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EVAPORATING AND DEHUMIDIFYING APPARATUS

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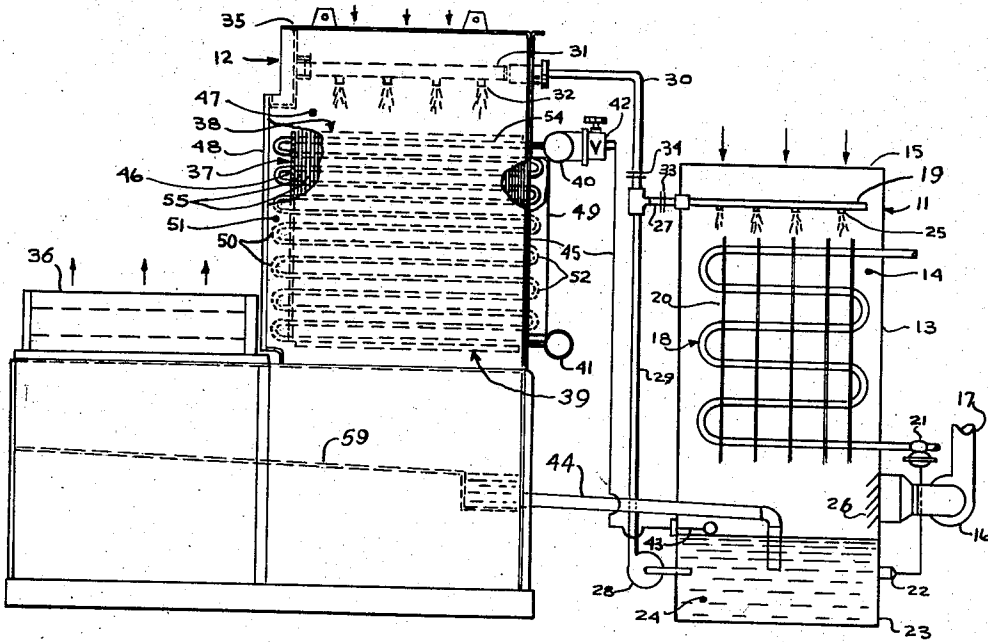


FIG. 1.

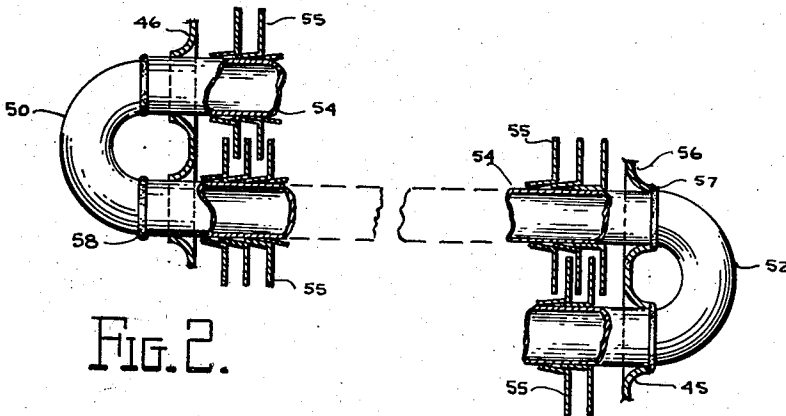


FIG. 2.

FIG. 3.

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EVAPORATING AND DEHUMIDIFYING APPARATUS

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4 Claims. (Cl. 159—4)

This invention pertains to an improved coil assembly for location in a duct of moving gas and has particular application in air conditioning units.

In a dehumidifying and cooling unit, air is passed over a plurality of coils located in a duct and over which a hygroscopic fluid is sprayed. Water or refrigerant is passed through the coils to cool the air. The hygroscopic fluid is collected in a sump at the bottom of the unit and pumped to the spray again.

A portion of this fluid in the sump is passed to a regenerator unit which expels excess water from the fluid. This is done by spraying the fluid over steam-heated coils in contact with an air stream which is supplied from, and exhausted to, space outside the air conditioned space and which carries off the excess water.

The coils in the latter unit consist of finned tubes placed transversely in a duct. Tube sheets, which are metal sheets that may form two opposite sides of the duct, serve to space and support the tubes which extend through the sheets and are connected near the outer sides of the sheets by return bends.

If the tubes passing through the tube sheets are allowed to float freely, hygroscopic fluid tends to leak to the outer sides of the tubes sheets through the small openings inherent between the tube and the sheet. This fluid, being highly corrosive, quickly causes deterioration of the sheets as the fluid dries. This will not occur if the exposed surface is continuously washed with the solution. However, these openings are not large enough to provide this.

In lieu of this problem, the tubes may be continuously welded to the tube sheets. Although leakage is reduced by this method, the tubes are not free to expand through the tube sheets with the result that the welds eventually break or hair line cracks occur and leakage again evolves.

The finned tubes are arranged in the duct so that the transverse or face areas of the assembly are small compared to that of the longitudinal or side areas. This is known as a "deep coil"—one in which the tubes tend to be distributed more along the length of the duct than across its width. A deep coil allows more water removal with less air flow since less of the heat from the finned tubes is utilized for increasing sensible heat in the air and more is used for actually evaporating moisture from the hygroscopic solution into the air.

Although this arrangement affords greater heating efficiency, the exiting air is heavily laden with moisture and has a dew point relatively close to the dry bulb temperature—approximately 200° F. dry bulb, with a dew point of 125° F. This condition tends to cause condensation in the exhaust duct as the outgoing air cools. The condensate consists of distilled water at 125° F. or higher which is corrosive and hence damaging to the duct which is generally sheet metal.

Furthermore, this deep coil arrangement involves a greater pressure drop across the coils, thus requiring a larger fan to maintain the same air flow than would be

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available with a "shallow" coil. It has been found that it is economically impractical to provide a larger fan in a regenerator unit and thus a smaller air flow must be accepted for a given fan size.

For maximum efficiency the fins should occupy the entire duct width up to the side walls. In order to accomplish this it would be necessary to weld the tubes to the tube sheets and have the return bends on the outside of the tube sheets or duct walls. As previously explained if this method is used, the tubes are not free to expand, and cracks in the welds will result.

To completely minimize stress on the tube assembly and to minimize leakage of and consequent corrosion by the hygroscopic solution, it would be necessary to have the two supporting tube sheets located entirely within the duct so that the tube sheets and welds would be washed by hygroscopic solution. This well known construction would reduce efficiency because the fins could not fill the duct width up to the side walls on either side because of the return bends.

To eliminate the aforementioned problems and to obtain the maximum efficiency consistent therewith, we have invented a tube assembly whose coils are secured at one end to a tube sheet and freely mounted at the other end to a tube support sheet with a by-pass duct located around the tube support sheet. Such an assembly prevents thermal stresses from occurring, since one end is freely movable, and provides continuous washing for the outer side of the tube support sheet at this end to prevent corrosion.

The by-pass also allows more air to be moved for a given fan size. This permits more water to be carried off and allows less water to be absorbed per cubic foot of air, thus resulting in a lower dew point of the exiting air and lessening the danger of condensation forming in the exhaust duct. Since the return bends at one end of the assembly may now be utilized in heat transfer, approximately a ten percent increase in water removal capacity is realized.

Locating the tube sheet within the duct and thereby forming a by-pass duct between the tube sheet and one duct wall illustrates the preferred embodiment of the invention; however, the coils could be freely mounted within the duct in any suitable manner as long as the support member does not obstruct the free flow of hygroscopic solution over the return bends and associated welds.

For further consideration of what we believe to be novel and our invention, refer to the drawing, description, and claims.

In the drawings:

Figure 1 illustrates an air conditioning unit embodying our invention,

Figure 2 shows a detail of a portion of Figure 1, and

Figure 3 shows another detail of a portion of Figure 1.

Referring to the drawing and more specifically to Figure 1: a dehumidifying apparatus comprising a washer unit 11, shown schematically, and a regenerator unit 12 is disclosed. Washer unit 11 has a metal casing 13 forming a duct 14 through which air is drawn from an opening at the top 15 of the unit and expelled near the bottom by blower 16 through duct 17. This air passes by a coil assembly 18 containing fins 20. Cooling water or a refrigerant is run through these coils to counteract the heat added by the regenerator as will be explained later. This cooling medium also permits decreasing the dry bulb temperature of the air if a refrigerant is employed. A valve 21 controls the flow of the cooling medium through the coil assembly and is responsive to a thermostatic unit 22 in sump 23. The valve allows a greater quantity of the coolant to flow through the coils as the temperature in the sump increases to maintain a

constant dry bulb temperature of the conditioned air. Sump 23 contains hygroscopic liquid 24 and receives hygroscopic liquid from spray nozzles 25 after it passes over coil assembly 18, and from a filter 26 that traps any of the hygroscopic liquid entrained in the air passing through duct 14. This liquid is then pumped back to spray nozzles 25 through spray bar 19 and pipes 27 and 29 by means of a pump 28. The liquid is also pumped through pipes 29 and 30 to a similar spray bar 31 and nozzles 32 located in regenerator 12. Orifices 33 and 34 are located in pipes 27 and 30 respectively to proportion the flow to each of the spray bars.

Air entering washer unit 11 is ducted from the conditioned space and the processed air, having been cooled and dehumidified, re-enters this space through duct 17. For regenerator 12 scavenger air is used and is received from an outside source through a duct (not shown) connected to the top 35 of the regenerator. After passing through the unit it is passed through a plenum chamber and blower (not shown) located on top of filter 36 and is expelled again to the outside source.

In regenerator 12, hygroscopic liquid is sprayed over coil assembly 37 through which steam is passed, entering the coils by means of an inlet manifold 40 and discharging to drain manifold 41. Flow through these coils is controlled by a valve 42 which is responsive to a float 43 located in sump 23. A rise in the liquid level in sump 23 increases steam flow since it indicates the hygroscopic solution is being excessively diluted with water absorbed from the air. The heat of the steam passing through coil assembly 37 boils off water from the hygroscopic solution thus tending to concentrate it. The temperature of the coils is maintained below the boiling point of the hygroscopic solution to prevent dissipation of it. If the level in sump 23 falls below a predetermined point it indicates that excessive boiling is occurring and that the solution is too concentrated. Steam input will then be decreased by means of valve 42. The water is carried away by the scavenger air and any hygroscopic liquid in it is collected by filter 36 where it drains to drain plate 59 and is carried back to sump 23 by means of pipe 44.

Coil assembly 37 contains a tube sheet 45 and a tube support sheet 46. Tube sheet 45 also functions as a wall of duct 47 and tube support sheet 46 is welded to the side plates of duct 47 and spaced far enough from wall 48 to allow sufficient room for return bends 50, thus forming a by-pass duct 51 around the assembly. Return bends 52 at the other end of the assembly project outside of duct 47 and may be projected by a metal plate 49. Each of the horizontal tubes 54 extends through tube sheet 45 and tube support sheet 46 and has fins 55 attached. These fins are made from a continuous strip of metal segmented and formed in an L-shape similar to those disclosed in the patent to E. F. Tilley Number 1,932,610. This strip is then helically wound around tubes 54 with the bottom legs of the L welded to one another. The fins on adjacent tubes overlap approximately one-eighth to one-quarter of an inch with the upper and lower fins extending to dotted lines 38 and 39 respectively.

At tube sheet 45, tubes 54 extend through so the ends are flush with the projecting portions 56 formed around the holes in tube sheet 45 through which the tubes 54 extend. Return bends 52 are simultaneously affixed to tubes 54 and projecting ends 56 by weld 57 to produce a fixed, liquid-tight junction. The term "weld" is used in its broad sense to generically include a fusion-welded, brazed, or soldered joint. At the other end of the assembly, tubes 54 extend approximately half an inch through tube support sheet 46 and have a snug but sliding fit therewith. Return bends 50 then are affixed by weld 58 to the tubes 54 only. This construction allows the tubes 54 to expand and contract through tube support sheet 46 without establishing thermal stresses which

would occur if both ends of tubes 54 were welded as at the end shown in Figure 3. Such stresses tend to eventually break the welds or produce cracks in the tube sheet. Furthermore, the use of the construction as shown in Figure 2 eliminates the more expensive construction as shown in Figure 3 at one end of the assembly. The latter cost more since the weld is more difficult to achieve and the tube sheets for this method require more careful production and closer inspection to prevent and detect any hairline cracks that particularly occur around the holes and projections 56, and would allow the corrosive hygroscopic liquid to leak through to the outer side of the tube sheet.

The use of by-pass 51 around coil assembly 37 at the "floating" end thereof is an essential part of this assembly. By allowing the outer side of tube support sheet 46 to be continually washed, corrosive action is prohibited since the hygroscopic solution contains an inhibitor. Where such a surface is intermittently exposed to the liquid—alternately wetted and dried—corrosion occurs rapidly in spite of the inhibitor and deterioration of the tube support sheet is rapid.

Although heretofore considered to be poor practice in the art because of reduced efficiency, we have discovered the by-pass has several operational advantages with the deep coil assembly. The problem of employing a larger fan is eliminated, thus saving on initial costs and operational costs. This is possible since the by-pass has relatively little restriction compared to the main assembly containing the many tubes and fins, hence increasing the volume of air moved by a given fan.

With additional air passing through the unit, less water is absorbed per given volume of air, resulting in a higher superheat of the scavenger air and less possibility of condensation occurring in the duct. This additional superheat could only otherwise be accomplished by the installation of an after-heating coil near the discharge end of the unit. This would entail excessive initial and operational costs.

The use of the return bends further permits greater utilization of the available heat transfer area and correspondingly increases the water removal capacity. This amounts to approximately ten percent with the exact percent depending on the ratio of the heat transfer area of the return bends in the by-pass to the total heat transfer area available.

Although this invention has been described in conjunction with a regenerator unit, it can be readily appreciated that the invention can be used in many devices to condition air such as washer unit 11 of Figure 1. Coil assembly 18 in washer 11 has been drawn schematically to simplify the showing.

The foregoing description and drawings have been intended to serve in a descriptive and not a limiting sense. Various modifications may be made without departing from the scope of our invention.

We claim:

1. In a gas and liquid contacting and heat exchanger unit having wall means forming a duct, heat exchange tubes extending across said duct for passing a heat transfer medium therethrough, means for delivering a normally corrosive hygroscopic liquid through said duct and in contact with said tubes, and means for circulating a stream of gas to be contacted through said duct, across said tubes and in contact with said liquid for the transfer of heat between said heat exchange tubes and said liquid and gas, the improvement wherein: one end of each of said tubes is welded to a first wall of the duct; and the other ends of said tubes are located within the duct next adjacent a second wall opposite said first wall, and comprising: first return bends interconnecting each end of said tubes within said duct next adjacent said second wall to provide series flow from one tube through a return bend to the next tube; second return bends interconnecting each end of said tubes which is welded to said first wall to provide series flow from one tube through a return

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bend to the next tube; support means within said duct next adjacent said second wall supporting said tubes in spaced relation to each other; and inlet and discharge means delivering a heat transfer medium to and discharge it from said tubes, whereby the heat transfer medium flows in a single sinuous path from said inlet means, through said tubes and first and second return bends, to said discharge means. 5

2. Apparatus according to claim 1 wherein said second return bends are jointly affixed by a single weld to said first wall of said duct and to said tubes to provide series flow from one tube through a return bend to the next tube. 10

3. Apparatus according to claim 1 wherein the support means supporting said tubes in spaced relation to each other consists of a tube support sheet disposed within said duct next adjacent said second wall, said tube support sheet being attached to said wall means. 15

4. Apparatus according to claim 3 wherein the means of attaching said tube support sheet to said wall means 20

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is by welding in such a manner so as to divide the duct into two passages so that liquid will pass through the two passages thus formed.

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