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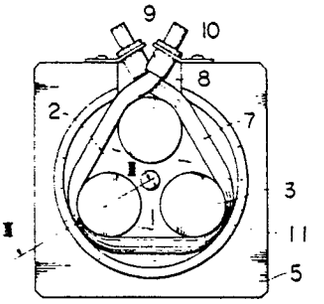
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(54) **STRETCHED TUBE PUMP.**

(57) The peristaltic pump according to the present invention is of the type in which a looped tube is squeezed by the rotating rollers in a housing. The improvements according to the present invention in a pump of this type reside in that a flexible tube having a large wall thickness for its inner diameter is stretched to a suitable length and passed around rollers so as to apply a suitable tensile force to the tube, whereby a fluid delivery speed and pressure far higher than those with a conventional pump of the same type can be attained. This enables the tube to be replaced very easily, and the range of application of the tube pump to be greatly increased.

FIG. 1



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DESCRIPTION

STRETCHED TUBE PUMP

「Technical Field」

The peristaltic pump of the present invention is of a type in which a tube enclosed as a loop in a housing is progressively compressed, while it is held between rollers mounted on a rotating disc and the inner circle of the housing.

「Background Art」

In the tube pump of this type, since the liquid contacts only the inside of the tube, contamination otherwise caused when the liquid is exchanged can be perfectly prevented by internally washing the tube or exchanging the tube. Therefore, tube pumps using silicone, etc. are widely used for medical and chemical purposes.

A large motive for the present invention is to mechanize the work of preparing drops by mixing small amounts of chemical solutions in several kinds of glass ampoules with the main ingredient in the dripping bottle, for many patients.

Conventionally since there has been no suitable machine or tool, injectors have been being used even though they are known to be unsatisfactory. To mechanize the work, a tube pump is the best in view of the above feature. However, the conventional tube pumps used for medical and chemical purposes have various disadvantages for this particular purpose.

Firstly, no filter can be used due to insufficient pressure. Unless the pressure is 2 to 4kg/cm^2 or higher, when a fine filter is set in the circuit, the air entering the tube for partitioning one prescription from another causes air lock, not to allow the pump to function.

Secondly, the rorating speed is too low to use a tube with a small diameter. To prevent the liquid from remaining due to the mixing of liquid and air in the tube even at a high pressure, it is desirable to use a tube with a small diameter of about 2 to 3 mm.

However, to obtain a practical flow rate of 200 to 500 cc/min at a pressure of 2 to 4 kg/cm^2, a speed of 600 to 1,200 rpm is required. This speed corresponds to 2 to 10 or more times those of the conventional pumps.

Most frequently adopted tube pumps are of a type in which the tube is set like a loop along the inner circle of the housing and progressively compressed, being held between the rollers and the inner circle, without being lengthened.

To raise the pressure, the clearance between the rollers and the inner circle must be made smaller, and if this is carried out, the tube slips in the progression direction or is pressed out sideways. If the rotating speed is raised, the tube also slips in the rotating direction or comes off from the engagement with the rollers, or it also occurs that the rollers fold the tube double in the freely movable space in the housing. To provide a groove or guides for preventing such accidents is effective to some extent, but it makes tube exchange very difficult. This is the third disadvantage.

Pumps with the tube lengthened and wound around rollers as disclosed in Japanese Patent Publications Nos. 73-2124 and 87-37237 are intended mainly to obtain the effect of operating with small power without the housing and the inner circle. These pumps are suitable for low pressures or applications sensitive to pressure rise, and are designed to control the flow rate by adjusting the tube in combination with annular pieces. They are not suitable for high pressure applications requiring pressure adjustment and filter use as allowed

by the present invention. Furthermore, those pumps require guides as stated in Japanese Patent Laid-Open No. 84-8968. There is also a type in which after the tube is wound around rollers, a housing is closed and retained by a spring. However, this type does not allow the pressure to be kept constant, and at high speeds, the rollers hit to jolt the housing noisily. In addition, since the tube also deviates, guides are required. These pumps are,therefore, not suitable for high speeds and high pressures, and cannot be used for the object intended by the present invention.

「Disclosure of Invention」

A flexible and elastic tube is lengthened at a proper rate and is set around the rollers of a rotating structure, then being firmly held by clamps, etc. at or near the inlet/outlet port of the housing. The inner circle of the housing forms a concentric circle around the rotating shaft at a proper distance away or part of the concentric circle and is fixed.

Since this keeps the tube under proper tension, the tube does not slip or come off even if the rotating speed is raised, and thus the pressure can be raised, without generating any noise and requiring any guide in the housing, to allow the tube to be exchanged very easily.

「Brief Description of Drawings」

Fig. 1 is a front view showing an example of the present invention. Fig. 2 is a top view of Fig. 1. Fig. 3 is the AA sectional view of Fig. 1. Fig. 4 is a variation of Fig. 3. Fig. 5 is a front view showing another example of the present invention.

「Best Mode for Carring Out the Invention」

Figs. 1 to 3 show an example of the present invention. A rotating disc 2 is fixed around a motor shaft or any other rotating shaft 1. Rollers 3 are rotatably fixed to the rotating disc 2 by respective arbors 4, and revolve round the rotating shaft 1 together with the rotating disc 2, while being rotated around the respective arbors 4 and while compressing a tube. Though not illustrated, bearings, etc. should be used to assure smooth rotation. The housing 5 has an inner circle 6 concentric around the rotating shaft 1 and is externally formed like a square or cylinder or any other form, being fixed. The housing 5 is provided with an inlet/outlet port 8 for a tube 7, as a groove in this example. The tube 7 with a proper length has, for instance, couplers, etc. attached to have protrusions 9 at both the ends, and is set around the rollers 3, then being fastened by retainers 10, to be kept at constant tension.

If the circle generated by the rollers 3 revolving round the rotating shaft 1 is, say, 50 mm in diameter, the length of the tube required for setting around the rollers without any looseness and without any stretching between the protrusions is 17 cm in the structure of this example, but in the case of the present invention, a 15 cm long tube, i.e., 2 cm shorter, is lengthened to be set around the rollers 3.

Furthermore, the clearance 11 between the rollers 3 and the housing 5 is adjusted to suit the required pressure. For instance, if a tube of 1.5 mm in wall thickness, 2 mm in inner diameter and 5 mm in outer diameter is rotated at a speed of 600 to 1200 rpm, a clearance 11 of 2.4 mm can provide a pressure of approximately 2 kg/cm^2. In this case, a filter of 0.45 μm can be used, but that of 0.2 μm cannot be used. If the clearance is reduced to 2.1 mm, a pressure of about 4 kg can be obtained, to allow the use of a filter of 0.2 μm.

If the clearance between the rollers and the housing is reduced like this, the pressure can be gradually raised, but if the tube is compressed too much, it is fatigued earlier. Therefore, the clearance is recommended to be larger to such an extent that the objective is achieved. If the tube is loosened, it becomes larger in wall thickness, to raise the pressure, but a higher rotating speed causes the tube to be lengthened, causing it to be built up at the inlet/outlet or to come off from the engagement with the rollers. If the tube is increasingly pulled, it becomes small in wall thickness, to make the pressure insufficient. If a tube moderately large in wall thickness is kept in a certain range of tension suitable for the pump and a clearance suitable for the objective is selected, then high speed rotation and high pressure can be obtained.

However, the above applies to a case of attempting to achieve the highest speed. It should be noted that if the speed is lower, the applicable tension range is wider, and that in this case, on the contrary, by adjusting the tension, the pressure can be adjusted considerably.

However, if the tension of the tube is adjusted to approach 0, the tube will deviate together with the rotation of the rollers, to finally come off from the rollers no matter how low the speed may be. This is usually prevented by guides. In the present invention, the tension at which the tube does not deviate from the revolving rollers being held between the rollers and the inner circle free from the guides is the minimum tention. The extent depends on the smoothness of the revolution of the rollers as well as on the revolving speed, and if the revolution of the rollers is smooth due to bearings, etc. used, the tension can be small.

Another example for sustaining the tension of the tube is shown

in Fig. 5.

This example uses a long tube 12 without using any couplers, and the tube is marked 13 at intermediate portions of the tube but at both the ends of the loop corresponding to the inlet/outlet, and fastened there by clamps 14. For instance, if a tube of 5 mm in outer diameter is fastened by clamps 14 with a hole of 4.5 mm in diameter, tension as normally used in the pump does not cause any loosening. However, if the tube is pulled with some force applied, it will move, and if the tube length changes by 5 mm, pressure insufficiency or tube disengagement occurs immediately. Therefore, marks 13 indicating always correct positions are recommended to be provided.

As another method, protrusions may be provided at both the ends of an intermediate corresponding section, by bonding small pieces made of the same material as the tube, etc.

The parts to be held such as marks or protrusions provided on the tube and the corresponding holders such as clamps or retainers provided at or near the inlet/outlet port of the housing can be provided in various forms, but the effect is the same.

As can be seen in Fig. 3, the inner circle of the housing 5 is smooth on the surface and neither guide nor groove is required. The tube can be set around the rollers by holding both the protrusions of the tube by the corresponding retainers, letting one of the rollers hold part of the tube, and turning the roller by one revolution without allowing the tube to come off. The tube can be removed by removing either or both of the protrusions from the retainers, and pulling the tube.

To illustrate another method for setting the tube, Fig. 4 shows a condition before setting the tube of Fig. 3. If the inner circle 6 is cut off at the edge, to widen the clearance at the edge as shown

there, or if the rollers are slightly protruded from the housing, to facilitate the setting of the tube around the rollers 3, simple setting as shown in Fig. 4 causes the tube to be guided into the clearance between the rollers and the inner circle when the rotating disc 2 is rotated, to attain automatic proper positioning as shown in Fig. 3. It does not of course occur that the tube comes off or is caught during rotation.

Thus, even if the housing does not move, the tube can be very easily set and removed. This is also convenient since the housing can be removed for cleaning, etc. by unscrewing. In short, it is only required that the inner circle is firmly fixed during use, as a concentric circle around the rotating shaft at a certain distance away or as part of the concentric circle.

Since neither guide nor groove is used, plural tubes can be set in parallel to allow use as plural pumps if there is a sufficient depth available between the rollers and the inner circle, and if a higher pressure is required, the tube can be set spirally. As an example of such variations, if the tube is crossed at the inlet/outlet as shown in Fig. 1, the tube can be progressively compressed for as long a distance as possible in one round, with the load of the rollers kept uniform over the entire circumference.

What is most important in the inlet/outlet port for the tube is the angle formed between the port and the inner circle of the housing. To avoid such problems that the sharpness of the angle can damage the tube or fold and crush the tube and that the tube pressed at the inlet/outlet angle by the rollers may go off, the conventional pumps have the inlet/outlet port circumscribed around the inner circle of the housing. The pump of the present invention can have one or two pores orienting toward the center of the inner circle as shown in Fig.

1 or 5 without any practical trouble. As for the reason, in addition to the fact that the tube used for a tube pump uses a material and wall thickness high in restoring force, the tube used in the present invention is recommended to be somewhat larger in wall thickness than the ordinary tube, depending on the pressure, since it is pulled during use. Therefore, the strong restoring force prevents the tube from being crushed by folding at the angle of the wall of the inlet/outlet, and the tension applied prevents the tube from going off. Of cource, it is allowed to round the angle or to provide an inlet/outlet port circumscribed about the inner circle of the housing.

Furthermore, as shown in Fig. 5, forming the inlet and outlet ports 8 on the mid-slope of the housing 5 is good for keeping the strength of the housing 5. However, the inlet/outlet port 8 formed from the surface of the housing 5 as shown in Figs. 1 and 2 is good for easy exchange of the tube 7.

Therefore, the inlet/outlet port can be formed relatively freely.

「Industrial Applicability」

As can be seen from the above description, the present invention provides the following effects:

Firstly, the rotating speed of the pump can be raised, and a tube smaller in diameter can be used. The liquid does not remain in the tube, and practical flow rates can be secured.

Secondly, since high speed rotation can be done with the tube kept in position even if the clearance between the housing and the rollers is narrowed, the pressure can be raised, and even if a fine filter (0.2 to 0.45 μm) is used, no air lock is caused. Therefore, even a small amount of a liquid can be fed by air, and the broken fine glass pieces entering when ampoules are opened and the miscellaneous

microbes entering from air can also be removed.

Thirdly, even without any guide, the tube does not go off or is not caught. Therefore, the tube can be easily set or removed to allow simple exchange. Since neither rollers nor housing is required to be moved, the structure is simple and the precision does not change.

Fourthly, the housing can be of any form, and the inner circle only is required to be a real circle or part of the real circle. The inlet/outlet port of the tube is also simple, and can be very easily worked to suit the liquid fed, tube, pressure, etc.

Fifthly, by controlling the tension of the tube, the pressure of the pump can be controlled in a range from 0 to 4 kg/cm^2 or more. Accordingly, the pressure can be reduced or increased to suit to the required degree for various liquids and their contents while the pump is rotating, for example not to break the coupsels in the blood.

Thus, the mixing work of drops can be automated with labor saved for the first time by this pump. In addition, since divisional filling can be made concurrently with filtration, small to medium amounts of preparations can be very easily made, even though hitherto both a filter and divisional fillers must be prepared and settled.

In addition, when used also for suction and separation of blood during operation, the pump can be used by changing the tube only for each patient without infection. Thus, it can be used for various medicai applications, but it is very valuable for use also as a high performance tube pump in general industries.

CLAIMS

(1) A tube pump, which is composed of a housing with an inner circle and an inlet/outlet port for a tube, a rotating disc fixed around a rotating shaft, plural rollers rotatably fixed to the rotating disc by respective arbors, and an elastic tube, said tube being progressively compressed while being held between the inner circle and the rollers, comprising said inner circle, being fixed as a concentric circle around the rotating shaft or as part of the concentric circle, and said tube, being lengthened to be set around the rollers, to be kept in proper tension.

(2) A tube pump, which is composed of a housing with an inner circle and an inlet/outlet port for a tube, a rotating disc fixed around a rotating shaft, plural rollers rotatably fixed to the rotating disc by respective arbors, and an elastic tube, said tube being progressively compressed while being held between the inner circle and the rollers, comprising said inner circle, being fixed as a concentric circle around the rotating shaft or as part of the concentric circle; parts to be held such as protrusions or marks, being provided at both the ends of said tube when the tube is shorter than the length required for setting around the rollers without any looseness or without any stretching, or being provided at both the ends of a section corresponding to the length of said short tube when the tube is longer than the required length; and holders such as retainers or clamps, being provided at or near the inlet/outlet port of the house; wherein said tube is lengthened to be set around said rollers, while said parts to be held are fixed by said holders, to keep the tube in proper tension.

(3) A tube pump, according to claim 1 or 2, wherein the tension of the tube is adjusted by adjusting the holders such as retainers or clamps

provided at or near the inlet/outlet port of the housing or the parts to be held of the tube.

(4) A tube to be used for the tube pump stated in any of claim 1 to 3, comprising parts to be held such as protrusions or marks, being provided at both the ends of said tube when said tube is shorter by a proper length than the length required for setting around the rollers without any looseness and without any stretching or being provided at both the ends of a section corresponding to the length of said short tube when the tube is longer than said required length.

FIG. 1

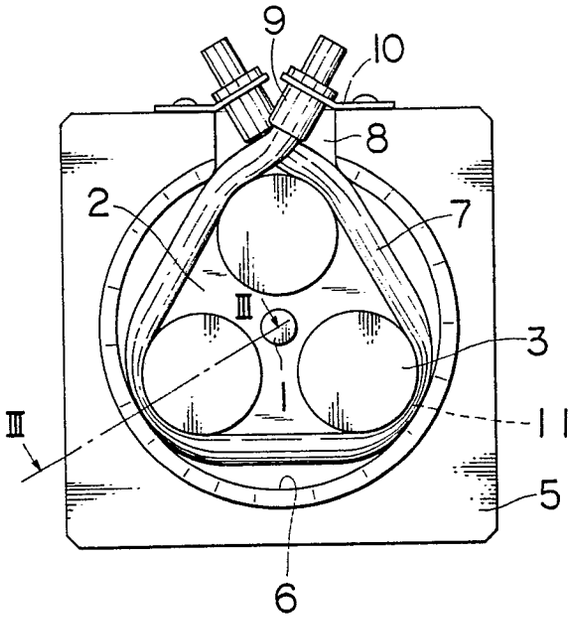


FIG. 2

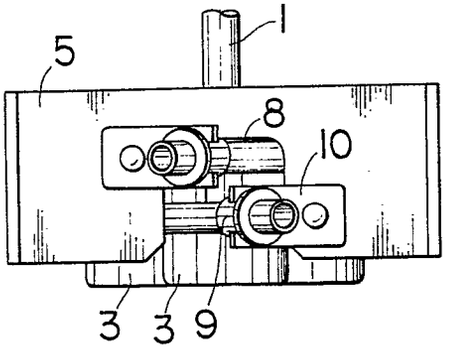


FIG. 3

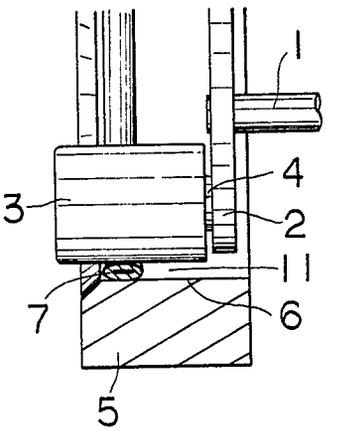


FIG. 5

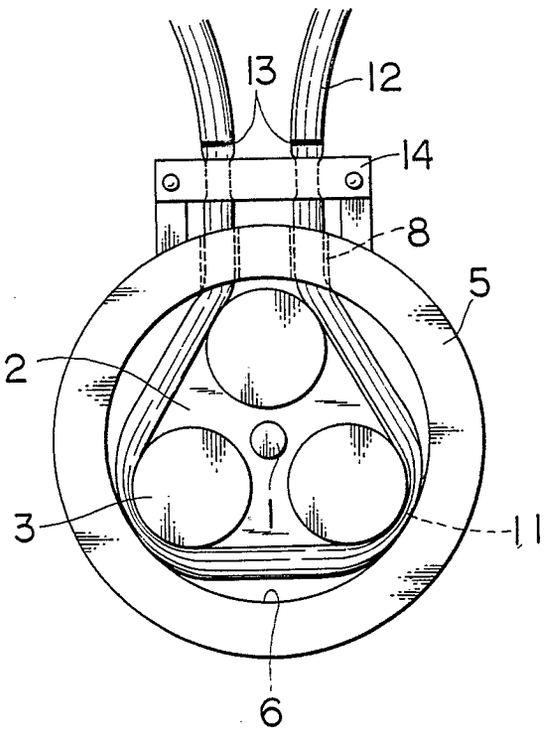
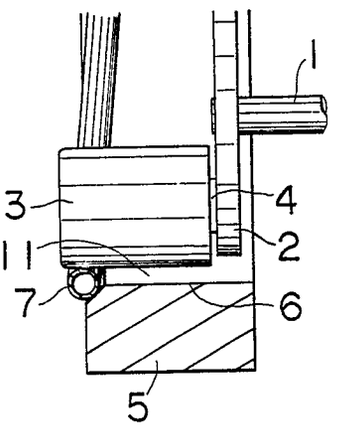


FIG. 4



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP88/01200

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[4] F04C5/00 341, A61M1/10 321

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	F04C5/00 341, A61M1/10 321

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho 1926 - 1987
Kokai Jitsuyo Shinan Koho 1971 - 1987

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	JP, B2, 62-37237 (Edwarl, Maleb) 11 August 1987 (11. 08. 87) (Family: none)	1-4
X	JP, A, 59-8968 (Fujisawa Pharmaceutical Co., Ltd.) 18 January 1984 (18. 01. 84) & US, A, 4,515,584 & EP, A2, 98,592 & EP, A2, 99,508	1, 3
X	JP, A, 60-116890 (Fujisawa Pharmaceutical Co., Ltd.) 24 June 1985 (24. 06. 85) & US, A, 4,515,584 & EP, A2, 98,592 & EP, A2, 99,508	1, 3

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
December 13, 1988 (13. 12. 88)	December 26, 1988 (26. 12. 88)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	