

[54] **ROLLER PUMP**

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[51] Int. Cl. .. **F04b 43/08, F04b 43/12, F04b 45/06**

[58] Field of Search..... **417/477, 475**

[56] **References Cited**

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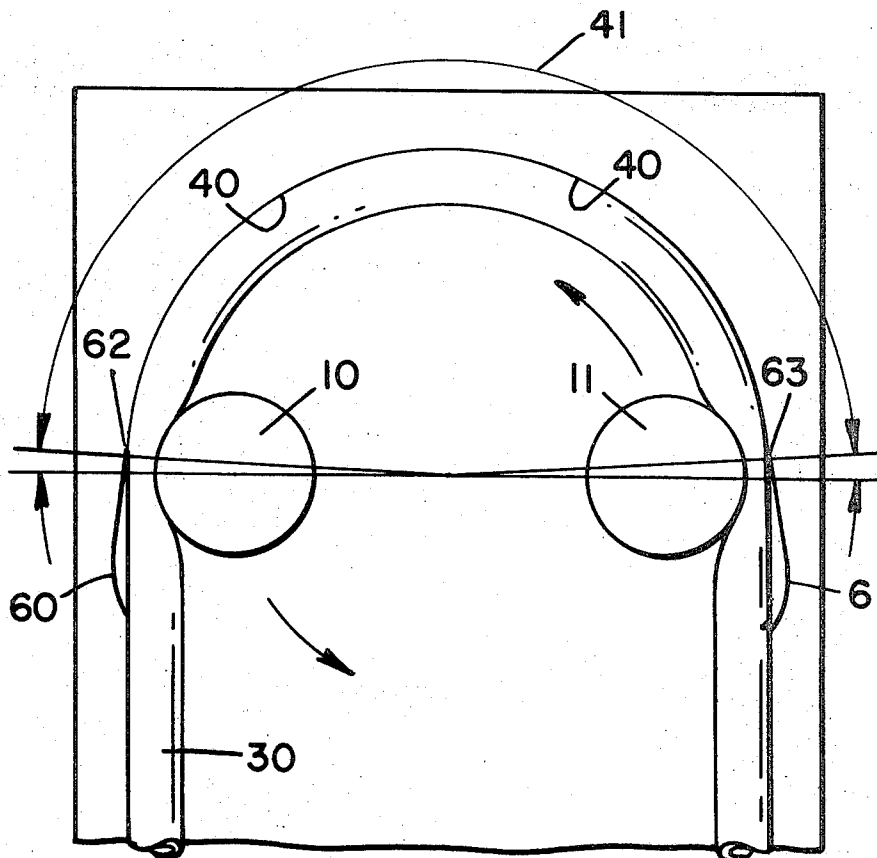
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[57] **ABSTRACT**

A roller pump with a pair of opposed rollers which travel in a circular path concentric with a bearing surface of angular length less than 180° and squeeze a flexible tube against the bearing surface. Lead ramps extend outwardly from the ends of the bearing surface so that as one roller begins to squeeze the flexible tube, the opposite roller begins to disengage said flexible tube; thereby providing a relatively constant driving torque and smooth operation of the pump.

6 Claims, 7 Drawing Figures



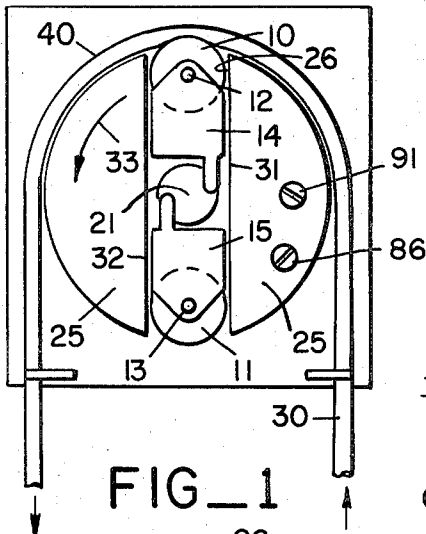


FIG_1

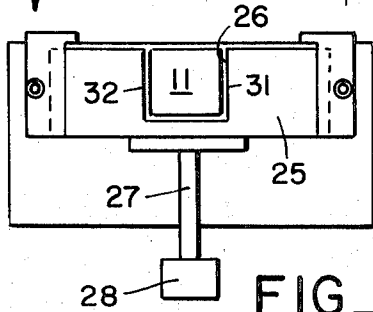


FIG_2

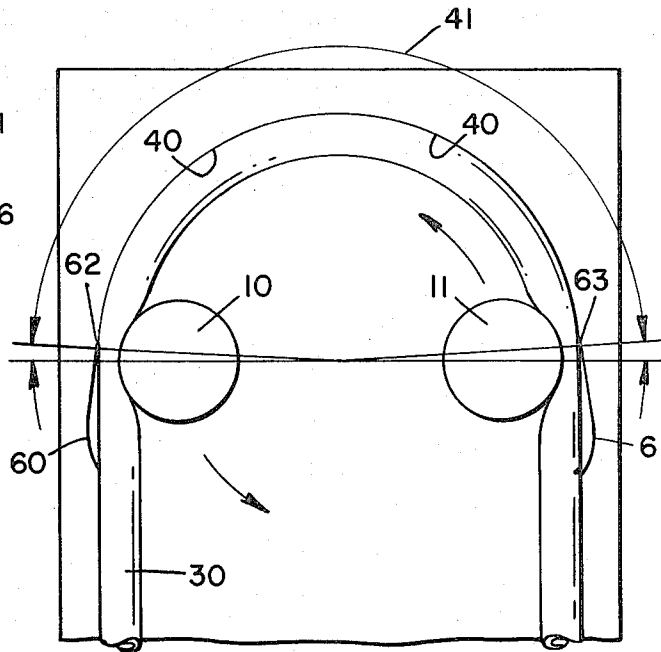


FIG_3

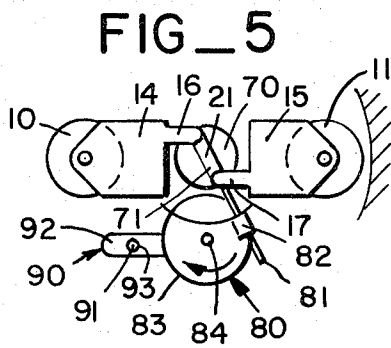


FIG_5

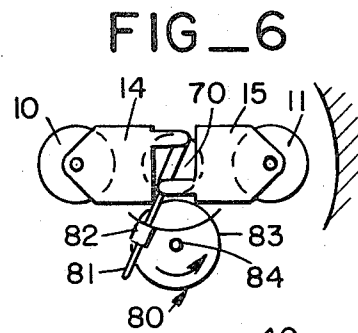


FIG_6

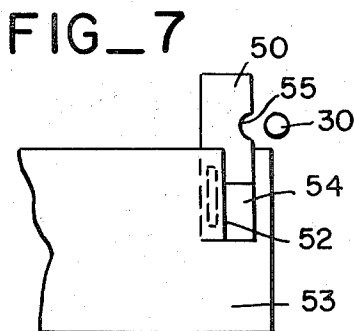


FIG_7

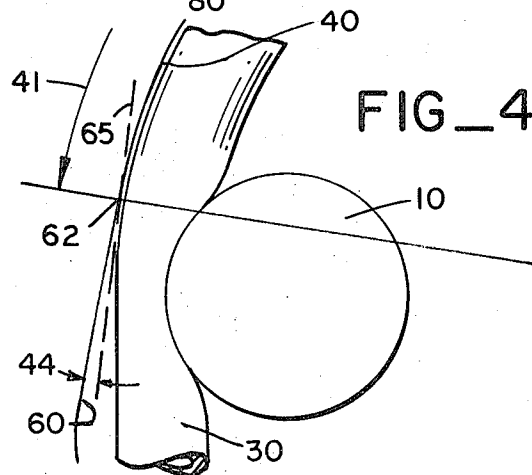


FIG_4

ROLLER PUMP

This invention pertains generally to roller pumps and more specifically to roller pumps designed to handle human blood.

Roller pumps have typically utilized opposed rollers to engage and squeeze a flexible tube which is carried by a semi-circular bearing surface. Bearing surfaces of the prior art are typically a full semi-circle, i.e., 180°. The opposed rollers are typically carried at 180° displacement from each other. Thus there is a point at which both rollers fully engage the flexible tubing, requiring twice the driving torque as compared to that necessary when only one of the rollers is engaged with the flexible tubing. This substantial variation in the torque requirements causes uneven pumping action.

It is exceedingly important when pumping human blood, as for example in conjunction with hemodialysis, that the pumping action be very smooth.

The instant invention pertains to a roller pump which is extremely reliable and operates evenly.

A primary object of this invention is to provide a roller pump which has a relatively constant driving torque and which operates smoothly and efficiently.

Another object of this invention is to provide a roller pump which because of the relatively constant and reduced torque requirement, may utilize a smaller, less powerful motor than would otherwise be needed.

A further object of this invention is to provide a roller pump in which the rollers may be readily adjusted to accommodate different sized flexible tubing and to facilitate removal of the flexible tubing from the pump.

Further objects and advantages of the invention will become apparent from the specification and drawings, in which:

FIG. 1 is a top view of the roller pump of this invention;

FIG. 2 is a side-elevational view, partly in section, of the pump shown in FIG. 1;

FIG. 3 is a schematic diagram showing the critical dimensions involved in the present invention;

FIG. 4 is an enlargement of a portion of FIG. 3, showing in exaggerated form the critical dimensions of the present invention;

FIG. 5 is a bottom view of a portion of the roller pump showing the adjustment mechanism thereof;

FIG. 6 is a bottom view showing the components of FIG. 5 in a different position; and

FIG. 7 is a side view, partly in section, showing the clamp used to hold the flexible tubing in the pump.

FIG. 1 shows opposed rollers 10 and 11 which rotate about axes 12 and 13 respectively. The rollers are carried pivotally by roller carriers 14 and 15 which rotate about axis 21. Axes 12, 13 and 21 in FIGS. 1, 3 and 5 are perpendicular to the plane of the drawing.

A rotor 25 carries rollers 10 and 11 and roller carriers 14 and 15 in slot 26 shown best in FIG. 2. Roller carriers 14 and 15 slidably fit between walls 31 and 32 of slot 26. Rotor 25 is attached to the output shaft 27 of an electric gear motor shown schematically as 28. As rotor 25 rotates about axis 21 due to the driving action of motor 28, walls 31 and 32 bear against roller carriers 14 and 15, causing roller carriers 14 and 15 and rollers 10 and 11 to move around the circular path indicated by arrow 33. The axes 12 and 13 of rollers 10 and 11 travel along a circular path concentric with bearing surface 40. In this embodiment, means for pivotally carry-

ing rollers 10 and 11 comprise roller carriers 14 and 15 respectively, and means for moving rollers 10 and 11 around the circular path comprises motor 28 and rotor 25.

Flexible tubing 30 is carried by arcuate bearing surface 40. As roller carriers 14 and 15 rotate about axis 21, rollers 10 and 11 pivot or rotate about axes 12 and 13 respectively and squeeze flexible tubing 30 against bearing surface 40, thereby pumping fluid such as blood through flexible tubing 30 in the direction of the arrows shown in FIG. 1. Clamps 50 and 51 prevent flexible tubing 30 from creeping around bearing surface 40 due to the action of rollers 10 and 11.

FIG. 3 is a schematic top view showing roller 11 as it begins to squeeze flexible tubing 30 against bearing surface 40 and roller 10 as it begins to disengage from flexible tubing 30. This is the point at which roller pumps of the prior art required increased torque to keep the pump operating smoothly. In this invention, the bearing surface 40 is arcuate over an angular length 41 which is less than 180°. Lead ramps 60 and 61 are provided at each end of the arcuate portion of bearing surface 40, lead ramp 60 starting at point 62 and lead ramp 61 starting at point 63. Line 65 as shown in FIG. 4 is the tangent at point 62 of the circle which includes bearing surface 40. Lead ramp 60 extends in an outward direction, the term "outward" as used in this specification and in the claims meaning in a direction away from axis 21 (which is the center or focus of bearing surface 40) and on the opposite side of tangent 65 from axis 21. Lead ramps 60 and 61 in the described embodiment are cut at an angle 44 of 10 degrees to tangent 65.

The effect of lead ramps 60 and 61 is to provide for disengagement of roller 10 to begin as roller 11 begins to squeeze flexible tube 30. "Disengagement" as used herein means reduction of occlusion of tube 30 by a given roller. During operation of the pump, it is necessary that flexible tube 30 be sufficiently occluded to prevent a backflow of fluid, such as blood, through the pump. Rollers 10 and 11 in the position shown in FIG. 3 must together provide sufficient occlusion of flexible tube 30 to prevent backflow while lead ramps 60 and 61 reduce the torque required to drive the pump through the position shown in FIG. 3. In this manner a relatively uniform torque demand is placed upon the driving motor, which facilitates the use of a much smaller motor than would be necessary otherwise.

The angular length 41 of bearing surface 40 bears a relationship to the diameters of rollers 10 and 11 and to the outer diameter and wall thickness of flexible tubing 30. As the wall thickness or outer diameter of flexible tubing 30 increases, the angular length 41 of bearing surface 40 should be decreased. Similarly if larger diameter rollers 10 and 11 are used, angular length 41 of bearing surface 40 should again be reduced. Conversely, if the thickness or outer diameter of flexible tube 30 or the diameter of rollers 10 and 11 is decreased, the angular length 41 of bearing surface 40 should be increased. In all cases however, the angular length 41 of bearing surface 40 will be less than 180°.

In the preferred embodiment, the diameter of rollers 10 and 11 is 1.125 inches, the thickness of flexible tubing 30 is one-sixteenth inch, the outer diameter of flexible tubing 30 is three-eighths inch, and the angular length 41 of bearing surface 40 is 177°. In this configu-

ration, a practical angle 44 for lead ramps 60 and 61 is 10°. If desired, only one lead ramp may be used, which in the above configuration would be cut at 20°.

When pumping blood, it is desirable to avoid full occlusion of flexible tube 30 since full occlusion crushes the blood cells. FIGS. 5 and 6 show bottom views of adjusting means carried by rotor 25 which facilitates the changing of flexible tubing used in the pump and which also facilitates varying the extent to which rollers 10 and 11 occlude flexible tubing 30.

The adjusting means comprises slot cam 70 positioned between rollers 10 and 11 and which pivots about its central axis 21, followers 16 and 17 which extend from roller carriers 14 and 15 respectively into slot 71 defined in slot cam 70, and means for rotating slot cam 70, shown generally as 80 in FIG. 5. As slot cam 70 is rotated clockwise from its position as shown in FIG. 5, rollers 10 and 11 are drawn closer to axis 21, as is shown in FIG. 6.

Means for angularly displacing slot cam 70 to selectively position rollers 10 and 11 relative to flexible tubing 30 is shown generally as 80 in FIGS. 5 and 6. A drive bar 81 extends from slot cam 70. Drive bar 81 extends slidably through pivotable slide block 82 which is carried by eccentric 83 which pivots about axis 84. Eccentric 83 is connected to adjusting shaft 86, the top of which is shown in FIG. 1. As eccentric 83 is pivoted, pivotable slide block 82 moves from one position as for example that shown in FIG. 5 to a position such as shown in FIG. 6, with drive bar 81 following, thereby angularly displacing slot cam 70. Adjusting means 80 therefore provides means to position rollers 10 and 11 in any desired position.

Locking means 90, also carried by rotor 25, is provided to engage eccentric 83 and lock it in place when rollers 10 and 11 are in the desired position. Locking means 90 may comprise a wedge lock 92 which frictionally engages cam 83 in the locked position, and locking shaft 91, the top of which is shown in FIG. 1. Locking shaft 91 has a tip of reduced diameter which carries a spring and which slidably extends through hole 93 in wedge lock 92. To release the lock, shaft 91 is rotated, driving wedge lock 92 downward and away from eccentric 83.

FIG. 7 is a side view showing in greater detail clamp 50 which is carried in slot 52 which extends into base 53 of the pump. Flexible tubing 30 is placed into mouth 55 of clamp 50. Clamp 50 is then pushed downwardly into slot 52, thereby moving flexible tubing 30 downward into opening 54 in base 53 and securing flexible tubing 30 in the position shown in FIG. 2, which prevents flexible tubing 30 from creeping around bearing surface 40 due to the action of the rollers 10 and 11.

I claim:

1. A pumping comprising,
 - an arcuate bearing surface with an angular length less than 180°,
 - a flexible tube carried by said bearing surface through which fluid may pass,
 - a single pair of rollers spaced 180° apart, the axes of which travel along a circular path concentric with said bearing surface,
 - means for moving said rollers around said circular path,
 - means for pivotally carrying said rollers,
 - said rollers squeezing said flexible tube surface for 180° as they travel around said circular path, and
 - a lead ramp extending outwardly from at least one end of said bearing surface so that as one roller begins to squeeze said flexible tube, the opposite roller begins disengaging said flexible tube.
2. A pump comprising,
 - an arcuate bearing surface with an angular length less than 180°,
 - a flexible tube carried by said bearing surface through which fluid may pass,
 - a pair of opposed rollers, the axes of which travel along a circular path concentric with said bearing surface,
 - means for moving the axes of said rollers around said circular path,
 - means pivotally carrying said rollers,
 - said rollers squeezing said flexible tube against said bearing surface as they travel around said circular path,
 - adjusting means for varying the extent to which said rollers occlude said flexible tubing, and
 - lead ramps extending outwardly from each end of said bearing surface so that as one roller begins to squeeze said flexible tube, the opposite roller being disengaging said flexible tube.
3. The device of claim 2 in which said lead ramps extend outwardly at an angle of 10°.
4. The device of claim 2 in which said bearing surface extends for 177°.
5. The device of claim 2 in which said adjusting means comprises,
 - a pivotable slot cam positioned between said rollers,
 - a follower extending from each roller carrier into the slot of said slot cam, and
 - means for angularly displacing said slot cam to selectively position said rollers relative to said flexible tubing.
6. The device of claim 5 further comprising locking means for locking said slot cam in a selected position.

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