

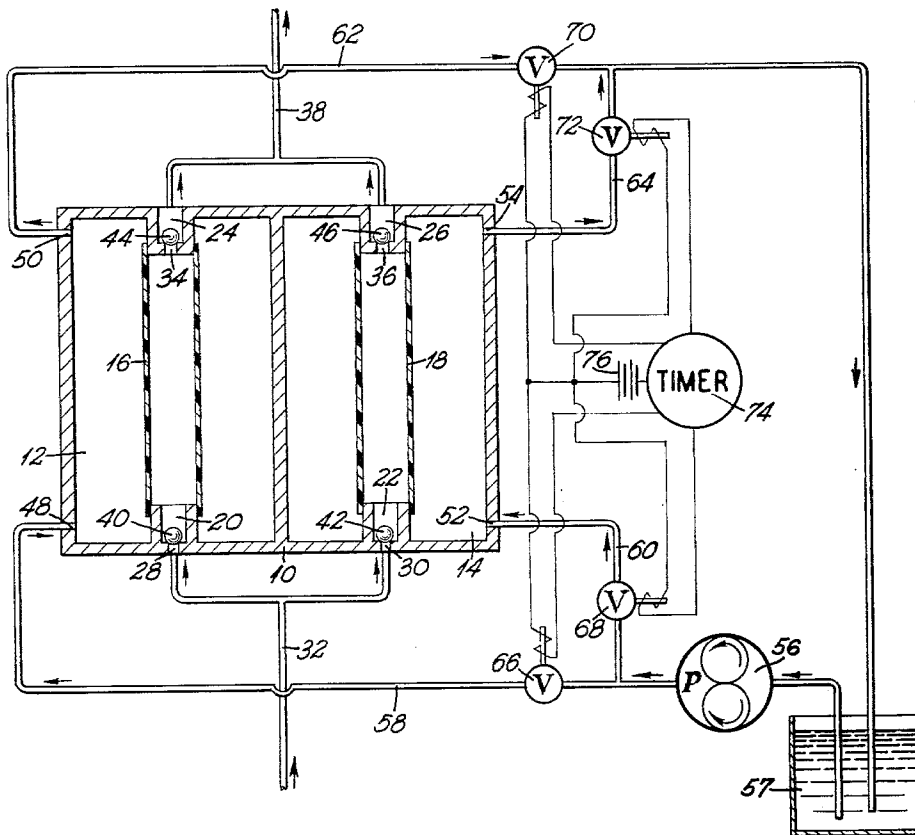
May 10, 1966

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3,250,226

HYDRAULIC ACTUATED PUMPING SYSTEM

Filed Sept. 8, 1964



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3,250,226

HYDRAULIC ACTUATED PUMPING SYSTEM

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Filed Sept. 8, 1964, Ser. No. 394,658

3 Claims. (Cl. 103—152)

This application is a continuation-in-part of application Serial No. 241,319, filed November 30, 1962, now abandoned, in the name of Walter D. Voelker.

This invention relates to fluid pumping apparatus and particularly to pumping apparatus of the peristaltic type which is adapted to deliver a constant volumetric flow of fluid.

Heretofore, there have been pumps in which the pumped fluid flowed through a flexible tube which was subjected to alternate application and release of hydraulic pressure whereby the fluid was advanced through the tube in a peristaltic manner. Such pumps are particularly useful in handling corrosive or foaming liquids which are not conveniently handled by more conventional pumps, since the pumped fluid is in contact with essentially only the flexible tube rather than the main body of the pump and a non-corrosive, easily handled, hydraulic fluid can be utilized to impart the pressure to the flexible tube, but suffer from the disadvantage that the flow of pumped fluid is a pulsating flow. The pumping apparatus of the present invention is an improved pump operating on this same basic principle which utilizes a combination of a constant output hydraulic pump and a fast-acting cyclically operated valve system to provide a continuous flow of pumped fluid at a substantially constant volumetric rate.

It is an object of this invention to provide fluid pumping apparatus that avoids the difficulties of the prior art pumps referred to hereinabove. A further object of this invention is to provide fluid pumping apparatus of the peristaltic type which is capable of delivering a substantially constant volumetric flow of pumped fluid. A still further object of this invention is to provide a simple and inexpensive pumping apparatus, utilizing collapsible tubes through which the pumped fluid is directed by application and release of the pressure of a hydraulic fluid surrounding the tubes, which is capable of providing a substantially constant flow of fluid.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing which is a schematic, partially sectional, view of an embodiment of the present invention.

Referring now to the drawing, the fluid pumping apparatus is shown as comprising an enclosed housing 10 containing two separate hydraulic chambers 12 and 14 which respectively enclose collapsible tubes 16 and 18 that are retained in position by inlet heads 20 and 22 and by outlet heads 24 and 26 to which they are sealed by, for example, clamp rings (not shown). Collapsible tubes 16 and 18 can be made of polyethylene or other suitable material capable of withstanding repeated flexure without rupturing. Disposed within each of inlet heads 20 and 22 are inlet conduits 28 and 30 which communicate with the inlet sides of collapsible tubes 16 and 18 respectively and also with the pumped fluid supply line 32; while disposed within each of outlet heads 24 and 26 are outlet conduits 34 and 36 which communicate with the outlet sides of collapsible tubes 16 and 18 respectively and also with the pumped fluid discharge line 38.

At the inlets of collapsible tubes 16 and 18, there are located inlet ball check valves 40 and 42 respectively while at the respective outlets there are located outlet ball check valves 44 and 46. These four check valves function together to restrict the flow of pumped fluid through col-

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lapsible tubes 16 and 18 to a single direction, that is, they permit flow from the inlet side to the outlet side only. In each instance the ball of the check valve is positioned above the plate defining the exit of the respective inlet or outlet conduit and seats so as to close off the conduit. Suitable springs (not shown) are employed to retain the ball in a seated position until such time as the fluid pressure exerted against the ball is sufficient to unseat it.

Hydraulic chamber 12 is provided with means for admitting hydraulic fluid to the annular space surrounding collapsible tube 16 and for exhausting hydraulic fluid from this space; such means comprising an inlet port 48 and an outlet port 50. Similarly, hydraulic chamber 14 is provided with an inlet port 52 and an outlet port 54. A constant output hydraulic pump 56 is connected from its discharge side by conduits 58 and 60 to inlet ports 48 and 52 respectively of hydraulic chambers 12 and 14, and from its suction side to sump or reservoir 57 into which conduits 62 and 64, connecting respectively to outlet ports 50 and 54 of hydraulic chambers 12 and 14, are discharged. The constant output hydraulic pump 56 is shown as a gear pump but other pumps capable of delivering a constant volumetric output could also be employed.

The flow of hydraulic fluid to hydraulic chambers 12 and 14 is controlled by electrically operated solenoid valves 66 and 68 located in conduits 58 and 60 respectively and by similar electrically operated solenoid valves 70 and 72 located in conduits 62 and 64 respectively. The cyclic operation of these four valves is controlled by timer 74 which is connected to a source of electric current 76 and to each of the electrically operated solenoid valves and which serves to open and close the valves in sequence so as to alternately admit the hydraulic or actuating fluid continuously impelled by hydraulic pump 56 to hydraulic chambers 12 and 14. The electrically operated solenoid valves 66, 68, 70 and 72 are fast-acting valves, e.g. valves capable of passing from a fully open position to a fully closed position in about 0.01 second or less, so that the application and release of hydraulic pressure applied to collapsible tubes 16 and 18 will be very rapid and consequently the flow of pumped fluid will occur in very closely spaced pulses so as to give in effect a continual substantially constant flow. These valves are operated by the timer and connecting circuitry at a set rate which can be varied by adjustment of the timer and since such operation is not regulated by the degree of collapse of collapsible tubes 16 and 18, as with certain prior art devices, the valves operate at a cyclic rate which is independent of pressure obtaining in hydraulic chambers 12 and 14. The cyclically operated valve system need not consist of a timer and electrically operated solenoid valves as illustrated but can be any other valve system capable of providing the rapid cyclic operation required. For example, the cyclic valve system may comprise spring-loaded valves biased to a closed position with projecting operating stems slideably contacting opening cams arranged on a shaft driven by the same motor that drives hydraulic pump 56, an arrangement somewhat similar to that found in the multiple exhaust-intake cam driven valves in conventional internal combustion engines. Any other functionally equivalent arrangement is considered suitable as a routine mechanical expedient as to this part of the present invention.

In operation, pump fluid is continually supplied to supply line 32 at low pressure by a gravity feed system, or if desired by a low pressure pump, and is continually discharged through discharge line 38. Constant output hydraulic pump 56 is operated continuously to direct the actuating fluid to hydraulic chambers 12 and 14, with the actuating fluid flowing from one of chambers 12 and 14 to sump 57 and thence to the suction side of hydraulic pump 56 while simultaneously being directed into the other of chambers 12 and 14 from the discharge side of hy-

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draulic pump 56. This operation is effected by means of timer 74, which functions to open and close solenoid valves 66, 68, 70 and 72, in appropriate sequence. At an instant when solenoid valves 66 and 72 are open solenoid valves 68 and 70 are closed. Accordingly, hydraulic fluid is pumped from hydraulic pump 56 through conduit 58 and into hydraulic chamber 12 by way of inlet port 48 whereby the hydraulic pressure within hydraulic chamber 12 is increased and in consequence a squeezing action is exerted on collapsible tube 16. This squeezing action causes ball check valve 40 to close and ball check valve 44 to open and pumped fluid within collapsible tube 16 to be impelled through outlet conduit 34 and into discharge line 38. At the same time that pumped fluid is being expelled from collapsible tube 16, additional pumped fluid is entering collapsible tube 18, which will have been partially collapsed as a result of the previous cycle of operation, through inlet conduit 30 and past ball check valve 42 so as to expand collapsible tube 18 to its original configuration and simultaneously expel actuating fluid from hydraulic chamber 14 through outlet port 54, conduit 64 and open solenoid valve 72 to sump 57. At the point where collapsible tube 18 has expanded to its normal configuration, collapsible tube 16 will have reached a condition of maximum contraction and timer 74 will simultaneously close solenoid valves 66 and 72 and open solenoid valves 68 and 70. This will result in a flow of actuating fluid through valve 68 and into hydraulic chamber 14 by way of inlet port 52 so as to increase the pressure in hydraulic chamber 14 and squeeze collapsible tube 18 and thereby expel pumped fluid from collapsible tube 18 through outlet conduit 36 and into discharge line 38. At the same time actuating fluid from within hydraulic chamber 12 will flow through outlet port 50, conduit 62, and open solenoid valve 70 to sump 57. It is thus apparent that while hydraulic pump 56 continually impels the actuating fluid at a fixed volumetric rate the cyclic operation of the electrically operated solenoid valves admits the actuating fluid to hydraulic chambers 12 and 14 alternately and an alternating increase and decrease of hydraulic pressure within hydraulic chambers 12 and 14 is thereby attained. Moreover, it will also be apparent that the volume of pumped fluid expelled through discharge line 38 will be the same as the volume of actuating fluid pumped by hydraulic pump 56 and since hydraulic pump 56 is a pump that provides a substantially constant output, the flow of pumped fluid will take place at a substantially constant volumetric rate. Also, since the cyclically operated solenoid valves are fact-acting valves, the pulsations in the flow of pumped fluid will be very close together and as a result the flow of pumped fluid will be a substantially continuous or non-pulsating flow.

The materials of construction employed in the pumping apparatus of this invention are not critical so that any suitable materials can be used. However, all conduits in the pumping apparatus should be constructed of rigid tubing so that no volumetric change in the system can occur except through the contraction of collapsible tubes 16 and 18 which are composed of a suitable flexible material such as polyethylene. To guard against possible damage to collapsible tubes 16 and 18 due to excessive flexing, rigid perforated tubes (not shown) are preferably mounted so as to surround each of the collapsible tubes.

The pumping apparatus of this invention finds application wherever corrosive or abrasive fluids, foaming or reactive fluids, or fluids otherwise difficult to handle in conventional pumps are encountered. It is of particular utility where such fluids must be dispensed at a substantially constant volumetric rate. An example of a situation wherein the pumping apparatus disclosed herein finds particular application is in the pumping of polyurethane foam-forming compositions in processes for continuous production of polyurethane foam articles. In such processes the ma-

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terial to be pumped is a relatively viscous reactive liquid consisting of a mixture of several components which interact chemically. This material must be dispensed at an exact and constant flow rate without surging, and holdup in the pumping apparatus must be avoided because of the reactive nature of the material. The pumping apparatus of this invention is obviously well suited to such application.

It will be obvious to those skilled in the art to which this invention appertains that many structural details may be changed or minor modifications made without departing from the spirit and scope of the invention. It is possible, for example, in the light of the foregoing description, to multiplex the apparatus to more than two chambers and sets of collapsible tubes, with appropriate additional valves and timer points, and thus produce and even more continuous and smooth discharge of a pumped fluid. It is accordingly intended that all such changes and modifications be included within the scope of the following claims.

What is claimed is:

1. Fluid pumping apparatus for delivering a constant volumetric flow of fluid comprising, in combination:

- (a) an enclosed housing containing a pair of hydraulic chambers;
- (b) a collapsible tube disposed within each of said hydraulic chambers;
- (c) an inlet conduit for supply of a pumped fluid communicating with an inlet side of each of said collapsible tubes;
- (d) an outlet conduit for delivery of said pumped fluid communicating with an outlet side of each of said collapsible tubes;
- (e) valve means disposed at the inlet and outlet of each of said collapsible tubes for restricting flow of pumped fluid therethrough to a single direction;
- (f) a constant output hydraulic pump;
- (g) a reservoir for an actuating fluid communicating with the suction side of said hydraulic pump;
- (h) first conduits connecting the discharge side of said hydraulic pump to each hydraulic chamber;
- (i) second conduits connecting each hydraulic chamber to said reservoir;
- (j) cyclically operated fast-acting valve means disposed in each of said first and second conduits for alternately admitting the actuating fluid impelled by said hydraulic pump to each of said hydraulic chambers; and
- (k) control means operatively connected to said cyclically operated valve means for operation thereof at a cyclic rate which is independent of pressure obtaining in said hydraulic chambers; whereby the actuating fluid flows from one of said hydraulic chambers to said reservoir while simultaneously being directed into the other of said hydraulic chambers from the discharge side of said hydraulic pump to thereby effect successive alternate increases and decreases of hydraulic pressure in each of said hydraulic chambers and accordingly to subject said collapsible tubes to successive alternate squeezing and impel said pumped fluid at a substantially constant volumetric rate.

2. Apparatus as claimed in claim 1 wherein said valve means for restricting flow of pumped fluid are ball check valves.

3. Apparatus as claimed in claim 1 wherein said cyclically operated valve means are solenoid valves.

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