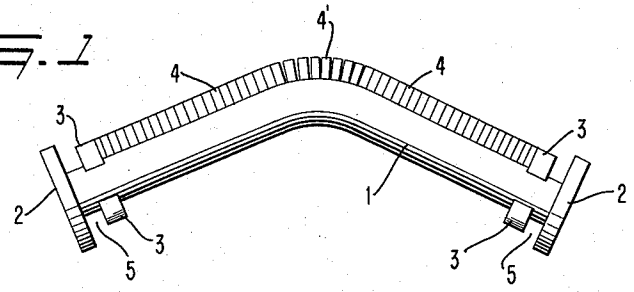
April 4, 1961 L. A. SEYLER 2,977,890

PUMPS AND COMPRESSORS OF THE FLEXIBLE-TUBE TYPE

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Fig. 1



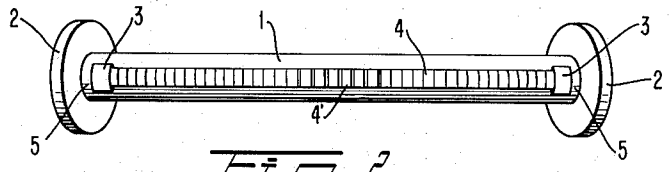
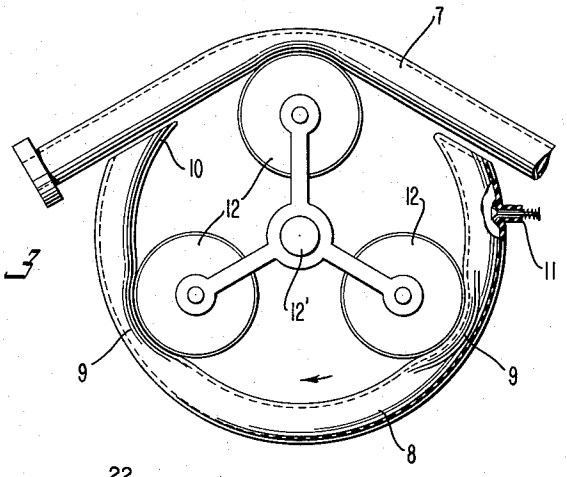


Fig. 2

Fig. 3



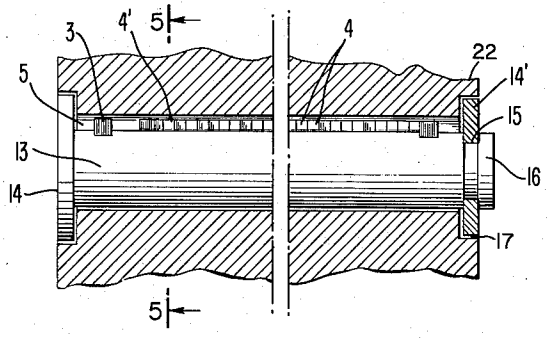


Fig. 4

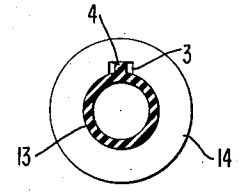


Fig. 5

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Fig. 6

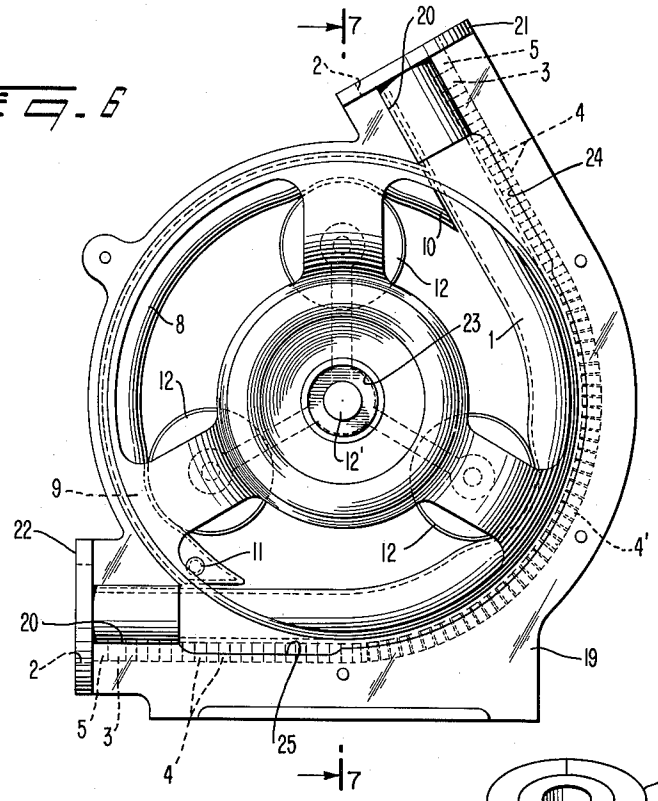
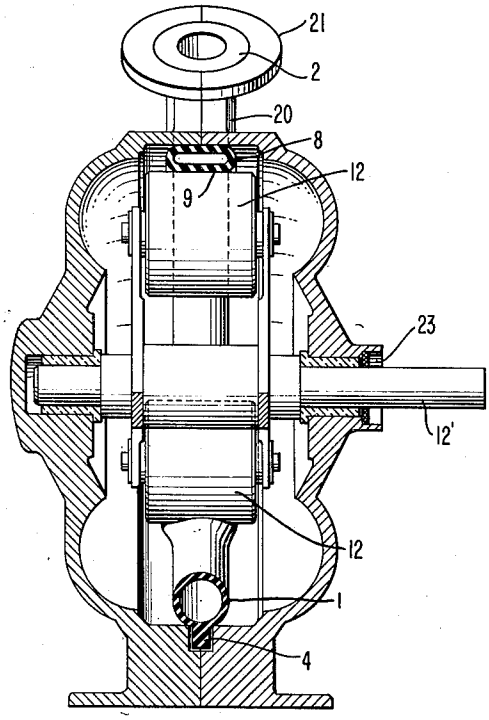


Fig. 7



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PUMPS AND COMPRESSORS OF THE FLEXIBLE-TUBE TYPE

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10 Claims. (Cl. 103—149)

This invention relates to fluid displacement devices, i.e. pumps and compressors, of the type wherein the fluid is propelled by the squeezing action of a flexible tube with resiliently deformable walls through which the fluid flows, the walls of the tube being cyclically compressed or flattened in order to impart the desired displacement to the fluid. In one known form of construction of such devices, the flexible tube is arranged in an arcuate path within a casing in which one or more squeezer rollers engaging the tube wall is or are rotated about an axis coincident with the center of said arcuate path, so that at each rotation the roller will act to propell the fluids within the tube before it.

Pumps of this general character have many important advantages, including the fact that the displaced fluid is at no time brought into contact with any metallic parts such as pistons, vanes or rotors; moreover the delivery of such a pump can, theoretically at least, be controlled with high accuracy over a wide range.

Such pumps have heretofore been open to the drawback that the flexible tube becomes rapidly worn and requires frequent replacement. It is therefore a general object of this invention to provide a fluid displacement device of the type described, wherein the deformable tube element will have a considerably longer service life than has been heretofore the case.

Generally speaking there are several ways in which the engagement of the roller with the tube acts to subject the tube to objectionable wear and tear.

(*a*) First, the tube tends to be driven longitudinally by the roller, tending to be pushed into the casing at the inlet side and to be pulled out of the casing at the outlet side.

(*b*) The tube may be subjected to torsional strain twisting it within its recess.

(*c*) At the point of initial engagement of the roller with the tube, the tube is subjected to an impact due, in the first place, to the fact that the roller compresses it suddenly at said point, and secondly, to the fact that the roller is allowed to revolve freely about its axis over the idling part of the rotational cycle so that the roller, at the initial point of the active portion of each cycle, strikes the tube with increased rotational energy due to its said free rotation.

(*d*) Additional and high stresses are developed in the tubeas a roller disengages it at the end of the active portion of the cycle and as the tube suddenly springs back to its initial open shape.

Specific objects of the invention, accordingly, lie in preventing or minimizing any or all of the above objectionable effects which are primarily responsible for the rapid wearing out of the tubes in prior devices of the type contemplated herein.

In accordance with a feature of the invention, the tube is provided with a continuous longitudinal retainer ridge for retaining the tube against lateral displacement, the ridge being formed with a plurality of transverse cuts or separations so as to allow the requisite curvature to

be imparted to the tube without subjecting the ridge and the tube wall to objectionable stresses. According to further features of the invention, the tube is integrally formed with end flanges for retaining it against longitudinal displacement, and with reenforcing bosses or projections. In a modified form of the invention, the tube may comprise only a single flange at one of its ends to facilitate its insertion and removal into and from the casing, the casing being constructed in two sections adapted to be readily opened apart and closed with respect to each other for insertion and removal of the tube. Further, the invention may include the provision of means within the casing for damping the deformations of the tube, which means comprise an auxiliary tube having one end open to atmosphere and its other end opening within the casing. According to another feature, the casing may be formed with expansion chambers adjacent to the opposite ends of the tube to facilitate the expansion of the latter.

The above and further objects, advantages and features of the invention will become apparent as the description proceeds with reference to the accompanying drawings, given by way of illustration but not of limitation, and wherein:

Fig. 1 is a side view of a flexible tube element according to the invention, formed with a cross-cut retainer ridge, end retainer flanges, and bosses according to the invention;

Fig. 2 is a top plan view of Fig. 1;

Fig. 3 illustrates schematically the general lay-out of the device for varying the fluid pressure, the casing being removed;

Fig. 4 is an axial sectional view of a modified tube according to the invention, the tube being shown in position in the casing;

Fig. 5 is an end view of the pump flange usable in conjunction with the tube as shown in Fig. 4 as seen along section line 5—5 in Fig. 4;

Fig. 6 illustrates one half of a stator casing formed from two interconnecting substantially identical members for a pump constructed in accordance with the invention showing the relative relationships of the tubes and the squeezer elements defined by the rollers; and

Fig. 7 is a sectional view taken approximately along the line 7—7 of Fig. 6 and illustrating the sealed casing which surrounds the working mechanism of the pump of the invention.

First referring to Figs. 1 and 2, it will be noted that the tube element 1 is provided with end flanges 2 for preventing longitudinal displacement of the tube in the casing under the stress of the rollers engaging it. Further the tube has a longitudinal ridge 4 secured to its wall, said ridge being formed as a continuous elongated bead of, for example, rectangular cross section, formed with a multiplicity of transverse cuts 4' in it. Moreover, two opposite pairs of bosses 3 are provided at both ends of the ridge 4 and spaced a definite short distance from the end flanges 2, as shown by the spaces 5.

On insertion of the tube 1 into the casing, the end bosses 3 are arranged to be compressed to a substantial degree while the ridge 4 is stressed to a lesser degree or allowed to remain substantially uncompressed, so as to be capable of free elongation in the arcuate condition of the tube, illustrated in Fig. 1. The spaces 5 between the bosses 3 and flanges 2 serve a similar purpose. The arrangements just described serve both to reduce the wear and tear of the tube in operation, and to minimize distorsion of the end flanges 2, thereby preserving tight fluid seals at the points of connection of the tube 1 with inlet and outlet conduits (not shown), it being noted that the flanges 2, in addition to the retaining function thereof described above, preferably also serve as connecting means for said inlet and outlet conduits.

If the retainer ridge 4 were formed by a plurality of entirely separate bosses formed on or secured to the tube wall, this would in effect provide a tube element having a wall of non uniform thickness, and the stresses developed in the tube in operation would be correspondingly non uniform along the length of the tube, resulting in considerable vibration and rapid wear of the tube. According to the invention therefore, the ridge 4 is made essentially continuous in character, thereby preserving desirable uniformity in the stresses developed throughout the length of the tube, while at the same time the transverse cuts or slits formed across the continuous ridge permit a fanning-out of the ridge (as clearly shown in Fig. 1) so that the arcuate conformation imparted to the tube does not apply undesirable differential tension strains between the top and foot of the ridge.

Fig. 3 illustrates a pump assembly according to the invention, including a further advantageous feature for improving the efficiency of the operation of the pump. Conventional pumps of the type specified herein are subject to limitations in their suction and discharge capacity, as determined by the capacity of the tube for restoration to its initial, fully open condition. Thus at the suction end of the tube the tube wall has to overcome atmospheric pressure which opposes the resilient flexing of the wall and tends to prevent its springing back to its wide-open condition, while at the discharge end, where the discharge pressure exceeds atmospheric pressure, there is a similar force opposing the resilient flexing of the wall and tending to prevent the tube from returning to its normal undeformed condition. Further objects of the invention, accomplished by means to be now described are to overcome such limitations and hence to improve the operating capacity of fluid displacement devices of the type specified, beyond that which has been heretofore found possible.

As shown in Fig. 3, the main resilient tube of the pump is shown at 7 as extending over a partial arc of the cylindrical casing. Over the remaining peripheral arc of the casing there extends an auxiliary resilient tube 8 of generally similar character to the tube 7, adapted to be engaged by the rollers 12 during their rotation in the casing. The tube 8 has one end, such as 10, opening into the interior space of the casing, while its other end 9 is closed adjacent tube 7 and therefore does not communicate with the interior of the casing but is connected with the outer atmosphere, e.g. through a check-valve 11 as shown. Thus the tube 8 acts as an auxiliary air pump and may be used for increasing or reducing the air pressure within the casing of the main pump, as desired. Specifically, depending upon the setting of the check-valve 11 to permit the egress or ingress of air from or into the tube 8, the auxiliary pump will act as a vacuum pump to aid the tube wall in springing back to normal shape and thereby increase the suction capacity of the pump, or as a compressor to increase the air pressure within the casing acting on the tube wall and thereby to increase the discharge capacity of the main pump. Where the arrangement shown in Fig. 3 is used, the pump casing should of course be made of a suitable airtight construction.

While in Fig. 3 the main pump tube 7 is shown as extending over a smaller arcuate extent than the auxiliary pump tube 8, this relationship is exemplary only. Thus the main tube 7 may be made to extend over a full 360° of the casing periphery. In the case of the auxiliary tube 8 it will generally be found satisfactory to have it extend over only a fraction of the circumference of the casing.

Figs. 4 and 5 illustrate a modification especially applicable to large capacity pumps. Such pumps require tubes with considerable wall thickness and subsequent their removal when worn and replacement usually involves a rather complete dismantling of the pump casing, especially if the tube is formed with the ridged reenforced and flanged structure illustrated in Figs. 1 and 2. According to a feature of the invention therefore, the tube 13 has a flange 14 formed at one of its ends only, while the opposite end 16 may be smooth or may preferably include a circumferential groove 15 in it for a purpose to be later described. The end 16 receives a flange member 14' in groove 15 which cooperates with a recess 17 formed in the connector flange 22 of the pump casing, shown in Fig. 4. In this embodiment, the pump stator comprises a two part casing, each part or shell of the casing being bolted to a common base by means of two bolts. One of the two stator shells, i.e. that one remote from the rotor shaft, is arranged to be displaced a limited amount axially towards and away from the other shell, as by providing a pair of elongated slots through which the bolts attaching it to the common base are passed. The length of the permissible axial displacement, as determined by the length of the slots, is selected with due regard to the length of the projecting stator shafting. Further, the displaceable one of the two stator shells is formed with a wide aperture therein, and a removable cover is adapted to be fitted thereover to seal the aperture. The purpose of this arrangement will appear presently. A pair of recesses are provided in the outlet side of the pump, being dimensioned complementarily to the ridges of the flexible tube.

For removing a worn tube element in such a pump and replacing it with a new element, the cover fitted over the perforate displaceable stator shell is first removed, and said shell is then pulled away from the other shell the extent permitted by the elongated bolt slots in its base. It will be noted that the rotor shaft remains supported in a part of its bearing means, so that it is at no time placed in an objectionable overhanging condition. At this stage the flexible tube element is released from its compressed condition in the stator and can easily be removed by rotating the pump rotor in the proper angular direction. However, since the presence of the ridge on the tube interferes with the free passing of the rollers, the movement of said rollers is preferably aided manually, this being readily accomplished by extending a hand through the wide perforation provided in the stator shell as previously described. After the old tubing has been thus withdrawn, a fresh tube element is inserted by following a generally reverse procedure from that just described.

That end of the tube 13 which is not provided with an integral flange on it is formed with a groove 15 as already indicated. A resilient annular ring or washer may be inserted in the groove after the tube has been inserted so as to provide the missing flange, and the latter will then be retained in position owing to the pressure of the flange of the connected conduit.

As previously indicated, a substantial part of the wear to which the flexible tube is subjected in operation, is ascribable to the sudden release of the roller pressure on the tube wall and the sudden return of the flattened wall to its normal rounded condition. The maximum stresses due to this effect occur at the outlet end of the tube and the resulting wear on the tube material is clearly visible especially on thin-walled tubes, even though its damage to the tube material is actually greatest in thick-walled tubes. The invention contemplates steps for overcoming this last mentioned source of wear and tear, generally comprising the provision of recesses in the stator casing adjacent the ends of the tube, whereby the tube will be able to initiate the resumption of its normal unstressed condition at a point in time slightly in advance of the actual disengagement of each roller from it. Such recesses have been illustrated in Fig. 6 of the drawings, wherein a pump casing half is shown comprising an integral casing 19 e.g. of aluminium alloy, including a toroidal recess 20 for the tube and end flanges 21 and 22. An axial recess is shown at 23 for the passing of the roller-carrying rotor shaft 12'. According to the features of the invention now described, the toroidal chamber 20 is formed with a pair of enlarged recesses 24 and 25.

As each roller 12 attains the inner end of either one of the recesses (the particular recess 24 or 25 involved depending on the direction of rotor rotation used), the compression stress exerted by the roller commences to be relieved, so that the tube wall is allowed to return to its normal condition in a more gradual manner and damage to the tube material is minimized. The recesses such as 24 and 25 may be formed integrally at casting, or by a subsequent machining operation, as by milling.

It will be understood that the invention is not limited to the specific embodiments illustrated and described, but modifications may be made therein within the scope of the claims.

What is claimed is:

1. In a fluid-displacement apparatus of the type described having a stator casing, a tube made from a resilient material and having a radial flange at at least one of its ends, a continuous ridge projecting along a generatrix over a major extent of the tube with an end of the ridge longitudinally spaced from said at least one end flange, transverse slits in the ridge to permit bending of the tube in the plane of the ridge, bosses projecting from the tube wall adjacent the ends of said ridge and spaced longitudinally of the tube from the related end flange, said stator casing being adapted to fixedly support the tube in an arcuately bent condition with the ridge outwardly of the arc and to retain the tube against lateral displacement, each boss and flange being adapted to engage the casing to retain the tube against longitudinal displacement, and at least one squeezer member supported in the casing for rotational movement about the center of said arc in squeezing relation with the tube along the inner wall of the arc to propel fluid from one end of said tube to the other.

2. In a fluid-displacement apparatus of the type described having a stator casing, a tube made from a resilient material and having a radial flange at at least one of its ends, a continuous ridge projecting along a generatrix over a major extent of the tube with an end of the ridge longitudinally spaced from said at least one end flange, transverse slits in the ridge to permit bending of the tube in the plane of the ridge, bosses projecting from the tube wall adjacent the ends of said ridge and spaced longitudinally of the tube from the related end flange and a second boss diametrically opposite each first boss, said stator casing being adapted to fixedly support the tube in an arcuately bent condition with the ridge outwardly of the arc and to retain the tube against lateral displacement, each boss and flange being adapted to engage the casing to retain the tube against longitudinal displacement, and at least one squeezer member supported in the casing for rotational movement about the center of said arc in squeezing relation with the tube along the inner wall of the arc to propel fluid from one end of said tube to the other.

3. In a fluid-displacement apparatus of the type described having a sealed stator casing, a first tube having resilient walls supported over an arcuate path in said casing, a second tube having resilient walls adapted to be supported along an arcuate path in said casing coplanar with said first arcuate path and forming an extension of said first arcuate path, whereby to form a substantially closed substantially circular path, said second tube being formed with aperture means connecting one end of said second tube with the interior of said casing, vent means connecting the other end of said second tube with the outer atmosphere, and roller means supported in the casing for rotation about the common center of said arcuate paths for squeezingly engaging said first and said second tubes along the walls thereof positioned inwardly of said arcuate paths so as to propel said fluid through the first tube, and to propel air between the interior of the casing and the atmosphere through the second tube.

4. In a fluid-displacement apparatus of the type described having a sealed stator casing, a first tube having resilient walls supported over a first arcuate extent of the casing, a second tube with resilient walls supported along another arcuate extent of the casing so as to define a substantially common circumference with said first arcuate extent, said second tube being formed with connecting one end of said second tube with the casing interior, check valve means connecting the other end of said second tube with the outer atmosphere, and roller means supported in the casing for rotation about the center of said circumference for squeezingly engaging said tubes in successive parts of each revolution so as to displace said fluid means through the first tube, and to displace air through said second tube.

5. In apparatus as claimed in claim 1, wherein said bosses projecting from the tube wall adjacent the respective ends of said ridge and spaced from the related end flange have a greater lateral dimension than said ridge.

6. A tube element for use in a fluid displacement apparatus of the type described comprising, a cylindrical tube body made of resiliently flexible material and having end flanges, a continuous ridge of said material projecting outwardly from the wall of said body along a generatrix thereof over a major extent of said body, transverse slits in said ridge to permit an arcuate bending of the body in the plane of the ridge, and a pair of retainer bosses adjacent the ends of said ridge and spaced longitudinally of the tube body from the related end flanges.

7. A tube element as claimed in claim 6, including a second pair of bosses diametrically opposite said first-named pair of bosses.

8. A tube element for use in fluid displacement apparatus of the type described comprising, a cylindrical tube body made of resiliently flexible material and having a flange at one end thereof, an annular groove formed in the outer periphery of said tube body adjacent the other end thereof, and a continuous ridge of said material projecting outwardly from the wall of said element along a generatrix thereof over a major extent of said tube body, bosses projecting from the ends of said ridge and spaced longitudinally from the tube end and the flange, and transverse slits in said ridge to permit an arcuate bending of the tube body in the plane of the ridge.

9. Apparatus as claimed in claim 1, wherein said tube has only one end flange, and wherein said casing comprises two casing sections relatively displaceable transversely of the axis of said arc.

10. In the apparatus claimed in claim 2, recessed means in said casing adjacent the opposite end portions of said tube element to permit movement of part of said end portions into said recessed means and thereby to permit an easy restoration of the tube walls to the original unsqueezed condition thereof in said end sections upon disengagement of said squeezer member therefrom.

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