
ally to improvements in the structure of diaphragms for
the pressure responsive devices of such regulators which
result in greater accuracy in pressure regulation, a sub-
stantial increase in the period of trouble-free regulator
service with respect to diaphragm maintenance, and
greater ease of assembly of the regulators both initially
and during servicing.

Diaphragms of pressure regulators are generally circu-
lar, formed of substantially inextensible material, and in
assembly are clamped at their periphery between casing
shells which, with the diaphragm, form upper and lower
chambers into either or both of which fluid may be in-
troduced for control purposes. The central portions of
such diaphragms are clamped between opposed plates or
pans to which the diaphragm stem is secured and which
hold the central portion of the diaphragm substantially
flat. In these regulators, a slight excess of diaphragm
material is provided at the free portion of the diaphragm
intermediate its peripheral clamping area and the periph-
ery of the clamping plates. This excess of diaphragm
material forms a generally annular trough so that the
clamping plates and the diaphragm stem can be moved
relative to the casing shell without stretching the dia-
phragm. The necessary depth of this annular trough is
directly dependent upon the required length of stroke of
the diaphragm stem.

Although it has been customary in drawings both of pub-
lications and patents to illustrate the peripheral and cen-
tral areas as being perfectly flat and the intermediate, free,
annular trough as having a curved configuration in cross-
section and of perfect toroidal form, this ideal condition
is not that generally found in practice prior to my inven-
tion. This is due to the fact that, for the most part, the
prior art diaphragms prior to assembly are flat flexible
sheets of leather or synthetic material having a substan-
tially uniform thickness. When such flat diaphragms are
mounted in a pressure regulator, wrinkles will naturally
occur in the clampings regions and in the trough. It will
be recognized that as the depth of the trough is increased,
the number and size of the wrinkles will be increased.

The presence of these wrinkles in diaphragms presents
certain difficulties in assembly. The diaphragm must be
as free of wrinkles as possible in the portions at which
it is clamped because the application of sufficient clamp-
ing force to flatten any wrinkles which exist to make the
diaphragm chambers fluid tight will either cut through the
diaphragm or so weaken it that the application of a shock
load thereto during operation will cause it to rip. Mold-
ed diaphragms having preformed annular troughs have
been developed in the past. Such diaphragms, while
eliminating the wrinkle problem to a large extent, are
subject to damage in clamping and ripping upon the ap-
plication of a shock load.

It is toward the elimination of these difficulties in as-
sembly and sources of possible damage to the diaphragms
that the present invention is primarily directed.

2

In addition to the foregoing difficulties in assembly,
the presence of wrinkles in the annular trough portion of
flat diaphragms and the extensibility of the molded
troughs or preformed diaphragms prevents uniform
smooth movement of the diaphragm stem and central por-
tion in response to changes in the applied control pres-
sure and produces a relatively large variation in the effec-
tive diaphragm area between the limits of movement of
the diaphragm stem. This results in non-uniform line
pressure control.

In order to overcome these disadvantages of prior art
pressure regulators, it is a primary object of the present
invention to provide, in a pressure regulator, a diaphragm
of an improved preformed construction, having a flat cir-
cular central portion, a flat rim portion, and a relatively
thin smooth annular concentric trough interconnecting
the central and rim portions and internally reinforced by
a rip resistant fabric anchored within the central and rim
portions so that the central and rim portions can be
smoothly clamped between opposed flat surfaces without
injury to the diaphragm and relative axial movement be-
tween the clamped portions may be effected without pro-
ducing wrinkles or other irregularities in the smooth con-
figuration of the free trough portion of the diaphragm.

Another object of the present invention is to provide,
in a pressure regulator, a diaphragm of such improved
construction that it can be firmly clamped both centrally
and at its periphery to form a fluid tight seal with the
clamping members without danger of possible injury to
the diaphragm.

A more specific object of the present invention is to
provide a diaphragm for pressure regulators which is
rendered rip-resistant by internal reinforcement at its free
portion by a strong, light weight, open weave fabric
which does not deleteriously affect the flexibility of such
free portion.

Another object of the present invention is to provide
a diaphragm of such improved construction that the
danger of damaging the diaphragm by clamping during
assembly in a pressure responsive device of a pressure
regulator is eliminated and by which a fluid tight seal be-
tween the diaphragm and the associated clamping parts
may be effected at a much lower clamping pressure.

A more specific object of this invention is to provide in
a pressure regulator, an improved rip-resistant diaphragm
which has relatively thick annular portions centrally and
at its periphery so that assembly in the pressure respon-
sive device of a regulator can be effected at a much lower
clamping pressure, and which has a relatively thin smooth
annular intermediate trough portion which is internally
reinforced by a strong, open weave fabric which pro-
vides the necessary flexibility and strength to permit
smooth actuation of the diaphragm without danger of its
being ripped by the application of a shock load.

A more specific object of this invention is to provide,
in a pressure regulator, an improved rip-resistant dia-
phragm which is so preformed that the regulator can be
readily assembled, the diaphragm being formed of strong
light weight open weave fabric, preferably nylon upon
which is vulcanized a coating of rubber, preferably
Buna-N, which is thicker at the peripheral and central
clamping regions to form a fluid-tight seal with the asso-
ciated clamping parts of the regulator and a cushion to
prevent damage to the fabric by such clamping parts and
which is relatively thin at the trough portion to provide
the necessary flexibility while retaining the necessary
strength.

These and other objects of the present invention will
become more fully apparent in reference to the appended
claims and as the following detailed description proceeds
in reference to the accompanying drawings wherein:

Figure 1 is a partially sectioned elevation view of a

fluid pressure regulator of the pilot-loaded balanced valve type embodying the present invention;

Figure 2 is a fragmentary perspective view of the preformed diaphragm of the present invention;

Figure 3 is an enlarged sectional view of the diaphragm of the present invention taken along the line 3—3 of Figure 2; and

Figure 4 is a fragmentary sectional view of the diaphragm assembled in the pressure regulator and schematically illustrating the change in cross-sectional configuration of the free portion of the diaphragm as the diaphragm stem is shifted to its various positions in response to variations in applied control pressure.

Referring now to Figure 1 of the drawing, the improved diaphragm of the present invention is illustrated as applied to a well known form of pilot-loaded balanced valve pressure regulator. The illustrated form of pressure regulator is of the general type described in detail in United States Letters Patent No. 2,334,496, issued November 16, 1943, to F. H. Kindl for Fluid Pressure Regulator to which reference is made if a more detailed explanation of the mode of operation of regulators of this type than that which follows is found to be necessary to a complete understanding of the present invention. For the purposes of understanding the present invention, the following brief description of the general regulator structure is believed to be sufficient.

The pressure regulator illustrated in Figure 1 is formed basically of three units, a balanced valve assembly 10, a main pressure responsive device 12, and an adjustable pilot regulator 14 for controlling the application of fluid pressure to the main pressure responsive device 12.

The valve assembly 10 is provided with a pair of valve members 16 and 18, which are fixed to a common valve stem 20, for coaction respectively with valve seats 22 and 24, which are fixed in coaxially aligned apertures through a partition 26 separating the inlet of the valve from the outlet thereof.

Pressure responsive device 12 is provided with a pair of casing shells 28 and 30 which are formed respectively with opposed concave faces 32 and 34 and between which a diaphragm 36, which embodies the principles of the present invention, is peripherally clamped. Casing shells 28 and 30 are formed with aligned annular shoulders 38 and 40 and with outwardly projecting annular flanges 42 and 44 which are provided with bolt receiving apertures (not shown). Peripherally spaced bolts 45, which extend through these apertures, clamp casing shells 28 and 30 together so that the outer rim of the diaphragm 36 is firmly gripped between the annular shoulders 38 and 40. Diaphragm 36 thus divides the space defined between casing shells 28 and 30 into first and second diaphragm chambers which are defined respectively between concave face 32 and diaphragm 36 and between concave face 34 and diaphragm 36.

The central portion of the diaphragm 36 is held flat between the adjacent flat faces of pans 46 and 48 which are of conventional form and disposed respectively in the first and second diaphragm chambers, pans 46 and 48 being clamped together between reinforcing plates 50 and 52 by nuts 54 and 56 which are threaded at opposite sides of the diaphragm 36 upon the threaded portion of the diaphragm stem 58.

Diaphragm stem 58 is coaxially aligned with the valve stem 20 and connected thereto by a coupling 60. A stuffing box assembly 62 is provided in the lower portion of the casing shells 30 around the diaphragm stem 58 to prevent fluid leakage therealong between the second diaphragm chamber and the valve assembly.

The improved diaphragm of the present invention is best shown in Figures 2 and 3, wherein it is shown in its normal preformed shape before assembly in the pressure regulator. This diaphragm 36 is an integral molded structure, having a peripheral rim portion 64, which is flat and provided with peripherally spaced apertures 65 for the reception of the bolts 45 shown in Figure 1, a

central portion 66 which is also generally flat, and an intermediate portion 68 which has the shape of a smooth annular trough. Apertures 67 are provided at opposite sides of the diaphragm to facilitate orientation thereof relative to opposed casing shells 28 and 30. As is best shown in Figure 3, the peripheral or rim portion 64 and the inner part 69 of the central portion 66 are substantially thicker than the intermediate trough portion 68. The diaphragm is formed of a flexible moldable rubber material, preferably synthetic rubber known as Buna-N. The relatively thin trough portion 68 is internally reinforced by an annular piece of fabric 70 which extends between and is anchored internally of the outer rim portion 64 and the inner part 69 of the central portion 66 of the diaphragm at which the diaphragm is clamped. The outer and inner edges of this reinforcing fabric 70 lie within the body of the rubber coating well back of the outer peripheral edge and the edge of the diaphragm stem receiving aperture 71 so that leakage of fluid along the threads of the fabric is prevented.

The particular composition of the flexible material of the diaphragm which is molded upon the fabric 70 is selected for its resistance to decomposition under exposure to the fluid being controlled, its ability to withstand flexure over long periods of time without deterioration, its impenetrability by fluids under pressure, and for its ability to form a fluid tight seal with the part by which it is clamped and with the threads of the fabric during molding.

The fabric 70 should be of an open weave construction so that the rubber can flow between the woven threads, tend to impregnate the cloth, and make it leak tight; sufficiently strong to prevent ripping of the diaphragm under shock loads or failure thereof due to fatigue resulting from the constant flexure at the free trough portion; and sufficiently lightweight and flexible to permit smooth flexure to the free trough portion in response to variations of the applied control pressure while maintaining the general smooth trough shape to minimize the change in effective diaphragm area.

Prior to the application of the molded Buna-N synthetic rubber coatings to the fabric, it is preferable that the fabric be coated with an adhesive to aid in attaining a rubber to fabric bond and to improve the leak-resistant qualities of the completed diaphragm. We have found that the best fabric for internal reinforcement of diaphragms of this type is nylon cloth having a thread count of approximately thirty-seven by thirty-six threads per inch square, a total weight of twenty-one ounces per square yard (fabric and coating), a tensile strength of two hundred fifty pounds per square inch by two hundred fifty pounds per square inch, and a bursting strength of three hundred pounds per square inch (Mullen). Numerous other fabrics have been tested but none have been found to be as highly satisfactory as this from the standpoints of rip and leakage resistance.

As is apparent in Figure 1, the relatively thick rim portion 64 of the diaphragm is clamped adjacent the outer edge of the trough portion 68 between the annular shoulders 38 and 40. The entire flat central portion 66 is confined between the pans 46 and 48, the thicker inner part 69 thereof being compressed to substantially the thickness of the outer part thereof to form a fluid tight seal between the pans 46 and 48 and the diaphragm stem 58. The preformed internally reinforced smooth annular trough portion 68 lies between the periphery of the pans 46 and 48 and the annular shoulders 38 and 40 and is free to roll smoothly with changes in the position of the pans 46 and 48 in response to variations in the applied control pressure.

This preformed diaphragm construction of our invention eliminates the disadvantages of the prior art diaphragm outlined at the outset by providing thickened flat portions peripherally and centrally of the diaphragm so that the central portion of the diaphragm can be

5

clamped between pans or plates and the rim portions can be clamped firmly between the edges of the casing shells without the danger of injury to the diaphragm resulting from clamping.

Because of the smooth annular molded shape of the internally reinforced trough portion 68, this free portion of the diaphragm can roll easily and smoothly with variations in the applied control pressure. As a result, pressure variations in the line being controlled, which result from changes in the effective diaphragm area with changes in the diaphragm position, have been minimized. This smooth rolling action of the free area of the diaphragm is best illustrated in Figure 4, an intermediate position of the diaphragm 36 being illustrated in full lines, and an upper position and a lower position being illustrated in phantom lines. As is apparent from this figure, the change of effective diaphragm area for a given movement of the diaphragm stem, is much less than that for prior art flat or molded diaphragms.

The extra thickness of rubber at the central and peripheral clamping areas provides greater ease of assembly by assuring that these portions will be flat, provides a relatively thick cushion which assures proper fluid tight sealing engagement with the annular shoulders 38 and 40 and with the pans 46 and 48 and the diaphragm stem 58, and reduces to a minimum the possibility of cutting of the diaphragm or the reinforcing fabric when it is being clamped.

Seepage of high pressure fluid along fibers of the inserted fabric 70 is prevented by the special type of weave employed, the use of adhesive upon the fabric prior to application of the molded rubber, and by sealing off the fabric insert well back of the outer and inner diaphragm edges as is clearly shown in Figure 3.

While the improved pressure responsive device and diaphragm therefor of our present invention have been disclosed as applied to a pilot loaded balance valve type pressure regulator, it will be recognized by those skilled in the art that the principles herein taught are equally applicable to pressure responsive devices of other types of pressure regulators.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A flexible diaphragm having a preformed annular trough at its intended region of flexure intermediate inner and outer annular clamping regions comprising a single centrally apertured woven fabric disk, said fabric being of sufficiently open weave construction that during a molding operation rubber can flow between the woven threads of said fabric and extending between said inner and outer clamping regions through said trough, a body of flexible rubber upon said fabric disc and providing a smooth outer surface covering layer entirely covering each side and the outer peripheral edge of and extending through said fabric between the threads thereof whereby, in the event of rupture of said covering layers sufficient to provide a fluid leakage path to a thread thereof, escape of fluid

6

along such thread to the outer periphery of the diaphragm is prevented, said rubber body having uniformly thick annular regions at said outer and inner annular clamping regions of sufficient thickness to provide a cushion to permit clamping of said diaphragm in such regions without exposure of or producing damage to said fabric disc and being of uniform thickness throughout said trough to permit uniform free flexure of said diaphragm.

2. A flexible diaphragm having a preformed annular trough at its intended region of flexure intermediate inner and outer annular clamping regions comprising a single centrally apertured woven fabric disc, said fabric being of sufficiently open weave construction that during a molding operation rubber can flow between the woven threads of said fabric and extending between said inner and outer clamping regions through said trough, a body of a flexible rubber upon said fabric disc and providing a smooth outer surface covering layer entirely covering each side and the outer peripheral edge thereof and extending through said fabric between the threads thereof whereby, in the event of rupture of said covering layers sufficient to provide a fluid leakage path to a thread thereof, escape of fluid along such thread to the outer periphery of the diaphragm is prevented, said rubber body having uniformly thick annular regions at said outer and inner annular clamping regions of sufficient thickness to provide a cushion to permit clamping of said diaphragm in such regions without exposure of or producing damage to said fabric disc and being of uniform thickness throughout said trough less than that of said annular regions to permit uniform free flexure of said diaphragm.

3. The diaphragm defined in claim 2 wherein an adhesive material is interposed between said body and the threads of said fabric at least partially impregnating certain of said threads to improve the bond between said fabric and said rubber body.

4. The diaphragm defined in claim 2 wherein the thread count of said fabric is in the order of 36 by 36 threads per inch square, said thread count establishing the openings of said open weave construction.

5. The diaphragm defined in claim 2 wherein said flexible rubber is synthetic rubber known as Buna-N and the fabric is nylon.

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