Feb. 20, 1962 L. L. BOLSTAD 3,021,793

FLUID PUMP

Filed Dec. 9, 1959

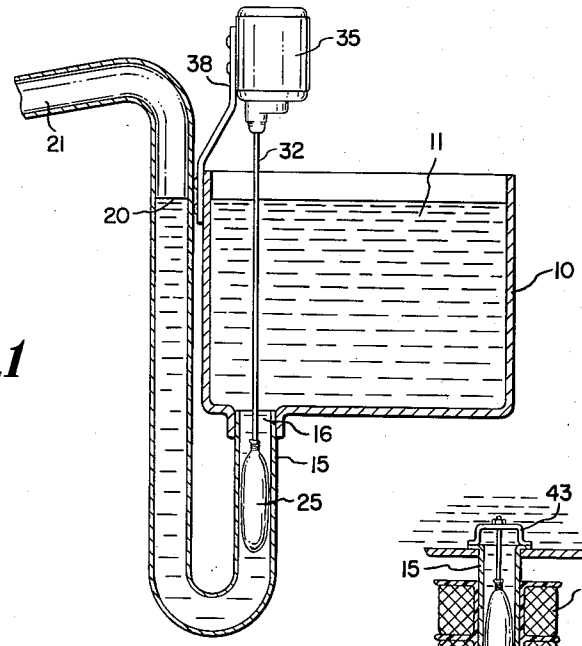

Fig. 1

Fig. 7

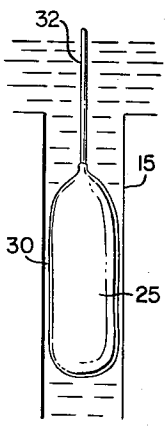

Fig. 2

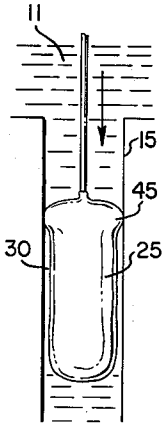

Fig. 3

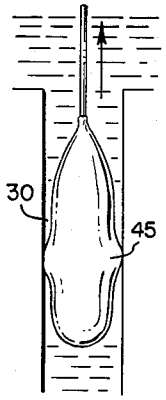

Fig. 4

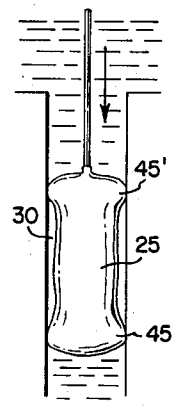

Fig. 5

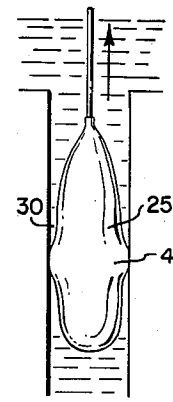

Fig. 6

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FLUID PUMP

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My invention relates to pumps and more particularly to an improved pump of the valveless type.

The design and manufacture of pumps is well established and highly developed. Pumps have taken many forms in defining or establishing variable volume chambers to provide for displacement or flow through the pump, and many valving configurations to control the entrance and exit for exhaust of fluid being pumped therethrough. In addition the field of valveless pumps include other types which do not operate on the variable volume principle but rather utilize the characteristics of the fluid, such as conductivity or expansion to cooperate with a motivating source and provide the pumping action. The present disclosure is directed basically to the variable volume type pump utilizing basically a new piston or chamber configuration. It is also specifically applicable to a valveless type pump. My improved valveless pump design is particularly applicable to the pumping of fluids which could be mechanically damaged by the use of valves or mechanical surfaces which squeeze portions of the fluid to effect the characteristics of the same. For example this improved pump design is particularly applicable to pumping of human blood which because of its nature is particularly susceptible to mechanical damage. However, it should be noted that this particular pump design is applicable for pumping of any type of fluid and is particularly desirable because of its simplicity in structure. It is therefore an object of this invention to provide an improved valveless type pump. Another object of this invention is to provide an improved pump of this type for pumping fluids which are susceptible to mechanical damage such as human blood. A further object of this invention is to provide an improved valveless type pump operated by the generation of waves on a piston member of the pump which cooperates with an enclosing casing to generate a variable volume chamber which moves the fluid through the pump. A still further object of this invention is to provide an improved pump of this type which is simple in design and economical to manufacture and maintain. These and other objects of this invention will become apparent from a reading of the attached description together with the drawings wherein;

FIGURE 1 is a schematic disclosure of the pump, and FIGURES 2, 3, 4, 5, and 6 are schematic disclosures of portions of the pump in various stages of operation.

FIGURE 7 is a schematic drawing of a portion of the pump showing another embodiment of the invention.

As will be seen in FIGURE 1, the schematic disclosure of the pump includes a container or reservoir indicated at 10 designed to contain a fluid medium indicated at 11 which is to be pumped. Reservoir 10 has a cylindrical passage or conduit 15 attached thereto, shown at the bottom of the reservoir 10 with an open extremity 16 or inlet communicating with the reservoir 10 such that fluid may pass therethrough. The conduit as shown in FIGURE 1 is bent so that the fluid flow will not be normally passed therethrough due to gravitational effects but rather will be trapped at the height of the fluid in the container such as is indicated as 20 in FIGURE 1. The extremity of the conduit 15 indicated at 21 forms the outlet for the pump to which connection may be made to receive the outlet from the pump. Positioned in the conduit 15 is a cylindrical member 25 or piston-like member which acts

to move the fluid through the conduit 15, as will be later described. Piston or cylindrical members 25 is made basically of an elastic material which may be solid or hollow but is capable of having a wave generated on the surface of the same which will advance down the length of the piston or member in a rolling type action in accordance with a frequency of oscillation imparted to the same. The clearance between the piston member 25 and the conduit 15 will define a gap area, better seen in FIGURES 2 through 6 (and indicated at 30) through which the fluid will move. The cylindrical member or piston or blob will be of the undulating type upon shock or oscillation being imparted thereto. This member may be made of a soft gel-like material substantially uniform in density which will not absorb the oscillation or shock imparted thereto but will rather, as previously indicated, generate a wave on the surface of the same. Actually the piston may be made of a latex type bag filled with a fluid, such as a rubber balloon with the liquid or fluid therein being non-shock absorbing. The dimensional clearance of the gap will be determined basically by the characteristics of the piston material such that the waves generated thereon, as will be seen in FIGURES 3–6, touch or be positioned closely to the walls of the conduit 15 such that it will present a variable volume chamber moving down the side of the piston or plug advancing the fluid through the gap from inlet to outlet. Actually the clearance between the piston and the conduit will depend upon the amplitude of the waves produced, the main feature being that there will be a minimum amount of backflow from outlet to inlet with the operation of the piston. The frequency of oscillation of the cylindrical member or plug should be such that at least one wave and preferably two appear on the surface of the piston at a given time thus forming an annular volume or a succession of annular volumes moving down the piston. The velocity of the wave will be determined by the density difference between the piston material and fluid as well as the rigidity of the piston.

In FIGURE 1 the piston is shown as actuated mechanically by means of a shaft 32 to which the piston is suitably attached by means not shown, the shaft being driven by an oscillating type motor or driver 35 which in effect is a frequency generator or oscillator imparting shocks to the piston. This motor is mounted or clamped by means of a suitable bracket 38 to the walls of the container or reservoir 10 such that the piston will remain fixed relative to the conduit and the fluid will advance from the reservoir 10 through the outlet 21.

The driver could also be activated electromagnetically by an external coil positioned around the conduit and being influenced by a suitable magnetic means positioned inside the piston. This will make it possible to pump fluid in the closed system containing no valves or packing glands. FIGURE 7 shows schematically a magnetic coil arrangement indicated at 40 which cooperates with an internally positioned piston-like member 42 including a cooperating magnetic part 44, the member 42 positioned in the conduit 15. The piston type member 42 is positioned with respect to the conduit by means of a support or bracket indicated at 43 attached to the conduit when allowing flow passages from the inlet to the conduit.

In FIGURE 2 a portion of the apparatus is shown with the piston member 25 positioned in the conduit 15 without any waves being generated thereon, this being an indication of the rest position of the device. FIGURE 3 shows an initial shock or oscillation imparted to the piston-like member 25 generating a wave such as is indicated at 45 from a surface thereof which wave will touch or substantially touch the walls 15 of the conduit. Fluid in the conduit ahead of the wave will be trapped and be forced in the gap 30 between the piston and the

conduit advancing with the movement of the waves, such as is indicated in FIGURE 4 which shows the wave in an intermediate position. A change in direction of oscillation will continue to advance the wave toward the extremity of the piston forcing the fluid ahead of the same as the shock is imparted to the piston in the opposite direction. FIGURE 5 shows the piston 25 in the condition where one wave 45 has advanced to the extremity of the piston forcing the fluid ahead of the same and a second wave 45' is being generated at the upper surface thereof trapping fluid and advancing the same through the gap. FIGURE 6 is similar to FIGURE 4 in that the initial wave has now subsided and the second wave 45' has advanced substantially along the length of the piston 25 forcing the fluid ahead of the same.

While I have shown a cylindrical piston member and a cylindrical conduit, it may be recognized that these parts may take any configuration desired. Similarly, as in FIGURE 7, the piston may include a portion of the motor or oscillating apparatus which generates the shock or oscillation and a cooperating or energizing port being included around the outer portion of the conduit instead of being mechanically attached thereto. Further while a single wave is shown generated on the surface of the piston member, in actual fact a plurality of waves are generated on the same making a series of annular volumes which advance the fluid down the walls of the conduit in the gap between the piston-like member or cylindrical member on the conduit 50.

The particular pump disclosed herein is particularly adaptable for use with human blood flow as an artificial heart or mechanical heart in that it includes no valving members which mechanically damage through pinching or clamping the blood to destroy the balance between the red and white corpuscles of the same. In this improved pump, a soft piston member has waves generated upon the same which roll or advance down the sides of the container urging blood flow ahead of the same to prevent any mechanical breakdown or damage to the blood. It should be recognized, however, that the apparatus is particularly adaptable for uses other than pumping this type of fluid and the simplicity of the structure makes it economical to manufacture and maintain.

In considering this invention it should be remembered that the present disclosure is illustrative only and I wish to be limited only by the appended claims.

I claim:

1. A fluid pump comprising, a casing, a piston type member positioned in said casing and providing a gap therebetween, a fluid supply source common to one end of said casing and outlet means connected to the other end of said casing, and means included in part with said piston member to impart a plurality of shocks thereto at a predetermined frequency to oscillate said piston member in said casing, said piston member being made of an elastic material such that said shocks imparted thereto generate waves on the surface thereof which cooperate with the casing to force fluid through said gap in the direction of propagation of said waves.

2. A fluid pump comprising, a casing, a piston type member positioned in said casing and providing a gap therebetween, a fluid supply source common to one end of said casing and outlet means connected to the other end of said casing, and means connected in part to said piston member to impart a plurality of shocks thereto at a predetermined frequency to oscillate said piston member in said casing, said piston member being made of an elastic material such that said shocks imparted thereto generate waves on the surface thereof which cooperate with the casing to force fluid through said gap in the direction of propagation of said waves.

3. A fluid pump comprising, a casing, a piston type member positioned in said casing and providing a gap therebetween, a fluid supply source common to one end of said casing and outlet means connected to the other end of said casing, and means including in part with said piston member to impart a plurality of shocks thereto at a predetermined frequency to oscillate said piston member in said casing, said piston member being made of a soft gel-like material being flexible in form such that said shocks imparted thereto generate waves on the surface thereof which cooperate with the casing to force fluid through said gap in the direction of propagation of said waves.

4. A fluid pump comprising, a casing, a piston type member positioned in said casing and providing a gap therebetween, a fluid supply source common to one end of said casing and outlet means connected to the other end of said casing, and means included in part with said piston member to impart a plurality of shocks thereto at a predetermined frequency to oscillate said piston member in said casing, said piston member having an elastic surface and being filled with a non-shock absorbing material such that said shocks imparted thereto generate waves on the surface thereof which cooperate with the casing to force fluid through said gap in the direction of propagation of said waves.

5. A fluid pump comprising, a casing, an elastic plug positioned in said casing and providing a spacing therebetween, an inlet and an outlet means for fluid at the extremities of said casing, said plug being made of an elastic material the surface of which will have waves generated thereon upon oscillation of said plug at a predetermined frequency, and driving means connected to said plug for oscillating the same at said frequency to generate waves of sufficient magnitude to cooperate with said casing to provide a pumping action.

6. A fluid pump comprising, a casing, an elastic plug positioned in said casing and providing a spacing therebetween, an inlet and an outlet means for fluid at the extremities of said casing, said plug being made of an elastic material the surface of which will have waves generated thereon upon oscillation of said plug, and a driving means connected to said plug for oscillating the same at a predetermined frequency, the elasticity of the material in said plug and the frequency of oscillation of said driving means being such that a plurality of waves are generated on the surface of the plug at any given time to cooperate with said casing and provide a pumping action.

7. A fluid pump comprising, a casing, a plug positioned in said casing and providing a spacing therebetween, an inlet and an outlet means for fluid at the extremities of said casing, said plug being made of an elastic material the surface of which will have waves generated thereon upon oscillation of said plug above a predetermined range of frequency, the waves on the surface of said plug cooperating with said casing to form variable volume chambers with said casing which advance from said inlet toward said outlet in said casing with oscillation of said plug, and driving means connected to said plug for oscillating said plug at a frequency of oscillation to provide a pumping action through the formation of said variable volume chambers.

8. A fluid pump comprising, a cylindrical casing, a cylindrical member positioned in said casing and providing a spacing therebetween, inlet and outlet passage means at the extremities of said casing, said cylindrical member being made of an elastic material and adapted to be oscillated at a predetermined frequency in said casing so as to generate waves on the surface thereof, said waves on said surface of said cylindrical member cooperating with said casing to form a succession of annular volumes moving along said casing and adapted to advance a fluid entering said casing at said inlet toward the outlet of said casing, and driving means being fixed relative to the casing and connected to said cylindrical member to oscillate the same at said frequency to generate the waves thereon.

9. A fluid pump comprising, a container, a fluid medium positioned in said container and adapted to be pumped,

outlet means, conduit means connecting said container and said outlet means and being so positioned that flow does not normally flow therethrough, an elastic piston positioned in and spaced from said conduit means and adapted to have waves generated on the surface thereof upon oscillation of said piston at a predetermined frequency which cooperate with the surface of said conduit means to move the fluid medium through said conduit means, and means for oscillating said piston to generate said waves while maintaining said piston in a relatively fixed relationship to said conduit means.

10. A fluid pump comprising, a reservoir, a fluid medium positioned in said reservoir adapted to be pumped, outlet means, conduit means connecting said reservoir and said outlet means, an elastic piston positioned in and spaced from said conduit means and adapted to have waves generated on the surface thereof upon oscillation of said piston at a predetermined frequency which cooperate with the surface of said conduit means to move the fluid medium through said conduit means, and means fixed in part relative to said conduit means and connected in part to said piston for oscillating said piston to generate said waves.

11. A fluid pump comprising, a reservoir, a fluid medium positioned in said reservoir adapted to be pumped, outlet means, conduit means connecting said chamber and said outlet means, an elastic piston positioned in and spaced from said conduit means and adapted to have waves generated on the surface thereof upon oscillation

of said piston at a predetermined frequency which cooperate with the surface of said conduit means to move the fluid medium through said conduit means, and shock generation means included in part with said piston and imparting a shock to said piston to generate said waves.

12. A fluid pump comprising, a reservoir, a fluid medium in said reservoir adapted to be pumped, outlet means, conduit means connecting said reservoir and said outlet means and being positioned relative thereto that flow of the fluid medium from said reservoir does not normally flow therethrough, an elastic piston positioned in and spaced from said conduit means and adapted to have a plurality of waves generated on the surface thereof upon oscillation of said piston, and shock generation means included in part with said piston and imparting a shock to said piston to oscillate said piston at a predetermined frequency to generate said waves, the dimensions of said conduit means and said piston and the material forming said piston being such that the spacing between said piston and said conduit means is substantially filled by the waves generated on the surface of said piston to provide a succession of volumes of fluid medium advancing along the surface of said piston during said oscillation.

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