

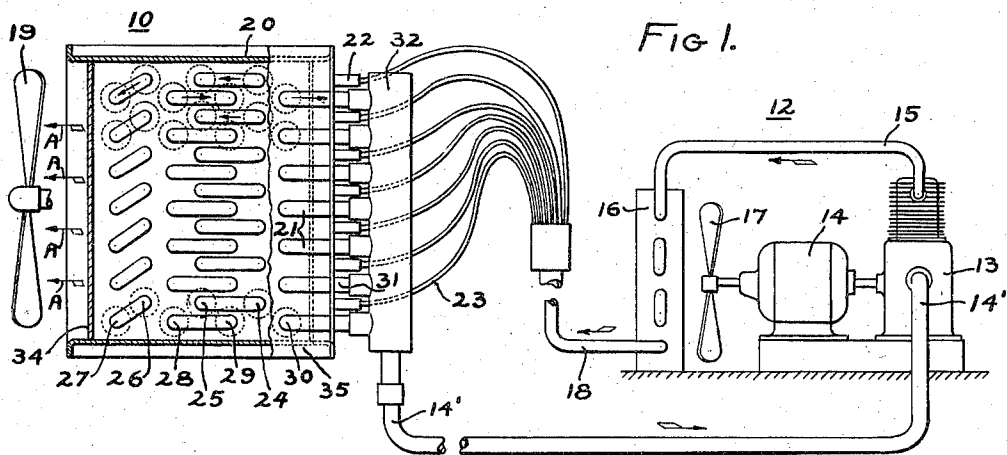
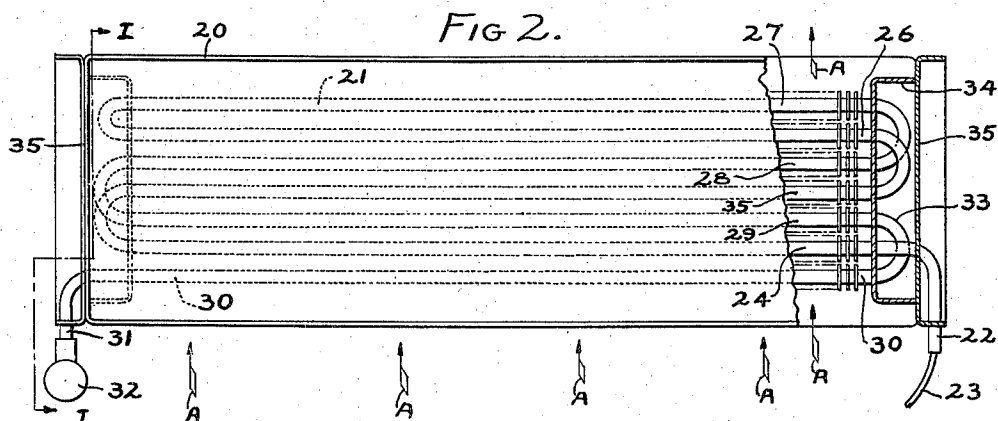
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COOLING APPARATUS

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WITNESSES.

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COOLING APPARATUS

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6 Claims. (Cl. 62—129)

My invention relates to cooling or refrigerat-
ing apparatus, more particularly to an evapo-
rator of the "dry expansion" type for cooling
air or other fluid, and it has for an object to
provide an improved evaporator.

It is an object of my invention to provide an
evaporator for cooling a fluid, having an im-
proved arrangement of refrigerant passage with
respect to flow of the fluid being cooled.

It is another object of my invention to utilize
the heat-transfer surfaces of the evaporator in
the most efficient manner.

A further object is to provide a more nearly
uniform temperature difference between the re-
frigerant and the fluid being cooled, and there-
fore, a higher mean effective temperature dif-
ference.

In accordance with my invention, I provide
an evaporator of the so-called "dry expansion"
type, having a passage in which refrigerant flows
in the same direction as the fluid being cooled,
for the first portion of its path, and then flows
in the opposite direction.

The utility of this arrangement will be under-
stood from a consideration of the following:
A pressure drop of the refrigerant is required
to force the same through the passages, that is,
the pressure of the refrigerant is highest at the
inlet end and decreases toward the outlet end.
The temperature of the refrigerant also decreases
from the inlet toward the outlet end, as long as
it is a mixture of liquid and gas. By placing
the inlet end toward the incoming fluid to be
cooled, the warmest portion of the latter is
brought into heat-exchanging relation with the
warmest refrigerant, and successively cooler por-
tions of the fluid are brought into successively
cooler portions of the refrigerant, whereby a more
nearly uniform temperature difference is pro-
vided, and, consequently, more cooling for a given
amount of cooling surface.

When the refrigerant is completely evaporated,
it is superheated upon further addition of heat,
its temperature increasing instead of decreasing.
I, therefore, reverse the direction of flow as near
as practical to the point where evaporation is
completed, causing the refrigerant to flow in the
direction opposite to that of the fluid being
cooled. In this case, again, the warmest por-
tion of the refrigerant is brought into heat-
exchanging relation with the warmest portion
of the fluid being cooled; this arrangement being
the well-known counterflow arrangement.

The above and other objects are effected by
my invention as will be apparent from the fol-

lowing description and claims taken in connec-
tion with the accompanying drawing forming a
part of this application, in which:

Fig. 1 is a diagrammatic view of refrigerat-
ing apparatus embodying my novel evaporator,
which is shown in end elevation, partly in sec-
tion, as seen along the line I—I of Fig. 2; and

Fig. 2 is a plan view of the evaporator.

Referring to the drawing in detail, I show an
evaporator 10 supplied with liquid refrigerant by
a refrigerating unit 12, which may be of con-
ventional design so far as the present invention
is concerned. As shown, the refrigerating unit
12 comprises a compressor 13 driven by a motor
14. The compressor receives vaporous refrigerant
through a suction conduit 14' and the com-
pressed refrigerant is conveyed through a con-
duit 15 to a condenser 16. A fan 17, driven by
the motor 14, provides circulation of air or
other cooling fluid through the condenser 16.
The condensed refrigerant is conveyed to the
evaporator through a conduit 18.

The evaporator 10 is designed for circulation
of air, or other fluid to be cooled, in a given
direction through the evaporator. In the present
embodiment, I provide one or more blowers 19
which effect circulation of air through the evapo-
rator in the direction indicated by the arrows
A in the several figures, which is to the left
in Fig. 1. The evaporator 10 has a casing 20,
which has top, bottom and end walls but is open
on the two sides through which the air passes
into and out of the casing, as shown in the right
hand end portion of Fig. 2. The evaporator 10
further comprises a bank or plurality of coils
21 therein which are arranged in parallel rela-
tion with respect to air flow, that is, they are
arranged in superimposed relation as shown in
Fig. 1, so that each coil is subjected to the same
air temperatures and the action of the several
coils is substantially identical. Each coil has an
inlet 22 receiving liquid refrigerant from the
conduit 18 through a flow resistance or capillary
tube 23. The coil comprises tubes or turns 24,
25 and 26 arranged in a horizontal plane, parallel
to the direction of air flow, from the air inlet
toward the air outlet; and further tubes or turns
27, 28, 29 and 30, arranged in an adjacent par-
allel plane in the reverse order, that is, from the
air outlet toward the air inlet, and preferably in
staggered relation to the first tubes. The latter
four tubes are preferably below the first three
tubes, so that the flow of liquid refrigerant from
the tube 26 to the tube 27 is assisted by gravity.
The last tube or turn 30 of each coil is con-

ected through the outlet end 31 to a suction manifold 32, connected to the suction conduit 14'. The successive turns of each coil are connected at their ends by reverse bends 33 disposed in a bracket 34 carried by the end wall 35 of the evaporator casing for supporting the coils in the evaporator.

In the operation of the above described apparatus, refrigerant is compressed by the compressor 13 and condensed by the condenser 16 in the usual manner. The condensed refrigerant is distributed to the several coils, in this case, preferably in equal portions, by the capillary tubes 23. Since the coils 21 provide relatively long and narrow passages for refrigerant, an appreciable pressure drop or pressure difference is required to force the refrigerant through the coils with sufficient velocity. As an example, using dichlorodifluoromethane as refrigerant, the pressure at the inlet end may be assumed to be 40.7 lbs. per square inch and the pressure at the outlet end 35 lbs. per square inch, providing a pressure drop of 5.7 lbs. per square inch. Also assume 10° superheating of the refrigerant vapor discharged at the outlet of the coil. In this case, then, the refrigerant entering the coil at the inlet end would have a temperature of 44° F. and at some point in the evaporator near the outlet end, where all the refrigerant has been evaporated, the temperature will be about 38° F. The temperature of the refrigerant vapor at the outlet end would then be about 48° F.

It is desirable to have the point at which all of the liquid is vaporized, at which point the temperature is at a minimum, as near to the air outlet as possible, but in a practical construction, such as shown in Figs. 1 and 2, embodying substantially the same number of tubes in the two rows of each coil, this point may be somewhat spaced from the outlet end, for example, this point may occur in the tube 28 or possibly in the tube 29. However, the coolest region of each coil is adjacent the air outlet end while the warmer regions at the ends of each coil are adjacent the air inlet. Also, the tubes nearest the air outlet are at nearly the coolest temperature.

The tubes adjacent the inlet, that is, tubes 24 and 25, contain the highest pressure and, therefore, the highest temperature of the refrigerant. Being arranged adjacent the air inlet they are in heat exchange relation with the warmest portions of the air, that is, the incoming air. As the refrigerant continues in its flow through the coil toward the air outlet, its pressure and temperature decrease, and it comes into contact with cooler portions of the air, that is, the air which has been partially cooled adjacent the air inlet and which is about to leave the evaporator. When the refrigerant has been completely evaporated, it is no longer capable of absorbing heat by evaporation, so that the addition of further heat increases the temperature of the refrigerant. The refrigerant then flows toward the air inlet so as to be in heat exchange relation with warmer air, that is, in counter-flow relation, and providing a more uniform difference between temperatures of the air and refrigerant.

It will be seen from the above description that I have provided an evaporator wherein a nearly uniform temperature difference is provided. The portion of each coil, adjacent the inlet end, containing a mixture of liquid and gaseous refrigerant provides for flow of refrigerant in the same direction as the flow of air, while the portion adjacent the outlet end provides for flow of the

gaseous refrigerant in a direction opposite to the flow of air. It will be noted that I have provided one more tube in the second or lower row of each coil than in the upper row, the reason for this being that the heat absorbing capacity of the vaporous refrigerant is less than the liquid refrigerant.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications, without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. An evaporator for air cooling comprising a casing having two opposed side walls and two opposed end walls and being open on the two remaining opposed sides for the passage of air therethrough, and a plurality of coils, each coil comprising a plurality of tubes or turns extending between the end walls of the casing, the tubes of each coil being disposed substantially in two adjacent rows parallel to said side walls and connected so that refrigerant flows through the tubes of one row successively from one open side to the other open side and then through the tubes of the adjacent row successively from the last-mentioned open side to said one open side, said coils being arranged in a bank or row extending from one side wall to the other so that the air flows over said coils in parallel, the evaporator being arranged for flow of refrigerant through the several coils in parallel.

2. An evaporator for air cooling comprising a casing having two opposed side walls and two opposed end walls and being open on the two remaining opposed sides for the passage of air therethrough, a plurality of coils, each coil comprising a plurality of tubes or turns extending between the end walls of the casing, the tubes of each coil being disposed substantially in two adjacent rows parallel to said side walls and connected so that refrigerant flows through the tubes of one row successively from one open side to the other open side and then through the tubes of the adjacent row successively from the last-mentioned open side to said one open side, said coils being arranged in a bank or row extending from one side wall to the other so that the air flows over said coils in parallel, means for supplying refrigerant in parallel in substantially equal amounts to the first tube of the several coils, and an outlet or suction header connected in parallel to the last tube of each coil.

3. In air cooling apparatus, the combination of a bank of coils, each coil having an inlet and an outlet at one side of said bank and comprising tubes or turns arranged and connected so that refrigerant flows through successive tubes from the inlet on said one side to the opposite side of the bank and then back to the outlet on said one side, means for effecting forced circulation of air over said coils in parallel from said one side to said opposite side, means for supplying vaporizable liquid refrigerant to the inlet of each coil, and means for withdrawing vaporized refrigerant from the outlet of each coil and for effecting complete vaporization of the liquid refrigerant before the refrigerant completes its passage through the coil, whereby the tubes adjacent the inlet contain liquid refrigerant decreasing in temperature in the direction

of air flow and the completely vaporized refrigerant is superheated in the portion of the coil adjacent the outlet by the relatively warm incoming air.

4. An evaporator unit for cooling air comprising a plurality of coils, a common supporting structure for said coils, each coil having its inlet end and its outlet end at one side of the unit and comprising tubes or turns arranged and connected so that refrigerant flows through successive tubes from the inlet end on said one side to the opposite side of said unit and then back to the outlet end on said one side, the evaporator unit being constructed and arranged for flow of air over said coils in parallel from said one side to said opposite side, means for distributing a vaporizable liquid refrigerant from a common source in substantially equal portions to the inlet ends of the several coils, and a common discharge header connected to the outlet ends of the several coils.

5. An evaporator unit for cooling air comprising a plurality of coils, a common supporting structure for said coils, each coil having its inlet end and its outlet end at one side of the unit and comprising tubes or turns arranged and connected so that refrigerant flows through successive tubes from the inlet end on said one side to the opposite side of said unit and then

back to the outlet end on said one side, the evaporator unit being constructed and arranged for flow of air over said coils in parallel from said one side to said opposite side, means for distributing a vaporizable liquid refrigerant from a common source to the inlet ends of the several coils, and a common discharge header connected to the outlet ends of the several coils.

6. In air cooling apparatus, the combination of an evaporator unit comprising a plurality of coils and a common supporting structure for said coils, each coil having an inlet and an outlet at one side of said unit and comprising tubes or turns arranged and connected so that refrigerant flows through successive tubes from the inlet on said one side to the opposite side of the unit and then back to the outlet on said one side, means for effecting forced circulation of air over said coils in parallel from said one side to said opposite side, a common discharge header connected to the outlet ends of the several coils, a compressor having its inlet connected to the discharge header for withdrawing vaporized refrigerant from said coils and compressing the same, means for condensing the compressed refrigerant, and means for distributing the condensed refrigerant to the inlet ends of the several coils.

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