

[54] ICE BANK HEAT EXCHANGER

[72] Inventor: Arthur Bernstein, 2636 North Hutchinson Street, Philadelphia, Pa. 19133

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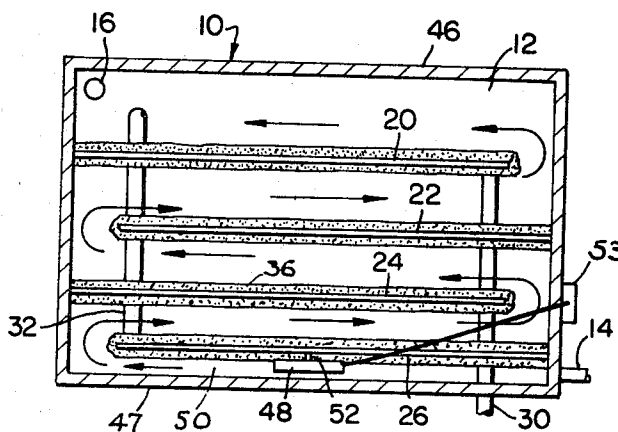
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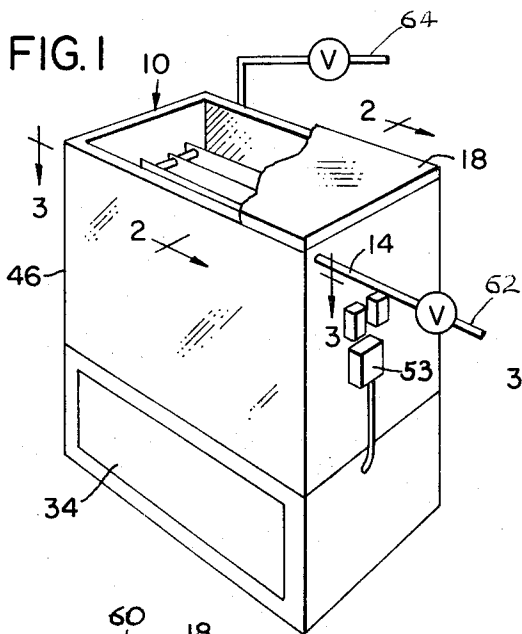
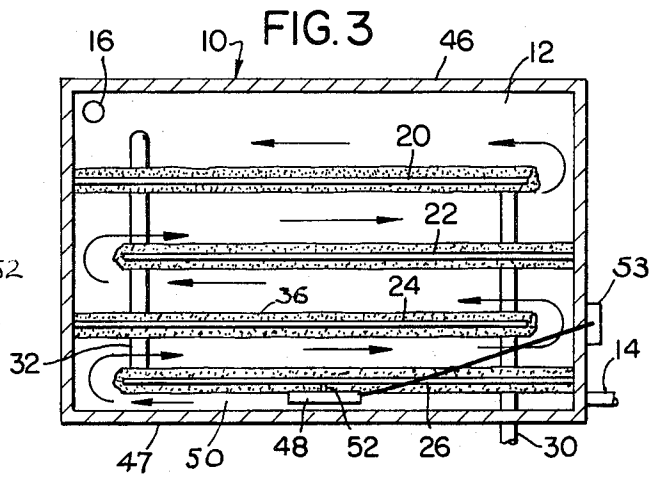
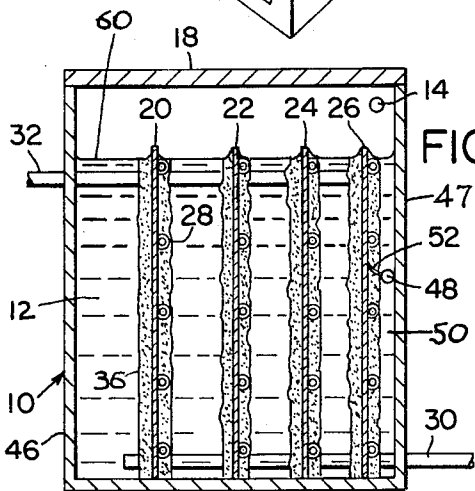
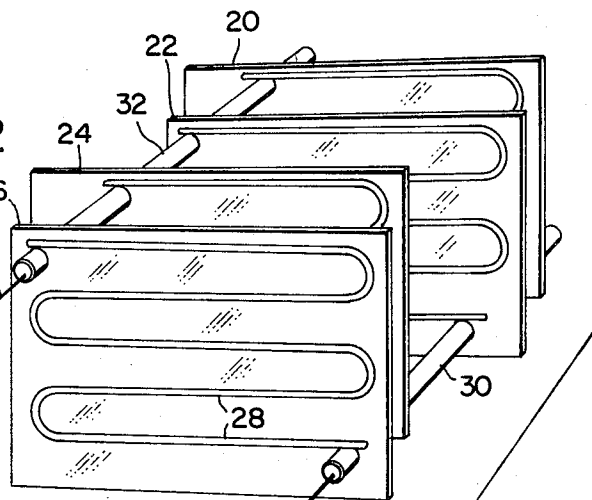
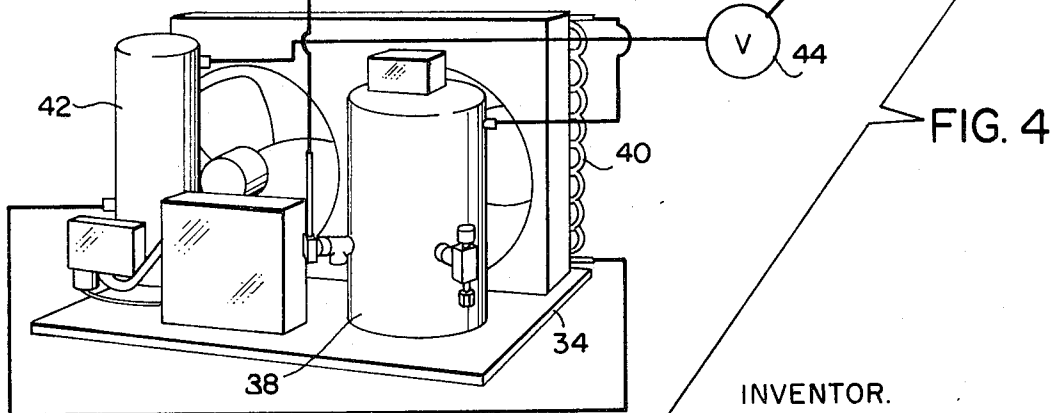
Primary Examiner—William L. Wayner
Attorney—Karl L. Spivak

[57] ABSTRACT

An ice bank heat exchanger including a process water retaining reservoir provided with a hot process water inlet and a water outlet returning cooled water to the process equipment, a refrigeration unit associated with the said reservoir and expanding through evaporator coils contained within the said water reservoir, the evaporator coils being affixed to ice bank plates which are arranged within the reservoir to freeze the stored process cooling water and to provide a serpentine water path therethrough from the hot water inlet connection to the cooled water outlet connection.

1 Claim, 4 Drawing Figures





INVENTOR.
ARTHUR BERNSTEIN
BY

Kurt L. Spivak
ATTORNEY.

ICE BANK HEAT EXCHANGER

BACKGROUND OF THE INVENTION

The present invention relates to an ice bank type of heat exchanger suitable for reducing the temperature of heated process cooling water economically and in an extremely confined area.

In various industrial processes such as dry cleaning, it is necessary to reclaim the solvents or other materials being employed in the equipment such as perchlorethylene or trichlorethylene to thereby facilitate economical process utilization. In the past, it has been customary to reclaim solvents and other materials by means of coils of copper tubing positioned within the equipment to permit relatively cool city water to flow therethrough to cool the heated solvents. Perchlorethylene and trichlorethylene are particularly suited for the service inasmuch as they are non-flammable and have the property to condense sufficiently for reuse from the vaporized state after utilization for cleaning purposes to the liquid state at temperatures below 90° F. Accordingly, normally available city water has usually proved satisfactory for solvent condensing without further cooling. On occasion, however, during extended not weather periods, the ground water has reached temperatures that were sufficiently elevated as to seriously interfere with the cooling process. Such temperatures resulted in great loss in efficiency. Also, it was the usual practice to waste all water used for solvent cooling purposes, thereby providing a system that was further unsatisfactory both from a standpoint of operating economy and also from a standpoint of water conservation.

Normal water reclaiming machinery such as cooling towers and evaporative condensers have been employed by prior workers in the field in an attempt to solve the difficulties above mentioned. However, it was found that these devices were not suitable for use in many dry cleaning establishments for several reasons. Cooling towers are quite bulky in size and require large volumes of air. It has usually been found that the necessary space and air requirements for his type of equipment is not readily available, especially in heavily populated metropolitan area. Additionally, such water cooling equipment must operate throughout the year and accordingly, considerable winterizing costs were encountered by prior workers in those areas subject to freezing temperatures. Such units also provided problems in the summer time in locations subject to excessive heat wherein high wet bulb temperatures would be approaching the top permissible solvent condensing temperatures. Evaporative condensers, when they were employed, incorporated most of the same design problems as encountered with cooling towers with the addition that such equipment greatly increased the initial installation costs.

It has thus become necessary to design a piece of equipment that is capable of eliminating consumption and waste of water and at the same time is capable of producing relatively cool water to increase the efficiency of the solvent reclaiming process. As a design criterion, the equipment must be compact enough to be installed in the work area of crowded plants and must further be capable of operating at high ambient temperatures in the work area under all outside conditions of climate and humidity.

Prior workers in the art have heretofore been unable to design a trouble-free, economical and efficient water cooling unit of a size compact enough to fit within the space available in crowded plants requiring the use of process cooling water.

SUMMARY OF THE INVENTION

Accordingly, the present invention relates to a relatively compact ice bank heat exchanger of the closed circuit type suitable for water cooling purposes under all ambient conditions of temperature and humidity.

In order to conserve space, the present invention includes an insulated reservoir of water which incorporates a refrigerated ice bank capable of freezing a quantity of ice in the retained water. Inlet and outlet water connections commu-

nicate the liquid to be cooled with the interior of the water reservoir and a gasketed cover prevents evaporation of the cooling water. Inasmuch as the heat of fusion of ice is 144 BTU/lb./°F., in contrast to the heat of water above freezing which gives up only one BTU/lb./°F., the storage value of such a refrigerated ice bank reservoir is therefore 144 times as great as that of a given weight of water. Accordingly, an extremely small, efficient water reservoir can thus be employed to achieve the cooling effect of a much larger water type heat exchanger. Additionally, since the process utilizing the vapors being condensed is not normally operated over a 24 hour day period and 7 days a week, the periods of plant down time can be employed for manufacturing ice for utilization during the operating period, thus economically permitting the installation of a smaller compressor and motor.

Ice making plates have been provided within the interior of the water reservoir and the plates are so arranged as to cause the heated process cooling water flowing through the unit to follow an elongated serpentine path between the water inlet and water outlet to thereby prolong contact between the cooling water and the ice to assure adequate cooling. Additionally, because the water delivered from the process equipment to the reservoir inlet is generally warm from the nature of the process, ice at the plates nearest the water inlet melts first to cool the water. As the temperature of the cooling water declines because of the cooling effect of the ice, ice on the remaining plates melts at a declining rate as the plates are spaced further from the water inlet, thereby leaving more ice on the plates furthest from the inlet. Thus, when the unit goes back into the ice making cycle during the off peak hours, continued operation of the compressor would tend to build up more ice on the furthest plates from the water inlet inasmuch as they would have been unequally defrosted. Without the plate spacing compensation, a solid ice build-up between plates could occur, thereby clogging the serpentine water path through the unit. It is a feature of this invention to space the plates furthest from the water inlet a progressively increasing distance apart to thus prevent unequal solid ice build-up by equalizing the equivalent cooling effect between plates.

An ice bank control is provided near the first plate closest to the water inlet and is spaced from the plate to thereby control the thickness of ice-build on the plate to thus furnish the refrigeration unit with a control responsive to the icing conditions within the water reservoir. The uneven spacing of the plates tends to keep the freezing thickness of ice upon the plates approximately equal throughout the unit.

Accordingly, it is an object of the present invention to provide an improved ice bank heat exchanger of the type set forth.

It is another object of the present invention to provide an ice bank heat exchanger capable of economically cooling a water system.

It is another object of the present invention to provide an ice bank heat exchanger of the closed type designed to provide efficient water cooling facilities without loss of water through waste or evaporation.

It is another object of the present invention to provide an ice bank heat exchanger including a completely closed water cooling system incorporating a water reservoir that is internally divided by plates into an elongate water flow path.

It is another object of the present invention to provide an ice bank heat exchanger designed to produce an ice bank during off-peak periods by economically utilizing the smallest possible refrigeration system.

It is another object of the present invention to provide an ice bank heat exchanger incorporating adjustable means to regulate the build-up of ice upon interior plate construction.

It is another object of the present invention to provide an ice bank heat exchanger incorporating a water reservoir and a plurality of ice plates spaced within the reservoir, the spacing between the plates being varied.

It is another object of the present invention to provide an ice bank heat exchanger incorporating a water reservoir and a

plurality of plates spaced within the reservoir, the spacing between the plates being progressively wider the more distant the plates are positioned from the water inlet.

It is another object of the present invention to provide an ice bank heat exchanger that is rugged in construction, simple in design and economical when in use.

Other objects and advantages of the invention will become apparent by referring to the following description and claims of the preferred embodiments thereof, taken in conjunction with the accompanying drawing, wherein like reference characters refer to similar parts throughout the several views and in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of an ice bank heat exchanger constructed in accordance with the present invention, partially broken away to show the internal construction.

FIG. 2 is a cross sectional view taken along Line 2—2 of FIG. 1, looking in the direction of the arrows.

FIG. 3 is a cross sectional view taken along Line 3—3 of FIG. 1, looking in the direction of the arrows.

FIG. 4 is a schematic, perspective view showing the refrigeration system and plates.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Although specific terms are used in the following description for the sake of clarity, these terms are intended to refer only to the particular structure of my invention selected for illustration in the drawings and are not intended to define or limit the scope of the invention.

Referring now to the drawings, I show an ice bank heat exchanger generally designated 10 and including a generally rectangular water reservoir 12 which is preferably interiorly fabricated of non-corrosive material such as stainless steel. Process cooling water inlet and outlet connections 14, 16 communicate with the interior of the reservoir at diagonally opposed locations to facilitate the flow of process water thorough the apparatus for optimum cooling purposes. The reservoir jacket preferably is fabricated of insulated materials to minimize heat loss through the jacket. A tight fitting, gasketed cover 18 encloses the top of the heat exchanger to thereby provide a closed water system to reduce water loss through evaporation to a minimum.

A plurality of corrosion resisting plates 20, 22, 24, 26 vertically position within the reservoir 12 and affix at alternate ends of the reservoir to provide an elongate water path from the water inlet 14 to the water outlet 16 through the unit as best seen by following the arrow path illustrated in FIG. 3. Each plate 20, 22, 24, 26 preferably is formed of aluminum or other corrosion resistant heat conductive material and each plate carries an affixed length of evaporator coil 28 thereon which preferably arranges in a serpentine pattern in well-known manner to uniformly produce ice 36 over the sides of each plate. As best seen in FIG. 4, each refrigerant coil 28 operatively connects between the refrigerant inlet manifold 30 and the suction manifold 32 to thereby uniformly develop a layer of ice 36 upon the sides of each plate.

It is the purpose of this invention to utilize the refrigerant coils 28 in conjunction with the refrigerating unit 34 to build up a bank of ice 36 on the plates 20, 22, 24, 26 during the evening hours when the plant (not shown) is not normally operating. In this manner, a refrigerating unit 34 of the smallest possible size may thus be economically employed for process water cooling purposes. The supply of ice 36 that is produced during the evening hours is then utilized during the day for process water cooling purposes when the plant is normally operated. Inasmuch as ice is equivalent to 144 BTU's per pound per hour for cooling purposes, and 1 pound of water gives up 1 BTU per pound per hour per °F., one pound of ice will then have the equivalent cooling capacity of 144 pounds of water, thus permitting economical utilization of the smallest possible size heat exchanger.

Referring now to FIG. 4, the refrigerating unit 34 comprises a compressor 38 which receives refrigerant from the suction manifold 32. Compressed refrigerant flows from the compressor 38 to the air cooled condenser 40 where heat is expelled to condense the refrigerant from a gas to a liquid in the usual manner and the liquid refrigerant is then directed to the refrigerant receiver 42. The stored refrigerant in the receiver 42 flows to the inlet manifold 30 of the evaporator coils 28 through a thermostatic expansion valve 44 in accordance with well-known refrigerating principles in response to a system control device such as the bulb 48. The coils 28 each connect in parallel across the inlet manifold 30 to the suction manifold 32 to thereby provide uniform cooling effects at each plate 20, 22, 24, 26 throughout the interior of the reservoir 12.

The refrigerating plates 20, 22, 24, 26 discreetly space within the reservoir to provide a serpentine path of water travel from the water inlet 14 through to the water outlet 16 to maximize the contact of the process cooling water 60 with the ice 36 to assure adequate cooling during the course of water travel through the unit 10. It should be noted that the water introduced at the inlet connection 14 is warm after removing heat from the plant process and accordingly, the elevated water temperatures will melt the ice at the plates closest to the water inlet 14 more rapidly when the process water is being cooled during its serpentine path through the reservoir 12. As the process water cools upon contact with the ice 36 which has formed on the plates 24, 26, ice on the plates furthest from the inlet 14 will be melted at a declining rate because of the drop in process water temperature as it flows past the plates. More ice will thus remain on the plates furthest from the inlet 14. Continued operation of the compressor 38 to rebuild the ice bank on the plates 24, 26 closest to the water inlet 14 would tend to build an increasing thickness of ice on the plates furthest from the water inlet which had unequally defrosted. Such a condition could result in the build-up of a solid freeze of ice between the plates 20, 22 or between the plate 20 and the reservoir side wall 46 to thereby interfere with normal water passage through the heat exchanger 10.

Accordingly, I have found that this problem may be readily compensated by varying the spacing between the individual plates within the heat exchanger 10. Thus, as best seen in FIGS. 2 and 3, the plates 20, 22 furthest from the water inlet 14 are spaced an increasingly greater distance apart both from each other and from the reservoir side wall 46. Thus, for example, should the plates 20, 22 have a tendency to build up a greater thickness of ice, the greater distance between the plate 20 and the unit side wall 46 and the distance between the plates 20, 22, will permit a greater build-up of ice without completely clogging the serpentine water path through the unit from the water inlet 14 to the water outlet 16.

An ice bank control bulb 48 of conventional design to sense contact with ice mounts upon the plate 26 and extends into the space 50 between the plate 26 and the reservoir side wall 47 by means of the bendable supporting bracket 52. The ice bank control bulb 48 wires into the compressor operating circuit at the junction box 53 to stop the refrigeration unit 34 upon sensing the build-up of a predetermined thickness of ice 36 upon the plate 26. The thickness of the ice build-up may be readily regulated by simply bending the bracket 52 to hold the control bulb 48 either nearer or further from the plate 26.

In order to use my invention, a completely closed process water path is constructed by conducting heated water from the process (not shown) to the reservoir water inlet 14 by means of the inlet piping 62 and connecting cooled water from the reservoir outlet 16 back to the process through the outlet piping 64 for introduction to the equipment being cooled. If desired, a process water pump may be furnished with the ice bank heat exchanger to thereby provide a completely self-contained operating unit. The process water 60 is directed through the heat exchanger 10 wherein it follows an increasingly widening path between the plates 20, 22, 24, 26 from the inlet 14 to the outlet 16. A gasket cover 18 completes the closed water system and serves to prevent loss of water by evaporation at the heat exchanger 10.

Process water 60 is introduced into the reservoir 12 to a controlled depth less than the height of the evaporator coil plates 20, 22, 24, 26 and the refrigeration unit 34 activates to cool the water 60. Operation of the compressor unit 38 during periods of plant inactivity when no water flows through the reservoir 12 provides sufficient cooling at the coils 28 to freeze the water adjacent the plates 20, 22, 24, 26 to thus build up a bank of ice 36 on each side of each plate. The thickness of ice may be precisely regulated by varying the distance of the ice sensing bulb 48 from its associated plate 26. The bulb 48 should position to control the expansion valve 44 to close before there is a complete ice blockage between plate 26 and the reservoir side wall 47 which is adjacent the water inlet 14 or between the pair of plates 20, 22 most remote from the water inlet 14.

The ice sensing bulb 48 preferably positions in the space 50 which initially receives the heated process water from the inlet 14, thus causing ice at the bulb 48 to melt first. In this manner, the sensing bulb functions to activate the refrigeration system 34 immediately upon initiation of melting within the reservoir 14 to retard the rate of ice disappearance. Accordingly, the refrigeration unit 34 functions during the off peak hours to build up an ice bank for water cooling purposes and further functions during the plant operating periods to retard the ice melting rate by tending to freeze additional quantities of ice.

It should be noted that the process water 60 itself is utilized to freeze to form the ice bank 36. When the ice 36 is melted by the warmed process water, the water from the melt mixes with the process water and is recirculated therewith. Thus the same water supply serves the dual purpose of cooling the process equipment and also of supplying the necessary water for the build-up of the ice bank.

I claim:

1. In an ice bank heat exchanger suitable for cooling previously heated water of the type including a refrigeration system to build up a supply of ice within the unit on plates positioned

therewithin, the combination of

- A. a water storage reservoir receiving the said heated water and including a bottom and a pair of spaced sides and a pair of spaced ends which define an interior space,
 1. said reservoir being provided at one end thereof with a heated water inlet and at the other end thereof with a cooled water outlet;
- B. a plurality of evaporator plates positioned within the interior space and extending vertically from the said bottom,
 1. said plates positioning in vertical planes parallel with the reservoir sides,
 2. said plates forming substantially water tight connections with the reservoir bottom,
 3. each plate being generally rectangular in shape and having a connected edge and a free edge,
 - a. the said connected and free edges defining a lateral distance less than the distance between the ends of the reservoir,
 - b. the connected edge of each plate affixing to one end of the reservoir in a substantially water tight connection,
 - c. the said plate connected edges being staggered alternately from end to end of the reservoir to form a serpentine water path through the reservoir from the water inlet to the water outlet,
 4. the horizontal spacing between adjacent plates increasing as the plates position further from the said water inlet; and
- C. a refrigerant system control associated with the first plate positioned closest to the water inlet,
 1. said control stopping the refrigeration system upon the build-up of a predetermined thickness of ice upon the said first plate.

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