Nov. 21, 1967 J. W. BASTIAN 3,353,491

PUMPING DEVICE

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FIG. 1

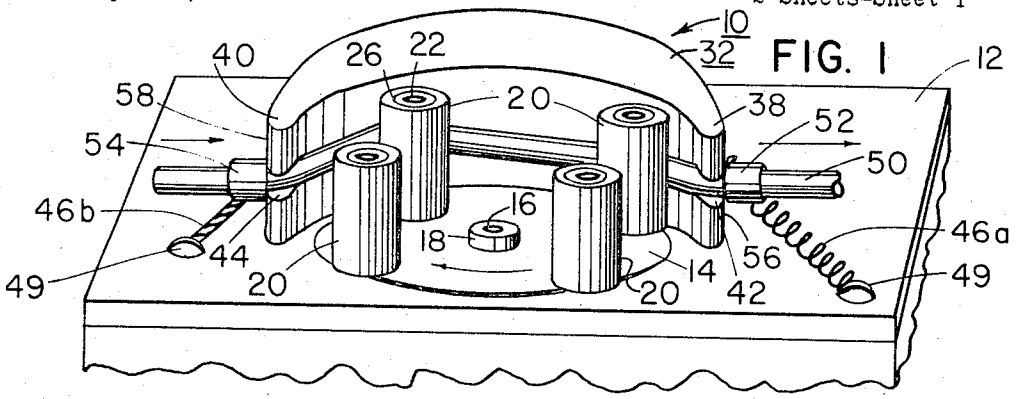


FIG. 2

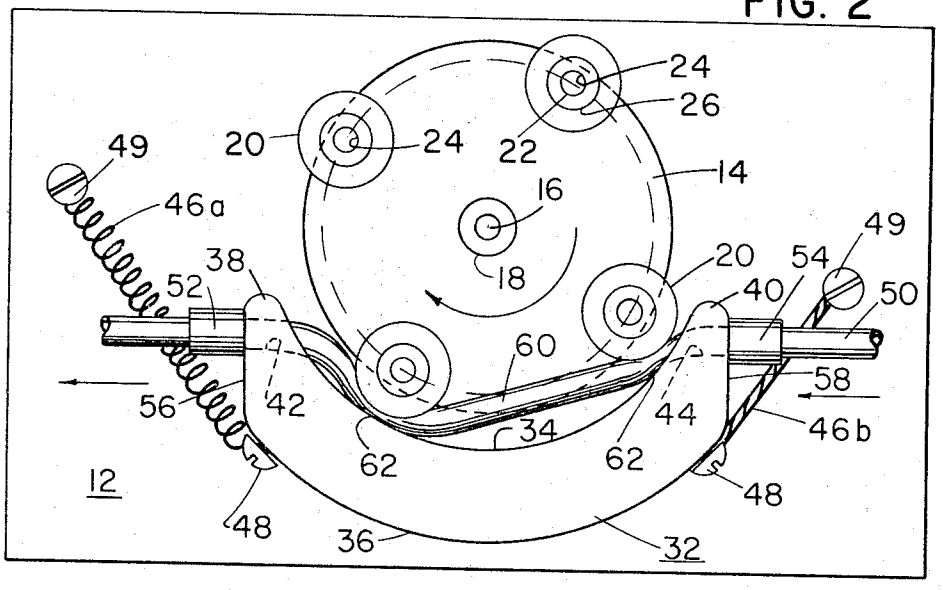
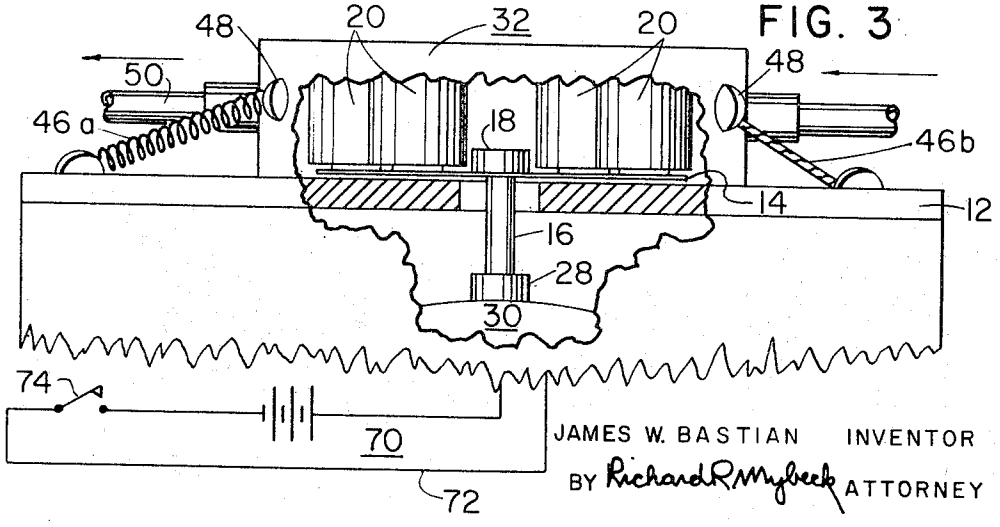


FIG. 3



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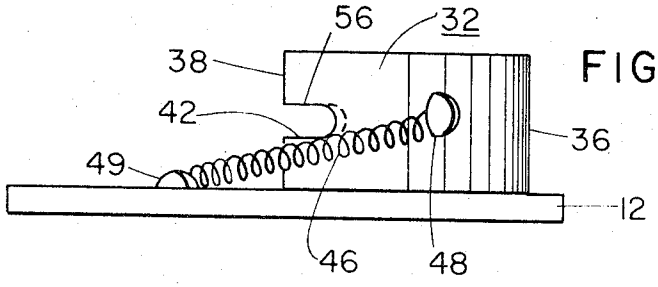


FIG. 4

FIG. 5

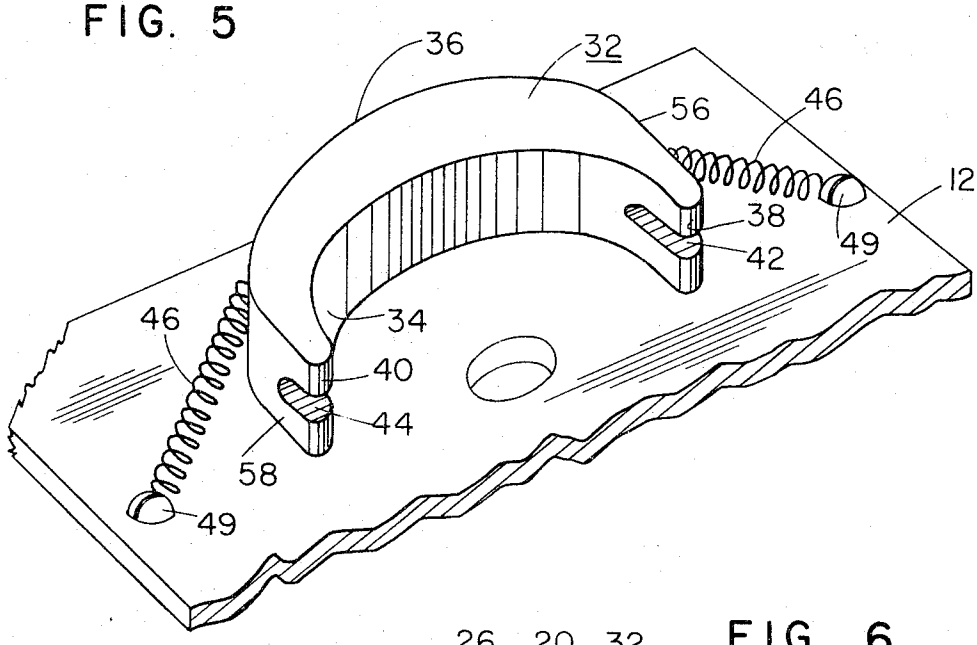
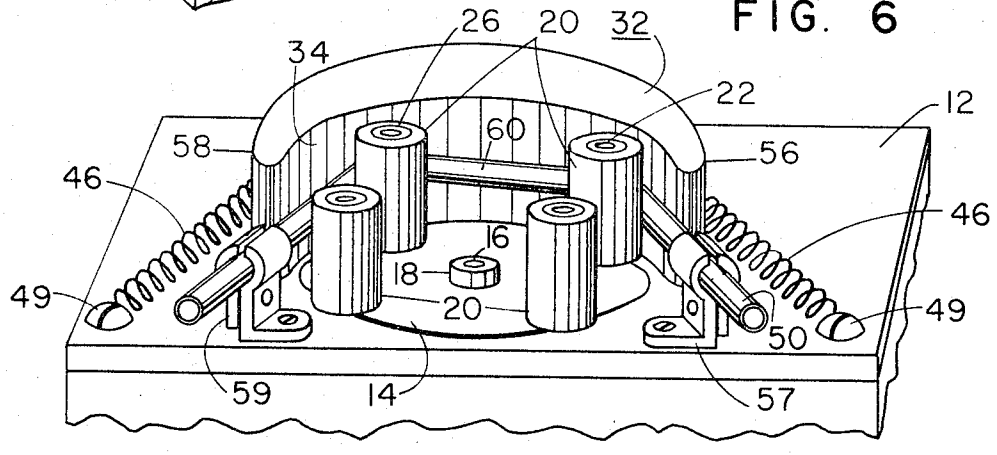


FIG. 6



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3,353,491

PUMPING DEVICE

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14 Claims. (Cl. 103—149)

ABSTRACT OF THE DISCLOSURE

An improved peristaltic-type pump in which the operating forces imparted to an arcuate back up plate are controlled, and the position of the back up plate is automatically maintained, by the interaction of a support surface and tension means connected to the back up plate and extending obliquely away therefrom to a connection on the support surface.

This invention relates generally to a pumping device and more particularly to improvements in the so-called "peristaltic" type of pump.

Peristaltic pumps of the specific type with which I am concerned are those in which the pumping action is obtained by the application of an external force on a flexible tube disposed between and acted upon by a compressor roll and a complementary platen, one or the other or both of which is urged toward the other to compress a region of the tube. This compressed region is then mobilized by advancing the compressor roll, and hence the region, in the direction of desired fluid flow.

Such pumps find many useful applications where contamination of the transported fluid by the pump must be avoided, for instance, when the fluid is sterile blood plasma and the like; where contamination of the pump parts by the fluid causes a grossly inconvenient pump clean up, for instance, when the fluid is printer's ink and the like; or where contact of pump parts by the fluid causes serious damage to the pump, for instance, when the fluid is metal corrosive chemicals, and the like.

Of the many peristaltic pumps which are now known, there are none which are capable of avoiding substantial changes in applied pressure in response to relatively minor changes in the amount or condition of the fluid being transmitted thereby. Without exception, all peristaltic pumps create external force on the tube with a biasing arrangement in which the force imparted thereby is completely dependent on the space between the platen and the compressor roll, since for all intents and purposes, the space at the time operation begins remains relatively fixed throughout the operation. But, the prior pumps possess an inherent sensitivity to slight changes in this space with the net effect being to permit feed-back or, at the other extreme, to overload the tube or the pump motor or both with a resulting failure of the part so over-taxed.

Also, in the absence of heavy castings or special auxiliary holders or guides, the prior art pumps have suffered from lateral slippage of the tube out of proper engagement which renders the pump substantially ineffective.

Other pumps require specialized machining of the compressor rollers or the platen or both. Such machining further increases manufacturing costs and provides a device which requires extreme care (so as not to mar the surfaces) during its operation.

The present invention is predicated upon my development of a peristaltic pump of novel design in which all of the enumerated disadvantages of the prior art are obviated. More particularly, I have discovered a unique substantially free-floating back-up member and suspension means therefor which eliminates not only readjustment, blow-out and the like, but which requires no machining, either of itself or the roller members, and yet achieves

excellent results when transporting a variety of fluids. I have further discovered that a much less sensitive system is created by the utilization of tension means to interconnect my platen (or "back-up member" as I call it) and my supporting structure since the tension means such as my long stretch springs are used while in a prestretched condition (e.g. about 2 times its resting length). Thus, when the spring extends in response to operating platen displacement, the increased distance becomes a relative minor portion, say 20%, of the extended spring length and hence only a minor force variation occurs.

Contrast this with the prior art addiction to the use of compression springs for platen bias. With a compression spring, a slight platen displacement can cause a dimension change of several hundred percent in the spring and, consequently, cause an increase in the applied force of several hundred percent. When an occlusion is in the tube, this force can be more than enough to rupture the tube, spill out the fluid and, in general, completely abort the purpose for which the pump was selected in the first instance.

Accordingly, a principal object of the present invention is to provide a new and improved design for peristaltic pumps which markedly reduces force-distance relationships heretofore prevalent in prior pumps and thereby eliminate occlusion-induced tube rupture or "blow-outs."

Another object of the present invention is to provide a new and improved design for peristaltic pumps which substantially eliminates all machining costs and therefore is less expensive to produce and operate.

A further object of my invention is to provide an improved peristaltic pump in which the lateral slippage of the fluid-conveying tube is substantially eliminated as a problem.

Another object of my present invention is to provide an improved peristaltic pump in which pre-stretched-biasing means are provided to substantially eliminate radical force-distance relationships between the pump impeller and the cooperating back-up member.

Still another object of the present invention is to provide an improved pumping device in which automatic adjustment of the compressive force members is achieved to provide substantially radially acting forces upon the fluid-conveying tube member operatively interposed therebetween.

Still another object of the present invention is to provide a new and improved pumping device.

These and still further objects as shall hereinafter appear, are fulfilled in a remarkably unexpected manner by the present invention as can be readily discerned from a consideration of the following detailed description of a preferred embodiment thereof, especially when considered in conjunction with the accompanying drawing in which:

FIG. 1 is an isometric showing, partially broken away, of a pumping device embodying the present invention;

FIG. 2 is a plan view of the device of FIG. 1;

FIG. 3 is a side elevation, partially broken away, of the device of FIG. 2;

FIG. 4 is an end elevation of a fragmentary portion of the device as shown in FIG. 2; and

FIG. 5 is an isometric showing of a back-up member employing alternative tension means in accordance with the invention.

Referring now to the drawing in which like parts bear like numerals throughout the several views, my improved pumping device is indicated by the general reference **10**.

As shown in FIG. 1, pumping device **10** comprises a support **12** to which a wheel member **14** is mounted for rotation on an axle **16** to which it is secured by a suitable fastener such as locking collar **18**. A plurality of

cylindrical roller members **20** are mounted on wheel member **14** for rotation about their respective axles **22**, for instance cylindrical rods or the like, which, in turn are integrally secured to wheel member **14**. Each roller member **20** is tubular in that a suitable axially extending bore **24** is defined therethrough to permit the passage of axle **22** therethrough. Roller members **20** are secured to their respective axles **22** in any suitable fashion such as by fasteners **26**. The several axles **22** are arranged so that where they contact wheel member **14**, they define points on a circle (shown in dotted line in FIG. 2) which is concentric to the longitudinal axis of axle **16**. Wheel member **14** and its associated parts will be hereinafter referred to as a rotor.

The axle **16** of wheel member **14** extends through support **12** where it is connected as by coupling **28** in driveable engagement with suitable driving means such as motor **30**.

Adjacent to wheel member **14** is a back-up member **32** having an arcuate concave surface **34** and an arcuate convex surface **36**. These two surfaces meet at ends **38**, **40**. Back-up member **32** is provided adjacent each end **38**, **40** thereof with substantially centrally disposed longitudinal grooves **42**, **44**, respectively, the function of which will hereinafter be more fully explained.

Back-up member **32** is in relatively free slideable engagement with support **12** and is connected thereto only by suitable tension means **46**, such as stretch spring **46***a* or cable **46***b*. Tension means **46** are connected suitably, as with screws **48**, to surface **36** disposed inwardly from the adjacent one of end **38**, **40**, and extends obliquely therefrom to a connecting point in support **12** disposed axially away from and in front of back-up member **32**.

Tension means **46** thus coact with back-up member **32** and support **12** to permit back-up member **32** to move freely relative to the rotor and slide freely relative to support **12** while providing sufficient tension force to enable substantially complete coaction with roller members **20** as shall be described. Further, as was previously mentioned, my use of stretched springs **46***a* provides my pump with the decided advantage of being able to accept substantial operating changes in the space between the back-up member **32** and the coacting roller member **20** without a corresponding increase in the magnitude of pressure created therebetween. This substantially avoids the risk of blow-out which might otherwise occur from an occlusion passing in the tube member **50** operatively disposed therebetween.

Elongated tube **50** is formed of suitable plastic or rubber material or of other compressible elastic materials, and is disposed between roller members **20** and the back-up member **32** through slots or grooves **42** and **44** under slight tension for simultaneous engagement by at least one roller member **20** and the back-up member **32**. Preferably, collars **52** and **54** will be fixed in circumscribing relationship to tube **50** in axial spaced relationship to each other along the tube. The distance between collars **52**, **54**, approximates but is somewhat less than the straight-line distance between the remote edges **56** and **58** of back-up member **32** adjacent grooves **42** and **44**, respectively, so as to thereby maintain that increment **60** of tube **50** disposed therebetween under at least slight tension but not so great as to obstruct the passage of fluids through tube **50**. This distance between collars **52** and **54** should always be sufficient to maintain a slight tension in tube **50**.

As an alternative to defining slots **42**, **44** in the back-up member **32**, I find satisfactory results are obtained when suitable clamping devices **57**, **59** are secured to support **12** respectively, adjacent edges **56**, **58** of the back-up member and generally in line (though not critically so) with the line of tangential departure defined by tube **50** on the arcuate-bearing surface **34** of back-up member **32**. When clamping devices **57**, **59** are used, in lieu of or in conjunction with slots **42**, **44**, the circumscribing collars **52**, **54**, can be omitted if desired. In any event, the considerations with respect to maintaining segment **60** under slight tension should still be observed.

Referring again to FIG. 2, back-up member **32** thus is positioned relative to the pump rotor, that is, wheel member **14** and roller members **20**, so that when the wheel member **14** is rotated in the direction as shown by the arrow, and in response to the selective activation of the driving means **30** connected therewith, one of the roller members **20** will engage tube **50** approximately adjacent slot **44** and coact with back-up member **32** to create in the tube **50** a substantially complete zone of radial compression, designated as **62**. Zone **62** then is migratory toward end **38** and hence the output end of tube **50** by the continued rotation of wheel member **14**.

Tension means **46** maintains the compressive force on tube **50** while permitting back-up member **32** to adjust its position relative to the compression zones **62** so as to maintain a substantially radial force thereupon throughout a complete revolution of wheel member **14** on its axle **16**.

The unique arrangement of tension means **46** with the back-up member **32** and support **12**, as described, causes the force imparted to back-up member **32** to remain relatively uniform irrespective of the variations in the spatial relationship between back-up member **32** and roller members **20** for the reasons already explained.

The use of tension springs **46***a* or a tension cable **46***b* with a spring **46***a*, as shown in FIGS. 2 and 3, appear to provide good results so that either may be incorporated into my pump.

In my experience, however, more uniform pressures are obtained when tension means comprises a pair of prestretched springs **46***a*. Regardless, it is critical that these connectors hold back-up member **32** in tension if the benefits of my design are to be obtained. I have observed that when I am pumping fluids having a relative heavier viscosity, that is, viscosities of the nature of or thicker than 30 weight motor oil, it is desirable to use cable **46***b* at the input side of the pump.

A control means **70**, comprising an extension cable **72** extending from electrical connection with motor **30** into a suitable manual switch **74** whereby the selective actuation of the switch **74**, and hence the driving means **30**, effects the rotation of wheel member **14** and thereby enables the operator of the switch to accurately and precisely control the output of fluids from the tube **50**.

In operation, the input end of the tube (not shown) is connected to a suitable liquid reservoir and the control means **70** are engaged to actuate the motor **30** which through coupling **28** rotates axle **16** and hence wheel member **14** and roller members **20**. In rotation of wheel member **14**, roller members **20** engage tube **50** which is operatively interposed between the members **20** and the back-up member **32** to create substantially a complete zone of radial compression which is then migratory in the direction of rotation of the wheel member **14** by the rolling action of roller members **20** about their respective axles **22** against the arcuate surface **34** of back-up member **32**. Roller members **20** and back-up member **32** thus coact on tube **50** to effect both the positive displacement of fluid in tube **50** ahead of the zone of compression while creating a sufficient vacuum behind the zone of compression to siphon additional fluid from the reservoir into the tube **50** for engagement by the next succeeding roller member **20**. Once tube **50** is substantially completely filled with fluid, the control of fluid output from my pump is very precise.

From the foregoing, it becomes apparent that the aforestated objects have been fulfilled by the present invention in a remarkably unexpected manner. It is, of course, understood that while the present invention has been described and illustrated with respect to specific embodiments, they are presented herewith to exemplify the present invention and not by way of limitation. It is further

understood that such applications, modifications and alterations of the present invention as may readily occur to the skilled artisan when confronted with this disclosure are intended within the spirit of the present invention, especially as it is defined by the scope of the claims appended hereto.

What is claimed is:

1. A pumping device comprising in combination: a support; a rotor rotatably mounted on said support and having a plurality of spaced roller members mounted thereupon for rotation therewith and independent rotation relative thereto; a back-up member freely slidable upon said support and having a concave arcuate surface disposed in spaced cooperating relationship to said roller members; tension means resiliently biasing said back-up member toward said roller members while simultaneously providing substantially equal opposed forces normal to the forces urging said back-up member toward said rotor; driving means mounted on said support and selectively actuatable to rotate said rotor; and a compressible elongated tube having an input and an output end and disposed in a substantially fixed position relative to said arcuate surface intermediate said back-up member and said roller members, said back-up member coacting with at least one said roller members to create a zone of substantially complete radial compression of said tube upon engagement of said tube therebetween, said zone being movable toward the output end of said tube in response to the rotation of said rotor.

2. A device according to claim 1 in which said back-up member has at each end thereof a centrally disposed slot extending thereinto, said slots coacting with each other to receive and hold said tube in substantially true alignment with said slots even during rotation of said rotor.

3. A device according to claim 2 in which said tube comprises first and second circumscribing collars, said collars being spaced from each other axially along said tube a distance sufficient to place said tube under tension, but not to materially obstruct the passageway therethrough, when said collars abut the surface of said back-up member remote from said roller members.

4. A device according to claim 1 having first and second clamping means mounted upon said support in spaced relationship to each other at opposite ends of said back-up member in alignment with said back-up member even during rotation of said rotor, said first and second clamping means cooperating to hold said tube therebetween in a stationary position relative to said support.

5. A device according to claim 1 in which said tension means comprises at least one stretchable tension spring connected to said back-up member and extending obliquely therefrom into connective relationship with said support.

6. A device according to claim 5 in which said tension means comprises a pair of obliquely diverging (relative to the back-up member) stretchable tension springs interconnecting said back-up member and said support.

7. A device according to claim 1 in which said tension means coact with said back-up member to automatically adjust said arcuate surface to said coacting roller member so that the forces received by said surface are substantially radial thereto.

8. A pumping device comprising in combination, a support, a wheel member rotatably mounted on said support, a plurality of roller members mounted on said wheel member for rotation therewith and relative thereto, each of said roller members having an axis of rotation disposed along a circle concentric with the axis of rotation of said wheel member and being in spaced relationship to the other of said roller members, a back-up member freely slidable relative to said support and having a concave arcuate surface disposed in spaced proximate relationship to at least one of said roller members, stretchable spring means operatively interposed between said back-up member and said support in tension to resiliently bias said back-up member toward said one of said roller members while simultaneously providing substantially equal and opposite forces away from said wheel member along a path transversing said wheel member whereupon said back-up member is permitted to slide relative to said support and to automatically return to its static position by the coaction of said spring means thereupon, driving means mounted on said support and actuatable to rotate said wheel member, control means operatively connected to said driving means and operable to selectively actuate said driving means and rotate said wheel member, and a compressible elongated tube having an input and an output and disposed in a substantially fixed position relative to said arcuate surface of said back-up member intermediate said back-up member and at least one of said roller members, said back-up member coacting with at least one of said roller members to create a zone of substantially complete radial compression of said tube upon engagement of said tube therebetween, said zones being each movable with said coacting roller member toward the output end of said tube in response to the rotation of said wheel member.

9. A pumping device comprising in combination: a support, a plurality of roller members carried by said support for rotation relative thereto about an axis, said members being disposed in a circle concentric with said axis and in spaced relationship to each other; a back-up member slidable relative to said support and having a concave arcuate surface disposed in spaced proximate relationship to at least one of said roller members; stretchable tension means resiliently biasing said back-up member toward said members and toward said support; driving means actuatable to rotate said roller member about said axis; and a compressible elongated tube having an input and an output and disposed along a substantially fixed line relative to said arcuate surface of said back-up member and intermediate of said back-up member and at least one of said roller members, said tension means and said back-up member coacting with at least one of said roller members to create a zone of substantially complete radial compression in said tube and to move said zone toward the output end of said tube by the rotation of said roller members about said axis.

10. A device according to claim 9 in which said back-up member has at each end thereof, a centrally disposed slot extending thereinto, said slots coacting with said tube to maintain the tube in substantially true alignment with said slots even during rotation of said roller members.

11. A device according to claim 9 in which said tube is provided with first and second peripheral collars, spaced from each other and axially along said tube a distance sufficient to place said tube under tension when said collars abut the surface of said back-up member remote from said roller members but not sufficient to substantially obstruct the passage therethrough.

12. A device according to claim 9 in which said tension means comprises first and second stretchable springs operatively interposed between said back-up member and said support and obliquely thereof, said springs coacting with said back-up member to automatically adjust said arcuate surface relative to said coacting roller members so that the forces received by said surface are substantially radial thereto.

13. A device according to claim 9 including means preventing the disengagement of said back-up member from sliding engagement with said support.

14. In a peristaltic pump comprising a support, a rotor, a flexible tube, and a back-up plate, an improved mounting means for said back-up plate comprising at least one stretchable tension spring attached to said back-up plate adjacent one end thereof and extending therefrom under tension to a first connective point on the support, and a flexible non-yieldable cable attached to said back-up plate adjacent the other end thereof and extending therefrom under tension to a second connective point on the support whereupon said spring and said cable coact to urge said

back-up plate toward said rotor and oppose each other to control the movement of said back-up member relative to the circumference of said rotor.

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