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(54) Energy balanced refrigeration system.

(57) An energy balanced refrigerated unit includes a refrigerated cabinet (10) and a refrigeration system. The refrigeration system comprises a self-contained refrigeration fluid circuit (12) for cooling the cabinet and removes heat from the refrigeration fluid by air and fluid cooled condensers (20,24). The air condenser (20) removes heat and returns it to the immediate vicinity of the refrigerated unit (10) to maintain the energy balance in the immediate vicinity while the fluid cooled condenser (24) is connected to a suitable fluid circuit (26) and the heat extracted therefrom is removed to a remote location so as not to effect the temperature of the surrounding environment.

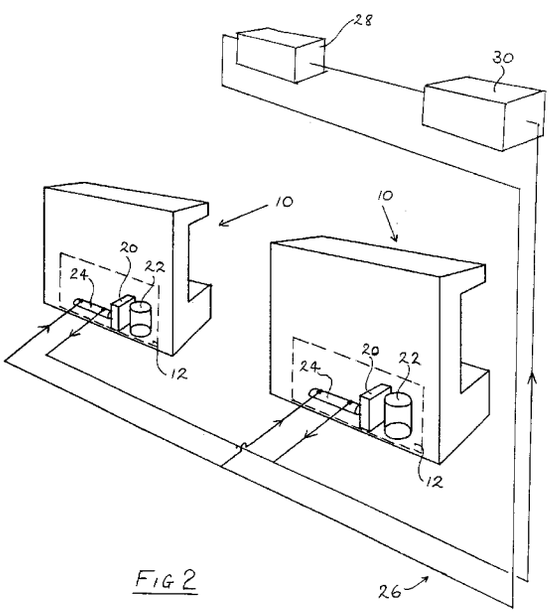

FIG 2

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The invention relates to refrigeration units.

Prior art refrigerated display cabinets provided on shop floors fall broadly into two categories; mobile display units, and substantially fixed display units. Mobile display units include all the system components for performing the entire refrigeration cycle, including a compressor and air cooled condenser, within the display unit. They extract all the heat generated by the compressor, condenser and other energy inputs and eject it into the surrounding environment. Display units of this type have the advantage that they can be positioned at any required location but, as the heat they generate is greater than that absorbed by the refrigerated cabinet, the overall effect of running the refrigeration cycle on the area in which the unit is placed is an undesirable warming of the environment. In addition, the compressors required to extract heat from the refrigeration used in the refrigeration cycle are large and generate a great deal of noise which can also be unacceptable.

Fixed refrigerated display units are used in some environments. These units do not perform their own refrigeration cycles. Instead refrigeration fluid is supplied to each of a number of units through a fixed refrigeration pipework system, and returned through such system to a remote location for heat extraction. The refrigeration fluid passes through evaporators in the display units in order to cool their contents, and is returned to a common compressor and condenser where the refrigeration fluid from a number of units is condensed and heat extracted. This type of system has the advantage that the condenser and the noisy compressor can be located well away from the site of the display unit so that the extracted heat and the noise does not effect the immediate surroundings. However, each display unit must be attached to the refrigeration fluid system on installation and on any subsequent repositioning of the unit. This must be done by refrigeration engineers inevitably increasing the delay and cost involved in rearranging display cabinets in the interior of a store. Also, since all the heat is extracted at a location remote from the cabinets, the refrigeration units tend to absorb heat from the surroundings making the environment cooler than would otherwise be the case. Although this may be advantageous in hot climates or during hot weather spells, it is in general a problem requiring the provision of a controlled heating system to compensate for the environmental heat loss. It has been proposed, for example, to return a part or all of the heat extracted by the remote refrigeration unit to the area where the display units are located to counteract this cooling.

In addition, the low temperature piping supplying refrigeration fluid to the various units must be heavily insulated in order to maintain the refrigeration at its low supply temperature prior to entering the units and to stop condensation from forming on the exterior of the pipes.

It is an aim of the present invention to provide a refrigeration system that alleviates at least some of the above mentioned problems with prior art refrigeration units.

In accordance with a first aspect of the present invention there is provided a refrigerated unit comprising a cabinet and a refrigeration system comprising a self-contained refrigeration fluid circuit for cooling the cabinet, first and second means for removing heat from the refrigeration fluid the first of which is operable to remove an amount of heat and return it to the environment surrounding the refrigerated unit and the second of which is operable to remove heat for transmission to a location remote from the refrigeration unit.

By providing a refrigerated unit that has a self-contained refrigeration fluid circuit and performs its own refrigeration cycle extracting heat from the refrigeration fluid and ejecting it at two separate locations, firstly to the surrounding environment and secondly to a remote location, the temperature of the environment surrounding the refrigeration unit can be maintained at a desired level.

The first and second means for cooling may respectively comprise an air and a fluid cooled condenser. The compressor may also be fluid cooled with heat generated by the compressor being removed by a heat exchanger also cooled by the cooling fluid. To further reduce noise both the compressor and heat exchanger may be encased in a sound proof container.

The fluid used to remove the excess heat may be water or could be another suitable fluid. By using a fluid supply that is at a higher temperature than refrigeration fluid, the insulation on supply piping need only be relatively light in order to prevent formation of condensation on the external surfaces and reduce heat pick-up from the environment. The temperature of the cooling fluid can be varied depending upon system specifications but will likely be between 0 and 20°C. By providing cooling fluid at a temperature above 0°C, water can be used as the cooling fluid without the addition of anti-freezing additives. In addition, as the cooling fluid system and refrigeration circuit are independent, refrigeration engineers are not required for installation or subsequent removal or rearrangement of the units. The display units need only be positioned at a required location, plumbed into the fluid cooling system, and plugged into an electricity supply for use in a new location to begin. The refrigeration unit of the present invention therefore provides significant benefits in flexibility of store planning and allows considerable reductions in installation time and costs to be made over prior art units as well as maintaining acceptable levels of heat and noise in the immediate vicinity of the display units.

In accordance with a further aspect of the pres-

ent invention there is provided a refrigeration system comprising a refrigeration unit having a self-contained refrigeration fluid circuit for cooling the unit and means for extracting an amount of heat from the refrigeration fluid and returning it to the environment; and a fluid supply system for providing and retrieving cooling fluid respectively to and from the refrigeration unit for transmitting excess heat from the refrigeration fluid above that returned to the environment to a location remote from the refrigeration unit.

In accordance with another aspect of the invention there is provided a refrigeration system for providing the cooling effect for a refrigeration unit and for assisting in maintaining the environment surrounding the refrigeration unit at a desired temperature, comprising a refrigeration fluid circuit, means for maintaining the condensation temperature of the refrigeration fluid at substantially the desired temperature, first means for removing heat from the refrigeration fluid which includes a cooling fluid at substantially the temperature of the surrounding environment and which removes an amount of heat and returns it to the surrounding environment, such that heat is returned to the surrounding environment when the temperature of the surrounding environment is lower than the desired temperature and second means for removing heat from the refrigeration fluid which includes a cooling fluid at a lower temperature than the condensation temperature and which removes heat from the refrigeration fluid for transmission to a location remote from the refrigeration unit.

By providing a first means for removing heat which uses fluid at the temperature of the surrounding environment to remove heat and return it thereto with a refrigeration fluid having a condensation temperature that is substantially equal to the desired temperature of the surroundings, less and less heat will be extracted by the first means as the actual temperature of the environment approaches the desired temperature. As this happens a correspondingly larger amount of heat is removed by the second means and transmitted to a remote location so as not to influence the temperature of the immediate surroundings. As the second means uses a cooling fluid at a temperature lower than the condensing temperature, even if no heat is extracted by the first means the refrigeration cycle is still maintained.

In prior art systems using air at the ambient temperature to remove heat from the refrigeration fluid, it is necessary for the condensation temperature of the refrigeration fluid to be substantially higher than the expected or usual ambient temperature. In the present invention, however, as the condensation temperature of the refrigeration fluid is substantially equal to the desired temperature, the condensation temperature is considerably lower than in prior art systems. This leads to a reduction in the size of compressor necessary to maintain the desired condensation temperature, which provides a useful reduction in noise as well releasing valuable space.

In accordance with a further aspect of the invention there is provided a fluid supply system for providing and retrieving cooling fluid to and from at least one refrigeration unit and for transmitting heat from the at least one refrigeration unit to a remote location, comprising a heat exchanger cooled by ambient air and means for energizing the air cooled heat exchanger when the temperature of the ambient air is below that of the retrieved cooling fluid.

In order that the invention may be better understood an embodiment thereof will be described, by way of example, with reference to the accompanying drawings wherein:

Figure 1 shows a section through a refrigerated display unit; and

Figure 2 is a schematic representation of a refrigerated display unit and fluid cooling system according to the invention.

Figure 1 shows an open display unit 10 of the type typically used to display perishable products in supermarkets. Such refrigerated units tend to reduce the temperature of the surrounding environment. A cold air curtain 16 at the front of the display unit ensures that food displayed is maintained at a desirable temperature. Each of the display units 10 shown in Figure 2 comprises a closed refrigeration circuit 12 in which a refrigeration fluid circulates. The refrigeration system includes an evaporator 14 for cooling air drawn into the base of the unit 10 by the action of a fan 18 for forming the air curtain. A compressor 22 pressurises the vaporised refrigerant and heat is then reclaimed from the refrigeration fluid by an air cooled condenser 20 and a water cooled condenser 24.

An external water supply circuit 26 provides cooling water to the water cooled condenser 24, collects the cooling water and removes it from the site of the display unit. The cooling water supply circuit may discharge heated water at a remote location, use it for a suitable application, or may extract the heat absorbed from within individual display units and return the cooled water to resupply the water cooled condensers of the system as in the system of Figure 2.

The air cooled condenser 20 heats air that is then returned to the atmosphere in the immediate vicinity of the display unit 10. By maintaining a refrigeration fluid condensation temperature substantially equal to a desired ambient temperature (around 22°C) the refrigeration unit is self-regulating to substantially compensate for any heat lost from the surroundings as a result of cooling by the display cabinet. This is because when the air temperature drops substantially below the desire temperature, the temperature difference between the condensing refrigerant and the air at the air cooled condenser will be relatively large so that a substantial amount of heat is returned to the environment. Conversely when the ambient air is near

or at the desired temperature little or no heat will be returned to the environment. By including a water cooled condenser 24 for extracting heat generated in the refrigeration fluid surplus to that extracted by the air cooled condenser 20, and removing it so that it does not effect the temperature of the environment in which the display unit is positioned, the energy balance in the immediate surroundings of the display unit can be maintained. The capacities of the air cooled and water cooled condensers are chosen so that the refrigerator is fully operational even when no heat is removed by the air cooled condenser. A balance must, however, be achieved so that heat will be extracted by the air cooled condenser when the ambient temperature is lower than desired. A self-regulating system such as this could also be used in a refrigeration unit that does not include a self-contained refrigeration fluid circuit.

The speed with which heat is returned to the surroundings by the air cooled condenser 20 will depend upon the air supply rate. The compensation benefits will be achieved with a fixed supply rate air cooled condenser 20. However, it may be desirable to suitably regulate the air flow.

By extracting heat using a cooling fluid such as water at a temperature between 0 and 20°C , i.e. below expected ambient temperature, the condensation temperature can be lowered with respect to that achievable with only an ambient air cooled condenser. The compressor 22 can accordingly operate at lower capacity with a consequent reduction in generated noise. The display system is therefore considerably quieter than conventional mobile display units. In addition, since the compressor is of reduced capacity it takes up less space, leaving more room for providing a display area in the unit. To decrease the noise produced still further, the compressor and a water cooled heat exchanger removing heat therefrom can be encased in a sound proofed casing.

The cooling water supply pipes of the water supply circuit 26 are lagged to prevent them from absorbing heat from the surrounds. The lagging however, need only be light as the cooling water is between 0° and 20°C, i.e. at a temperature relatively high compared to that of the refrigerant in the prior art system. Cooler temperature water or other cooling fluid could be used. This, however, would require heavier lagging of the pipes to prevent heat absorption and if water below 0°C were used additional additives to prevent freezing would be necessary. The lower the temperature of the cooling fluid supplied, the faster the water cooled condenser would operate. This benefit should, however, be balanced against the increased complexity of the cooling fluid supply system and care would also need to be taken to ensure that the capacity of the water cooled condenser was not so large that it prevented cooling from taking place at the air cooled condenser when required.

The heat extracted by the cooling fluid may itself be extracted from the cooling fluid at a remote location. The system illustrated in Figure 2 extracts heat from the cooling fluid which is then re-supplied to the refrigeration units. Heat is extracted by a water chiller 28 and an air cooled heat exchanger 30 in series. The retrieved cooling fluid flows first through the air cooled heat exchanger 30 and then through the water chiller 28. A fan 32 is energized in the air cooled heat exchanger 30 when the air temperature falls below the temperature of the retrieved cooling water. In this manner the water chiller 28 employing a refrigeration cycle, will only operate to remove that heat which cannot be removed by the air cooled heat exchanger. This results in an energy saving. At times when the air temperature is low, for example at night, little chilling will need to be done by the water chiller. This energy saving arrangement can be used to remove heat in other cooling systems including those in which refrigeration fluid is provided to a plurality of refrigeration units. It is not restricted to use with the refrigeration systems described herein.

It is clear from the above that the specific embodiment provides a versatile system that can be tailored to a variety of needs. Once a cooling water supply circuit is provided in an area, mobile display units providing their own refrigeration cycles can be plumbed into the system at any required location. The amount of heat returned to the surroundings is self regulating in order to assist in maintaining a desired temperature. The speed with which heat is extracted by the condensers and therefore returned to the atmosphere can be regulated by controlling the temperature or flow rate of the cooling water supply and/or the rate of air flow through the air cooled condenser.

Although the invention has been described in relation to display units, it will find utility with other refrigeration units, for example, chest freezers requiring flexibility in positioning and an energy balanced environment.

Claims

1. A refrigerated unit comprising a cabinet and a refrigeration system comprising a self-contained refrigeration fluid circuit for cooling the cabinet, first and second means for removing heat from the refrigeration fluid the first of which removes an amount of heat and returns it to the environment surrounding the refrigerated unit and the second of which removes heat for transmission to a location remote from the refrigerated unit.

2. A refrigerated unit according to claim 1 further comprising a fluid cooling system for transmitting heat to a location remote from a refrigeration unit.

3. A refrigeration unit according to claim 2 wherein the fluid cooling system provides a cooling fluid to the refrigeration unit at a temperature between 0 and 20°C.

4. A refrigeration unit according to any one of the preceding claims wherein the refrigeration system comprises a compressor.

5. A refrigeration unit according to claim 4 wherein heat is removed from the compressor to a location remote from the refrigeration unit.

6. A refrigeration unit according to claim 4 or claim 5 wherein heat is extracted from the compressor by a heat exchanger and wherein a sound proof container encases the compressor and heat exchanger.

7. A refrigeration unit according to any one of the preceding claims wherein the first and second means for cooling respectively comprise an air and a fluid cooled condenser.

8. A refrigeration unit according to any one of the preceding claims wherein the fluid is water.

9. A refrigeration system comprising a refrigeration unit having a self-contained refrigeration fluid circuit for cooling the unit and means for extracting an amount of heat from the refrigeration fluid and returning it to the environment; and

a fluid supply system for providing and retrieving cooling fluid to and from the refrigeration unit for transmitting excess heat from the refrigeration unit above that returned to the environment to a location remote from the refrigeration unit.

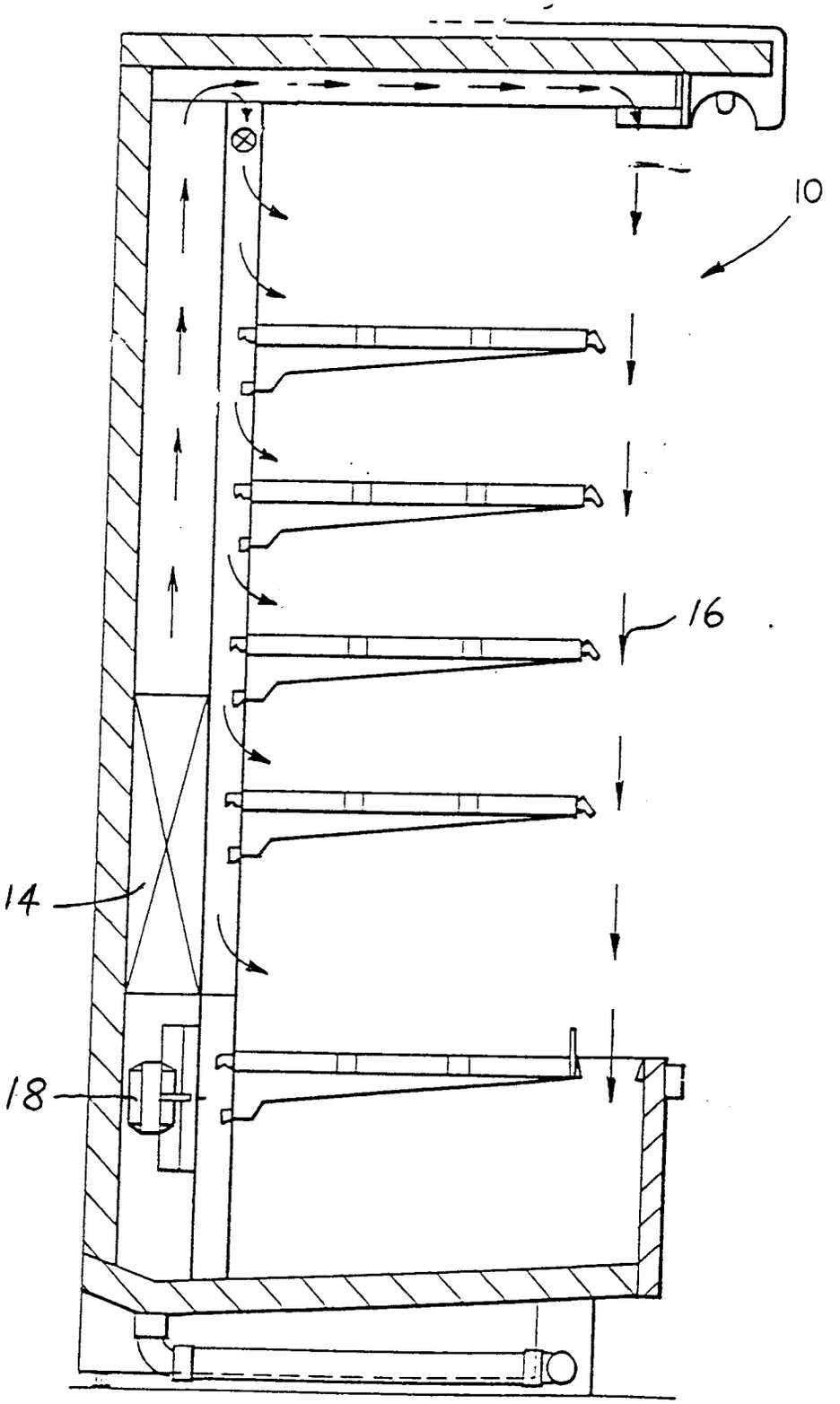
10. A refrigeration system according to claim 9 wherein the fluid supply system comprises means for extracting the transmitted heat from the cooling fluid comprising a heat exchanger cooled by ambient air, and means for energizing the air cooled heat exchanger when the temperature of the ambient air is below that of the retrieved cooling fluid.

11. A refrigeration system for providing the cooling effect for a refrigeration unit and for assisting in maintaining the environment surrounding the refrigeration unit at a desired temperature, comprising a refrigeration fluid circuit, means for maintaining the condensation temperature of the refrigeration fluid at substantially the desired temperature, first means for removing heat from the refrigeration fluid which includes a cooling fluid at substantially the temperature of the surrounding environment and which removes an amount of heat and returns it to the surrounding environment, such that heat is returned to the surrounding environment when the temperature of the surrounding environment is lower than the desired temperature and second means for removing heat from the refrigeration fluid which includes a cooling fluid at a lower temperature than the condensation temperature and which removes heat from the refrigeration fluid for transmission to a location remote from the refrigeration unit.

12. A fluid supply system for providing and retrieving cooling fluid to and from at least one refrigeration unit and for transmitting heat from the at least one refrigeration unit to a remote location, comprising an air cooled heat exchanger and means for energizing the air cooled heat exchanger when the air temperature is below that of the retrieved cooling fluid.

13. A fluid supply system according to claim 12 wherein means for removing heat from the cooling fluid is provided in series with the air cooled heat exchanger.

FIG.1.



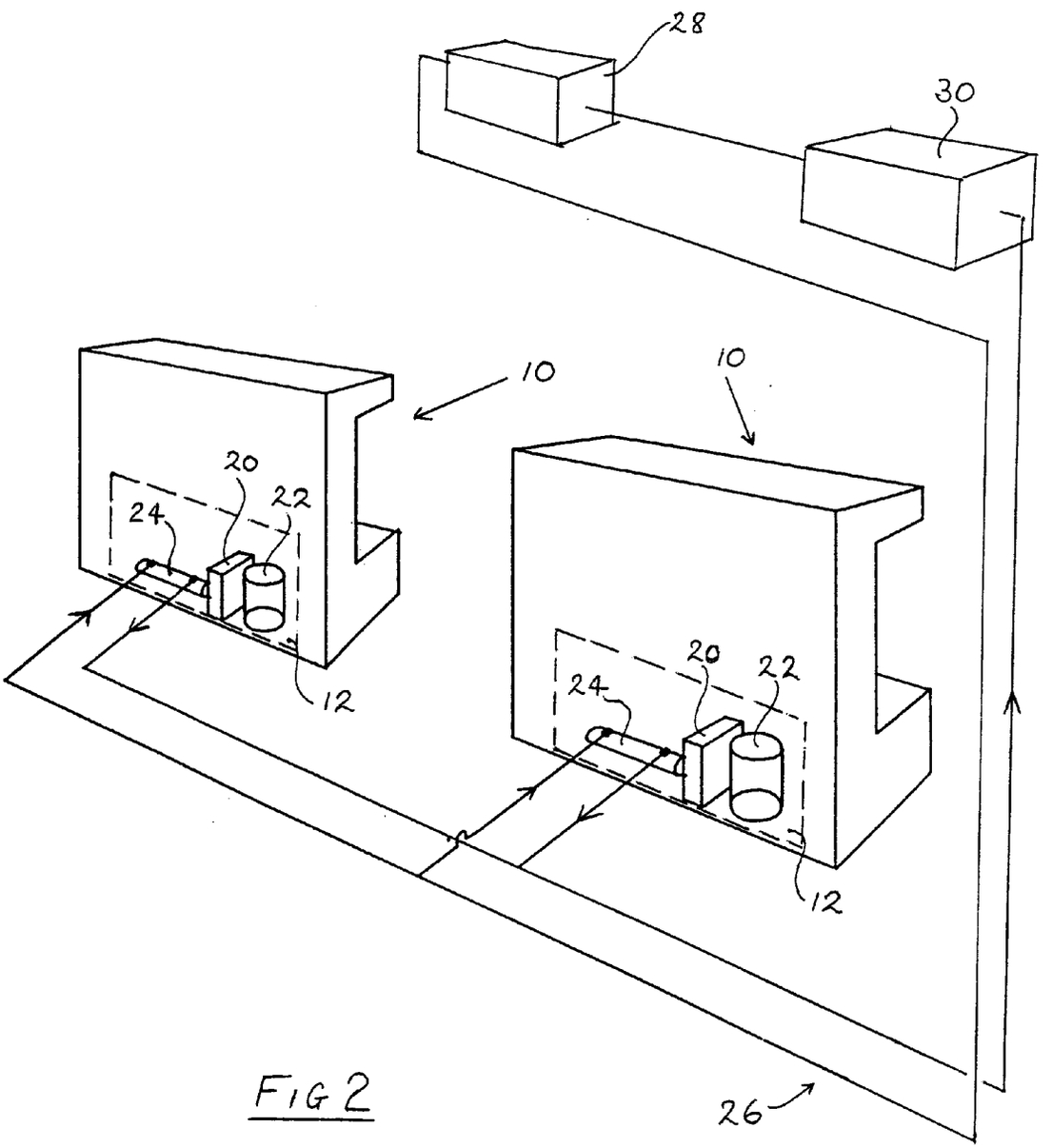


FIG 2

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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 6304

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	US-A-3 230 732 (RUTISHAUSER) * column 2, line 23 - column 6, line 15; figures 1-7 *	1,2,4, 7-12	F25B6/00 F25D23/00 A47F3/04
Y	US-A-4 314 452 (WATERS) * column 2, line 29 - column 3, line 68; figures 1-4 *	1,2,4, 7-12	
A	US-A-3 180 109 (KIMMEL) * column 2, line 7 - column 4, line 4; figure *	1,2,4, 9-12	
A	DE-A-29 17 845 (HOFFMANN) * page 6, last paragraph - page 7, paragraph 1; figure 1 *	1,4,7-9, 11	
A	US-A-3 210 957 (RUTISHAUSER) * column 3, line 26 - column 6, line 56; figures 1-6 *	1,2,4, 9-12	TECHNICAL FIELDS SEARCHED (Int.Cl.5) F25B F25D A47F
A	US-A-4 220 011 (BERGMAN) * column 3, line 4 - column 6, line 56; figure *	1,2,4, 7-9,11	
A	US-A-2 250 648 (PHILIPP) * page 1, left column, line 40 - page 2, right column, line 3; figures 1-3 *	4-6	
A	GB-A-2 198 220 (GEORGE BAKER)		
A	US-A-4 484 450 (DOLCE)		

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 November 1993	BOETS, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 6304

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	US-A-4 803 848 (LABRECQUE)		
A	US-A-4 535 603 (WILLITTS)		
A	FR-A-747 508 (SOCIÉTÉ ANONYME DES ÉTABLISSEMENTS NEU)		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

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