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SOLID INTERPHASE INDICATOR CONTROLLER

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FIG. 1

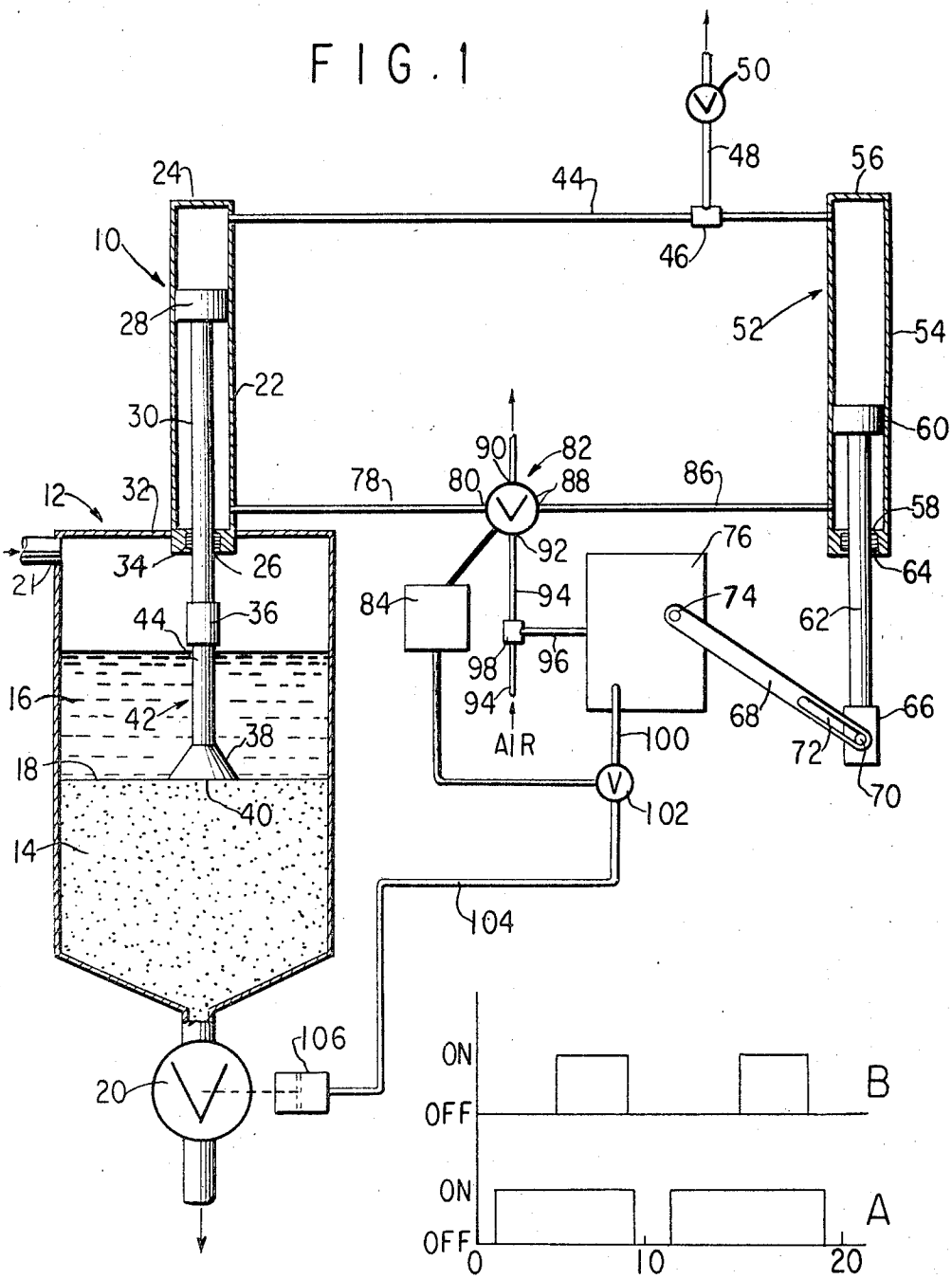


FIG. 2

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SOLID INTERPHASE INDICATOR CONTROLLER

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ABSTRACT OF THE DISCLOSURE

A device for remotely indicating and controlling the level of a solid-liquid inter-phase particularly where there is turbulence, comprising a pair of dual acting pistons and cylinders which are hydraulically directly coupled at one end of each cylinder and pneumatically coupled at the other end to a four-way pneumatic servo valve. An inverted cone-shaped feeler projecting into the solid-liquid medium is axially attached to the lower end of the piston rod of one of the cylinders while the second cylinder has a lever arm extending from the piston rod coupled to a position transmitter. A two cam timer controls the four-way pneumatic servo valve so as to periodically activate the pair of pistons and cylinders thereby hydraulically driving the pistons and piston rods in a reciprocating vertical path and forcing the feeler into the solid liquid medium until it contacts sufficient solid obstruction to stop. The arresting of the feeler is hydraulically communicated to the second piston thereby remotely indicating at the position transmitter at what level the feeler is stopped. The position indicator automatically activates an unloading valve at a preset level indication.

Background of the invention

This invention relates to an apparatus for automatically and remotely indicating and controlling the level of solids particularly in an enclosed and inaccessible volume.

In many processes it is important to maintain adequate control of the level of different phases in closed containers. Such processes may include those for the separation of a liquid from a solid such as that existing in the extraction of bitumen from tar sand, wherein the tar sand is originally mixed with water to obtain a slurry, and the sand allowed to settle to the bottom while the bitumen rises to the top of the water. It is necessary to know the level of the sand within the container so as not to overload it. Additionally, either agitation may be supplied or a gaseous hydrocarbon or air may be pumped into the tank through the sand to more readily obtain separation of the bitumen. Thus, a great deal of turbulence is produced in the liquid above the settled solids creating various problems in measuring the level of the solids. For instance, if the apparatus according to U.S. Patent No. 2,854,752 where a weight is suspended from a cable were used, the turbulence would upset the true indication of level by moving the weight transversely. If a heavier weight were used in order to overcome the effect of turbulence, the weight would sink into the sand or particulate matter. Thus the weight itself may be shaped so as to lightly load the solid. Also a direct force may be used in place of the weight to sense the level.

Additionally, a problem exists in providing sufficiently strong force to remove the level sensor from any particulate solid material which may have accumulated around and above the sensor. Thus, various requirements are posed for a level sensor. It must not penetrate into the solid particulate mass. It must have sufficient force to remove it from entrapment by the particulate mass and it must have sufficient rigidity to overcome any turbulence present at the solids-liquid inter-phase. The prior art shows the use of rigid direct measuring level indicators such as disclosed by Crowley, Jr. et al. in U.S. Patent No. 2,352,080 showing the placement of virtually the entire apparatus adjacent the feeler rod. Such apparatus has the disadvantage of a relatively complex electro-mechanical system requiring placement adjacent the container or tank and which, therefore, may subject the system to a deleterious environment. Hence, it is necessary to provide a reliable device having the required force for moving a level feeler out of a particulate solid, rigidity to withstand any solids-liquid turbulence, and yet not penetrate the solid particulate surface. Furthermore, remote location of the control and drive mechanisms eliminates any detrimental environmental conditions and facilitates maintenance.

Summary of the invention

Accordingly, I have invented a device for remotely sensing and automatically controlling the level of a solids-liquid interphase having a pair of double acting actuators hydraulically connected and pneumatically activated by a preset control to reciprocally drive a vertically mounted feeler attached to one of the actuators, said feeler upon being arrested by the solid, transmits its position hydraulically to the second actuator which is coupled to a position indicator and a preset level control valve.

Accordingly, it is an object of this invention to provide an apparatus for remotely measuring and indicating a level in a closed container.

A further object of this invention is an apparatus for automaticaly controlling the level of a solids-liquid interphase.

Other objects and advantages of this invention will be apparent from the drawings and description of the embodiments which follow.

Brief description of the drawings

FIGURE 1 shows a cross-sectional view of the apparatus of the invention.

FIGURE 2 shows the operating cycle of the double cam timer.

Description of the preferred embodiment

With reference to FIGURE 1 wherein a level sensor actuator **10** is mounted atop a separation vessel **12**. The separation vessel may be one used to separate a solid such as sand **14** and water **16** from a water sand bitumen slurry where a gas such as air or a light hydrocarbon is pumped from a source not shown through the mass to lower the density of the trapped bitumen. Alternatively the slurry itself may be mixed or agitated as where water and tar sand is added to the vessel **12** and mixed to allow the water to separate the bitumen from the tar sand, while the sand settles to the bottom of the vessel **12** where it is removed. As such turbulence would be present at the solid-liquid interphase generally indicated at **18**. A discharge port and valve **20** is located at the bottom of the vessel to allow removal of sand periodically from the vessel **12** in order to maintain the desired level of sand in the vessel **12**. A slurry inlet conduit **21** passes the slurry into the vessel's top wall **32** while product is removed through ports and valves not shown.

The level sensor actuator **10** is a dual acting hydraulic and pneumatic actuator having an outside cylinder **22** with a hydraulically sealed wall **24** at the top end thereof and a passage **26** at the lower end.

A piston **28** is slidably mounted within the cylinder **22** in the conventional manner, said piston being so constructed so as to susbtantially seal the cylinder on either

side of the piston to the passage of hydraulic or pneumatic fluid from either side of the piston. This may be accomplished by piston rings, close tolerances or other means known to those skilled in the art. A piston rod **30** is attached at its top end to the bottom of the piston **28** and is sized so as to readily move through the passage **26** at the lower end of the cylinder **22**.

The lower end of the cylinder **22** is fixedly mounted to the top wall **32** of the vessel **10** by conventional means such as bolting or welding (not shown). Packing **34** or other means for sealing the passage **26**, while allowing the piston rod **30** to reciprocally move through the passage **28** is located between the piston rod **30** and the walls of the passage **26**.

The lower end of the piston rod **30** is axially attached by a suitable means such as welding, threading or a tight fit to a coupling **36**. A feeler **38** having an inverted cone-shape at the bottom so as to present a large flat surface **40** to contact the surface of the sand at its lower end and extending upwardly as a rod **42** is coaxially affixed at its top end **44** to the coupling **36** so as to be rigidly coaxially connected to the piston rod **30**. The length of the rod **42** and coupling is predetermined so as to extend into the vessel **12** a suitable distance in order to allow the feeler to contact the solid-liquid interphase during operation of the vessel **12**.

At the upper end of the cylinder **22** (or actuator **10**) a port is communicatingly connected by suitable hydraulic fittings not shown with hydraulic pipe **44** of indeterminate length. A filling means for the hydraulic pipe **44** is connected by a T fitting **46** to another similar hydraulic pipe **48** and a hydraulic valve **50** to allow the addition or replacement of hydraulic fluid and the bleeding of entrapped air.

The other end of the hydraulic pipe **44** is connected to the top end of a second double acting actuator **52**. The second double acting actuator **52** is substantially similar to the first double acting actuator **10**, although this is not necessarily so. The second actuator **52** may be made with any suitable or desired stroke provided the hydraulic capacity or displacement of the second actuator is sufficient to provide sufficient hydraulic fluid for the stroke of the first actuator **10**. Such engineering design is conventional and well known to those skilled in the art.

The second actuator **52** has a cylinder **54** with a top wall **56** sealing the top end of the cylinder and a circular passage **58** at the bottom end of the cylinder **54**.

A second piston **60** sideably mounted within the cylinder **54** has attached to its bottom side a piston rod **62** extending through a passage **58** in the bottom of the cylinder **54** and coaxial with the piston **60**. Suitable packing **64** is placed between the piston rod and the passage walls so as to allow the piston rod to be slidably movable within the packing and to provide appropriate sealing for pneumatic devices. At the other end of the piston rod **62** a coupler **66** is permanently affixed. The coupler **66** has a lever arm **68** pivotally mounted to the coupler by pin **70** or other suitable means. Additionally, a rectangular slit **72** in which the pin **70** may slide is present in the lever arm **68** to allow for a change in distance between the pin **70** and a shaft **74** as the piston rod reciprocally moves within the cylinder. The end of the lever arm **68** farthest away from the pivot **70** is fixedly mounted to the shaft **74** which is rigidly coupled to a position transmitter **76**, specifically a Foxboro control positioner (CP).

At the lower end or piston rod end of each of the cylinders pneumatic tubing is connected by suitable fittings. The pneumatic tubing **78** connected to the first cylinder **22** is connected to one port **80** of a four-way pneumatic servo valve **82** which is controlled by a two cam timer **84**. Pneumatic tubing **86** is connected by suitable fittings to the piston rod end of the second cylinder **54** and connected at the other end of the tubing **86** to another port **88** of four-way servo valve **82**. The four-way servo valve **82** has an exhausting port or vent port **90** and an intake port **92** connected to pneumatic tubing **94** through which air is supplied under pressure from a source not shown. The position transmitter **76** is supplied with air under pressure through pneumatic tubing **96** interconnecting at T fitting **98** with the gas supply tubing **94**.

The control position transmitter **76** also encompasses a valve (not shown) controlled by the position transmitter **76** which passes air from pneumatic tubing **96** through the position transmitter to pneumatic tubing outlet **100** when the position of the shaft **74** has reached a predetermined angular position corresponding to the desired maximum level of the solid-liquid interphase in the vessel tank. As long as the shaft **74** is in such a "flow" position, the position transmitter valve (not shown) will allow air to pass through the outlet tubing **100** of the position transmitter **76**. A two-way pneumatic servo valve **102** is connected to the pneumatic outlet tubing **100** and controls the flow of air to pneumatic tubing **104** which activates the valve and sand operator **106** opening sand valve **20** and unloading the vessel.

The two cam timer **84** has a cam schedule as shown in FIGURE 2 where the four-way servo valve **82** is operated according to cam schedule A, said cam schedule causing air under pressure from the air supply to pass out of port **88** and into the piston rod end of the second actuator thereby driving the piston **60** against the hydraulic fluid for the period the cycle is operative, approximately 8 seconds. The movement of the piston **60** in cylinder **54** forces the hydraulic fluid under pressure into the top end of the cylinder **22** thereby forcing the piston **28** and the piston rod and feeler down into the vessel until it is stopped by the obstructing sand at the solid-liquid interphase. At this time the position of lever **68** indicates the level of the interphase **18**. For the remaining 2 seconds of the cycle the port **88** is closed and a port **80** is opend to air under pressure from the air supply (not shown) so as to drive the piston **28** of actuator **10** upwardly against the hydraulic fluid thereby raising the feeler away from the liquid solid interphase.

The two cam timer operating on cam schedule B as shown in FIGURE 2 controls the two-way servo valve **102** so as to open the valve periodically for a period of about 5 seconds in a 10 second cycle at the same time the feeler **42** is being extended into the vessel to be arrested by the solid-liquid interphase. The two cam timer will first activate the pneumatic servo valve **82** so as to pneumatically drive the piston **60**, thereby hydraulically activating the first actuator **10** so as to drive the piston **28** downwardly until the feeler attached to actuators is stopped by the sand. If the position where the feeler is stopped is such as to cause the position control **76** to allow pressurized air to pass out through output **100**, the second cam cycle for controlling valve **102** will activate the valve **102** for a period of five seconds opening the sand valve **20** and discharging sand periodically. The relatively short time cycle of the two cam timer **84** is such that the solid-liquid interphase will remain at a relatively constant level during use of the vessel.

While the aforesaid description is of the preferred embodiment of this invention various other embodiments may be used without detracting from the spirit or scope of the invention. For instance in place of pneumatically driving the piston **28** of actuator **10** upwardly thereby raising the feeler, a coil spring can be inserted in the lower portion of cylinder **22** which is compressed when the piston **28** is subjected to hydraulic pressure from the second actuator **52**, but drives the piston **28** upwardly when the pressure is removed. Additionally, the feeler itself may be of any shape suitable for the purpose of contacting and being arrested by the solid material such as disc, spherical, hemispherical or cylindrical shapes, to name but a few. Also, while the aforementioned level indicating and controlling apparatus has been described in conjunction with a substantially closed vessel, any

means for containing material may be used together with a fixed base for the level sensing first actuator.

Having thus described the invention and wishing to cover both the spirit and the scope of the invention,

I claim:

1. An apparatus for remotely indicating and controlling the level of solid material comprising:

(a) a base;

(b) a first hydraulic actuator fixedly mounted to the base above the level of the solid material and characterized by a reciprocating stroke;

(c) a feeler positioned above the level of the solids and attached to said first actuator and stroked thereby;

(d) a second hydraulic actuator hydraulically coupled to said first hydraulic actuator and characterized by a reciprocating stroke;

(e) indicating means attached to said second hydraulic actuator for showing the position of the stroke of said second hydraulic actuator; and

(f) activating means for actuating said second hydraulic actuator whereby the actuation is hydraulically communicated to the first hydraulic actuator and the feeler is moved into abutting relationship with the solids thereby arresting the feeler, and the first and second actuators, said second actuator being at a position on the indicating means indicative of the level of the solids.

2. The apparatus of claim **1** wherein the second actuator is a dual acting actuator and the means for actuating the second actuator comprises;

(a) a high pressure gas supply;

(b) a pneumatic servo valve having an input communicating with the gas supply and a plurality of outputs communicating with at least one actuator; and

(c) a control timer having a preset cycle and operatingly connected to the pneumatic servo valve to alternately activate one of the servo valve outputs.

3. The apparatus of claim **2** which additionally comprises;

(a) a vessel containing the solid material;

(b) a solids discharge valve mounted in the underside of the vessel;

(c) a valve operator adapted to open and close said solids discharge valve; and

(d) control means for controlling said valve operator and responsive to the position of the indicating means.

4. The apparatus of claim **3** wherein the first actuator is a dual acting actuator pneumatically communicating on its activator side with a second of the outputs of the pneumatic servo valve, whereby the control timer periodically and alternately activates the pneumatic pressurized gas supply to the first and second dual acting actuators thereby driving them reciprocally.

5. The apparatus of claim **4** wherein said first actuator comprises;

(a) a closed cylinder;

(b) a dual acting piston slidingly mounted within said cylinder;

(c) a piston rod fixedly attached at one end to the piston and at the other end to the feeler and extending out through the cylinder; and

wherein said second actuator comprises;

(a) a second closed cylinder;

(b) a dual acting piston slidingly mounted within said second closed cylinder;

(c) a second piston rod fixedly attached at one end to said second piston, and at the other end attached to the indicating means.

6. The apparatus of claim **5** wherein the indicating means comprises;

(a) a control position transmitter having as an input a rotatable shaft for angularly indicating a specific position;

(b) a lever arm fixedly attached at one end to the rotatable shaft and having a rectangular slit space at the other end of the arm;

(c) a pin attached to the end of the second piston rod and slidably mounted to move within the rectangular slit.

7. The apparatus of claim **6** wherein the activating means comprises: a two cam timer having two separate control cycles; and wherein said pneumatic servo valve is a four-way servo valve having an input from the high pressure gas supply and responsive to the first control cycle of the two cam timer, whereby the two cam timer controls application of the pressurized gas to activate and inactivate the first actuator and the second actuator alternately.

8. The apparatus of claim **7** wherein the control means is responsive to the angular position of the rotatable shaft of the control position transmitter, and additionally comprises;

(a) a two-way pneumatic servo valve responsive to the second control cycle of the two cam timer, said control means responsively supplying high pressure gas to the two-way pneumatic valve input which at the appropriate portion of the second cam timer cycle causes the solids valve operator to open the solids discharge valve.

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