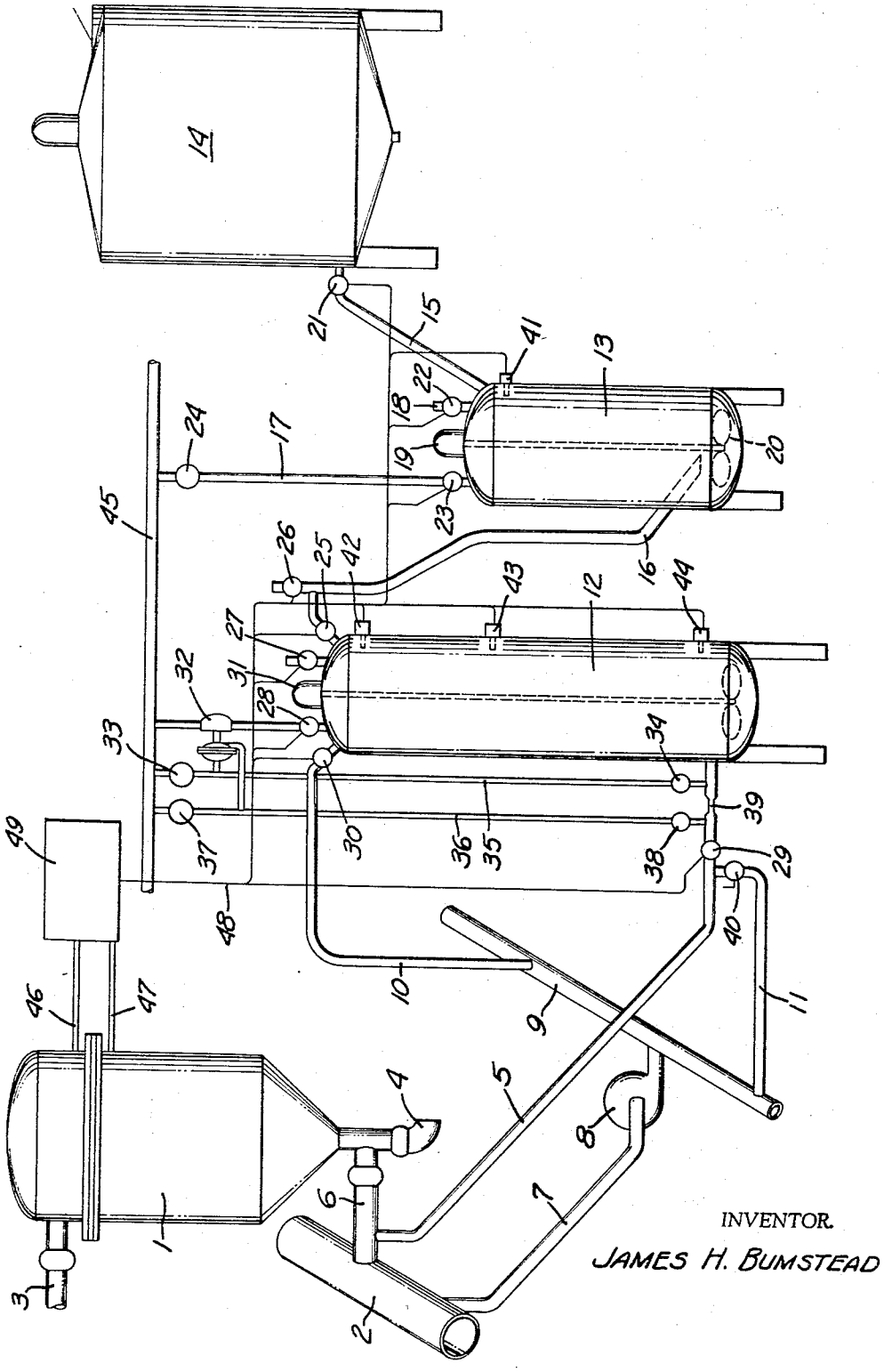
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METERING PUMP

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METERING PUMP

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My invention relates to an improvement in metering pumps for liquids, and more specifically to an improvement in slurry feeders for diatomaceous earth filtration systems.

Frequently, chemical solutions and slurries are required to be pumped at a determined rate, and for this purpose a positive displacement piston or diaphragm pump is used. The pumping rate is usually adjustable by varying the length of stroke. Pumps of this kind produce a pulsating flow of variable capacity per stroke. Other positive displacement type pumps adjust the pumping rate by varying the frequency of pulsation, keeping the capacity per stroke constant. Experience has shown that pumps of both of these types, when pumping abrasive slurries, especially at high pressures, need frequent replacement of moving parts that are in contact with the fluids.

At the present state of the art, other means of pumping chemical solutions and slurries at determined rates, frequently use an eductor to suck the slurry into the pressure pipeline, and centrifugal or turbine pumps for boosting. The means for accurately proportioning the chemicals is done on the suction side of the eductor by means of pulsating valves, automatic dry feeders, or the like. Frequently, in such systems, the pressure downstream of the eductor is such that a booster pump must be located in the pipe which carries the chemical. The eductor and booster pumps commonly used for these applications, when handling abrasive slurries, especially at high pressure, are subject to excessive wear. The abrasive slurry is also reduced in quality after having passed through the eductor and pump.

It is therefore a major object of my invention to provide a metering pump that has no moving parts in contact with the liquid being pumped, thus reducing maintenance costs.

Another object of the invention is to provide a metering pump that will not break down slurries by turbulent action of pistons, diaphragms, impellers, jets, and the like.

Still another object of the invention is to provide a metering pump that will automatically control the body-feed in a diatomaceous earth filtration system.

Another object of the invention is to provide a metering pump that will produce a continuous instead of a pulsating flow.

These and other objects of my invention will become evident from the following description of the preferred embodiment of the same, reference being had to the accompanying drawing, which shows a schematic representation of a diatomaceous earth filtration system having a slurry feeder for body feed.

The drawing shows a diatomaceous earth filter **1** with influent header **2**, effluent header **3**, and drain pipe **4**, which are of standard construction. The filter, for purposes of illustration, is an automatic backwash type that has valves controlled by electrical, hydraulic, or pneumatic means, which are not shown since they are not a part of this invention.

The body feed system for this filter is illustrated in detail to show my method and means for pumping and controlling the flow of body feed to the filter. It consists generally of a gravity slurry tank **14**, a refill tank **13**, a slurry feeder **12**, a booster pump **8**, and assorted pipes and valves. The gravity slurry tank **14** is of standard construction, with agitator, drain, water supply and loading hatchway, the details of which are not shown for brevity.

In operation, a slurry is mixed in the gravity slurry

tank **14** once a day or so. The slurry then automatically flows into the refill tank **13** until said refill tank is full, then air pressure is applied on top of the slurry to force it out of the refill tank **13**, and into the feeder tank **12**. The feeder tank **12** is continually under pressure by compressed air which is forcing the slurry out of the feeder tank through a meter tube **39** and into the body-feed pipeline **5** which carries it to the influent to the filter to mix with the turbid fluid.

Although not essential to this invention, I have illustrated a preferred method of diluting the slurry to keep the slurry pipe **5** from plugging, by means of a booster pump **8** which takes water from the influent header **2** by suction pipe **7**, and boosts it into the high pressure water header **9** and thence into the flush water supply line **11**, which leads to the slurry feeder, and is injected through throttle valve **40** just downstream of the slurry outlet valve **29**.

Although not essential to my invention, I have illustrated a means for automatically diluting the slurry in the slurry feeder tank **12**, to compensate for varying turbidity of flow through the filter. A control panel **49** having a differential pressure measuring device which is connected across the filter elements by pressure-sensing lines **46** and **47**, automatically programs the operation of the valves on the slurry feeder tank **12** and refill tank **13**. The method and mechanism of the control panel is illustrated in my co-pending application Ser. No. 226,981, dated Mar. 20, 1964, now abandoned. The principle of operation of the system is that each time the pressure differential in the filter reaches one of several predetermined pressure settings, the slurry feeder tank would automatically fill with water to a certain level, and then fill with slurry from the refill tank to a certain level, during which time the slurry would continue to flow at a constant rate out of the slurry feeder tank **12**, and into the influent to the filter **2**. The elapsed time it takes for the differential pressure across the filter to reach the next higher pressure setting, depends upon the rate of flow and the filterability of the fluid, which may be variable. Since the rate of flow of slurry out of the slurry feeder is constant, the amount of slurry left in the slurry feeder tank after said variable elapsed time would also be variable. Thus a variable amount of water which is proportional to the elapsed time, would be added to the slurry to bring it up to a certain level, and a definite amount of slurry would be added to bring it to the next certain level. Thus, each time one of the pressure differential levels is reached, the slurry feeder is refilled with a variable amount of water and a definite amount of slurry. This will vary the concentration of the slurry in the slurry feeder tank in response to the rate at which the filter is plugging. The faster the filter is plugging, the less water is added to the slurry feeder tank, and the more concentrated the slurry will become, thus compensating for the fast rate of plugging of the filter.

As stated before, the automatic dilution feature is not essential for my invention. If desired, the body feed rate may be held constant by causing the refilling cycle of the slurry feeder to be triggered by the slurry reaching a certain level in the slurry feeder tank. Thus, there would always be a definite amount of water and a definite amount of slurry added to the tank. In a more simplified version of this type, the step of adding water to the slurry feeder tank could be eliminated, and only a certain quantity of slurry would be added when needed.

Many other variations of this principle will be obvious to those skilled in the art. A detailed description of the mechanism for accomplishing the above operation follows:

Typically a filter plant consists of two or more filters

with a slurry feeder tank **12** for each filter, but only one refill tank **13**, one gravity slurry tank **14**, and one high pressure water system with a booster pump **8**, and an air compressor (not shown). To ready the plant for service, the gravity slurry tank **14** is filled with filter aid slurry of the proper concentration. The slurry agitator motors **19** and **31** are started; pump **8** is started; and the control panel for those filters which are desired to be put into automatic service are selected by manual selector switches. From then on, the filters selected will automatically come on in sequence, automatically wash, precoat, recirculate, fill the slurry feeder **12**, and go on stream, with the slurry feeder **12** going on stream too. The panel control **49** controls all of the functions of the filter unit and the body feed system.

Initially the filter **1** is washed, precoated, and recirculated in the standard manner. The booster pump **8** is in service supplying high pressure water from suction line **7** to a high pressure water header **9** which also supplies the other filters in the plant (not shown). The dilution water circulates through flush water supply line **11** and throttle valve **40**, slurry supply line **5**, and into the influent header upstream of the influent valve **6**, which is closed during the recirculation cycle. Slurry outlet valve **29** is initially closed so that no slurry is being fed wastefully into the system during the recirculation cycle of the filter.

Before any of the filters are ready to go on stream, the refill tank **13** is filled in preparation for service by the following means: The control panel **49**, by means of time switch or other appropriate device in the filter sequence sends an initial signal through control line **48** to open the slurry inlet valve **21** to refill the tank, which allows slurry to flow through pipe **15** by gravity, or other means not shown, into the refill tank **13**. Air is displaced by the slurry and flows out of valve **22** through pipe **18**. Valve **26** at the top of outlet pipe **16** from the refill tank is open so that air may be displaced as the slurry seeks its level in this pipe during filling of the refill tank **13**. The agitator blade **20**, driven by motor **19**, keeps the slurry in suspension and all of the pipes that carry slurry should be designed to allow the slurry to drain back into the agitated tanks, thus preventing plugging of the lines. When the level of the slurry in the refill tank reaches the high probe **41**, a control signal is sent to the panel **49**, and the control panel responds by sending out a signal closing slurry inlet valve **21** to the refill tank, and air outlet valve **22** in the refill tank, and also closing outlet valve **26**. The refill tank **13** is now ready for service.

The slurry feeder tank **12** is initially full of air at atmospheric pressure and all valves except air outlet valve **27** are closed. The slurry level probes **42**, **43** and **44** are dry. When a filter unit is selected to be put in service, the slurry feeder tank is also readied for service by starting the agitator motor **31**. When the controller **49** receives the signal that the refill tank **12** is ready for service, the air inlet valve to the refill tank **23** is opened, allowing compressed air to flow from air supply header **45**, through a rate-of-flow valve **24** and pipe **17** into the refill tank **13**. This air pressure forces the slurry up into the slurry feeder tank **12** through pipe **16**. The slurry inlet valve to slurry feeder **25** is then opened and the compressed air pushes the slurry into the slurry feeder tank **12** at a constant rate. The air in the slurry feeder tank is dispelled out through the air outlet valve **27**. When the slurry reaches the probe **42**, slurry inlet valve **25** and air outlet valve **27** to the slurry feeder tank close. The slurry feeder is ready for service.

It may be seen by those skilled in the art that diatomaceous earth slurries, handled by air pressure in the fashion described, will not be broken down by the action of moving parts such as impellers or jets or pistons. The device for controlling the rate of flow of slurry is an air regulating valve **32**, which may be of the constant pressure, constant flow type, or constant differential pressure type, or any other type consistent with the way the rate of flow of slurry is to be controlled. The air regulating valve **32** provides a low maintenance means of metering the slurry, since the abrasive slurry does not pass through moving parts. The standard air regulator is also easily adjusted for varying the rate of flow of slurry when desired.

The flow of the slurry out of slurry feeder **12** into filter tank **1** will not be intermittent or pulsating flow. The uniform flow of air into the slurry feeder tank **12** will maintain a uniform flow of slurry out of the feeder. It will be shown later, how the slurry flow is maintained even while the slurry feeder tank is being refilled by means of refill vessel **13**.

When slurry feeder tank **12** is in service, the rate of flow of compressed air into the tank through regulating valve **32** must equal the rate of flow of slurry out of the tank through meter tube **39**. As the slurry in tank **12** is used up, normally it will be desirable to refill the slurry feeder tank **12** while it is in service and without substantially changing the rate of flow of slurry through meter tube **39**. When the slurry feeder tank is to be refilled with slurry, some of the compressed air in the tank must be displaced by the slurry which is filling the tank. This air will be expelled through valve **27**. The rate of flow of slurry into the slurry feeder tank **12** during refilling may be adjusted by means of air flow control valve **24** which controls the flow of air into the refill tank **13** which pushes the slurry under pressure into the slurry feeder tank **12** at a uniform rate. The air which flows out of slurry feeder tank **12** through valve **27** should be approximately equal to the rate at which the slurry is entering the tank, and for this purpose valve **27** may have an adjustable stop to keep it from opening all the way.

It may be impractical and/or unnecessary to adjust the air release from the slurry feeder tank **12** through valve **27** to exactly equal the inflow of slurry from the refill tank as controlled by air flow valve **24**. Air regulating valve **32** will either increase or decrease its air flow in order to maintain a constant flow of slurry through meter tube **39**.

When the slurry feeder tank **12** is filled, the refill tank **13** then is refilled as follows: Air inlet valve **23** closes, and air outlet valve **22** opens, releasing air pressure from the tank. Air valve **26** opens, allowing slurry to drain back into the refill tank and seek its level. Slurry inlet valve **21** opens, allowing refill tank **13** to again fill as before.

Now that the slurry feeder tank **12** is ready for service, at an appropriate time just before the filter **1** goes on stream, the slurry feeder is put in service as follows: Air inlet valve **28** is opened, allowing compressed air to flow through regulating valve **32** into the slurry feeder tank **12**. Slurry outlet valve **29** is opened and the compressed air forces the slurry out to the filter **1**. In passing through meter tube **39**, the restriction of flow of slurry causes a pressure drop across the meter tube, and that pressure drop is sensed by sensing lines **35** and **36**. I have illustrated here a bubbler arrangement to keep the slurry from getting into the sensing lines **35** and **36**, by means of check valves **34** and **38**. The pressure is sensed by causing a low flow of air in the sensing lines to bubble through the check valves **34** and **38**, and to be carried out into the influent pipe **2**. The flow of air in the sensing lines is controlled by valves **33** and **37**, which are standard air flow control valves. The differential pressure across the meter tube is used in a standard manner to control the flow of air through regulating valve **32**, and thus maintains a constant flow of slurry through the meter tube **39**. Thus the body feed system continues to operate until either the slurry tank **12** needs to be refilled, or the filter **1** is turned off or backwashed.

As filtration proceeds, the pressure differential builds up across sensing lines **46** and **47**, and the pressure differential device in control panel **49** rotates a program switch which initiates the refill action as follows:

The slurry in slurry feeder tank **12** has reached some undetermined level, say between probes **43** and **44**, when the command signal is received to refill. Since probe **43** is dry, water inlet valve **30** will open, allowing water, from high-pressure water header **9**, to enter the slurry feeder tank through pipe **10**, until the level reaches probe **43**. Water valve **30** then closes, and slurry inlet valve **25** opens, allowing the slurry to fill to the level of probe **42**. In order to fill the slurry feeder tank in this fashion, without disturbing the flow of slurry past the meter tube **39**, air outlet valve **27** on top of the slurry feeder tank is opened to allow the displaced air to escape to the outer atmosphere. The air outlet valve **27** is then closed and slurry inlet valve **25** is closed, thus returning slurry feeder tank **12** to normal service.

If the automatic slurry dilution feature is not used, the slurry feeder refill cycle is initiated by probe **44** becoming dry, and the water fill is omitted.

Several variations and different applications of my invention may occur to those skilled in the art without departing from the spirit and scope thereof, and therefore this disclosure is not to be limited by the precise details shown in the drawings or particularly described in the specification by way of example, but only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A liquid transfer device comprising a pressure vessel having;

a liquid inlet pipe adapted for connection to a source of liquid to be metered;

a gas outlet pipe connected to the upper portion of said pressure vessel, for venting gas expelled from the pressure vessel while the latter is being filled with liquid;

a gas inlet pipe adapted for connection to a source of pressurized gas, and having gas regulating valve means operable to control the flow of pressurized gas into the liquid-filled pressure vessel;

a liquid outlet pipe connected to the lower part of the pressure vessel, and having a liquid metering device provided therein; and

control means operatively connected to said gas regulating valve for controlling the flow of gas into said pressure vessel responsive to the metered outflow of said liquid through said outlet pipe.

2. A liquid transfer device as described in claim **1**, wherein the liquid metering device is a differential pressure producing device;

and wherein said gas regulating valve means is of the type operable to regulate the flow of gas responsive to the differential pressure produced across said liquid metering device.

3. A liquid transfer device comprising a pressure vessel having;

a liquid inlet pipe adapted for connection to a source of liquid to be metered;

a gas outlet pipe connected to the upper portion of said pressure vessel, for venting gas expelled from the pressure vessel while the latter is being filled with liquid;

a gas inlet pipe adapted for connection to a source of pressurized gas, and having gas regulating valve means operable to control the flow of pressurized gas into the liquid-filled pressure vessel;

a liquid outlet pipe connected to the lower part of said pressure vessel, and having a liquid metering device provided therein, said liquid metering device including a device producing a pressure differential between two points in said liquid outlet pipe;

a high pressure sensing line connected to said liquid outlet pipe on the high pressure side of said differential pressure producing device;

a low pressure sensing line connected to said liquid outlet pipe on the low pressure side of said differential producing device;

control means connected to said sensing lines and operatively connected to said gas regulating valve for controlling the flow of gas into said pressure vessel, said gas regulating valve means being of the type operable to regulate the flow of gas into said pressure vessel responsive to the pressure differential; and

means for preventing liquid from entering said sensing lines, said means comprising a source of gas under pressure connected to said high and low pressure sensing lines, whereby gas is forced through said sensing lines and bubbles into said liquid outlet pipe, said differential regulating valve being operable responsive to the differential pressure in said sensing lines.

4. A liquid transfer device comprising a pressure vessel having:

a liquid inlet pipe adapted for connection to a source of liquid to be metered, said inlet pipe having first valve means provided therein;

a gas outlet pipe connected to the upper part of said pressure vessel, for venting gas expelled from the pressure vessel while the latter is being filled with liquid, said outlet pipe having second valve means provided therein;

a gas inlet pipe adapted for connection to a source of pressurized gas, and having gas regulating valve means operable to control the flow of pressurized gas into the liquid-filled pressure vessel;

a liquid outlet pipe connected to the lower part of said pressure vessel, and having a liquid metering device provided therein; and

control means operatively connected to said gas regulating valve for controlling the flow of gas into said pressure vessel responsive to the metered outflow of said liquid through said outlet pipe; and

level sensing means operatively connected to said first and second valve means to refill said pressure vessel to a prescribed high level when a prescribed low level is reached, while maintaining uninterrupted flow of slurry out of the pressure vessel.

5. Apparatus for liquid metering by displacing the liquid from a pressure vessel by means of a gas, with provision for refilling the pressure vessel with liquid, comprising:

(1) a first pressure vessel having:

(a) a liquid inlet pipe and associated valve means connected to a source of liquid to be metered;

(b) a gas outlet pipe and associated valve means for venting the gas being displaced during the filling of the vessel with liquid;

(c) a gas inlet pipe and associated gas regulating and shutoff valve means connected to a source of pressurized gas, for supplying the pressurized gas to the pressure vessel;

(d) a liquid outlet pipe near the bottom of said first pressure vessel;

(2) a second pressure vessel having:

(a) a liquid inlet pipe and associated valve means connected to the liquid outlet pipe of said first pressure vessel, for receiving the liquid therefrom;

(b) a gas outlet pipe and associated valve means for venting the gas which is displaced during filling of the second pressure vessel;

(c) a gas inlet pipe connected to a source of pressurized gas and having a shutoff valve means, and regulating valve means suitable for maintaining a substantially uniform outflow of liquid being displaced by the gas; and

(d) a liquid outlet pipe with associated valve means.

6. Apparatus for feeding body feed in a filtration system, comprising:

(1) a gravity slurry tank for containing the body feed slurry;

(2) a first pressure vessel having a slurry inlet pipe connected to said gravity slurry tank, and having valve means for filling said pressure vessel with slurry by gravity;

(3) a gas vent pipe in the first pressure vessel having valve means for venting the gas displaced by the slurry inflow;

(4) a source of pressurized gas;

(5) a gas inlet pipe in said first pressure vessel connected to said source of pressurized gas and having valve means controlling the flow of pressurized gas into the first pressure vessel for displacing the slurry in a controlled manner;

(6) a slurry outlet pipe near the bottom of said first pressure vessel connected to the slurry inlet of a second pressure vessel, having valve means for stopping the flow of slurry and for venting the slurry outlet pipe;

(7) a gas outlet pipe in the top of the second pressure vessel having valve means for expelling the gas displaced while filling the second pressure vessel;

(8) a gas inlet pipe in the second pressure vessel connected to said source of pressurized gas and having regulating and control valve means for controlling and regulating the flow of pressurized gas into the second pressure vessel, thereby maintaining the outflow of displaced slurry at a substantially uniform rate;

(9) a liquid outlet pipe near the bottom of the second pressure vessel, having valve means for stopping the flow of slurry out of the second pressure vessel, said liquid outlet pipe connecting to the influent to the filter for mixing the slurry with the liquid being filtered;

(10) a first control means for opening the slurry inlet and gas outlet valves to the first pressure vessel for filling the first pressure vessel;

(11) a first liquid level sensing device located near the top of said first pressure vessel having control means for closing the slurry inlet valve and gas outlet valve to the first pressure vessel when the liquid has reached the level sensing device;

(12) second control means for opening the gas inlet valve to the first pressure vessel, and opening the slurry inlet and gas outlet valves to the second pressure vessel for filling the second pressure vessel while the filter is being prepared for service;

(13) a second liquid level sensing device located near the top of the second pressure vessel and operatively connected to a third control means to close the slurry inlet valve and gas outlet valve to the second pressure vessel, and closing the gas inlet valve, and opening the slurry inlet valve and gas outlet valve to the first pressure vessel when the slurry level reaches said second liquid level sensing device;

(14) fourth control means for opening the gas inlet and slurry outlet valves to the second pressure vessel, thus allowing slurry to flow to the filter when the filter goes on stream, and for closing the gas inlet and slurry outlet valves when the filter goes off stream for backwash.

7. A method of metering liquids, comprising the steps of:

(1) filling a pressure vessel to a desired level with the liquid to be metered thereby displacing gas out of the pressure vessel during the filling process;

(2) pressurizing the liquid in the pressure vessel with gas, thereby causing the liquid to flow out of the pressure vessel through an outlet pipe;

(3) metering the rate of outflow of the displaced liquid;

(4) continuously regulating the inflow of pressurized gas as a function of the outflow rate of said liquid, whereby the quantity of gas admitted to said pressure vessel is such as to maintain a constant liquid outflow rate.

8. A method of continuously metering a liquid, comprising the steps of:

(1) filling a first pressure vessel to a desired level with liquid to be metered, thereby displacing the gas out of said pressure vessel;

(2) pressurizing the first pressure vessel and thereby forcing the liquid contents out of the first pressure vessel at a controlled rate into a second pressure vessel;

(3) venting some of the gas in the second pressure vessel during the infilling process so as not to materially change the pressure in the second pressure while filling it with liquid;

(4) pressurizing continuously in a controlled manner the second pressure vessel with gas and thereby forcing the liquid contents out of the second pressure vessel at a substantially uniform rate;

(5) refilling the first pressure vessel in the same manner as step 1; and

(6) at any desired time before the liquid contents of the second pressure vessel are depleted, refilling the second pressure vessel, while continuously maintaining a substantially uniform flow of liquid out of the second pressure vessel as in step 2.

9. Apparatus for metering body feed in a filter system, comprising:

a source of diluent;

a source of body feed;

a source of pressurized gas;

a first pressure vessel operably connected to said source of body feed for periodically filling said first pressure vessel with said body feed, and operably connected to said source of pressurized gas for periodically pressurizing said first pressure vessel containing said body feed;

a second pressure vessel operably connected to said first pressure vessel for receiving therefrom said body feed which is displaced by said pressurized gas, and operably connected to said source of pressurized gas for pressurizing said second pressure vessel, and operably connected to a filter for delivery thereto of said body feed which is displaced by said pressurized gas, and a diluent inlet pipe operably connecting said second pressure vessel to said source of diluent;

a pressure differential measuring device operably connected across said filter;

control means operably connected to said pressure differential measuring device and said first and second pressure vessels for filling said second pressure vessel with diluent to a predetermined intermediate level when the pressure differential reaches a predetermined value, and when the level of body feed is below said intermediate level, and then filling said second pressure vessel to a predetermined high level with body feed from said first pressure vessel.

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