Aug. 5, 1941. F. W. DAVIS 2,251,664

LIQUID CIRCULATING SYSTEM

Original Filed June 20, 1936

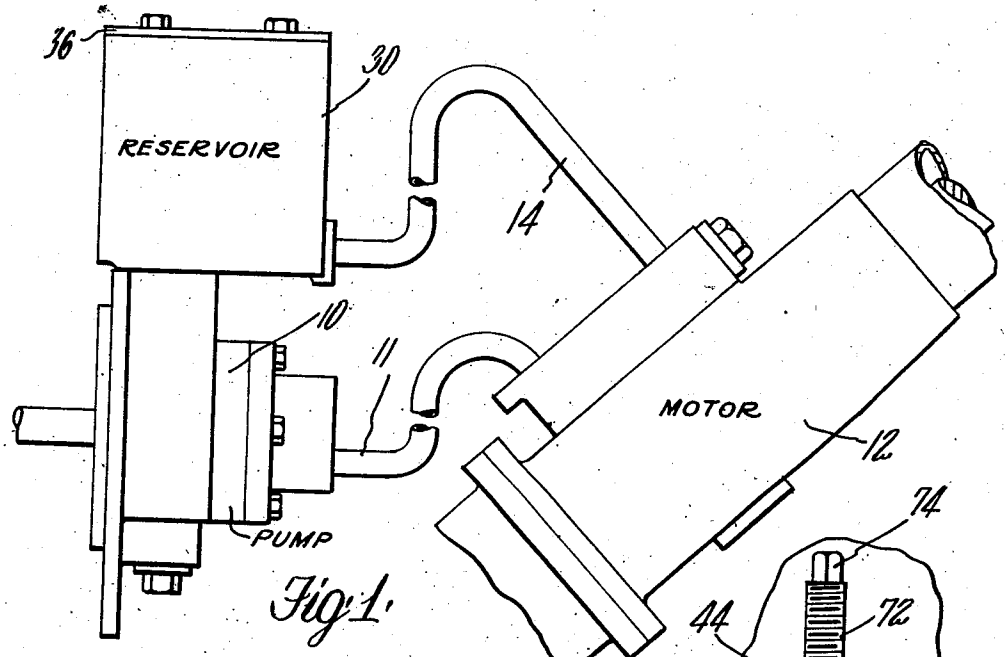


Fig. 1.

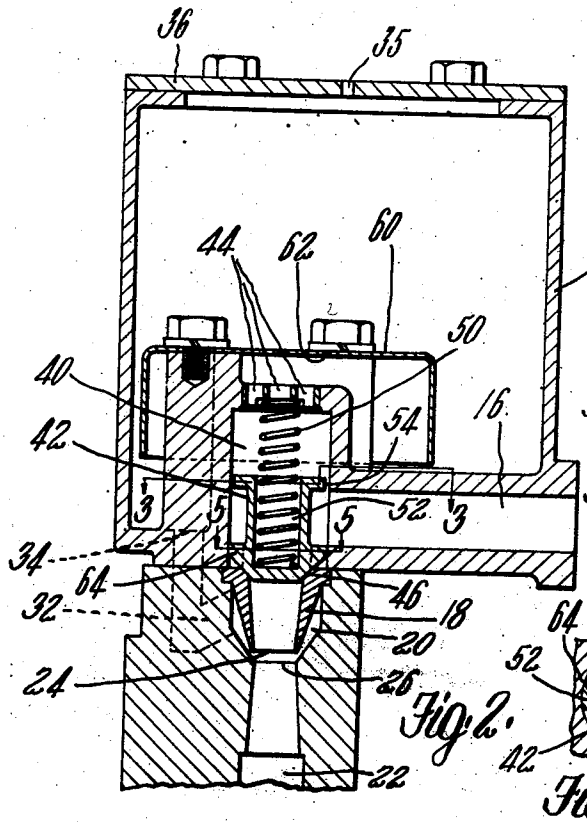


Fig. 2.

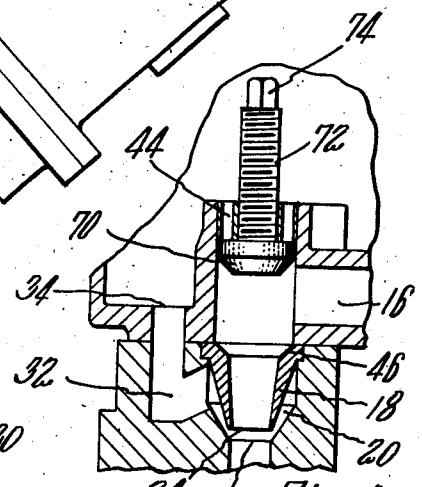


Fig. 4.

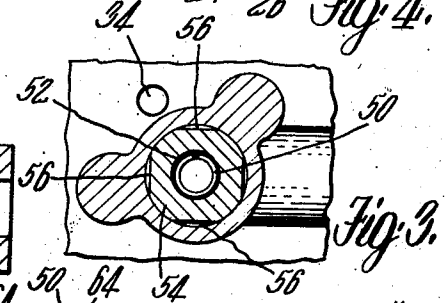


Fig. 3.

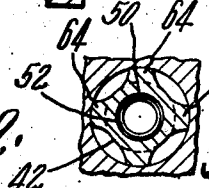


Fig. 5.

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LIQUID CIRCULATING SYSTEM

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Application June 20, 1936, Serial No. 86,315
Renewed January 20, 1940

10 Claims. (Cl. 60—52)

This invention relates to apparatus for improving the action of a liquid circulating system wherein a substantially constant quantity of liquid is circulated continuously through a circuit including a pump and a motor.

The invention more particularly relates to circulating systems adapted to be carried on vehicles such as automobiles for the operation of one or more mechanisms thereon such as a power steering gear, power-actuated brakes, doors on busses, and the like. It is convenient in such cases to drive the pump of the system by some moving part of the motor which drives the vehicle, as for example the cam shaft. It is evident that, owing to the various speeds at which the vehicle may be operated, the pump will ordinarily be operated at widely differing speeds. When the vehicle is traveling at a high rate of speed, the pump will be operating at a proportionally high speed. This may result in cavitation at the suction side of the pump, particularly when the liquid is relatively thick or sluggish. Such a condition is liable to occur when an automobile is first started up and where the circulated liquid is oil which is comparatively thick and viscous when cold.

It is an object of the present invention to prevent cavitation at the suction side of the pump even when the pump is operating at very high speeds.

It is a further object of the invention to provide means for ridding the system of any gas or air bubbles which may get into the liquid stream. Such bubbles foster a tendency toward cavitation and interfere with the proper functioning of the apparatus. When the bubbles of air or gas are entrained in a rapidly moving stream of liquid, however, it is difficult to separate them from the stream.

According to the invention, the tendency toward cavitation at high speeds is overcome, or at least greatly reduced, by the use of a Venturi device operating on the injector principle to maintain the liquid in the suction line at a pressure considerably higher than it would have ordinarily. To this end, a reservoir is provided for excess liquid, this reservoir communicating with the injector device so as to maintain a constant head of liquid therein. The injector tends to suck liquid from the reservoir, but, since the liquid passing through the injector nozzle represents substantially the entire discharge stream from the pump, the liquid actually drawn from the reservoir is only that which is required to make good any liquid which may be lost by leakage or otherwise.

For the escape of air, valve means are provided by which the stream of liquid approaching the suction side of the pump may be by-passed partly or wholly through the reservoir. This gives the bubbles a chance to rise in a comparatively quiet pool, and thus to escape from the top of the reservoir.

For a more complete understanding of the invention, reference may be had to the description of certain embodiments thereof which follows, and to the illustration thereof on the drawing of which—

Figure 1 is an elevation of a liquid circulating system embodying the invention.

Figure 2 is a sectional view of the reservoir and a portion of the apparatus associated therewith.

Figure 3 is a section on the line 3—3 of Figure 2.

Figure 4 is a fragmentary sectional view of a modified form of valve means.

Figure 5 is a section on the line 5—5 of Figure 2.

In Figure 1, a fluid pump, preferably of the gear type, is indicated at 10, this pump having a discharge line 11 leading to a fluid motor 12. The motor is preferably of a type permitting a through flow of the power fluid at all times, both when the motor is operating and when it is at rest. A motor of this type is described and illustrated in my Patent No. 1,790,620. After passing through the motor 12, the fluid returns through a suitable pipe 14 to the suction side of the pump.

The pipe 14 leads to a passage 16 (Figure 2) which in turn discharges through a nozzle 18 into a chamber 20 from which leads a passage 22 to the suction side of the pump 10. The nozzle 18 tapers somewhat so that its orifice 24 is reduced in cross section. Directly opposite this orifice 24 is the orifice of the suction passage 22. The reduction of the cross section of the nozzle 18 results in the projection of a high velocity jet of liquid into the suction passage 22. The suction passage 22 increases in cross section from the orifice 26 so that the velocity of the stream is converted into liquid pressure within the larger portion of the passage 22, this pressure being employed to boost the pump and to prevent cavitation at the suction side thereof when the pump is running at high speed. The chamber 20 is maintained full of liquid by a connection with a reservoir 30 conventionally located above the chamber so that the gap between the orifice 24 of the nozzle and the orifice 26 of the

pipe leading to the suction end of the pump is always surrounded by a yielding liquid seal. To this end, a suitable passage 32 leads from an opening 34 in the bottom of the reservoir and opens into the side of the chamber 20. The reservoir 30 is maintained partly filled with liquid so that the liquid in the chamber 20 is constantly under a small liquid head in addition to atmospheric pressure which is available through a vent 35 in the reservoir cover 36. Since the amount of liquid in actual circulation within the system is substantially constant, the only liquid actually drawn from the reservoir is that required to replace loss through leakage, etc.

In order to get rid of air in the system when liquid is first introduced thereinto after the system has been drained, and to maintain the system free from small entrained gas bubbles, a two-way valve mechanism may be provided as illustrated in Figure 2. As therein shown, the passage 16 leads into a valve chamber 40. A valve member 42 is vertically movable within this chamber. The upper end of the chamber communicates with the interior of the reservoir as by a number of ports 44. The lower end of the chamber opens directly into the nozzle 18, at the upper end of which is a valve seat 46. When the pump is not in operation, the valve member 42 rests on the seat 46 by its own weight. This may be augmented by a suitable spring 50, which, as shown, may bear against the upper end wall of the chamber at one end and against the valve itself at its other end, the valve member being hollow as at 52 to permit the use of a relatively long spring. The valve member 42 has a reduced external diameter at its mid-portion, the upper end portion 54 being a flange which fits slidably in the upper portion of the valve chamber but which is partly cut away as indicated at 56 in Figure 3 to permit limited flow of liquid from the passage 16 up through the ports 44 into the reservoir. Figure 2 shows the valve in its lower portion seated on the seat 46 so as to cause all of the stream entering through the passage 16 to flow up through the ports 44 into the reservoir and thence down through a passage 32 into the chamber 20 and the suction line 22. In order to prevent splashing in the reservoir, a baffle 60 may be mounted over the ports 44, this baffle being provided with one or more small holes 62 to permit the escape of air or gas which might otherwise collect under the baffle.

The lower portion of the valve member 42 is accurately ground to seat snugly on the seat 46. The portion 64 of the valve member, immediately above its seat-engaging portion, is of sufficient diameter to engage loosely the walls of the chamber 40 and center the valve member, this portion being notched, as indicated in Figure 5, to permit free access of fluid to the under face thereof at all times. The valve member 42 occupies the position shown in Figure 2, when the flow of liquid through the passage 16 is of insufficient velocity to raise the valve from its seat. The spring 50 is preferably such that, when the pump is running at low speeds, the valve will be in the position shown in Figure 2, thus causing the liquid to be by-passed through the reservoir where entrained air bubbles can readily escape. When the pump is speeded up, however, so that there is danger of cavitation at the suction side thereof, the increased velocity and pressure of the stream in the passage 16 act on the under surface of the flange 54 to raise the valve 42. As soon as the valve is raised from its seat, the liquid pressure also acts on its lower end to force the valve up against the upper end of the end wall of the chamber 40, thus closing the ports 44 and preventing the further flow of liquid into the reservoir. Thus, as long as the high velocity of flow is maintained, the stream will be directed through the nozzle 18, and the increase of velocity of the stream as it leaves the nozzle will be utilized to raise the pressure within the suction line 22 and thereby to prevent cavitation.

Figure 4 illustrates a modified form of valve mechanism which can be employed to relieve the system of entrained air or gas bubbles. As shown, a valve member 70 is mounted on the lower end of the screw-threaded shaft 72 having a polygonal head 74 to receive a suitable wrench. Manual rotation of the threaded shaft 72 moves the valve up or down to close the ports 44, as illustrated in Figure 4, or to engage the seat 46 so as to divert the stream from the passage 16 through the reservoir. When the system is first filled with liquid, the valve is moved down against the seat 46 so that the air in the system can readily escape through the reservoir. After the air has been driven out of the system by operation of the pump for a suitable period, the valve is raised manually to the position illustrated in Figure 4, whereupon the system is ready for regular operation. In case air bubbles get into the system, they can readily be removed by moving the valve 70 against the seat 46 for a short period during which the pump is operated to circulate the liquid through the reservoir.

It is evident that various modifications and changes may be made in the particular embodiments of the invention herein shown and described, without departing from the spirit or scope of the invention as defined in the following claims.

I claim:

1. In a liquid circulating system, a pump, a fluid motor, a discharge line leading from said pump to said motor, a suction line leading from said motor to said pump, a reservoir communicating with said suction line and adapted to maintain a liquid head in said suction line when the pump is not operating, and means for utilizing the velocity of liquid returning from said motor to maintain in said suction line during the operation of the pump a pressure exceeding that of the liquid head plus atmospheric pressure.

2. In a liquid circulating system, a pump, a fluid motor, a discharge line leading from said pump to said motor, a suction line leading from said motor to said pump for the continuous circulation of a constant quantity of liquid through said pump and motor, a reservoir communicating with said suction line and arranged to maintain a liquid head therein when the pump is not in operation, and means for utilizing the circulating stream from the motor to maintain in said suction line during the operation of the pump a pressure exceeding that of said liquid head plus atmospheric pressure.

3. In a liquid circulating system, a vented reservoir at the high point of said system, a chamber, a passage leading from said chamber, a nozzle projecting into said chamber and arranged to direct a jet into said passage, a permanently open passage from said reservoir opening into said chamber beside said nozzle whereby a liquid head is maintained in said chamber, a supply pipe opening into said nozzle and said reservoir,

and valve means for directing the stream in said supply pipe through said nozzle or into said reservoir.

4. In a liquid circulating system, a pump adapted to be operated at various speeds, a discharge line leading from said pump, a suction line leading to said pump and connected to said discharge line so as to return to said pump substantially the entire stream delivered therefrom, a reservoir above and communicating with said suction line so as to maintain a liquid head therein, and means responsive to liquid flow from said discharge line to guide such flow directly into said suction line when the velocity of the flow is high and to by-pass the flow through the reservoir when the velocity of flow is low.

5. In a liquid circulating system, a pump having a discharge and a suction, means for returning to said suction substantially the entire stream of liquid passing through said discharge, said means including a chamber, a suction pipe leading from said chamber to the suction side of the pump, a nozzle projecting into said chamber, means for directing substantially the entire discharge stream from the pump through said nozzle, and a reservoir above said chamber open to the atmosphere and communicating with said chamber.

6. In a liquid circulating system, a pump having a single discharge line leading therefrom and a suction line leading thereto, a Venturi device consisting of a chamber opening into said suction line and a nozzle projecting into said chamber, means connecting said nozzle with said discharge line so as normally to direct the entire stream from the pump through the nozzle, a by-pass around the nozzle leading into said chamber and including an open reservoir above the nozzle, and a two-way valve automatically operated by the stream from the discharge line to direct said stream through the by-pass when the pump is operating at low speeds and to direct the stream through the nozzle when the pump is operating at high speeds.

7. In a liquid circulating system, a pump, a motor, a discharge pipe line from said pump to said motor, a return pipe line from said motor to said pump for the continuous circulation of a constant volume of liquid in said system, and means for boosting the liquid pressure at the suction end of said pump, said means comprising a Venturi device in said return line and a yielding liquid seal for said device.

8. In a liquid circulating system, a pump, a motor, a discharge pipe line from the pump to the motor, and a return line from the pump to the motor for the continuous circulation of a constant volume of liquid through the system, said return line comprising a chamber, a pipe from said motor terminating in a nozzle with a reduced orifice within said chamber, a pipe connecting said chamber with the suction end of said pump, the entrance orifice of said last-mentioned pipe being directly opposite the orifice of said nozzle, and means for maintaining a yielding liquid seal around the gap between said orifices.

9. In a liquid circulating system, a pump, means for conducting substantially the entire stream of liquid discharged from said pump back to the suction end of the pump, said means comprising a chamber, a short pipe leading from said chamber to the suction end of the pump, said pipe having an orifice of reduced diameter opening into the chamber, a nozzle within said chamber directed toward said orifice, the extremity of said nozzle being near said orifice and having an internal diameter substantially equal to that of said orifice, and means for conducting substantially the entire stream delivered from the pump to said nozzle to be discharged therethrough, and means for maintaining said chamber filled with liquid.

10. In a liquid circulating system, a pump, a chamber, a short pipe extending from said chamber to the suction end of said pump, said pipe opening into said chamber with an orifice of less area than that of the cross-section of the interior of the pipe, a nozzle having a discharge orifice of substantially the same size and shape of said pipe orifice directed toward said pipe orifice, means for conducting to said nozzle substantially the entire discharge stream from said pump, and means for maintaining in said chamber a body of liquid surrounding said orifices.

FRANCIS W. DAVIS.