United States Patent

Schoonman

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[54] AIR-COOLED HEAT EXCHANGER

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[52] **U.S. Cl.** **165/112,** 165/124, 165/176

[51] **Int. Cl.** **F28b 1/06**

[58] **Field of Search**.......165/111, 110, 124, 176, 112

[56] **References Cited**

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Primary Examiner—William E. Wayner

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[57] **ABSTRACT**

An air cooled heat exchanger, having U-tubes, for cooling gases or liquids. Each tube is connected at one end to an inlet manifold and at the other end to a collection manifold. Cooling air flows co-currently with the condensing vapor or cooling liquid, thus preventing subcooling and freezing.

7 Claims, 3 Drawing Figures

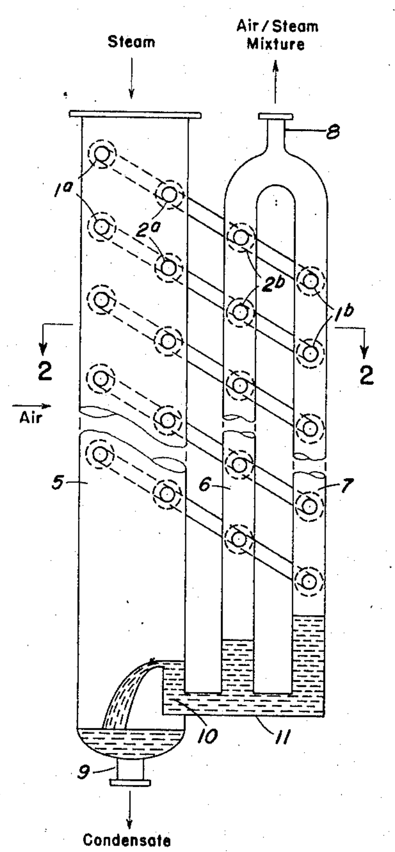

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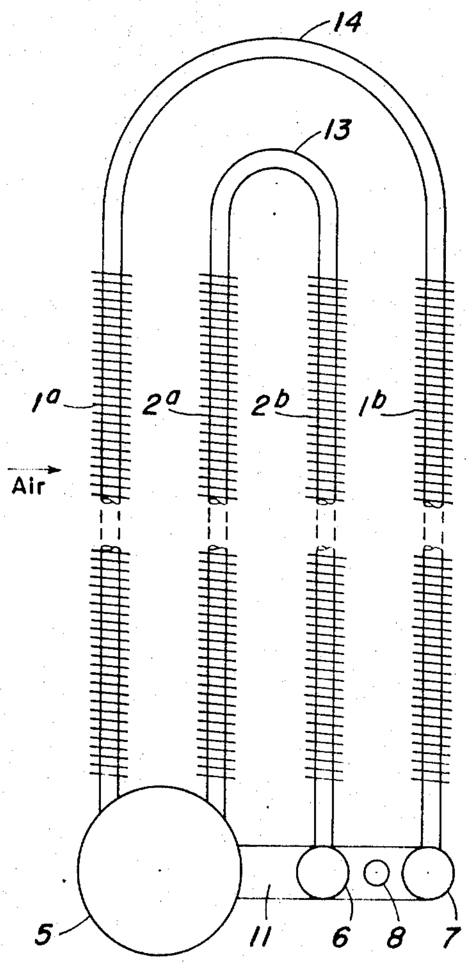
Fig. 2.



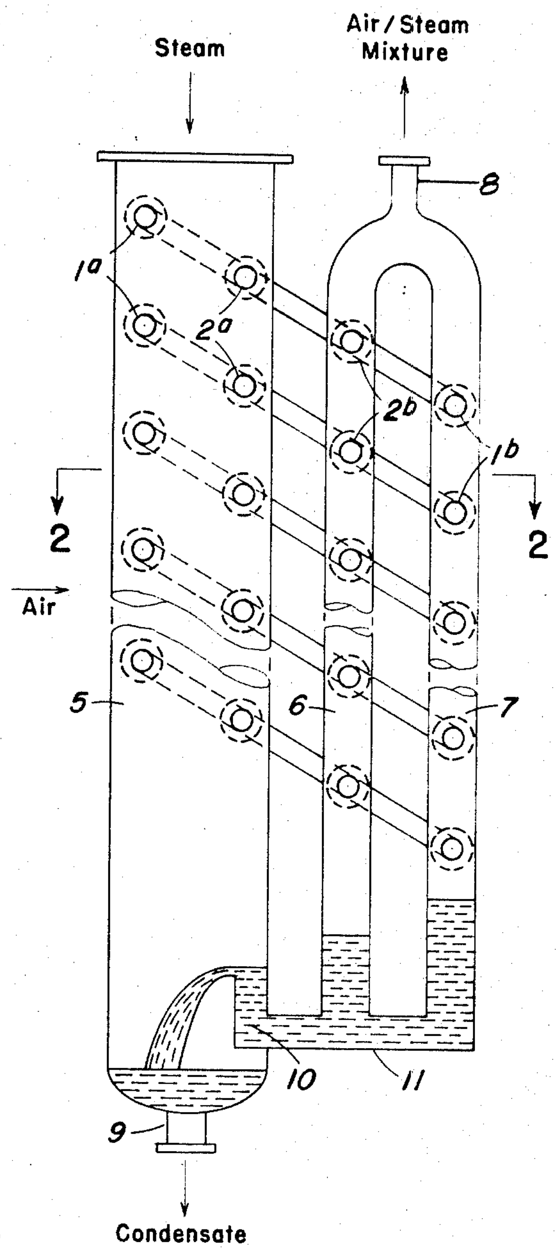
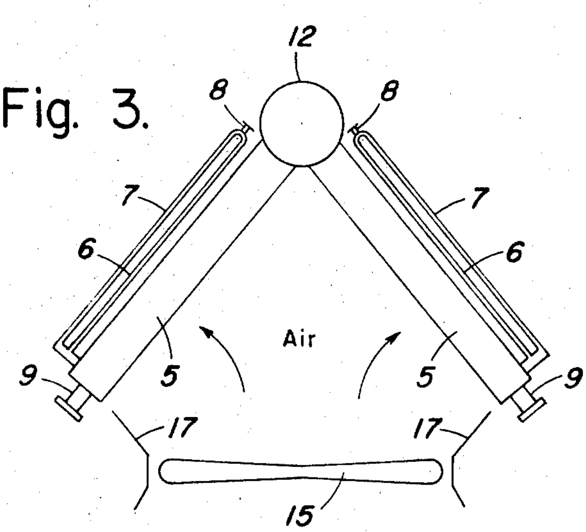


Fig. 1.

Fig. 3.



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AIR-COOLED HEAT EXCHANGER

BACKGROUND OF THE INVENTION

Numerous types of air cooled heat exchangers for condensing steam and other vapors by indirect heat exchange with flowing air have been described and patented. A common factor in the design of such equipment is the necessity of preventing subcooling and consequent freezing of condensate in the tubes of the exchanger. However, few of the designs devised to overcome or prevent this problem have proven suitable for use in extreme weather conditions, e.g., at low ambient temperatures. Nor are most designs sufficiently versatile so as to be used in areas of the world in which the temperature may vary widely from season to season.

SUMMARY OF THE INVENTION

This invention comprises a design for an air cooled heat exchanger; particularly a vapor condenser, in which subcooling of the condensate is prevented, even at low ambient temperatures. However, the invention is not limited to use at such temperatures; it can be used in any situation in which vapor is to be condensed by indirect heat exchange with cooling air. In fact, subcooling does not only occur at low ambient temperatures; it can take place at higher temperatures in situations in which the vapor flows at a low rate, and condensate accumulates in the tubes.

In general, the invention relates to an air cooled heat exchanger for condensing vapors, comprising an inlet manifold, a first condensate manifold, a second condensate manifold, a first plurality of substantially U-shaped tubes connecting the inlet manifold to the first condensate manifold, a second plurality of substantially U-shaped tubes connecting the inlet manifold to the second condensate manifold, means for directing air to flow over the outsides of the tubes to condense vapor therein, means for draining condensate from the condensate manifolds, means for removing vapor from the condensate manifolds, the first plurality of tubes having an upstream leg connected to he inlet manifold and a downstream leg connected to the first condensate manifold, the second plurality of tubes having an upstream leg connected to the inlet manifold and a downstream leg connected to the second condensate manifold, the first and second pluralities of tubes being so disposed that the air flows first over the upstream legs of the first plurality of tubes, then over the upstream legs of the second plurality of tubes, then over the downstream legs of the second plurality of tubes, and finally over the downstream legs of the first plurality of tubes.

DETAILED DESCRIPTION OF THE INVENTION

The invention is more clearly shown and described in the accompanying drawings, in which:

FIG. 1 is an elevational view of an embodiment of the invention, in a vertical arrangement;

FIG. 2 is a section of FIG. 1 taken along line 2—2;

FIG. 3 shows schematically an inclined arrangement of two exchangers embodying the invention, with a common source of vapor.

The exchanger of FIGS. 1 and 2 generally comprises an inlet manifold **5**, condensate manifolds **6** and **7**, tubes **1** and **2**, vapor outlet **8** and condensate outlet **9**.

Steam or other vapor enters the inlet manifold **5** from an external source (e.g., **12** in FIG. **3**). From the manifold it flows into the upstream legs **1***a*, **2***a* of tubes **1** and **2**, which are generally of the finned type. Tubes **1** and **2** are of a generally U-shaped configuration, with the upstream legs of the "U" (**1***a*, **2***a*) connected to the corresponding downstream legs **1***b*, **2***b* by bends **14**, **13**. The tubes may be integral or composed of several sections connected together, as by welding. The ends of legs **2***b* are connected to condensate manifold **6**; the ends of legs **2***a* to condensate manifold **7**, which is separate from, but located adjacent to manifold **6**. In the embodiment of FIGS. **1** and **2**, the lower ends of manifolds **6** and **7** are connected by a connecting pipe **11** which carries the condensate via loop seal **10** to the bottom of manifold **5**, from which it is removed in outlet **9**. Air and uncondensed vapor are removed from manifolds **6** and **7** through outlet **8**, which connects the upper ends of both manifolds.

Air is passed over the exchanger by means of a fan or other device in the direction shown by the arrows in FIGS. **1** and **2**; that is, cocurrently with the flow of vapor and condensate. As shown in the figures, the cold air first encounters the hottest steam, in tubes **1***a*. The slightly warmed air is then heat exchanged against an additional quantity of the hottest steam in tubes **2***a*, followed by heat exchange against condensate in tubes **2***b*. Finally the warmed air is heat exchanged against the coldest condensate in tubes **1***b*.

Some heat exchange may also take place between cold air and the steam in manifold **5**, but this is not detrimental as it contributes to the heating of the air and the condensate thus formed can easily be removed, through outlet **9** or otherwise.

The tubes **1***a*, **2***a* are arranged in what is known as a triangular pitch, that is, the tubes **2***a* are staggered with respect to tubes **1***a* so that a combination of two tubes in any row (for example row **1***a*) with the nearest tube in the other row (**2***a*) forms a triangle. Similarly, the tubes **2***b* are arranged with tubes **1***b* in a triangular pitch. This allows for maximum use of the cold air, since that portion of the cooling air which passes between the tubes **1***a* will be encountered by tubes **2***a*. Preferably, as shown in FIGS. **1** and **2**, the row of tubes **2***a*, **2***b* is situated within the area enclosed by the U-shape of tubes **1***a*, **1***b*.

The Figures depict the exchanger as having two sets of tubes (**1**,**2**) joined by U-bends, with two condensate manifolds. However, the exchanger may have three or more sets of tubes, each with its accompanying condensate manifold.

Because of the cocurrent flow of air and steam, and the danger of subcooling the condensate in tubes **2***b*, and particularly in tubes **1***b*, is eliminated, since the air which is heat exchanged against the condensate has been warmed by previous contact with hot steam. Similarly, even though condensate may accumulate in the bottom of manifolds **6** and **7**, there is no danger of subcooling since the air passing over the manifolds has been sufficiently warmed.

As shown in FIG. **1**, the tube bundles are preferably sloped so that the downstream legs **1***b*, **2***b* of the tubes are located at a lower level than the upstream legs **1***a*, **2***a* to permit drainage of condensate from the tubes by gravity.

Under some operating conditions the amount of steam condensed in the outer row of tubes **1***a*, **1***b* can be appreciably higher than that condensed in tubes **2***a*, **2***b*. This will result in a higher pressure drop across tubes **1***a*, **1***b* than across tubes **2***a*, **2***b*, with an accompanying loss of sensible heat. The condensate outlet construction shown in FIG. **1** enables this heat loss to be recovered by contact of exiting condensate with hot steam in the lower part of the steam manifold **5**. The higher level of condensate in manifold **7**, resulting from the higher pressure drop in tubes **1***a*, **1***b*, combined with the loop seal construction **10**, causes some increase in the flow of condensate, resulting in a greater heat transfer. Additionally, the direct contact with hot steam prevents any subcooling of the exiting condensate which might take place owing to its proximity to the coldest air. The lower portion of manifold **5** can also be insulated to prevent such subcooling.

However, this construction is but a preferred embodiment of the invention; the condensate manifolds may be drained in any convenient manner, by separate drain pipes or by a simple common drain.

FIG. **3** depicts an inclined arrangement of two condensers of the present design, operating from a common vapor inlet **12**. The drawing depicts the vapor inlet connected to the top of vapor manifolds **5**, but it may in fact be connected wherever convenient. Air is supplied by fans **15** here shown located below the exchangers, with guides **17** for guiding the air across the exchangers. The fans may also be located above the exchangers, causing air to flow over them by induced draft.

While the apparatus of the present invention has been described mainly in terms of condensing steam, it is equally applicable to the cooling of other vapors, such as hydrocarbons, and to the cooling of liquids such as hydrocarbons and water.

While this invention has been described in terms of certain preferred embodiments and illustrated by way of particular drawings, these are only illustrative, as many equivalents and alternatives will present themselves to those skilled in the art as within the spirit and proper scope of the invention. The invention is therefore not to be construed as limited, except as set forth in the following claims:

I claim:

1. An air cooled heat exchanger for condensing vapors comprising an inlet manifold, a first condensate manifold, a second condensate manifold, a first plurality of substantially U-shaped tubes connecting the inlet manifold to the first condensate manifold, a second plurality of substantially U-shaped tubes connecting the inlet manifold to the second condensate manifold, means for directing air to flow over the outsides of the tubes to condense vapor therein, means for draining condensate from the condensate manifolds, means for removing vapor from the condensate manifolds, the first plurality of tubes having an upstream leg connecting to the inlet manifold and a downstream leg connected to the first condensate manifold, the second plurality of tubes having an upstream leg connected to the inlet manifold and a downstream leg connected to the second condensate manifold, the first and second pluralities of tubes being so disposed that the air flows first over the upstream legs of the first plurality of tubes, then over the the upstream legs of the second plurality of tubes, then over the downstream legs of the second plurality of tubes, and finally over the downstream legs of the first plurality of tubes.

2. The apparatus of claim **1** in which the first and second pluralities of tubes are disposed in a triangular pitch arrangement.

3. The apparatus of claim **1** further comprising means for gravity draining liquid from each of the pluralities of tubes.

4. The apparatus of claim **1** wherein the tubes of the second plurality of tubes are located within the space enclosed within the U-bends of the first plurality of tubes.

5. The apparatus of claim **1** wherein the first and second condensate manifolds are connected by a common liquid drain means.

6. The apparatus of claim **5** wherein the common liquid drain means comprises a collection pipe connected to the inlet manifold by a loop-seal structure, and means for draining liquid from the inlet manifold.

7. Apparatus according to claim **6** further comprising means in the inlet manifold for bringing liquid drained from the condensate manifolds into direct heat exchange contact with vapor.

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