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PUMP ANTI-CAVITATION DEVICE

Filed Aug. 10, 1960

FIG. 1

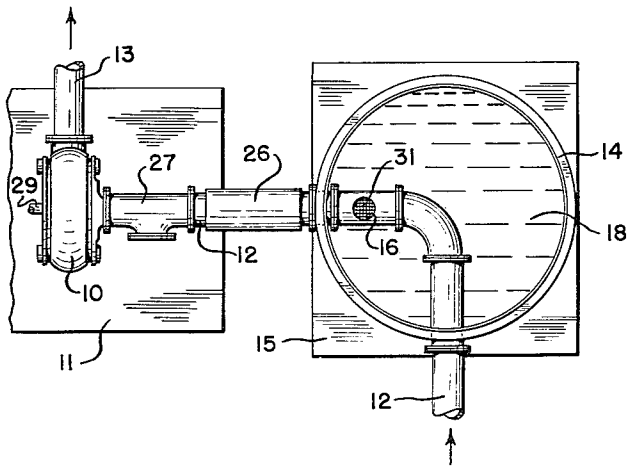


FIG. 2

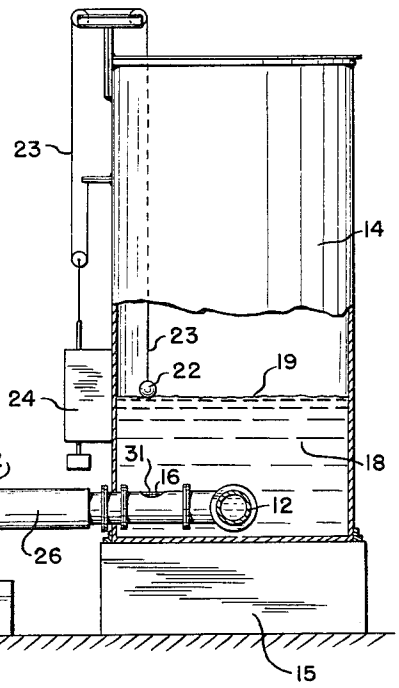
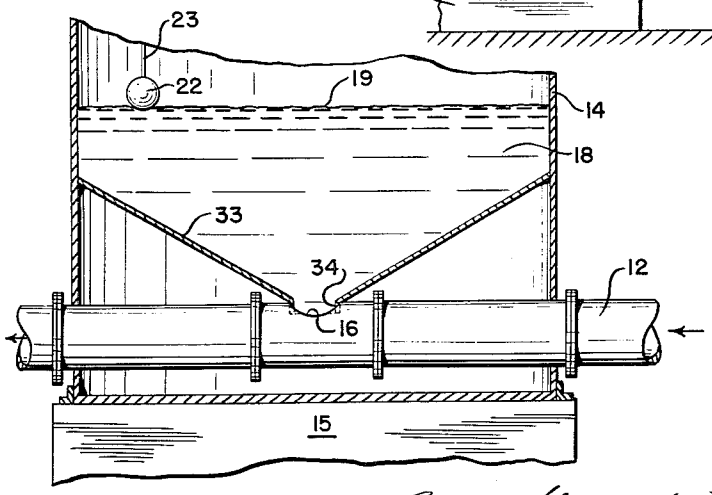


FIG. 3



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PUMP ANTI-CAVITATION DEVICE

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This invention relates to an anti-cavitation device for centrifugal pumps, and more particularly to a device for allowing air bubbles contained in the liquid in the pipe line connected to the suction side of the pump to escape therefrom while maintaining a positive head of liquid on the suction side of the pump.

In the pumping of solutions or slurries, such as an aqueous slurry of phosphate ore, air bubbles sometimes become entrained in the liquid being pumped. Moreover, the pressure drop within the pipe line connected to the suction side of a pump often causes cavities of air bubbles to form in the liquid in the pipe line due to the release of dissolved air, this well-known phenomenon being termed cavitation. The presence of cavities or air bubbles in the liquid being pumped is a serious problem in that it causes a drop in pump head-capacity and in pump efficiency. Moreover, cavitation results in impeller vane pitting and corrosion-fatigue failure of metal pump parts, and in extreme cases when the column of liquid within the pipe line actually becomes parted total disintegration of the pump can occur when the void reaches the pump impeller.

I have now devised an anti-cavitation device that is used in conjunction with the intake or suction line of a centrifugal pump and that is adapted to allow air bubbles or cavities in the liquid contained in the suction line to escape therefrom while at the same time maintaining a positive head of liquid on the intake of the pump so as to eliminate cavitation and consequent damage to the pump impeller and parts associated therewith. The elimination of cavitation within the pipe line and pump casing greatly increases pump efficiency and greatly reduces pump wear and pump maintenance. Moreover, as my anti-cavitation device maintains a positive liquid pressure on the suction side of the pump at all times, pump efficiency is increased and the pump never loses its prime. In addition, when used in conjunction with long pipe lines having a number of pumps disposed in series along the line, my new device makes it possible to automate the pumping line by the use of pump speed regulators controlled by the level of liquid in the device associated with each pump in the manner hereinafter described.

My new anti-cavitation device comprises, in combination with a centrifugal pump, a tank adapted to contain a body of the liquid or slurry being pumped, the bottom of the tank being below the level of the intake of the pump and the liquid level within the tank being maintained above the highest part of the pump shell. The tank is located adjacent the intake or suction of the pump, and the intake line of the pump extends substantially horizontally through the lower portion of the tank. The section of the pump intake pipe line located within the tank is formed with at least one opening in the uppermost surface of the pipe line, the diameter of this opening being between about one quarter and three quarters of the inside diameter of the pipe line. Moreover, means are provided for maintaining the level of liquid in the tank above a predetermined point, and advantageously within predetermined limits.

My new pump anti-cavitation device will be better understood from the following description thereof in conjunction with the accompanying drawings of which

FIG. 1 is a plan view of an advantageous embodiment of my new device;

FIG. 2 is a side elevation of the device shown in FIG. 1 with the lower portion of the tank wall partly broken away and showing one means for maintaining a uniform liquid level within the tank; and

FIG. 3 is a sectional view through the lower portion of the tank showing an advantageous modification of the tank structure.

The pump anti-cavitation device of my invention will be described below as it is used in conjunction with a heavy duty sand or dredge pump of the type employed in the Florida phosphate industry to pump an aqueous slurry of phosphate rock from the mine pit to the plant in which the rock is processed. However, the device is readily adapted to be used in connection with any pumping operation in which the pump is subject to damage or loss in pumping efficiency due to cavitation in the liquid stream on the suction side of the pump.

As will be seen best in FIGS. 1 and 2, the anti-cavitation device is employed in conjunction with a centrifugal pump 10 mounted on a base 11 and having a suction or intake line 12 and a pressure or discharge line 13 connected thereto. The device is associated with the suction or intake pipe line 12 of the pump 10 and comprises a tank 14 through which the suction pipe line 12 extends, the tank 14 being mounted on a base 15 and the portion of the pipe line 12 within the tank 14 being formed with an opening 16 disposed in the uppermost surface of the pipe line 12. A body of liquid 18 substantially identical to the liquid being pumped is established in the tank 14, the level 19 of the liquid being maintained above the highest point of the pump 10 in order to provide a liquid seal for the opening 16 in the pipe line 12 and to maintain a positive head of liquid on the suction side of the pump 10. The tank 14 is further provided with means for maintaining the liquid level 19 above a predetermined height, and preferably within predetermined vertical limits, within the tank.

The means provided for maintaining the liquid level 19 within the tank 14 above a predetermined height can comprise a simple mechanically or electrically operated float valve controlling a supply line for introducing make-up liquid into the tank 14, and the make-up liquid supply line can be connected to the output pipe line 13 of the pump 10 or to a separate source of make-up liquid. However, as shown in FIGS. 1 and 2, the liquid level control means advantageously comprises a float 22 connected by means of a cable 23 or the like to a control apparatus 24, the control apparatus 24 advantageously comprising a plurality of micro-switches activated by the vertical movement and position of the float 22. The control means 24 can be adapted to regulate the height of the liquid level 19 in a variety of ways; for example, is can be connected through appropriate control equipment to an independent pump or pumps which will introduce liquid into the tank from an outside source or will withdraw liquid from the tank as may be required to maintain the liquid level 19 above a predetermined height or within predetermined vertical limits. When the pump 10 is one of a number of pumps employed in series along a long pipe line, the control apparatus 24 can be utilized to automate the pumping line by automatically speeding up or slowing down the individual pumps in the line to compensate for fluctuations in the flow of liquid through the line. In this situation the micro-switches of the control apparatus 24 control the operation of a speed regulator for the motor (not shown) of the pump 10. Thus, when the liquid level 19 falls below a predetermined minimum height (i.e. a predetermined height above the highest point of the pump casing) the control apparatus 24 causes the pump motor to slow

down until the liquid within the tank **14** is replenished by liquid from pipe line **12** flowing into the tank through opening **16** and the liquid level **19** is raised above the predetermined minimum height; and when the liquid level **19** exceeds a predetermined maximum height the control apparatus **24** causes the pump motor to speed up until the liquid level **19** is lowered below said predetermined maximum height.

In the particular embodiment of the device shown in FIGS. 1 and 2, the portion of the suction pipe line **12** between the tank **14** and the suction side of the pump **10** is provided with a flexible section **26** and a clean-out or access section **27**; however, these pipe sections form no part of the present invention. Moreover, the portion of the suction pipe line **12** within the walls of the tank **14** is shown to have a 90° bend; however, this portion of the pipe line **12** may be straight as shown in FIG. 3 or it may bend at some angle other than 90° as dictated by the particular requirements of the pump installation. As previously pointed out, the anti-cavitation device is shown as it is used in conjunction with one of a series of heavy duty dredge pumps employed to pump an aqueous slurry of phosphate rock from mine pit to processing plant a distance often in excess of five miles. In a typical installation these pumps are capable of handling in excess of 650 tons of solids per hour, and the pipe lines carrying the slurry have an inside diameter of 16 inches. In such an installation the diameter of the opening **16** formed in the pipe line **12** is advantageously about 10 inches, although in other installations the optimum diameter of the opening **16** will depend upon the particular operating conditions and requirements of that particular installation—the essential requirement being that air bubbles contained in the liquid flowing through suction pipe line **12** be allowed to escape readily therefrom through the opening **16**. In general, I have found that the diameter of the opening **16** should be between about one-quarter and three-quarters of the inside diameter of the pipe line **12**.

In the operation of my device the pump **10** driven by a shaft **29** connected to a motor (not shown) draws in the liquid contained in the suction pipe line **12** and pumps it into the outlet or pressure pipe line **13** connected to the discharge side of the pump. Air bubbles present in the liquid contained in the suction pipe line **12**, whether due to entrainment of air in the liquid or as a result of cavitation, escape from the pipe line **12** through the opening **16** formed therein and thus are removed from the liquid in the pipe line before reaching the pump **10**. The body of liquid **18** in the tank **14** acts as a liquid seal to prevent the entrance of air into the pipe line **12** and also serves to supply make-up liquid for the pipe line **12** so as to prevent the pump **10** from losing its prime due to a lack of liquid in the pipe line **12**. When the "liquid" being pumped comprises an aqueous slurry or suspension of solid matter small quantities of the solid matter occasionally escape from the pipe line **12** through the opening **16**, especially when there is a pressure surge within the pipe line **12** that is not immediately compensated for by the pump **10**. The loss in solid matter from the pipe line **12** is not serious, and much of the material subsequently reenters the pipe line **12** through the opening **16**. However, this loss can be minimized if not completely prevented by the provision of a coarse screen **31** in the opening **16**.

The loss of solid matter from the pipe line **12** can also be minimized by modifying the tank **14** as shown in FIG. 3 of the drawing. In this modification of my device the portion of the tank **14** immediately above the pipe line **12** is provided with a conical or funnel-shaped structure **33** the apex of which is provided with an opening **34** that coincides with the opening **16** formed in the pipe line **12**. Thus, any solid matter expelled from the pipe line **12** through the opening **16** settles on the downwardly sloping walls of the conical structure **33** of the tank **14** and

is returned to the pipe line **12** through the opening **16**. The connection or juncture between the conical bottom structure **33** of the tank **14** and the pipe line **12** may be a permanent water-tight joint such as a weld so that the space in the tank **14** below the conical bottom wall is free of liquid, or the joint may be a relatively loose mechanical fit that permits liquid to enter the space between the conical structure **33** and the bottom of the tank.

The use of my anti-cavitation device virtually eliminates pump cavitation by permitting air in the pipe line **12** to escape through the opening **16**, and the elimination of cavitation in the pump greatly increases pump efficiency and reduces pump wear and pump maintenance. In extreme cases pump cavitation can cause sudden disintegration and complete destruction of the pump, and this fact has made it uneconomic to construct the heavy duty sand pumps employed in the Florida phophate industry from the more costly abrasion resistant materials such as hard nickel alloys. As a consequence in the past pump parts have had to be replaced at frequent intervals due to the extreme wear and abrasion caused by the slurry of phosphate rock being pumped. Now as a result of my anti-cavitation device the pump is not subject to sudden severe damage as in the past, and it is now economical to construct these sand pumps from harder but more expensive materials and metal alloys which are able to withstand the extreme abrasive action of the phosphate rock slurry; hence the pumps have a much longer life expectancy than in the past and significant savings result from less frequent replacement of worn pump parts.

From the foregoing it will be seen that my new pump anti-cavitation device is an important contribution to the art to which my invention relates.

I claim:

1. A pump anti-cavitation device for a pump comprising a tank located adjacent the intake of the pump, said tank being open to the atmosphere and containing a body of liquid being pumped, the liquid within the tank being under atmospheric pressure, a suction pipe line connected to the intake of the pump and extending substantially horizontally through the lower portion of the tank, the section of the pump suction pipe line within the tank being formed with at least one opening in the uppermost surface of said pipe, and means for maintaining the liquid level within the tank at a predetermined height above the highest part of the pump shell, whereby air contained in the liquid within said pump suction pipe line can escape therefrom through the opening formed therein.

2. A pump anti-cavitation device for a centrifugal pump comprising a tank located adjacent the intake of the pump, said tank being open to the atmosphere and containing a body of liquid being pumped, the liquid within the tank being under atmospheric pressure, a suction pipe line connected to the intake of the pump and extending substantially horizontally through the lower portion of the tank, the section of the pump suction pipe line within the tank being formed with at least one opening in the uppermost surface of said pipe, the diameter of said opening being between about one-quarter and three-quarters of the inside diameter of the suction pipe line, and means for maintaining the liquid level in the tank within predetermined minimum and maximum heights above the highest part of the pump shell, whereby air contained in the liquid within said pump suction pipe line can escape therefrom through the opening formed therein.

3. The anti-cavitation device according to claim 2 in which the means for maintaining the liquid level in the tank above a predetermined minimum height comprises a float floating on the surface of the liquid in the tank, said float being connected to and being adapted to operate control means whereby make-up liquid is supplied to said tank.

4. The anti-cavitation device according to claim 2 in which the means for maintaining the liquid level in the tank within predetermined minimum and maximum heights comprises a float floating on the surface of the liquid in the tank, said float being connected to control means adapted to decrease the speed of the pump when the liquid level falls below said predetermined minimum height and to increase the speed of said pump when the liquid level rises above said predetermined maximum height.

5. A pump anti-cavitation device for a centrifugal pump adapted to pump a slurry of solid material suspended in a liquid comprising a tank located adjacent the intake of the pump, said tank being open to the atmosphere and containing a body of liquid being pumped, the liquid within the tank being under atmoshperic pressure, a suction pipe line connected to the intake of the pump and extending substantially horizontally through the lower portion of the tank, the section of the pump suction pipe line within the tank being formed with at least one opening in the uppermost surface of said pipe, the diameter of said opening being between about one-quarter and three-quarters of the inside diameter of the suction pipe line, and means for maintaining the liquid level in the tank a predetermined minimum height above the highest part of the pump shell, whereby air contained in the liquid within said pump suction pipe line can escape therefrom through the opening formed therein.

6. A pump anti-cavitation device for a centrifugal pump adapted to pump a slurry of solid material suspended in a liquid comprising a tank located adjacent the intake of the pump, said tank being open to the atmosphere and containing a body of liquid being pumped, the liquid within the tank being under atmospheric pressure, a suction pipe line connected to the intake of the pump and extending substantially horizontally through the lower portion of the tank, the section of the pump suction pipe line within the tank being formed with at least one opening in the uppermost surface of said pipe, means for maintaining the liquid level in the tank a predetermined minimum height above the highest part of the pump shell, and means adapted to prevent the escape

through the opening formed in the pipe line of any appreciable amount of the solid material contained in the slurry being pumped along the pipe line, whereby air contained in the liquid within said pipe line can escape therefrom through the opening formed therein.

7. The anti-cavitation device according to claim 6 in which the means for preventing the escape of any appreciable amount of solid material comprises a coarse screen disposed in the opening formed in the pump suction pipe line.

8. The anti-cavitation device according to claim 6 in which the means for preventing the escape of solid material comprises a conically-shaped structure disposed in the tank directly above the pump suction pipe line, said conically-shaped structure being formed with an opening at the apex thereof that coincides with the opening formed in said pump suction pipe line, whereby any solid material escaping from said pipe line through the opening formed therein is returned thereto by said conically-shaped structure.

References Cited in the file of this patent

UNITED STATES PATENTS

1,536,961	McMillan	May 5, 1925
1,789,528	Lewis	Jan. 20, 1931
2,111,473	Hudson	Mar. 15, 1938
2,204,788	Borden	June 18, 1940
2,318,251	Moore	May 4, 1943
2,379,615	Walker	July 3, 1945
2,425,070	Nicolette	Aug. 5, 1947
2,747,507	Jacuyzi	May 29, 1956
2,784,674	Carver	Mar. 12, 1957
2,798,767	Andrews	July 9, 1957
2,816,573	Kaddis	Dec. 17, 1957
2,841,088	Daddario	July 1, 1958
2,912,112	Wetzel	Nov. 10, 1959

FOREIGN PATENTS

439,299	Great Britain	Dec. 4, 1935
469,463	France	May 22, 1914
771,379	France	Oct. 6, 1934
795,324	France	Mar. 1, 1936