Oct. 3, 1967 J. L. HARDIN 3,344,799

APPARATUS FOR CONTROLLING THE VISCOSITY OF A LIQUID

Filed July 20, 1964

Fig. 1.

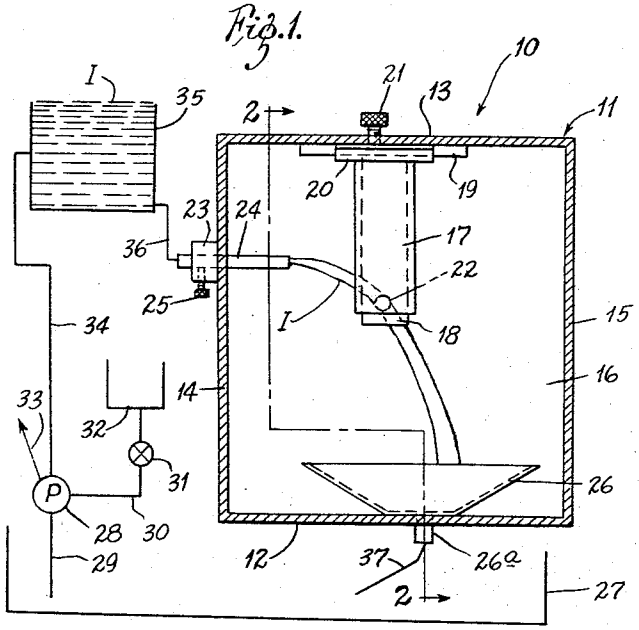


Fig. 2.

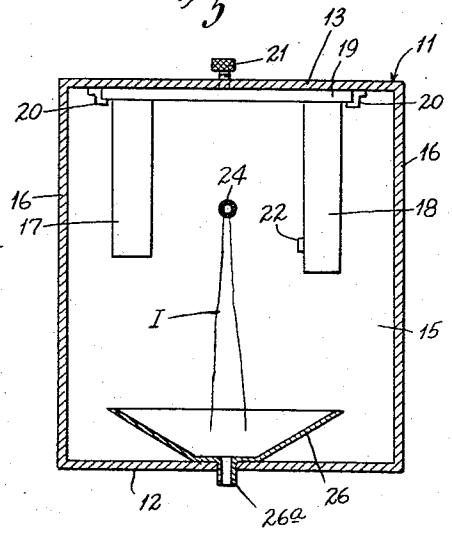
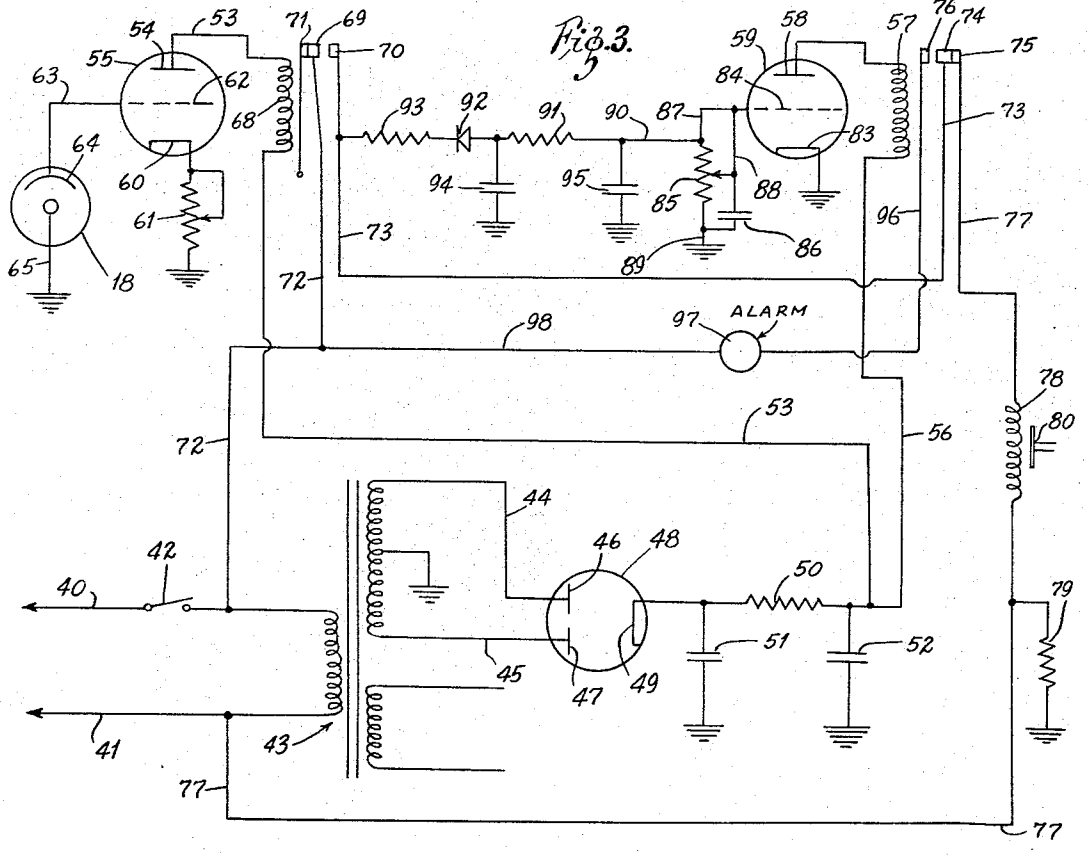


Fig. 3.



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APPARATUS FOR CONTROLLING THE VISCOSITY OF A LIQUID

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ABSTRACT OF THE DISCLOSURE

Apparatus for controlling the viscosity of a liquid, such as ink used in printing operations, providing a light beam directed toward a photoelectric cell with means to vary the viscosity in response to changes in reception of light by the photoelectric cell and by directing a free flowing stream of fluid in a path the direction of which varies with variations in viscosity of the fluid to cause the path of fluid to move in and out of intersection with the light beam.

The viscosity of ink is especially critical when colors are printed, the colors deviating rapidly from their true hues when the viscosity varies from what is proper. It is standard to control the viscosity of ink by adding alcohol, or some other thinner to the ink. In this invention, an accurate control of the addition of this alcohol or thinner is provided. In addition, this invention automatically provides a control over the addition of alcohol or thinner to the ink in instantaneous response to the viscous condition of the ink.

In general, the invention comprises an enclosure into which a stream of the ink is directed. There is a funnel for collecting the ink directed into the enclosure. A light source and a photo cell pickup are positioned in spaced relation to one another in the enclosure. The stream of ink passes through the path of the light beam toward the photoelectric cell device when the viscosity of the ink is correct and blocks reception of the light beam by the photoelectric cell.

The photoelectric cell is wired to a circuit which includes a solenoid for controlling the opening or closing of a valve which, in turn, controls the supply of alcohol or thinner to the ink. The circuit is connected so that the alcohol or thinner supplying valve is closed when the photoelectric cell receives no signal, e.g., when the stream of ink blocks reception of light from the light source by the photoelectric cell. When the viscosity of the ink increases, the stream of heavier ink falls in a different arc and misses the path of the light beam. This allows the photoelectric cell to conduct to regulate appropriate solenoids to cause the alcohol or thinner valve to open. More alcohol or thinner is added to the ink until its viscosity is sufficiently reduced to bring the arc of the ink stream back into the path of the light beam.

The circuit also includes a safety cutoff mechanism coupled with an alarm. The safety cutoff mechanism is energized when the photoelectric cell has conducted longer than normally required to reduce the viscosity of the ink to its proper level. Such a duration indicates that the entire ink supply is depleted. The safety cutoff mechanism not only closes the alcohol or thinner valve, but it also operates an audible alarm to warn a mechanic that the ink needs replenishing.

The general object of this invention is to provide a device for automatically controlling the viscosity of a fluid, such as ink, in automatic and instantaneous response to the viscosity of the fluid.

Another object of the invention is to provide a viscosity control for a fluid that is subject to variations in viscosity, wherein the control of viscosity is responsive to the operation of a photoelectric cell as controlled by the instantaneous viscosity of the fluid.

Still another object of the invention is to provide a viscosity control for fluids that operates in response to the trajectory arc of a laterally directed fluid stream to control the introduction of a fluid regulator which will correct the viscosity as the arc varies with variations in viscosity of the fluid.

Another object of the invention is to provide a viscosity control which responds to changes in the viscosity of a fluid, to admit a thinning agent into mixture with the fluid, but which automatically discontinues the admission of such thinning agent when the supply of the fluid is depleted.

An additional object is to provide such a control which energizes an alarm to warn an operator that the fluid is depleted.

Other objects of the invention are to provide a control according to the foregoing which is extremely economical in cost, is effective and positive in operation, and is of compact construction.

Other objects and advantages will be apparent to those skilled in the art.

In the drawing:

FIGURE 1 is a view in longitudinal vertical section through the electric eye and stream projecting and recovering apparatus, with the ink reservoir, pump, ink trajectory pressure control receptacle, thinner reservoir, and thinner control valve shown schematically;

FIGURE 2 is a view in section taken along the line 2—2 of FIGURE 1; and

FIGURE 3 is a schematic wiring diagram of the control circuit.

Referring now to the drawing, the control system **10** shown in FIGURE 1 includes an enclosure **11** which, for reference purposes, has a bottom wall **12**, a top wall **13**, a front wall **14**, a back wall **15**, and side walls **16**. A light beam transmitting device **17** and a photoelectric cell pickup device **18** are supported within the enclosure **11**. These devices **17** and **18** are conveniently mounted upon a common, slidable frame **19** which rests upon and between parallel support brackets **20** affixed to the top wall **13**. The support brackets **20** permit slidable adjustment of the frame **19** longitudinally, that is, toward or away from the front wall **14**. A set screw **21** threaded through the top wall **13** permits the frame **19** to be secured in any adjusted position.

The light beam transmitting device **17** and the photoelectric cell pickup device **18** are of conventional construction. The light beam transmitting device **17** is so oriented as to direct a narrow beam of light directly toward a light receiving lens **22** on the photoelectric cell pickup device **18**. The light receiving lens **22**, of course, faces the directed light beam. As is conventional in such devices, an obstruction in the path of the light beam will prevent reception of the beam by the lens **22**.

A bushing or sleeve **23** connected to the front wall **14** slidably supports a fluid inlet tube **24**. The bushing **23** preferably holds the tube **24** in a generally horizontal position above the path of the light beam from the light transmitting device **17** and pointing directly toward the area between the devices **17** and **18**. There is a set screw **25** for releasably locking the inlet tube **24** in a selected position.

An open-top funnel **26** rests upon the bottom wall **12** of the enclosure **11**. The funnel **26** has a tube **26***a* leading from its lower side and extending through the bottom wall **12**.

A fluid reservoir **27** holds the ink which is to be supplied to a printing machine as well as to the viscosity control **10**. A double supply-double outlet pump **28** has one supply pipe **29** submerged in the ink within the

reservoir 27. The other supply pipe 30 to the pump 28 is connected through a valve 31 to a reservoir 32 which holds alcohol or other fluid thinning agent.

One outlet pipe 33 goes to the printing machinery or apparatus (not shown). The other outlet pipe 34 leads to a pressure control receptacle 35 positioned directly above and within the outer perimeter of the ink reservoir 27. The receptacle 35 is positioned above the fluid inlet tube 24. The pipe 34 is connected into the receptacle above its bottom wall to prevent any sludge or foreign matter from clogging the pipe 34. A pipe 36 leading from a portion of the receptacle 35 above its bottom wall is connected to the fluid inlet tube 24.

Fluid collected by the funnel 25 is returned to the receptacle 27 by a pipe 37.

As shown in FIGURE 3, there are two conductors 40 and 41 connected across a 120-volt AC power supply. A master on-off switch 42 is provided in one of the conductors 40. A transformer 43 is connected across the AC power supply conductors 40 and 41, the transformer secondary leads 44 and 45 being connected to the plates 46 and 47 of a rectifying tube 48. The cathode 49 of the rectifying tube 48 is connected through a 10K ohm resistor 50 having two 20 microfarad, 600 volt filter capacitors 51 and 52 on its opposite sides leading to ground. Thence, a conductor 53 carries the DC supply current to the plate 54 or a 12AT7 tube 55, and another conductor 56 carries the DC rectified current through a relay coil 57 to the plate 58 of another 12AT7 tube 59.

The cathode 60 of the tube 55 is connected through a variable biasing resistor 61 to ground. The grid 62 of the tube 55 is connected by a conductor 63 to the cathode 64 of the photoelectric tube 18 already mentioned as being mounted in the enclosure 11. The anode 65 of the photoelectric tube 18 is connected to ground.

The polarity of the photoelectric tube 18 in the circuit is such that when it is nonconducting, a sufficient positive charge is supplied to the grid 62 to allow the tube 55 to conduct. When the photoelectric tube 18 intercepts light from the light transmitter 17, it deposits a negative charge on the grid 62 of sufficient magnitude to block conduction of the tube 55.

There is a relay coil 68 in the conductor 53 leading to the plate 54. The relay coil 68 controls the position of a relay contact 69, which is movable, between a switch terminal 70 and a dummy contact 71. The latter merely acting as a stop. The relay contact 69 is connected by a conductor 72 to one of the AC power supply conductors 40. The switch terminal 70 is connected by a conductor 73 to another movable relay contact 74. The contact 74 is movable alternately into contact with two switch terminals 75 and 76. The switch terminal 75 is connected by a conductor 77 through a valve operating coil 78 to the other AC power supply conductor 41. A 19K ohm resistor 79 is connected from the conduit 77 to ground.

A valve controlling lever 80 is schematically shown opposite the coil 78 in FIGURE 3. When no current is passing through the coil 78, the valve control lever 80 automatically holds the valve 31 closed, and when the coil 78 conducts current, the lever 80 opens the valve 31. This operation is readily understandable to those skilled in the art without further explanation.

The tube 59 is connected in a circuit for controlling the flow of current through the coil 57 to control the position of the relay contacts 74. The tube 59 has its cathode 83 connected to ground. The grid 84 of the tube is connected to a timing circuit including a variable 1 megohm resistor 85 having a 25 microfarad capacitor 86 connected across it. One side of the resistor 85 is connected by a conductor 87 to the grid 84, and one side of the capacitor 86 is connected by a conductor 88 to the grid 84. A conductor 89 connects the other sides of the resistor 85 and capacitor 86 to ground.

A conductor 90 is connected from the resistor 85 and conductor 87 through a 5K ohm resistor 91, a diode 92, and a 27K ohm resistor 93 to the conductor 73 leading to the switch contacts 70. A pair of 20 microfarad filter capacitors 94 and 95 are connected to ground on opposite sides of the resistor 91.

The switch contact 76 associated with the relay coil 57 is connected by a conductor 96 to one side of an alarm 97. The alarm 97 may be a buzzer or any other device for attracting the attention of an operating person when the alarm 97 is energized. The other side of the alarm 97 is connected by a conductor 98 to the conductor 72 leading to the supply conduit 40.

Operation

This invention is particularly useful to control the viscosity of printing inks, and is described in such a combination, but it may be used in any other system to control the viscosity of a liquid. As shown, the ink receptacle 27 is supplied with ink to be used in a printing operation. The ink may be tinted in any desired color. The pipe 29 is submerged in the ink bath contained in the receptacle 27, enabling the pump 28 to suck ink from the receptacle 27 and pump it through the pipe 33 for use in the printing operation. The pump 28 also delivers ink through the outlet pipe 34 to the receptacle 35.

Ink from the receptacle 35 flows by gravity through the pipe 36 to the fluid inlet tube 24. The pipe 36 is of smaller diameter than the pipe 34 so ink cannot flow as rapidly from the receptacle 35 through the pipe 36 as it is supplied to the receptacle by the pipe 34. Consequently, ink always flows over the top of the receptacle 35 and falls back into the ink reservoir 27. By this means, the level of ink in the receptacle 35 is maintained constant, and this maintains a constant pressure upon the ink delivered to the fluid inlet tube 24.

Because of the constant pressure forcing the ink into the tube 24, ink I, of a given viscosity, leaving the tube 24 in a generally horizontal direction falls in a particular arc toward the funnel 26. This arc can be adjusted longitudinally by adjusting the position of the pipe 24 relative to the bushing 23. The object of adjusting the position of the ink stream arc is to cause it to intercept the path of the light beam from the light source 17 to the lens 22 of the photoelectric cell 18 when the viscosity of the ink emerging from the tube 24 is proper or optimum. Another adjustment which can be made to accomplish this object is in the position of the frame 19. This frame may be slid along the support brackets 20 until the proper position is reached. The set screws 21 and 25 lock the frame 19 and the tube 24 in the selected positions. FIGURE 1 shows the ink stream I flowing in an arc which does intercept the light beam. Hence, the viscosity of the ink is correct and light transmitted toward the photoelectric cell 18 is blocked from reception by the lens 22.

The enclosure 11 prevents wind drafts and intense outside light from affecting the arc of the ink or the operation of the photoelectric cell. In some cases such outside influences may not be present and an entirely enclosing enclosure 11 maybe unnecessary.

In the correct viscosity condition of the ink, the photoelectric cell 18 does not conduct and therefore, does not establish a negative charge on the grid 62 of the tube 55. Accordingly, the tube 55 discharges and passes current through the relay coil 68, a circuit being completed from ground through the tube 65, the coil 68, the conductor 53, and the rectifier tube 48 to the transformer 43 connected across the DC supply 40–41. While current is passing through the relay coil 68, the coil holds the relay contact 69 against the open stop 71. This opens the circuit to the valve coil 78, which circuit includes the conductor connected to the AC supply conductor 40, the relay contact 69, the switch terminal 70, the conductor 73, the relay contact 74, the switch terminal 75, the conductor 77, the coil 78, and the conductor 77 leading to the other AC supply conductor 41. Normally, closing of the relay contact 69 against the switch terminal 70 will

close this valve coil circuit. When the circuit for the valve coil **78** is open, the valve lever **80** occupies a position which holds the valve **31** closed. Hence, no alcohol or thinner is drawn from the reservoir **32** through the valve **31** and the pipe **30** to the pump **28** (see FIG. 1).

When the alcohol or thinner evaporates, or for some other reason the viscosity of the ink increases, the ink flows downwardly at a sharper angle from the inlet tube **24** and falls short of the path of the light beam from the transmiter **17** to the lens **22**. When the photoelectric cell **18** receives the transmitted light, it conducts and deposits a negative charge on the grid **62** blocking discharge of the tube **55**. This opens the circuit which includes the relay coil **68**, and when the coil **68** does not conduct current, the relay contact **69** automatically swings over into contact with the switch terminal **70**. This closes the previously mentioned circuit which includes the valve coil **78**. When current flows through the valve coil **78**, the valve lever **80** is immediately opened to operate the valve **31** and admit alcohol or thinner through the pipe **30** to the pump **28**. The pump **28**, then pumps both ink from the reservoir **27** and thinner from the reservoir **32** to its outlet pipes **33** and **34** until the ink is sufficiently thinned to reduce its viscosity to the correct value. When the correct value of viscosity is reached, the arc of ink I emanating from the tube **24** is again in the path shown in FIGURE 1, and the photoelectric cell **18** stops conducting.

The relay coil **57** is normally carrying only a very low current because of only slight conduction by the tube **59**, so the relay contact **74** normally occupies the position against the switch contact **75** as illustrated in FIGURE 3. However, whenever the relay contact **69** closes against the switch contact **70**, it begins to charge the capacitor **86** through a circuit which includes the conductor **72**, the relay contact **69**, the switch terminal **70**, the resistor **93**, the diode **92**, the resistor **91**, the conductor **90**, the conductor **87**, the conductor **88**, and the capacitor **86**, which leads to ground. The setting of the RC timing device including the resistor **85** and the capacitor **86** can be adjusted for any time interval. The time interval adjustment is made with reference to the time normally required to thin the ink to the desired viscosity. A longer time interval indicates that the ink reservoir **27** is empty. When the ink receptacle **27** is empty, it is undesirable to continue to pump alcohol or thinner to the printing apparatus, or through the enclosure **11** into the receptacle **27**. Accordingly, upon the expiration of a set time duration following closing of the relay terminal **69** against the switch terminal **70**, the capacitor **86** reaches a level which will establish a positive charge on the grid **84**. This causes the tube **59** to discharge and establish a sufficiently high current through the coil **57** to cause the relay contact **74** to swing against the switch terminal **76**. When this happens, the circuit through the valve coil **78** is opened, and the valve lever **80** shifts to close the valve **31** and block the flow of alcohol or thinner. Also, when the relay contact swings against the switch terminal **76**, a circuit which includes the alarm **97** is closed. This circuit includes the conductor **72**, the conductor **98**, the alarm **97**, the conductor **96**, the switch terminal **76**, the relay contact **74**, the conductor **73**, the switch terminal **70**, the relay contact **69**, and the conductor **72**. The alarm **97** notifies an attendant that the ink reservoir **27** needs filling.

In the foregoing, the device has been described as operating with the ink stream intercepting the light beam when the proper liquid viscosity exists. This operation may be revised. The ink stream arc I may be set to pass immediately above the light beam when the viscosity is proper. Under this condition the valve **31** would be closed. Then, in this reverse arrangement, when the ink stream falls into the light beam path, blocking off the light beam will cause opening of the valve. All of this provides revisal of certain connections in the electric circuit as will be appreciated by those skilled in the art.

Various changes and modifications may be made within the purview of this invention as will be readily apparent to those skilled in the art. Such changes and modifications are within the scope and teaching of this invention as defined by the claims appended hereto.

What is claimed is:

1. A viscosity control device comprising means to transmit a beam of light, means in the path of the beam of light for intercepting the light including a photoelectric cell, a source of fluid, means to discharge the fluid in a path of free flowing fluid wherein the direction of the fluid path varies with the viscosity of the fluid, means to position the path of fluid such that when its viscosity is at a desired level, the fluid flowing in the said path is at a predetermined position relative to interception of the light beam, and means responsive to changes in reception of light by the photoelectric cell resulting from variations in the path of said fluid flow caused by changes in the fluid viscosity for controlling the viscosity of the fluid to reestablish the desired viscosity level, the last named means comprises an electric circuit including control means for a valve and including switch means to close the circuit and open the valve in response to variations the path of fluid flow caused by changes in the fluid and means connected through the valve for delivering thinner to the fluid when the valve is open.

2. The device of claim **1** including a timer initiated upon closing of the circuit, and means responsive to the timer for opening the circuit when the circuit has remained closed for a predetermined period of time.

3. The device of claim **1** including an enclosure surrounding the light transmitting means, the photoelectric cell, and the path of free flowing fluid.

4. The device of claim **1** including means responsive to reception for a predetermined time duration of the light beam by the photoelectric cell for discontinuing the means for controlling the viscosity of the fluid.

5. The device of claim **4** including an alarm connected for actuation upon discontinuing the means to cause changes in the viscosity of the fluid.

6. The device of claim **1** including means to selectively adjust the arc of fluid relative to the light beam.

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