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[54] AIR-OPERATED EDUCTOR CONTROL
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[50] Field of Search 103/25, 232

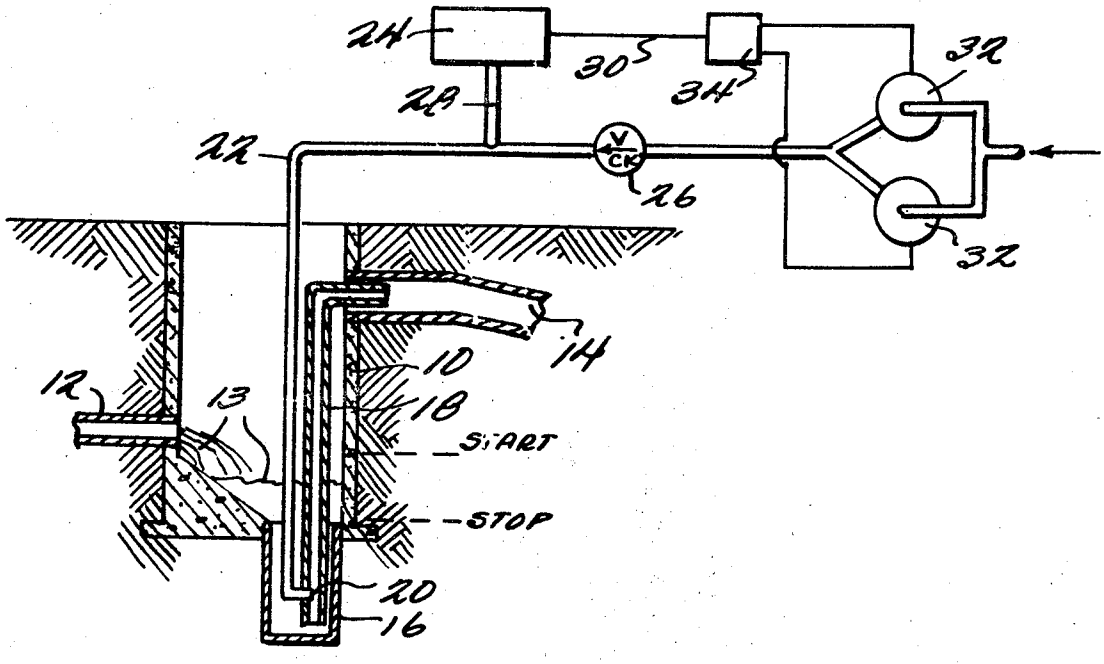
[56] References Cited

UNITED STATES PATENTS

1,987,466	1/1935	Collin	103/25
2,707,440	5/1955	Long et al.	103/25
2,891,625	6/1959	Hube	103/25
3,191,681	6/1965	Hubby	103/232
3,285,181	11/1966	Howard	103/25
3,302,574	2/1967	Mitchell	103/25

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ABSTRACT: A liquid waste collection tank is provided with an airlift for periodically pumping out the waste. The airlift comprises an upright eductor pipe dipping into the waste, an air supply line connecting with the submerged portion of the eductor pipe and a blower system for delivering compressed air to the supply line. The air pressure in the supply line varies with the liquid level in the tank, and a pressure responsive control system is operative to activate and deactivate the blower system at predetermined high- and low-liquid levels in the tank, respectively. A loss of pressure in the supply pipe occasioned by a leak will render the normal control elements inoperative, but a safety element responsive to a pressure drop will activate the blower system to prevent flooding of the tank.



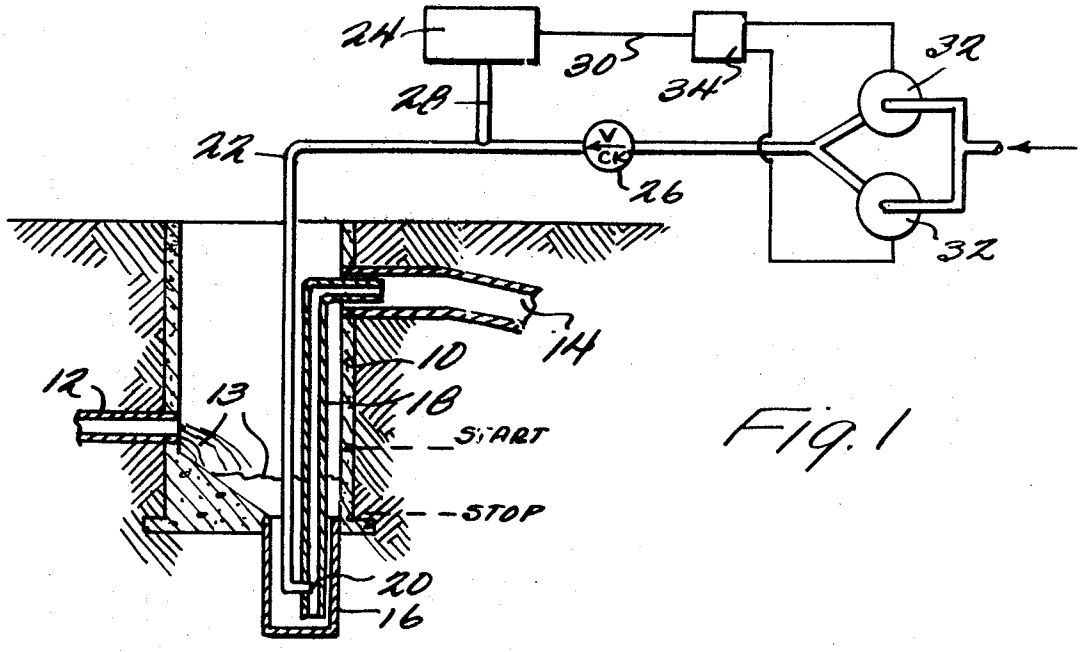


Fig. 1

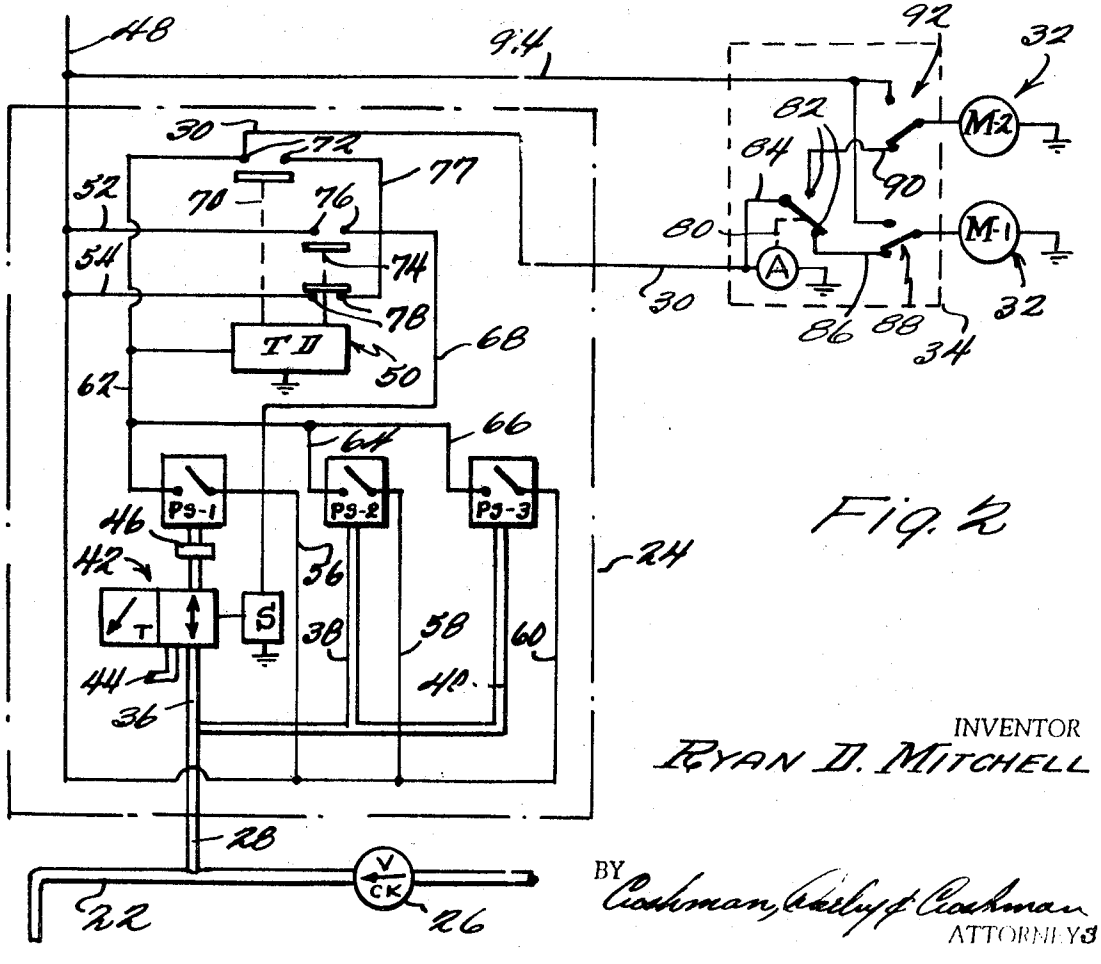


Fig. 2

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AIR-OPERATED EDUCTOR CONTROL

DISCLOSURE

This invention relates to the control of an air lift pump employed to pump out a wet well or the like and in particular to an on-off blower control system which is not susceptible to fouling by material in the wet well.

In the handling of sewage and other liquid waste it is conventional practice at some stage to collect the waste in a wet well, sump or other receptacle and to pump out the waste periodically to a processing plant or to another collection stage. One common type of pump employed for this purpose is an air lift the essential parts of which are an upright eductor pipe disposed in the wet well with its open lower end submerged and a compressed air supply line connected to the lower end of the eductor pipe for introducing air into the latter. In operation of this kind of pump the compressed air, usually supplied from a motor-driven blower system, mixes with the liquid waste in the lower part of the eductor pipe, and the resulting low-density mass rises in the pipe and then flows by gravity to its destination. The air lift is controlled conventionally with an on-off control device which activates and deactivates the air supply system in response to predetermined high- and low-liquid waste level in the well.

It is the primary object of the present invention to provide an airlift pumping installation with an improved control system which obtains its control signals from the pressure in the air supply pipe. The primary advantage of the arrangement is that the control elements are located outside the well and are therefore not subject to fouling by contact with the liquid waste. According to the principles of the present invention this object is realized, broadly, by sealing the air supply line at some point above the liquid level in the wet well or the like when the air lift is not operating, that is, when no air is flowing through the supply line. Under this condition the static pressure head of the liquid above the submerged lower end of the supply line is transmitted to the air trapped in the supply line. A pressure responsive control system for the compressed air source is pressure connected to the supply line downstream of the seal and is activated and deactivated at pressures which correspond to desired maximum and minimum liquid levels, respectively, in the wet well.

It is a further object of the invention to provide an air lift and pressure responsive control system of the type described above in which the control system is adapted to compensate for the pressure changes in the air supply line occasioned by starting and stopping the flow of compressed air. The pressure in the supply line just before startup is a measure of the height of liquid surrounding the eductor pipe, and the pressure after blower startup is considerably higher due to the pressure of the air flowing through the line. After the liquid level has dropped to the desired cutoff level due to the pumping action of the air lift, the pressure in the supply line remains higher than the pressure prior to startup. A single on-off pressure switch will not deactivate the air supply system at the desired time, because the pressure in the line is higher than the trip pressure of the switch.

In the preferred embodiment a first pressure switch is employed to activate the air supply system at the relatively low pressure resulting solely from the static head in the wet well at the desired maximum liquid level. A second pressure switch having a higher trip pressure then comes into play, the higher trip pressure being equal to the pressure which will exist in the supply line while air is still flowing and when the liquid level in the well has fallen to the desired low level. In order that the first switch will not continue to activate the air supply system due to the high air pressure in the supply line, the control system shifts control to the second switch after the air supply system has started.

The preferred embodiment also includes a third pressure switch which will activate the air supply system in the event

that ambient air leaks out of the supply line. Under this condition a rise in liquid level in the well may not increase the pressure to the trip pressure of the first pressure switch. If the leak continues, the pressure in the supply pipe will drop toward atmospheric pressure. The third pressure switch has a trip pressure which is lower than the trip pressure of the first switch so that the drop in pressure occasioned by the leak will trip the third switch and start the air supply system.

The invention will be further understood from the following detailed description of a preferred embodiment taken with the drawings in which:

FIG. 1 is a schematic elevational view, partly in section, of a wet well, air lift and control system; and

FIG. 2 is a diagrammatic view, on an enlarged scale, of the control system of FIG. 1.

Referring to FIG. 1, there is shown schematically a typical wet well constructed in the form of a below-ground cement tank 10 having an inlet pipe 12 for receiving sewage or other liquid waste 13 and a discharge pipe 14 for carrying away the sewage. The lower end of the tank 10 is provided with a depending sump pipe 16 of lesser diameter than the tank 10. An air lift pump dips into the sump pipe 16 and extends to the level of the discharge pipe 14. The essential parts of the air lift include an upright eductor pipe 18 having its lower end 20 open below the liquid level in the sump pipe 16 and a compressed air supply pipe 22 for injecting air into the submerged portion of eductor pipe 18. The upper end of the eductor pipe 18 communicates by an L with the discharge pipe 14. In operation of the system, air, which is injected under pressure into the eductor pipe 18, forms bubbles in the sewage, and the resulting low-density mixture rises in the eductor pipe 18. When the liquid level has dropped to a desired level, the supply of air to the air line 22 is discontinued, and pumping of sewage stops.

The above description is applicable to wet wells and similar installations which are in common use. Thy present invention is concerned with a control system 24 for this type of installation, the control system 24 being responsive to the pressure changes in the air supply line 22 to deliver compressed air to the supply line 22 when needed. The primary advantage of the arrangement is that the sensing or measuring elements which are employed lie outside the wall and are thereby accessible for maintenance and not subject to fouling, as are the more conventional bubblers electrodes and submerged pressure switches.

In order that the magnitude of the air pressure in the supply line 22 indicate the level of the waste in the tank 10 when no air is flowing, the supply line 22 must be closed at some point above the the liquid level. Conveniently, this may be accomplished by providing in the supply line 22 an automatic valve, such as a check valve 26, which closes when compressed air stops flowing toward the eductor pipe 18. Under these conditions the static pressure head of liquid at the lower open end 20 of the air supply line 22 is transmitted to the air which is trapped in the latter by the closing of the valve 26. Thereafter, the air pressure in the supply line 22 increases and decreases with a rise and fall, respectively, of the liquid level in the tank 10, because the static pressure head changes with changes in liquid level. The normal occurrence is, of course, an increase in liquid level due to entry of additional waste through the inlet pipe 12.

It follows from the above discussion that the pressure in the supply line 22 will increase rapidly to a high value when compressed air is admitted to the line 22. This pressure will depend in part, of course, on the magnitude of the applied air pressure. However, it will also depend, in part, on the magnitude of the static pressure head. Therefore, for a given constant air supply the pressure in the supply line 22, when compressed air is flowing, will be a measure of the liquid level in the tank 10. Of course, the total pressure in the line 22 will always be higher than the static pressure head unless leaks develop.

Referring more specifically to the control system 24 illustrated schematically in FIG. 1 it will be seen that a pressure tap 28 is provided in the air supply pipe 22 at a location downstream of the check valve 26. The output of the control system 24, in the form of an electrical signal is conducted by an electrical lead 30 to the compressed air supply which may be of any convenient form. As shown, the compressed air supply includes a pair of electric motor driven blowers 32 which are operated alternately through a secondary control circuit 34. The latter, in response to an on-signal from the primary control system 24, starts one or the other of the blowers 32 so as to maintain one blower in a stand by condition.

Referring to FIG. 2, it will be seen that the preferred embodiment of the control system 24 includes three pressure responsive switches PS-1, PS-2 and PS-3, each of which is pneumatically connected to the pressure tap 28 by connections 36, 38 and 40, respectively. The switches are normally open, as shown, and are set to close at predetermined trip pressures. MOre specifically, PS-1 closes at the static pressure head existing in the supply line 22 when the liquid level in the tank 10 has risen to the desired maximum level illustrated at "-Start" in FIG. 1. The trip pressure of PS-2 is that pressure which exists in the supply line 22 while the blower 32 is operating and when the liquid level in the tank 10 is at the "-Stop" level illustrated in FIG. 2. That is, PS-2 will close when the blower 32 starts and will open when the well has been pumped down to the "Stop" level. PS-3, a safety switch whose function is described later, closes at a lower trip pressure than the trip pressure of PS-1.

The pneumatic connection 36 to PS-1 includes a solenoid operated valve 42 adapted in one position, as shown, to transmit air pressure to PS-1 and in another position to connect PS-1 to atmosphere through a vent 44. A pulsation snubber 46 is provided in the connection 36 between the valve 42 and the switch.

The electrical components of the control system 24 include a hot wire 48 which connects with various contacts in a time delay relay 50 by means of wires 52 and 54 and with one contact of each pressure switch through wires 56, 58 and 60. The other contacts of the pressure switches are connected to the relay 50 by wires 62, 64 and 66. The relay also connects with the output wire 30 and with the solenoid S of the valve 42 by means of a wire 68.

The relay 50 includes a longitudinally movable shaft 70 and armature plate adapted to close a pair of normally open contacts 72 instantaneously upon energization of the relay 50. A second shaft and armature plate 74 is adapted to close a pair of normally open contacts 76 and to open a pair of normally closed contacts 78 a predetermined time after energization. Upon deenergization of the relay 50 both shafts 70 and 74 drop back to the illustrated positions. A wire 77 connects the right-hand contact 72 with the right-hand contact 78. Another wire 79 connects the wire 62 with the left-hand contact 72 which also connects with the control lead 30.

The secondary control circuit 34 forms no part of the present invention and need be described only in general terms. As indicated previously, the primary purpose of the circuit 34 is to operate the two blowers 32 alternately when the primary circuit 24 calls for a supply of compressed air. As shown schematically, there is included an alternating device A and a mechanical linkage 80 which moves a switch lever between two contacts 82, the lever being held in engagement with each contact 82 for a predetermined length of operating time. The lever is electrically connected to the control wire 30 by means of a wire 84. A wire 86 leads from one of the contacts 82 through a manual switch 88 to the starting coil M-1 of one of the blowers 32, and a wire 90 leads from the other contact through another manual switch 92 to the starting coil M-2 of the other blower 32. The manual switches 90 and 92 are electrically connected to the hot wire 48 by a wire 94, and are therefore adapted to energize their respective starting coils independently of the control circuits 24 and 34 in the event that manual operation of the blowers 32 is desired.

OPERATION

As previously described, the air pressure in the air supply line 22 varies with changes in the level of the liquid waste 13 in the tank but varies between different limits depending on whether one of the blowers 32 is operating. In the illustrated position of the elements in FIGS. 1 and 2, the check valve 26 is closed, the blowers 32 are not operating, and the level of the waste 13 is rising. For purposes of illustration it may be said that the pressure in the line is 4 units on an arbitrary pressure scale.

When the waste level rises to the "Start" level, the pressure in the line 22 will have increased to, say, five arbitrary units, which is the trip pressure of PS-1. PS-1 closes and current flows through wires 48, 56 and 62 to the relay 50. Simultaneously one of the blowers 32 becomes energized due to current flowing from the wire 62 through wires 79, 30, 84 and 86.

Upon energization of the relay 50 its timing mechanism begins operating. Simultaneously the armature shaft 70 moves up to close the contacts 72. This locks in the relay. The armature shaft 74 remains stationary at this time, but will move up when the timer times out.

As soon as the blower 32 starts, the pressure in the line 22 increases to, say, eight arbitrary units, this figure representing both the static head pressure of the liquid at the "Start" level in the tank 10 and the additional pressure supplied by the blower The the check valve 26 opens, and compressed air flows through the line 22 into blower lower end portion of eductor pipe 18 to operate the air lift in a well-known manner. PS-2, which is wired in parallel with PS-1, will close at the higher pressure now existing in the line 22, and closing of this switch establishes a circuit from the hot wire 48 to wires 58, 64 and 62. The timer times out a few moments after the relay 50 has been energized and after the blower 32 has started. When the timer times out, the armature shaft 74 moves up to close the contacts 76 and to open the contacts 78. The other armature shaft 70 remains up. Opening of the contacts 78 releases the lock of the relay 50.

Closing of the contacts 76 energizes the solenoid S of the valve 42 through a circuit established by wires 48, 52 and 68. The solenoid S changes the position of the valve 42 so that the air pressure in PS-1 is exhausted to atmosphere through the vent 44. At the same time the valve prevents loss of air pressure from the tap 28. When the pressure in PS-1 drops to its trip pressure its contacts open thereby breaking the circuit through the wire 56. At this time PS-2 remains closed so that the relay 50 continues to be energized through wires 48, 58, 64 and 62.

As the liquid level in the tank 10 is lowered by the pumping action of the air lift the pressure in the line 22 will drop to, say, six arbitrary units when the level arrives at the "Stop" level. The trip pressure of PS-2 has been set for this value so that its contacts open thereby stopping the blower 32 by breaking the circuit through wires 58 and 64.

Opening of the contacts of PS-2 also deenergize the relay 50. This allows the armature shafts 70 and 74 to drop to their normal positions illustrated in FIG. 2. Opening of the contacts 72 removes the lock. Opening of the contacts 76 deenergizes the solenoid S of the valve 42 thereby reconnecting PS-1 to the pressure tap 28. The snubber 46 prevents the pressure surge caused by reconnection from closing the contacts of PS-1. Closing of the contacts 78 resets the circuitry so that it may repeat the above-described sequence.

PS-3 operates as a safety device in the event that pressure is lost in the line 22 or in some other part of the pneumatic circuitry, as by improper seating of the check valve 26 or by the development of a leak in the line 22 or the tap 28. For example, either of these occurrences might equalize the pressure in the line 22 with atmospheric pressure and thereby prevent the pressure acting on PS-1 from rising to its trip pressure. In this event a rising liquid level in the tank would not start one of the blowers 32 and flooding would result.

However, the trip pressure of PS-3 is set lower than the trip pressure of PS-1 so that loss of pressure in the line 22 will

cause PS-3 to close. When this occurs, current will flow through the wires 60,66 and 62 to start one of the blowers and to energize the relay 50. Starting of the blower 32 will recharge the line 22 so that PS-3 will open, but the blower 32 ill continue to operate due to the circuit established by wires 48, 54, contacts 78, wire 77, contacts 72 and wire 30. Of course, PS-2 may close if the pressure in the line 22 is high enough, in which case the blower 32 will operate independently of the circuit which includes the wire 77. If the liquid level in the tank 10 is at the "Stop" level, PS-2 will not close, in which case the blower will operate only until the timer times out. Under this condition timing out causes the armature shaft 74 to move up in the usual manner, but it immediately drops down because no current is energizing the relay through the wire 62.

While preferred embodiments of the present invention have been described, further modifications may be made without departing from the scope of the invention. Therefore, it is to be understood that the details set forth or shown in the drawings are to be interpreted in an illustrative, and not in a limiting sense, except as they appear in the appended claims.

I claim:

1. In an air lift pump: an upright eductor pipe disposed with its open lower end submerged in a body of liquid; compressed air supply means; an air supply line connecting said air supply means with the lower submerged end of said eductor pipe; means associated with said air supply line at a location between said air supply means and said submerged end of said eductor pipe for closing said line when air is not being supplied from said air supply means and for automatically passing air through said line to said submerged end of said eductor pipe when air is supplied from said air supply means whereby the pressure in said line is proportional to the static pressure head of liquid acting on the submerged end of said eductor pipe plus the pressure of the air, if any, being supplied from said air supply means; and a control system associated with said air supply means for starting operation of the air lift when the liquid surrounding said eductor pipe rises to a predetermined high level and for stopping operation of the air lift when the liquid surrounding said eductor pipe falls to a predetermined low level, said control system including means responsive to a predetermined first pressure in that portion of said air supply line between said submerged end of said eductor pipe and said cloying means initiating flow of compressed air into said supply line and responsive to a subsequent predetermined second pressure in said supply line for stopping the flow of compressed air into said supply line, said predetermined second pressure being higher than said first pressure and lower than the pressure which exists in said supply line upon initiation of air flow thereinto.

2. Apparatus as in claim 1 wherein said control system includes additional pressure responsive means for flowing compressed air into said air supply line when a predetermined third pressure lower than said first pressure exists in said air supply line whereby a reduction in pressure in the latter due to outward leakage of air will cause said air lift to operate.

3. Apparatus as in claim 1 wherein said pressure responsive means includes a first device operative to flow compressed air into said air supply line when activated by a pressure equal to or greater than said predetermined first pressure, and a second device operative to flow compressed air into said air supply line when activated by a pressure equal to or greater than said predetermined higher pressure and operative to stop the flow of compressed air when deactivated by a pressure below said second pressure, said control system further including timing means for deactivating said first device a short time after it has been activated by said first pressure whereby said second device maintains air flow until said second pressure is effected in said air supply line.

4. Apparatus as in claim 3 wherein said control system includes a third pressure responsive device operative to flow compressed air into said air supply line when activated by a predetermined third pressure in the latter which is less than said first pressure whereby reduction of pressure in said supply line resulting from outward leakage of air will cause said air lift to operate.

5. An air lift pump for periodically pumping out a wet well or the like and a control system for operating said air lift upon a rise in the liquid in the wet well to a predetermined level comprising: an upright eductor pipe disposed with its lower end submerged in the liquid; blower means for generating compressed air; a compressed air supply line connecting said blower means with the lower submerged end of said eductor pipe; one-way valve means in said supply line for passing compressed air to said eductor pipe when said blower means is operating and for sealing said supply line when said blower means is not operating whereby the pressure in said supply line on the downstream side of said valve means is a measure of the level of the liquid surrounding said eductor pipe when said blower means is operating and when said blower means is not operating; an electrical control circuit which when energized operates said blower means; a first pressure responsive device associated with said supply line downstream of said valve means, said first device being activated by a pressure increase in said supply line to a predetermined first pressure occasioned by a rise in the liquid level surrounding said eductor pipe; means responsive to activation of said first device to energize said control circuit; a second pressure responsive device associated with said supply line downstream of said valve means, said second device being activated by a further increase in pressure in said supply line occasioned by operation of said blower means and being deactivated by a decrease in pressure in said supply line to a second predetermined pressure which is higher than said first predetermined pressure, said pressure decrease being occasioned by a drop in the liquid level surrounding said eductor pipe as said air lift operates; means responsive to activation and deactivation of said second pressure responsive device for energizing and deenergizing said control circuit; and means for deactivating said first pressure responsive device after said second pressure responsive device has been activated whereby said control circuit remains energized until the pressure in said supply line falls to said second predetermined pressure.

6. Apparatus as in claim 5 wherein said means for deactivating said first pressure responsive device includes timing means operable to deactivate said first pressure responsive device after said second pressure responsive device has been activated.

7. Apparatus as in claim 6 wherein said timing means is connected to said first pressure responsive device so as to begin timing upon activation of said first pressure responsive device.

8. Apparatus as in claim 5 including a third pressure responsive device associated with said supply line downstream of said valve means, said third device being activated by a lower pressure in said supply line than said first predetermined pressure to energize said control circuit, whereby undesired air leakage out of said supply line and consequent loss of pressure therein during a period when said blower means is not operating will energize said control circuit.

9. Apparatus as in claim 1 wherein said means for closing said air supply line and for subsequently passing air therethrough includes a one-way valve in said air supply line.