Dec. 8, 1942. R. B. P. CRAWFORD 2,304,150

SOLUTION CONCENTRATION SYSTEM

Filed May 13, 1938 2 Sheets-Sheet 1

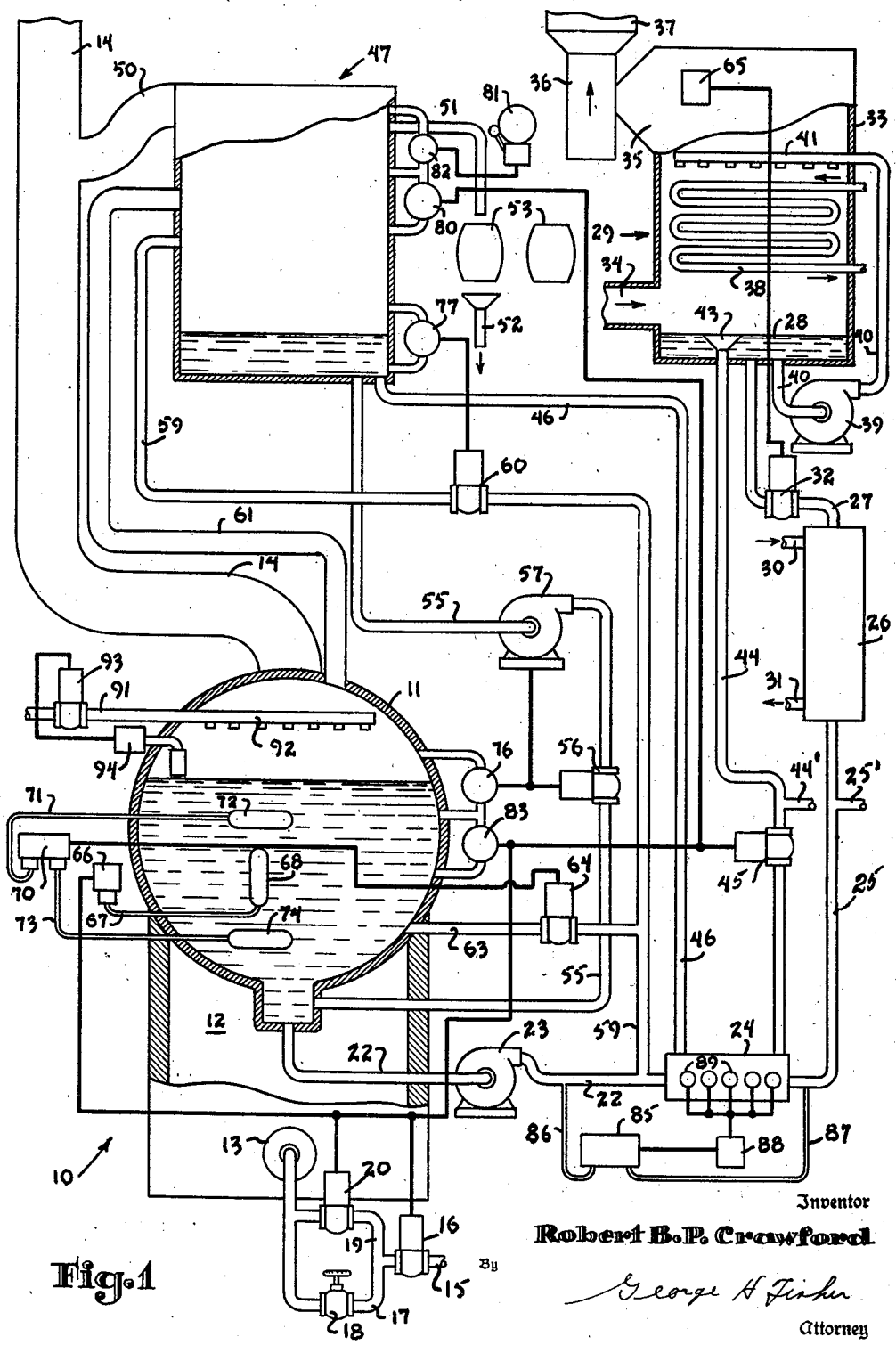

Fig. 1

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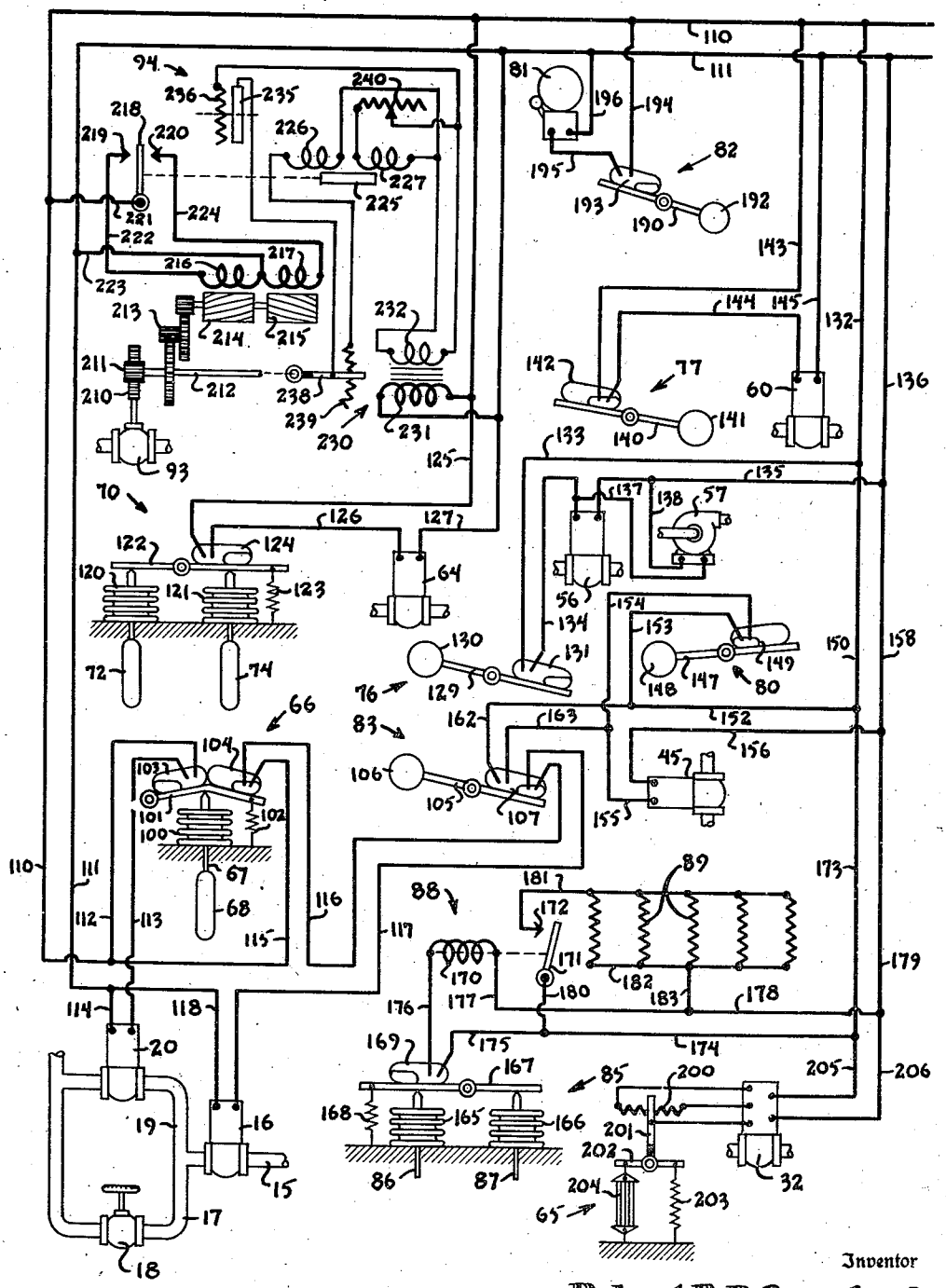

Fig. 2

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UNITED STATES PATENT OFFICE

2,304,150

SOLUTION CONCENTRATION SYSTEM

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Application May 13, 1938, Serial No. 207,795

13 Claims. (Cl. 159—44)

This invention relates to solution concentrating systems for chemical dehumidifying systems in general and more particularly to an automatic control system therefor to insure safe operation thereof.

The chemical dehumidifying system of this invention may utilize a hygroscopic fluid such as calcium chloride, lithium chloride or any other chemical having moisture absorbing characteristics and it may comprise a boiler for heating the hygroscopic fluid to increase the concentration thereof, a first conduit for conducting hygroscopic fluid of relatively high concentration from the boiler to a dehumidifying unit provided with means for contacting the hygroscopic fluid with the air to be dehumidified, a second conduit for conducting hygroscopic fluid of relatively low concentration from the dehumidifying unit to a reservoir and a third conduit for conducting the fluid from the reservoir to the boiler.

An object of this invention is to provide a means for obtaining counterflow heat exchange between the hygroscopic fluid flowing through the first and second conduits whereby the efficiency of the system is greatly increased.

Another object is to provide heating means in the first conduit to prevent solidification of the fluid of relatively high concentration flowing through the first conduit.

A further object is to provide means for maintaining at least a predetermined amount of fluid in the reservoir so that the boiler may be at all times supplied with fluid.

Still another object is to provide means for decreasing the flow of fluid to the reservoir if the level of fluid therein becomes excessively high.

A further object is to provide means for maintaining the temperature of the fluid in the boiler at a substantially constant value by controlling the firing means of the boiler.

Another object is to cause agitation of the fluid in the boiler in case it tends to stratify. This may be accomplished by controlling the agitation of the fluid in accordance with the difference in temperature of the fluid at different points within the boiler.

Another object is to maintain the level of the fluid in the boiler at a substantially constant value by controlling the flow of fluid from the reservoir to the boiler.

Still another object is to shut off the firing means for the boiler and supply fluid to the reservoir and hence to the boiler if the fluid level in the boiler should decrease to a predetermined low value.

A further object is to supply air under pressure to prevent excessive turbulence of the fluid in the boiler.

This invention also contemplates the combination of these various features into a composite control arrangement to insure safe operation of a chemical dehumidifying system.

Other objects and advantages will become apparent to those skilled in the art upon reference to the accompanying specification, claims and drawings, in which

Figure 1 is a diagrammatic illustration of this invention with the control system applied thereto.

Figure 2 is a schematic wiring diagram showing schematically the construction of the various control instruments and the wiring connections therebetween.

Referring now to Figure 1, a concentrator in the form of a boiler is generally designated at 10. This boiler may comprise a shell 11 in which is contained the hygroscopic fluid to be concentrated, and a firing chamber 12 for heating the hygroscopic fluid in the shell 11. The boiler may be fired by means of a burner, such as a high-low oil burner 13. Gases of combustion are withdrawn from the boiler 10 by means of a flue or breech 14 extending to a stack, not shown. Fuel such as oil may be supplied to the burner 13 through a pipe 15 under the control of a motorized main valve 16. A branch pipe 17 extending to the burner 13 is controlled by a manually adjusted throttle valve 18 and a branch pipe 17 extending to the burner 13 may be controlled by a motorized valve 20. When the motorized main valve 16 is open, fuel is supplied to the burner 13 and if the motorized valve 20 is closed the fuel passes through the manual valve 18 to provide a low flame, and if the motorized valve 20 is open, a high flame is provided.

Hygroscopic fluid of a relatively high concentration, for example 50%, is withdrawn from the shell 11 by a pump 23 through a conduit 22, a heat exchanger 24, a conduit 25, a cooler 26 and a conduit 27 to a sump 28 of a dehumidifying unit generally designated at 29. Preferably the pump 23 is maintained continuously in operation. The cooler 26 may be provided with an inlet 30 and an outlet 31 for a cooling fluid such as well-water for cooling the hygroscopic fluid before it passes to the sump 28 of the dehumidifying unit 29. A branch conduit 25' may be utilized for supplying hygroscopic fluid to other

dehumidifying units, not shown. A motorized valve 32 located in the conduit 27 may be utilized for controlling the supply of concentrated fluid to the dehumidifying unit.

The dehumidifying unit 29 may comprise a chamber 33 provided with an air inlet 34 and an air outlet 35. Air is drawn through the chamber 33 by means of a fan 36 and discharged by a conduit 37 to the space or room to be conditioned. Located in the chamber 33 is a cooling coil 38 for cooling the air passing through the chamber. This cooling coil may be provided with a cooling fluid in any suitable manner. A pump 39 withdraws hydroscopic fluid from the sump 28 through a conduit 40 and discharges this hygroscopic fluid through a spray 41 so that the hygroscopic fluid is contacted by the air passing through the dehumidifying unit to absorb moisture therefrom. As a result, the concentration of the hygroscopic fluid is decreased to a predetermined low value such as 45%. This hygroscopic fluid of relatively low concentration passes from the sump 28 through an overflow connection 43, a conduit 44, the heat exchanger 24 and a conduit 46 to a reservoir generally designated at 47.

The temperature of the hygroscopic fluid of relatively high concentration passing through the conduit 22 from the boiler is relatively high and it is necessary that this temperature be reduced before the highly concentrated hygroscopic fluid is supplied to the dehumidifying unit 29. Also, the temperature of the less concentrated hygroscopic fluid returning from the dehumidifying unit 29 is of relatively low temperature and must be heated in the boiler 10 to drive off the moisture contained therein. The heat exchanger 24 causes counterflow heat exchange between the hygroscopic fluid of relatively high concentration and the hygroscopic fluid of relatively low concentration, whereby the overall efficiency of the system is increased.

The reservoir 47 may comprise a container 49 in which the hygroscopic fluid may be stored preparatory to being supplied to the boiler 10. The container 49 is provided with a duct 50 leading to the breech 14. The container 49 is provided with an overflow passage 51 which empties into a sewer 52. It is possible that under certain extreme conditions such as failure of the controls, the reservoir 47 may become filled with hygroscopic fluid to an overflow point and instead of permitting this fluid from passing out through the flue or breach, it is made to pass out through the overflow conduit 51. Under these conditions suitable receptacles such as barrels or tanks 53 may be utilized for catching this overflow of hygroscopic fluid so that it will not be wasted.

A conduit 55 extending from the reservoir 47 to the shell 11 of the boiler 10 supplies hygroscopic fluid from the reservoir 47 to the shell 11. The supply of fluid is controlled by a motorized valve 56 and if the level of the reservoir 47 with respect to the boiler 10 is such that gravity flow is not sufficient for this purpose a pump 57 may be utilized.

A conduit 59 connected between the conduit 22 and the reservoir 47 may be utilized under certain conditions for supplying highly concentrated fluid from the boiler 10 to the reservoir 47. This conduit 59 is controlled by a motorized valve 60. A conduit 61 extends between the boiler shell 11 and the reservoir 47 so that the steam and entrained fluid escaping from the boiler will pass through this conduit 61 into the reservoir 47 and the moisture will pass through the passage 59 into the breech or flue 14. The conduit 61 also serves to equalize the pressures between the boiler shell 11 and the reservoir 47.

The conduit 59 is connected by a conduit 63 to the boiler shell 11 and this conduit is controlled by a motorized valve 64. When the valve 64 is open, circulation is permitted through the conduit 22, pump 23 and conduits 59 and 63 to agitate or stir up the fluid contained in the boiler shell 11. This is an effective method for agitating the fluid in the boiler shell 11 to prevent stratification and consequent crystallization of the fluid therein.

A humidity responsive controller 65 responsive to the relative humidity of the dehumidified air leaving the dehumidifying unit controls the valve 32 to regulate the amount of hygroscopic fluid of relatively high concentration delivered to the dehumidifying unit.

A temperature responsive controller 66 connected by a capillary tube 67 to a bulb 68 located in the fluid in the boiler shell 11 is utilized for controlling the operation of the fuel valves 16 and 20 to maintain a substantially constant temperature within the boiler shell 11. When the temperature is low the temperature controller 66 maintains both fuel valves 20 and 16 open to provide a high flame for the boiler. As the temperature increases the valve 20 is closed to provide a low flame and if the temperature increases to a predetermined higher value the valve 16 is closed to shut down the burner 13. Preferably the temperature controller 66 is so adjusted that it will maintain the temperature of the fluid in the boiler at substantially 275°.

A differential temperature controller 70 is connected by a capillary tube 71 to a bulb 72 located in the upper portion of the fluid in the boiler and is also connected by a capillary tube 73 to a bulb 74 located in the lower portion of the boiler. This differential temperature controller 70 therefore responds to the temperatures at two points in the fluid in the boiler and operates to open the valve 64 when the temperature differential exceeds, say 5°. This causes agitation of the fluid in the boiler and therefore prevents stratification and crystallization of the fluid in the boiler.

A liquid level controller 76 controls the valve 56 and the pump 57 to supply fluid to the boiler shell 11 from the reservoir 47 upon a decrease in level therein. In other words, the liquid level controller 76 operates to maintain the level of the fluid in the boiler substantially constant.

A liquid level controller 77 connected to the lower portion of the reservoir 47 controls the valve 60 to admit fluid from the boiler 10 to the reservoir 47 when the level of the fluid in the reservoir falls to a predetermined low value. Accordingly, the liquid level controller 77 operates to maintain at least a predetermined amount of liquid in the reservoir 47.

Liquid level controller 80 connected to the reservoir 47 in the upper end thereof operates the valve 45 to close the valve 45, which prevents the supply of fluid to the reservoir 47 when the level therein reaches a predetermined high value. In other words, the liquid level controller 80 operates to shut off the supply of fluid to the reservoir 47 to prevent overflow therefrom.

If the liquid level in the reservoir approaches the overflow conduit 51, a liquid level controller 82 sounds an alarm 81 indicating that the level in the reservoir 47 is extremely high and that

the system is not operating properly. When this alarm 81 is sounded the engineer on the job is notified of the fact that the system is not operating properly and if he feels that the reservoir 47 may overflow he may place the containers 53 under the overflow conduit 51 to catch the fluid in case it overflows from the reservoir 47.

A second liquid level controller 83 connected to the boiler 10 at a lower level operates to shut off the burner 13 and to open the valve 45. This provides a safety control for the boiler to shut off the burner when the level of the fluid therein gets too low and to open the valve 45 to supply fluid to the reservoir 47 and hence to the boiler 11 if fluid is available.

A differential pressure controller 85 connected by pipes 86 and 87 to the conduits 22 and 25 measures the pressure drop across the heat exchanger 24. If the fluid coming from the boiler 10 tends to be too highly concentrated and there is danger that the fluid will crystallize or solidify in the heat exchanger 24 upon being cooled, the pressure differential across the heat exchanger 24 will increase and in response to this increase in pressure differential the differential pressure controller 85 will pull in a relay 88 to energize heaters 89 in the heat exchanger 24 to heat up the hygroscopic fluid of relatively high concentration to prevent the crystallization or solidification of the fluid in the heat exchanger 24. This is an extremely practical and sure method of insuring that the hygroscopic fluid will not crystallize and solidify in the heat exchanger 24 during the starting up period or during periods when dehumidifying unit 29 is shut down. It is found that in boilers of this type for concentrating a hygroscopic fluid that on occasions the fluid in the boiler becomes extremely turbulent and in order to reduce this turbulence to prevent priming of the boiler, that is, the flow of fluid out of the boiler, I supply air under pressure to the surface of the fluid in the boiler. This has a marked effect on the turbulence of the fluid in the boiler. It is found that the application of air to the surface of the fluid in the boiler decreases the turbulence thereof to a minimum and acts as a carrier for the steam flowing through the conduit 61, reservoir 47, duct 50 and breech 14 to the stack, not shown. The air under pressure also has a tendency to pierce or break up the bubbles caused by boiling, and the breaking up of the bubbles in this manner materially decreases the bubbling effect and therefore materially decreases the turbulence of the fluid. This supplying of air is accomplished by means of a pipe 91 leading from some source of air under pressure, not shown, to a nozzle arrangement 92 located in the boiler above the level of the fluid therein. The supply of air through the pipe 91 to the nozzle arrangement 92 may be controlled by a motorized valve 93 which may be graduatingly positioned by a resistance type controller 94 contacted by the fluid in the boiler. The fluid being a relatively good conductor of electricity will vary the resistance of the resistance type controller 94 which will graduatingly position the valve 93 in accordance with the amount of splashing or turbulence of the fluid to maintain the turbulence of the fluid at a minimum. If desired an "on and off" type controller as distinguished from the modulating or proportioning type illustrated may be utilized to turn on the air supply if the turbulence of the fluid becomes excessive.

The particular manner in which the various controls illustrated in Figure 1 are connected together and operated is shown in Figure 2.

The temperature responsive controller 66 is shown to comprise a bellows 100 connected by the capillary tube 67 to the bulb 68. The bulb 68 contains a volatile fluid so that the bellows 100 is expanded and contracted in accordance with variations in temperature affecting the bulb 68. The bellows 100 operates a pivoted lever 101 against the action of a tension spring 102 to operate switches 103 and 104. Upon an increase in temperature the switch 103 is first opened and then at a higher temperature the switch 104 is opened and likewise upon a decrease in temperature the switch 104 is first closed and then the switch 103 is closed. By adjusting the tension in the spring 102 the temperature setting of the controller 66 may be adjusted at will.

The liquid level controller 83 may comprise a lever 105 provided with a float 106 responding to the level of the liquid in the boiler shell 11. The lever 105 operates a double-ended mercury switch 107. When the level of the liquid in the boiler shell 11 is normal the two right-hand electrodes are bridged by the mercury and the two left-hand electrodes are unbridged. When the liquid level in the boiler shell 11 becomes abnormally low the switch 107 is tilted to the opposite position to unbridge the right-hand electrodes and bridge the left-hand electrodes.

Line wires leading from some source of power, not shown, are designated at 110 and 111. Assume now that the level of the fluid in the boiler 11 is normal and that the temperature thereof is low so as to cause both switches 103 and 104 to be closed. A circuit is then completed from the line wire 110 through wire 112, switch 103, wire 113, motorized valve 20 and wire 114 back to the other line wire 111. Completion of this circuit causes opening of the motorized valve 20. At this same time another circuit is completed from the line wire 110 through wire 115, switch 104, wire 116, switch 107, wire 117, motorized valve 16 and wire 118 back to the other line wire 111. This circuit opens the motorized valve 16. With the two valves 16 and 20 open, the burner 13 is operating under high flame. If now the temperature of the fluid within the boiler increases so as to move the switches 103 and 104 to the positions shown in Figure 2, the circuit through the motorized valve 20 is broken to close the valve 20. As a result, the burner 13 is operating on low flame. If the temperature of the fluid becomes too high so as to open the switch 104 or if the level of the fluid in the boiler shell 11 decreases to an abnormally low value, the switches 104 or 107 respectively are opened and since these switches are connected in series with the motorized valve 16, the valve 16 is closed to shut off the supply of fuel to the burner 13. Accordingly, the burner 13 is controlled in accordance with the temperature of the fluid in the boiler shell 11 and if the temperature should become too high or if the level of the fluid therein becomes too low the burner 13 is shut off.

The differential temperature controller generally designated at 70 may comprise a bellows 120 connected to the bulb 72 containing a volatile fluid and a bellows 121 connected to the bulb 74 containing a volatile fluid. The bellows 120 and 121 are therefore operated in accordance with the temperature affecting their respective bulbs. The bellows 120 and 121 operate a pivoted lever 122 for operating a mercury switch 124. A spring 123 urges the lever 122 in a clockwise di-

rection so that the temperature affecting the bulb 74 must increase a predetermined amount above the temperature affecting the bulb 72 before the lever 122 is rotated in a counter-clockwise direction. For purposes of illustration, it is assumed that when the temperature affecting the bulb 74 becomes 5° more than the temperature affecting the bulb 72 the spring 123 is overcome to tilt the switch 124 to a closed position. By adjusting the tension in the spring 123 the differential in temperatures at which the switch 124 is operated may be adjusted at will. When the switch 124 is moved to a closed position as a result of the temperature affecting the bulb 74 being 5° above the temperature affecting the bulb 72, a circuit is completed from the line wire 110 through wire 125, switch 124, wire 126, motorized valve 64 and wire 127 back to the other line wire 111. Completion of this circuit opens the motorized valve 64 to cause agitation of the fluid in the boiler shell 11 in the manner pointed out above. As a result of this agitation, the temperature differential is decreased and the switch 124 is moved to the open position as shown in Figure 2 and the valve 64 is closed. Accordingly, when stratification tends to take place in the boiler 10 so as to cause the temperature at the lower portion thereof to be more than the temperature at the upper portion thereof, the valve 64 is opened to cause agitation of the fluid in the boiler to decrease to a minimum the stratification of the fluid.

The liquid level controller 76 is shown to comprise a pivoted lever 129 connected to a float 130 operated in response to variations in level of the fluid in the boiler shell 11. The lever 129 operates a mercury switch 131 so that when the level in the boiler decreases to a predetermined value the switch 131 is closed. When the switch 131 is closed a circuit is completed from the line wire 110, through wires 132 and 133, switch 131, wire 134, motorized valve 56 and wires 135 and 136 back to the other line wire 111. Completion of this circuit opens the motorized valve 56 to supply fluid from the reservoir 47 to the boiler 10 to maintain the level of the fluid in the boiler at a substantially constant value. The pump 57 located in the conduit 55 may be connected in parallel with the motorized valve 56 by wires 137 and 138 so that when the valve 156 is opened the pump 57 is operated. This insures the supply of fluid through the boiler shell 11 if the gravity head is not sufficient to supply the fluid.

The liquid level controller 77 may comprise a pivoted lever 140 operated by a float 141 in response to the level of the fluid in the reservoir 47. The lever 140 operates a mercury switch 142 to a closed position when the level of the liquid in the reservoir 47 decreases to a predetermined value. Closure of the switch 142 completes a circuit from the line wire 110 through wire 143, switch 142, wire 144, motorized valve 60 and wire 145 back to the other line wire 111. Completion of this circuit opens the motorized valve 60 to supply fluid from the boiler 10 to the reservoir 47 to insure that there will always be at least a predetermined amount of fluid in the reservoir 47 for supply to the boiler. When the level of the fluid in the reservoir 47 rises to the desired minimum value the switch 142 is opened and the motorized valve 60 is closed to stop the further supply of fluid.

The liquid level responsive controller 80 may comprise a pivoted lever 147 carrying a float 148 responsive to the level of the liquid in the reservoir 47. The lever 147 carries a mercury switch 149 which is normally maintained in the position shown in Figure 2 wherein the electrodes are bridged. With the parts in this position a circuit is completed from the line wire 110 through wires 132, 150, 152 and 153, mercury switch 149, wires 154 and 155, motorized valve 45 and wires 156, 158 and 136 back to the other line wire 111. Completion of this circuit maintains the motorized valve 45 open so that fluid of relatively low concentration may be supplied to the reservoir 47. If the level of the fluid in the reservoir 47 should become extremely high the switch 149 is tilted in a clockwise direction to unbridge the electrodes. Unbridging of the electrodes interrupts the circuit through the motorized valve 45 to close the same and interrupt the supply of fluid to the reservoir 47.

The left-hand electrodes of the mercury switch 107 of the liquid level controller 83 are connected in parallel with the left-hand electrodes of the mercury switch 149 of the liquid level controller 80 by means of wires 162 and 163 so that if the electrodes of the mercury switch 149 are unbridged to normally have the valve 45 closed, the left-hand electrodes of the switch 107 of the liquid level controller 83 may open the valve 45 if the level of the fluid in the boiler 10 should become dangerously low. In other words, the liquid level controller 80 may close off the valve 45 to prevent the further supply of fluid to the reservoir 47, but if the level of the liquid within the boiler 10 should decrease to a dangerously low value this valve 45 will be opened by the liquid level controller 83 regardless of whether the liquid level controller 80 demands that the valve 45 be closed.

The differential pressure controller generally designated at 85 may comprise a bellows 165 connected by a pipe 86 to the conduit 22 and a bellows 166 connected by a pipe 87 to the conduit 25. The bellows 165 and 166 operate a pivoted lever 167 and a tension spring 168 urges this lever in a counter-clockwise direction. The lever 167 operates a mercury switch 169. The spring 168 operates against the bellows 165 so that when the pressure affecting the bellows 165 rises a predetermined amount above the pressure affecting the bellows 166 the mercury switch 169 is moved to a closed position. By adjusting the tension in the spring 168 the differential pressure setting of the differential pressure controller 85 may be varied at will. The switch 169 controls the relay generally designated at 88, and the relay 88 may comprise an operating coil 170 for moving a switch arm 171 with respect to a contact 172. When the operating coil 170 is energized, the switch arm 171 is moved into engagement with the contact 172 and when it is deenergized the switch arm 171 is moved out of engagement with the contact 172 by means of springs, gravity or other means, not shown.

When there is danger of the fluid of relatively high concentration passing through the heat exchange 24 crystallizing or solidifying, the differential pressure controller closes the switch 169 to complete an energizing circuit for the relay 88 which may be traced from the line wire 110, through wires 132, 150, 173, 174 and 175, switch 169, wire 176, operating coil 170 and wires 177, 178, 179, 158 and 136 back to the other line wire 111. Completion of this circuit energizes the relay 88 to move the switch arm 171 into engagement with the contact 172. Movement of the switch arm 171 into engagement with the contact

172 completes a circuit from the line wire 110, through wires 132, 150, 173, 174 and 180, switch arm 171, contact 172, wire 181, heater elements 89 connected in parallel, and wires 182, 183, 178, 179, 158 and 136 back to the other line wire 111. Completion of this circuit causes energization of the heater 89 to heat the fluid of a relatively high concentration passing through the heat exchanger 24 to insure that the fluid will not crystallize or solidify in the heat exchanger 24. When the pressure differential decreases the switch 169 is opened, the relay 88 is dropped out and the heaters 89 are deenergized.

The liquid level controller 82 may comprise a pivoted lever 190 operated by a float 192 for operating a switch 193. When the level of the liquid in the reservoir 47 rises to a value which indicates that the fluid in the reservoir 47 may overflow through the conduit 51, the float 192 rises to close the mercury switch 193 to complete a circuit from the line wire 110 through wire 194, mercury switch 193, wire 195, alarm 81 and wire 196 back to the other line wire 111. Completion of this circuit operates the alarm 81 to notify the engineer that the system is not operating properly and that there is danger of the fluid in the reservoir 47 overflowing.

The valve 32 which controls the supply of hygroscopic fluid of relatively high concentration to the dehumidifying unit 29 may be operated by a proportioning motor of the type shown and described in Patent No. 2,028,110 granted to D. G. Taylor on January 14, 1936. This proportioning motor is provided with three control terminals which are connected to a potentiometer resistance 200 and slider 201 controlled by the humidity responsive controller 65. The humidity responsive controller may comprise a lever 202 for operating the slider 201 with respect to the potentiometer resistance 200. The lever 202 is biased in one direction by means of a spring 203 and is positioned by a humidity responsive element 204. Power is supplied to the proportioning motor from the line wires 110 and 111 by wires 205 and 206. Upon an increase in relative humidity the slider 201 is moved to the right with respect to the resistance element 200 and the valve 32 is moved toward an open position in an amount proportional to the amount of movement of the slider 201. Upon a decrease in relative humidity the slider 201 is moved to the left and the valve 32 is moved towards a closed position in proportion to the amount of lefthand movement of the slider 201. Accordingly, the valve 32 is positioned in accordance with the relative humidity of the air leaving the dehumidifying unit 29 to regulate the flow of concentrated hygroscopic fluid to the dehumidifying unit to maintain the relative humidity of the air leaving the unit at a subtantially constant value.

The valve 93 which regulates the supply of air to the surface of the liquid in the boiler shell 11 may be operated by a rack 210 which in turn is operated by a pinion 211 mounted on a shaft 212. The shaft 212 is operated through a reduction gear train 213 by motor rotors 214 and 215. The motor rotors 214 and 215 are provided with field windings 216 and 217 respectively. The field windings 216 and 217 are controlled by a switch arm 218 cooperating with contacts 219 and 220. When the switch arm 218 is moved into engagement with the contact 219 a circuit is completed from the line wire 110 through wire 221, switch arm 218, contact 219, wire 222, field winding 216 and wire 223 back to the other line wire 111. Energization of the field winding 216 in this manner causes movement of the valve 93 towards an open position. When the switch arm 218 is moved into engagement with the contact 220 a circuit is completed from the line wire 110, through wire 221, switch arm 218, contact 220, wire 224, field winding 217 and wire 223 back to the other line wire 111. Energization of the field winding 217 in this manner moves the valve 93 towards a closed position. When the switch arm 218 is midway between the contacts 219 and 220 as illustrated in Figure 2, neither field winding 216 or 217 is energized and therefore the valve 93 remains in the position at which it is.

The switch arm 218 is controlled by an armature 225 which is operated by relay coils 226 and 227. When the field winding 226 is more highly energized than the field winding 227 the switch arm 218 is moved into engagement with the contact 219 to move the valve 93 towards an open position and when the field winding 227 is more highly energized than the field winding 226 the switch arm 218 is moved into engagement with the contact 220 to move the valve 93 towards a closed position. When the relay coils 226 and 227 are equally energized the switch arm 218 is maintained midway between the contacts 219 and 220 and therefore the valve 93 remains stationary. Power may be supplied to the relay coils 226 and 227 by means of a step-down transformer 230 having a primary 231 connected across the wires 125 and 127 which are in turn connected across the line wires 110 and 111 and a secondary 232.

The resistance type controller 94 may comprise a conductor 235 and a resistance element 236. The conductor 235 and the resistance element 236 are engaged by the fluid in the boiler shell 11, and since this fluid conducts electricity quite readily the conductor 235 and resistance element 236 form a variable resistance the adjustment of which depends upon how much of the resistance is engaged by the fluid in the boiler shell. When the fluid becomes turbulent it engages more and more of the resistance 236 to in effect decrease the resistance thereof.

The shaft 212 of the motor which operates the valve 93 operates a slider 238 with respect to a resistance element 239. The slider 238 assumes a position with respect to the resistance element 239 corresponding to the position of the valve 93. As the valve 93 is moved towards an open position the slider 238 is moved downwardly and as the valve 93 is moved towards a closed position the slider 238 is moved upwardly. The relay coil 227 is connected across the secondary 232 of the transformer 230 and has located in series therewith a variable resistance 240. The relay coil 226 is also connected across the secondary 232 and has located in series therewith the variable resistance 236 of the controller 94 and the variable resistance 239 of the motor operated valve.

With the level of the liquid midway of the resistance 236 of the controller 94 and the valve 93 in a mid position, the resistance 240 is so adjusted that the energizations of the relay coils 226 and 227 are equal, whereupon the parts remain stationary in the position shown in Figure 2. Assume now that the level of the liquid due to turbulence rises, the resistance 236 is decreased whereupon the relay coil 226 becomes more highly energized than the relay coil 227. This causes movement of the valve 93 towards an open position and also downward movement

of the slider 238. When the slider 238 has moved downwardly sufficiently far to increase the resistance in series with the coil 226, the coils 226 and 227 become equally energized and the valve 93 is maintained in its newly adjusted position. Conversely, upon a lowering of the level due to a decrease in turbulence of the fluid, the resistance 236 is increased and the relay coil 227 then becomes more highly energized than the relay coil 226. This moves the switch arm 218 into engagement with the contact 220 to move the valve 93 towards a closed position and to cause upward movement of the slider 238. When the slider 238 has moved sufficiently far upwardly to cause the energization of the relay coils 226 and 227 to become equal, the switch arm 218 is moved to the position shown in Figure 2 and the valve 93 is maintained in its new position. Accordingly, the valve 93 is modulatingly or graduatingly positioned in direct accordance with the amount of turbulence of the fluid within the boiler shell 11. By graduatingly controlling the supply of air under pressure to the surface of the level of the liquid in the boiler shell 11, in this manner the turbulence of the liquid is maintained at a minimum at all times.

From the above it is seen that a complete control system for a chemical dehumidifying system is provided to maintain the concentration of the hygroscopic fluid flowing to the dehumidifying unit at a substantially constant value, and at the same time to insure that the chemical dehumidifying system operates safely.

Although for purposes of illustration one form of this invention has been disclosed, other forms thereof may become apparent to those skilled in the art upon reference to this disclosure, and therefore this invention is to be limited only by the scope of the appended claims and prior art.

I claim as my invention:

1. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, heat exchanger means for causing counterflow heat exchange between the solution passing through the first and second conduits, heating means for said heat exchanger means, and means responsive to the pressure differential of the solution of relatively high concentration flowing through said heat exchanger means for controlling said heating means.

2. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, a pump for forcing solution through said third conduit, a fourth conduit for conducting solution from the boiler to the reservoir, and means responsive to the level of the solution in the reservoir for controlling the flow of solution through the fourth conduit.

3. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, a pump for forcing solution through said third conduit, a fourth conduit for conducting solution from the boiler to the reservoir, means responsive to a low solution level in the reservoir for causing flow of solution through the fourth conduit, and means responsive to a high solution level in the reservoir for decreasing the flow of solution through the second conduit.

4. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, and means responsive to the level of the solution in the boiler for controlling the flow of solution through the third conduit for maintaining said level at a substantially constant value, means responsive to the level of the solution in the reservoir for decreasing the flow through the second conduit when said level reaches a predetermined high value, and means responsive to a low level of solution in the boiler for increasing the flow through the second conduit independently of said first named means.

5. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, means responsive to the level of the solution in the reservoir for decreasing the flow through the second conduit when said level reaches a predetermined high value, and means responsive to a low level of solution in the boiler for increasing the flow through the second conduit independently of said first named means.

6. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, firing means for the boiler, means responsive to the temperature of the solution in the boiler for controlling the firing means, and means responsive to a predetermined low level of the solution in the boiler for deenergizing the firing means.

7. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, firing means for the boiler, means respon-

sive to a predetermined low level of the solution in the boiler for deenergizing the firing means, means responsive to a predetermined high level of the solution in the reservoir for decreasing the flow through the second conduit, and means responsive to a predetermined low level of the solution in the boiler for increasing the flow through the second conduit independently of the level of the solution in the reservoir.

8. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, firing means for the boiler, means responsive to a predetermined low level of the solution in the boiler for deenergizing the firing means, means responsive to a predetermined high level of the solution in the reservoir for decreasing the flow through the second conduit, means responsive to a predetermined low level of the solution in the boiler for increasing the flow through the second conduit independently of the level of the solution in the reservoir, and means responsive to the temperature of the solution in the boiler for controlling the firing means to maintain a substantially constant temperature thereof.

9. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, firing means for the boiler, means responsive to a predetermined low level of the solution in the boiler for deenergizing the firing means, and means responsive to the level of the solution in the boiler for controlling the flow of solution through the third conduit to maintain said level at a substantially constant value.

10. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, firing means for the boiler, means responsive to a predetermined low level of the solution in the boiler for deenergizing the firing means, means responsive to the level of the solution in the boiler for controlling the flow of solution through the third conduit to maintain said level at a substantially constant value, and means responsive to the temperature of the solution in the boiler for also controlling the firing means to maintain said temperature at a substantially constant value.

11. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, and a fourth conduit for conducting steam and entrained solution from said boiler to said reservoir where said solution may be separated from the steam and may return to said boiler.

12. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a reservoir for the solution, a second conduit for conducting solution of relatively low concentration to the reservoir, a third conduit for conducting the solution from the reservoir to the boiler, a fourth conduit for conducting steam and entrained solution from said boiler to said reservoir where said solution may be separated from the steam and may return to said boiler, a combustion chamber adapted to contain a fire for heating the solution in said boiler, a flue for conducting the products of combustion to the atmosphere, and a fifth conduit for conducting steam from said reservoir to said flue.

13. In a system utilizing a solution, the combination of, a boiler for heating the solution to increase the concentration thereof, a first conduit for conducting solution of relatively high concentration from the boiler to a point of use, a heat exchanger means for cooling the solution passing through said conduit, heating means for said heat exchange means, and means responsive to the pressure differential of the solution of relatively high concentration flowing through said heat exchanger means for controlling said heating means.

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