

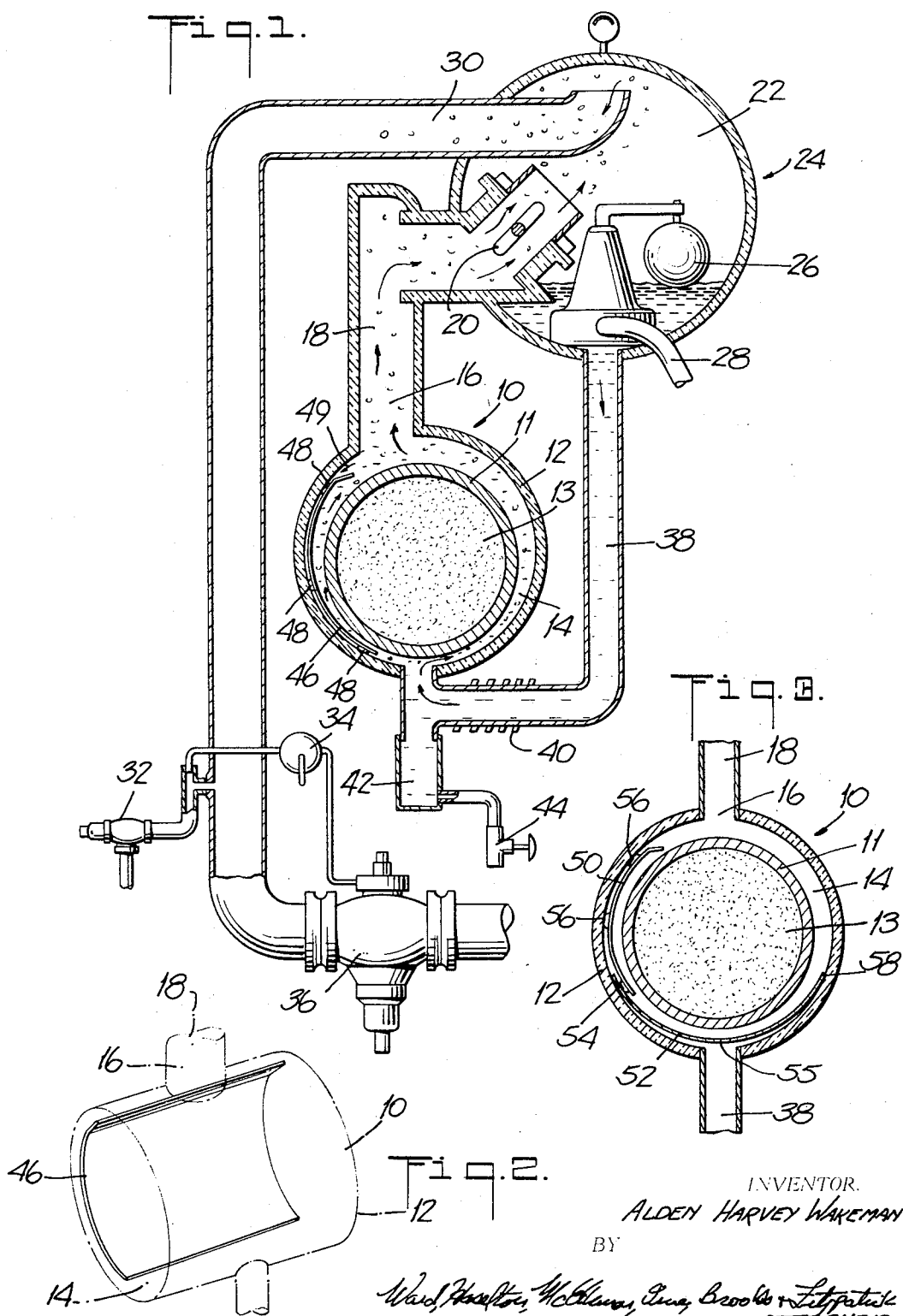
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REFRIGERATING APPARATUS WITH TUBULAR EVAPORATOR

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REFRIGERATING APPARATUS WITH TUBULAR EVAPORATOR

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ABSTRACT OF THE DISCLOSURE

Refrigerating apparatus having an accumulator, an evaporator including a tube in which a product may be cooled, an outer shell spaced from the tube to form a chamber which has a lower inlet that is connected to a liquid refrigerant portion of the accumulator and an upper inlet which is connected to a refrigerant vapor portion of the accumulator, liquid refrigerant being supplied to and vapor refrigerant being removed from their respective portions of the accumulator, and a baffle mounted in spaced relationship between the shell and the tube for preventing vapor bubbles from forming and remaining on the outside surface of the tube.

This invention relates to heat transfer apparatus and more particularly to means for greatly increasing the efficiency of heat transfer between a liquid and a solid.

The concepts according to this invention are useful for various heat transfer apparatus such as ice cream freezers, chillers, boilers, for example.

In a refrigeration system, the transfer of heat from the freezer barrel to the liquid refrigerant results in the formation of gas, which shows up in the formation of bubbles on the outer wall of the freezer barrel at the point where heat is being transferred to the liquid. It will be appreciated that any bubbles which contact and adhere to the exterior surface of the barrel will substantially reduce the heat transfer coefficient between the barrel contents and the refrigerant. The bubbles formed on the exterior surface of the barrel will break loose in accordance with certain factors such as physical properties of the liquid refrigerant, turbulence or currents in the liquids and the angle of the wall on which the bubbles collect. It will be apparent that if bubbles collect on the top of a horizontal wall they can readily rise from such a surface due to gravity, and if the wall is vertical, the bubbles can shear off without difficulty. However, where bubbles form on the under surface of a horizontal wall, gravity is of no assistance in breaking them loose and only movement of the heavier liquid pushing the bubbles sideways until they come to the edge of the surface will be effective in eliminating them. If the horizontal wall is tilted, it will be seen that gravity becomes a factor since the bubbles can slide up the inclined wall. Relating all of this to the under surface of the barrel, it will be appreciated that bubbles forming anywhere along the barrel except on the bottom region thereof will be rather easily removed by several factors such as gravity and currents in the fluid. However, the bubbles which form at and near the bottom will not be so readily torn away.

As it happens, for a number of reasons, most commercial freezers of the type in question utilize horizontal barrels so that the conditions described above are an important factor in the operation of these freezers and it is the purpose of the present invention to eliminate bubbles from the lower portion of the barrel or to cause them more readily to break free.

In brief, the refrigeration system according to this invention includes an accumulator which has a lower portion for containing a liquid refrigerant and an upper portion for containing refrigerant vapor. Means are pro-

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vided for supplying liquid refrigerant to the lower portion and means are also provided for withdrawing refrigerant vapor from the upper portion. The refrigeration system also includes an evaporator, having a tubular member through which a product to be cooled may be passed, and an outer shell spaced from and enclosing the tubular member, thereby forming a chamber therebetween. Inlet means are disposed on the lower side of the shell and means interconnecting the inlet with the lower portion of the accumulator in fluid flow communication are provided. Outlet means are disposed on the upper side of the shell and means are provided interconnecting said outlet means with the upper portion of said accumulator in fluid flow communication. And a baffle member is mounted on the inside of the shell in spaced relationship with respect to said shell and said member.

A feature of this invention resides in the provision of a new and improved heat transfer apparatus which has a substantially increased efficiency and which has a substantially increased capacity.

Another feature of this invention is the provision of means for sweeping and preventing formation of bubbles of gas along the transfer surface normally encountered with heat transfer apparatus of the character aforementioned.

Additionally, the foregoing means is operable under full flooded conditions and functions solely on the basis of natural flows caused by differences in density within the chamber. Thus, such means may take the form of a baffle which is of simple and practical construction, and which is relatively inexpensive to manufacture.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter which will form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception on which this disclosure is based may readily be utilized as the basis for designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that the claims be regarded as including such equivalent constructions as do not depart from the spirit and scope of the invention.

Several embodiments of the invention have been chosen for purposes of illustration and description, and are shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. 1 is a schematic diagram of a refrigeration system constructed in accordance with the concept of this invention;

FIG. 2 is an enlarged perspective view of the baffle means and an insulating jacket or shell; and

FIG. 3 is a medial sectional view of another embodiment of the invention showing an evaporator including a freezer barrel, an alternate baffle arrangement and an insulating jacket.

In the embodiment of the invention illustrated in FIG. 1, the refrigeration system comprises an evaporator indicated generally at 10 and including a tubular member or freezer barrel 11 through which a product to be cooled may be passed, such as ice cream 13, for example. The barrel is normally cylindrically shaped, as best seen in FIG. 2, and is fabricated from nickel chrome stainless steel. An outer shell or jacket 12 is attached to the barrel 10 at its ends, not shown, to provide an annular chamber or space 14 between the two members for containing refrigerant fluid such as ammonia, for example. The jacket is fabricated from thermal insulating material. A

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vapor outlet 16 leads from the upper portion of the annular space 14 through pipe 18 to a shut off valve 20 disposed in the upper or vapor portion 22 of an accumulator indicated generally at 24. The accumulator further contains a lower float valve 26 which controls the refrigerant liquid inlet 28 which, in turn, leads from a refrigerating liquid supply source, not shown.

In the upper portion of the accumulator 24, there is a pipe line 30 which carries vapor from the top of the accumulator to the compressor, not shown, of the refrigeration system. Various control means are located in this pipe line including a high pressure relief valve 32, a pilot regulator or suction pressure control 34 and a gas operated pressure suction valve regulator 36.

A pipe line 38 connects the bottom of the accumulator 24 with the bottom of the annular space 14, a heater tape 40 being disposed adjacent the evaporator 10. An oil sump 42 and an oil drain valve 44 are located just below the connection between line 38 and the bottom of the annular space, as shown in FIG. 1.

Still referring to FIG. 1, the evaporator 10 further comprises a baffle 46 which is plug welded to the jacket 12 as at 48, leaving limited space between the baffle and the jacket. The baffle extends from a point adjacent the top of the annular chamber to a point close to the bottom of that space. Also, the baffle extends the full horizontal length of the jacket and is provided with an inlet flare 49 to assist the entrance of fluid between the baffle and the shell as will be explained more fully hereinafter. Referring to FIG. 3 there is shown another form of baffle which includes two portions 50 and 52 interconnected as by means of welding 54. This baffle extends from a point adjacent the top of chamber 14 to a point an arcuate distance greater than 180 degrees around the inside of the chamber. Openings 55 are provided at the bottom of the baffle for the return flow of liquid refrigerant. Portion 50 is connected to the jacket 12 by plug welds 56 leaving a small space between the baffle and the jacket and portion 52 is connected to the jacket at its ends, one end being adjacent the connection 54 and the other end being indicated at 58.

In operation, a liquid refrigerant level is maintained in the bottom of the accumulator 24, and this liquid drains into the freezer jacket 12, thus completely immersing the freezer barrel 11. As the liquid refrigerant absorbs heat from the product to be cooled disposed within the freezer barrel some of the refrigerant boils and the resulting vapors are carried into the accumulator 24 through outlet 16 and pipe line 18. While vapor bubbles and foam are in the annular space 14, the liquid in the bottom of the accumulator 24 and in the pipe line 38 leading from the accumulator to the bottom of the annular space 14 will be relatively free of any vapor bubbles. It will be noted that the pipe line 38 acts in effect as one leg of a U tube, the other leg being the annular space 14 and the pipe line 18, and because the gas-free liquid is considerably heavier than liquid containing gas bubbles and foam, the refrigerant in the liquid leg or pipe line 38 will be heavier than the refrigerant in the leg containing the annular space 14, so that the pressure from the liquid level downward on the liquid leg side to the bottom of the annular space 14 will be greater than the pressure difference in the leg containing the annular space up to that same liquid level; such a pressure differential results in a flow, which may be of rather high magnitude, of refrigerant liquid down pipe line 38 into the annular space 14.

As pointed out hereinbefore, the transfer of heat from the freezer barrel 11 to the liquid refrigerant results in the formation of gas, which shows up in the formation of bubbles on the outer wall of the freezer barrel at the point where heat is being transferred to the liquid. It will be appreciated that any bubbles which contact and adhere to the exterior surface of the barrel 11 will substantially reduce the heat transfer coefficient between the barrel contents and the refrigerant. The bubbles formed

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on the exterior surface of the barrel will break loose in accordance with certain factors such as physical properties of the liquid refrigerant, turbulence or currents in the liquids and the angle of the wall on which the bubbles collect.

In the illustrated embodiment, this is achieved by the provision of the baffle 46, FIG. 1, which as pointed out hereinbefore, extends from a point adjacent to the top of the annular space 14 to a point close to the bottom of that space, this baffle being spaced somewhat from the outer jacket 12, and spaced at an even greater distance from the barrel 11.

In a similar manner the baffles 50 and 52 of FIG. 3 extend from adjacent the top of the edge of the space 14 to a point close to the bottom of that space, and likewise this baffle is spaced somewhat from the outer jacket and is spaced at a greater distance from the barrel 11. Since the jacket 12 is ordinarily heavily insulated and the refrigerant does not absorb appreciable heat from the jacket or the baffle itself, bubbles or foam ordinarily will not form between the jacket and the baffle, and, since the baffle extends the full horizontal length of the jacket, it provides in effect a U-shape tube, and again because the fluid between the baffle and jacket is heavier than the foaming fluid between the barrel 11 and the baffle, a flow is induced downwardly along the outside surface of the baffle and upwardly along its inner surface, thus creating currents in the lower portion of the annular space which are effective to remove the bubbles from the lower region of the barrel, that is, with the baffle 46 of FIG. 1, the fluid flows downwardly along the outside surface, around the lower end of the baffle and upwardly between the baffle and the barrel. With the baffles 50 and 52 of FIG. 3 the fluid flows downwardly along the outside of the baffles, through the openings 55 and upwardly between the baffles and the barrel.

It will be appreciated that whenever a bubble is attached to the heat transfer surface, the liquid refrigerant cannot get in to wet the surface until the bubble breaks loose. In other words, the bubble displaces a certain amount of heat transfer surface. The thermal conductivity of the gas filling the bubble is relatively low compared to the thermal conductivity of the liquid so that any heat that can be transferred at the unwetted surface covered by the bubble must be transferred through the gas in the bubble. It is, therefore, desirable for efficiency purposes to have the maximum possible surface area wetted.

If the heat entering the heat transfer surface on the warm side enters slowly, there is poor surface conductance, and if the heat transfer wall, as it usually is, has a high conductivity, the effect of the bubbles reducing the amount of wetted surface is not very noticeable. If, however, as in the case of an ice cream freezer, the conductance from the warm side is extremely high, the effect of the bubbles can be very serious, both in reducing the performance and also resulting in possible unstable conditions, causing temperature fluctuations in the ice cream, both of which being desirable.

From the foregoing description, it will be seen that the present invention contributes a new and improved refrigeration system which has greatly improved heat transfer characteristics and which has increase capacity for a unit of a given size.

Although particular embodiments of the invention are herein disclosed for purposes of explanation, various modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains, reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. In a refrigeration system of the class described, the combination comprising an accumulator having a lower portion for containing a liquid refrigerant and an upper portion for containing refrigerant vapor, means for sup-

plying liquid refrigerant to said lower portion, means for withdrawing refrigerant vapor from said upper portion, an evaporator having a tubular member of substantial diameter through which a product to be cooled may be passed, an outer shell spaced from and enclosing said tubular member to form a narrow annular chamber therebetween, inlet means disposed on the lower side of said shell, means interconnecting said inlet means with the lower portion of said accumulator in fluid flow communication, outlet means disposed on the upper side of said shell, means interconnecting said outlet means with the upper portion of said accumulator in fluid flow communication, a baffle member mounted in spaced relationship between said shell and said tubular member, the space between said baffle and said tubular member being substantially greater than the space between said baffle and said shell, said baffle extending from a point adjacent the top of said chamber to a point close to the bottom of said chamber, said outer shell, baffle member and tubular member being disposed with respect to each other to form in effect a U-shaped tube to induce the flow of said refrigerant downwardly between said baffle member and said jacket and upwardly between said baffle and said tubular member, thereby to introduce a turbulence in the refrigerant adjacent the under surface of the tubular member.

2. In a refrigeration system of the class described, an evaporator comprising the combination of a horizontally disposed tubular member of substantial diameter through which the product to be cooled may be passed, an outer shell spaced from and enclosing said tubular member to form a narrow annular chamber therebetween, inlet means disposed on the lower side of said shell and outlet means disposed on the upper side of said shell, a baffle member mounted in spaced relationship between said shell and said tubular member, said chamber being flooded with refrigerant during the operation of said system, and means for supplying liquid refrigerant to said inlet means and means for removing refrigerant vapor from said outlet means, said outer shell, baffle member and tubular member being disposed with respect to each other to form in effect a U-shaped tube to induce the flow of said refrigerant downwardly between said baffle member and said jacket and upwardly between said baffle and said tubular member, thereby to induce turbulence in the refrigerant adjacent the under surface of the tubular member.

3. A refrigeration system according to claim 2 wherein the space between said baffle and said tubular member is substantially greater than the space between said baffle and said shell.

4. A refrigeration system according to claim 2 wherein said baffle extends from a point adjacent the top of said chamber to a point close to the bottom of said chamber.

5. A refrigeration system according to claim 2 wherein said baffle extends the full horizontal length of said shell.

6. In a refrigeration system of the class described, an evaporator comprising the combination of a horizontally disposed tubular member through which a product to be cooled may be passed, an outer shell spaced from and enclosing said tubular member to form a chamber therebetween, inlet means disposed on the lower side of said shell and outlet means disposed on the upper side of said shell, a baffle member plug welded to the inside of said shell in spaced relationship with respect to said shell and said tubular member, said baffle member having a flared upper portion to assist the entrance of fluid between the baffle and the shell, said chamber being flooded with refrigerant during operation of said system, and means for supplying heated liquid refrigerant to said inlet means and means for removing refrigerant vapor from said outlet means.

7. In a refrigeration system of the class described, an evaporator comprising the combination of a horizontally disposed tubular member through which the product to be

cooled may be passed, an outer insulated shell spaced from and enclosing said tubular member to form a chamber therebetween, inlet means disposed on the lower side of said shell and outlet means disposed on the upper side of said shell, a baffle member mounted in spaced relationship between said shell and said tubular member, the space between said baffle and said tubular member being substantially greater than the space between said baffle and said shell, said baffle extending from a point adjacent the top of said chamber to a point close to the bottom of said chamber, said baffle extending the full horizontal length of said shell, said chamber being flooded with refrigerant during the operation of said system, and means for supplying liquid refrigerant to said inlet means and means for removing refrigerant vapor from said outlet means.

8. In a refrigeration system of the class described, the combination comprising an accumulator having a lower portion for containing a liquid refrigerant and an upper portion for containing refrigerant vapor, means for supplying liquid refrigerant to said lower portion, a float valve for controlling the liquid refrigerant level in said accumulator, compressor means for withdrawing refrigerant vapor from said upper portion, regulator means for controlling the rate of withdrawal of the refrigerant vapor from the upper portion, an evaporator having a horizontally disposed tubular member through which a product to be cooled may be passed, an outer shell spaced from and enclosing said tubular member to form a chamber therebetween, said shell being thermally insulated, inlet means disposed on the lower side of said shell, a pipe line interconnecting said inlet means with the lower portion of said accumulator in fluid flow communication, heating means for heating the fluid passing through said pipeline adjacent said evaporator, outlet means disposed on the upper side of said shell, a pipeline interconnecting said outlet means with the upper portion of said accumulator in fluid flow communication, a baffle member mounted on the inside of said shell in spaced relationship with respect to said shell and said tubular member being substantially greater than the space between said baffle and said shell, said baffle extending from a point adjacent the top of said chamber to a point close to the bottom of said chamber, and said baffle extending the full horizontal length of said shell, said baffle having a flared upper portion to assist the entrance of fluid between the baffle and the shell, whereby a turbulence is induced in the refrigerant adjacent the under surface of the tubular member.

9. In a refrigerating system of the class described, an evaporator comprising the combination of a horizontally disposed tubular member through which the product to be cooled may be passed, an outer shell spaced from and enclosing said tubular member to form a chamber therebetween, inlet means disposed on the lower side of said shell and outlet means disposed on the upper side of said shell, a baffle member mounted in spaced relationship between said shell and said tubular member, said baffle member extending from a point adjacent the top of said chamber an arcuate distance greater than 180 degrees around the inside of said chamber, said chamber being flooded with refrigerant during the operation of said system, and means for supplying liquid refrigerant to said inlet means and means for removing refrigerant vapor from said outlet means, thereby to induce turbulence in the refrigerant adjacent the under surface of the tubular member.

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