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

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Description

The present invention relates generally to heat exchangers for utilizing heat from the refrigerant of refrigerating machines, especially of a commercial cube/crushed ice-making machine, and to refrigerating machines equipped with such an exchanger.

It has long been known that there is substantial heat rejection from a condenser in a conventional refrigeration unit consisting serially of a compressor, condenser, expansion valve and evaporator. Various devices and systems have been employed in attempts to utilize 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; 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 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.

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 to external water supplies in those buildings, and have realized that in certain installations a refrigerant to water indirect heat exchanger 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.

Prior known energy conservation systems which have been combined with refrigeration units have heretofore included controls which were responsive to changes in the temperatures of the refrigerant being cooled and the fluid being heated, see for example US—A—4134274. While the temperature of the fluid being heated is an important parameter for control purposes, 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. Though CA—A—1048802 shows a pressure sensitive valve system on the output side of a refrigerating machine, without combining it with a heat exchanger, and US—A—4089667 shows a valved by-pass round a water-refrigerant heat-exchanger, none of the energy conservation systems heretofore known have disclosed the present control system, which op-

timizes the efficiency of the refrigeration unit while providing a controlled transfer of heat energy from the refrigeration condenser to an external air or water supply.

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

The control system is adapted to be responsive to refrigerant pressure at the outlet of the exchanger so as to maintain it at an optimum efficiency for the refrigeration system, as well as to the output water temperature from the condenser.

The heat exchanger may be combined with a refrigerating machine such as a refrigerator or ice-making machine having a closed loop refrigeration system of which the refrigerant side of the exchanger forms part; and the system may include 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.

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:—

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.

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

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 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 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.

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 12 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 one 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.

In accordance with one aspect of the invention, the flow of water from pump 13 into the refriger-

ant-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 6,9 bar (100 psig) to about 11 bar (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 temperature actuated 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.

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 6,9—8,3 bar (100—120 psig) in the refrigerant at the outlet port 12b of condenser 12. If the initial temperature of the water is about 15.5°C, water flow through the condenser will be minimized such that the water exit temperature therefrom approximates 38°C. The refrigerant temperature at outlet port 12b may then approximate 27°C.

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 38°C or above. As long as the temperature in the water supply is approximately 33°C or less, the refrigerant may be maintained at approximately 49°C and 8,3 bar (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 sub-cooling 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 on the external water supply rises in temperature above 38°C to approximately 43°C, the temperature or pressure of the refrigerant will be sufficiently high (approximating 49°C and 7,3 bar (106 psig) to actuate the switch 18a and turn on the motor of the cooling fan 18 of the air-cooled secondary condenser 17. Until such time as the inlet water temperature of water supply reaches approxi-

mately 52°C, the switch 18a cycles the fan on and off at approximately two-minute intervals. The additional condenser capacity in this embodiment acts to lower the refrigerant pressure to a satisfactory level approximating 8,3 bar (120 psig), but nevertheless, 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 52°C, the dual condensers can no longer lower the refrigerant pressure to 8,3 bar (120 psig) and the fan motor the air-cooled condenser 17 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 desuperheating will be added at a lower rate than previously described.

When the condenser outlet water temperature in this embodiment reaches a preset maximum, approximating 82°C, 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 17. 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. 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 14a, 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 con-

nection 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 17. The water-cooled secondary condenser 40 would operate in a manner similar to air-cooled condenser 17 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 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.

Claims

1. Energy-conserving heat exchange apparatus for extracting heat from a refrigerant which includes a water/refrigerant indirect heat exchanger (12), one side of which is for the refrigerant and the other side of which is for inclusion in a hot water supply system (22, 23, 24, 14), and

a control system controlling the flow of water and refrigerant through said water/refrigerant heat exchanger, characterised in that the control system includes means (26) adapted to be responsive to refrigerant pressure at a refrigerant outlet (12b) of the exchanger (12) to control flow of water through said water/refrigerant heat exchanger and means (30, 28) adapted to be responsive to water temperature at a water outlet (12d) of the exchanger to control the flow of refrigerant through said water/refrigerant heat exchanger.

2. A refrigerating machine having a closed-loop refrigeration circuit, the said refrigerant side of the heat-exchanger as claimed in claim 1, being in the said closed loop.

3. A refrigerating machine according to claim 2, characterised in that the closed-loop refrigeration circuit (11) includes in series a compressor (15), the said one side of the water/refrigerant indirect heat exchanger (12), expansion means (20) for the refrigerant and an evaporator (12).

4. Heat-exchange apparatus or refrigerating machine according to claim 1, claim 2 or claim 3 wherein temperature-responsive (30, 28) of the control means act to control a bypass duct (27) for refrigerant past the exchanger (12).

5. 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).

6. 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 are operative to actuate the auxiliary heat-exchanger (17, 40).

7. 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 the control means (18a) or a fan (18).

8. Heat exchange apparatus or refrigerating machine according to claim 6 wherein the auxiliary heat exchanger is a water/refrigerant heat exchanger (40) actuated by operation by the control means (41) of a cooling water system (42, 43).

9. Heat exchange apparatus or refrigerating machine according to any one of claims 6 to 8 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.

10. Heat exchange apparatus or refrigerating machine according to claim 9 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.

11. 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.

Revendications

1. Echangeur de chaleur conservant de l'énergie pour extraire la chaleur d'un fluide réfrigérant qui comprend un échangeur indirect de chaleur (12) eau/réfrigérant, dont une côté est pour le réfrigérant et l'autre côté est pour une inclusion dans un système d'alimentation en eau chaude (22, 23, 24, 14), et

un système de réglage réglant l'écoulement d'eau et du réfrigérant à travers ledit échangeur de chaleur eau/réfrigérant, caractérisé en ce que le système de réglage comprend un moyen (26) adapté à répondre à la pression du réfrigérant à une sortie du réfrigérant (12b) de l'échangeur (12) pour régler l'écoulement de l'eau à travers ledit échangeur de chaleur eau/réfrigérant et un moyen (30, 28) adapté à répondre à la température de l'eau à une sortie de l'eau (12b) de

l'échangeur pour régler l'écoulement du réfrigérant à travers ledit échangeur de chaleur eau/réfrigérant.

2. Machine frigorifique ayant un circuit de réfrigération en boucle fermée, ledit côté réfrigérant de l'échangeur de chaleur selon la revendication 1 étant dans ladite boucle fermée.

3. Machine frigorifique selon la revendication 2 caractérisée en ce que le circuit de réfrigération en boucle fermée (11) comprend en série un compresseur (15), ledit premier côté de l'échangeur indirect de chaleur eau/réfrigérant (12), un moyen détendeur (20) du réfrigérant et un évaporateur (12).

4. Echangeur de chaleur ou machine frigorifique selon la revendication 1, la revendication 2 ou la revendication 3 où le moyen sensible à la température (30, 28) du moyen de réglage sert à régler une gaine de bypass (27) du réfrigérant au-delà de l'échangeur (12).

5. Echangeur de chaleur ou machine frigorifique selon l'une quelconque des revendications précédentes où les moyens (26) répondant à la pression du moyen de réglage servent à régler le taux d'alimentation en eau vers une entrée d'eau (12c) de l'échangeur (12).

6. Echangeur de chaleur ou machine frigorifique selon l'une quelconque des revendications précédentes où il y a de plus au moins un échangeur de chaleur auxiliaire (17, 40) dans le circuit en boucle fermée et où des moyens sensibles à la pression (18a, 41) de moyen de réglage servent à actionner l'échangeur de chaleur auxiliaire (17, 40).

7. Echangeur de chaleur ou machine frigorifique selon la revendication 5 où l'échangeur de chaleur auxiliaire est un condenseur (17) refroidi à l'air actionné par une opération par le moyen de réglage (18a) ou un ventilateur (18).

8. Echangeur de chaleur ou machine frigorifique selon la revendication 6 où l'échangeur de chaleur auxiliaire est un échangeur de chaleur (40) eau/réfrigérant actionné par une opération par le moyen de réglage (41) d'un système (42, 43) d'eau de refroidissement.

9. Echangeur de chaleur ou machine frigorifique selon l'une quelconque des revendications 6 à 8 où le moyen sensible à la pression (18a, 41) est adapté à une première gamme prédéterminée de pression à actionner l'échangeur de chaleur auxiliaire (17, 80) par intermittence.

10. Echangeur de chaleur ou machine frigorifique selon la revendication 9 où le moyen (18a, 41) est adapté à une seconde gamme prédéterminée de pressions supérieure à la première, à actionner continuellement l'échangeur auxiliaire de chaleur (17, 40).

11. Echangeur de chaleur ou machine frigorifique selon l'une quelconque des revendications précédentes où le moyen de réglage comprend un moyen sensible à la température (32) pour arrêter la machine frigorifique à une température prédéterminée de l'eau.

Patentansprüche

1. Energiesparende Wärmeaustauschvorrichtung, um einem Kältemittel Wärme zu entziehen, die einen indirekten Wasser/Kältemittelwärmetauscher (12) aufweist, dessen eine Seite für das Kältemittel und dessen andere Seite für den Einschluß in ein Warmwasserversorgungssystem (22, 23, 24, 14) dient, und ein Steuersystem zum Steuern der Strömung des Wassers und des Kältemittels durch den Wasser/Kältemittelwärmetauscher umfaßt, dadurch gekennzeichnet, daß das Steuersystem eine auf den Druck des Kältemittels am Kältemittelauslaß (12b) des Wärmetauschers (12) ansprechende Einrichtung (26) umfaßt, um den Durchsatz des Wassers durch den Wasser/Kältemittelwärmetauscher zu steuern, und auf die Wassertemperatur an einem Wasserauslaß (12d) des Wärmetauschers ansprechende Einrichtungen (30, 28) aufweist, um den Durchsatz des Kältemittels durch den Wasser/Kältemittelwärmetauscher zu steuern.

2. Kältemaschine mit einem geschlossenen Kältemittelkreislauf, wobei sich die Kältemittel-seite des Wärmetauschers nach Anspruch 1 in dem geschlossenen Kreislauf befindet.

3. Kältemaschine nach Anspruch 2, dadurch gekennzeichnet, daß der geschlossene Kältemittelkreislauf (11) in Serie einen Kompressor (15), die besagte eine Seite des indirekten Wasser/Kühl-mittelwärmetauschers (12), eine Expansionseinrichtung (20) für das Kältemittel und einen Verdampfer (12) umfaßt.

4. Wärmeaustauschvorrichtung oder Kältemaschine nach Anspruch 1, 2, oder 3, wobei die temperaturempfindlichen Einrichtungen (30, 28) des Steuersystems eine den Wärmetauscher (12) umgehende Kurzschlußleitung (27) für das Kältemittel steuern.

5. Wärmeaustauschvorrichtung oder Kältemaschine nach einem der vorhergehenden Ansprüche, wobei die druckempfindliche Einrichtung

(26) des Steuersystems betätigbar ist, um den Wasserzufluß zu einem Wassereinlaß (12c) des Wärmetauschers (12) zu steuern.

6. Wärmeaustauschvorrichtung oder Kältemaschine nach einem der vorhergehenden Ansprüche, wobei zusätzlich mindestens ein Hilfs-wärmetauscher (17, 40) in dem geschlossenen Kreislauf angeordnet ist und wobei druckempfindliche Einrichtungen (18a, 41) des Steuersystems den zusätzlichen Wärmetauscher (17, 40) betätigen.

7. Wärmeaustauschvorrichtung oder Kältemaschine nach Anspruch 5, dadurch gekennzeichnet, daß der zusätzliche Wärmetauscher ein luftgekühlter Kondensator (17) ist, der durch die Steuereinrichtung (18a) oder ein Gebläse (18) betätigbar ist.

8. Wärmeaustauschvorrichtung oder Kältemaschine nach Anspruch 6, wobei der zusätzliche Wärmetauscher ein Wasser/Kühlmittelwärmetauscher (40) ist, der durch die Steuereinrichtung (41) eines Kühlwassersystems (42, 43) betätigbar ist.

9. Wärmeaustauschvorrichtung oder Kältemaschine nach einem der Ansprüche 6 bis 8, wobei die druckempfindliche Einrichtung (18a, 41) bei einem ersten vorbestimmten Druckbereich den zusätzlichen Wärmetauscher (17, 40) intermittierend betätigen kann.

10. Wärmeaustauschvorrichtung oder Kältemaschine nach Anspruch 9, wobei die druckempfindliche Einrichtung (18a, 41) bei einem zweiten vorbestimmten Druckbereich, der höher ist als der erste Druckbereich, den zusätzlichen Wärmetauscher (17, 40) kontinuierlich betätigen kann.

11. Wärmeaustauschvorrichtung oder Kältemaschine nach einem der vorhergehenden Ansprüche, wobei das Steuersystem eine druckempfindliche Einrichtung (32) umfaßt, um die Kältemaschine bei einer vorbestimmten Wassertemperatur abzuschalten.

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FIG 2

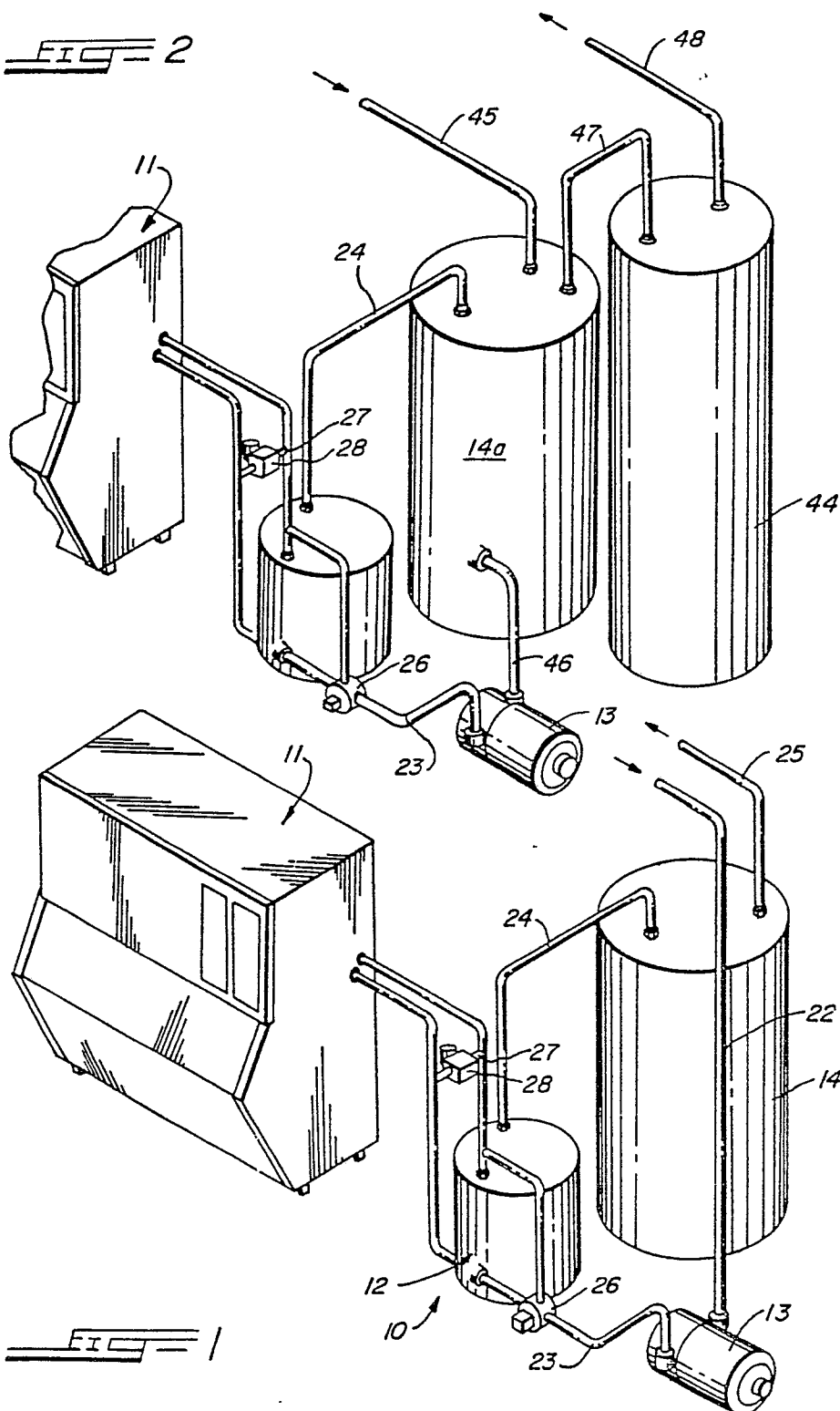


FIG 1

