United States Patent [19]

Slaasted et al.

[11] **3,759,050**

[45] **Sept. 18, 1973**

[54] **METHOD OF COOLING A GAS AND REMOVING MOISTURE THEREFROM**

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[73] Assignee: **Modine Manufacturing Company,** Racine, Wis.

[22] Filed: **Feb. 24, 1972**

[21] Appl. No.: **229,015**

Related U.S. Application Data

[63] Continuation of Ser. No. 807,492, March 17, 1969, abandoned.

[52] **U.S. Cl.** **62/93,** 62/285, 62/290, 165/151, 165/111, 165/181

[51] **Int. Cl.** **F25d 21/14**

[58] **Field of Search** 165/110, 111, 181; 62/93, 285, 288, 289, 290

[56] **References Cited**

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[57] **ABSTRACT**

The method of chilling a gas that contains moisture and simultaneously condensing and removing the moisture to prevent the condensate being blown in substantial amounts with the chilled gas in which the moisture containing gas is blown sideways across upright solid surfaces that are chilled to a temperature less than the dew point of the gas to form condensate on the surfaces, intercepting the condensate and directing it in paths of low surface tension along the surfaces and out of the gas stream.

2 Claims, 4 Drawing Figures

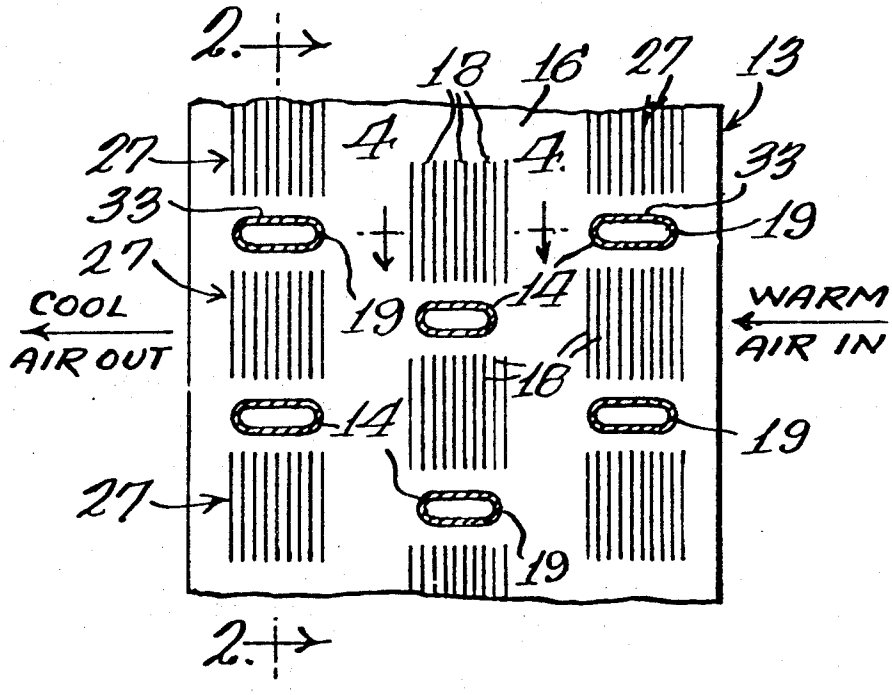


Fig. 1.

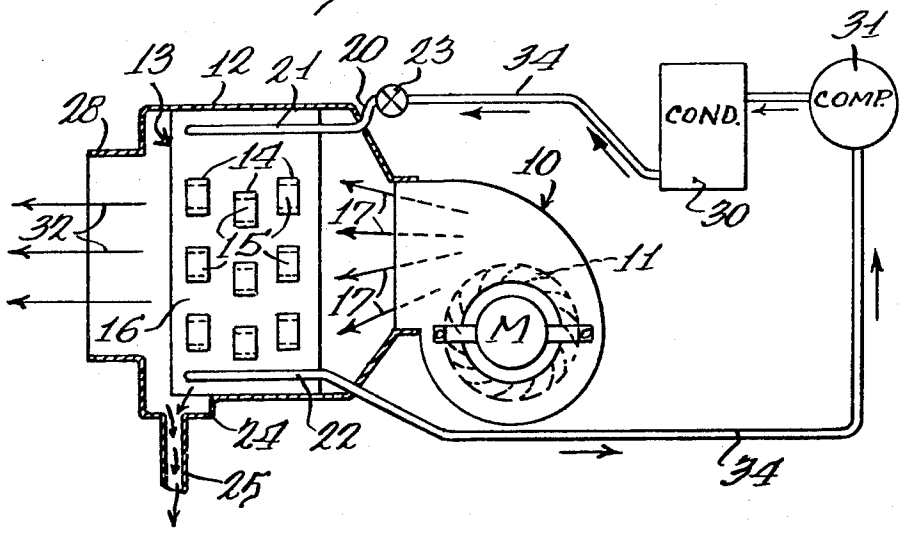


Fig. 2.

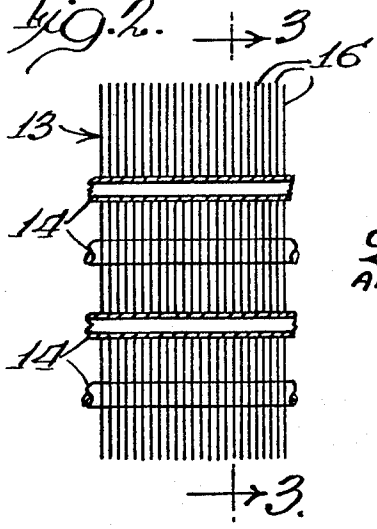
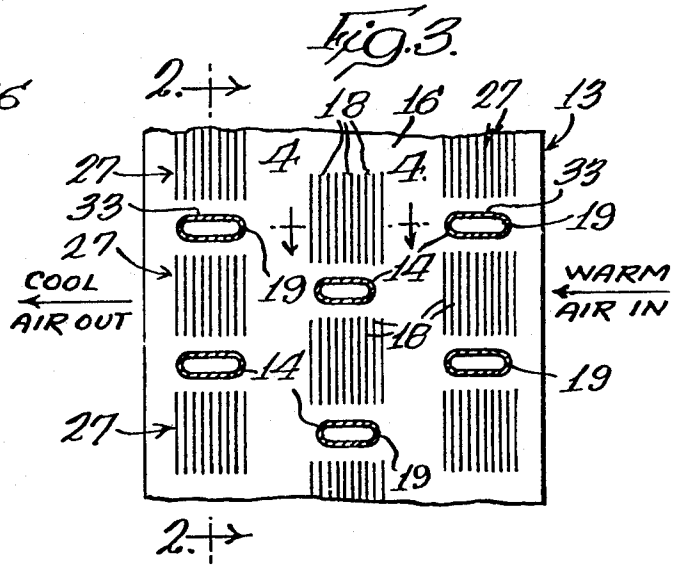


Fig. 3.



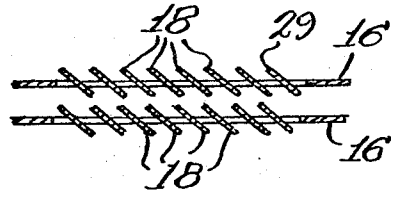


Fig. 4.

METHOD OF COOLING A GAS AND REMOVING MOISTURE THEREFROM

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of our copending application Ser. No. 807,492, filed Mar. 17, 1969, now abandoned.

BACKGROUND OF THE INVENTION

The chilling of gas such as air containing substantial amounts of moisture such as water vapor to condense the moisture therefrom is widely practiced especially in summertime air conditioning. Customarily the air is blown through chilled surfaces such as the surfaces of tube and fin heat exchangers to cool the air and condense the moisture. The resulting condensate which collects on the solid surfaces tends to be blown along with the air and particularly where the moisture content is high condensate is frequently blown from the surfaces to the exterior so that the downstream areas of the flowing air become wet. The method of this invention prevents this as the condensed moisture is intercepted before it can get beyond the surfaces on the downstream side and is directed in paths of relatively low surface tension away from the main air stream.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a semi-diagrammatic elevation, partially in section, of an air cooling system embodying the invention.

FIG. 2 is a vertical sectional view through the heat exchanger matrix of the system of FIG. 1 taken substantially along line 2—2 of FIG. 3.

FIG. 3 is a fragmentary vertical sectional view through the matrix and taken substantially along line 3—3 of FIG. 2.

FIG. 4 is a detail sectional view through a portion of the fin structure and taken substantially along line 4—4 of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A system for practicing the method of the invention is disclosed in the drawings of which FIG. 1 shows semidiagrammatically a system comprising a housing 10 formed as a conduit in one end of which is positioned an ordinary air blower 11 which exits into a chamber 12 that forms a part of the housing 10. Located within the chamber 12 is a heat exchanger matrix 13 that comprises back and forth passes of a refrigerant conduit defining a plurality of spaced heat conducting cooling tubes 14 that are generally horizontal and connected by end tubular bends 15 in the customary manner.

The matrix 13 also comprises a plurality of upright spaced heat conducting fins 16 that are arranged edgewise to the direction of the stream of moisture containing gas, here shown as air, indicated by the air flow arrows 17. The tubes 14 including the tubular bends 15 and the fins 16 are of heat conducting material such as metal and particularly aluminum or copper.

The matrix 13 includes liquid drain means 18 here shown as spaced louvers on the fins immediately above the tubes for providing liquid flow paths of liquid condensate along the fins onto the tubes 14 and from there down between the tubes. The specifically embodied louvers 18 are formed integrally with the fins 16 as indicated in FIG. 4 and extend above the tubes 14 for gravity flow of liquid condensate along these louvers onto the tubes that are beneath them.

Each of the tubes 14 is of flat transverse cross section as shown in FIG. 3 with a major axis which is here shown as horizontal and a minor axis at right angles thereto to provide an edge 19 facing the incoming fluid or air stream 17.

In the preferred structure as shown in the drawings the louvers 18 are provided in sets 27 of a plurality of spaced louvers 18 with each set being located above the broad upper surface of a tube as indicated in FIG. 3. Each tube 14 is of generally oval transverse cross section arranged with the edge facing the incoming fluid stream 17 and the tubes are arranged in adjacent but horizontally spaced vertical rows.

In the embodiment illustrated, the tubes 14 of the matrix are supplied with liquid refrigerant 20 from a conduit system 34 in the customary manner through a header pipe 21. In the tubes 14 this refrigerant vaporizes or boils taking up heat so as to cool the tubes 14 and fins 16. The refrigerant then exits through an exit header 22 and into the system 34. Flow of liquid refrigerant is controlled by a customary valve 23.

The heat exchanger of this invention provides high heat transfer capability for cooling a moisture containing gas such as air with means for removing condensate rapidly from the air flow paths through the matrix so that the performance of the heat exchanger approaches that achieved with a dry gas where condensate is no problem. This is accomplished by providing tubes for the cooling medium such as the refrigerant of low resistance to air flow through the matrix such as by the oval-shaped construction illustrated with the thin edge of each tube facing the incoming air stream. With this, air flow is rapid through the matrix and heat transfer from the tubes to the air is efficient. In addition to this shape of the tubes heat transfer is also improved by providing spaced fins interconnecting the plurality of tubes and through and across which the air flows.

Further, in order to remove condensate from the air flow paths so that air flow will not be blocked and so that the condensate will not be blown from the matrix louvers are provided in the fins in sets above each tube. As can be seen in FIG. 4 the louvers 18 project from the fin 16 into the air flow space between the fins. With this arrangement the condensate from the air collects on the louvers and the louvers intercept condensate pushed across the fins by the air. The louvers also direct the condensate rapidly by gravity flow onto the upper surfaces of the tubes where it is out of the main air stream. The condensate then flows from each tube principally down the fins to a lower tube and into the bottom of the chamber 12 where the condensate collecting trough 24 is located. Any condensate that is blown from a tube will be intercepted by a next set 27 of louvers 18 so that substantially no condensate is blown from the matrix 13.

Thus the vertical louvers 18 not only intercept the condensate blown sideways by the air stream which in the embodiment of FIG. 3 enters from the right and exits from the left but also provides vertical edges 29 as shown in greater detail in FIG. 4 down which the condensate flows out of the principal air stream which as stated in the illustrated embodiment is from right to left. Because the condensate can flow downwardly along the vertical louvers 18 and can be concentrated

at the downstream edges **29** these louvers provide paths of low surface tension for the draining liquid and thereby result in the rapid removal of the condensate downwardly from the sideways flowing principal air stream. Flow of the condensate along these louvers is of course by gravity.

The upright fins **16** provide solid surfaces that are chilled by the evaporation of refrigerant in the matrix **13** to a temperature less than the dew point of the entering gas as indicated by the arrows **17** in FIG. **1.** This gas which in the illustrated embodiment is air is therefore blown sideways across and between the fin surfaces from an entering side which is the side adjacent the blower **11** and indicated by the legend "Warm Air In" in FIG. **3** to a leaving side which is indicated in FIG. **3** by the legend "Cool Air Out" and shown by the arrows **32** in FIG. **1.** This simultaneously chills the gas and condenses moisture to a liquid condensate on the fin surfaces and the stream of gas forces this condensate sideways along the surfaces. The condensate is intercepted in its flow across the surfaces from right to left as shown in FIG. **3** by intercepting members embodied in the vertical louvers **27** located between the entering and leaving sides of each surface to prevent blowing substantial amounts of condensate beyond the fin surfaces. This condensate intercepted by the louvers **18** is directed along the intercepting members or louvers **18** away from the fin surfaces and out of the main stream as indicated by the flow arrows at the drain pipe in FIG. **1.** The louver intercepting members **18** are integral with the fin **16** surfaces and have upright edges as shown at **29** in FIG. **4** spaced from their respective surfaces **16** to provide the paths of low surface tension.

In operation liquid refrigerant from the condenser **30** which is supplied with compressed gaseous refrigerant from the compressor **31** is fed through the valve **23** into the pipe **21** and from these through the tubes **14** of the matrix **13.** In flowing through the tubes **14** and into the exit header **22** the refrigerant evaporates and cools the air forced through the matrix **13** as indicated by the arrows **17.** In passing through the matrix **13** the air **17** is cooled rapidly and efficiently.

Any moisture condensing within the matrix **13** tends to gather on the fins **16** and to be blown along the fins by the air stream **17.** However, the louvers **18** which are arranged in sets **27** above the upper surfaces **33** of the tubes **14** intercept the flowing condensate and direct it by gravity flow onto the upper surfaces **33** of the tubes and thereby out of the main portion of the air stream. Thus the surface tension forces of the condensate cooperating with the vertical louvers **18** substantially prevent horizontal travel of the condensate. Once the condensate is on the surface of the tubes **14** air flow causes the condensate to travel along the surfaces of the tubes until reaching the space between the vertical rows of tubes. The condensate then drops downwardly between the tubes and primarily along the surface of the fins **16** to the bottom collecting trough **24.** If, however, some of the condensate should travel angularly downwardly to the next row of tubes this condensate will impinge on the succeeding series of louvers and will be guided downwardly in the same manner.

We claim:

1. The method of chilling a gas that contains moisture and simultaneously condensing and removing moisture therefrom, comprising: chilling spaced, upright, solid surfaces to a temperature less than the dew point of said gas; blowing a main stream of said gas sideways across and between said upright surfaces from an entering side to a leaving side of said surfaces for simultaneously chilling said gas and condensing moisture to a liquid condensate on said surfaces, the stream of gas forcing liquid condensate with it sideways along the surfaces; intercepting said condensate on said surfaces during said forcing by a plurality of adjacent intercepting members integral with said surfaces located between said entering and leaving sides of each said surface to prevent blowing substantial amounts of condensate beyond said surfaces; and directing the intercepted condensate along said plurality of intercepting members on each of said surfaces away from said solid surfaces and out of said main stream along paths of low surface tension thereby resulting in the rapid removal of said condensate from said main stream.

2. The method of claim **1** wherein said intercepting members have upright edges spaced from the respective side surfaces to provide said paths of low surface tension.

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