

March 6, 1962

E. THIELE
VALVELESS PUMP

3,023,708

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2 Sheets-Sheet 1

Fig.1

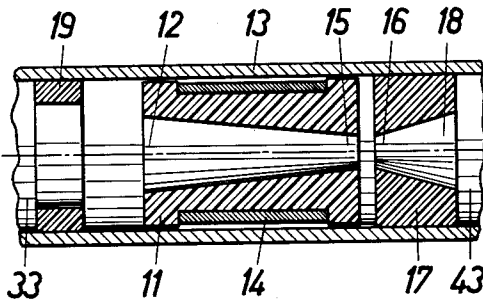


Fig.2

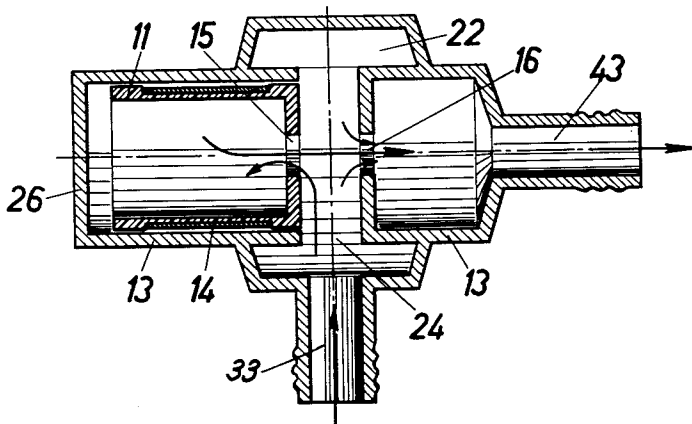
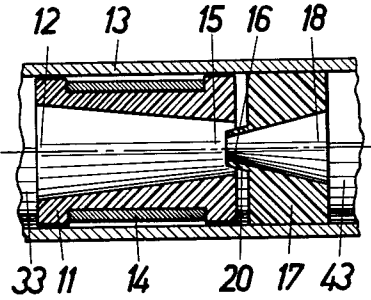


Fig.3

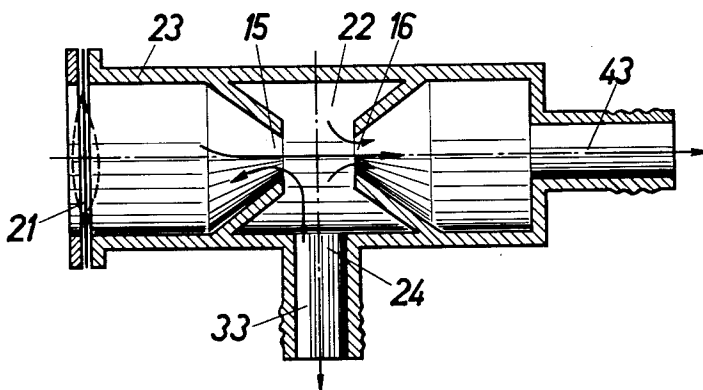


Fig.4

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2 Sheets-Sheet 2

Fig.5

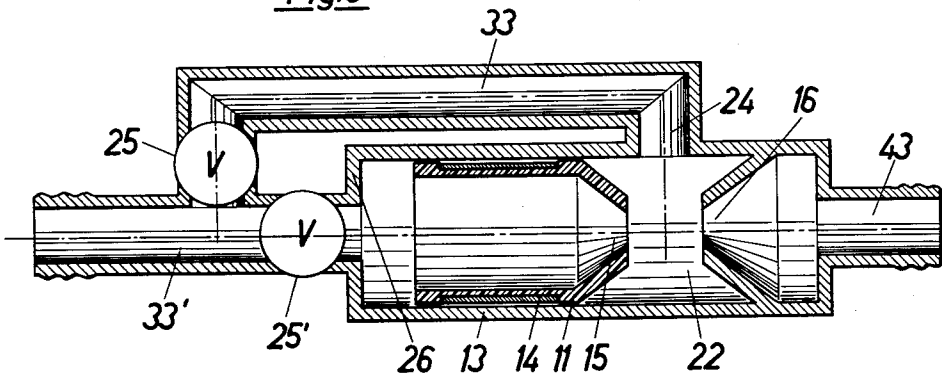
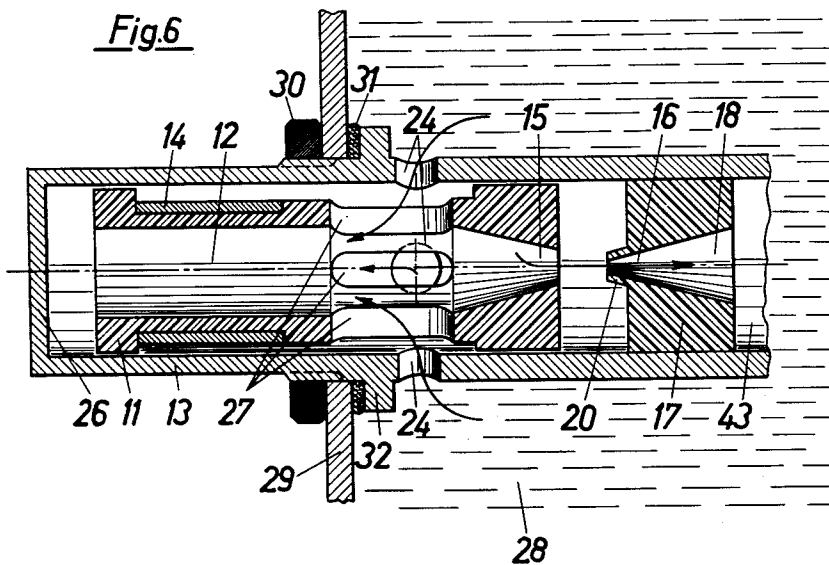


Fig.6



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1

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VALVELESS PUMP

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16 Claims. (Cl. 103—53)

This invention relates to pumps having liquid handling pistons or diaphragms which oscillate at high speed and which are particularly driven electromagnetically. In most types of pumps of this kind the direction of handling is determined by valves, which are arranged either in the pipe system or in the oscillating piston itself. At least in the latter case the piston has a through passage controlled by a valve. All these pumps have disadvantages which are peculiar to valve pumps and which reside in that the valve seats are liable to become leaky or that the valves can be clogged or highly stressed valve parts are liable to break. Besides, the valves oscillating at high speed must be of particularly light weight construction owing to the inertia and the small operating forces and for this reason will not withstand particularly high stresses. Moreover, the efficiency of valves operated at high speed is rather poor owing to the high velocities of flow therethrough, involving high turbulence and a consumption of energy.

In order to avoid these disadvantages, valveless pumps have already been described the oscillating pistons of which have also at least one flow passage parallel to the piston axis. In these types of pumps the handling is mainly due to the fact that the flow passage has the shape of a nozzle tapering in the direction of flow. However, the handling effect of such pumps is very small and sufficient only for a few specific purposes. Other solutions reside in that the piston has imparted thereto a non-uniform motion, comprising a high speed forward movement and a slow return movement. These proposals have previously remained without significance, however, particularly because a direct mechanical control of the piston or of a diaphragm involves mechanical difficulties and an indirect electromagnetic control of this type is complicated.

It is an object of the invention to provide a valveless pump comprising a cylinder, a member which oscillates in said cylinder at high speed and imparts motion to the liquid to be handled, at least one handling duct disposed in the path of the moved liquid, and at least one stationary constriction in the discharge path close to the outlet opening of the handling duct in the target direction of the liquid jet emerging from said handling duct.

It is another object of the invention to drive the high-speed oscillating part electromagnetically according to a sine function.

According to the invention a considerable increase in the handling effect of such pumps is achieved in that at least one stationary constriction is arranged in the discharge path close to the outlet opening of the handling duct in the target direction of the liquid jet, the cross-section of which constriction is approximately of the order of magnitude of the cross-section of the outlet opening.

Another desirable feature of the invention resides in that the constriction is formed by the end of a duct which widens in the direction of flow and is provided in a fitting. The fitting which is formed with the duct and the constriction may be slidable in the cylinder or tube forming the liquid path relative to the outlet opening of the flow passage in order to enable an adjustment. During operation the fitting is clamped in position. According to another feature of the invention the inlet passage for the liquid is formed by that end of the cylinder which is opposite to the constriction.

2

Some advantageous embodiments of the invention are shown by way of example in the figures of the drawings in sectional views taken through the center lines of the cylinders or pump tubes. FIG. 1 shows more particularly the arrangement of the constriction in the form of a duct which widens in the direction of flow and FIG. 2 shows the pipe-like extension of the fitting forming the constriction, which extension extends into the outlet opening of the handling duct. Both figures relate to pumps in which the inlet path for the liquid is formed by that end of the cylinder which is opposite to the constriction. FIGS. 3, 4 and 5 are diagrammatic views of different combinations of the several elements according to the invention. FIG. 3 shows a pump having a cylinder which is closed at its rear end by a bottom plate, and a piston provided with the outlet opening. FIG. 4 shows a pump having a working diaphragm and an outlet opening fixedly arranged in the pump tube. FIG. 5 shows another pump with a cylinder and an outlet opening arranged in the piston. In all pumps shown in FIGS. 3 to 5 the liquid is supplied from the side through annular passages, and in the pump shown in FIG. 5 provision is also made for a supply of liquid from the rear. Finally, FIG. 6 shows a particularly simple type of construction of a pump, which extends partly into the vessel filled with the liquid to be handled and which is directly fed with liquid from the side, whereas the other cylinder portion, which carries the drive system, not shown, extends out of the vessel. Arrows in the figures of the drawings indicate directions of flow of the liquid.

The valveless pump shown in FIG. 1 has a piston 11, which is electromagnetically driven to oscillate at high speed and which is formed with a central handling duct 12, which extends in the direction of the axis of the piston and which tapers in the direction of flow. The piston 11 reciprocates slidably in a cylinder 13 of low wall thickness consisting of non-magnetizable, preferably insulating material, through which the magnetic fields of any known oscillation-producing drive system (not shown), which surrounds the cylinder, act on the piston 11, which consists, e.g., of insulating material and is surrounded by a longitudinally slotted shell 14 of sheet iron. Opposite to the outlet opening 15 of the handling duct 12 a fixed constriction, particularly of the discharge path, is provided in the target direction of the liquid jet formed by the opening 15 near the forward dead center of the piston 11, which is shown in this position. The cross-section of this constriction is approximately of the order of magnitude of the cross-section of the outlet opening 15. The constriction 16 is formed in a fitting 17 of rubber, plastic or the like, which is clamped in position and is formed with a central duct 18, which follows the constriction 16 and widens in the direction of flow. The fitting 17 may serve for delimiting the oscillation of the piston 11 in one direction whereas a stop 19, which consists, e.g., of a rubber ring, may be arranged on the other side. To enable an adjustment of the pump in the cylinder 13 the fitting 17 as well as the stop 19 are longitudinally displaceable relative to the magnetic system not shown. It is sufficient, however, if only the stop 19 is displaceable if the magnetic drive system itself is arranged to be displaceable for adjustment and to be fixed in position for operation relative to the fitting 17, which in this case may be fixedly arranged in the cylinder 13. The inlet path 33 and the outlet path 43 open preferably into pipe connections not shown.

The mode of operation of such pump may be explained as follows: During the movement of the piston in the direction toward the fitting 17 the liquid enclosed between the piston 11 and the fitting 17 is displaced and flows partly through the duct 18 and, in a smaller part through the handling duct 12 owing to the inertia of the

3

column of liquid flowing in the discharge direction. When the piston is reversed the space enclosed between the piston 11 and the fitting 17 is enlarged. As a result of the inertia of the liquid column following up through the cylinder 13 and the movement of the piston opposite to this direction of flow, a sharp jet issues out of the small end 15 of the tapering handling duct 12. This jet is directed into the constriction 16 of the fitting 17 and prevents a backflow of liquid from the same. Thus the inherent backflow-preventing action of the handling duct 12 is supported by the blocking action of the constriction 16 during the return movement of the piston. For this reason the capacity and efficiency of such valveless pumps are much higher than with the known valveless pumps.

The embodiment shown in FIG. 2 of the drawing proves particularly satisfactory in those cases in which it is desired to utilize the temporary formation of a jet at the small end 15 of the handling duct 12 to retain rather than to compensate the highly pulsating liquid pressure. This applies, e.g., to room fountains with ejection nozzles from which the liquid jet should emerge divided into as many fine droplets as possible. To this end a tubular extension 20 may be provided on the fitting 17 formed with the constriction 16. This extension may be provided at that end of the fitting 17 which faces the oscillating piston 11 to extend into the outlet opening 15 of the handling duct 12 in the front dead center position of the oscillating piston 11. The same effect will be obtained, e.g., if the tubular extension 20 is provided on the piston and extends into the constriction 16 at the end of the stroke.

Particularly favorable results will be obtained in all embodiments of the invention if the handling duct 12 as well as the duct 18 are designed according to flow-dynamical considerations in order to avoid superfluous turbulence. This appears to be achieved best if said ducts are given the shape of nozzles. Pumps of this kind, in which the liquid is supplied from the rear, produce particularly favorable total heads. Where high capacities are more important, however, it has proved desirable to supply the liquid to be handled from the side. Such pump is shown in FIG. 3. The piston 11 oscillating at high speed has at its end the outlet opening 15, which is faced by the constriction 16. An annular inlet passage 22 is connected to the cylinder 13, which is tightly closed at its rear end by the bottom plate 26. This inlet passage 22 enables a supply of liquid through the cylinder 13, which has registering holes or slots 24, or is interrupted at this point, into the space between the outlet opening 15 and the constriction 16. The tubular extension 33 is connected to the inlet duct 22 and the tubular extension 43 is connected to the cylinder 13 to form a discharge path.

FIG. 4 shows a pump which is provided with a working diaphragm 21, which forms instead of the bottom plate 26 the closure of the tube 23. In this pump, which can be driven by a drive system of particularly simple construction, e.g., a solenoid, the fitting formed with the outlet opening 15 is also fixedly arranged relative to the fitting formed with the constriction 16 and the annular inlet passage 22 is formed by these fittings and the tube 23, which has a lateral inlet opening 24 and the pipe connection 33. The discharge path is formed by the pipe connection 43.

FIG. 5 shows an embodiment of the pump according to the invention which is similar to the pump according to FIG. 4 with respect to the construction of the annular inlet passage 24. This is a piston pump the piston 11 of which has at its conical end face the outlet opening 15 so that the annular passage 22 is formed by the end face of the piston 11, the cylinder 13 and the fitting formed with the constriction 16. The lateral supply is again effected through pipes 33 and holes or slots 24 in the cylinder wall and the discharge path is formed by the pipe connection 43. Liquid may also be supplied from

4

the rear through a branch pipe or hose 33', which opens into an opening of the bottom plate 26. This has the advantage that the discharge characteristics of the pump can be selectively varied by adjusting the valves 25, 25' arranged in the two inlet pipes 33. When the valve 25' controlling the supply from the rear is closed and the lateral valve 25 is opened a large amount of liquid will be handled whereas in the opposite valve position a large total head can be obtained with the same pump. It is obvious that valve positions in which both inlet paths are more or less open are also possible and may be desirable from time to time. It is particularly suitable to couple the two valves for rotation or to provide a double valve so that both valves can be adjusted in opposite senses by a single manipulation.

It is also obvious that in the embodiments illustrated in FIGS. 3 to 5 the outlet opening 15, the fittings formed with the outlet opening 15 and with the constriction 16 as well as other components disposed in the liquid path are designed according to flow dynamical considerations, and more particularly that the two fittings are adjustable. Finally, the inlet and outlet paths 33 and 43 may be designed differently from the form shown. They may consist, e.g., of shells fitted over the cylinder 13 or the tube 23.

FIG. 6 shows a valveless pump in which the liquid to be handled is directly supplied from the side. In this case it is not necessary to provide an annular inlet passage because that part of the cylinder 13 which carries the inlet openings 24 extends into the liquid-filled space 28. This is tightly sealed by a wall 29 from the remaining part of the cylinder 13, which carries the piston and the drive means, not shown. The tight seal is effected, e.g., by the nut 30 and the annular gasket 31, which is forced against the collar 32 of the cylinder 13. The pump cylinder is closed at the rear by the bottom plate 26. The elongated piston 11 carries the iron shell 14 for the drive and at its front end close to the outlet opening 15 has slots 27 which register with the holes 24 in the walls of the cylinder 13 and enable the liquid to flow from the space 28 through the holes 24 into the handling duct 12. In order to eliminate the need for means for guiding the piston 11 along a straight line, the outside diameter of the piston is smaller adjacent to the opening 27 or 24 than the inside diameter of the cylinder 13 so that there will be an open path for the liquid even if the openings 27 and 24 have been relatively rotated. The other parts of the pump are constructed in accordance with the embodiment shown in FIG. 2.

What is claimed is:

1. A valveless piston pump which comprises a cylinder having a wall of nonmagnetizable material, a piston oscillating at high speed in said cylinder in an axial direction and imparting movement to the liquid to be conveyed, said piston containing magnetizable material for actuation by an external electromagnetic system, at least one liquid-handling duct extending through the piston and opening into a nozzlelike opening in the end face of the piston, and a stationary transverse wall in the cylinder which has at least one nozzlelike opening decreasing in size toward the piston in axial registry with the opening in the end face of the piston and is connected to a duct for forwarding the liquid, the opening in the end face of the piston and the registering opening in the transverse wall having approximately the same width and said openings lying close to each other when the piston is at its forward dead center.

2. A liquid pump according to claim 1 characterized in that the piston contains a single duct which tapers in streamline form in the direction in which the liquid is conveyed and the center line of which coincides with the center line of the piston.

3. A liquid pump according to claim 1 characterized in that the transverse wall in the cylinder is formed by a plug which contains also the duct for forwarding the

5

liquid and which is displaceable for adjustment in the cylinder whereas it is fixed in the cylinder during the operation of the pump.

4. A liquid pump according to claim 3 characterized in that the plug is clamped in the cylinder and forms the forward limitation for the oscillation of the piston during the operation of the pump.

5. A liquid pump according to claim 1 characterized in that the oscillation of the piston is limited at its end remote from the end face by an annular stop which is fittingly inserted and clamped in the cylinder and forms the inlet.

6. A liquid pump according to claim 1 characterized in that lateral inlet openings for admitting the liquid are provided in a part of the wall of the cylinder.

7. A liquid pump according to claim 6 characterized in that said duct of the piston is provided with liquid entry openings in a side wall of the piston and lateral to said nozzlelike opening, the lateral inlet openings of said cylinder being disposed to admit the liquid to the cylinder in directions toward said liquid entry openings in the piston.

8. A liquid pump according to claim 6 characterized in that the lateral inlet openings admit the liquid to the cylinder in a space between the end face of the piston and the transverse wall in the cylinder.

9. A liquid pump according to claim 7 characterized in that said liquid entry openings of the piston are larger than the inlet openings in the cylinder and remain in registry with the latter substantially throughout the travel of the piston during its oscillations.

10. A liquid pump according to claim 9 characterized in that the outside diameter of the piston adjacent to the said liquid entry openings of the piston is smaller than the inside diameter of the cylinder.

11. A liquid pump according to claim 6 characterized in that the said part of the wall of the cylinder which has the lateral inlet openings extends into a space which is filled with the liquid to be conveyed whereas the remaining part of the cylinder is disposed outside the liquid filled space for support of the external electro-

6

magnetic system and is sealed by a partition from said space.

12. A liquid pump according to claim 6 characterized in that the cylinder is sealed by a bottom plate at the end in which the piston oscillates.

13. A liquid pump according to claim 12 characterized in that the bottom plate which seals the cylinder is provided with an additional inlet opening.

14. A liquid pump according to claim 1 characterized in that the cylinder is provided with a plurality of feed lines to permit entry of a liquid to the cylinder, said feed lines containing adjustable valves for regulating the rate of flow of entering liquid.

15. The pump of claim 1 comprising an extension projecting from one of said ducts and extending into the other of said ducts when the piston is in its forwardmost position.

16. A fluid pump comprising a cylinder, a piston disposed in said cylinder for axial reciprocating movement therein and provided with an inlet duct extending there-through having a greater coefficient of discharge from inlet to outlet side than in the opposite direction, an outlet duct aligned axially with said inlet duct having a greater coefficient of discharge from outlet to inlet side than in the opposite direction, said ducts being close to each other when the piston is at its forwardmost position so that upon retracting movement of the piston a jet of fluid passes from said inlet duct to said outlet duct and upon forward movement of the piston a portion of the fluid between said ducts flows through said outlet duct.

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