

April 14, 1964

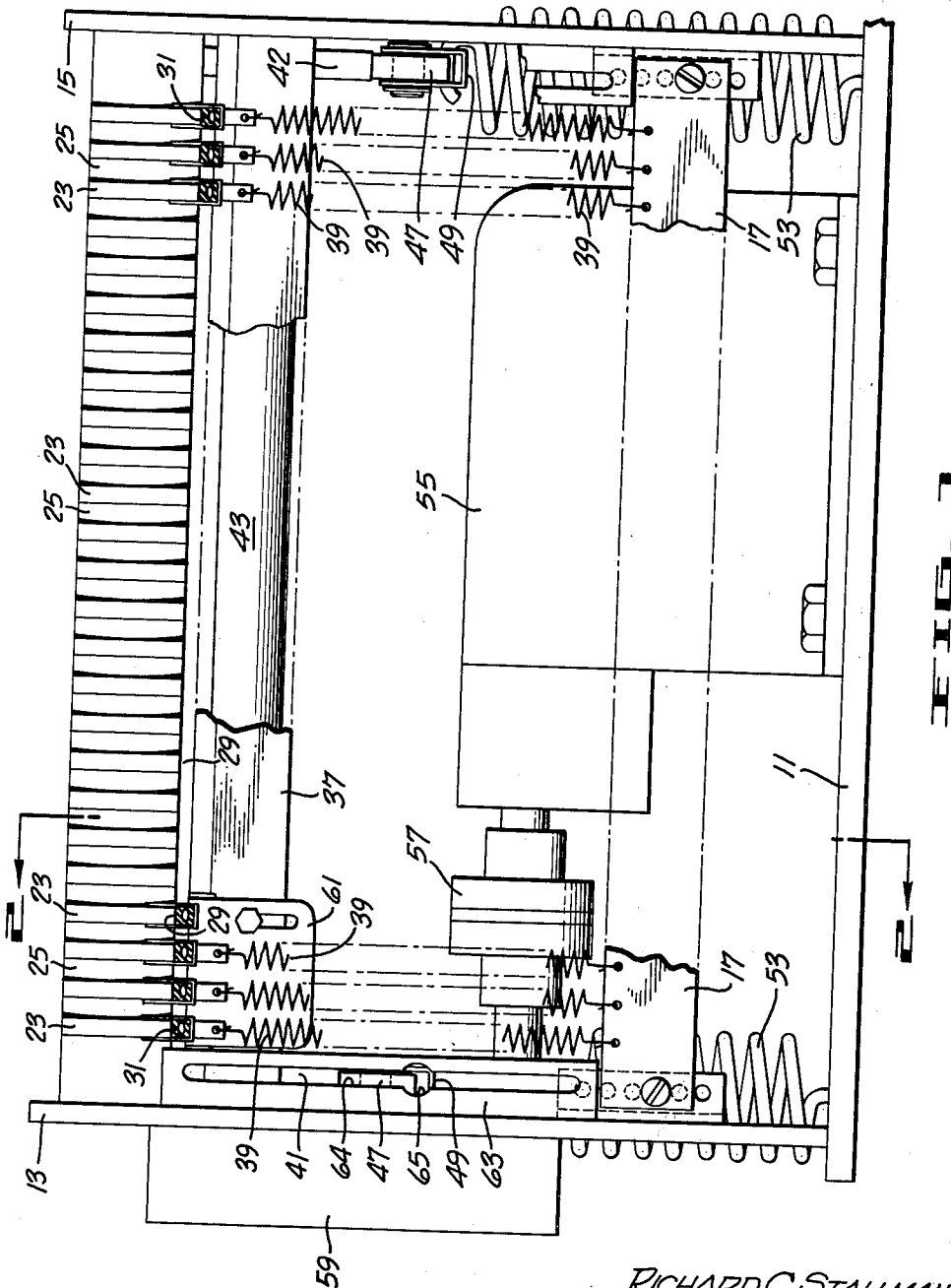
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3,128,716

PERISTALTIC PUMP

Filed July 17, 1961

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

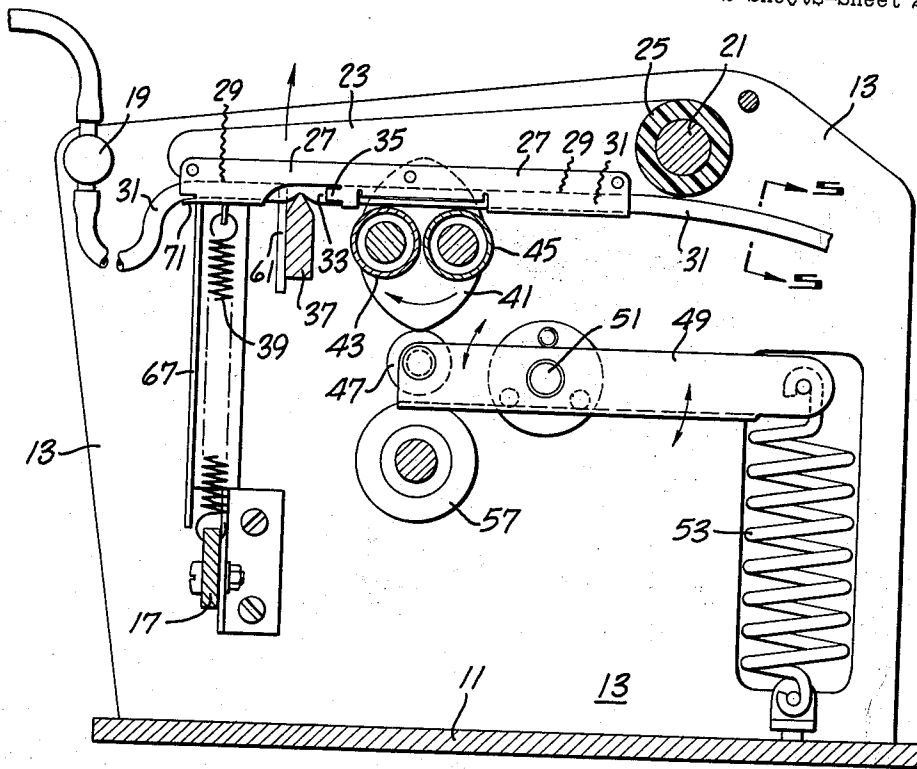


FIG. 2

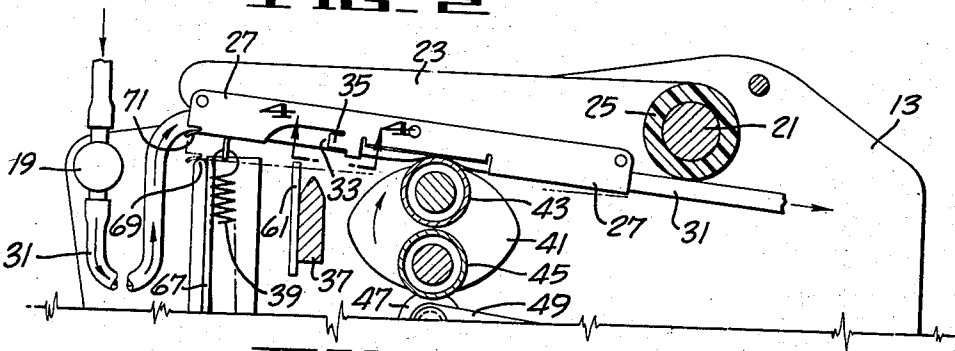


FIG. 3

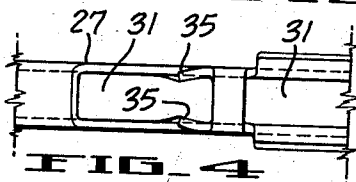


FIG. 4

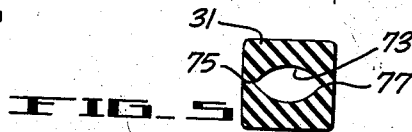


FIG. 5



FIG. 6

FIG. 7

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PERISTALTIC PUMP

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39 Claims. (Cl. 103-149)

This invention relates, in general, to peristaltic pumps and more particularly to peristaltic pumps wherein a plurality of tubes are employed.

Peristaltic, or tube pumps, are well known in the art. However, prior art pumps have had several major disadvantages. Ordinarily, circular tubes are employed and are repeatedly kneaded by multiple fingers such that there is always one or more fingers engaged with the tube. In other pumps of the prior art, the tubing is arranged in a circular arc with two or more rollers rotating within the arc against the tube.

In each of the aforementioned pumps, a roller continually and progressively contacts the tube, and the tube consequently is continually stretched with a tendency to drag it through the pump. The result of this continuous stretching and drag is tube scuffing which develops rapid tube wear.

Moreover, the circular cross section of the tube has relatively poor wearing characteristics due to the compression alone. When a circular tube is compressed to the point that its internal opening is completely closed, the inner and outer peripheries are subjected to extreme and damaging compression and tension, respectively. Thus, the sides of the circular tube are quickly weakened and fractured.

Although there are peristaltic pumps of the prior art which do provide intermittent kneading action, either fluid back flow is permitted through the tube; or alternatively, complicated valving mechanisms are required to prevent the back flow. Even in these pumps having intermittent kneading action, no means are provided to permanently position the tube in the pump and at the same time reduce the wear due to scuffing.

It is, therefore, a general object of this invention to provide an improved peristaltic pump.

It is a more particular object of this invention to provide a peristaltic pump wherein means are provided to reduce the wear of the pump tubes.

It is another object of this invention to provide a peristaltic pump having the aforementioned characteristics which may be economically constructed and which provides an accurate pumping action.

It is still another object of this invention to provide a peristaltic pump wherein the tubes are alternately kneaded and released whereby tube scuffing is avoided.

It is a further object of this invention to provide a peristaltic pump having the aforementioned characteristics wherein means are provided for selectively varying the stroke of the pumping action.

Another object of this invention is to provide a peristaltic pump having the aforementioned characteristics wherein a plurality of the tubes are employed.

It is another object of this invention to provide a tube for use in a peristaltic pump, which tube includes a novel cross-section for reducing the wear thereof.

It is still a further object of this invention to provide a peristaltic pump having the aforementioned characteristics and which employs a tube having a novel cross-section.

It is still another object of this invention to provide a peristaltic pump having intermittent action wherein means are provided to compensate the load on the prime mover of the pump.

It is a further object of this invention to provide a

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peristaltic pump having the aforementioned characteristics wherein simple valve means are provided to prevent back flow of the fluid.

The aforementioned objects are accomplished generally by employing a frame upon which are pivoted a plurality of arms. A plurality of tubes are retained on the arms with at least a portion of each tube slidable with respect to its associated arm. Eccentric rotating means are provided for intermittently compressing the tubes while urging the arms about their pivot point against a resilient force. When the tubes are not being compressed by the eccentric rotating means, the resilient force urges the arms toward a stop which collapses the tubes to prevent back flow.

Upon review of the following description in conjunction with the accompanying drawing, the aforementioned objects as well as other objects and features of the invention will become apparent.

Referring to the drawing:

FIGURE 1 is a front elevational view of a peristaltic pump in accordance with the invention;

FIGURE 2 is a sectional view taken along the lines 2-2 of FIGURE 1;

FIGURE 3 is a partial sectional view taken along the line 2-2 of FIGURE 1 wherein the operation of the pumping action is shown;

FIGURE 4 is a view taken along the line 4-4 of FIGURE 3;

FIGURE 5 is a cross-section of one embodiment of a resilient tube used in accordance with the invention;

FIGURE 6 is a cross-section of another embodiment of a resilient tube used in accordance with the invention; and

FIGURE 7 is a cross-section of the tube shown in FIGURE 6 in its normal partially compressed state as used in accordance with the invention.

Referring to FIGURES 1 and 2, it is seen that the pump includes a frame having a base member 11 and a pair of upright members 13 and 15 secured thereto. The upright members 13 and 15 may be held in spaced relationship by a cross bar 17, by a tube retaining bar 19, and by an arm shaft 21.

A plurality of arms 23 are rotatably mounted on the shaft 21 and are separated from each other by spacers 25. The straight underside 29 of each of the arms 23 includes a channel 27 and a tube 31 is retained in each of the channels 27. A portion of each tube, for instance, that as shown in the area 33, is firmly secured in the channel 27 to prevent longitudinal movement of that portion while allowing longitudinal stretch and contraction of the remainder of the tube. As shown in FIGURE 4, segments 35 of the channel walls are forced inwardly into the tube 31 at the area 33 to provide the locking action. Thus, the tube along the straight edge of the arm 23 may be easily stretched to and away from the lock portion 33, but its overall position is maintained.

Valving means is provided in the form of a stationary bar or stop 37 extending between the upright members 13 and 15. A plurality of springs 39, one spring associated with each of the arms 23, is connected between the individual arms 23 and to the cross bar 17. Thus, the arms 23 are resiliently urged in a counterclockwise direction as viewed in FIGURE 2, and when so rotated, the tube 31 is urged against the stop 37 and is consequently closed.

An elliptically shaped cam 41 is pivotally secured to the upright member 13 and a similar cam 42 may be secured to the upright member 15 in a position directly opposite the cam 41. The cams are preferably rotatable about the intersection of their major and minor elliptical axes. A pair of rollers 43 and 45 extend across the pump as seen in FIGURE 1 and are rotatably secured

on one side to the cam 41 and on the other side to the cam 42. The rollers 43 and 45 are preferably secured to the cams 41 and 42 along the minor axis thereof and are equally spaced on opposite sides of the point of cam rotation. It is observed that upon rotation, the rollers 43 and 45 pivotally contact the tube 31 urging the arm 23 in a clockwise rotation against the force of the spring 39. During the contact, as seen in FIGURE 3, tube 31 is compressed in a longitudinally progressing manner whereby fluid will be forced therethrough. As rollers 43 and 45 urge the arm 23 in a clockwise direction, the tube 33 is retracted from the stationary valve or stop 37 whereby the passage through the tube is open except for the longitudinally progressing pressure caused by the rollers.

A cam follower 47 is secured to an arm 49 which is pivoted about a bearing 51 and resiliently urged in the clockwise direction by a spring 53. It is seen that during a portion of the cycle of cam 41, the rotation is resisted by the force of the springs 39 as applied to the arms 23. When the rollers 43 and 45 are not in contact with the tube 31, the rotation of the cam 41 is resisted by the resilient action of the spring 53. Thus, the motive means for rotating the cam 41 is subjected to a substantially constant load despite the intermittent contact between the rollers 43 and 45 against the tubes 31 on the arms 33.

As seen more clearly in FIGURE 1, rotative motive power is applied to the cam 41 from the motor 55 through a coupler 57, and gear train enclosed by a gear box 59. Any type of gear train may be employed in the box 59. However, a worm gear is preferable due to the minimum play and back lash thus attained. The output of the gear train is applied to rotate the cam 41 which, in turn, rotates the cam 42 through the eccentrically pivoted rollers 43 and 45.

It is apparent that, if desired, motive power may be applied to both cams 41 and 42. Moreover, it is apparent that a substantially constant load may be applied to the motive means with a single cam 41. In such an instance, the cam 42 may be replaced by a plate which receives the eccentrically located rollers 43 and 45.

Referring to FIGURE 1, it is noted that on the left-hand side of the bar 37 an adjustable plate 61 is secured. The plate 61, in the embodiment shown, underlies four of the arms 23 and serves to alter the pumping stroke of the tube associated with the four overlying arms 23. It is obvious that the amount the plate 61 is raised may be sufficient to clear the tubes 31 associated therewith above the rotating rollers 43 and 45 during the complete cycle of rotation of the cam 41. With the plate 61 in this high position, no fluid will be pumped through the tubes 41 overlying the plate 61. It is equally obvious that the stroke may be adjusted at any point from this extreme high position downward to the level of the bar 37. Alternatively, the plate 61 may completely replace the bar 37 whereby the stroke of the particular arms overlying the plate 61 may be adjusted to provide any stroke variation between complete non-contact to continuous contact with the rollers 43 and 45.

Another feature of the invention is provision of means to prevent permanent seating of the tubes 31 against the stop 37 or plate 61 when the pump is not in use and thus avoid a permanent set in the tubes. To this end, guides 63 having slots 64 are provided on each of the upright members 13 and 15. Each of the slots 64 includes an enlarged portion 65. A plate 67 (FIGURES 2 and 3) has a pair of rivet-like members along the upper edge thereof. The rivet-like members include an enlarged head portion of a diameter only slightly smaller than the enlargements 65 in the guide 63 and a neck portion having a diameter slightly smaller than the slot 64 itself. Near the lower end of the plate 67 is another pair of rivet-like members having an enlarged head portion slightly smaller than the enlarged section 65 on

the slot 64. The rivet-like members at the lower portion of the plate 67 have a neck larger than the slot 64 but smaller than the head portion of the rivets. Thus, the rivets at the top of the plate may first be inserted in the enlargement 65, and the entire plate raised until the heads of those rivets at the lower portion of the plate can be inserted through the enlargement 65. The plate is then released; the neck portions of the rivets along the lower edge of the plate will retain the plate from downward excursion. The portion of the slot 64 below the enlargements 65 may be employed to store the plate while the pump is in use by retaining merely the rivet-like members near the upper edge of the plate.

The uppermost edge 69 of the plate 67 cooperates with the underside 71 of the channel 27. The underside 71 of the channel 27 completely encloses the tube 31 whereby pressure applied thereto is not transferred to the tube itself. The dimension of the plate is such that when the rivet-like members along the lower edge are locked into the enlargement 65 of the guides 63, the tubes 31 are held away from the stop 37. After positioning the plate 67, the rollers 43 and 45 are then rotated into position shown in FIGURE 2 and the tube 31 is completely free of any pressure. Consequently, the tube 31 does not receive a permanent set from the rollers 43 and 45, nor the stop 37 when the pump is not in use.

Referring to FIGURE 5, a cross-section is shown of the tube 31 in accordance with one embodiment of the invention. Here, it is noted that the cross-section is externally rectangular or square. The internal orifice 73 of the tube, however, is lip-shaped in cross-section and has convergent corners 75 and 77. Preferably, the convergent corners 75 and 77 lie in a plane substantially parallel to the surface of the arm 23 against which the tube is retained. Thus, when the upper and lower edges of the tube are progressively squeezed, the lip-shaped orifice 73 tends to become completely closed without undue stress on the side walls of the tube.

The cross-section of another embodiment of the tube is shown in FIGURES 6 and 7. Here, the tube is designated by the reference numeral 31' and is similar to that as shown in FIGURE 5 but includes a membrane 79 which extends between the convergent corners 75 and 77. In use, the embodiment of the tube shown in FIGURE 6 is normally held partially compressed as shown in FIGURE 7. In partial compression, it is noted that the convergent lips 75 and 77 are spread outwardly, and consequently the membrane 79 is placed in a slight tension. Thus, with even the slightest compression increase beyond normal, the membrane 79 will have sufficient tension to cause the corners 75 and 77 to be drawn together and the tube will expand in the vertical direction to the conditions shown in FIGURE 7.

Referring to FIGURES 2 and 3, the general operation of the pump may be explained. The left-hand portions of the tubes 31 may be placed in communication with a source of fluid to be pumped and the right-hand portions of the tubes are connected to a suitable apparatus for receiving the fluid pumped. The plate 67 is lowered so that the arms 23 are resiliently urged against either the stop means 37 or one of the rollers 43 or 45. The motor 55 is started and the rollers 43 and 45 are rotated in a clockwise direction about the axis of the cams 41 and 42. As seen more clearly in FIGURE 3, when the rollers reach the position as shown therein, the tubes 31 are contacted and the arms 23 are urged in a clockwise direction about the shaft 21. Since the resilient action of the springs 39 is greater than the resilient force of the tube 31, the tube is progressively compressed from left to right to provide the desired pumping action.

As the rollers 43 and 45 compress the tube from left to right, it is apparent that the tube is likewise urged in the same direction. However, due to the clamping action 33, the overall position of the tube is retained. When the rollers are retracted from a tube, as shown in FIG-

URE 2, that portion of the tube 31 to the right of the area 33 is released and the resilient tube contracts generally from right to left to assume its original overall position. Thus, scuffing of the tube through the channel 27 by the rollers is avoided. During the period when the rollers 41 and 43 do not contact the tube 31, the tube is urged against the stop 37 by the springs 39 acting on the arms 23.

Thus, it is seen that a new and improved peristaltic pump is provided wherein means are included to reduce the wear on the pump tubes by alternately kneading and releasing of the tubes. Moreover, means are provided for selectively varying the stroke of the individual ones or even all of the arms 23. Also, a peristaltic pump has been provided which may easily accommodate a plurality of individual pumping tubes with the aforementioned intermittent action and that even with such intermittent action the prime mover of the pump is subjected to a substantially constant load. Further, the pump described includes extremely simple valve means in the form of a stop which prevents back flow of the pump while there is no pumping action. Moreover, new and advantageous tube structures for use in such peristaltic pumps have been shown which cooperate with the pump itself to provide extensive tube life.

We claim:

1. A peristaltic pump comprising a frame, an arm pivotally secured to said frame, a resilient tube, said resilient tube positioned along a surface of the arm facing the direction of pivotal rotation, a portion of said tube being restrained from axial movement, another portion of said tube being slidably retained along said surface, means for resiliently urging said arm about its pivot point in a direction toward said tube, means disposed for eccentric rotation on said frame, said last named means being movably positioned adjacent said tube for intermittent contact therewith whereby during its eccentric rotation it alternately compresses and retracts from said tube.
2. A peristaltic pump as defined in claim 1 wherein the surface of the arm along which said tube is retained is straight.
3. A peristaltic pump as defined in claim 1 wherein the cross-section of said resilient tube is externally rectangular, the internal shape of said tube in cross-section being lip-shaped.
4. A peristaltic pump as defined in claim 3 wherein the convergent corners of the lip-shaped interior lie in a plane substantially parallel to the surface of said arm along which the tube is retained.
5. A peristaltic pump as defined in claim 1 wherein the cross-section of said resilient tube is externally rectangular, the internal shape of said tube in cross-section being lip-shaped and having convergent corners, and a membrane extending between said corners.
6. A peristaltic pump as defined in claim 5 wherein said membrane lies in a plane substantially parallel to the surface of said arm along which the tube is retained.
7. A peristaltic pump as defined in claim 5 wherein said tube is normally retained along said arm in partial compression whereby said membrane is in tension.
8. A peristaltic pump as defined in claim 1 wherein a portion of said tube is secured to said arm.
9. A peristaltic pump as defined in claim 1 wherein said means disposed for eccentric rotation comprises a rotatable plate, and at least one roller rotatably secured at an eccentric point on said plate, said roller being positioned adjacent said tube whereby during its eccentric rotation it alternately compresses and retracts from said tube.
10. A peristaltic pump as defined in claim 9 wherein said plate is elliptical in shape and is rotatable about the intersection of its major and minor axis, a pair of rollers rotatably secured to said plate, said rollers being secured to said plate at points equally spaced from and on opposite sides of said intersection, together with cam follower

means resiliently urged against the elliptical surface of said plate whereby load compensation is accomplished.

11. A peristaltic pump as defined in claim 1 together with stop means secured to said frame, said stop means comprising stationary means secured to said frame at a position to compress said tube when said means disposed for eccentric rotation is retracted from said tube and to release said tube when said last named means compresses said tube.

12. A peristaltic pump as defined in claim 1 together with selectively removable means for retaining said arm at a position displaced from the means disposed for eccentric rotation whereby the tube may be released from compression when the pump is not used.

13. A peristaltic pump comprising a frame, stop means secured to said frame, an arm pivotally secured to said frame and resiliently urged toward said stop means, a resilient tube having a portion thereof retained along a surface of said arm facing said stop means, a part of said portion of said resilient tube being restrained from axial movement, means disposed on said frame for eccentric rotation, said last named means being spaced from said tube during a portion of its rotation and in contact with said tube during another portion of its rotation.

14. A peristaltic pump as defined in claim 13 wherein said stop means is adjustably secured to said frame in the direction of arm rotation whereby travel of said arm and tube caused by said means disposed for eccentric rotation and time of contact between said last named means and said tube is adjustable.

15. A peristaltic pump as defined in claim 13 wherein the side of the arm along which said tube is retained is straight.

16. A peristaltic pump as defined in claim 13 wherein the cross-section of said resilient tube is externally rectangular, the internal shape of said tube in cross-section being lip-shaped.

17. A peristaltic pump as defined in claim 13 wherein the convergent corners of the lip-shaped interior lie in a plane substantially parallel to the surface of said arm along which the tube is retained.

18. A peristaltic pump as defined in claim 13 wherein the cross-section of said resilient tube is externally rectangular, the internal shape of said tube in cross-section being lip-shaped and having convergent corners and a membrane extending between said convergent corners.

19. A peristaltic pump as defined in claim 18 wherein said membrane lies in a plane substantially parallel to the surface of said arm along which the tube is retained.

20. A peristaltic pump as defined in claim 13 wherein said tube is normally retained along said arm in partial compression wherein said membranes are in tension.

21. A peristaltic pump as defined in claim 13 wherein said part of said tube is secured to said arm.

22. A peristaltic pump as defined in claim 13 wherein said means disposed for eccentric rotation comprises a rotatable plate, and a roller rotatably secured at an eccentric point on said plate, said roller being positioned adjacent said tube whereby during its eccentric rotation it alternately compresses and retracts from said tube.

23. A peristaltic pump as defined in claim 13 wherein said means disposed for eccentric rotation comprises a rotatable plate, said plate being elliptical in shape and rotatable about the intersection of its major and minor axes, a pair of rollers rotatably secured to said plate at points equally spaced from and on opposite sides of said intersection, together with cam follower means resiliently urged against the elliptical surface of said plate whereby load compensation is accomplished.

24. A peristaltic pump as defined in claim 13 wherein said stop means comprises a stationary means secured to said frame at a position to compress said tube when said means disposed for eccentric rotation is retracted from said tube and to release said tube when said last named means compresses said tube.

25. A peristaltic pump as defined in claim 13 together with selectively removable means for retaining said arm at a position displaced from the means disposed for eccentric rotation whereby the tube may be released from compression when the pump is not used.

26. A peristaltic pump comprising a frame, a plurality of arms pivotally disposed on said frame about a common axis, stop means secured to said frame parallel to the axis of said arms, said arms being resiliently urged toward said stop means, a plurality of resilient tubes each being retained on individual ones of said arms along those surfaces of said arms facing said stop means, at least a portion of each of said resilient tubes being restrained from axial movement, means disposed on said frame for eccentric rotation about an axis parallel to the axis of said arms, said last named means being alternately spaced from and in contact with each of said resilient tubes during its eccentric rotation.

27. A peristaltic pump as defined in claim 26 wherein said stop means is adjustably secured to said frame in the direction of arm rotation whereby travel of said arms and tubes caused by said means disposed for eccentric rotation and time of contact between said last named means and said tubes is adjustable.

28. A peristaltic pump as defined in claim 26 wherein the surface of each of said arms along which said tubes is retained is straight.

29. A peristaltic pump as defined in claim 26 wherein the cross-section of each of said resilient tubes is externally rectangular, the internal shape of said tubes in cross-section being lip-shaped.

30. A peristaltic pump as defined in claim 29 wherein the convergent corners of the lip-shaped interior lie in a plane substantially parallel to the surface of said arms along which the tubes are retained.

31. A peristaltic pump as defined in claim 26 wherein the cross-section of each of said resilient tubes is externally rectangular, the internal shape of said tubes in cross-section being lip-shaped and having convergent corners, and a membrane extending between said convergent corners.

32. A peristaltic pump as defined in claim 31 wherein said membrane lies in a plane substantially parallel to the surface of said arms along which the tubes are retained.

33. A peristaltic pump as defined in claim 31 wherein said tubes are normally retained along said arms in partial compression wherein said membranes are in tension.

34. A peristaltic pump as defined in claim 26 wherein a portion of each of said tubes is secured to its respective arm.

35. A peristaltic pump as defined in claim 26 wherein said means disposed on said frame for eccentric rotation is alternately spaced from and in contact with all of said resilient tubes simultaneously.

36. A peristaltic pump as defined in claim 26 wherein said means disposed for eccentric rotation comprises a rotatable plate, and a roller rotatably secured at an eccentric point on said plate, said roller being positioned adjacent said tubes whereby during its eccentric rotation it alternatively compresses and retracts from said tubes.

37. A peristaltic pump as defined in claim 36 wherein said plate is elliptical in shape and is rotatable about the intersection of its major and minor axes, a pair of rollers rotatably secured to said plate, said rollers being secured to said plate at points equally spaced from and on opposite sides of said intersection, together with cam follower means resiliently urged against the elliptical surface of said plate whereby load compensation is accomplished.

38. A peristaltic pump as defined in claim 26 wherein said stop means is secured to said frame adjustably in the direction of arm rotation whereby travel of said arms and tubes caused by said means disposed for eccentric rotation and time of contact between said last named means and said tubes is adjustable.

39. A peristaltic pump as defined in claim 26 together with selectively removable means for retaining said arms at a position displaced from the means disposed for eccentric rotation whereby the tubes may be released from compression when the pump is not used.

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