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(54) Peristaltic pumps

(57) A pump for e.g. a blood-treatment apparatus, comprises a stator 14 to support a portion of a pumping tube 53 extending from a "cassette" 50 and a rotor 12 furnished with tube-compressing

rollers 17, 18, 19, which may be on pivoted arms 21, 22, 23, the stator being movable perpendicularly relative to the rotor to facilitate installation of the tube. Movement of the stator may be effected by turning a cylindrical member (44), Fig. 3 (not shown), which carries an eccentric pin (42), 46 engaging with a slot 43 in the stator.

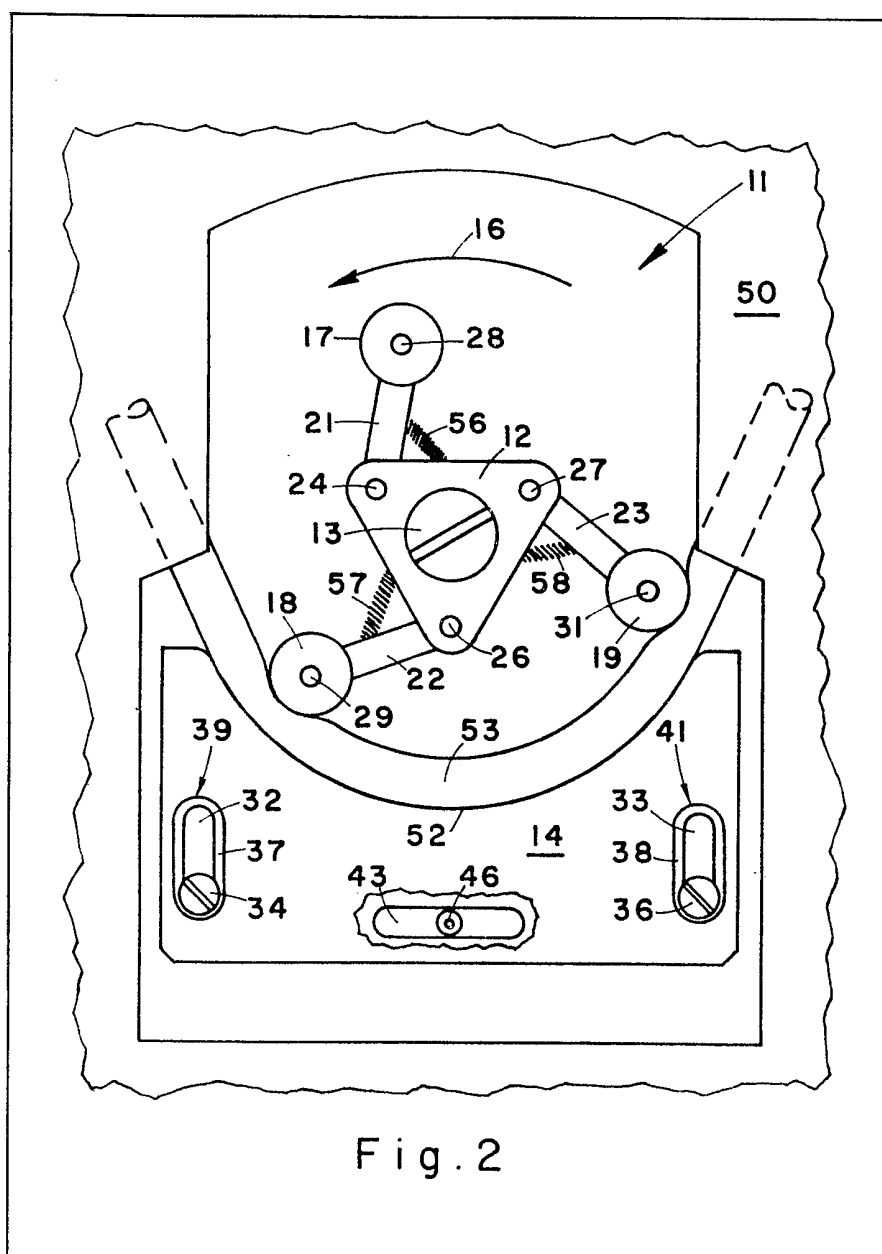


Fig. 2

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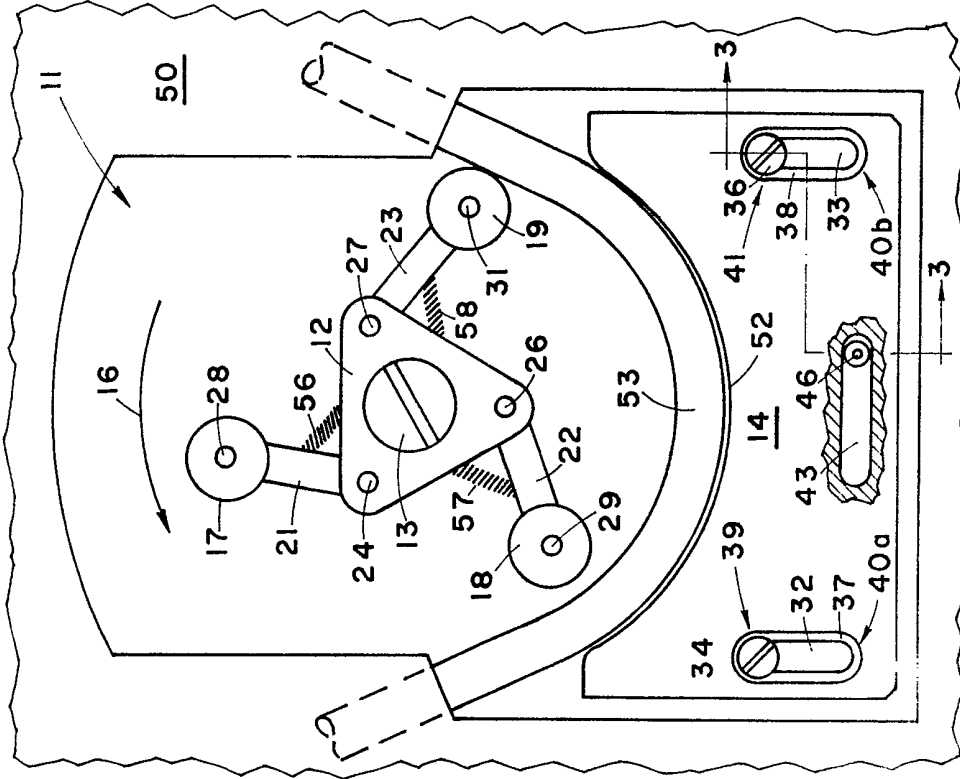


Fig. 1

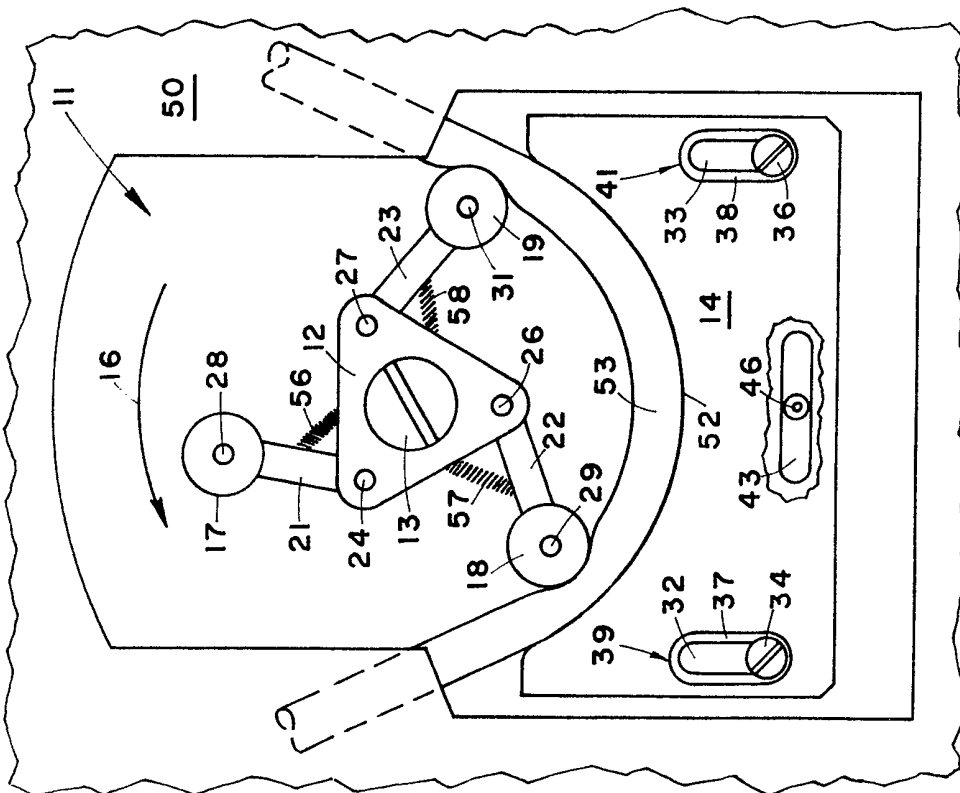


Fig. 2

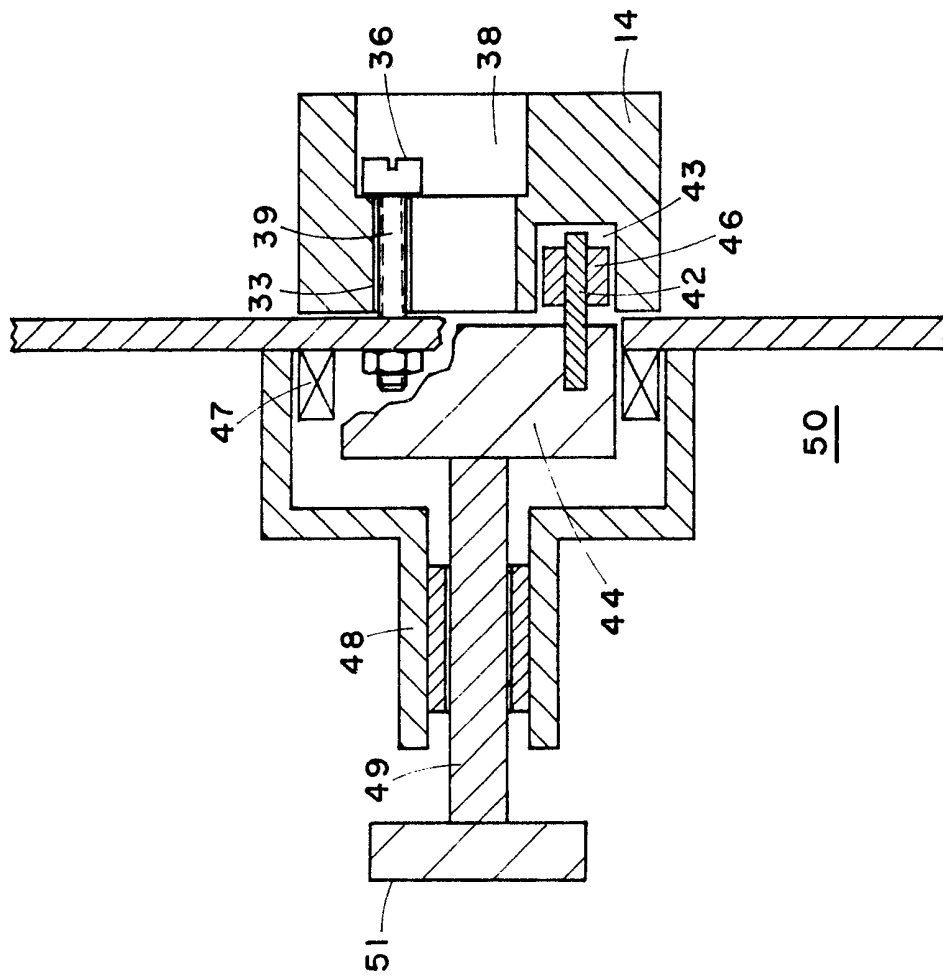


Fig. 3

SPECIFICATION

Peristaltic pumps

This invention is concerned with peristaltic pumps and more particularly with rotary pumps which generate wave motion in fluid-carrying tubing for generating pressures and/or actuating the forward movement of the fluid in the tubing.

Peristaltic pumps used to pump fluid in tubing wherein the tubing comprises an integral part of the pumps, are well known. Such pumps are used, for example in artificial kidney machines or artificial heart apparatus. Peristaltic pumps are extremely efficient in apparatus such as artificial kidney machines. Such pumps minimize the number of valves required, since the pumps also act as valves, when the pumps compress the flexible tubing and stop flow therethrough while the rotor compresses the tubing.

Prior art pumps of this type cannot be assembled by merely dropping the tubing between the rotor and the stator because the rotor and the stator are usually in abutment leaving little room for the flexible tubing. Thus, flexible tubing cannot be placed between the rotor and the stator without manually moving the rotor stator combination from the abutting position.

Oftentimes in the prior art pumps the assembly is accomplished by first removing either the rotor or the stator. The method normally used for assembling the tubing into the peristaltic pumps is to feed an end of the tubing into abutting relation with both the stator and rotor and then to rotate the rotor by hand to work the tubing into its final position.

In machines such as artificial kidney machines it is important that the pump can be assembled in a short time in order to get the maximum usage per machine. Also, for artificial kidney machines using cassettes for the tubing, such as in the machine described in the co-pending patent application entitled "Blood Treatment System" filed on 6 October 1982 under application No. 82.28590, it is important that the pump receive the tubing between the stator and the rotor automatically when the cassette is mounted on the machine.

It is an object of the present invention to provide a new and improved rotary pump in which the above-referred to disadvantages are substantially reduced or overcome.

According to the present invention a peristaltic pump is provided comprising:

rotor means,

a plurality of roller means mounted to said rotor

means to define a locus as said rotor means rotates,

fluid carrying tubing in cassette means,

stator means movable between an operating position forcing said tubing into abutment with said locus and a loading position facilitating the placement of said tubing between said rotor means and said stator means, and

means for moving said stator means between said loading and operating positions.

A further feature of the rotary pump is that the stator movement is linear and means are provided for maintaining said linearity. Yet another feature of the invention lies in said locus being substantially cylindrical. Still another feature of the invention lies in the utilization of cam means for moving said stator between said first and second positions and means for electromagnetically moving said cam means to automatically position said stator relative to said rotor.

The invention accordingly comprises the features of construction, combinations, developments and arrangements of parts which will be exemplified in the constructions hereinafter set forth and the scope of the invention will be indicated in the claims.

For a further understanding of the invention, reference is had to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 schematically shows the stator and the rotor in the loading position;

Fig. 2 shows the stator and the rotor in the operating position; and

Fig. 3 is a sectional view taken along the plane 3—3 in Fig. 2 looking in the direction of the arrows, showing details of the stator moving mechanism.

The pump shown in the figures is ideally suited for use with the artificial kidney system described and claimed in the above referred to patent application filed on even date herewith.

Fig. 1 shows the rotary pump 11 in the loading position, i.e. with the rotor 12 and stator 14 spaced apart. The rotor unit rotates about its fixed axis shown as 13. The stator 14 is movable relative to the rotor axis, for example in a vertical direction. In Fig. 1 stator 14 is removed as far as it can move from axis 13 of the rotor 12.

A plurality of rollers such as rollers 17, 18 and 19 are fixed to the rotor 12 by lever arms 21, 22 and 23 respectively. The lever arms pivot around pivot points 24, 26 and 27 respectively. The rollers themselves are rotatable about axes 28, 29 and 31 on the lever arms 21, 22 and 23 respectively.

Means are provided for guiding and limiting the stator in its movement relative to the rotor. More particularly slots 32 and 33 are shown in Figs. 1 and 2. The slots are shown as double slots, that is there are larger slots 37, 38 designed to accommodate the heads of the fasteners 34, 36, 39 and 41 respectively. The slots 32 and 33 accommodate the bodies of the fasteners 39 and 41.

The double slots are in general larger than the bodies and heads of the fasteners so as to prevent the stator from being "lodged" in a non-terminal position. Note however that the ends of the slots at 40a and 40b are narrower to positively position the stator in the operating position.

It should be understood that while slots are shown, other guide means such as rails could be used within the scope of the invention.

Means are provided for actuating the stator in its movement towards and away from the rotor. More particularly a cammed pin 42 is shown. The pin fits into a blind horizontal slot 43. The pin is a cam member in that it is attached to rotating cylindrical member 44 at a point off centre. The pin 42 is shown surrounded by friction reducing bearing means such as nylon coating 46 to reduce the frictional effect between the pin and the stator.

As best seen in Fig. 3, the cylindrical member 44 rides on the bearing 47 and is surrounded by the housing 48. The motivating parts of the rotor pump are ideally located in the kidney machine shown as everything on the left side of the outer covering 12A. Thus the rotor axis 13 is shown schematically extending through the partition 12A. The cylinder 44 is connected to a drive axle 49 which is driven by a gear 51 attached to a motor, for example (not shown). The cylinder 44 is designed so that it rotates approximately 160°. When it so rotates then a pin 42 pushes on the walls of the slots 43 of stator 14 forcing the stator up or down vertically as controlled by the slots 32 and 33 in cooperating with fasteners 39 and 41 respectively.

In the position of the stator shown in Fig. 1 there is plenty of room between the rollers of the rotor and the top 52 of the stator. The top 52 of the stator is shaped to be tangential to the locus of the rollers as the rotor rotates. The room between the stator and the rotor easily accommodates fluid-carrying tubing 53 shown extending from a cassette 50 a portion of which is shown in Figs. 1 and 2. The room, thus enables the automatic positioning of the tubing between the stator and the rotor when the pump is part of a blood treatment machine and the tubing is in a cassette.

Means are provided for forcing the rollers away from the rotor 12 and maintaining them in the position shown in Figs. 1 and 2. More particularly resilient means such as springs schematically indicated as springs 56, 57 and 58 connected between the lever arms 21, 22 and 23 and the rotor body 12 respectively maintain the rollers positioned as shown. Note that in a preferred embodiment springs are located about the pivot points.

In Fig. 2 the stator is shown closest to the rotor axis 13. Note that the pin 42 has moved away from the side of the slot 43 and that the fasteners 39 and 42 have moved from the top of slots 32 and 33 to the bottom of slots 32 and 33. The rollers are now firmly held against the tubing 53 in a manner such as to compress the tubing and stop the flow therethrough. Thus in addition to its other benefits this rotary pump minimizes the need for valving since even when the pump is not rotating and pumping it acts as a closed valve as long as the stator is in the position closest to the rotor axis as shown in Fig. 2.

The peristaltic pumping action is more easily discerned in Fig. 2. As the rotor turns in the direction of the arrow 16 fluid is forced along the tubing 53 as the roller pushes in the counter-clockwise direction. Immediately behind the roller

there is a vacuum which pulls at the fluid. Immediately in front of the rollers the fluid is forced along the tubing. Thus the pumping action is provided which keeps the fluid moving as desired.

The pump is easily loaded with the tubing because of the movable stator as distinguished from previous rotary pumps of this type.

In operation then, the pump is positioned as shown in Fig. 1 with the stator removed as far as possible from the rotor so that the tubing fits between the stator and the rotor even when the tubing extends from a cassette. When pumping or a closed valve is desired, the stator is moved so that the rotor presses the tubing between the rollers of the rotor and the stator. This stops all flow. However, when the rotor rotates flow is forced or pumped through the tubing. The resilient members on the lever arms of the rollers enables the device to be built without extremely close tolerance.

While the principles of the invention have been described above in connection with specific apparatus and applications, it is to be understood that this description is made by way of example only and not as a limitation on the scope of the invention.

CLAIMS

1. A peristaltic pump comprising:
 - rotor means,
 - a plurality of roller means mounted to said rotor means to define a locus as said rotor means rotates,
 - fluid-carrying tubing in cassette means and extending therefrom,
 - stator means movable between an operating position wherein said tubing is forced into abutment with said locus and a loading position wherein the stator means is spaced apart from said rotor means facilitating positioning said tubing extending from the cassette means between said rotor means and said stator means, and
 - means for moving said stator means between said loading and operating positions.
2. The peristaltic pump of Claim 1, wherein said stator means moves linearly between said loading and operating positions.
3. The peristaltic pump of Claim 2 including means for maintaining the linearity of said stator movement.
4. The peristaltic pump of Claim 3, wherein said means for maintaining the linearity of said stator movement comprises a pair of slots on the stator movable on pins extending through said slots.
5. The peristaltic pump of Claim 4, wherein said slots are generally wider than said pins except at the ends thereof defining the operating position.
6. The peristaltic pump of claim 1 wherein said means for moving said stator means comprises cam means.
7. The peristaltic pump of Claim 6, wherein said cam means extends through a cam slot in said stator.
8. The peristaltic pump of Claims 4 and 7,

wherein said cam slot is positioned normal to said pair of slots.

9. The peristaltic pump of Claim 1 wherein said locus is a cylinder and wherein resilient means
5 maintain the position of said roller means removed

from said rotor means to define said locus.

10. A peristaltic pump substantially as hereinbefore described with reference to the accompanying drawings.