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[54] **SURGE CONTROL**

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Related U.S. Application Data

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[52] **U.S. Cl.** **417/53,** 417/279

[51] **Int. Cl.** **F04b 49/00**

[58] **Field of Search** 417/279, 53, 197–199, 417/543; 137/183

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[57] **ABSTRACT**

A bleed tube extends upward from the inlet of a pump. The bleed tube is closed at the top and has a plurality of perforations therein. As the level of the reservoir lowers below these perforations, air is drawn into the inlet of the pump inversely proportional to the reservoir level. At the outlet of the pump, the air is separated from the liquid and the air is used to reduce the fluid flow.

A plurality of choke valves are used in a long line, each choke valve being controlled by the air in the pipe at that point. This prevents water hammer at the beginning of fluid flow.

17 Claims, 4 Drawing Figures

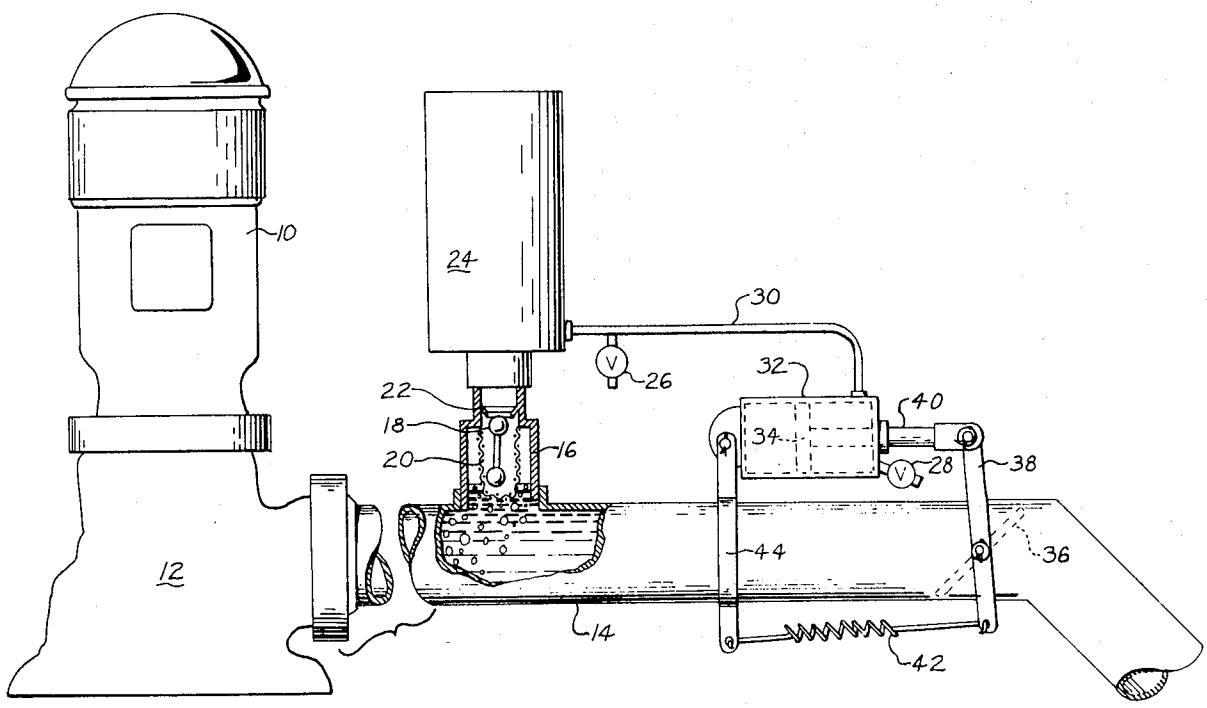


Fig-1

Fig-2

Fig-3

Fig-4

SURGE CONTROL

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of my previously filed patent application Ser. No. 311,706, filed Dec. 7, 1972, pending in Group 343. Also, the invention is described in Disclosure Document No. 015191, dated Dec. 4, 1972, the transfer of which is hereby requested according to MoPEP 1706.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to fluid flow by pumps and more particularly to regulators for liquid pumps.

2. Description of the Prior Art

Problems exist when pumping from confined reservoirs. In the field of agriculture, a problem exists when pumping from underground aquifers, often the reservoir is over 100 feet below the surface of the earth. The pumps, which are located below ground, are often powered by a constant-speed electric motor above ground. When the well is first started, the pump, initially pumping the water to the surface of the ground, will force a large slug of air ahead of it. Also, there is no back pressure upon the motor and, therefore, it pumps high volumes. This often produces an unsatisfactory result. If the pump is then pumping into a long horizontal line, this mixture of water and air causes undesirable water hammer.

In addition, the water flow characteristics of the aquifer result in only a limited flow of water being available. If the pump is operated at a capacity greater than the availability of the water, the pump will "break suction," which means that the inlet of the pump is above the liquid level within the reservoir. My prior patent application dealt with this problem and, particularly, discussed the turbulent situation found at the pump and at the bottom of the well in such an instance. However, in pumping from any reservoir, the pump can be regulated as soon as air reaches the inlet of the pump, as discussed in my prior patent application. However, in certain instances, it is desired to begin to regulate the pump so the pump is regulated even though the surface of the liquid is above the inlet of the pump.

At present times when pumping petroleum products from storage tanks, it is common to have the outlet of the tank in the bottom of the tank. These tanks are also provided with level controls or floats which indicate the level of liquid in the tank, therefore, cutting off the pump when the level reaches near the bottom of the tank. In such cases, it is necessary to have an opening into the tanks so the float can be inside the tank. Generally, a transmitter is on the outside wherein the mechanical position of the float is transformed into an electrical signal. This electrical signal is transferred by wire to a control panel which may be located at the pump and then the electrical signal is used to change an air control valve or other mechanism at the pump.

My prior patent application is specifically referred to for patents of which I was specifically aware at the time this application was filed.

SUMMARY OF THE INVENTION

1. New and Different Function.

I solve the problems outlined above in part by having a tube extended upward from the pump inlet. This tube has a series of small openings therein. The bottom of the tube is opened at the inlet of the pump at a place of low pressure. If any of the openings in the tube are above the surface of the liquid, they will begin to admit air into the inlet of the pump. This air is separated from the liquid and used to control the fluid flow; particularly, it is adaptable to use to control the fluid flow by means of a choke valve.

In long lines, I have found it desirable periodically to space these air detectors and choke valves so when the pump is first started in the initial operation and when there is a mixture of the air and liquid in the pipe, the air can be separated out from the liquid and the air used to close the choke valve; thereby, slowing the flow of water and thus reducing or eliminating the water hammer.

In the case of pumping petroleum products from storage tanks, if the perforated tube is extended above the outlet of the tank, only a single conduit conveys both the liquid from the reservoir to the pump and the same single conduit conveys information concerning the level of the reservoir to the pump. Therefore, it is not necessary to have the more complex and complicated system to transmit the information of the liquid level in the reservoir to the pump, but only a simple mechanism at the inlet of the pump which detects the level at the time the level gets low and the single conduit conducts both the liquid to the pump and also transmits the information as to reservoir level.

2. Objects of this Invention

An object of this invention is to regulate a pump system to maintain a liquid level at a preset distance above the pump inlet.

Another object is to reduce water hammer in a long liquid conduit.

Other objects are to achieve the above with a device that is sturdy, compact, durable, lightweight, simple, safe, efficient, versatile, and reliable, yet inexpensive and easy to manufacture, install, adjust, operate, and maintain.

Further objects are to achieve the above with a method that is versatile, rapid, efficient, and inexpensive, and does not require skilled people to install, adjust, operate, and maintain.

The specific nature of the invention, as well as other objects, uses, and advantages thereof, will clearly appear from the following description and from the accompanying drawing, the different views of which are not to the same scale.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view of a well head showing a water regulator according to this invention, with parts broken away for clarity of illustration, other parts are schematically shown.

FIG. 2 is a schematic representation of an embodiment of this invention, with parts broken away for clarity of illustration.

FIG. 3 is an enlarged sectional view showing the inlet of the pump with the perforated tube therewith.

FIG. 4 is a schematic representation of a long flow line with a plurality of choke valves therein to regulate the water flow to prevent water hammer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, the basic control unit is shown.

Electric motor **10** sets upon a well head **12.** Not shown in FIG. **1** would be the pump pipe, pump, and inlet pipe extending downward from the well head, e.g., 100 feet to a reservoir of water in a well, all as shown and described in my prior application. In this arrangement the pump is located 100 feet below the earth's surface. Outlet pipe **14** is shown broken away in the area of air trap **16** to show the bubbles of air which would be entrained in the water. Obviously any air in the water flows to the top and would be caught within the air trap **16.**

Float valve **18** within cage **20** will seal against seat **22** if there is no air within the trap **16.** i.e., if all the air has been drained from the trap **16** and only water is present, the valve **18** will be against seat **22,** preventing any flow. The air in air accumulator tank **24** will bleed from bleed valve **26** or bleed valve **28.** Additional air flowing into the air trap **16** flows into the accumulator tank **24** and this will increase the pressure on the accumulator tank **24** which is transmitted through air tubing **30** to air motor **32.** Therefore, the increase of air pressure in air tubing **30** will move piston **34** which will close choke valve **36.** The choke valve is actuated by arm **38** attached to piston rod **40.** Normally, the choke valve **36** is held in the full open position by spring **42** which extends from the end of the arm **38** to bracket **44** by which the motor **32** is attached to the outlet pipe **14.** Those skilled in the art will understand by analysis that various changes could be made. e.g., the accumulator tank **24** can, in many instances, be eliminated. Also, the air motor **32** can take the form of a diaphragm type motor wherein the piston **34** is replaced by a large diaphragm. Therefore, very slight changes of air pressure are sufficient to change the choke valve **36.**

Also, the mechanism shown in FIG. **1** is primarily that which has been shown in my previous patent application identified above. In my previous patent application, I depended mainly upon the vortex around inlet pipe **48** within reservoir **46** (FIG. **2**). i.e., no air entered into the inlet pipe **48** to be detected in the outlet **14** until the level of the liquid **52** in the reservoir **46** reached a level so there was air being pulled into pump **50** by the vortical depression.

In the schematic representation of FIG. **2,** there can be identified the air trap **16** with the air tubing **30** leading to the motor **32,** which controls the choke valve **36,** the operation being largely controlled by the bleed valve **26.**

One of the improved features shown of this invention is bleed tube **54** shown in FIG. **2** and shown at a larger scale in FIG. **3.** The bleed tube **54** has considerably smaller diameter than pump inlet **48** and is, in general, J-shaped; i.e., the bleed tube has outlet **56** at the inlet **58** of the inlet pipe **48.** The inlet tube or bleed tube **54** extends vertically upward from the inlet. Top **60** of the inlet tube is closed, but there is a plurality of evenly spaced bleed holes **62** therein. The holes have been exaggerated as to size for clarity of illustration.

If the liquid level in the reservoir **46,** and particularly the vortex, reaches a point so there is air at the top of the bleed tube **54,** air will be sucked in through the uppermost bleed hole **62.** The air trap **16** will trap the air from one bleed hole **62.** With the setting of the bleed valve **26,** the fluid flow characteristics can be adjusted so either a slight correction or no correction is made when air from one bleed hole **62** reaches the outlet **14.** If the bleed valve **26** is regulated so slight adjustment is made responsive to the air coming through one bleed opening **62,** then, if the level of the reservoir falls further so two openings **62** receive air, a greater and more decisive adjustment would be made by the system to further close the choke valve **36** and, thus, further limit the flow of liquid from the reservoir **46.**

Likewise, if three bleed holes **62** were exposed, even more adjustment would be made; if four bleed holes **62** were open, additional regulation would be made.

Therefore, by providing the tube **54** above the inlet and by regulation of the bleed valve **26,** the mechanism may be set to maintain almost any level within the reservoir **46,** assuming that the capacity of the pump **50** is sufficient to pump the reservoir **46** down. If the bleed tube **54** extended vertically five feet above the inlet **58** of the pump **50,** a 5 foot range of adjustment could be made. Those skilled in the art will understand that the length of the tube **54** and the size and spacing of the bleed holes **62** can be regulated along with the size of the opening of bleed valve **26** to achieve whatever degree of control is desired.

Reviewing the disclosure of my previously filed application, not only could fluid flow be controlled by a choke valve **36,** but it could be controlled by regulating the speed of the pump in the event a variable speed motor were used. Specifically, for example, if an internal combustion engine were used rather than an electric motor **10,** the air motor **32** could be connected to the throttle of the internal combustion engine as disclosed therein. Also, if the reservoir **46** were something besides an underground aquifer, the liquid supply to the reservoir could be regulated.

Even if an electric motor **10** were used, in certain cases, it might be desired to completely stop the electric motor. However, as mentioned before, those problems are dealt with in my prior application; this application is directed toward the problem of early detection and more exact determination of the level within the reservoir.

FIG. **4** illustrates additional ways a choke valve type arrangement may be used. There is depicted an extremely long outlet pipe **14.** Although the length of the outlet **14** is no set amount, it would be sufficiently long so water hammer might develop therein if not controlled. Also, FIG. **4** illustrates a reservoir of liquid **46** with the pump **50** having inlet pipe **48** with bleed tube **54** and outlet pipe **14.** Further, a plurality of air traps **16** are spaced along the outlet pipe **14.** Each of the air traps is connected to air motor **32,** preferably in the form of a diaphragm motor by the air tubing **30.** Each air motor **32** controls choke valve **36.** In FIG. **4,** the bleed valve **26** or bleed valve **28** have not been shown for clarity of illustration.

A large diameter air motor **32** is desirable because it is necessary that these motors react upon a very small pressure increase. When the pump **50** is first started, there will be a rush of liquid within the outlet pipe **14,** pushing air ahead of it. If the air pressure increases a very small amount, the motors **32** are controlled to close the choke valve **36,** preventing an undesirable combination of air and liquid, which causes the water hammer. By choking the flow of liquid in the pipe **16,** water hammer is prevented, resulting in a smooth beginning of the operation of the pump without damage otherwise caused by the water hammer.

The embodiments shown and described above are only exemplary. I do not claim to have invented all the

parts, elements or steps described. Various modifications can be made in the construction, material, arrangement, and operation, and still be within the scope of my invention. The limits of the invention and the bounds of the patent protection are measured by and defined in the following claims. The restrictive description and drawing of the specific examples above do not point out what an infringement of this patent would be, but are to enable the reader to make and use the invention.

I claim as my invention:

1. In a liquid pumping system having
a. a pump with
i. an inlet and
ii. an outlet pipe,
b. said inlet submerged in a liquid reservoir, and
c. an air trap on the outlet pipe;
d. THE IMPROVED STRUCTURE COMPRISING:
e. a bleed tube with
f. a bleed tube outlet at the submerged pump inlet,
g. said bleed tube extending upward from said pump inlet,
h. a plurality of spaced apart holes in the bleed tube,
j. an air tube from the air trap on the outlet to
k. an air motor, and
m. control means attached to said air motor for controlling the fluid flow.

2. The invention as defined in claim **1** with an additional limitation of
n. a bleed valve connected to the air tube.

3. The invention as defined in claim **1** wherein said control means is in the form of
n. a choke valve in the outlet pipe adjacent the air trap to which it is connected.

4. The invention as defined in claim **3** with additional limitations of
o. additional air traps in the outlet pipe,
p. all of said air traps spaced apart from all other air traps.

5. The invention as defined in claim **4** with an additional limitation of
q. a bleed valve connected to the air tube.

6. In a liquid pumping system having
a. a pump with
i. an inlet and
ii. an outlet pipe,
b. said inlet submerged in a liquid reservoir, and
c. an air trap in the outlet;
d. THE IMPROVED STRUCTURE COMPRISING:
e. at least one additional air trap in the outlet pipe spaced from all other air traps,
f. an air tube from each air trap,
g. an air motor attached to each air tube, and
h. a choke valve in the outlet pipe connected to each air motor,
j. so that at any point there is air in the outlet pipe the fluid flow is choked to lessen water hammer.

7. The invention as defined in claim **6** with additional limitations of
k. a bleed tube with
m. a bleed tube outlet at the submerged pump inlet,
n. said bleed tube extending upward from said pump inlet, and
o. a plurality of spaced apart holes in the bleed tube.

8. In a liquid pumping system having
a. a pump with
i. an inlet and
ii. an outlet pipe,
b. said inlet submerged in a liquid reservoir, and
c. an air trap in the outlet;
d. THE IMPROVED METHOD COMPRISING:
e. supplying small amounts of additional fluid into the inlet at a level above the main liquid inlet,
f. detecting the presence of air in the outlet, and
g. reducing the fluid flow responsive to the presence of air in the outlet.

9. The invention as defined in claim **8** with additional limitations of
h. reducing the fluid flow proportional to the amount of air detected in the outlet,
j. so that as more air is detected in the outlet, the reduction of fluid flow is greater.

10. The invention as defined in claim **8** with additional limitations of
h. detecting the presence of air at a plurality of points spaced along the outlet pipe, and
j. choking the fluid flow in the outlet pipe at each point of detection of air in the outlet pipe.

11. The invention as defined in claim **8** with an additional limitation of
h. bleeding away the detected air in the outlet at an adjustable rate.

12. The invention as defined in claim **11** with additional limitations of
j. reducing the fluid flow proportional to the amount of air detected in the outlet,
k. so that as more air is detected in the outlet, the reduction of fluid flow is greater.

13. The invention as defined in claim **12** with additional limitations of
m. detecting the presence of air at a plurality of points spaced along the outlet pipe, and
n. choking the fluid flow in the outlet pipe at each point of detection of air in the outlet pipe.

14. In a liquid pumping system having
a. a pump with
i. an inlet and
ii. an outlet pipe,
b. said inlet submerged in a liquid reservoir, and
c. an air trap in the outlet;
d. THE IMPROVED METHOD OF LESSENING WATER HAMMER IN LONG OUTLET PIPES COMPRISING:
e. detecting air in the outlet pipe at plurality of spaced apart points, and
f. choking the fluid flow in the outlet pipe at each point air is detected.

15. The invention as defined in claim **14** with additional limitations of
g. choking the flow of fluid in the pipe proportional to the amount of air detected in the pipe,
h. so that as more air is detected the greater the choking, thus the greater reduction of fluid flow.

16. The invention as defined in claim **14** with an additional limitation of
g. bleeding away the detected air at each point detected at an adjustable rate.

17. The invention as defined in claim **16** with additional limitations of
h. choking the flow of fluid in the pipe proportional to the amount of air detected in the pipe,
j. so that as more air is detected the greater the choking, thus the greater reduction of fluid flow.

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