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(54) Energy conserving heat exchange apparatus for refrigerating machines, and refrigerating machine equipped therewith.

(57) For an ice making machine including a refrigeration unit (11) there is provided a water-to-refrigerant heat exchange condenser (12) connectible to an external water supply (13, 14) for heating water therein. The heat exchange relation between the refrigeration unit (11) and the external water supply is determined by a control system (26, 28, 30) which is responsive to both refrigerant pressure at the condenser refrigerant outlet (12b), and the water temperature at the condenser water outlet (12d) for controlling water flow through the condenser while maintaining a pre-determined optimum range of refrigerant pressures in the heat exchanger (12).

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ENERGY-CONSERVING HEAT EXCHANGE APPARATUS FOR
REFRIGERATING MACHINES, AND REFRIGERATING
MACHINE EQUIPPED THEREWITH.

The present invention relates generally to refrigerat-
ing machines, and more particularly to a commercial cube/
5 crushed ice-making machine.

It has long been known that there is substantial
heat rejection from a condenser in a conventional refriger-
ation unit consisting serially of a compressor, condenser,
expansion valve and evaporator. Various devices and systems
10 have been employed in attempts to utilise the rejected heat
for purposes of heating fluids such as water and air.
Embodiments of specific refrigeration systems and specific
heat applications therefor are disclosed in the following
United States Letters Patents; 3,926,008; 4,041,726;
15 3,922,876; 3,358,469; 3,513,663; and 2,739,452. Further,
most heretofore known commercial ice-making machines with
a capacity approximating 150 - 500 kgs. of ice per day have
utilized air-cooled condensers, rather than more efficient
water-cooled condensers, because an air-cooled condenser
20 is cheaper and less bulky.

Recent worldwide increases in fuel and energy
costs have created a need for expanding the use of
heat conservation and heat reclamation

systems, with specialized refrigeration systems not heretofore considered for such use.

Additionally, the prior known energy conservation systems which have been combined with
5 refrigeration units have heretofore included controls which were responsive to changes in the temperatures of the refrigerant being cooled and the fluid being heated. While the temperature of the fluid being heated is an important parameter for control purposes,
10 the temperature of the refrigerant in the condenser is important, but only secondarily to the efficiency of the refrigeration system. A prime factor in refrigeration efficiency is an optimum (not a maximum) pressure drop across the thermal expansion valve.
15 None of the energy conservation systems heretofore known have disclosed a control system which optimizes the efficiency of the refrigeration unit while providing a controlled transfer of heat energy from the refrigeration condenser to an external air or
20 water supply.

We have noted that a substantial number of commercial ice-making machines are permanently installed for use in buildings such as motels, hotels, restaurants, etc. in close proximity
25 to external water supplies in those buildings, and have realized that in certain installations a refrigerant to water condensor may be used in a commercial ice-making machine and combined with or

tapped into an adjacent external water supply to provide added efficiency to the ice-making machine and, at the same time, save energy by acting as a secondary heat source for the external water supply.

5 It is one object of the present invention, generally stated, to provide for a refrigerating system having improved efficiency by including a heat reclaiming heat exchanger for heating an external water supply and an automated control for that heat exchanger.

10 The control system is responsive to a refrigerant pressure in the condenser so as to maintain it at an optimum efficiency for the refrigeration system, as well as to the output water temperature from the condenser.

 More specifically, a refrigerator or ice-making
15 machine has a closed loop refrigeration system including in series therein: a compressor, a refrigerant-to-water condenser whereby heat rejected from the closed loop system is transferred to the heat reclamation means through the condenser, an expansion valve, and an evaporator. The
20 machine includes a control system having means responsive to both a refrigerant pressure in the condenser and a water temperature in the condenser for controlling heat exchanging water flow through the condenser while maintaining a pre-determined refrigerant pressure therein.

This invention may best be understood by reference to the following description of presently preferred embodiments thereof taken in conjunction with the accompanying sheets of drawings, in which:-

5 Figure 1 is a perspective view of an ice-making machine including an embodiment of heat reclamation device operatively connected to an external water supply.

10 Figure 2 is a perspective view of a modification of the heat reclamation device shown in Figure 1 including the addition of a hot water heater thereto.

Figure 3 is a schematic diagram of the embodiment of refrigeration system, heat reclamation means, and a portion of an external water supply shown connected for operation, and

15 Figure 4 is a fragmentary diagrammatic view of a water-cooled secondary condenser which may be substituted for the air-cooled secondary condenser shown in Figure 3.

Referring to Figures 1 and 3, an ice-maker and heat reclamation system constructed in accordance with the
20 present invention, and generally indicated at 10, includes

a commercial ice-maker 11 such as sold under the trademark ROSS-TEMP, and an indirect heat reclamation device which is a refrigerant-to-water condenser 12 which is conventional in itself and which, in this embodiment, is positioned
5 externally of the ice-maker. The condenser 12 is preferably connected to a conventional external-water supply which, in this embodiment, is shown to include a water pump 13 and a hot water storage tank 14 connected in series with the coolant side of the condenser 12.

10 While any commercial ice-maker may be utilized in the system of the present invention, two commercial ice-making systems (neither shown) are

ideally suited for use with the heat reclamation system of the present invention. In the first type, a layer of ice is formed on the bottom of a working sheet or plate. When the layer of ice has achieved a sufficient thickness, it is separated from the plate and dropped onto a heated grid or matrix. As the sheet of ice passes through the matrix, it is divided into ice cubes thereby. The second type of commercial ice-maker utilizes a hollow cylinder with ice being formed on an exterior surface thereof. An auger or the like is sleeved over the evaporator and includes a helical working edge which sweeps across the hollow cylindrical surface to shave ice therefrom in order to create "crushed" ice.

As shown most clearly in Figure 3, the refrigeration system of the ice-maker 11 includes a conventional refrigerant compressor 15 having a high pressure exhaust port 15a which is connected by conduit 16a to refrigerant inlet port 12a of the heat reclamation condenser 12. The refrigerant outlet port 12b is connected by conduit 16b to a secondary air-cooled condenser 17 having a cooling fan 18 and a fan control switch 18a associated therewith. A refrigerant receiver or accumulator 19 is operatively positioned between the secondary condenser and a thermal expansion valve 20 by conduits 16c and 16d. A conventional evaporator 21 and conduit 16e are

downstream of the valve and operatively connected via conduit 16f to a low pressure inlet port 15b of the compressor. It can be appreciated that for ease of adaptability, the air-cooled secondary condenser 17 may be the original equipment condenser for the separate ice-maker. If the refrigerant-to-water condenser 12 is mounted within the physical confines of the ice-maker 11, it is understood that it could be sized to completely replace the secondary air-cooled condenser 17. The purpose of the secondary condenser will be discussed in connection with the operation of the system. In the embodiment shown in Figures 1 and 3, the water supply includes a pump 13 which receives water from an inlet conduit 22 and pumps same through outlet conduit 23 to the water inlet port 12c of the refrigerant-to-water condenser 12 where the water is positioned in heat exchange relation with the high pressure refrigerant and passes out water outlet port 12d, through temperature actuated sensor 30, and conduit 24 to the hot water storage tank 14 where the water may be discharged through conduit 25.

Depending upon the circumstances surrounding an individual installation, i.e., the size and amount of use of the ice-maker, and the size and use of the external water supply, the condenser 12 may act as a primary or secondary heating source for the water supply. However, since the control

system, to be discussed in detail below, does not provide for operation of the compressor if the ice machine is filled to capacity, it is assumed that in most installations the condenser 12 will act as only a secondary heat source for the water supply.

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In accordance with one aspect of the invention, the flow of water from pump 13 into the refrigerant-to-water condenser 12 is regulated by a valve 26 which acts in response to the pressure of the refrigerant at outlet 12b of the condenser. The operational pressure of the refrigerant proximately ranges from about 100 psig to about 160 psig as discussed in more detail hereafter. Additionally, a condenser bypass conduit 27 which bridges between the refrigerant inlet and outlet ports 12a, 12b, respectively, of the condenser 12 includes a solenoid operated valve 28 therein which is actuated by a temperature sensor 30 positioned adjacent the water discharge port 12d of condenser 12. Valve 28 is a fail-safe valve which, in this embodiment, shuts off the heat exchanging condenser if water usage is so minimal that the water temperature reaches a severely high level.

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In operation, when the ice machine compressor 15 is initially turned on, the pressure regulation valve 26 controls the flow of water through the condenser 12 to maintain a preset pressure, in this embodiment approximately 100-120 psig, at the outlet port 12b of condenser 12. If the initial temperature of the water is about ^{17.5°C} ~~100°F~~, water flow through the condenser will be minimized such that

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the water exit temperature therefrom approximates ^{38°C}~~100°F~~. The refrigerant temperature at outlet port 12b may then approximate ^{27°C}~~80°F~~.

Depending upon the size of the external water system, as the inlet water temperature rises, valve 26 gradually opens to allow greater water flow through the condenser 12 in order to maintain the pre-determined refrigerant pressure at the condenser outlet 12b. In the embodiment shown, the water flow through the condenser will be at its maximum when the inlet water temperature is approximately ^{39°C}~~100°F~~ or above. As long as the temperature in the water supply is approximately ^{33°C}~~100°F~~ or less, the refrigerant may be maintained at approximately ^{49°C}~~120°F~~ and 120 psig, and all of the heat rejected from the ice machine is absorbed into the water system. This heat includes the sensible heat from superheating the refrigerant vapor, the latent heat from condensing the refrigerant, and the sensible heat from subcooling the refrigerant liquid. Also since a water-cooled condenser has been utilized, the refrigerant discharge pressure has been lower than the usual discharge pressure achieved when solely using an air-cooled condenser. With the high pressure refrigerant being an optimal value, which is lower than achievable with an air-cooled condenser, the machine has been operating more efficiently than heretofore-known ice machines of comparable size.

In the embodiment shown, as the water ^{38°C} ~~180°F~~ ^{43°C} ~~110°F~~ ^{45°C} ~~120°F~~ ^{52°C} ~~125°F~~ ^{53°C} ~~125°F~~

the external water supply rises in temperature above ~~180°F~~ to approximately ~~110°F~~, the temperature or

pressure of the refrigerant will be sufficiently

high (approximating ~~120 psig~~ and 106 psig) to actuate

the switch 18a and turn on the motor 18 of the air-

cooled secondary condenser 17. Until such time as

the inlet water temperature of water supply reaches

approximately ~~125°F~~, the switch 18a cycles the fan

on and off at approximately two-minute intervals..

The additional condenser capacity in this embodi-

ment acts to lower the refrigerant pressure to a

satisfactory level approximating 120 psig, but never-

theless, to a level which is higher than the discharged

pressure when the refrigerant-to-water condenser 12

was the sole heat rejection means in the system.

However, since the refrigerant-to-water condenser

is still in the system, the refrigerant high side

pressure is still lower and closer to optimum

than if an air-cooled condenser alone were present

in the system; thus, the system is still more efficient

than a system solely using an air-cooled condenser.

When the external water system temperature reaches

approximately ~~125°F~~, the dual condensers can no

longer lower the refrigerant pressure to 120 psig and

the air-cooled condenser motor 18 begins to run

constantly rather than cyclicly. With the air-cooled

condenser fan on constantly, the heat transferred

to the water in the condenser 12 through desuper-

heating will be added at a lower rate than previously

described.

When the condenser outlet water temperature in this embodiment reaches a preset maximum, approximating ^{81°C}~~180°F~~, the sensor 30 actuates the solenoid 28 to open the bypass line 27 allowing most of the hot refrigerant vapor to pass directly to the air-cooled condenser 18. Thus, heating in the external water system is stopped although the ice machine may continue to function. An additional safety sensor 32 at the hot water storage tank 14 is capable of stopping the operation of the compressor 15 if the water temperature in the tank reaches an unsafe temperature, approximating ^{93°C}~~200°F~~. It should be noted that during normal operation both hot water usage and actual ice usage will, to some extent, determine the operation of the heat reclaiming device. During normal operating hours, when both the ice machine and hot water system would be in use, the condenser 12 would be of sufficient size to handle all heat rejected by the ice machine. If the use of the external water supply should drop substantially or stop, in connection with an embodiment having a secondary air-cooled condenser, it may be expected that the secondary condenser would run in its cyclic phase during such extreme circumstances.

Referring to Figure 2, in a second embodiment of the present invention, the hot water storage tank 14, in accordance with another aspect of the

invention, serves as a pre-heater which is positioned in the hot water system in parallel with a conventional hot water heater 44 such that the water supply inlet conduit 45 directs water into the storage tank where that water is mixed with heated water already in the tank. There are two discharge conduits from the hot water storage tank 44a, a first conduit 46 feeding the water pump 13, and a second conduit 47 feeding the water heater 44 which has a conventional discharge conduit 48. Operation of this system is similar to the operation described above in connection with the first embodiment.

Referring to Figure 4, a modification of the system shown in connection with Figure 3 may include a second independent water-to-water condenser 40 or a second stage of condenser 12 may be positioned in the refrigeration unit to replace the air-cooled condenser 13. The water-cooled secondary condenser 40 would operate in a manner similar to air-cooled condenser 13 in that the pressure regulating valve 41 would not turn on a separate water cooling system, indicated by inlet conduit 42 and outlet conduit 43, until the primary refrigerant-to-water condenser 12 was operating at full heat reclaiming capacity.

Thus, the commercial ice-maker and heat reclamation device combination of the present invention provides an efficient means of reclaiming the heat rejected from the refrigeration cycle of a

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commercial ice-making machine and transferring same to an external hot water supply. Not only does the system of the present invention provide an additional refrigeration device from which heat may be reclaimed, but the use of a refrigerant-to-water condenser in a commercial ice-maker coupled with a control system which is responsive to refrigerant condenser outlet pressure rather than temperature provides added efficiency to the commercial ice-making device while, at the same time, reclaiming the heat rejected from the refrigerant cycle.

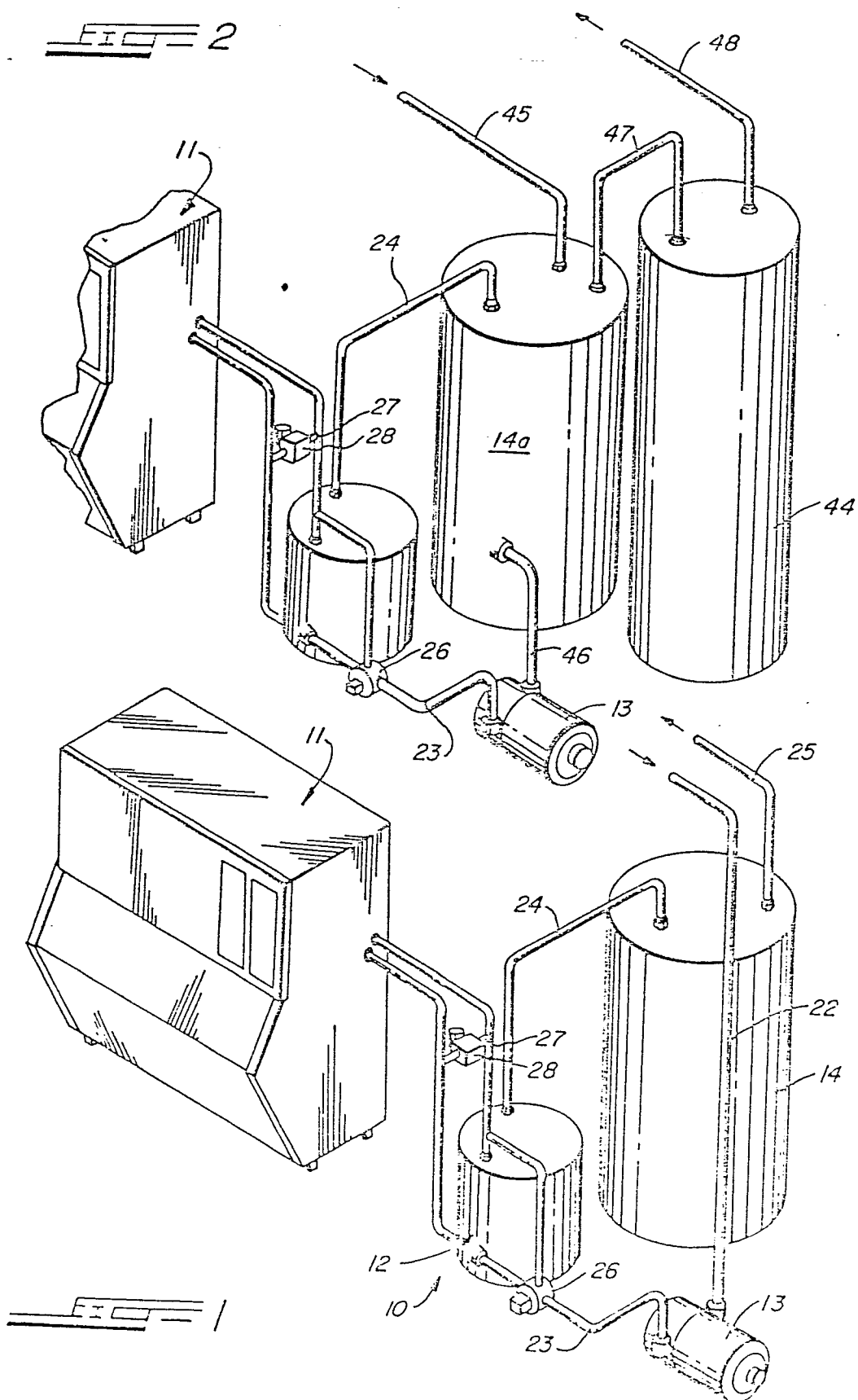
While three particular ~~embedments~~ and variations of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects. ~~Therefore, the aim in the appended claims~~ is to cover all such changes and modifications as may fall within the true spirit and scope of the invention.

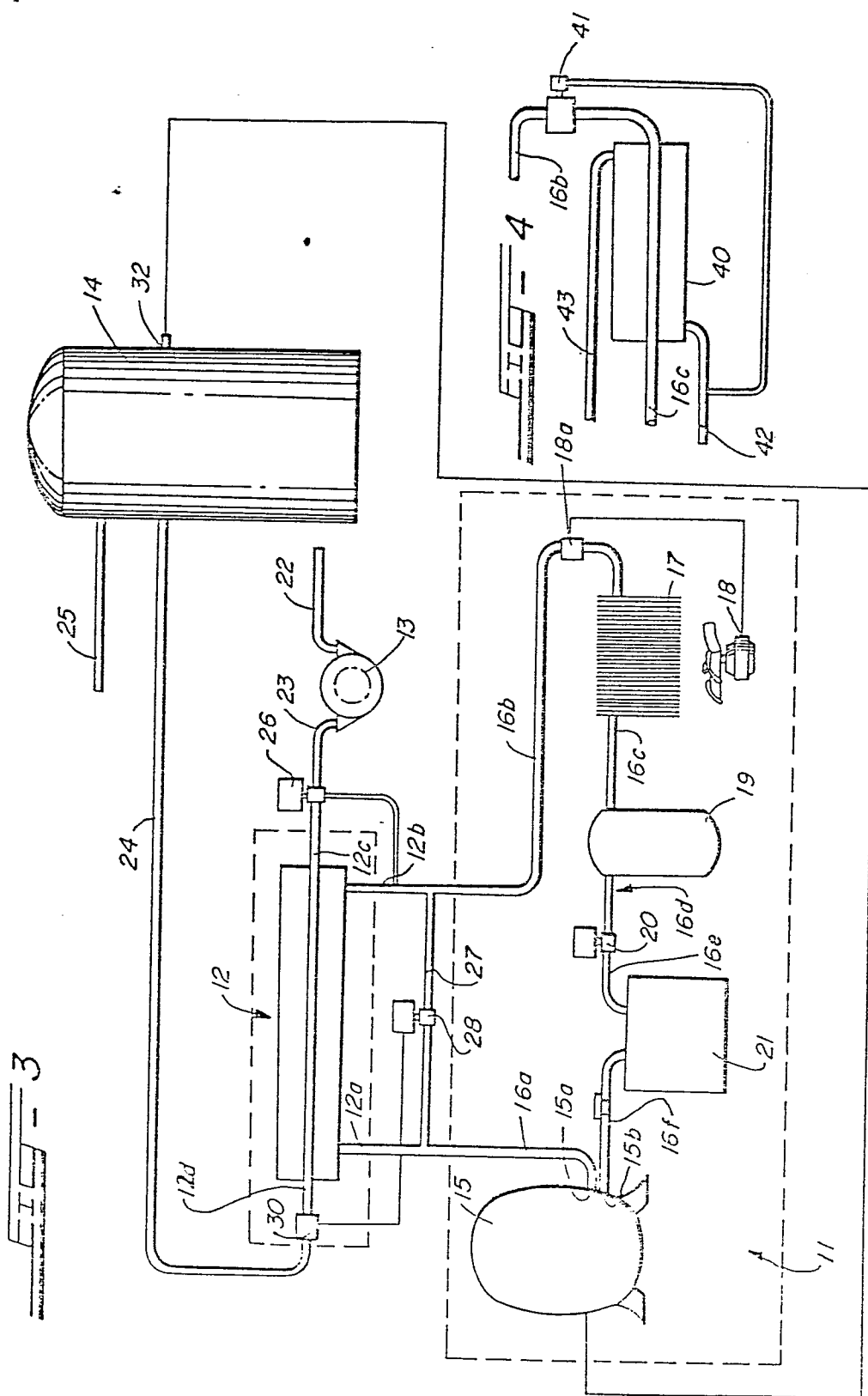
CLAIMS

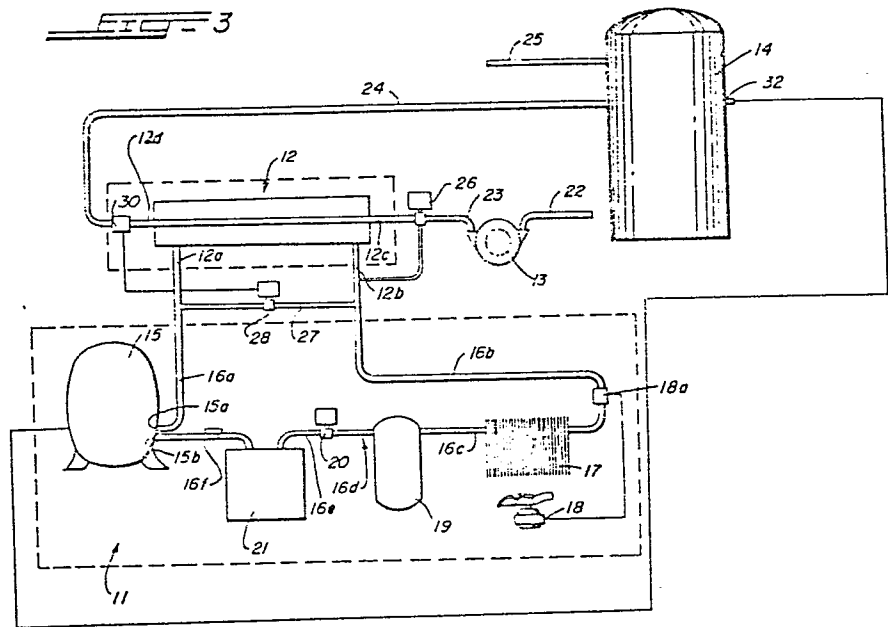
1. Energy-conserving heat exchange apparatus for a refrigerating machine having a closed-loop refrigeration circuit (11), the heat exchange apparatus including a control system (26, 28, 30) and a water/refrigerant indirect heat exchanger (12) characterised in that
the control system includes both means (26) adapted to be responsive both to refrigerant pressure at a refrigerant outlet (12b) of the exchanger (12) and means (30, 28) adapted to be responsive to water temperature at a water outlet (12d) of the exchanger.
2. Refrigerating machine equipped with a heat-exchange apparatus, the refrigerating machine having a closed-loop refrigerant circuit including in series a compressor (15), one side of a water/refrigerant indirect heat exchanger (12), expansion means (20) for the refrigerant and an evaporator (21), and control means for the heat exchanger (14) characterized in that the other side of the heat exchanger (12) is for inclusion in a hot water supply system (22, 23, 24, 14) and in that the control means includes both means (26) responsive to refrigerant pressure in the circuit between an outlet (12b) of the exchanger and the expansion means (20) and means (28, 30) responsive to the temperature of the water output from the exchanger (12)

3. Heat-exchange apparatus or refrigerating machine according to claim 1 or claim 2 wherein temperature-responsive (30, 28) of the control means act to control a bypass duct (27) for refrigerant past the exchanger (12).
- 5 4. Heat exchange apparatus or refrigerating machine according to any one of the preceding claims wherein pressure-responsive means (26) of the control means are operable to control a rate of water feed to a water inlet (12c) of the exchanger (12).
- 10 5. Heat exchange apparatus or refrigerating machine according to any one of the preceding claims wherein there is additionally at least one auxiliary heat-exchanger (17, 40) in the closed-loop circuit and wherein pressure-responsive means (18a, 41) of the control means
15 are operative to actuate the auxiliary heat-exchanger (17, 40).
6. Heat exchange apparatus or refrigerating machine according to claim 5 wherein the auxiliary heat-exchanger is an air-cooled condenser (17) actuated by operation by
20 the control means (18a) or a fan (18).
7. Heat exchange apparatus or refrigerating machine according to claim 5 wherein the auxiliary heat exchanger is a water/refrigerant heat exchanger (40) actuated by operation by the control means (41) of a cooling water
25 system (42, 43).

8. Heat exchange apparatus or refrigerating machine according to any one of claims 5 to 7 wherein the pressure responsive means (18a, 41) is adapted at a first predetermined range of pressures to actuate the auxiliary heat exchanger (17, 80) intermittently.
9. Heat exchange apparatus or refrigerating machine according to claim 8 wherein the means (18a, 41) is adapted at a second predetermined range of pressures, higher than the first, to actuate the auxiliary heat exchanger (17, 40) continuously.
10. Heat exchange apparatus or refrigerating machine according to any one of the preceding claims wherein the control means includes temperature-responsive means (32) for shutting down the refrigerating machine at a predetermined water temperature.









European Patent
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EUROPEAN SEARCH REPORT

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Application number

EP 81 30 0602

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	CA - A - 1 048 802 (ADAMS) * Page 3, line 25 - page 10, line 10; figures * -- DE - A - 2 842 841 (ECKERFELD) * Page 6, paragraph 4- page 13, paragraph 2; figures 1-5 * -- US - A - 4 238 931 (CAMPBELL) * Column 5, line 10 - column 10, line 37; figures 1-5 * -- US - A - 1 874 803 (REED) * Page 1, line 25 - page 2, line 55; figures 1,2 * -- US - A - 2 356 261 (McGRATH) * Page 1, left-hand column, line 35 - page 3, left-hand column, line 20; figures 1-3 * -- US - A - 2 702 671 (CARTER) * Column 1, line 63 - column 4, line 47; figures 1,2 * -- US - A - 1 854 402 (GOOSMANN) * Page 1, line 30 - page 2, line 128; figures 1,2 * --	1,2,3 1,2,5,6 1,2 1,2,3 1,2 1,2,4 1,2	F 25 B 49/00 29/00 F 24 D 17/00 TECHNICAL FIELDS SEARCHED (Int. Cl.) F 25 B F 24 D F 24 J CATEGORY OF CITED DOCUMENTS X. particularly relevant A. technological background O. non-written disclosure P. intermediate document T. theory or principle underlying the invention F. disclosing application D. document cited in the application L. cited in the prior art X. member of the same patent family Corresponding document
The present search report is based on the following documents:			
Place of search	Date of publication of the search	Examiner	
The Hague	14-10-1981	M. ETC	



DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>US - A - 2 181 354 (WINTERS)</u> * Page 2, left-hand column, line 3 - page 4, left-hand column, line 35; figures 1-14 * --	1,2,4	
	<u>DE - A - 2 712 110 (BROWN BOVERI YORK)</u> * Page 6, paragraph 1 - page 12; paragraph 1; figures 1,2 * --	5,6	
	<u>FR - A - 2 370 424 (VIRONNEAU)</u> * Page 6, line 10 - page 12, line 38; figures 1-4 * --	5,6	TECHNICAL FIELDS SEARCHED (Int. Cl.)
	<u>US - A - 2 700 279 (STICKEL)</u> * Column 1, line 62 - column 3, line 82; figures * --	10	
A	<u>US - A - 4 226 606 (YAEGGER)</u>		
A	<u>US - A - 4 134 274 (JOHNSON)</u>		
A	<u>US - A - 4 089 667 (JONSSON)</u>		
A	<u>US - A - 2 807 145 (HENDERSON)</u>		
A	<u>US - A - 2 952 991 (ST. PIERRE)</u>		
A	<u>DE - A - 1 476 957 (ANDREAS)</u> ----		