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ENERGY CONTROLLER
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3,448,691

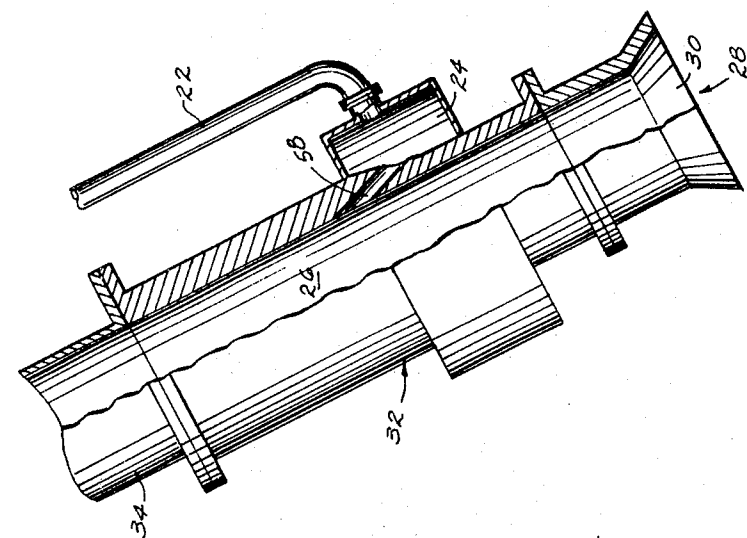


Fig. 2

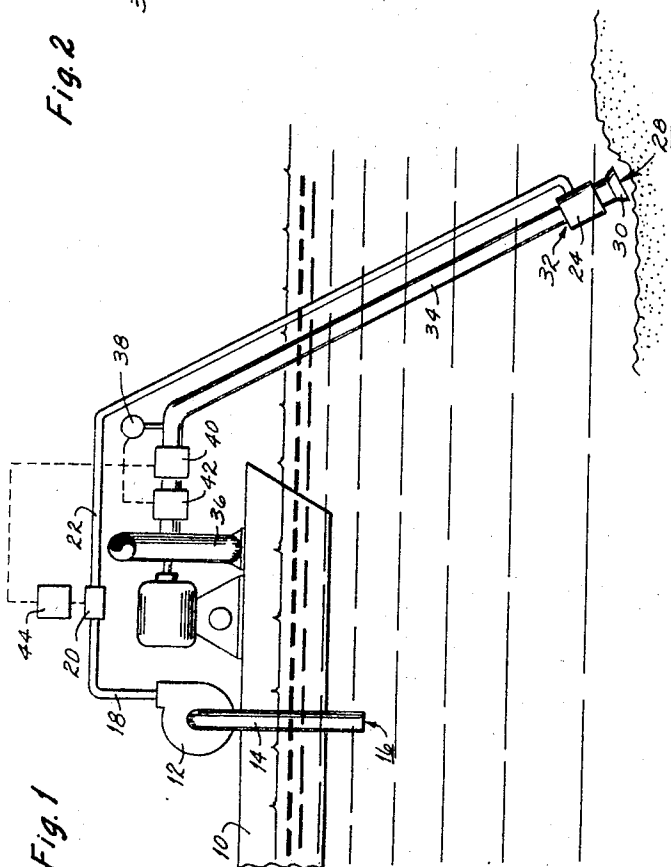


Fig. 1

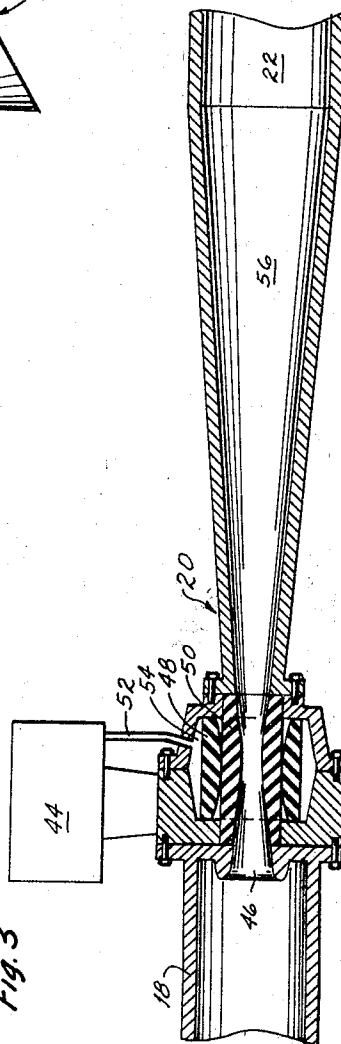


Fig. 3

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ENERGY CONTROLLER

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8 Claims

ABSTRACT OF THE DISCLOSURE

Method and means for controlling the liquid energy supply to slurry pumping jet pumps whereby pressure, velocity and slurry density sensing devices actuate a variable orifice which is in series with the jet liquid supply pump, to effectively control pipeline velocity and pressure.

This invention relates to a method and means for controlling the liquid energy supply to jet pumps, and more particularly to the control of either jet liquid supply pressures, or jet liquid supply quantities, or both.

It is well known in the hydraulic sciences that liquid, when pressurized, possesses energy and the capacity to do work. This is motive energy upon which a jet pump operates. And, by controlling either the volume or the pressure of the liquid entering the jet pump, its work capacity may be controlled. By controlling jet pump power, one can control pipeline velocities or pressures.

When the driving liquid of a jet pump is continuously pressurized, the liquid will transmit power. Power may be defined as the energy possessed by a liquid by virtue of its pressure and/or velocity. One of the practical uses of such power is in the transporting of solids by combining the solids with a liquid, and pumping the mixture through pipes and hoses as a slurry. A typical solids handling jet pump is described in U.S. Patent No. 3,213,807. In such slurry work, high pressure, high energy flow is introduced as primary flow into the jet pump where it mixes with the slurry, or secondary flow, as it is more commonly called. Disregarding friction and turbulence losses, the primary flow or liquid and secondary flow of liquid mixture will assume an energy level which is equal to the average of the energy of the two liquids prior to entering the jet pump. Solids handling jet pumps are presently limited to using low pressure primary liquid due to the fact that higher pressures increase entry velocity of the primary liquid to the point where severe cavitation quickly destroys the jet pump, and hydraulic losses become great. These two factors limit the amount of energy which may be practically introduced through present jet pumps.

In using jet pumps, it is customary to utilize a constant speed centrifugal pump to pressurize the primary liquid. In pressurized form, it flows into the plenum chamber of the jet pump, and then through fixed orifices into the pump chamber. The orifice size controls the quantity and pressure of the primary liquid. Hence, it controls the energy being introduced into the pumping system. However, since the energy requirements of a slurry system are constantly variable, and especially dependent upon the quantity of solids being introduced, a means of vary-

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ing the energy introduced, via the jet pump, is desirable. To date, no such technique is believed in existence.

Accordingly, an object of this invention is to provide a means for varying the primary liquid pressure entering a jet pump.

Another object is to provide a means for varying the discharge pressure of a jet pump.

Still another object is to provide a means for varying the discharge velocity of the jet pump.

A further object is to provide a means of mounting orifices and other controlling devices at a location which is remote from the jet pump, so as to make them more accessible and practical especially where the jet pump is submerged in water or underground.

A still further object is to provide a high efficiency orifice and diffuser in the primary liquid supply pipe.

Another object is to provide a means for handling high pressure primary liquid in a practical manner.

Another object is to provide a means of controlling the velocity of the primary liquid as it enters the jet pump pumping chamber.

Another object is to reduce wear due to cavitation within the jet pump.

Another object is to provide a means for increasing the energy, or pressure input introduced into a single jet pump.

Another object is to increase its pump efficiency by better control of hydraulic losses.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

It has now been found that by proper control of pressure energy in a jet pump assisted slurry operation, one can effectively control pipeline velocity and pressure throughout the system. More specifically, by utilizing an energy controller consisting of an adjustable orifice with appropriate pressure, velocity and density sensing devices for regulating the size of said orifice, one can, at a point remote from the jet pump, actually control the pressure energy of said pump to more effectively control pipeline velocity and pressure. As an auxiliary benefit, cavitation in the jet pump can be avoided by proper control of said variables.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others and the apparatus embodying features of construction, combination of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of this invention, reference should be had to the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a side view illustrating a preferred embodiment of the invention showing the system utilized for dredging.

FIG. 2 is a detailed side view, partly in section, showing the details of the jet pump.

FIG. 3 is a cross sectional view of the entrance nozzle, orifice, diffuser and actuator arrangement.

Similar reference characters refer to similar parts throughout the several views of the drawings.

As seen in FIG. 1, the system of this invention, when adapted for dredging, includes a dredge barge 10 on which a high pressure pump 12 is mounted. Pump 12 is driven at a constant speed, and it may be either a centrifugal or a positive displacement type. The liquid, in this case water, is sucked up to the pump 12 through suction pipe 14 from the water 16 upon which the barge floats. It is pressurized by the pump 12, as high pressure primary liquid, and is discharged into drive pipe 18. It then flows through novel energy controller 20, the details of which are illustrated in FIG. 3. After passing through energy controller 20, the water enters primary jet liquid supply pipe 22, subsequently moving into jet pump plenum chamber 24 (see FIG. 2) and into the pumping chamber 26 (FIG. 2) where it mixes with the dredged solution or secondary flow 28 from suction head 30. The mixture of the secondary and primary flow moves through the jet pump 32 into the dredge pump suction pipe 34, thence to the dredge pump 36 where the mixture is pumped from the dredge barge.

The pressure, density, and velocity of the mixture of solids and water are sensed by a pressure sensor 38, a density sensor 40 and a velocity sensor 42, respectively. The signals from the three sensors are integrated into a single signal, which is then fed to the energy controller regulator 44. (See also FIG. 3.)

Referring now to FIG. 3 for a detailed description of the energy controller 20 and its regulator 44, the controller comprises an annular throat 46 with a flexible annular diaphragm 48 bearing against compressible sleeve orifice 50. The diameter of orifice 50 is varied by fluid pressure from regulator 44 acting through pipe 52 and annular cavity 54 behind annular diaphragm 48.

The throat 46 is fed with liquid from drive pipe 18 (see FIG. 1) and discharges into diffuser 56 and thence into jet water supply pipe 22.

In the operation of the energy controller 20, high pressure liquid is supplied to the drive pipe 18 by pump 12 (FIG. 1) and thence through the compressible sleeve orifice 50. Here the energy content of the drive liquid is varied by varying the back pressure in drive pipe 18 by appropriate adjustment of the diameter of orifice 50. The liquid then moves into a conventional diffuser tube 56 where the kinetic energy of the liquid is converted to pressure energy. Subsequently such pressure energy is conveyed through primary jet liquid supply pipe 22 at the speed of sound. This pressure energy is subsequently consumed in lifting the dredged solids, with accompanying liquid, and in overcoming friction and turbulence losses in the dredge pump suction pipe 34. If an insufficiency or over abundance of pressure energy is supplied by the jet pump 32, it is sensed at the pressure sensor 38, velocity sensor 40, and density sensor 42, said sensors initiating a signal to the energy controller regulator 44. The regulator then adjusts orifice 50 to satisfy the demand.

Referring back to FIG. 2, the primary liquid flowing in jet liquid supply pipe 22 enters jet pump plenum chamber 24, and thence flows through jet orifices 58 of fixed diameter and into the pump chamber 26. The orifices 58 do not regulate the flow quantity or pressure as these are controlled from the dredge barge by energy controller 20. The only function of jet orifices 58 is to fix the entry velocity of the primary flow entering the pumping chamber as the particular application may require, and this is built into the design of the jet pump when it is manufactured.

Since the entry velocity of the primary flow through orifice 58 is dependent upon proper sizing of the orifice, it should be evident that it may be designed so that the entry velocity would not cause cavitation and/or pump wear. Similarly, entry losses due to turbulence in the pumping chamber may be minimized, as they also are a function of entry velocity. While present practice limits the pressures developed by a jet pump to approximately 200 p.s.i., the invention herein makes pressures of up

to 1400 p.s.i. practical, thus increasing jet pump power in direct ratio up to seven times what it used to be.

The primary liquid flowing through jet liquid supply pipe 22 and through the pumping chamber 26 induces a secondary flow of solids with accompanying liquid 28 into the jet pump suction mouth 30, into the pump chamber 26 where it mixes with the primary flow. The resultant mixture travels into the dredge pump suction pipe 34.

The following is offered as an explanation of the theory behind the success of the system, although it should be understood that such explanation should not be construed as controlling of the scope of protection. It is well known that pressure energy is the primary source of energy which is supplied and which is consumed within any pumping system. Pressure energy travels through the liquid medium at the speed of sound, as it is propagated in wave form. So, by properly adjusting for the desired level of pressure energy at energy controller 20, aboard the dredge, one automatically controls the pressure energy supplied to the jet pump 32.

With different pumps, different adjustments are made to take advantage of the pumping action. Thus, when pump 12 is a positive displacement pump, the orifice is reduced to increase the energy supply to jet pump 32, and increased to reduce the energy supply. When pump 12 is a centrifugal pump, the orifice is increased to increase the energy supply to the jet pump, and decreased to reduce the energy supply.

It should be evident that the invention herein is a substantial advance in the art of slurry operation.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained, and since certain changes may be made in carrying out the above method and in the construction set forth without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention, which, as a matter of language, might be said to fall therebetween.

Now that the invention has been described, what is claimed is:

1. Apparatus for the more efficient operation of a slurry pumping jet pump comprising an orifice variable in diameter in series with a slurry pumping jet pump, an actuator capable of adjusting the diameter of said orifice by a fluid medium exerting a variable pressure acting upon a compressible sleeve, said sleeve comprising said orifice, said actuator being controlled by sensors consisting of a density sensor and a velocity sensor located on the outlet side of said pump to sense the condition of the slurry at the outlet of said jet pump whereby the pressure of the slurry may be controlled in accord with the density and velocity of said slurry being pumped.

2. The apparatus of claim 1 wherein said orifice is installed contiguous to said jet pump.

3. The apparatus of claim 1 wherein said orifice and jet pump are integral.

4. The apparatus of claim 1 wherein said orifice is installed remote from said jet pump.

5. The apparatus of claim 1 wherein the pressure energy is generated by a variable displacement pump and where the orifice is increased to introduce more pressure energy into the pump.

6. The apparatus of claim 1 wherein the pressure energy is generated by a positive displacement pump and where the orifice is diminished to introduce more pressure energy into the pump.

7. The apparatus of claim 1 wherein said orifice leads

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into a diffuser, and said orifice and diffuser are connected in series with said pump.

8. The apparatus of claim 7 wherein said diffuser has a divergent development with interior wall angles of between 1° to 4° from the flow axis.

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