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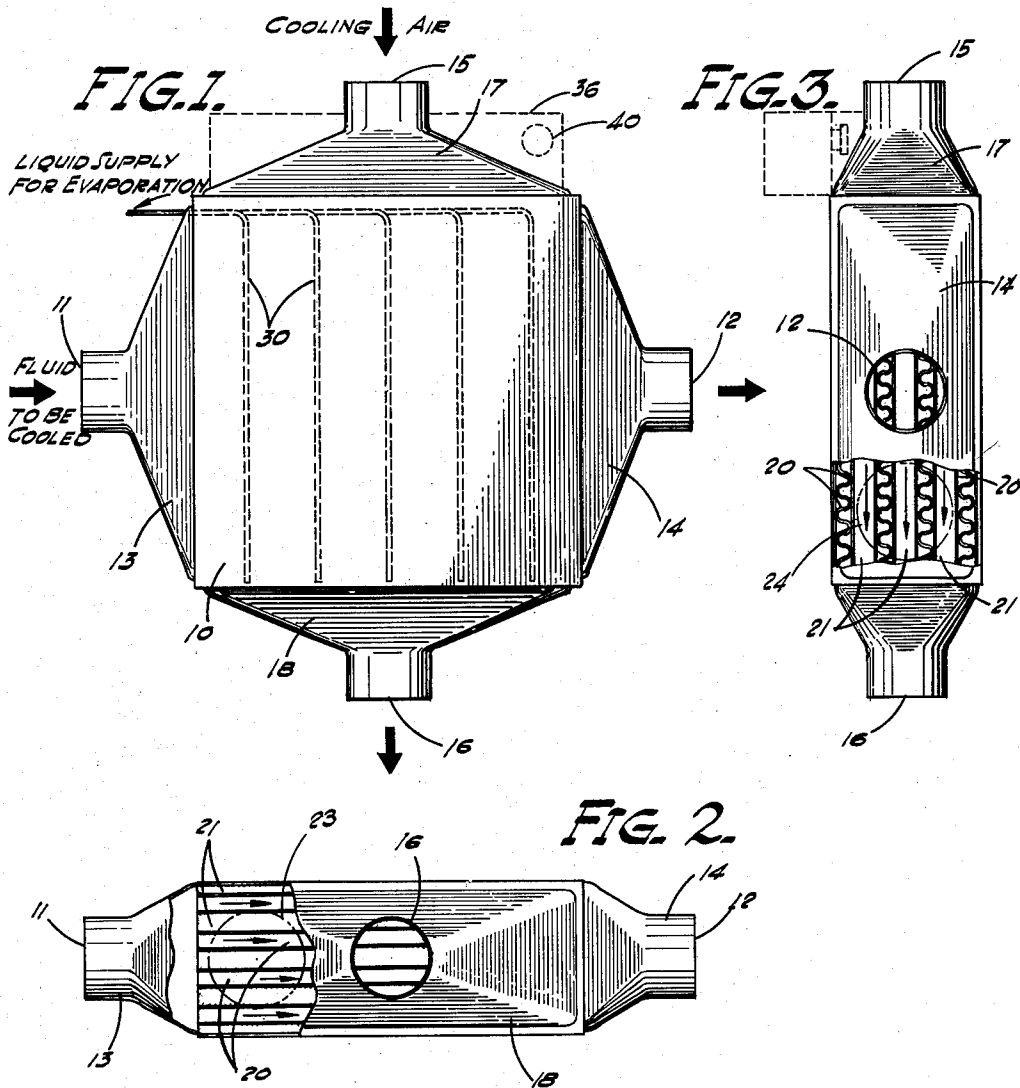
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2,990,696

EVAPORATIVE HEAT EXCHANGER

Filed Sept. 13, 1957

2 Sheets-Sheet 1



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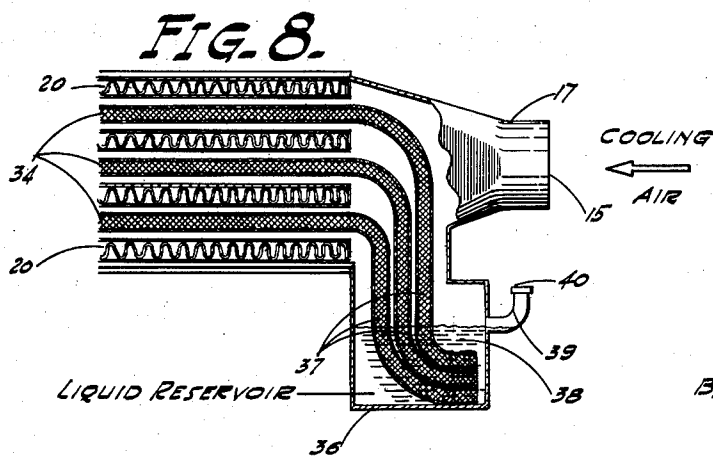
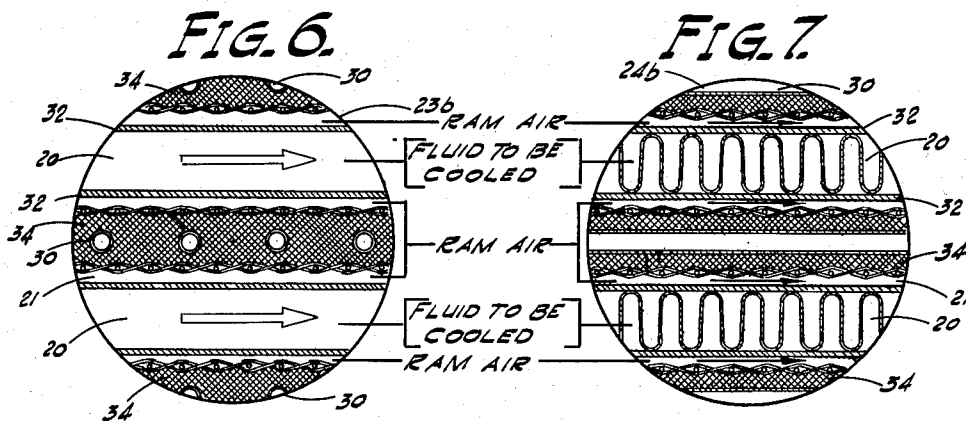
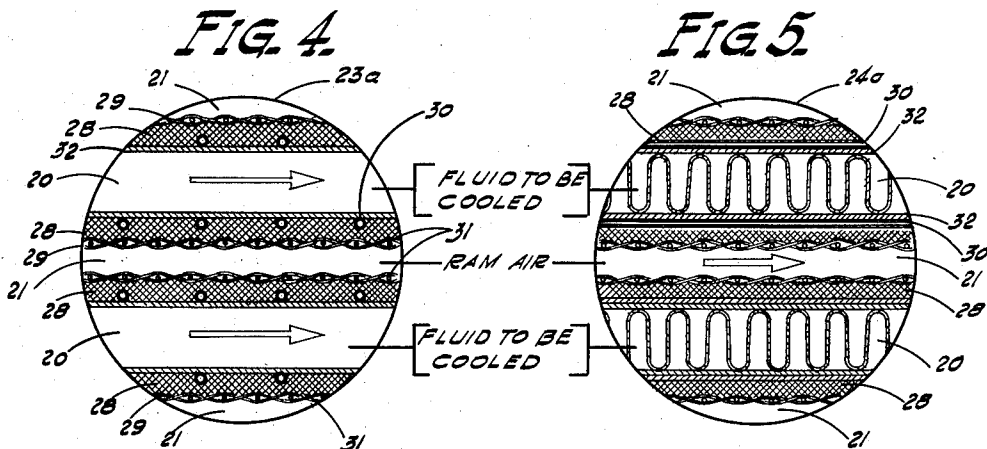
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EVAPORATIVE HEAT EXCHANGER

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2 Sheets-Sheet 2



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EVAPORATIVE HEAT EXCHANGER

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This invention relates to an improved evaporative heat exchanger. In this class of heat exchanger, liquid is evaporated into an air stream which flows past one side of a heat exchanger wall so as to cool a fluid on the other side of this wall. The principle of evaporation may be used either to cool a liquid which contacts a heat exchange surface, or in an alternative arrangement to cool air which in this instance is in contact with the heat exchange surface.

In the prior art heat exchangers of this type, the cooling liquid is usually sprayed through appropriate nozzles into the air stream as it enters the exchanger. Evaporation occurs because the liquid is broken up into small droplets. All of the droplets do not evaporate, however, and some pass out of the exchanger, where it is usually customary to have baffles or water eliminators to trap or conserve the liquid. A reservoir and a pump are also required to supply the liquid used for evaporation. The fluid to be cooled flows through passages located on the other side of the exchanger.

Other evaporative exchangers attempt to retain the evaporating liquid against the heat transfer surfaces through the use of baffles or material such as excelsior. Obviously, this type of construction will contain water only by gravity and thus can be used only in one attitude.

Accordingly, a principal object of this invention is to provide an improved evaporative heat exchanger in which a cooling liquid is retained within the exchanger regardless of the attitude of the exchanger.

Another object is to improve control over the amount of cooling liquid evaporated in an evaporative heat exchanger.

Another object is to provide means for evaporating substantially all of the evaporating liquid in an evaporative heat exchanger without loss in efficiency occasioned by droplets falling into the cooling air stream.

Another object is to provide improved means for retaining an evaporating liquid in a cooling air stream flowing at high air velocities until the liquid is evaporated.

Another object is to provide improved means for retaining an evaporative liquid within an evaporative heat exchanger which means is not subject to organic attack, corrosion, or chemical attack, as would be the case with certain metals and natural sponge-like materials.

Another object is to provide a means for retaining an evaporating liquid against a hot heat exchange surface while the liquid is being evaporated.

A preferred embodiment of the evaporative heat exchanger of this invention employs an outer casing which encloses a multipass heat exchanger of the plate and fin type or other suitable core construction. The core defines a plurality of stacked passages for the fluid to be cooled. Each of the foregoing fluid passages is separated from the adjacent fluid passages by an intervening passage for cooling air.

In a first embodiment, two separated layers of wick material are disposed within each cooling air passage and in contact with the hot exchange surfaces defining a fluid passage. The layers of wick material communicate with a source of liquid in such a manner that the liquid is carried to the surfaces of the various layers of wick material adjacent a cooling air stream flowing therebetween. This air stream evaporates the liquid contained

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within the wick layers. The resulting evaporation of liquid lowers the temperature of all of the liquid contained by the wick layers. This action causes the temperature of the liquid which contacts the hot exchange surfaces to be lower than the temperature of the supply liquid. Because of this lower temperature, relatively more heat is removed or transferred from the hot exchange surfaces.

In a modified or second embodiment, each of the wick layers is centrally disposed within a different cooling air passage. The liquid supplied to the various wick layers is distributed evenly through the wick material. This liquid is evaporated into the cooling air streams, thereby lowering the temperature of the air which is in contact with the hot heat exchange surfaces.

The foregoing exchanger structure is capable of retaining the cooling liquid within an exchanger casing regardless of the attitude of the exchanger. In the event the exchanger is inverted, the wick retains the liquid by capillary attraction and in opposition to the forces of gravity.

In order that all of the structural features for attaining the objects of this invention may be readily understood, detailed reference is herein made to the drawings wherein:

FIG. 1 is a plan view of a heat exchanger constructed in accordance with the principles of this invention;

FIG. 2 is an elevation view of the exchanger shown in FIG. 1 with portions of the casing thereof being broken away so as to show generally the internal construction;

FIG. 3 is an elevation view taken at a 90° angle to the view shown in FIG. 2, with portions of the casing thereof being broken away so as to show generally the internal construction;

FIG. 4 is a fragmentary view of the broken away circular section of FIG. 2 and showing the interior exchanger details of a first embodiment;

FIG. 5 is a fragmentary view of the broken away circular section of FIG. 3 and showing the interior details of said first embodiment;

FIG. 6 is a fragmentary view of the broken away circular section of FIG. 2 and showing the interior exchanger details of a second embodiment;

FIG. 7 is a fragmentary view of the broken away circular section of FIG. 3 and showing the interior details of said second embodiment; and

FIG. 8 shows an alternative arrangement for supplying evaporation cooling liquid to the heat exchanger structures of the foregoing figures.

Referring to the heat exchanger shown in FIGS. 1, 2 and 3 of the drawings: Outer casing 10 encloses the internal structure of the exchanger as hereinafter described in detail. The fluid to be cooled enters inlet opening 11 and leaves from outlet opening 12. Adapter 13 defines inlet opening 11, and adapter 14 defines outlet opening 12.

The cooling air or gas enters inlet opening 15 and leaves from outlet opening 16. Adapter 17 defines inlet opening 15, and adapter 18 defines outlet opening 16.

The fluid to be cooled enters inlet opening 11, passes through adapter 13 and into hot fluid passages 20 (FIGS. 2 and 3). Passages 20 are shown as having a conventional plate and fin construction. These passages, however, may have other kinds of extended surfaces, or they may be plain or tubular as dictated by particular heat exchange requirements.

Cooling air enters inlet 15, passes through adapter 16 and the cooling air passages 21 (FIGS. 2 and 3). The structural details of the internal exchanger construction for the typical sections enclosed within circle sections 23 and 24 of FIGS. 2 and 3, respectively, are shown in the circular sections 23a and 24a of FIGS. 4 and 5. Each

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cooling air passage 21 is sandwiched between a pair of layers or sheets of wick material 28. Each layer of wick material 28 is held in place with a screen or other suitable open mesh type material 29.

A plurality of perforated tubes 30 are embedded in each layer of wick material 28. The network of tubes 30 (FIG. 1) supplies a liquid for evaporation to the various wick layers 28. The liquid passing through the perforations in tubes 30 causes the surfaces 31 exposed to the cooling air to become wet. The liquid then evaporates into the cooling air streams flowing through passages 21. The liquid also tends to distribute evenly through the layers of wick material 28, thereby contacting the hot plates 32 defining the passages 20 for the fluid to be cooled.

The evaporation of liquid from the surfaces 31 lowers the temperature of all of the liquid in the wick layers 28, thereby causing the temperature of the liquid which contacts the plates 32 to be lower than the temperature of the liquid that enters the wick material through the perforations in tubes 30. Because of this lower temperature, relatively more heat is removed or transferred from the hot surfaces of plates 32 and in turn from the fluid passing through passages 20. Because cooling liquid is maintained in wick material 28 by capillary attraction, it is impossible for this liquid to be released in droplet form into the air stream so long as those portions of the wick layers 28 adjacent the air stream of passages 21 are not saturated with liquid.

The structural details of a second internal exchanger construction for the typical sections enclosed within circle sections 23 and 24 of FIGS. 2 and 3, respectively, are shown in the circular sections 23b and 24b of FIGS. 6 and 7. The internal exchanger construction of the second embodiment is generally the same as that shown in the first embodiment of FIGS. 4 and 5, with the exception that each layer of wick material 34 is disposed centrally within the associated air flow passage 21. With this arrangement an intervening space appears between the adjacent layer surfaces of wick 34 and the plates 32 of the passages 20.

In operation, cooling air travels through passages 21. The liquid supplied to the various wick layers 34 from perforated tubes 30 is distributed evenly through the wick layers to the outer surfaces adjacent plates 32. The liquid then evaporates into the cooling air, thereby lowering the temperature of this air which is also in contact with the hot heat exchange plates 32. Accordingly, the cooling air flowing within passages 21 is capable of transferring more heat because of the step of temperature lowering through evaporation. It should be noted that in the second embodiment the evaporating liquid is contained by the wick material and, therefore, will not be lost in unevaporated drops to the air stream as would be the case in the event that this liquid were sprayed from a nozzle into this same air stream.

FIG. 8 shows alternative or supplemental apparatus for supplying liquid to the various wick layers of the internal exchanger embodiments hereinbefore described in detail. This liquid supply apparatus is preferably associated with the heat exchanger casing 10 in a general manner shown by the broken lines 36 of FIGS. 1 and 2, which generally outlines a liquid reservoir the details of which are shown in FIG. 8.

In FIG. 8 a wick arrangement is shown in which each wick layer is spaced from the associated plates of the fluid passages 20 in the detailed manner shown in FIGS. 6 and 7. It should be noted, however, that the wick layers 34 are extended by means of wick portions 37 so that each of the wick layers communicates with the liquid mass 38 contained within liquid reservoir 36. The capillary action of the wick causes each wick layer 34 to become moist throughout. Accordingly, these layers are capable of supplying moisture to the cooling air flowing through passages 20. Fill tube 39, which is normally

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closed by cap 40, communicates with the interior of liquid reservoir 36, whereby this reservoir may be supplied with liquid as required.

The wick material for the heat exchangers hereinbefore described is preferably fabricated from an inert and fireproof substance such as fiberglass. For example, the fibrous silica insulation material manufactured and sold by H. I. Thompson Fiber Glass Company of Los Angeles, California, under the trade name "Refrasil" is highly satisfactory as wick material for the novel heat exchangers described herein.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the scope of the invention.

What is claimed is:

1. An evaporative heat exchanger comprising a heat exchanger casing, means disposed within said casing defining a plurality of hot fluid passages with each of said fluid passages being spaced from an adjacent fluid passage by an intervening cooling air passage and with each fluid passage presenting a heat exchange surface to each of the adjacent cooling passages, a layer of wick material centrally disposed within each of said cooling air passages with each layer being separated from the adjacent heat exchange surfaces, means for supplying cooling air to each of said cooling passages, and means for supplying a cooling liquid to said wick layers for evaporation by said cooling air.

2. An evaporative heat exchanger comprising a heat exchanger casing, means disposed within said casing defining a pair of hot fluid passages with the fluid passages being spaced from one another by an intervening cooling fluid passage and with each hot fluid passage presenting a heat exchange surface to said cooling passage, a layer of wick material centrally disposed within said cooling fluid passage and separated from the adjacent heat exchange surfaces, means for supplying cooling fluid to said cooling passage for flow between the centrally disposed wick layer and the adjacent heat exchange surfaces, and means for supplying a cooling liquid to said wick material for evaporation by said cooling fluid.

3. An evaporative heat exchanger comprising a heat exchanger casing, means disposed within said casing defining a plurality of hot fluid passages with the fluid passages being spaced from one another by an intervening cooling fluid passage and with each hot fluid passage presenting a heat exchange surface to said cooling passage, a single mass of wick material disposed within said cooling passage and being removed from at least one of said heat exchange surfaces to define a cooling fluid flow path therebetween, said mass of wick material being the only wick material in said cooling passage, means for supplying cooling fluid to said cooling passage, and means for supplying a cooling liquid to said wick mass for evaporation by said cooling fluid.

4. The combination of claim 3 in which said liquid supply means includes one or more liquid supply pipes embedded within said mass of wick material.

5. The combination of claim 3 in which said liquid supply means includes a liquid reservoir and additional wick material communicating said mass of wick material with said liquid reservoir.

6. In a heat exchanger, a plurality of hollow heat exchange members in parallel positions, a plurality of wicks positioned between and spaced from the heat exchange members, the members and the wicks being so constructed as to define fluid passages therebetween, means supplying a fluid to be cooled to the interiors of the heat exchange members, means for supplying a liquid coolant to the wicks, and means for passing a cooling fluid through the passages.

7. In a heat exchanger, a plurality of sheet-like heat

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exchanger members, a plurality of sheet-like wicks each positioned between a pair of the heat exchange members and spaced from both of the members to define coolant fluid passages therewith, a casing enclosing the members and the wicks and having a pair of aligned coolant fluid openings in opposite sides thereof communicating with the ends of the coolant fluid passages, the casing also having openings for fluid to be cooled connected to the opposite ends of the heat exchange members and extending at right angles relative to the coolant fluid openings, and means supplying a liquid coolant to the wicks.

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