Oct. 13, 1964 H. J. KAUFMAN 3,152,877

COMPRESSED AIR DEHYDRATOR

Filed July 3, 1957 2 Sheets-Sheet 1

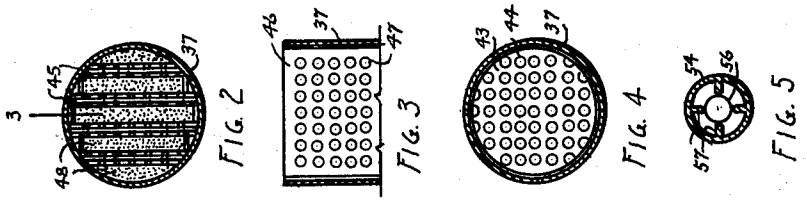


FIG. 2 FIG. 3 FIG. 4 FIG. 5

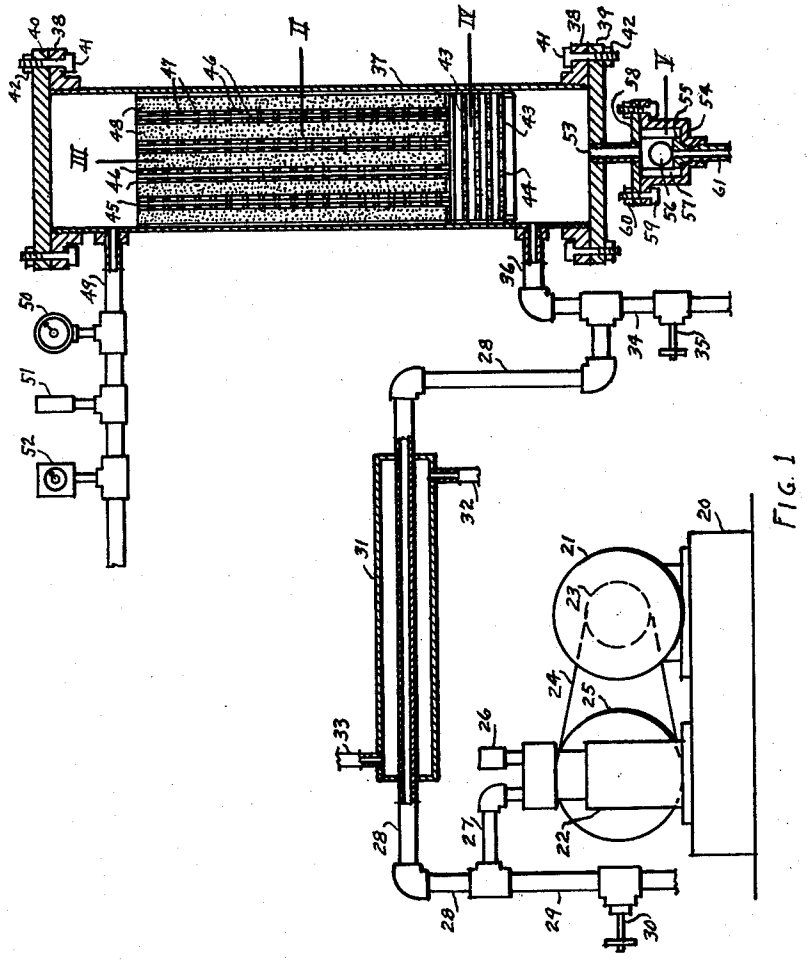


FIG. 1

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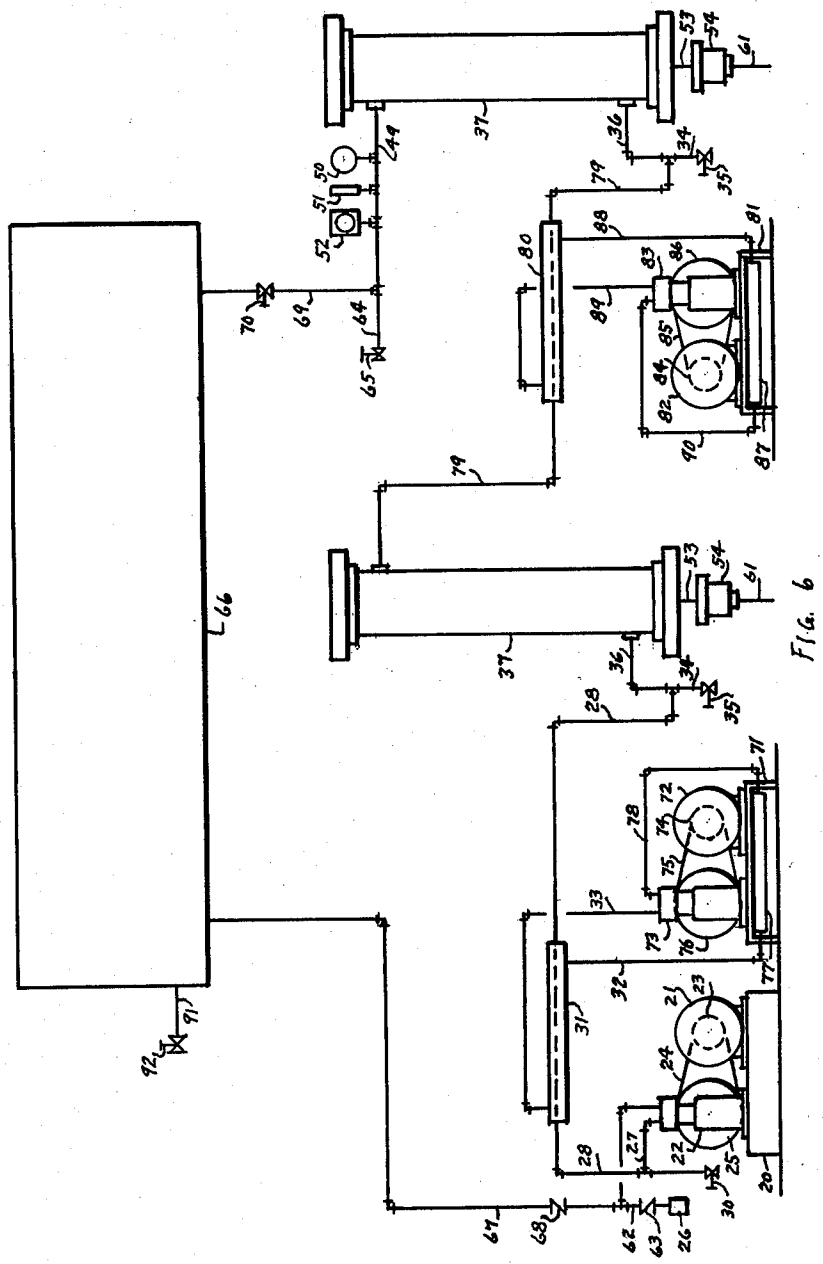


Fig. 6

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COMPRESSED AIR DEHYDRATOR

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6 Claims. (Cl. 55—30)

The invention relates to a method and apparatus for dehydrating air and particularly relates to a system wherein the air is subjected to superatmospheric pressures during the dehumidification process.

In dehydrating equipment utilizing hygroscopic agents the moisture removing efficiency is largely dependent on the difference of the vapor pressures of the air and hygroscopic agent. Thus, the effective water removing capacity of a given dehumidifying unit may be increased by controlling and widening the difference between the vapor pressures of the air and agent. This is the principle employed with the present invention providing maximum water absorbing characteristics. The differences of the respective vapor pressures being maintained by increasing the vapor pressure of the air by compression and lowering the vapor pressure of the dehydrating agent by cooling.

It is thus an object of the invention to produce dehumidifying apparatus of relatively simple design wherein the air is cooled and subjected to a hygroscopic agent while under superatmospheric pressures.

Another object of the invention is to provide apparatus for dehydrating air to an extremely low moisture content without the use of heating equipment.

A further object of the invention is to provide air dehydrating apparatus employing a hygroscopic agent wherein the air-agent contact chamber is self-cleaning and the air is sequentially exposed to a dilute dehydrating solution, a saturated dehydrating solution and the solid hygroscopic agent.

Yet another object of the invention is to provide air dehydrating apparatus using refrigeration to continuously cool air above freezing temperatures, or air above dew point temperatures when below freezing temperatures, without loss of efficiency due to ice formation on the coils and without shut downs for defrosting or deicing, eliminating the necessity for spare equipment.

Another object of the invention is to produce a hygroscopic agent absorption chamber which automatically permits drainage of the dilute hydrating solution during operation of the system without loss of air pressure.

These and other objects of the invention will become apparent when viewed with regard to the following specification and drawings wherein:

FIG. 1 is an elevational view, partly in cross section, of a single stage air dehydrating unit and absorption chamber,

FIG. 2 is a cross section plan view taken along the line II—II of FIG. 1,

FIG. 3 is a cross section elevational view taken along line III—III of FIG. 1,

FIG. 4 is a cross section plan view taken along line IV—IV of FIG. 1,

FIG. 5 is a cross section plan view taken along the line V—V of FIG. 1, and

FIG. 6 is a schematic drawing of a two stage dehydrating system employing the concepts of the invention.

A simplified dehumidifying system utilizing the theory of the invention is shown in FIG. 1 wherein an air compressor unit is mounted upon a base 20, the motor 21 being drivingly connected to the conventional compressor 22 by means of motor pulley 23, belt 24 and compressor pulley 25. Compressor 22 is supplied with air from the surrounding atmosphere through the intake port 26 and the compressed air is conducted from outlet 27 into piping 28. An oil trap 29 and valve 30 communicate with piping

28 adjacent outlet 27 removing water or oil discharged from the compressor.

The compressed air passing through piping 28 is cooled in a cooling unit 31 through which cold water or a refrigeration liquid circulates. The cooling medium enters unit 31 by the inlet 32 and flows counter to the direction of air travel leaving the cooling unit at outlet 33. The temperature of the cooling medium within unit 31 is such that the air moving through piping 28 is maintained at a temperature above freezing or above dew point when below freezing to prevent frosting or icing of the piping eliminating need for shutdown due to defrosting.

Piping 28 connects to the water trap 34, which may be emptied through valve 35, and communicates with the pipe 36 which serves as the inlet into the absorption chamber 37. In the illustrated embodiment, the absorption chamber 37 is of tubular construction provided at each end with drilled annular flanges 38. The lower end of the chamber being enclosed by the plate 39 and the upper end sealed by plate 40, a plurality of bolts 41 and nuts 42 maintain the flanges and plates in sealing engagement.

Various baffles, baskets and passages are located within chamber 37 to efficiently expose the air passing through the chamber to the hygroscopic agent. As seen in FIG. 1, the lower end of chamber 37 is left unobstructed and serves as the catch basin for the dilute hygroscopic solution, further up the chamber 37 a series of horizontal baffle plates 43 are arranged in spaced relation to aid in exposing air to the agent. The plates 43 are provided with a multiplicity of perforations 44 through which the compressed air may flow. To increase the efficiency of plates 43 the perforations 44 of adjacent plates are staggered increasing the length and turbulence of the air flow path. The air flow continues upward through the air passages 45 which are formed by the baskets 46. The baskets may be constructed of sheet metal and are perforated at 47 whereby the air may flow through the baskets and the saturated solution of dehydrating agent formed from the solid hygroscopic agent 48 contained within the baskets 46. The baskets 46 may be refilled with the solid particles of dehydrating agent, such as flake calcium chloride, magnesium chloride or other agents which on contact with moist air "melt" into a saturated solution, upon removing plate 40.

The dried compressed air passes out of the absorption chamber 37 through the pipe 49 wherein the pressure gage 50 may indicate the pressure within chamber 37. A pressure relief valve 51 and pressure regulating valve 52 maintain the proper pressure within the absorption chamber and the air passing through valve 52 is introduced into the area requiring the dried air.

The dilute hygroscopic solution collection in the bottom of chamber 37 is carried away by the drain pipe 53 threaded into plate 39. An automatic drain valve 54 connected to pipe 53 regulates the periods of draining by means of a removable annular valve seat 55 and ball float 56 engageable with the seat 55. As seen in FIG. 5 the guides 57, within valve 54 maintain the ball and seat aligned. The valve 54 is connected to drain pipe 53 by the cover plate 58, bolts 59 and nuts 60, and upon unseating of the ball 56 the solution will drain away via pipe 61.

As the hygroscopic agent parcticles 48 absorb moisture from the air a saturated dehydrating solution is formed which will slowly flow down the sides of the baskets 46, against the flow of air. The solution then drips through the staggered holes 44 in the baffle plates 43, also against the flow of the compressed air, and collects in the lower portion of chamber 37. The air entering chamber 37, having been cooled in the cooling unit 31, will in turn cool each state of the hygroscopic agent reducing the vapor pressure thereof.

The air entering the absorption chamber 37 at pipe 36 is first exposed to the dilute hygroscopic solution within the lower portion of the chamber, further contact is made with the dehydrating agent as the air passes through the perforations 44 of baffle plates 43 and up air passages 45 against the flow of saturated solution. The perforations 47 within baskets 46 permit the air to freely circulate through the solid hygroscopic particles within the baskets exposing the air to the surfaces of the particles which are constantly renewed as reaction with the water in the air "melts" or liquifies the dehumidifying agent. Therefore, the air passing through absorption chamber 37 is exposed to three concentrations of hygroscopic agents having progressively lower vapor pressures resulting in efficient removal of moisture in the air introduced into chamber 37.

A two stage dehumidification system utilizing the concepts of the invention for obtaining very low moisture content air is schematically shown in FIG. 6 wherein previously described components retain similar reference numerals. The air drawn into compressor 22 of FIG. 6 may be supplied from the pipe 62 through check valve 63 and atmosphere intake port 26 and the dry air ultimately supplied to pipe 64 and valve 65. When the two stage system is used in a recirculating cycle providing dry air to the enclosure 66 the compressor 22 will receive the intake air from return pipe 67 controlled by check valve 68 and the enclosure is supplied by pipe 69 regulated by valve 70.

Preferably in the two stage system the air cooling unit 31 is supplied with refrigerant from a motor driven refrigeration unit mounted on a base 71 supporting a motor 72 and compressor 73 drivingly interconnected by the motor pulley 74, belt 75 and compressor pulley 76. A condenser-receiver 77, mounted underneath base 71, supplies unit 31 with liquid refrigerant through inlet 32 which returns as a gas to the compressor 73 via outlet 33. The gas is recompressed and pipe 78 conveys the gas to condsenser-receiver 77 completing the cycle. The cooled compressed air then passes to absorption chamber 37 wherein the air is subjected to the hygroscopic drying agent as described above.

After the compressed air has passed through chamber 37 the piping 79 conducts the air through the cooling unit 80 where the air is further cooled and passed through a second absorption chamber. The cooling unit 80 is supplied by the refrigeration unit mounted on base 81, powered by motor 82 driving compressor 83 through pulley 84, belt 85, and pulley 86. Refrigerant is cycled from the condenser-receiver 87 to unit 80 through inlet pipe 88 and returned to compressor 83 via pipe 89 and then returns to the condenser 87 through pipe 90. The air then continues through the second absorption chamber past the regulating valve 52, through valve 70 and into enclosure 66. By recirculating air from enclosure 66 through the two absorption chambers extremely dry air may be produced as the dehydration process is accumulative and this air may be removed as desired through pipe 91 and valve 92. When recirculating dry air from enclosure 66 the pressure within the enclosure is automatically stablized, even though air is being removed at valve 92, by the check valves 63 and 68 which permit air to be drawn into the compressor 22 from intake 26 when the pressure within enclosure 66 is lowered to a predetermined point.

If desired, the enclosure 66 may consist of a room or vault wherein it is desired to maintain low humidity or may merely be a storage tank from which dry air is drawn. Draining of the absorption chambers 37 will automatically take place during operation of the system without decreasing the air pressure within the chamber. As the drain valve 54 fills up with the dilute dehydrating solution the air pressure on the top of the ball float 56 will maintain the ball in engagement with the valve seat 55 preventing the solution from flowing down pipe 61. However, when the solution rises to a depth sufficient to cover ball 56 the pressure on the ball will equalize due to the solution transmitting equal forces in all directions and the buoyance of the ball will raise the ball from the seat 55 draining the solution through pipe 61. Draining will continue until the ball contacts the seat, at which time the level of the solution will be less than the height of the ball and the air pressure within chamber 37 maintains the engagement of ball 56 and seat 55 until the ball once more is submerged under the dilute solution and may rise under the buoyance force again to repeat the draining cycle. As all the dilute solution is not removed from the drain valve 54 before the ball seats the air within chamber 37 is not permitted to escape and there is no loss of air pressure from the system.

The temperature of the refrigerant within cooling unit 31 is such that the moisture within the piping 28 will not freeze to form ice. However, as the air passes through cooling unit 80 the dew point of the air has been lowered due to the removal of moisture in the first absorption chamber 37 and the air may be cooled to below water freezing temperatures without the formation of ice within the piping. If extremely dry air is desired, three, four and five stages of dehumidification with progressively lower cooling temperatures may be used, yet the formation of ice is eliminated in each stage by always maintaining the air temperature above the dew point which will become progressively lower as the air becomes dryer.

The above system provides an efficient means for removing moisture from air in that the compression of the air, raising the vapor pressure thereof, and the cooling of the hygroscopic agent to lower the vapor pressure of the agent produces a vapor pressure differential increasing the moisture absorbing capacity of the agent. By cooling the hygroscopic agent through the air introduced into the absorption chambers all three forms of the dehumidifying agent will be effectively cooled. As the solid hygroscopic agent has the lowest vapor pressure, the saturated hygroscopic solution the intermediate vapor pressure and the dilute solution the highest vapor pressure the air entering the absorption chamber is exposed to a hygroscopic agent of decreasing vapor pressures maintaining a maximum differential between the vapor pressures of the air and agent. The absorption chamber is self-cleaning, efficiently subjects the air to the dehumidifying agent and is automatically draining. Also, since the air is not cooled below freezing temperatures or below dew point temperature when below freezing formation of ice on the piping is eliminated and shut downs for defrosting are unnecessary.

Recognizing that various modifications, within the spirit and scope of the invention, may be apparent to those skilled in the art it is intended that the invention not be limited to the described embodiment but only by the scope of the claims herein.

I claim:

1. The method of dehydrating air comprising the sequential steps of raising the vapor pressure of the air by compression, cooling all of the air so compressed to a temperature approaching but above water freezing temperatures, subjecting the cooled compressed air to sequential contact with a dilute hygroscopic solution, a saturated hygroscopic solution and a solid hygroscopic agent, recooling the compressed air to above dew point and below freezing temperatures and subjecting the recooled compressed air sequentially to a dilute hygroscopic solution, a saturated hygroscopic solution and a solid hygroscopic agent.

2. The method of dehydrating air as in claim 1 wherein the dried air is stored in a reservoir and at least a portion of the air being compressed is drawn from said reservoir.

3. Apparatus for dehydrating air comprising, an air compressor, means adapted to cool the air discharged from said compressor to a temperature approaching but above water freezing temperatures, a moisture absorption chamber receiving the cooled compressed air and having an air outlet, a hygroscopic agent within said chamber

adapted to remove the moisture from said air and air pressure regulating valve means operatively associated with said chamber outlet maintaining a predetermined superatmospheric air pressure within said chamber.

4. Apparatus for dehydrating air, comprising an air compressor, a cooling unit adapted to cool the compressed air discharged from said compressor to a temperature approaching but above water freezing temperatures, a moisture absorption chamber receiving the cooled compressed air, a lower section within said chamber into which said air is introduced, an intermediate section within said chamber in communication with said lower section, baffle means within said intermediate section, an upper section within said chamber in communication with said intermediate section, basket means within said upper section containing a solid hygroscopic agent, an automatic drain valve in fluid communication with said lower section and pressure regulating means in communication with said upper section maintaining a predetermined superatmospheric air pressure within said absorption chamber.

5. Apparatus for dehydrating air as in claim 4 wherein baffle plates are located in said intermediate section and

perforations are formed in said baffle plates such that the perforations of adjacent plates are in staggered relation.

6. Apparatus for dehydrating air as in claim 4 wherein said automatic drain valve consists of a housing, a drain opening having a concentric removable annular valve seat located in the bottom of said housing, a ball float adapted to engage said valve seat and guide vanes aligning said ball float with said seat, said float having sufficient buoyancy to raise from said seat upon the liquid within said housing reaching a predetermined level.

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