Sept. 7, 1937. O. KÜSTER 2,092,623

LIQUID LEVEL CONTROL

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FIG. 1

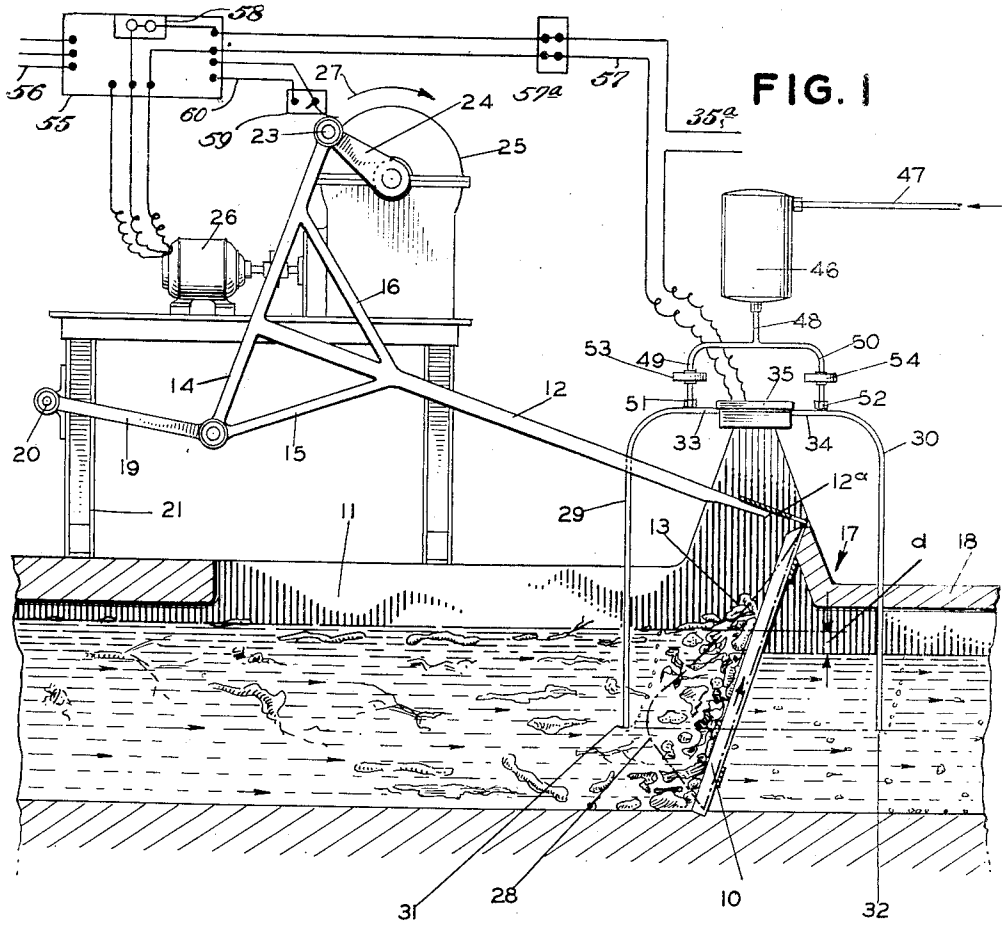
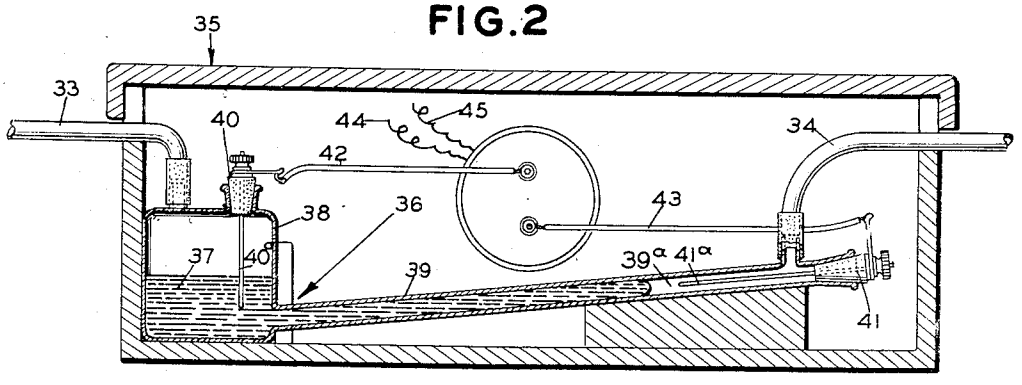


FIG. 2



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LIQUID LEVEL CONTROL

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2 Claims. (Cl. 210—176)

This invention relates to automatic control apparatus of the kind which is responsive to relative changes or differentials in the levels of a plurality of liquid bodies.

More in particular, and without in any way excluding many other conceivable applications this may be said to relate to control apparatus which serves to control the operation of a sewage bar screen cleaning device in response to an objectionable rise of liquid on the influent side of the screen due to blinding thereof. In principle, such a control mechanism communicates with the pulpy or coarse solids or refuse containing liquid before the screen, and with the screened liquid back of the screen, and it operates in such a way that whenever the screen on the influent side of the liquid becomes objectionably blinded or clogged with screenings and the liquid level on that side rises appreciably over the one behind the screen, such super-elevation or difference in levels will cause the control mechanism to respond and thus periodically to operate the screen-cleaning device to clear the solids therefrom, which cleaning operation will consequently restore the normal uniform level fore and aft the screen, whereupon the screen cleaning device ceases to function.

The object is to devise a differential liquid-level responsive control mechanism, which is simple and reliable; which avoids the use of movable elements such as floats and their mechanical connections; and which can readily be applied in connection with existing installations and readily adapted to a great variety of structural conditions and without necessitating any considerable provisions or changes; and which cannot be affected in its operation or fouled by solids or refuse when used for controlling sewage flow levels.

To this end the invention contemplates to transmit the hydraulic pressure difference, or difference in head, of the respective liquid levels hydraulically to a pressure-responsive device from which to actuate the liquid level control.

According to one feature there are provided hydraulic pressure-transmitting tube connections, which constitute a communication between say two respective liquid bodies on the one hand, and a differential pressure-responsive means, or differential pressure gauge, or switch device for liquid level control on the other hand, the arrangement being such that a super-elevation or increase in head in one of the liquid bodies will cause a corresponding relative increase of hydraulic pressure in the corresponding communicating tube, so that the pressure difference thus established between the two communicating tubes will cause the switch device to operate.

According to a preferred embodiment and in application to a sewage bar screen, there is constantly being introduced what may be called a balanced flow of an auxiliary gas or air under pressure into each of the communicating connections, and which is allowed to escape through the submerged open ends of the tubes. This auxiliary pressure, as long as it is balanced or equal in both tubes, will act evenly upon both sides of a differential responsive pressure gauge or switch device to keep the same ineffective or in neutral position, irrespective of the general level of sewage flow. If, however, a super-elevation or rise in head in one of the liquid bodies reduces or restrains the free outflow of the auxiliary air from the respective tubes, this will cause the pressure in both tubes to be unbalanced with respect to each other, and the resulting pressure difference will cause the switch device to function.

Other features lie in specific means for effecting the transmission of the pressure difference, due to super-elevation, to the pressure-responsive means or switch device for liquid level control.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description. In the accompanying drawing, for the purpose of example, there has been illustrated the best embodiment of the invention now known to me, but such embodiment is to be regarded as typical only of many possible embodiments and the invention is not to be limited thereto.

In particular, the invention is not confined to the means shown for rendering more effective the pressure differential, and such means may, for instance, include pressure-transmitting diaphragm devices connected to the respective pressure-transmitting tubes, and submerged in the respective liquid bodies and positioned at a proper and suitable elevation therein, and they may include a pressure supply of any suitable fluid to each of the pressure-transmitting communicating connections.

Also the embodiment of the differential pressure-responsive gauge or switch device may take on a variety of forms, that is to say, it may be in the form of a differential mercury pressure gauge, or it may be a differential diaphragm device or the like.

In the drawing:

Figure 1 is a side view upon a bar screen-cleaning mechanism in combination with the novel control device; and

Figure 2 is an enlarged sectional detail of a differential pressure-responsive switch device.

The bar screen and the bar screen cleaning mechanism, as herein shown to illustrate a practical application of the novel control device, may be of any suitable kind. In this case the bar screen is of the straight type and comprises rearwardly-inclined upright bars 10 mounted in a sewage channel or flume 11.

The bar screen cleaning mechanism comprises a raking arm or frame 12 having at the free end thereof a toothed raking element 12a corresponding to the bars 10 of the screen and adapted to remove screenings 13 therefrom. The raking arm 12 is formed at its rear end with a transverse or base portion 14 and with bracing portions 15 and 16. The rake arm 12 is connected with an actuating mechanism through which it can be given a bodily elongated cyclic movement effective to rake the screenings 13 upwardly along the bars 10 and into a depression 17 formed upon a top 18 covering the sewage channel. That is to say, the lower end of the transverse portion 14 of the rake arm 12 is pivotally connected with a rocker arm 19 pivoted at 20 upon a base structure 21, while the upper end of the transverse portion 14 has a pivotal connection through the crank pin 23 with a crank arm 24 which is driven through reduction gearing indicated by its casing 25, from a motor 26, both the gear casing and the motor being mounted upon the base structure 21. The rotation of the crank arm 24 in the direction of arrow 27 will cause the raking element 12a to move in an elongated cyclic path indicated by the numeral 28, and in the course of which it rakes the screenings 13 upwardly and over the top of the screen.

According to this invention the novel device for automatically controlling, or automatically starting and stopping, the screen cleaning device, comprises a pair of pressure transmitting tubular connections 29 and 30, each of which normally has its lower open end portions 31 and 32 respectively submerged at an exactly identical depth in the sewage liquid. The upper ends 33 and 34 of the two elements 29 and 30 have air-tight connections, each with a respective side of a differential pressure gauge or switch device 35 (see detail Figure 2).

The differential pressure gauge essentially consists of a container 36 which holds a suitable quantity of mercury 37. The container comprises a mercury well 38 of relatively large cross-section, and, extending from the lower portion of the well a slightly inclined tube portion 39 of relatively small cross section. Stoppers 40 and 41, respectively, make an air-tight closure for the mercury well 38 and the inclined tube portion 39, respectively. Each stopper has extending therethrough a conductor rod or terminal 40a and 41a, respectively, capable of making or breaking a current through the body of mercury in the gauge.

Normally the terminal 40a extends into and has constant contact with the mercury in the well 38, while the tip of the other terminal 41a is normally kept out of contact with the mercury column in the inclined tube portion 39 through an intervening air space 39a of suitable length. The terminals 40a and 41a are shown to have conductor connections 42 and 43 leading to a relay circuit indicated by conductors 44, 45, and which relay circuit, when closed, may effect the starting of the motor 26 through suitable power switches (not shown).

The parts of the control device so far described and in their whole simplicity really embrace the essence and basic idea of this invention. However, there is furthermore provided as a part, or refinement, or auxiliary of this automatic control device, a supply of fluid under pressure such as compressed gas or air, which supply is indicated by a compressed-air receiver 46 having a feed connection 47 and an outlet connection 48, which latter splits into a pair of symmetrical branch pipes 49 and 50 leading through air tight connections 51 and 52 into the afore-described pressure transmitting connections 29 and 30. Interposed in the flow of each of the branch pipes 49 and 50 is an orifice member 53 and 54, respectively, for a purpose hereinafter explained.

The electric current and wiring arrangement is now more specifically described:

The numeral 55 indicates an automatic power switch connecting a power line 56 with the motor 26. The power switch may be of standard make (such as from General Electric Company catalog of June, 1936, GEA—841–F, A. C. magnetic power switch CR–7006—D40) and is controlled through a pilot wire 57 from the differential pressure—responsive switch device 35 and a relay 57a (for instance General Electric Company relay CR–2811, size 00, from General Electric Company's Industrial Control Handbook page 5, February 1, 1937), low voltage being supplied to the pilot wire 57 from a source indicated at 35a; or else the motor can be made arbitrarily to operate as from a start-and-stop push button station 58 usually provided along with and included in the magnetic power switch unit 55. A separate stop switch 59 (such as a Cutler-Hammer limit switch, see Cutler-Hammer Price Book Bulletin 1271 of February, 1929) is provided to be controlled or tripped by the movement of the bar screen cleaning mechanism, and more specifically by the rotation of the driving crank arm 24 thereof, the stop switch 59 being connected with the power switch through a pilot wire 60. The switch 59 may be of the type that automatically returns to its closed position when released by the crank 24 as the motor starts it rotating, but is opened and is kept open by the crank when the same having completed a revolution returns to its initial position, thus opening the magnetic power switch 59 and stopping the motor 26.

The operation of the bar screen cleaning mechanism through the novel control device is as follows:

It must be assumed as a condition for proper operation of a control device of this specific embodiment, that the open end portions of the tube connections 29 and 30 are immersed to the identical depth in the sewage liquid relative to the normal equalized level thereof. In other words, the submerged tube outlet openings must be at the identical horizontal level.

If assuming normal and unimpeded flow of sewage liquid through the bar screen while the motor driven bar screen cleaning mechanism is at rest, then both of the pressure-transmitting tubular connections 29 and 30 will be under identical pressure, namely, the pressure which corresponds to the static head represented by the depth of immersion of the lower end portions 31 and 32 in the sewage liquid. Compressed air flow being furnished through the feed connection 47, the compressed air receiver 46, and the outlet connection 48, is divided as it enters under equal pressure into the branch pipes 49 and 50. Each branch flow passes through a corresponding orifice member 53 and 54, respectively, be-

fore entering into the corresponding tubular connections **29** and **30**.

At the same time, incident to the passing through its orifice and due to the size thereof, each divisional flow incurs a considerable pressure drop, the amount of which depends upon the flow velocity conditions of the air and upon the characteristics of the orifice. As a consequence, while balanced air flow conditions maintain on both sides there will also be a uniform escape of compressed air from each of the tubes **29** and **30**, and consequently the pressures reacting upon both sides of the differential pressure responsive switch device will show no differential, and will leave the body of mercury therein out of contact with the terminal **41** (see Fig. 2), and the motor drive for the bar screen cleaning mechanism will stay at rest. Preferably, the orifices should be of a size to produce a much higher pressure just before the orifice than immediately following it. At the same time, the rate of air flow through the orifice should be controlled to establish a certain rate of escape of air or air bubbles from the tubes **29** and **30**, which should not be so high as to cause undue agitation, and not so low as to give uneven pressure or unprecise pressure differences in order to insure optimum control at a minimum of compressed air expenditure.

Let us assume now that an undue amount of screenings **13** should clog the bar screen to such an extent that the water level at the front thereof starts rising above the water level back of the screen by an amount or differential which is indicated by the letter "*d*". This is equivalent to an increase of head or back pressure reacting into the tube connection **29**, and restraining or reducing a free outflow therefrom of compressed air, while allowing a relatively easier flow from the other tube connection **30**.

In other words, the pressure equilibrium previously maintained in the tube connection **29** and **30** will now be disturbed and a pressure differential be established. In establishing and maintaining this pressure differential the interposed orifice members **53** and **54** play an important part due to their throttling or checking effect upon the pressure of the compressed air supply. In other words, the relatively high pressure drop in both orifices creates a pressure barrier with does not at once permit the pressure differences to equalize back through the branch pipes **49** and **50**, but will permit a desired pressure difference to manifest itself in the tubes **29** and **30**, respectively. Expressing this in still other words, it can be said that with respect to each orifice member there exists a high-pressure side and a low-pressure side, and that consequently in the course of compressed air flow through these orifices the high-pressure sides are rendered substantially unresponsive or unaffected by relative pressure variations which may take place at the low-pressure sides.

Therefore, if the resultant pressure differential has reached or exceeds a predetermined limit, it will have depressed the mercury level in the well **38** sufficiently to force the mercury up through the inclined tube portion **39** far enough to fill the erstwhile air space **39a** and to make contact with the terminal **41a** so as to close the relay circuit **44**, **45**, which closing in effect may start the motor **26** and the bar screen cleaning mechanism, to cause the raking arm **12** or raking element **12a** to operate along its elongated cyclic path **28**. The raking arm **12** may begin its operative stroke from the bottom of the screen to rake the screenings **13** upwardly along the bars **10**, and emerging from the liquid it may cause the raked screenings to drop over the top of the bar screen into the dump or depression **17**, then to return to the bottom along a path spaced away from the bars of the screen for another raking stroke.

However, it will be understood that during the raking stroke of the raking arm **12**, as soon as it has cleared away sufficient screenings to permit equalization of the respective liquid levels, the pressures in the tube connections **29** and **30** will immediately restore themselves to their erstwhile balanced condition and consequently this will cause the mercury in the inclined tube portion **39** of the switch device to recede and to restore the contact to open condition. Such a breaking of the contact, however, should not, for obvious reasons, cause the immediate stoppage of the raking member **12**, while the same would be caught emerged in the middle of its upward stroke. The stopping of the raking arm should be caused after it has reached an end position in which it is entirely emerged from the liquid. To this end, provision may be made to have the raking member **12** continue in its upward raking movement even after the liquid levels have equalized, until it reaches a predetermined point of emergence where a trip switch device may be actuated by the movement of the cleaning mechanism, which in turn, will cause the stoppage of the motor **26**.

More specifically, as the mercury switch **35** closes under the effect of a static pressure difference between the liquid bodies fore and aft of the screen, it releases the power switch **55**, thus starting the motor **26** to drive the cleaning device. Since it is preferred to delay the stopping of the cleaning device until after the water levels are equalized, the separate automatic stop switch **59** will arrest the cleaning device only after it has gone through a certain desirable amount of movement. So, the stop switch **59** may be a trip switch operated by the bar-screen cleaning device after, say, one full operating cycle or revolution thereof. Such arrangement will insure against the cleaning device operating at too short an interval, such as might occur were the operation solely dependent upon the opening and closing of the differential pressure-responsive switch device **35**. For it can be readily seen that the switch **35** once closed would quickly open again as the water levels equalize through the screen, without giving the cleaning device a chance to effectively clean the same.

The arrangement herein disclosed for using auxiliary air pressure to cause the differential pressure gauge or switch device to respond, is one of a variety of possible embodiments of this invention, and it should be understood that instead of relying upon auxiliary pressure air it is also conceivable to use a pair of downwardly-open bells in connection with the end opening of the pressure-transmitting tubular connections **29** and **30**, in such a manner that the compression or expansion, respectively, of the entrapped air volume in the bells caused by the rise and fall of the sewage level, will operate the differential pressure device.

Also, the attachment of a diaphragm device at the end of each of the pressure-transmitting tubes **29** and **30**, is conceivable in this connection for the purpose of differential pressure manipulation. Also, when the ends of the pressure tubes are closed by a diaphragm or diaphragm device, the pressure-transmitting tube connections may

be filled with an auxiliary pressure fluid, gaseous or liquid, for transmission therethrough, of the pressure differentials.

I claim:

1. For use with and control of a motor-operated bar screen cleaning mechanism, a differential liquid level operated device adapted for use with a pair of liquid bodies such as the one before and the one after the bar screen, which comprises a differential pressure responsive switch device, a pair of pressure transmitting tubular connections between the respective liquid bodies and said differential-pressure responsive device, which connections are adapted to transmit pressure from static head of each liquid body permitting a differential pressure of such static heads due to clogging of the screen to actuate the differential pressure responsive switch device for starting thereby the motor of said bar screen cleaning mechanism, a source of compressed air, connections for introducing compressed air from said source into each of said tubular connections permitting said air to bubble from the open immersed ends thereof against the pressure of the static head of the respective liquid bodies, and flow restricting means interposed in each pressure air connection between the source of air and the differential pressure responsive switch device.

2. A differential liquid level operated device according to claim 1, in which the flow restricting means in each connection comprises an orifice member.

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