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J. F. TAPLIN

3,236,158

ROLLING DIAPHRAGMS

Original Filed Dec. 28, 1962

FIG. 1.

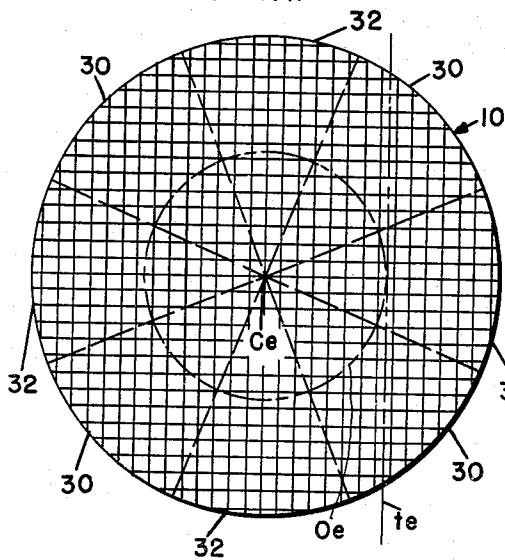


FIG. 2.

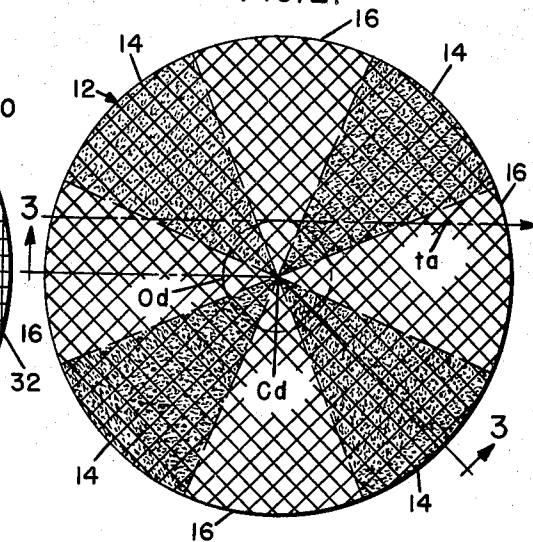


FIG. 4.

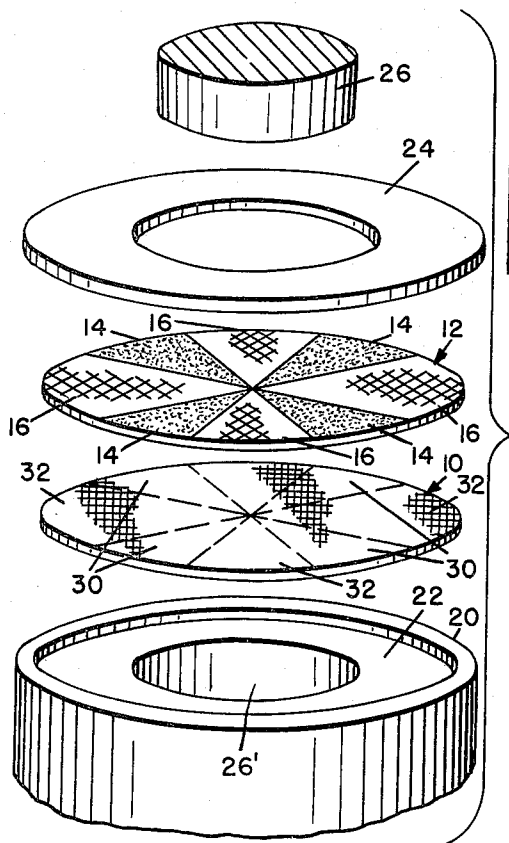


FIG. 3.

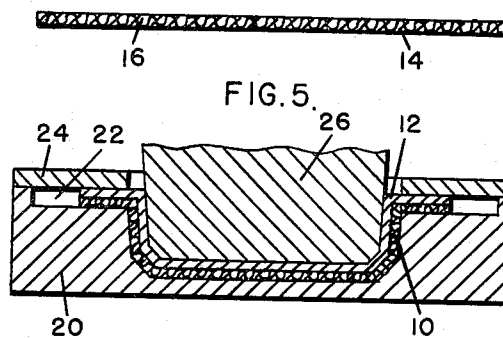
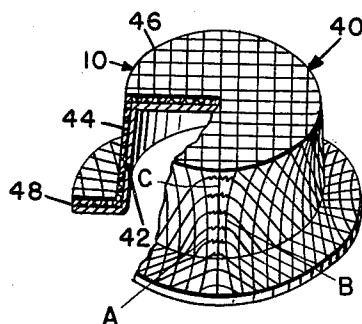


FIG. 6.



INVENTOR:
JOHN F. TAPLIN,
BY *Arwin Selzer*
ATTORNEY

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3,236,158

ROLLING DIAPHRAGMS

John F. Taplin, 15 Sewall St., West Newton,
Mass. 02165Original application Dec. 28, 1962, Ser. No. 248,049.
Divided and this application June 25, 1965, Ser. No.
467,142

8 Claims. (Cl. 92—103)

This is a division of my co-pending patent application Ser. No. 248,049, filed December 28, 1962, for Method of Making Rolling Seal Diaphragms.

The aforementioned patent application discloses a preferred method for making a novel type of rolling seal diaphragms or, briefly, rolling diaphragms, and the structural features of a rolling diaphragm manufactured in accordance with that method. Rolling diaphragms having these structural features may be manufactured by other methods though, the particular method disclosed in the above patent application, is the preferred method for manufacturing rolling diaphragms having certain novel structural features which will be considered below more in detail.

The present patent application is concerned with the structural features of rolling diaphragms such as produced, for instance, by the method disclosed and claimed in the aforementioned patent application.

U.S. Patent 2,849,026 to John F. Taplin, August 26, 1958, Flexible Fluid Sealing Diaphragm discloses and claims a type of rolling diaphragms having a combination of outstanding performance characteristics, including a minimal mass, lack of any significant spring gradient, a predetermined degree of circumferential extensibility, and a long useful life. Rolling diaphragms according to the above patent are subject to one limitation consisting in that the degree of circumferential extensibility is not uniform along the entire circumference or perimeter of the rolling wall thereof.

It is, therefore, an object of this invention to provide rolling diaphragms which have all the desirable performance characteristics of the rolling diaphragms disclosed and claimed in U.S. Patent 2,849,026, but are not subject to the aforementioned limitation of such structures.

Another object of this invention is to provide woven inserts for rolling diaphragms the constituent fill threads and warp threads of which are arranged in such a fashion that the degree of circumferential extensibility of rolling diaphragms made with such woven inserts is relatively uniform along the entire circumference or perimeter of the rolling wall thereof.

Another object of this invention is to provide rolling diaphragms having all the desired performance characteristics of rolling diaphragms disclosed and claimed in U.S. Patent 2,849,026, but having a longer useful life than the rolling diaphragms disclosed and claimed in that patent.

Rolling diaphragms according to U.S. Patent 2,849,026 have a woven insert the constituent fill threads and warp threads of which are re-arranged by drawing a woven fabric between male and female dies to compress circumferentially the constituent fill threads and warp threads thereof, such circumferential compression imparting circumferential extensibility to the rolling wall of the complete or finished rolling diaphragm which includes a skin of an elastomer.

I have discovered that the circumferential extensibility of the rolling wall of rolling diaphragms manufactured according to U.S. Patent 2,849,026 varies along the circumference or perimeter of the rolling wall thereof, exceeding at some points the required degree of circumferential extensibility and at other points falling short of

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the required degree of circumferential extensibility. Consequently, such rolling diaphragms are subject to an angular movement when rolling from the wall of a piston to that of a cylinder, or vice versa, and this results in increased wear and shortened useful life.

It is, therefore, another object of this invention to provide rolling diaphragms not subject to angular movement and consequent scrubbing and wear.

I have discovered that a high degree of equalization of circumferential extensibility of the rolling wall of a rolling diaphragm may be achieved by imparting a non-uniform rather than a uniform degree of thread compression to different regions or zones of the rolling wall portion of the woven fabric insert. This apparently paradoxical fact will be explained below more in detail.

It is, therefore, another object of this invention to provide rolling diaphragms having woven inserts the constituent fill threads and warp threads of which are circumferentially compressed in the rolling wall portions of the inserts in such a non-uniform fashion as to result in a more uniform circumferential extensibility of the rolling wall portion of the diaphragm than that characteristic of rolling diaphragms according to U.S. Patent 2,849,026.

Other objects of the invention and advantages and features thereof will appear from the following description of a process which may be adopted for making rolling diaphragms embodying the present invention, and of a rolling diaphragm structure embodying the present invention.

FIG. 1 is a top plan view of a woven blank that may be used for making an insert for a rolling diaphragm;

FIG. 2 is a top plan view of a deformable die that may be used for drawing the blank of FIG. 1;

FIG. 3 is a sectional view taken at 3—3 of FIG. 2;

FIG. 4 is an exploded view showing a woven blank and tools for drawing the same, i.e., a deformable die, drawing dies and a slip ring;

FIG. 5 is a view of a section through the drawing dies of FIG. 4 and showing the woven blank upon having been formed into an insert for rolling diaphragms; and

FIG. 6 is an isometric view of a rolling diaphragm embodying this invention and incorporating the insert of FIG. 5, a portion of the diaphragm being broken away to better reveal its internal structure.

Referring now in more detail to the drawings, there is diagrammatically shown in FIG. 1 a fabric blank 10 woven from warp and fill threads which interlock, but at the same time permit to at least some extent a relative movement of the threads. In FIG. 2 is shown a deformable die 12 which may be identical with blank 10, except that in zones 14 cured rubber material coats the warp and fill threads and fills the interstices between them. Therefore the circumferential compressibility of die 12 is relatively small or negligible in zones 14. Zones 14 of die 12 have surfaces characterized by a higher coefficient of friction than zones 16 of die 12 which lack the rubber impregnation. Even if the rubber material were omitted in zones 14, these zones are still less compressible circumferentially than the zones 16 which alternate with them. This will be more apparent from the following considerations.

By "circumferential" are meant directions constituting tangents to imaginary circles about the center C_e of blank 10, or the center C_d of the deformable die; for example, direction t_e tangent to imaginary circle O_e , or direction t_d tangent to imaginary circle O_d . The term "circumferential compression" of a woven fabric as used in this context means a relative reduction of the spacing between contiguous fill threads and contiguous warp threads. A circumferential compression of threads occurs in woven

fabrics when such fabrics are subjected to opposite circumferential forces.

If a woven fabric is deep drawn in the way disclosed in U.S. Patent 2,849,026, i.e., without controlling the relative degree of compression in the various regions of the fabric, maximum circumferential extensibility is achieved in the regions of the fabric where the directions of the fill threads and warp threads—prior to the re-arrangement thereof—enclose more or less equal angles with a direction of a tangent drawn at the particular point as set forth above, i.e., in the sectors 30 of blank 10. In a woven fabric deep drawn in the way disclosed in U.S. Patent 2,849,026, there are regions or zones of minimum circumferential extensibility, minimum circumferential extensibility occurring in the regions or zones of the fabric where the direction of either the fill threads or of the warp threads, is substantially the same as a direction of a tangent drawn at the particular point of the fabric, as set forth above. These regions of blank 10 are sectors 32 of FIG. 1.

The constituent fill threads and warp threads of die 12 have a different orientation from that of the threads forming blank 10. As a result of the different orientation of the fill threads and warp threads of die 12, sectors 14 of die 12 are regions of minimal circumferential compressibility and sector 16 of die 12 regions of maximal circumferential compressibility. The inherent circumferential compressibility of sectors 14 of die 12 is further reduced by rubberizing sectors 14, as set forth above. The rubbery material used in sectors or zones 14 may be of any desired sort, natural or synthetic. Indeed, any material reducing inherent circumferential compressibility may, if desired, be used, such as materials which reduce relative movability of threads without filling interstices.

In order to form out of blank 10 a fabric insert for rolling diaphragms, blank 10 is placed over female drawing die 20 around the central hole in which there is counterbore 22 having a depth corresponding to the thickness of a stack made up of blank 10 and deformable die 12. Thereupon slip ring 24 is brought into position, restraining blank 10 and stack 10, 12 against doubling upon themselves while being deep drawn by cylindrical male drawing die 26 into the cylindrical cavity 26' of die 20. The annular or radial spacing between the drawing dies 20 and 26 corresponds to the thickness of stack 10, 12 for the same purpose of preventing doubling of blank 10 or stack 10, 12 upon itself. In no event must the radial spacing between the drawing dies 20, 26 or the depth of the counterbore 22 significantly exceed the thickness of stack 10, 12, or be as much as three times the thickness of said stack. It will, however, be understood that the stack to be deep drawn may be made up of more than two thicknesses from the combined blanks and deformable dies therein. For example, a deformable die may be sandwiched between two blanks.

As shown in FIG. 4 of the drawing, the virtually circumferentially non-compressible zones 14 of the deformable die 12 are placed over the zones 30 of blank 10, while the circumferentially most compressible zones 16 of the deformable die 12 overlie the zones 32 of blank 10.

When the stack made up of blank 10 and deformable die 12 is drawn between drawing dies 20, 26 the zones 14 of the deformable die 12 not only resist circumferential compression, but tend to preclude circumferential compression of the constituent fill threads and warp threads in zones 30 of blank 10. While zones 14 of die 12 have a braking action limiting circumferential compression of zones 30 of blank 10, the circumferential compression of zones 16 of die 12 during the deep drawing process is considerable and is imparted to zones 32 of blank 10. In consequence, more uniform circumferential extensibility is produced around the entire periphery of the rolling wall of a rolling diaphragm including a fabric insert formed from blank 10 in the drawing dies 20, 26. This is achieved by limiting circumferential thread com-

pression in zones 30 of blank 10, and by a relative increase of circumferential thread compression in zones 32 of blank 10.

The fabric for blank 10 or the deformable die 12 may be any suitable fabric, such as Dacron, Orlon, or fiberglass; and setting thereof may be in any manner desired, for example using heat alone or with some impregnant, such as starch. The rolling diaphragm 40 is completed by securing a fluid tight layer 42 of elastomer thereto as shown in FIG. 6. Methods of doing this are fully disclosed in U.S. Patent 2,849,026. The elastomer may be natural rubber or synthetic rubber, as preferred.

According to FIG. 6 the layer of an elastomer is on the inside of the fabric insert, but may be on the outside thereof, if preferred. In either case the elastomer preferably permeates the interstices of the fabric element as well. The flange or base 48 of the rolling diaphragm may be trimmed as desired.

It will be apparent from FIG. 6 that a slightly conical shape may be imparted to blank 10 when impregnated with layer or skin 42 of an elastomer.

The drawing process illustrated in FIG. 4 does not involve a rearrangement of the constituent fill threads and warp threads of the radially inner head portion, or top portion, 46, of the woven insert. In other words, the constituent fill threads and warp threads of head portion 46 extend in two directions intersecting at right angles. This applies only to the head portion 46, but does not apply to the rolling wall portion 44 and to the radially outer flange portion 48 of the fabric insert. FIG. 6 clearly shows that the constituent threads of the head portion 46 of the fabric insert intersect at right angles. FIG. 6 shows also the geometry of the fill threads and that of the warp threads in the front sector 32 of FIG. 1, and the geometry of the fill threads and warp threads in sector or region 30 to the right of center sector 32 of FIG. 1. The geometry of the fill threads and warp threads is identical in all sectors of the blank or insert to which reference character 32 has been applied. The geometry of all the fill threads and all the warp threads is also identical in all sectors of the blank or insert to which reference character 30 has been applied. Sectors 30 are angularly displaced 90 degrees, and sectors 32 have the same angular displacement. Sectors 32 encompass circumferentially about 45 degrees, and sectors 30 encompass circumferentially about 45 degrees. Sectors 32 may be referred to as main rolling wall sectors and sectors 30 may be referred to as intermediate rolling wall sectors. The circumferential compression of the fill threads and of the warp threads of the rolling wall portion 44 of the insert increases progressively from the end of rolling wall portion 44 adjacent head portion 46 to the end of rolling wall portion 44 adjacent flange portion 48. This is apparent from FIG. 6 which shows that the circumferential spacing of contiguous threads A and B decreases from the upper circular edge of rolling wall portion 44 to the lower circular edge of rolling wall portion 44. As a result of the manufacturing process of the woven insert described in connection with FIG. 4, the circumferential compression of the fill threads and warp threads within the four main rolling wall sectors 32 exceeds the circumferential compression of the fill threads and warp threads in the four intermediate rolling wall sectors 30.

As shown in FIG. 6 the plane defined by the threads in top portion 46 of the fabric insert intersects with the slightly conical surface defined by rolling wall portion 44 of the fabric insert along a first circle, and the plane defined by the threads in flange portion or bottom portion 48 of the fabric insert intersects with the aforementioned surface of the rolling wall portion along a second circle having a slightly larger diameter than said first circle. The rolling diaphragm and its fabric insert, respectively, have a central axis. Said axis and the constituent threads of top portion 46 jointly define a pair of planes including

the aforementioned central axis and intersecting at right angles. One of said pair of planes extends parallel to the constituent fill threads of top portion 46, and the other of said pair of planes extends parallel to the constituent warp threads of top portion 46. The aforementioned pair of planes intersect with the slightly conical surface of rolling wall portion 44 along four generatrices of said surface. These generatrices are angularly displaced 90 degrees. Thread C of FIG. 6 is coextensive with one of said four generatrices. The circumferential compression of the constituent fill threads and warp threads of rolling wall portion 44 adjacent said four generatrices (i.e., in sectors 32 of FIG. 1) exceeds the circumferential compression of the constituent fill threads and warp threads of rolling wall portion 44 remote from said four generatrices (i.e., sectors 30 of FIG. 1). The front of the structure of FIG. 6 shows that the constituent fill threads and warp threads of rolling wall portion 44 adjacent the aforementioned four generatrices define two families of curves. The curves pertaining to a first family of curves intersect with both aforementioned circles bounding the rolling wall portion 44 of the fabric insert. The curves pertaining to the second family of curves intersect at two points with the lower of the two aforementioned circles, but do not intersect with the upper circle. The latter curves have generally the shape of parabolas and have peak regions situated along the four generatrices of the rolling wall portion 44 to which reference has been made above. As clearly shown in FIG. 6 the threads which are generally shaped in parabolic fashion are zig-zag shaped at, or adjacent to, the peak regions thereof. Such a zig-zag configuration of threads results from an extensive, locally limited, circumferential compression of threads, and it imparts, wherever it occurs, a high degree of circumferential extensibility to the particular portion of the rolling wall. The formation of the aforementioned zig-zag configuration is evidence showing that the circumferential compression of threads in sectors 32 of blank 10 exceeds the circumferential compression of threads in sectors 30 to an extent required to achieve sufficiently uniform circumferential extensibility of the rolling diaphragm at all points of the surface of the rolling wall thereof.

The rolling wall of a rolling diaphragm according to FIG. 6 is subjected to equal tangential forces when rolling from a piston having a relatively small outer diameter to an internal cylinder surface having a relatively large inner diameter, and vice versa, rolling from an internal cylinder surface having a relatively large inner diameter unto a piston having a relatively small outer diameter. The tangential forces tending to increase the circumference of the rolling wall in the region of sectors 32 are equal to the tangential forces tending to increase the circumference of rolling wall in the region of sectors 30. Regions 30 are, however, inherently circumferentially more stretchable or circumferentially more extensible. By increasing the pre-compression of the fill threads and warp threads in the regions of sectors 32 above and beyond that prevailing in the regions or sectors 30, the circumferential stretchability, or circumferential extensibility, along the entire circumference of the rolling wall of the rolling diaphragm is rendered substantially uniform.

While I have described my invention as embodied in a concrete preferred form in accordance with the provisions of the patent statutes, it should be understood that I do not limit my invention thereto, since various modifications thereof may occur to those skilled in the art without departing from the spirit and scope of my invention as defined in the appended claims.

I claim as my invention:

1. A rolling diaphragm comprising a woven fabric insert including fill threads and warp threads and an elastomeric skin coextensive with said fabric insert filling pores formed between said fill threads and warp threads, tending to resiliently maintain said fill threads and

warp threads in initial positions thereof and allowing limited relative movement between said fill threads and warp threads, said fill threads and warp threads of said fabric insert being arranged to form a radially inner head portion, a radially outer flange portion and a rolling wall portion intermediate said head portion and said flange portion, the constituent fill threads and warp threads of said head portion extending in two directions intersecting at right angles, said two directions defining four main rolling wall sectors angularly displaced 90 degrees and each of said four rolling wall sectors encompassing circumferentially about 45 degrees, said rolling wall portion further including four intermediate rolling wall sectors each situated between two of said four main rolling wall sectors, each of said intermediate rolling wall sectors encompassing circumferentially about 45 degrees, the constituent fill threads and warp threads of said rolling wall portion being circumferentially compressed and the circumferential compression of said fill threads and warp threads increasing progressively from the end of said rolling wall portion adjacent said head portion toward the end of said rolling wall portion adjacent said flange portion, and the circumferential compression of said fill threads and warp threads within said four main rolling wall sectors exceeding the circumferential compression of said fill threads and warp threads within said four intermediate rolling wall sectors.

2. A rolling diaphragm comprising a woven fabric insert including interlocking fill threads and warp threads and an elastomeric skin coextensive with said fabric insert filling pores formed between interlocking threads thereof, tending to resiliently maintain interlocking threads in initial positions thereof and allowing a limited relative movement between threads, said interlocking threads being arranged to form a radially inner head portion, a radially outer flange portion and a rolling wall portion intermediate said head portion and said flange portion, the constituent fill threads and warp threads of said head portion extending in two directions intersecting at right angles, said two directions defining four main rolling wall sectors angularly displaced 90 degrees and each of said four rolling wall sectors encompassing circumferentially about 45 degrees, said rolling wall portion further including four intermediate rolling wall sectors each situated between a pair of said four main rolling wall sectors, each of said intermediate rolling wall sectors encompassing circumferentially about 45 degrees, the constituent fill threads and warp threads of said rolling wall portion being circumferentially compressed and the circumferential compression of said fill threads and said warp threads of said rolling wall portion increasing progressively in the direction from said head portion toward said flange portion, the circumferential compression of said fill threads and said warp threads within said four main rolling wall sectors exceeding the circumferential compression of said fill threads and warp threads within said intermediate rolling wall sectors, and said four main rolling wall sectors including threads defining a family of parabola-like curves sig-zag-shaped at the apex regions thereof.

3. A rolling diaphragm comprising a woven fabric insert including fill threads and warp threads and an elastomeric skin filling pores formed between said fill threads and warp threads, tending to resiliently maintain said fill threads and warp threads in initial positions thereof and allowing limited relative movement between said fill threads and warp threads, said fill threads and said warp threads of said fabric insert being arranged inside a flat radially inner top portion defining a first plane, a flat radially outer flange portion defining a second plane and a rolling wall portion defining a surface of revolution and being integral with said top portion and said flange portion, said first plane intersecting with the surface of said rolling wall portion along a first circle, said second plane

intersecting with the surface of said rolling wall portion along a second circle, the directions of the constituent fill threads and warp threads of said top portion intersecting at right angles, the axis of said rolling wall portion and the constituent fill threads and warp threads of said top portion jointly defining a pair of planes including said axis and intersecting at right angles, one of said pair of planes extending parallel to the constituent fill threads of said top portion and the other of said pair of planes extending parallel to the constituent warp threads of said top portion, said pair of planes intersecting with the surface of said rolling wall portion along four generatrices of said surface angularly displaced 90 degrees, the constituent fill threads and warp threads of said rolling wall portion being circumferentially compressed and the circumferential compression thereof increasing progressively from the end of said rolling wall portion adjacent said first circle to the end of said rolling wall portion adjacent said second circle, and the circumferential compression of said constituent fill threads and warp threads of said rolling wall portion adjacent said four generatrices exceeding the circumferential compression of the constituent fill threads and warp threads of said rolling wall portion relatively remote from said four generatrices.

4. A rolling diaphragm comprising a woven fabric insert including fill threads and warp threads and an elastomeric skin filling pores formed between said fill threads and said warp threads, tending to resiliently maintain said fill threads and warp threads in initial positions thereof and allowing limited relative movement between said fill threads and warp threads, said fill threads and said warp threads of said fabric insert being arranged inside a flat radially inner top portion defining a first plane, a flat radially outer flange portion defining a second plane, and a rolling wall portion defining a conical surface and being integral with said top portion and said flange portion, said first plane intersecting with said conical surface of said rolling wall portion along a first circle, said second plane intersecting with said conical surface of said rolling wall portion along a second circle, the directions of the constituent fill threads and warp threads of said top portion intersecting at right angles, the axis of said rolling wall portion and the constituent fill threads and warp threads of said top portion jointly defining a pair of planes including said axis and intersecting at right angles, one of said pair of planes extending parallel to the constituent fill threads of said top portion and the other of said pair of planes extending parallel to the constituent warp threads of said top portion, said pair of planes intersecting with said conical surface of said rolling wall portion along four generatrices of said surface angularly displaced 90 degrees, the constituent fill threads and warp threads of said rolling wall portion being circumferentially compressed and the circumferential compression thereof increasing progressively from the end of said rolling wall portion adjacent said first circle to the end of said rolling wall portion adjacent said second circle, the circumferential compression of the constituent fill threads and warp threads of said rolling wall portion adjacent said four generatrices exceeding the circumferential compression of the constituent fill threads and warp threads of said rolling wall portion relatively remote from said four generatrices, the constituent fill threads and warp threads of said rolling wall portion adjacent each of said four generatrices defining first families of curves, each curve of said first families of curves intersecting with said first circle at one point thereof and intersecting with said second circle at one point thereof, the constituent fill threads and warp threads of said rolling wall portion adjacent each of said four generatrices further defining second families of curves, each curve of said second families of curves intersecting said second circle at two points thereof, said second families of curves having peak regions immediately adjacent to said four generatrices, and constituent

threads of said rolling wall portion being zig-zag-shaped at said peak regions.

5. A woven fabric insert for rolling diaphragms comprising fill threads and warp threads, said fill threads and warp threads being arranged to form a radially inner head portion, a radially outer flange portion and a rolling wall portion intermediate said head portion and said flange portion, the constituent fill threads and warp threads of said head portion extending in two directions intersecting at right angles, said two directions defining four main rolling wall sectors being angularly displaced 90 degrees and each of said four main rolling wall sectors encompassing circumferentially about 45 degrees, said rolling wall portion further including four intermediate rolling wall sectors situated between said four main rolling wall sectors, each of said intermediate rolling wall sectors encompassing circumferentially about 45 degrees, the constituent fill threads and warp threads of said rolling wall portion being circumferentially compressed, the circumferential compression of said fill threads and warp threads increasing progressively in the direction from said head portion toward said flange portion, and the circumferential compression of said fill threads and warp threads within said four main rolling wall sectors exceeding the circumferential compression of said fill threads and warp threads within said four intermediate rolling wall sectors.

6. A woven fabric insert for rolling diaphragms comprising fill threads and warp threads, said fill threads and said warp threads being arranged to form a radially inner head portion, a radially outer flange portion and a rolling wall portion intermediate said head portion and said flange portion, the constituent fill threads and warp threads of said head portion extending in two directions intersecting at right angles, said two directions defining four main rolling wall sectors being angularly displaced 90 degrees and each of said four main rolling wall sectors encompassing circumferentially about 45 degrees, said rolling wall portion further including four intermediate rolling wall sectors each situated between two of said four main rolling wall sectors, each of said four intermediate rolling wall sectors encompassing circumferentially about 45 degrees, the constituent fill threads and warp threads of said rolling wall portion being circumferentially compressed, the circumferential compression of said fill threads and warp threads increasing progressively in the direction from said head portion toward said flange portion, the circumferential compression of said fill threads and warp threads within said four main rolling wall sectors exceeding the circumferential compression of said fill threads and warp threads within said four intermediate rolling wall sectors, and said main rolling wall sectors including threads defining a family of parabola-like curves being zig-zag-shaped at the apex regions thereof.

7. A substantially hat-shaped woven fabric insert for rolling diaphragms comprising a radially inner top portion defining a first plane, a radially outer flange portion defining a second plane, and a rolling wall portion defining a cylindrical surface and being integral with said top portion and said flange portion, said first plane intersecting with said cylindrical surface of said rolling wall portion along a first circle, said second plane intersecting with said cylindrical surface of said rolling wall portion along a second circle, the directions of the constituent fill threads and warp threads of said top portion intersecting at right angles, the axis of said rolling wall portion and the constituent fill threads and warp threads of said top portion jointly defining a pair of planes including said axis of said rolling wall portion and intersecting at right angles, one of said pair of planes extending parallel to the constituent fill threads of said top portion and the other of said pair of planes extending parallel to the constituent warp threads of said top portion, said pair of planes intersecting with said cylindrical surface of said

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rolling wall portion along four generatrices of said cylindrical surface angularly displaced 90 degrees, the constituent fill threads and warp threads of said cylindrical rolling wall portion being circumferentially compressed and the circumferential compression thereof increasing progressively from the end of said rolling wall portion adjacent said first circle to the end of said rolling wall portion adjacent said second circle, and the circumferential compression of said fill threads and warp threads of said rolling wall portion adjacent said four generatrices exceeding the circumferential compression of the constituent fill threads and warp threads of said rolling wall portion relatively remote from said four generatrices.

8. A substantially hat-shaped woven fabric insert for rolling diaphragms comprising a radially inner top portion, a radially outer flange portion and a cylindrical rolling wall portion integral with said top portion and with said flange portion, said top portion defining a plane intersecting with the cylindrical surface of said rolling wall portion along a first circle, said flange portion defining a plane intersecting with the cylindrical surface of said rolling wall portion along a second circle, the constituent fill threads and warp threads of said top portion intersecting at right angles, the axis of said rolling wall portion and the constituent fill threads and warp threads of said top portion jointly defining a pair of planes including the axis of said rolling wall portion and intersecting at angles of 90 degrees, one of said pair of planes extending parallel to the constituent fill threads of said top portion and the other of said pair of planes extending parallel to the constituent warp threads of said top portion, said pair of planes intersecting with said cylindrical surface of said rolling wall portion along four

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generatrices of said cylindrical surface angularly displaced 90 degrees, the constituent fill threads and warp threads of said rolling wall portion being circumferentially compressed and the circumferential compression thereof increasing progressively from the end of said cylindrical rolling wall portion adjacent said first circle to the end of said cylindrical rolling wall portion adjacent said second circle, the circumferential compression of the constituent fill threads and warp threads of said cylindrical rolling wall portion adjacent said four generatrices exceeding the circumferential compression of the constituent fill threads and warp threads of said rolling wall portion relatively remote from said four generatrices, the constituent fill threads and warp threads of said rolling wall portion adjacent said four generatrices defining first families of curves, each curve of said first families intersecting with said first circle at one point thereof and intersecting with said second circle at one point thereof, the constituent fill threads and warp threads of said rolling wall portion adjacent said four generatrices further defining second families of curves, each curve of said second families intersecting with said second circle at two points thereof, each curve of said second families having a peak region immediately adjacent to one of said four generatrices, and constituent threads of said rolling wall portion being zig-zag-shaped adjacent said peak region.

No references cited.

SAMUEL LEVINE, *Primary Examiner*.

I. C. COHEN, *Assistant Examiner*.