A self contained air cooling unit, comprising: a refrigeration circuit, the condensing system of which is located in the space to be cooled; a thermal reservoir consisting of an ice bank contained in a flexible tank and in heat exchange relationship with the cooling system of the refrigeration circuit, a circulating system in communication with the ice bank and including a heat exchanger located in the space to be cooled for exchanging heat from the air in the space to chilled water circulated through the heat exchanger from the ice bank by means of a pump, a fan for circulating air in the space both through the heat exchanger and through the condensing system of the refrigeration circuit; and means for selectively and alternatively operating the refrigeration circuit and the circulating system to heat or to cool the space as desired.

9 Claims, 3 Drawing Figures
This invention relates to an air cooling unit, and in particular to a self contained and portable air cooling unit for use in domestic, commercial and industrial premises.

The principle of removing heat from a defined space by circulating air through a heat exchanger arranged to transfer the heat to a chilled water circuit, or, alternatively, by transferring the heat through a heat exchanger by vapourising liquid refrigerant injected on the tube side of a finned liquid to air heat exchanger, is well known. In the case of the chilled water system the low temperature water required for the heat transfer is usually provided by a separate plant situated remote from the air circulating and heat exchange unit. This separate water chilling unit in turn comprises a reservoir tank, and water pump or circulator for circulating the cooling medium from the reservoir to the heat exchanger in the space to be cooled, and a refrigeration circuit which includes a water chilling heat exchanger, a refrigeration compressor, a condenser, a refrigerant receiver, an expansion valve for determining the refrigerant evaporating temperature, and an electrical control circuit. For the direct expansion system, the refrigeration circuit may be remotely situated or mounted in a cabinet together with the air circulating and heat exchange unit.

The limitations of such existing systems are that the heat removed from the space and transferred to the cooling fluid requires the use of interconnecting pipe work between the condensing unit or water chilling unit or, in the case of the self contained unit water supply and return pipes, or, alternatively, a source of external air supply for the condenser. In all such systems some form of installation is required and none are portable.

The present invention provides a portable self contained air cooling unit for removing heat from a space when required without the use of external pipe work or duct work or an external source of air for ventilation of the refrigeration unit. The only external power source required will be an electrical supply.

The invention consists in a self contained air cooling unit, comprising: a refrigeration circuit the condensing system of which is located in the space to be cooled; a thermal reservoir for containing a thermal mass of heat exchange liquid in heat exchange relationship with the cooling system of the refrigeration circuit; means providing heat exchange communication between the space and the reservoir and including a heat exchange configuration in the space to be cooled; means for circulating air in the space in heat exchange contact with the heat exchange configuration; and means for selectively and alternatively operating the refrigeration circuit and the provision of heat exchange communication between the space and the reservoir to heat or to cool the space respectively.

In a particular preferred arrangement there may be provided a circulating system in communication with the reservoir and including a heat exchanger located in the space to be cooled for exchanging heat from the air in the space to the heat exchange liquid together with means for circulating the heat exchange liquid through the heat exchanger.

Accordingly, in the preferred arrangement, the invention consists in a self contained air cooling unit, comprising: a refrigeration circuit the condensing system of which is located in the space to be cooled; a thermal reservoir for containing a thermal mass of heat exchange liquid in heat exchange relationship with the cooling system of the refrigeration circuit; a circulating system in communication with the reservoir and including a heat exchanger located in the space to be cooled for exchanging heat from the air in the space to the heat exchange liquid together with means for circulating air in the space around the heat exchanger; and means for selectively and alternatively operating the refrigeration circuit and the circulating system to heat or to cool the said space respectively.

The operation of the refrigeration circuit and the circulating system will usually be controlled automatically by means of a time clock. The automatic operation of the time clock can be overridden manually, if desired.

In a preferred embodiment the thermal reservoir is an ice bank, but may comprise another fluid or material having suitable properties for thermal accumulation, for example a eutectic composition or a volume of chilled water at a temperature lower than that of the space to be cooled. The ice bank is preferably held in a flexible tank in which is located the evaporator of the refrigeration system.

The heat exchanger for cooling the space will usually consist of an air cooling coil arranged in the space and through which chilled water is circulated from the ice bank. Advantageously the heat exchanger is an extended fin liquid to air type through which chilled water is passed through the tube side while air from the space to be cooled is circulated over the fin side. The water in contact with the ice bank or other thermal storage media is usually circulated by means of a submerged pump or circulator located in the flexible tank. The refrigeration circuit will usually be a regular refrigeration circuit and comprise a refrigeration compressor, a condenser arranged in the space to be heated or cooled, a liquid receiver, an expansion valve, and an evaporator which in the preferred embodiment referred to above consists of an ice forming coil arranged in the thermal reservoir.

The means for circulating air in the space around the heat exchanger will usually be a fan, and, in a preferred construction, a single fan is arranged to circulate air both through the heat exchanger and the condensing system of the refrigeration circuit. Thus, in a preferred embodiment, the cooling unit is provided with two circuits, one circuit comprising the refrigeration system for freezing the water to form the ice bank and, additionally, as a by product to provide heating in the space by using heat rejected from refrigeration condenser, and the other circuit comprising the chilled water circulation system for cooling the space during the cooling phase. The heat exchanger for cooling the air and the refrigeration condenser are contained in separate circuits but are constructed in a single unit thus allowing a single fan to circulate air to both circuits.

The unit is primarily intended to provide space cooling; however, the heat from the refrigeration condenser rejected during the regeneration cycle, which is a by-product of the refrigeration process, can be usefully used for space heating in many instances when both heating and cooling are required at different times. For
example in climates with high day and low night temperatures cooling is generally required for known periods of the day and during the night there is usually a need for heating.

The heating phase is satisfied by removing the heat from the quantity of water held in the thermal reservoir by means of the regular refrigeration circuit. The heat so removed is passed into the space by means of the condensing process of the refrigeration system. During this heating phase the reduction in water temperature will change the state of the water into ice until at the end of the heating phase the water has nearly all frozen.

To provide cooling the water in contact with the ice bank previously formed during the heating phase is circulated by means of the pump or circulator into the heat exchanger coil of the chilled water circulation system, the water now heated by the cooling process being returned into contact with the ice bank thereby gaining the heat gained by melting a quantity of the ice. Cooling is thus available until the ice is fully melted.

The invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic diagram of an air cooling unit;

FIG. 2 is a schematic side view of the air cooling unit of FIG. 1; and

FIG. 3 is an enlarged view of a detail of the cooling unit shown in FIG. 2.

The air cooling unit shown in the drawing is intended primarily for cooling a space 1, and essentially comprises a chilled water circulation system 2 communicating with an ice bank 3, and a refrigeration system 4 for depositing ice in the ice bank. The refrigeration system 4 itself comprises a condenser 5 arranged in the space 1, a liquid receiver 6, an expansion valve 7, an ice forming coil 8, and a compressor 9, connected in sequence by pipework 10. The ice forming coil 8 is contained in a flexible tank 11 which holds the chilled water to be passed through the circulation system 2.

The circulation system 2 incorporates an air cooling coil 12 arranged in the space 1 and communicating with the ice bank 3 through pipework 13. Chilled water is passed through the circulation system by means of a submerged pump or circulator 14 arranged in the tank 11.

A fan 15 is provided in the space 1 for circulating air both through the condenser 5 of the refrigeration system 4 and the air cooling coil 12 of the circulation system 2.

The direction of flow of the refrigerant through the refrigeration system 4 and of the chilled water through the circulation system 2 is indicated by arrows 16 and 17 respectively. The air cooling unit is contained in a cabinet 18. In the side walls of the cabinet there are provided grills 19 through which air may be drawn into the unit, and in the top of the unit there is a grill 20 through which air is passed from the unit into the space 1.

Ice is formed and deposited in the ice bank by operation of the refrigeration system 4 to heat the space 1. The refrigerant is pressurized by the compressor 9 and passed through a pipe situated in the ice bank. The pipe is installed in close proximity to the inlet of the submerged pump and to the outlet pipe of the pump. The purpose of feeding the hot gas through the ice bank in close proximity to the water pump is to prevent the water freezing in this area and preventing the circulation of water. The hot gas is then passed to the space 1 where it is condensed in the condenser 5 and its heat removed and given off into the space 1. The condensed refrigerant is then passed via the liquid receiver 6 and expansion valve 7 through the ice forming coil 8 where it evaporates. Evaporation of the refrigerant absorbs heat from water held in the tank 11, the reduction in water temperature changing the state of the water into ice until at the end of the operation of the refrigeration system nearly all the water in the tank has frozen.

To cool the space 1 the water in contact with the ice bank 3 formed by the previous heating of the space as described above is circulated by means of the pump 14 through the heat exchanger coil 12 through which the air in the space is circulated by the fan 15. Heat is absorbed by the circulating chilled water thus cooling the space, and the heated water is returned into contact with the ice bank where it loses the heat gained by melting a quantity of ice. Chilled water is available for cooling the space until all the ice is fully melted.

The periods of cooling and ice regeneration by heating the space may be operated automatically by means of a time clock 21; the automatic operation of the time clock 21 can be overridden to provide immediate cooling of the space for a reduced period when required.

If the cooling unit is required for domestic use, for example, the tank 11 is suitably constructed to contain approximately 30 gallons of water. The unit may then be arranged to operate on a 24 hour cycle so that cooling will be provided during the daytime and the ice bank regenerated during the night time, giving off heat as a by-product. Such a unit would require approximately 16 hours to fully regenerate the ice bank, and after regeneration may be automatically switched over to cooling by the time clock when it will then provide 6 to 7 hours of cooling. The fan 15 may be provided with a two position switch to provide two capacities of cooling, the unit operating on the cooling cycle for a longer period of time on the minimum cooling rate than on the maximum cooling rate. For example the unit may provide 6 hours of cooling at maximum fan capacity or 7 hours of cooling at low fan capacity.

As indicated above, manual adjustment of the time clock will enable the user to switch to cooling or regeneration whenever required. In approximate terms, 2½ hours of regeneration will provide approximately 1 hour of cooling.

I claim:

1. A self contained air cooling unit, comprising: a refrigeration circuit, the condensing system of which is located in the space to be cooled; a thermal reservoir for containing a thermal mass of heat exchange liquid in heat exchange relationship with the cooling system of the said refrigeration circuit, means providing heat exchange communication between the said space and the said reservoir including a heat exchange configuration in the space to be cooled; means for circulating air in the said space in heat exchange contact with the said heat exchange configuration; means for selectively and alternatively operating the refrigeration circuit, the provision of heat exchange communication between the said space and the said reservoir to heat or to cool the said space respectively, and wherein a part of the refrigeration circuit downstream of the refrigeration compressor is located in the thermal reservoir and adja-
3,822,561

2. A self contained air cooling unit, comprising: a refrigeration circuit, the condensing system of which is located in the space to be cooled; a thermal reservoir for containing a thermal mass of heat exchange liquid in heat exchange relationship with a cooling system of the said refrigeration circuit; a circulating system in communication with the said reservoir and including a heat exchanger located in the space to be cooled for exchanging heat from the air in the said space to the said heat exchange liquid together with means for circulating the said heat exchange liquid through the heat exchanger; means for circulating air in the said space around the said heat exchanger; means for selectively and alternatively operating the said refrigeration circuit and the said circulating system to heat or to cool the said space respectively, and wherein a part of the refrigeration circuit downstream of the refrigeration compressor is located in the thermal reservoir and adjacent the said means for circulating the heat exchange liquid.

3. A cooling unit as claimed in claim 2 wherein the said thermal reservoir is a flexible tank for containing a mass of ice and in which is located the evaporator of the said refrigeration circuit.

4. A cooling unit as claimed in claim 3 wherein the said evaporator is an ice forming coil arranged in the said thermal reservoir.

5. An air cooling unit as claimed in claim 2 wherein the said means for circulating air is a fan.

6. An air cooling unit as claimed in claim 5 wherein a single fan is arranged to circulate air both through the said heat exchanger and through the said condensing system of the refrigeration circuit.

7. An air cooling unit as claimed in claim 2 wherein said means for selectively and alternatively operating the said refrigeration circuit and the said circulating system comprises a time clock for automatically operating the refrigeration system and the circulating system.

8. An air cooling unit as claimed in claim 7 further comprising means provided for manually overriding the operation of the time clock to provide immediate cooling for a reduced period.

9. An air cooling unit as claimed in claim 2 wherein the said means for circulating the heat exchange liquid is a pump located in the thermal reservoir.

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