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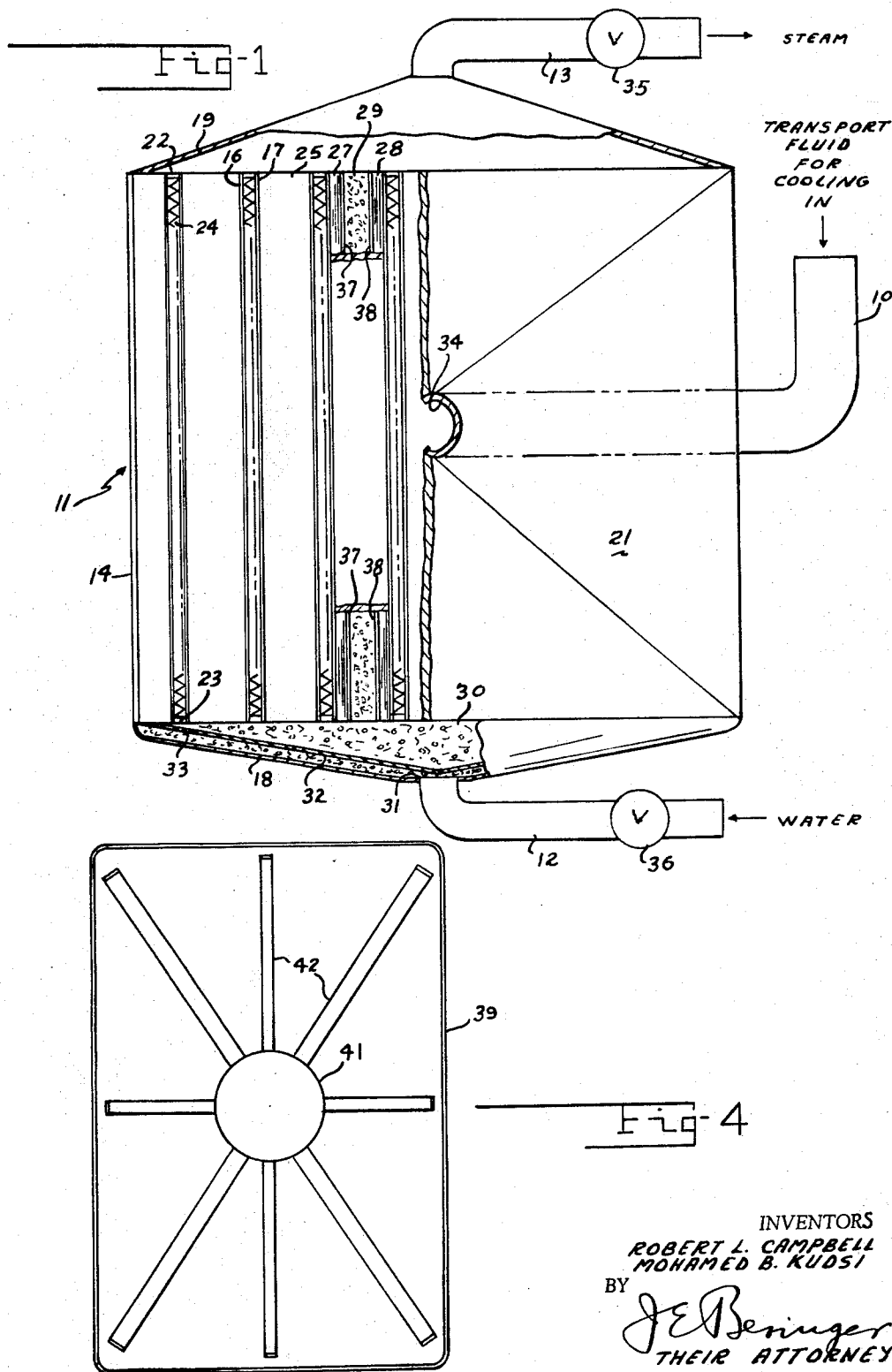
R. L. CAMPBELL ET AL

3,275,074

PLATE TYPE EVAPORATIVE COOLER AND WICK THEREFOR

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2 Sheets-Sheet 1



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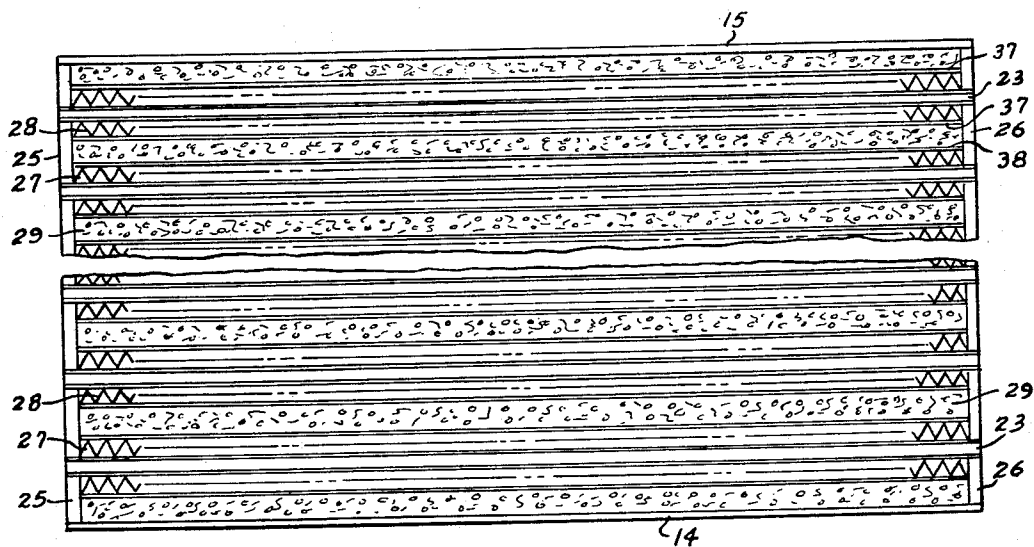


Fig-2

Fig-5

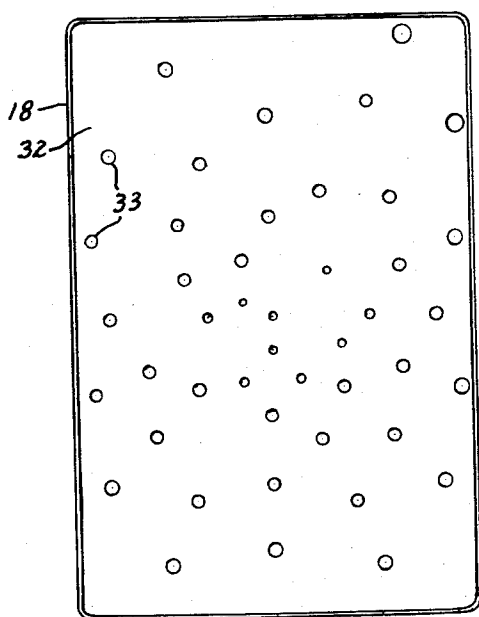
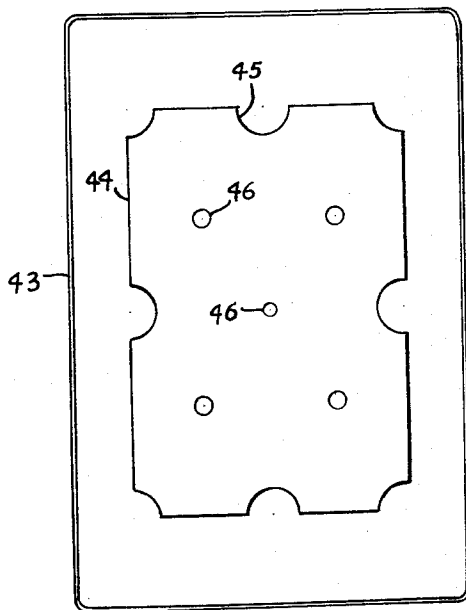


Fig-3



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11 Claims. (Cl. 165—166)

This invention relates to thermal conditioning systems,
and particularly to evaporative cooling means utilizing a
principle of water boiling on or in conjunction with a
heat transfer surface.

An object of the invention is to provide for heat trans-
fer by water boiling in a plate-type exchanger.

Another object of the invention is to supply water for
boiling in a manner equally to distribute the water over
the face of the heat exchanger core.

Still another object of the invention is to provide, in a
water boiling type heat exchanger as described, for use
of saturable wicking material positioned in a heat transfer
relation to heated plate surfaces in a generally novel
manner.

Other objects and structural details of the invention
will appear from the following description, when read in
connection with the accompanying drawings, wherein:

FIG. 1 is a partly diagrammatic view in side elevation,
with portions broken away, of a water boiling heat ex-
changer in accordance with the illustrated embodiment
of the invention;

FIG. 2 is a detail view of one side core face of the heat
exchanger of FIG. 1;

FIG. 3 is a plan view of the water inlet manifold as
shown in FIG. 1;

FIG. 4 is a view similar to FIG. 3, showing an alternate
form of water inlet manifold using a different distribu-
tion system; and

FIG. 5 is a view similar to FIGS. 3 and 4, showing still
another construction for a water distribution manifold.

Referring to the drawings, the invention is disclosed as
incorporated in a thermal conditioning system in which
a circulating transport fluid, having absorbed heat from a
heat producing source, is required variably to be cooled.
It is the object of the system to return the transport fluid
to the heat source at a temperature not exceeding a pre-
determined high value. Thus the transport fluid, which
may be methanol or any other fluid or liquid suited to its
purpose, and which is indicated in FIG. 1 as "transport
fluid for cooling," is directed by means of a duct 10 to a
heat exchanger 11. Within the heat exchanger the hot
fluid is brought into heat transfer relation to an expend-
able coolant, in the illustrated instance water, brought to
the heat exchanger by way of a duct 12. Acquiring a
boiling temperature within the heat exchanger 11, and
being vaporized thereby, the coolant leaves the system
by way of discharge duct 13, having now the form of
vapor or steam. The cooled transport fluid leaves the
heat exchanger by way of another duct (not shown) and
is directed back to the heat source for a reabsorption of
generated heat.

The core of the heat exchanger 11 is comprised of a
plurality of superposed stacked plates defining separated
circuits for the transport fluid and for the liquid-steam
coolant. These include end plates 14 and 15 and a plu-
rality of intermediately disposed pairs of plates 16 and 17.
The several plates have a four-sided configuration and
are aligned with one another in a manner to define a six-
sided figure, two opposing sides being closed by end plates
14 and 15. Other opposed sides are closed by manifolds
18 and 19 connected respectively to water inlet conduit
12 and steam outlet conduit 13. Of the remaining oppos-

ing sides one is enclosed by a manifold 21 connected to
the inlet duct 10 for the transport fluid. Within the con-
cept of a closed circulating system for the transport fluid
the opposite face of the core is enclosed by a similar
manifold (not shown) connected to supply the heat
source.

End plates 14 and 15 are relatively thick and have the
several manifolds mounted thereto by a brazing or other
attachment technique. The intermediately disposed pairs
of plates 16 and 17 are constructed of a heat conductive
material and made relatively thin for good heat transfer.
Each pair of plates 16 and 17 is held in a spaced relation
to one another by marginal spacer elements 22 and 23.
These are in an opposed relation to one another, along
two sides only of the plates whereby to define between
the spaced plates a flow pass extending through other
opposed ends of the space defined between the pair of
plates. Within the described space between each pair of
plates 16 and 17 is disposed a strip fin device 24 provid-
ing secondary heat transfer surface and serving as a tie
between adjacent plates 16 and 17, the strip fin device
being brazed to the plates 16 and 17 as a part of an opera-
tion uniting the plates, spacers 22 and 23 and companion
devices. In referring to a strip fin device herein it will
be understood that what is described is a part made of
thin ductile sheet metal or the like gathered or crimped
to an undulating configuration providing adjacent peaks
and valleys which in the present instance are respectively
in contact with plates 16 and 17.

Adjacent pairs of plates 16 and 17 are spaced apart a
distance greater than are the plates of each pair, this spac-
ing being accomplished by relatively broad spacer bars 25
and 26. The bars 25 and 26 are marginally disposed be-
tween adjacent pairs of plates 16-17 and at right angles
to spacer elements 22 and 23. As a result the space be-
tween each pair of plates 16-17 is bounded on two sides
by the spacers 25 and 26 and is open on its other sides,
the arrangement being the reverse of that provided be-
tween each pair of plates 16-17. The arrangement further
is one, in conjunction with selective placement of the
manifolds 18, 19 and 21, to place the opposite ends of
the spaces between adjacent pairs of plates 16-17 in com-
munication with the interiors of manifolds 18 and 19, and,
further, to place the spaces between each pair of plates
16-17 in communication at their one ends with the inter-
ior of manifold 21 and at their other ends with the mani-
fold (not shown) leading to the heat source.

The space defined by and between each pair of marginal
spacer bars 25 and 26 is occupied by an assembly of parts
comprising two spaced apart strip fin devices 27 and 28
in contacting relation respectively with respective plates
of the adjacent pairs of plates 16-17. Disposed between
the devices 27 and 28 is a thickness or layer of a liquid
absorbent, wicking material 29. Opposing ends of the
layer of material 29 extend to and may project into respec-
tive manifolds 18 and 19 while other opposing sides of
the layer of material are confined by the spacer bars
25-26. The strip fin devices 27 and 28 are similarly con-
fined at one pair of opposing sides by the spacer bars
25-26 and at their ends are approximately coextensive
with the plates 16-17. The devices 27 and 28, which
correspond in construction to the devices 24, serve a
multiple purpose in connection with the material 29.
Thus, the strip fin devices position the wicking material
centrally of adjacent pairs of plates 16-17, they serve a
heat conductive purpose in transmitting heat from the
plates 16-17 to the material 29, and, finally the fin devices
provide pathways of low resistance through which vapor
escaping from material 29 may reach manifold 19 with
facility and without expelling liquid to the manifold prior
to its having absorbed its heat of vaporization.

In the latter regard, material 29 is wetted by water admitted to manifold 18 through duct 12, the admitted water having access to the adjacent extremity of the layer of material 29 and being absorbed and distributed therein by capillary action. For more effective distribution to the plurality of layers 29, the interior of manifold 18 is in the illustrated instance filled with a material 30 which is or may be the same as that comprising layer 29 and is in a merging relation to such layer. Liquid from conduit 12 enters manifold 18 by way of a centrally located inlet 31 and is absorbed into the material 30 for transmission to the plurality of layers of material 29. In the interests of a more uniform distribution, there is installed in manifold 18 a plate 32 overlying and spaced from the end wall of the manifold and having therein a plurality of through openings 33. As indicated in FIG. 3, the openings 33 are differentially sized as to diameter, and located in a manner to promote a more uniform distribution. Thus, the openings 33 immediately in line with or near to the inlet opening 31 are of a minimum diameter while those adjacent the extremities of the manifold or farther removed from inlet 31 are of a maximum diameter, intermediate openings having intermediate diameters.

Side exteriors of the heat exchanger core may be considered to present faces to their respective manifolds. Water is distributed over one face of the core and travels by absorption into the body thereof. The heated transport fluid is introduced into manifold 21 by way of a centrally located inlet opening 34 therein. Within the manifold 21 the heated fluid distributes itself over the encountered face of the core and enters the open passageways defined by the spaces between each pair of plates 16-17. The fluid flows through such passes, confined at their sides by spacers 22 and 23, and discharges through the opposite face of the heat exchanger core. In the process the fluid gives up heat to the strip fins 24 and to the plates 16 and 17. These are in turn continuously cooled by an evaporative cooling process with the result that the flowing transport fluid leaves the heat exchanger at a reduced temperature. In the evaporative cooling process heat is conducted from the plates 16-17 through adjacent, contacting strip fin devices 27 and 28 to the layer of material 29. There the contained water is boiled with the resulting steam entering the passages defined by adjacent peaks and valleys of the strip fin devices 27-28 and flowing to manifold 19. A valve 35 in steam outlet duct 13 regulates the discharge of the steam and may be adjusted selectively to raise and lower the pressure within manifold 19 and communicating areas. In keeping with the scale relationship between pressure and boiling temperatures, therefore, liquid boiling in the heat exchanger may be inhibited or induced with a consequent regulating effect upon the outlet temperature of the flowing transport fluid. Similarly the input of water may be controlled by a valve 36 in the duct 12, and, it will be understood, that the control of valves 35 and 36 may be automatic and occur in response to a sensed changing condition, for example either or both the inlet and outlet temperatures of the transport fluid.

While the strip fin devices 27 and 28 may directly contact the layer of material 29, the latter is in the illustrated instance confined between perforated plates 37 and 38 simplifying the handling and installation of the wicking material.

The water distributing manifold may take forms other than that shown in FIG. 3. It may, as shown in FIG. 4, comprise a manifold body 39 wherein a cylindrical member 41 is open at one end to lie over the water inlet and is closed at its other end to define a plenum chamber. From such chamber flow tubes 42 radiate, terminating at different points in the interior of the manifold near the periphery thereof. Certain of the tubes are greater in diameter than others in the interests of uniformity of distribution, as described.

Further, the distributing manifold might take a form

as shown in FIG. 5 wherein a manifold body 43 has a plate 44 installed therein in covering relation to the water inlet. Plate 44 is formed with relatively broad peripheral notches 45 and with differentially sized openings 46, all serving a distribution purpose as brought out heretofore.

The invention provides in its illustrated form a thermal conditioning system and in particular a water boiler especially suited for operation under conditions discharging the developed steam to low pressure ambient conditions, for example the vacuum of outer space. Water is supplied to the heat exchanger upon demand. It is distributed by expansion velocity and wick material to the heat transfer surface. A transport fluid, entering the heat exchanger, is cooled by the evaporation of the water. Developed steam is vented under valve control to the ambient surroundings. The use of wick material in the coolant circuit provides for controlled water flow under zero and other than normal gravity conditions, for the containment of water in a proper position for vaporizing, for a controlled water distribution to the boiler surfaces and for inherently consistent performance.

The arrangement confining the layers of wicking material by strip fin devices 27 and 28, is moreover, one of general utility in plate type heat exchangers. While a particular manifolding arrangement has been illustratively disclosed it will be understood that the invention lends itself to other flow circuits. The transport fluid might, for example, be hot air blown through the core without benefit of manifolds. Released vapor might be discharged freely from the core instead of being collected in a manifold 19 and layers 29 might be supplied in a pool system with or without a continuing replacement of evaporated liquid.

What is claimed is:

1. Evaporative cooling means in a plate-type heat exchanger, including at least two spaced apart pairs of heat conductive plates, each pair defining a flow path for a heated fluid, a layer of liquid holding material intermediately disposed between said pairs of plates and spaced therefrom, and multiple purpose strip fin devices on opposite sides of said layer of material in mutually contacting heat transmitting relation between said pairs of plates and said liquid holding material, said devices positioning said material and being made of heat conductive material with an undulating crimped configuration providing escape paths for vapor released from said material.

2. Evaporative cooling means in a plate-type heat exchanger, including a pair of spaced apart parallel heat conductive plates, means for heating said plates, heat conductive strip fin devices between said plates and in contact with respective ones thereof, and a layer of liquid holding material positioned by and between said devices, said devices conducting heat to said material from said plates and providing escape paths for vapor released from said material, said fin devices being comprised of strip fin material having alternating peaks and valleys providing said escape paths.

3. Evaporative cooling means in a plate-type heat exchanger, comprising superposed stacked assemblies of parts, each assembly including a heat conductive plate, a heat conductive strip fin device in overlying contacting relation to said plate on one side thereof, a layer of a liquid holding material in overlying relation to said strip fin device, and means for holding said layer of material with one side thereof presented to and contacting said device, said fin device being formed with peaks and valleys providing long fluid flow passageways in facing communicating relation to said layer of material, and said holding means including another strip fin device on the opposite side of said layer of material and another plate backing said other fin device, the first said plate cooperating with a plate of a companion assembly corre-

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sponding to said other plate to define a flow path for a heated fluid.

4. Evaporative cooling means in a plate-type heat exchanger, including an assembly of four-sided superposed plates, spacers at opposite ends of said plates alternately at right angles to one another to define adjacent through passages at right angles to one another, a manifold on each side of said assembly, first opposing manifolds being in common communication with one set of passages between said plates and second opposing manifolds being in common communication with another set of passages between said plates, one of said first opposing manifolds receiving heated fluid under pressure for flow through said one set of passages to the other one of said first opposing manifold and one of said second opposing manifolds receiving liquid, absorbent wicking material disposed in said other set of said passages wetted by capillary action from the liquid in said latter manifold, and strip fin means in said other set of passages alongside said wicking material conducting heat from said plate into said material and providing low resistance flow paths by which vapor released from said wicking material may escape to the manifold opposed to the other one of said second opposing manifolds, said strip fin means being made of heat conductive material and having an undulating crimped configuration providing said flow paths.

5. Evaporative cooling means according to claim 4, characterized in that the said last mentioned manifold is filled with said wicking material in a contacting relation to the wicking material in said other set of said passages and in a closing relation to those portions of said other set of passages occupied by said strip fin devices.

6. A plate-type heat exchanger, including a core comprised of superposed stacked plates and marginal spacers providing a first set of spaced apart flow passes and in alternating relation to the passes of said first set a second set of flow passes, manifolds mounted to opposite faces of said core in closing relation to opposite ends of said first set of flow passes, one of said manifolds being filled with a liquid saturated wicking material and passes of said first set having layers of like material therein in contact at their one extremity with the material in said one manifold and wetted by capillary action, and strip fin means in the passes of said first set interposed between and in mutually contacting relation to said layers of said wicking material therein and a respective plate, the spaces in said passes of said first set occupied by said strip fin means being closed by the wicking material in said one manifold, and means for flowing a heated fluid through said second set of passes, heat being conducted through said plates to said first set of passes and through said strip fin means therein to said wicking material, vapors released from said material escaping through paths defined by said strip fin means to the other one of said manifolds, said strip fin means being made of heat conductive material and having an undulating crimped configuration defining said paths.

7. A plate-type heat exchanger, including a core comprised of superposed stacked plates and marginal spacers providing a first set of spaced apart flow passes and in alternating relation to the passes of said first set a second set of flow passes, manifolds mounted to opposite faces of said core in closing relation to opposite ends of said first set of flow passes, one of said manifolds being filled with a liquid saturated wicking material and passes of said first set having layers of like material therein in contact at their one extremity with the material in said one manifold and wetted by capillary action, and strip fin means in the passes of said first set interposed between said layers of said wicking material therein and

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a respective plate, the spaces in said passes of said first set occupied by said strip fin means being closed by the wicking material in said one manifold, and means for flowing a heated fluid through said second set of passes, heat being conducted through said plates to said first set of passes and through said strip fin means therein to said wicking material, vapors released from said material escaping through paths defined by said strip fin means to the other one of said manifolds, said one manifold being formed with a liquid inlet at the center thereof and with means individually communicating said inlet with different locations of alignment with the respective adjacent face of the core, said last named means distributing liquid differentially to said locations.

8. A plate-type heat exchanger according to claim 7, characterized in that said last named means comprises a plenum chamber receiving liquid from said inlet and passages of different cross-sectional size for conducting liquid from said chamber to said locations.

9. A plate-type heat exchanger according to claim 7, characterized in that said last named means comprises a plate disposed intermediate said inlet and the adjacent face of said core, said plate having differentially sized selectively located openings for admitting liquid to said core face.

10. A plate-type heat exchanger, including a core comprised of superposed stacked plates and marginal spacers providing a first set of spaced apart flow passes and in alternating relation to the passes of said first set a second set of flow passes, a manifold mounted to one face of said core in enclosing relation to said first set of flow passes at one end thereof, a layer of wicking material in each of said first set of flow passes, other means in each of said flow passes of said first set in heat transmitting mutually contacting relation between said plates and said wicking material, said other means having an undulating configuration defining flow passes of low resistance in adjacent communicating relation to said wicking material, means for admitting liquid to said manifold, the liquid being absorbed into said wicking material by capillary action, wicking material in said manifold covering the said first set of flow passes at said one end thereof in the spaces occupied by said other means therein and in common contact with the layers of wicking material in said first set of flow passes, and means for flowing a heated fluid through said second set of passes, conducted heat evaporating liquid from said wicking material and released vapor escaping through said flow passes of low resistance from the core by way of the opposite end of the passes of said first set.

11. A plate-type heat exchanger according to claim 10, characterized by means distributing a liquid substantially uniformly over the said face of said core.

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