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DECANTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to fluid handling apparatus and, in particular, the invention provides improved apparatus for drawing off a particular fluid, or fluids, from a plurality of fluids.

2. Description Relative to the Prior Art

The invention, as embodied in a presently preferred form thereof, is especially useful for extracting automatically a particular fluid which is sandwiched between two other fluids within a container. Most prior art decanting and related arrangements are characterized by an automatic control which is slaved, say, to maintain a liquid interface between a pair of immiscible liquids (e.g. U.S. Pat. Nos. 2,985,305 and 3,275,565); or slaved to maintain a predetermined mix of fluids by controllably decanting one of such fluids (e.g. U.S. Pat. No. 2,946,443). A typical environment for the invention is in a process that requires a certain liquid to be drawn from a container, such liquid having had a sludge or the like precipitated from it, and a scum or a foam formed upon it. Liquid-interface controllers are not practical in the environment indicated because rather than maintain a liquid-interface, the intent in question is to eliminate interfaces. Liquid mix controllers are also not practical because there are no mixes here to be maintained but, rather, a certain liquid is to be drawn from a certain mix of liquids.

SUMMARY OF THE INVENTION

In one presently preferred form of the invention for the decanting of a liquid which is sandwiched between a scum and a sludge, the invention employs for decanting purposes a suction and a servovalve and motor, the valve and motor operating respectively to actuate and to position the suction. The suction mounts two sensors, one near the mouth of the suction, and the other back a bit from the suction mouth: the former sensor detects the presence of precipitated floc in the liquid to be drawn off; and the latter sensor detects, in this case, the liquid itself. To assure that the suction draws off the sandwiched liquid, without drawing off the scum atop such liquid, the invention provides a start-up open-loop control of the servomotor, whereby the suction plunges through the scum and into the sandwiched liquid in question. At the instant the liquid detector gets actuated, the open-loop servo control is removed; and both the servomotor and valve are placed under the control of the floc sensor, such sensor thereafter causing the suction to follow the floc downwardly as it settles to form sludge, the suction drawing off the sandwiched liquid during such settling of floc.

The above described technique, and an extension thereof which assures additionally against the drawing off of floc while permitting greater sucking speeds, will be described in detail later.

An object of the invention is to provide improved apparatus for decanting fluids.

Another object of the invention is to provide apparatus for decanting a particular fluid, or fluids, from a plurality of fluids.

Another object of the invention is to provide apparatus for decanting a fluid (or fluids) which is (are) sandwiched between other fluids.

Another object of the invention is to provide improved apparatus for rapidly decanting a supernatant without drawing off any floc precipitated from such supernatant.

The invention will be described with reference to the FIGS., wherein:

FIG. 1 is a schematic diagram, in block form, illustrating a presently preferred embodiment of the invention,

FIG. 2 is a perspective view of a sensor useful with apparatus according to the invention, and

FIG. 3 is a schematic diagram, in block form, illustrating an extension of the decanting system indicated in FIG. 1.

With reference to FIG. 1, a vessel 10 contains a supernatant fluid 12 which is to be decanted. A sludge 14, formed from floc 16 precipitated out of the supernatant fluid 12, resides at the bottom of vessel 10. And a scum (or foam) 18, formed as a result of processing the fluid(s) in question, floats atop the supernatant fluid 12.

A suction 20 is positionable relative to the scum, supernatant fluid, and sludge by means of a servo 22. And the suction 20 includes a normally closed valve 24 the opening of which permits fluid to be drawn off via the mouth 26 of the suction 20. A sensor 28 locates at the mouth 26 of the suction 20 and serves to detect a given characteristic of the supernatant fluid 12. In this form of the invention, the sensor 28 serves to indicate the presence of floc 16 in the supernatant fluid 12. The sensor 28 may take a variety of forms depending on the particular adaptation of, and the environment for, the invention. In the arrangement indicated, the floc 16 (and scum 18) is reflective of light at a certain frequency and, thus, a sensor of the form shown in FIG. 2 has proved quite useful.

With reference to FIG. 2, an encased lamp 30 is periodically excited by a pulser 32, the lamp 30 beaming pulses of light through an aperture 34. Light reflected, say off floc 14', falls upon ganged photocells 36 to produce a signal indicating the presence of floc. (If preferred, the sensor arrangement of FIG. 2 may be replaced by a gallium arsenide emitter and excitation circuit of the type manufactured and sold by General Electric Company with model designation "Emitting Diode," type SSL-4.)

Signals produced by means of the sensor 28 are applied to a NOT circuit 38. A NOT circuit, as is well known, produces an output signal so long as it, itself, does not receive an input signal, and vice versa. Therefore, in the absence of a floc-indicative signal from the sensor 28, the NOT circuit 38 produces an output signal and applies such signal to open the suction valve 24. So too, provided a relay-actuable switch 40 is set to its upper position, the servo 22 has the NOT circuit output signal applied to it for corresponding positioning of the mouth 26 of the suction 20. The switch 40 is actuated by means of a self-holding relay 42, the self-holding contacts of which are indicated at 44.

As is the case with this, the preferred adaptation of the invention, the scum 18 which floats atop the supernatant fluid 12 is electrically nonconductive; and the supernatant fluid 12 is electrically conductive. A fluid sensor 46, which may in the arrangement indicated be a pair of contacts which are electrically short-circuited when in the supernatant fluid 12, is mounted upon the suction 20, such fluid sensor being disposed behind the floc sensor 28 as the suction moves into the supernatant fluid 12. Therefore, whenever the fluid sensor 46 first actuates, the floc sensor 28 at that time must, of necessity, be immersed within the supernatant fluid 12. (If, in the arrangement of FIG. 1, the scum 18 were to have been electrically conductive, the fluid sensor 46 could still have been employed effectively; however, with such the case, the sensor 46 would have to be displaced from the sensor 28 by a distance at least as great as the depth of the scum 18, thereby assuring that the suction mouth 26 will be within the supernatant fluid 12 at the instant that the sensor 46 first actuates.) The fluid sensor 46 output signal is applied to actuate the self-holding relay 42 to place the servo 22 under the control of the floc sensor 28.

To provide start-up open-loop control of the servo 22, a power supply 48 is arranged to actuate the servo 22 via the switch 40 when such switch is in its lower position. The power supply 48 also keeps the relay 42 energized once the sensor 46 gets immersed in the supernatant fluid 12. And for efficient operation of the embodiment as in FIG. 1, the suction 20 is capable of drawing off fluid at a rate faster than the servo 22 can position the suction in the supernatant fluid 12, this being to assure that the mouth 26 of the suction 20 is lowered no faster than the suction can draw off the supernatant fluid 12.

OPERATION

With the suction 20 positioned above the vessel 10, the power supply 48 is energized by closing its switch, thereby applying, in open-loop fashion, a signal to drive the servo 22. As the suction drops into the scum 18, the sensor 28 produces an output signal, the NOT circuit thereby allowing the suction valve 24 to remain closed. The servo 22 continues to lower the suction 20 until the sensor 46 dips into the supernatant fluid 12, at which time the open-loop servo drive is ended. That is, the sensor 46 energizes the self-holding relay 42 so that the NOT circuit 38 operates the valve 24 and the servo 22. If the sensor 28 sees no floc, the suction valve opens and, as the supernatant fluid 12 is drawn off, the servo 22 lowers the suction 20 toward the sludge 14. Eventually, when all of the floc has settled as sludge, the supernatant fluid 12 will be completely drawn off, leaving within the vessel 10 only the scum 18 and the sludge 14.

As above indicated, the system of FIG. 1 may be modified slightly as in FIG. 3 to provide a faster operating control, and greater assurance that sludge and scum will not be drawn off. Note should be taken in the description which follows that the corresponding elements of FIGS. 1 and 3 are similarly designated; and where a modification has been made in FIG. 3 to an element of FIG. 1, such element in FIG. 3 has a primed designation.

A suction 20' having an upwardly extending mouth 26' mounts not only the floc sensor 28 at the suction mouth 26', but additionally supports a second floc sensor 29. The sensor 29 may be like the sensor 28; and the sensor 29 is disposed ahead of the suction mouth 26' in the downward movement of the suction 20'. The sensors 28 and 29 are selectively operable to control the movement of the suction 20' by means of a self-holding relay 50, and switch 51, the self-holding contacts of such relay being indicated at 52. Actuation of the relay 50 is by means of a timer 54. The timer 54 may be of any well known kind (mechanical, electronic, etc.) and provides an output signal whenever the floc sensor sees floc for longer than a predetermined time. A typical timer useful with the invention would be a digital counter which is set to a reference count, such counter being cooperative with a gate circuit that applies clock pulses to such counter for the duration of the sensor 29 output signal. When the clock count reaches the reference count, the counter produces an output signal. In the absence of a sensor 29 output signal, the NOT circuit 38 applies its output signal to clear the timer and ready the timer to measure the duration of the next floc indicative signal from the sensor 29.

The fluid sensor 46 output signal is applied to a relay 42' which, in this embodiment, is not of the self-holding variety, although the relay 42' is arranged to be held energized by means of the holding contacts 52 of the relay 50. The relay 42' operates ganged switches 40'(a,b). And for an understanding of how the switches 40'(a,b), in conjunction with the other elements of FIG. 3, operate to control the quick and exclusive decanting of supernatant fluid, the following description is provided: With the suction 20' supported above a fluid container such as the vessel 10, the switch of the power supply 48 is closed. Immediately the servo 22 starts to lower the suction 20', the valve 24 being in its normally closed state (switches 40' a,b, in their respective lower positions). After the suction has plunked through the scum 18 sufficiently to wet the fluid sensor 46, the relay 42' actuates to place the servo 22 and valve 24 under the control of the sensor 29 and the NOT circuit 38 (switches 40' a,b, in their respective upper positions). Since the floc sensor 29 is below the sensor 28, any time that the sensor 29 sees no floc, the sensor 28 even more assuredly sees no floc. Therefore, during the time that the sensor 29 and NOT circuit 38 control the sucking operation, the supernatant fluid 12 which is drawn off is necessarily considerably free of floc. In the event that the fluid sensor 46 pulls out of contact with the supernatant fluid 12 because of too fast a sucking speed, the relay 42' drops out, thereby causing the valve 24 to

close momentarily, and causing the servo 22 to lower the suction enough to wet the fluid sensor 46 again. So slaving the fluid sensor 46 to the upper face of the sandwiched supernatant fluid 12 helps to keep the mouth 26' of the suction sufficiently below the scum 18 that scum is not drawn down into the suction by fluid velocity effects in the vicinity of the suction mouth 26'; and also, such slaving assures that sucking is always performed at a high (therefore, assuredly, a more floc-free) fluid level.

Should the sensor 29 see floc at the same time that the fluid sensor 46 is wet, the servo 22 immediately stops driving; and the valve 24 closes, as was the case with the apparatus of FIG. 1. The timer 54 measures the duration that such floc is seen and, provided that the floc is settling fast enough, the timer 54 will be cleared before the self-holding relay 50 can be actuated, whereby sucking will be resumed. The reference time which is set into the timer 54, obviously, is of a duration long enough to permit the suction to follow the floc as it settles.

Eventually, the suction 20' lowers enough to cause the floc sensor 29 to become buried in the sludge 14, at which time the NOT circuit 38 ceases to produce an output signal, *i.e.* the floc sensor 29 produces a steady output signal. Since the duration of the floc sensor 29 output signal is at this time longer than the preset reference time, the timer 54 ultimately applies an output signal to the self-holding relay 50 to switch control of the servo 22 and valve 24 to the sensor 28. (The distance between the sensors 28 and 29 must be sufficiently small to permit the suction 20' to bury itself in the sludge up to, but not including, the mouth 26' of the suction.) Once the suction 20' starts to control the servo 22 and valve 24, the fluid sensor 46 is effectively disarmed, the relay 42' being pulled in by the steady application thereto of the power supply signal via the switch 52. The fluid sensor 46 is disarmed because, as the supernatant fluid 12 is drawn off, the fluid sensor eventually gets pulled out of fluid and, attendantly, absent such disarming, the fluid sensor would prematurely stop the decanting process before all of the supernatant fluid is withdrawn. As the suction 20' drops lower and lower under control of the sensor 28, the sandwiched fluid continues to be removed, the suction mouth 26' being upturned to prevent fluid velocity effects from drawing sludge into the suction 20' as it buries itself into the sludge.

Means not shown and forming no part of this invention may be provided with the apparatus of FIGS. 1 and 3 to raise the suction (20, 20') after the sucking operation has been completed.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. For example, it would be within the purview of the invention to lower the gain of the servo 22 after the sensor 28 becomes operative to control the sucking operation, whereby the servo would track the precipitating floc very slowly during the final stage of the sucking operation. So too, while the invention in its preferred mode is disclosed as being adapted to decant a sandwiched fluid, it would also be within the scope of the invention to adapt the principles herein disclosed to decant "sandwiching" fluids, rather than decant a given fluid which is sandwiched by those fluids.

I claim:

1. Apparatus for use in drawing off a fluid comprising:
 - a. a suction;
 - b. sensor means near the mouth of said suction responsive to a characteristic of said fluid;
 - c. valve means cooperative with said suction and responsive to the output of said sensor means; and
 - d. motor means cooperative with said suction and responsive to the output of said sensor means to position the mouth of said suction within said fluid.
2. A system for so decanting a supernatant from a plurality of fluids, one of which fluids is largely a precipitate of said fluid to be decanted, that substantially none of said precipitate is decanted with said supernatant comprising:
 - a. suction means;

- b. motor means for use in positioning the mouth of said suction means in said supernatant in the direction of said precipitate;
- c. sensor means situated at the mouth of said suction means for detecting the presence of said precipitate in said supernatant; and
- d. means cooperative with said sensor means for operating said motor means and said suction means when said precipitate is not detected by said sensor means.
3. Apparatus for use in decanting a particular fluid from at least two layers of fluids, which apparatus comprises:
- a. suction means having an inlet portion;
- b. motor means for positioning said suction means;
- c. means cooperative with said motor means to effect positioning of the inlet end of said suction means through said fluid layer which is not to be decanted and into said fluid which is to be decanted;
- d. first sensing means responsive to a characteristic of the fluid that is to be decanted, said first sensing means being adapted for positioning with, and disposed proximate, the inlet portion of said suction means; and second sensing means responsive to a characteristic of fluid and being also positionable with said suction means inlet portion, being however disposed behind said first sensing means in the direction of travel of said suction means inlet portion when said inlet portion moves through said fluid layer which is not to be decanted and into said fluid which is to be decanted; and
- e. means cooperative with and responsive to said second sensing means to place said motor means under the control of the output of said first sensing means, the distance between said first and second sensing means being sufficient to allow said first sensing means to be wetted by the fluid which is to be decanted at the same time that said second sensing means places the said motor means under the control of the output of said first sensing means, whereby said suction means inlet portion moves through and draws off said fluid layer to be decanted so long as said first sensing means senses the said characteristic of said fluid to be decanted.
4. Apparatus for use in so decanting a fluid which is sandwiched between two other fluids within a container that substantially none of said other fluids are drawn off during said decanting, which apparatus comprises:
- a. suction means having an inlet portion;
- b. motor means for positioning said suction means;
- c. means cooperative with said motor means to effect positioning of the inlet end of said suction means through one of said sandwiching fluids and into said fluid to be decanted;
- d. first sensing means responsive to a characteristic of said

sandwiched fluid and being positionable with and disposed proximate the inlet portion of said suction means; and second sensing means responsive to a characteristic of fluid and being also positionable with said suction means inlet portion, being however disposed behind said first sensing means in the direction of travel of said suction means inlet portion when said inlet portion moves through said one sandwiching fluid and into said fluid to be decanted; and

e. means cooperative with and responsive to said second sensing means to place said motor means under the control of the output of said first sensing means, the distance between said first and second sensing means being sufficient to allow said first sensing means to be wetted by the sandwiched fluid to be decanted at the time that said second sensing means places the motor means under the control of the output of said first sensing means, whereby said suction means inlet portion moves through and draws off said sandwiched layer so long as said first sensing means senses the said characteristic of said sandwiched fluid.

5. The apparatus of claim 4 wherein said first sensing means embodies a leading sensor and a trailing sensor, the trailing sensor being disposed at the mouth of said suction means, and said leading sensor being disposed ahead of said trailing sensor in the said direction of travel of said suction means, and wherein said apparatus includes means for selectively placing said motor means under the control of said leading sensor until that sensor senses the said characteristic of said sandwiched fluid for a time longer than a certain predetermined duration.

6. The apparatus of claim 5 wherein said leading and trailing sensors are each adapted to transmit and receive radiant energy reflected off floc within said sandwiched fluid; and wherein said second sensing means is adapted to produce a signal substantially at the moment that said second sensing means is wetted by fluid.

7. The apparatus of claim 6 including means operative in conjunction with said leading sensor for slaving said second sensing means to the interface between said sandwiched fluid and the sandwiching fluid through which said suction means moves into said sandwiched fluid.

8. The apparatus of claim 7 including means for periodically pulsing said sensors.

9. The apparatus of claim 8 wherein said first and second sensing means are secured to said suction means for positioning therewith.

10. The apparatus of claim 8 wherein said suction means is provided with a mouth which is turned away from its direction of travel while moving into said sandwiched fluid.

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