

May 4, 1954

P. D. CORNELIUS
RADIALY EXPANDING BELLOWS

2,677,393

Filed March 9, 1950

4 Sheets-Sheet 1

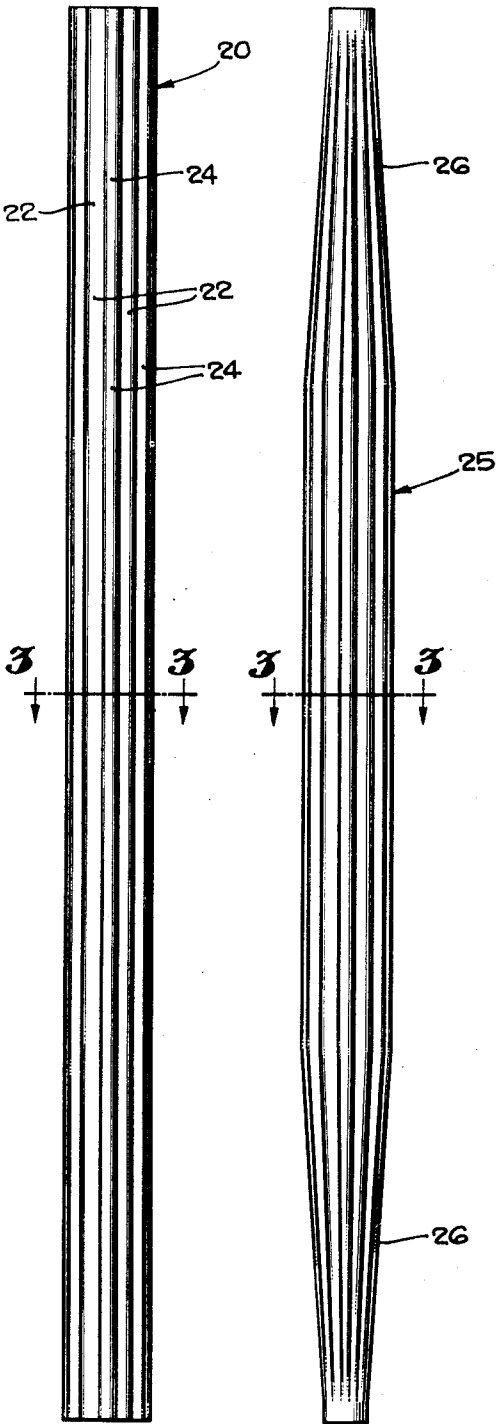


Fig. 1.

Fig. 2.

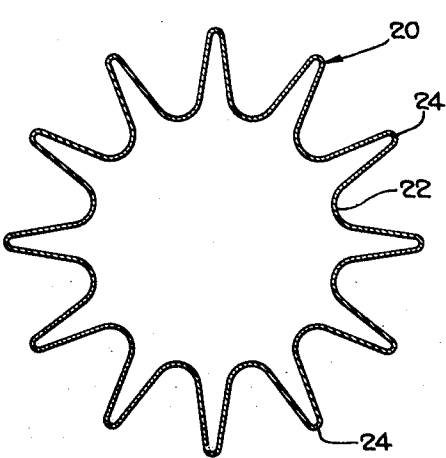


Fig. 4.

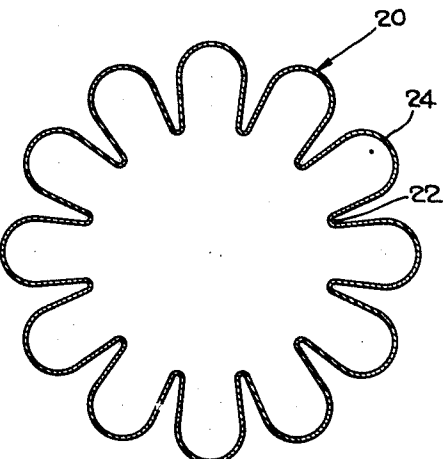


Fig. 5.

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4 Sheets-Sheet 2

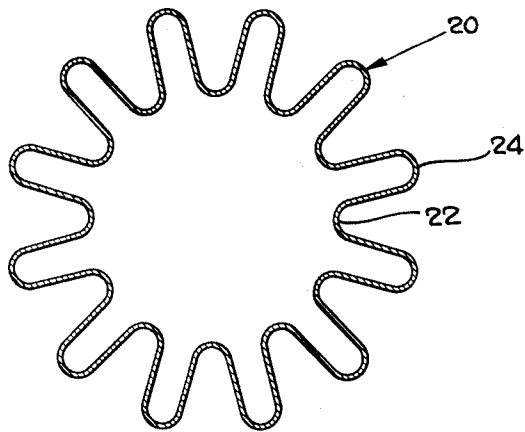


Fig. 3.

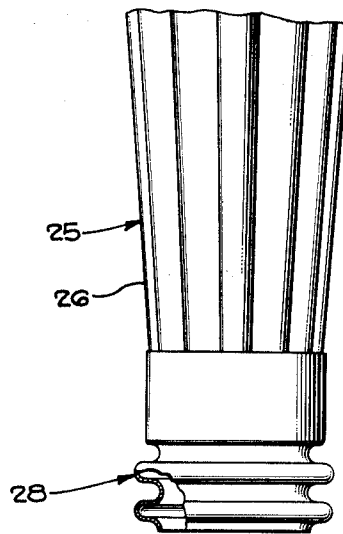


Fig. 6.

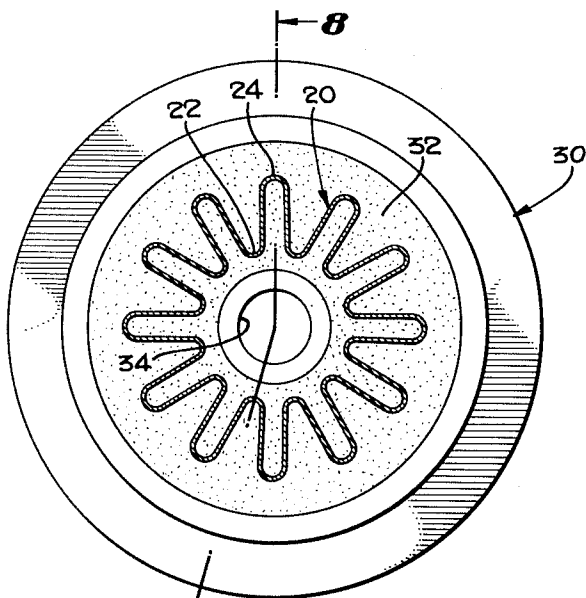


Fig. 7.

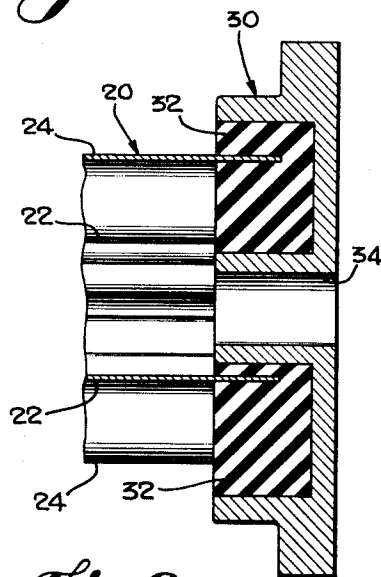


Fig. 8.

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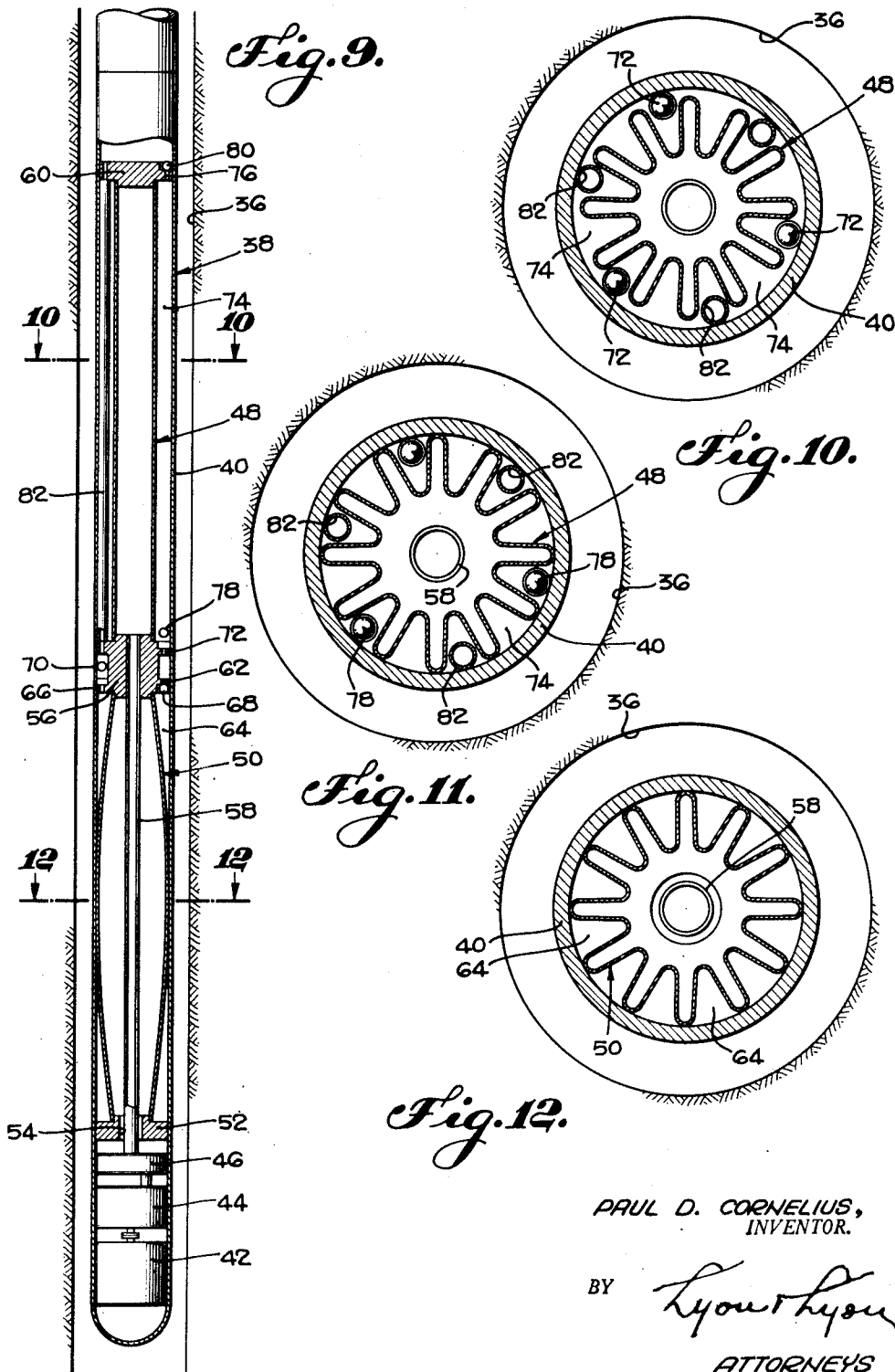
May 4, 1954

P. D. CORNELIUS
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2,677,393

Filed March 9, 1950

4 Sheets-Sheet 3



May 4, 1954

P. D. CORNELIUS
RADIALLY EXPANDING BELLOWS

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4 Sheets-Sheet 4

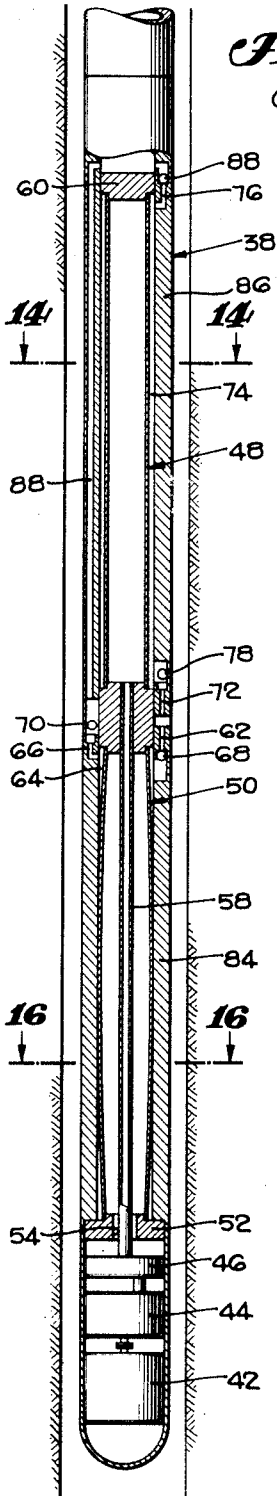


Fig. 13.

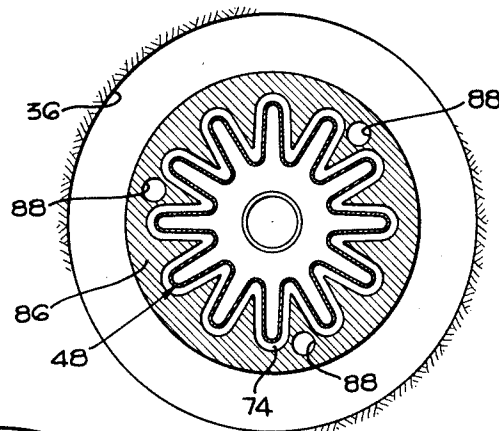


Fig. 14.

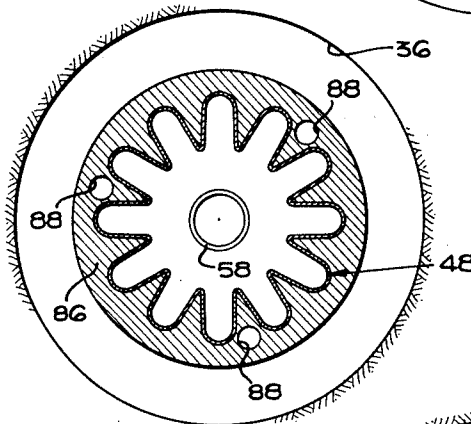


Fig. 15.

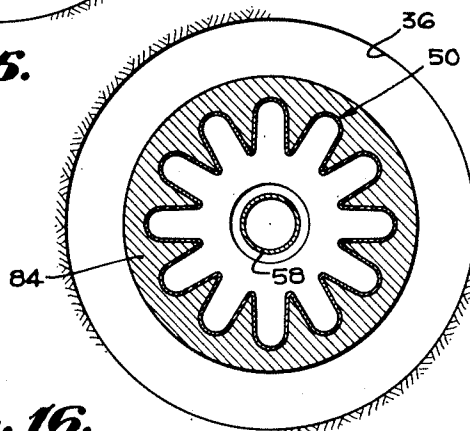


Fig. 16.

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RADIALLY EXPANDING BELLOWS

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6 Claims. (Cl. 137—796)

1

This invention relates to bellows and particularly to a bellows ideally suited to the displacement of fluid while occupying but a small space.

Conventional bellows, which may or may not consist entirely of metal, are either formed from corrugated tubing or built up from a series of disks joined at the edges, and are expansible longitudinally to provide volume change for the purpose of displacing fluid or for the purpose of varying pressures in fluids. The relative expansible or volume change of such bellows is limited by the depth and shape of the corrugations, or by the shape of the disks joined together in series. Such bellows are subject to early failure when used in fluids containing sediments that deposit in the recesses formed by the corrugations or disks. If maximum longitudinal flexing is desired and for that reason joined disks used, the type and amount of joining is frequently exceedingly costly. Moreover, the longer units of either the corrugated or disk type of bearings lack columnar stability and require guiding at intervals to insure straight-line action.

Some attempt has been made to provide a substitute for the aforesaid conventional bellows, which consists in the forming of a resilient sleeve of stretchable material, usually synthetic rubber, wherein to provide expansion, the walls of said sleeve are stretched. However, since the operation of such a means requires the use of materials having the aforesaid stretching quality, the use of such means is extremely limited. Such material cannot be exposed to either extremely high temperatures or extremely low temperatures without damage. It is only usable with fluids having a chemical composition which is not harmful to the rubber or other similar material of which the means is constructed. Finally, when the walls of such a stretchable sleeve are stretched in expansion, they are considerably reduced in thickness and thus are susceptible to sudden failure as a result of puncture or the like.

In order to avoid the above-described disadvantages, it is therefore the principal object of this invention to provide an entirely new and novel type bellows, which is neither dependent upon corrugations or disks, nor dependent upon being constructed of a readily stretchable material, and which obtains excellent volumetric differentials, although needing but a small narrow space within which to operate.

It is a further object of this invention to provide a bellows which does not depend upon longitudinal action for volumetric change and hence is not dependent upon straight-line action.

2

It is yet another object of this invention to provide a bellows which, while permitting large volumetric change, is not dependent upon complicated and expensive joining means for a series of specially shaped disks.

In the drawings:

Figure 1 shows a side elevation of the bellows incorporating the aforesaid invention;

Figure 2 shows a similar side elevation of a modified form of said bellows;

Figure 3 shows a cross-sectional view of the bellows of either Figure 1 or Figure 2, taken on the lines 3—3 of either Figure 1 or Figure 2;

Figure 4 shows an exemplary cross-sectional view of a bellows having a contour slightly modified from that shown in Figure 3;

Figure 5 shows an exemplary cross-sectional view of another bellows having a contour slightly modified from that shown in Figure 3;

Figure 6 shows a partial side elevation of the bellows of Figures 2 and 3 in combination with an expansion joint;

Figure 7 shows a cross-sectional view of the bellows of Figures 1 and 3 in combination with a resilient mounting;

Figure 8 shows a sectional view of the bellows and mounting of Figure 7, taken on the line 8—8 of Figure 7;

Figure 9 shows a side sectional view, partly diagrammatical, of a pump incorporating in combination a pair of bellows constructed according to the present invention;

Figure 10 shows a cross-sectional view of the pump structure of Figure 9, taken on the line 10—10 of Figure 9;

Figure 11 shows a similar cross-sectional view of the bellows of Figure 10 in expanded position;

Figure 12 shows a cross-sectional view taken on the line 12—12 of Figure 9;

Figure 13 shows a side sectional view, partly diagrammatical, of a modified pump incorporating a pair of bellows constructed in accordance with the present invention;

Figure 14 shows a cross-sectional view taken on the line 14—14 of Figure 13;

Figure 15 shows a similar cross-sectional view taken on the line 14—14 of Figure 13, showing the bellows in fully expanded position; and

Figure 16 shows a cross-sectional view taken on the line 16—16 of Figure 13.

The instant invention in its broadest scope consists in the provision of a bellows which neither depends upon longitudinal expansion for volumetric change nor upon a stretching of the material with which it is constructed but, on the

contrary, operates to expand and contract radially by virtue of a flexing action made possible by its novel shape. Such a bellows may be composed of a series of strips, preferably of thin metal, joined at their edges to provide alternate troughs and ridges to form an elongated fluted cylinder, or it may comprise a stamped or otherwise formed tube having the aforesaid surface contour. Such surface contour as described may be such contour as is shown in Figures 3, 4 or 5 or, indeed, may compose a series of sharply defined alternate ribs and depressions. In operation, internal pressure within such bellows flattens the curvature of the aforesaid troughs, moving said troughs outwardly and, at the same time, moving the ridges outwardly. External pressure, of course, reverses this action. Due to this change in curvature of the troughs small increases in diameter of the bellows result in large volumetric change in the bellows and consequently large displacements. The excessive flexing which is necessary in the longitudinally expansible type of bellows is absent, and hence material fatigue is diminished as is the abrasive effect of sedimentary deposit. Furthermore, the excessive stretching necessary to the aforesaid rubber sleeve type expedient is avoided and hence the limitations imposed by this means are not present.

A typical bellows of this construction is that shown in Figures 1 and 3, wherein is provided the bellows 22, consisting of a straight-sided cylindrical column composed of a series of metallic strips joined to form alternate troughs 22 and ridges 24.

Figures 4 and 5 show modified forms which the contour of said bellows might take, it being apparent that the ridges 24 of Figure 4 are more sharply defined than those of Figure 3, while the troughs 22 of Figure 5 are more sharply defined than those of Figure 3.

Figure 2 shows a bellows 25 similar in all respects to Figure 1 and having an identical center cross-section therewith, excepting only that Figure 2 is provided with the tapered extremities 26. Such bellows may, of course, have contours of the alternate embodiments shown in Figures 4 and 5, and while more difficult to fabricate than the bellows of Figure 1, provides a more satisfactory stress condition at its end portions under flexing motion, inasmuch as the sides of the bellows adjacent the tapered end portions need bend through a lesser angle.

Examples of the mountings of the aforesaid bellows are shown in Figures 6, 7 and 8. Figure 6 shows the tapered bellows 25 having its end affixed to a corrugated end member 28, said corrugated end member 28 being adapted to flex and release longitudinally. Although such expedient may be dispensed with, it will be appreciated that a bellows provided with one or more of such end members is afforded a resilient mounting for longitudinal contraction and expansion induced in the bellows for any reason. Figures 7 and 8 show the extremity of bellows 20 mounted in an end member 30, which carries an annular body 32 of resilient material, such as rubber. A bore 34 is provided in the end member 20 to afford access to the interior of the bellows. While it is again true that this expedient may be avoided in practical operation and rigid mountings used, it will be noted that the extremity of the bellows 20 being embedded in such resilient body 32, bending of the portion of the bellows adjacent the bellows extremity is cushioned by the rubber. As is ob-

vious, the tapered bellows 25 may be used with the end member 30 and the bellows 20 may be used with the end member 28.

It will be noted that while the aforesaid description provides for endwise mounting of the bellows, no provision has been shown for bracing members, guides, or the like, adjacent the sides of the bellows. As has been stated hereinbefore, while this is frequently necessary with the longitudinally expansible type of bellows, in order to assure columnar stability, it is unnecessary with the instant type bellows. However, it will frequently be found desirable to check the degree of radial expansion permitted in the radially expanding bellows. A limit of radial expansion may, of course, be inherent in the bellows itself where the strength of the metal and resistance to expansion may be sufficient to overcome the expanding effect of the particular pressure differential across the bellows. However, when a more positive action is desired, a stop member may be provided for the bellows which will ordinarily consist of the bellows chamber, such stop member having an inner circumference contoured to match the circumference of the bellows and acting as a stop means preventing any radial expansion of the bellows beyond a certain point. Such a means is shown in connection with a pump incorporating the instant bellows and will be described hereinafter.

Tests of bellows constructed either as the straight-sided embodiment of Figure 1, or the tapered-ended embodiment of Figure 2, indicate that either type is capable of displacing an appreciable amount of fluid with but a comparatively small change in diameter. Moreover, the bellows prove to possess a long operating life, although constructed of thin metal permitting a maximum of flexibility with a minimum of pressure differential. A bellows constructed in accordance with Figure 1 of .0125" stainless steel material, having a length of 72", was found to have a displacement of 78 cubic inches when expanded from a normal diameter of 3.5" to an expanded diameter of 3.95", such expansion being effected by a pressure differential across the bellows of only 2 pounds per square inch.

As is obvious, the aforesaid bellows are adaptable to many uses in industry. One particularly effective use is in the field of pumps, and Figures 9 to 16 show the incorporation of the said bellows as part of pumping combinations. Referring particularly to Figure 9, there is shown a well 36 into which is shown lowered a positive displacement well pump 38 of relatively small diameter. Such pump includes a pump housing 40, an electric motor 42, an ordinary hydraulic pump 44, and a common shuttle valve 46 hermetically sealed in hydraulic fluid. Said electric motor, hydraulic pump, and shuttle valve provide means for actuating two radially expansible bellows 48 and 50. The bellows 50 at its lower extremity is rigidly mounted to an end-piece 52, which has a bore 54 providing communication between shuttle valve 46 and the interior of the said bellows. At its upper extremity, the bellows 50 is affixed to a joining member 56 to which is also affixed the lower extremity of the bellows 48. The joining member 56 is bored to receive a tube 58, leading from the aforesaid shuttle valve 46 through the bellows 50 and to the interior of the bellows 48. The upper extremity of the bellows 48 is affixed to an end member 60.

Inlet ports 62 leading to the lower bellows chamber 64 are shown diagrammatically as are

5

outlet ports 66 leading therefrom, said ports being controlled by check valves 68 and 70, respectively. Inlet ports 72 leading to the upper bellows chamber 74 are shown diagrammatically, as are outlet ports 76 leading therefrom, said ports being controlled by check valves 78 and 80, respectively. Communicating with the outlet ports 66 for the lower bellows chamber 64 are conduits 82, which convey pump liquid from the lower bellows chamber 64 through the end member 60.

In operation the hydraulic pump 44 provides a pressure which, by means of the shuttle valve 46, is directed alternately into lower bellows 50 and upper bellows 48. In the operational position of the pump shown in Figure 9, the bellows 50 is expanded and pump liquid consequently forced through the conduits 82 and on through the end member 60. A common metering device may be used to reverse the shuttle valve 46 to direct pressure into the bellows 48, whereupon said bellows 48 will expand and the bellows 50 contract. When the bellows 50 contracts, the check valves 78 close, but the check valves 68 open permitting pump liquid to enter the bellows chamber 64. Conversely, the check valves 78 close and the check valves 80 open to permit pump liquid to be forced from said bellows chamber by the radially expanding bellows 48 out through the end member 60. Thus, as the bellows pairs alternately expand and contract, pump liquid is alternately expelled from one bellows chamber past the end member 60, while other pump liquid is drawn into the other bellows chamber.

It will be appreciated that in the pump embodiment shown in Figure 9, the shuttle valve 46 may be reversed either through the aforesaid metering device, or may be reversed in common manner by virtue of pressure differential. Such pressure differential may be provided inherently in the bellows by constructing said bellows as resistant to more than a predetermined radial expansion as a consequence of a given pressure differential across the bellows. The pressure differential may be also accomplished by expansion of a bellows to the position shown in Figure 11, whereby said expansion is checked by the walls of the bellows chamber itself. However, as hereinbefore described, a more satisfactory stop may be provided for the bellows by constructing an envelope for the bellows which, in this case, is the bellows chamber itself contoured to match the circumference of the said bellows. A pump incorporating this construction is shown in Figure 13, which pump is in all respects the same as the pump of Figure 9, with the exception of the walls of the respective bellows chambers. As shown in Figures 14, 15 and 16, the inner surfaces of the respective walls 84 and 86 of the bellows chambers 64 and 74 are contoured to match the circumferential surfaces of the respective bellows 48 and 50, and, as contrasted with the conduits 82 of the pump of Figure 9, passages 88 are provided within the wall 86 of the upper bellows chamber 74 for egress of pump liquid from the lower bellows chamber 64. Thus, in operation, as the outer surface of each bellows reaches the contoured inner surface of its respective bellows chamber, additional radial expansion is stopped, pressure is built up, and the shuttle valve 46 thrown, thus reversing the cycle of the pump.

It will thus be seen that the aforescribed radial bellows are particularly adaptable as component parts of small diameter pumps, it being

6

possible to hold pump clearances to a minimum by conforming the bellows chamber closely to the external shape of the bellows in its fully extended position.

While there has been described what is at present considered a preferred embodiment of the present invention, it will be apparent to those skilled in the art that various modifications and changes may be made without departing from the essence of the invention, and it is intended to cover herein all such modifications and changes as come within the true scope and spirit of the appended claims.

I claim:

1. A bellows comprising: a thin flexible tubular body of relatively inelastic material, said body including a radially expansible, axially inexpandible, substantially cylindrical major portion characterized by a longitudinally fluted surface formed by alternate troughs and ridges whereby pressure variations may vary the circumference of said portion to vary the volume without elongation thereof and at least one end portion having conically inclined straight side walls the cross section of which progressively diminishes in circumference outwardly from said major portion.

2. A bellows comprising: a thin flexible tubular body of relatively inelastic material, said body including a radially expansible, axially inexpandible, substantially cylindrical major portion characterized by a longitudinally fluted surface formed by alternate troughs and ridges whereby pressure variations may vary the circumference of said portion to vary the volume without elongation thereof and at least one end portion having conically inclined straight side walls the cross section of which progressively diminishes in circumference outwardly from said major portion, said end portion having extensions of the flutes of said major portion extending longitudinally thereof with diminishing heights and depths of said ridges and troughs outwardly from said major portion.

3. A bellows comprising: a thin flexible tubular body of relatively inelastic material, said body including a radially expansible, axially inexpandible, substantially cylindrical major portion characterized by a longitudinally fluted surface formed by alternate troughs and ridges whereby pressure variations may vary the circumference of said portion to vary the volume without elongation thereof and a pair of oppositely tapered end portions having conically inclined straight side walls the cross section of which progressively diminishes in circumference outwardly of said major portion, said end portions having extensions of the flutes of said major portion extending longitudinally thereof with diminishing heights and depths of said ridges and troughs outwardly from said major portions.

4. A bellows comprising: a thin flexible tubular body of relatively inelastic material, said body including a radially expansible, axially inexpandible, substantially cylindrical major portion characterized by a longitudinally fluted surface formed by alternate troughs and ridges whereby pressure variations may vary the circumference of said portion to vary the volume without elongation thereof, at least one end portion having conically inclined straight side walls the cross section of which progressively diminishes in circumference outwardly from said major portion and at least one mounting member compris-

7

ing an axially expansible, radially inexpandible, tubular extension of said bellows.

5. A bellows comprising: a thin flexible tubular body of relatively inelastic material, said body including a radially expansible, axially inexpandible, substantially cylindrical major portion characterized by a longitudinally fluted surface formed by alternate troughs and ridges whereby pressure variations may vary the circumference of said portion to vary the volume without elongation thereof, at least one end portion having conically inclined straight side walls the cross section of which progressively diminishes in circumference outwardly from said major portion and at least one cylindrical mounting member comprising an axially expansible, radially inexpandible, circularly corrugated, tubular extension of said bellows.

6. A bellows comprising: a thin flexible tubular body of relatively inelastic material, said body including a radially expansible, axially inexpandible, substantially cylindrical major portion characterized by a longitudinally fluted surface formed by alternate troughs and ridges whereby pressure variations may vary the circumference of said portion to vary the volume without elongation thereof, a pair of oppositely tapered end portions having conically inclined

8

straight side walls the cross section of which progressively diminishes in circumference outwardly of said major portion, said end portions having extensions of the flutes of said major portion extending longitudinally thereof with diminishing heights and depths of said ridges and troughs outwardly from said major portion, and a pair of cylindrical mounting members engaging the extremities of said end portions and comprising axially expansible, radially inexpandible, circularly corrugated tubular extensions of said bellows.

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