March 6, 1951 B. G. COPPING 2,544,628

PERISTALTIC PUMP

Filed June 15, 1946

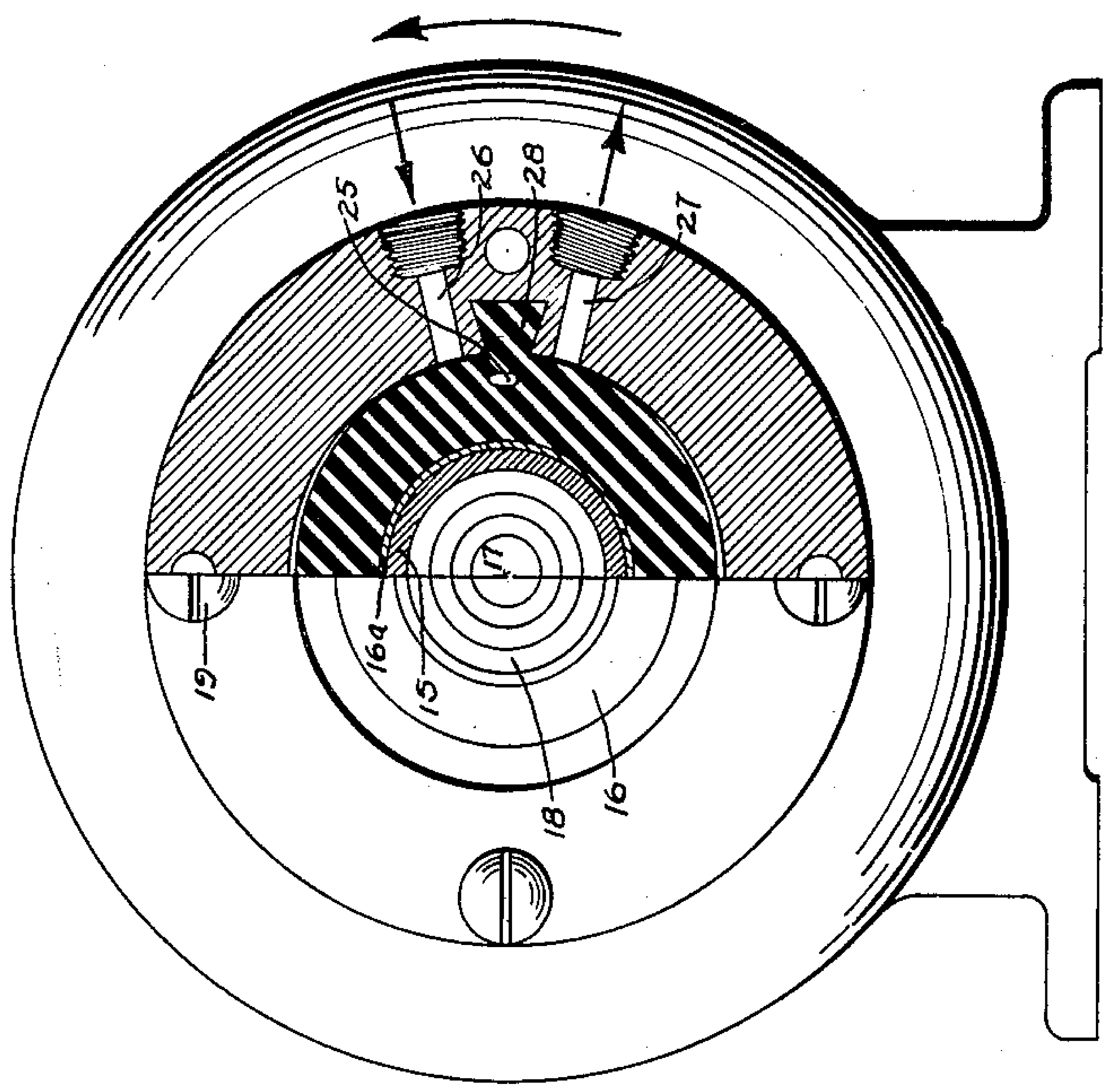

FIG. 2

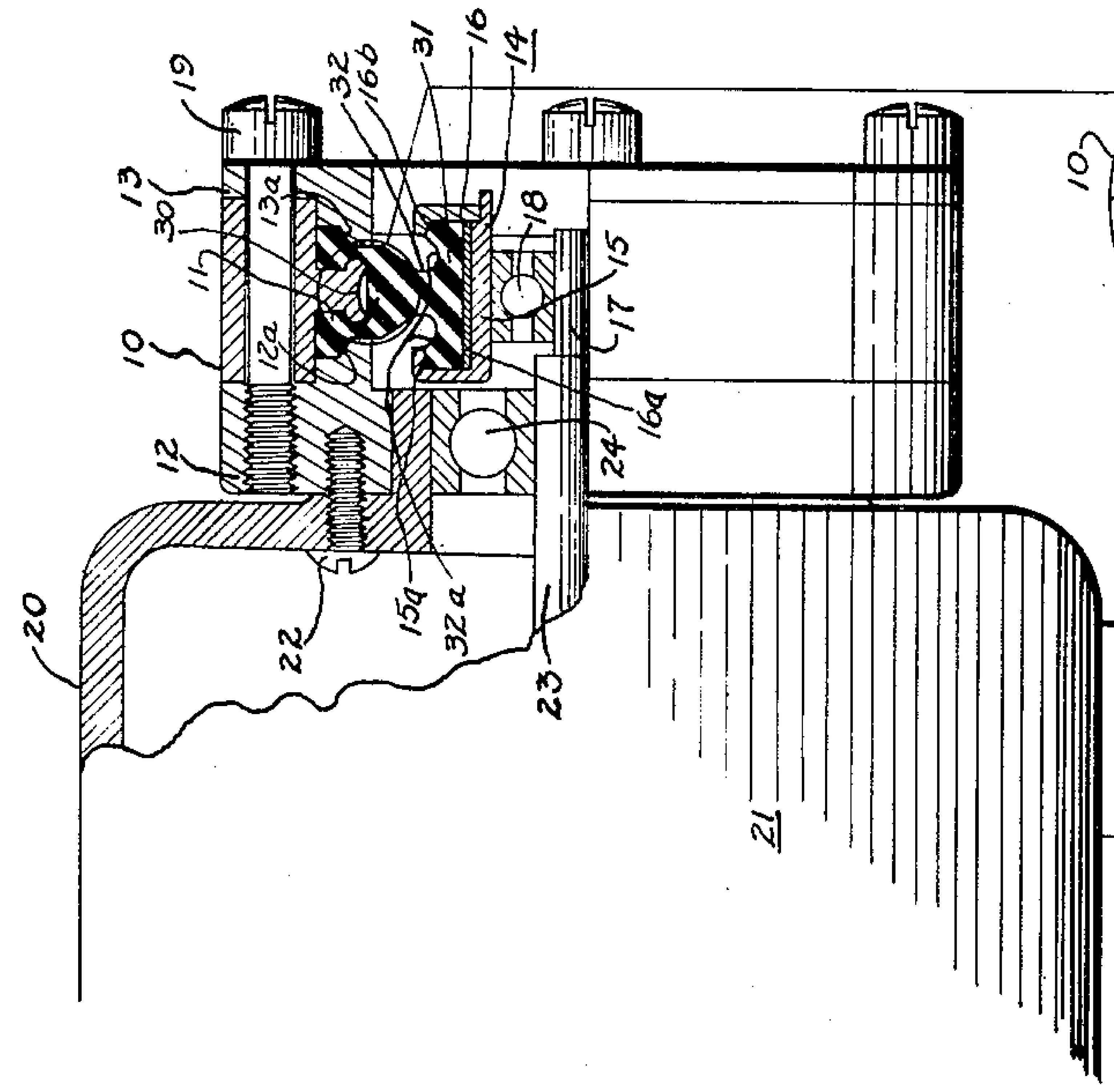

FIG. 1

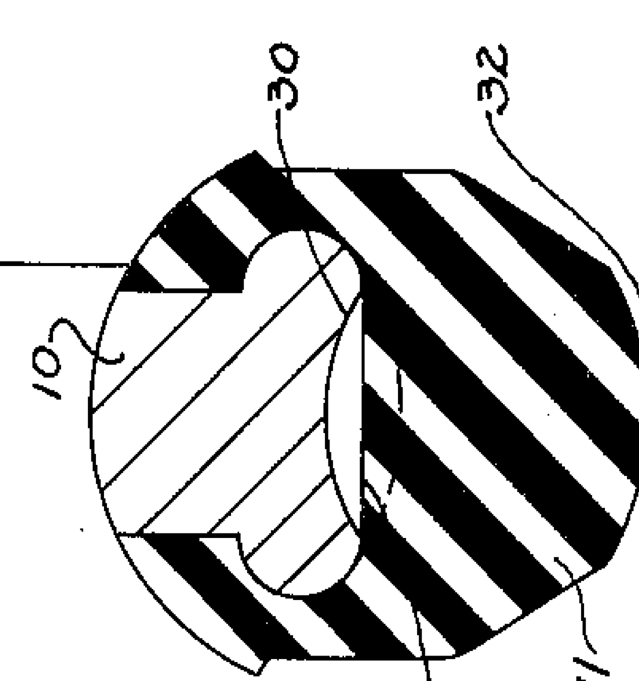

FIG. 3

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Patented Mar. 6, 1951 2,544,628

UNITED STATES PATENT OFFICE

2,544,628

PERISTALTIC PUMP

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Application June 15, 1946, Serial No. 676,929

13 Claims. (Cl. 103—149)

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This invention relates to pumps, and more particularly to a new and improved peristaltic pump.

Heretofore, sundry devices of this general type have been proposed, such generally contemplating the use of a block of rubber or rubber tube which is in some manner alternately compressed and extended to exert a pumping action on fluid contained in an opening or passage in, or adjacent the rubber element, the purpose of such pump being to eliminate the close machining, tight seals and multiplicity of parts characterising pumps of the gear displacement type. Unfortunately, however, it does not appear that these pumps have been commercially successful, the rubber therein usually wearing out at a rate which makes them impractical for any prolonged use. The chief factor in this wear is that of heat, and accordingly, it has been necessary to resort to expensive gearing down if such pumps are to be at all usable, the providing of speed reducing apparatus entailing additional cost and resulting in limited transfer of the fluid being handled.

An object of my invention is to provide a peristaltic pump which consistently operates at high speeds with small, inexpensive motors of standard design.

Another object is to provide longer life in such a device.

Another object is to make possible a wide variety of operating characteristics including those of high discharge pressure, and very low suction pressure in such a pump.

A still further object is to provide simplicity of construction and therefore cheapness of manufacture in a peristaltic pump.

Another object is to make possible economy of operation of such a device.

Another object is to provide ready accessibility to the parts of such a pump which are most likely to wear, thereby facilitating repairs when such are necessary.

Another object is to provide self-sealing means in a pump of the instant type.

Another object is to provide an automatic safety valve in a peristaltic pump.

These and other objects made apparent through the further progress of this specification are accomplished by means of my peristaltic pump, a full and complete understanding of which is facilitated by reference to the drawing herein in which:

Fig. 1 is a view in side elevation of the pump mounted on a motor, the upper half of the pump being illustrated in vertical cross-section;

Fig. 2 is an end elevation of the pump shown

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in Fig. 1, the right half of the pump being shown in vertical cross-section; and

Fig. 3 is an enlarged view illustrating detail around the pumping space.

Referring now to the drawing, 10 is a stator ring of generally T-shaped cross-section, said ring being fabricated of metal or other suitable rigid material. 11 is the pumping element, which has an approximate Y-shaped cross-section, this element being formed of rubber or other elastic material. 12 is an inside mounting ring, and 13 is an outside mounting ring, the two co-operating in a manner explained hereafter. 14 is an inner-ring assembly consisting of a sleeve and inner-flange 15, and a press on outer-flange 16, and 16*a* is an inner sleeve which is bonded strongly to the inner diameter of rubber element 11. 17 is an eccentric, mounted in conjunction with eccentric bearing 18. Elements 19 are main fastening screws holding together the pump assembly.

20 is the end-bell of a motor 21, to which the pump proper is attached through mounting screws 22. 23 indicates the motor shaft, which is positioned in operative relationship to motor shaft bearing 24.

A tension relief hole 25 is cored through the rubber pumping element 11, the function and operation of which aperture will be explained in detail at a later point in the instant specification.

26 is an inlet port through which a fluid (either liquid or gas) enters the pump proper, and 27 is the outlet port through which such fluid is ejected after having passed through and been boosted by the pump.

28 is a blow-by barrier, which will also be described and explained at a later point herein.

In assembling my peristaltic pump, stator ring 10, rubber pumping element 11, with the associated sleeve 16*a*; inside mounting ring 12, and outside mounting ring 13, are clamped together into an assembly by means of the four main fastening screws 19. The relative dimensions of these parts are such that when the assembly is made, the inside mounting ring 12 and the outside mounting ring 13 serve to tightly clamp the pumping element 11 hermetically to the stator ring 10. In this connection, it will be noted that elements 12 and 13 are provided with sloping faces 12*a* and 13*a*, which mate with corresponding sloping faces on element 11, and as the assembly is pulled together not only is said rubber element pressed inwardly and sealed against stator ring 10, but it is also drawn outwardly against such ring. This wedge action has the advantage of not only providing a more secure seal, but it also prevents any inward displacement of the rubber resulting from the squeezing-up action of the pumping operation.

Inner assembly 14 is likewise firmly clamped to the inner periphery of rubber pumping element 11, this clamping being effected by having the outer flange 16 form a press fit on the sleeve 15, said outer flange being pressed on to said sleeve with sufficient force as to give the desired clamping action against the inner periphery of pumping element 11. It will be noted that elements 15 and 16 are provided with sloping faces 15a and 16b at the points where said flanges contact complementary surfaces of rubber element 11, so that as the flanges are pressed inwardly they exert a strong radial pressure to hold element 11 strongly against the inner sleeve 16a, this minimizing any possibility of the rubber pulling away from said sleeve.

It is necessary to the proper operation of the pump and to its continued life that the fastening of the pumping element to the stator and to the inner ring assembly 14, be very secure; and the means illustrated in the drawing for accomplishing this result are by mechanical clamping. Such clamping may be supplemented, however, by binding or cementing the rubber to all adjoining metal parts, or it is practical in some application, to substitute cementing or bonding material for the mechanical clamping method which is shown herein for illustrative purposes. Advantages of the instant arrangement lie in ready dissembly of the pump and replacement of any worn or broken part in a minimum of time. Life tests to date indicate, however, that replacement of any parts is likely to be required at infrequent intervals.

Continuing further with the instant assembly, bearing 18 is pressed into the sleeve and inner flange 15, and in turn eccentric 17 is fitted into the inner diameter of said eccentric bearing, the eccentric, itself, being mounted on the end of motor shaft 23. Hence, it is apparent that when said motor shaft rotates, the eccentric 17, acting through its associated bearing, will cause the inner ring assembly to generate an eccentric motion, and since the inner ring assembly is rigidly fastened to the inner periphery of the pumping element 11, such eccentric motion is and must be translated to the inner part of said elastic cement 11.

In this connection reference is now specifically directed to Fig. 3 of the drawing, where it will be seen that the eccentric motion of the inner part of the rubber pumping element will result in the inside pumping face of said element 11 being automatically drawn away from and then pressed against the pumping face 30 of the stator ring 10. It is further apparent that, due to the eccentric nature of the motion, this squeezing action between the rubber and metal pumping faces will advance progressively and rotatively in the direction of the rotation of the motor, as suggested by the arrow on Fig. 2 of the drawing; thus setting up a peristaltic action which results in a fluid being drawn into the device through inlet port 26 and carried around and discharged through outlet port 27.

Referring again to Fig. 3, it will be noted that the pumping face of the rubber element, when not distorted in either direction by the eccentric, is flat; and deflection accordingly takes place in both directions from the flat position shown by the solid line of the drawing. Maximum outward deflection is suggested by the curved dotted line of the figure and the concave shape of the pumping face 30 of the stator ring 10 is so dimensioned that it permits a full inward deflection of the pumping face 29 of 11, minus a small factor which is provided to allow the rubber to squeeze up tightly against the pumping face 30 of ring 10. This concave shape of the pumping face of the stator ring is important, in that it increases the cross-sectional area of the opening very substantially, thereby increasing the capacity of the pump; and what is possibly more important, also permits the inward deflection of the rubber without undue distortion thereof. This factor, resulting in reduction of heat, and hence in greatly increased life of the rubber element and the pump itself.

Consideration is now directed to the specific shape of said pumping element 11, it being apparent that the portion 31 thereof which forms the base and stem of the Y suggested heretofore is provided with a narrowed section 32, and the width across this section relative to the width of pumping face 29 and to the width of the rubber gripped in the inner ring assembly 14, is of considerable importance. The width of said narrow section 32 is preferably slightly less than that of the pumping face 29 so that when the eccentric draws the rubber away from this point as established when the element is in a "neutral" position, the motion is taken up in the bending of the rubber at the outer edges of the pumping face, and little actual stretching of the rubber accordingly occurs. Upon analysis, it will be seen that if section 32 were made as wide or wider than the pumping face, it would mean that there would occur a stretching of the rubber itself at the outside edges, resulting both in severe stress on the rubber itself, and on the connection between the rubber and stator ring 10, with undesirable heat and wear consequences as pointed out heretofore.

It has also been found possible to control the maximum pumping pressure of the pump by controlling the width of this narrow section 32 relative to the width of the pumping face. For example, it will be seen that if said neck section is made very narrow, as compared with the pumping face, there will be areas at the outer edge of said face where the rubber does not have the direct pressure of the eccentric squeezing it against the pumping face 30 of the stator ring, and when this occurs, the only resistance to a backward flow or leakage of the liquid or gas being handled by the pump is by virtue of the hardness or elasticity of the rubber itself. By varying the width of section 32 and by using rubbers of various hardness and elastic characteristics, it has been found practicable to build pumps which will develop pre-determined maximum pressures, at which pressures the fluid being pumped overcomes the resistance of the rubber at the outer edges of the pumping surfaces and blows by, thus creating an automatic safety valve in the pump by means of which it protects itself against destruction in the event of a blockage of discharge.

The width of the inner periphery of the rubber pumping element which is clamped to the inner ring assembly 14 is made wider than the width of section 32. This is an important feature in that it provides for a slight flexing of that part of the rubber which is clamped in the inner ring assembly, which flexing has been found essential in preventing relative motion between the flanges of said inner ring assembly and that portion of the pumping element 11 which they grip. Any such relative motion between the inner ring assembly and the rubber pumping element results in a rapid wearing away of the rubber, and accordingly, the peculiar cross-sectional shape of the pumping element as described herein and arrived at only through considerable experimentation and research, is of great importance in securing a pump of satisfactory characteristics, including particularly, but not limited to long life.

Finally, it will be noted that adjacent to the points where element 11 is gripped by surfaces 15a and 16b, there is formed generally circular cut-out portions 32a which provide relief pockets at these points into which the rubber of base member 31, and to a lesser degree narrowed section 32, may displace during the pumping operation, this having been found desirable in preventing wear at these points.

A blow-by barrier 28 (Fig. 2) is provided between the inlet and outlet ports, the purpose of this barrier being to prevent fluid from short circuiting across between the inlet and outlet and negativing the effectiveness of the pump. Said barrier 28 is provided by forming element 11 with a wedge-like rubber projection which fits snugly into a complementary notch formed in the inner surface of stator ring 10, and when the assembly is clamped up the squeezing action of the inside mounting ring 12 and the outside ring 13 causes the rubber to expand in the barrier notch, thus effecting a hermetic seal against undesired short-circuiting of fluid.

A tension relief hole 25, which is also an important feature of the instant pump, is made necessary by the blow-by barrier 28, since at this particular point the eccentric motion or the pulling away motion of the rubber is firmly resisted by the above described gripping of the barrier in stator ring 10. Tension relief hole 25, however, provides a means for eliminating this direct pull on barrier 28, it being apparent that at this point, the pulling away motion only results in the deformation of the tension relief hole with a consequent relief of stress on the barrier itself.

It will be noted that a feature of the instant pump resides in the fact that when not running, it is automatically self-sealing, eccentric 17 and associated structure so bearing on pumping member 11 as to always press a portion of the inner face 29 of said pumping member against concave face 30 of stator ring 10, thereby effectively blocking and sealing the fluid passage at such point. The advantages of this arrangement are at once obvious to those skilled in the pumping art, and the broader field of hydraulics.

From the foregoing, it is apparent that I have disclosed and described a new and unique peristaltic pump which not only will develop a very high pressure on the discharge side, but also a pump having a positive suction, the weight of the walls of the rubber pumping element 11, coupled with the forced suction resulting from the pulling away action caused by the eccentric, making it possible for this pump to draw very high vacuum—as for example, in excess of twenty-nine (29) inches of mercury.

That my pump will handle liquids of all viscosities and gases with equal facility.

That its design is such that the fluid being pumped does not come into contact with the rotative elements and therefore no expensive or costly-to-maintain, power-consuming seals are required.

That this pump works with good efficiency at rotative speeds as high as 3,500 R. P. M., thus permitting direct coupling to small motors of standard design.

That a wide range of performance characteristics are made possible in my pump through dimensional changes in the rubber pumping element and/or changes in the characteristics of the rubber or other material from which this element is fabricated.

That it is possible to design this pump to a maximum operating pressure upon which fluid will simply blow by and thereby act as an automatic safety valve, this feature making it unnecessary to equip the pump with the conventional spring-loaded by-pass which is a costly and not always satisfactory feature of many small pumps.

That the instant peristaltic pump is susceptible to extreme cheapness in manufacture, all parts being of such a nature that close machining tolerances are not necessary, it being possible and practical to make all parts of the pump except the eccentric bearing by such economical manufacturing processes as stamping, molding, or die-casting.

While I have disclosed and described herein one embodiment of my invention, such action is not to be taken as limiting in any way, but on the contrary is purely illustrative, it being intended that the appended claims shall be interpreted, and given a construction and scope fairly in keeping with my contribution to the art.

I claim:

1. In a device of the character described, in combination, a source of power, and a pump operatively engaged therewith, said pump comprising a rigid stator ring of generally T-shaped cross-section, a flexible circular pumping element of approximate Y-shaped cross-section mounted adjacent said ring, an inner ring assembly securely engaging the lower portions of said Y-shaped pumping element, an inlet and an outlet for the pump, and an eccentric engaging said inner ring assembly, movement of the eccentric alternately compressing and expanding the pumping element, thereby driving a fluid through the pump.

2. In a device of the character described, in combination, a source of power, and a pump operatively engaged therewith, said pump comprising an outer circular stator ring, an inner rubber pumping ring, an aperture in said pumping ring, means for alternately compressing said pumping element against the inner surface of said stator ring and drawing said pumping element away from said surface, an inlet and an outlet for the pump, and a blow-by barrier formed integral with the pumping element and seating in a notch formed in the inner peripheral dimension of said stator ring, the barrier automatically disengaging itself from the notch at a pre-determined pressure, permitting fluid being handled by the pump to blow by at such time.

3. In a device of the character described, in combination, a source of power and a pump operatively mounted therewith, said pump comprising a circular metal stator ring of generally T-shaped cross-section, a flexible circular pumping element of approximate Y-shaped cross-section disposed in sealed relationship with said stator ring, an eccentric positioned within

said pumping element and in contact therewith, an inlet and an outlet for the pump, movement of the eccentric causing the pumping element to be progressively contracted and expanded, thereby impelling a fluid through the pump.

4. In a device of the character described, in combination, a source of power, and a pump operatively engaged therewith, said pump comprising a stator ring of generally T-shaped cross-section, a rubber pumping element associated therewith, said pumping element having an approximate Y-shaped cross-section, and an eccentric mounted adjacent said pumping element, an inlet and an outlet for the pump, the movement of the eccentric causing the pumping element to be progressively compressed and expanded, thereby impelling a fluid through the pump.

5. In a device of the character described, in combination, a source of power, and a pump operatively engaged therewith, said pump comprising a rigid stator ring, a flexible circular pumping element of approximate Y-shaped cross-section mounted adjacent said ring, an inner ring assembly securely engaging the lower portions of said Y-shaped pumping element, and an eccentric operatively engaging said inner ring assembly, an inlet and an outlet for the pump, movement of the eccentric alternately compressing and expanding the pumping element, thereby driving a fluid through the pump.

6. In a device of the character described, in combination, a source of power, and a pump operatively engaged therewith, said pump comprising a stator ring, a flexible circular pumping element of generally Y-shaped cross-section mounted adjacent said ring, an inner ring assembly securely engaging the lower portions of said pumping element, and an eccentric operatively engaging said inner ring assembly, an inlet and an outlet for the pump; movement of the eccentric alternately compressing and expanding the pumping element, thereby driving a fluid through the pump.

7. In a device of the character described, in combination, a source of power, and a pump operatively engaged therewith, said pump comprising an outer circular stator ring, an inner rubber pumping ring, a tension relief hole in said pumping ring, means for alternately compressing said pumping element against the inner surface of said stator ring and drawing said pumping element away from said surface, an inlet and an outlet for the pump, and a wedge-shaped blow-by barrier formed integral with the pumping element and seating in a notch formed in the inner peripheral dimension of said stator ring, the barrier automatically disengaging itself from the notch at pre-determined pressures, permitting fluid being handled by the pump to blow by at such time.

8. In a device of the character described, in combination, a source of power, and a pump operatively engaged therewith, said pump comprising an outer circular stator ring, an inner rubber pumping ring, means for alternately compressing said pumping element against the inner surface of said stator ring and drawing said pumping element away from said surface, an inlet and an outlet for the pump, and a blow-by barrier formed integral with the pumping element and seating in a notch formed in the inner peripheral dimension of said stator ring, the barrier automatically disengaging itself from the notch at pre-determined pressures, permitting fluid being handled by the pump to blow by at such time.

9. In a device of the character described, a rubber peristaltic piston, comprising a ring of generally Y-shaped cross-section, the stem of the Y being narrower than the upper arms thereof, there being sloping anchoring surfaces on said arms; an inlet and an outlet communicating with said piston, means including a central eccentric for motivating said piston, a circular stator ring surrounding said piston, and means hermetically sealing the outer peripheral margins of the piston, with the stator ring, said means comprising two casing halves, and means for securing said halves together and against the outer edges of said rubber piston.

10. In a device of the character described, a rubber peristaltic pumping element, comprising a ring of generally Y-shaped cross-section, the stem of the Y being narrower than the upper arms thereof, an inlet and an outlet communicating with said pumping element, means including a central eccentric for motivating said element, a stator ring surrounding said pumping element and being hermetically sealed thereto, a groove in said stator ring, and a peripheral groove in said pumping element, said latter groove cooperating with the groove of the stator ring in pumping liquid by peristaltic action.

11. A flexible pumping element for a peristaltic pump, comprising a circular ring of generally Y-shaped cross-section, the stem of the Y being narrower than the upper arms thereof.

12. In a device for pumping fluid by a peristaltic-like action, a grooved flexible pumping element, means for substantially deflecting only the bottom of the groove to squeeze fluid progressively in the groove, and means confining the flexing of the pumping element to substantially only the immediate portion of the groove being acted upon by said first mentioned means during a given phase of the pumping operation.

13. In a device of the character described, a rubber pumping element comprising a circular rubber ring of generally Y-shaped cross-section, a blow-by barrier formed integral with said ring on the outer peripheral edge thereof, and a tension relief hole formed in the pumping element adjacent said safety barrier; an inlet and an outlet communicating with said pumping element, and means for automatically compressing and distending said element to effect pumping by peristaltic action, whereby a minimum of stressing and distending of said rubber pumping element is present in establishing and maintaining such action.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,765,360	Baumann	June 24, 1930
2,246,488	Fraser	June 17, 1941
2,251,235	Weydell	July 29, 1941