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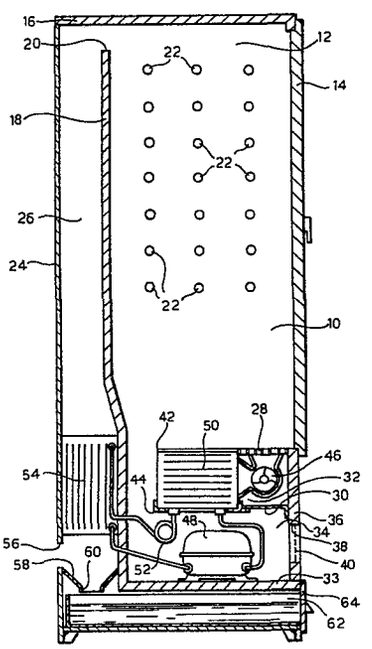
(54) Drier, in particular a clothes-drying cabinet.

(57) The drier includes a drying chamber (10) in a casing with closed-circuit air circulating means (46) in the chamber itself; means for heating the circulating air; an air cooling passage (26) for condensing humidity, situated next to the drying chamber (10) with a top inlet (20) communicating with the top of the drying chamber (10) and a bottom outlet (56); and a refrigerating circuit which acts as a heat pump and comprises, among other things, a compressor (48), a condenser (50) acting as the above mentioned heating means, and an evaporator (54) in the form of a heat exchanger situated in the cooling passage (26). The casing comprises an outside air inlet (38) which communicates with the bottom of the drying chamber via the above mentioned circulating means (46). The bottom end (56) of the cooling passage (26) comes out into the outside air.



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"Drier, in particular a clothes-drying cabinet".

The present invention relates to driers specially designed for household use as clothes-drying cabinets but which can be used equally well for drying various types of industrial articles.

In particular, the invention relates to a drier consisting of a drying chamber in a casing with closed-circuit air circulating means in the chamber itself; means for heating the circulating air; an air cooling passage for condensing humidity, situated next to the drying chamber with a top inlet communicating with the top of the drying chamber and a bottom outlet; and a refrigerating circuit which acts as a heat pump and comprises, among other things, a compressor, a condenser acting as the above mentioned heating means, and an evaporator in the form of a heat exchanger situated in the cooling passage.

We are already familiar with driers of this type which provide for drying a load of clothes or similar items with little electricity consumption, thanks to the fact that most of the air used is only recirculated in the drying chamber. On known models. a small proportion of the air is sent down the cooling passage and back into the drying chamber.

This arrangement provides for a relatively low loss in sensible heat in the damp air so that the refrigerating circuit condenser requires relatively little energy to compensate for the sensible heat absorbed by the evaporator or a cold wall in the cooling passage.

The drawback on these known types of driers, however, is that the efficiency of the cooling circuit gradually falls off as the drying cycle proceeds. The reason for this is that, as the cycle proceeds, the difference in temperature between the evaporator and the condenser gradually becomes smaller on account of a gradual increase in the temperature of the air recirculated along the cooling passage. Under such conditions, besides a gradual increase in the energy consumption of the compressor, the entire refrigerating circuit may even rise to unacceptable temperatures. On the one hand, this could damage the refrigerating system and, on the other, the temperature in the drying chamber could rise high enough to damage delicate fabrics such as synthetic fibres, silk and the like.

The aim of the present invention is to provide a unit as described earlier but which does not pose this problem.

According to the present invention, this aim is achieved by a drying unit, characterised by the fact that the casing comprises an outside air inlet which communicates with the bottom of the drying chamber via the above mentioned circulating means and that the bottom end of the cooling passage comes out into the outside air.

This arrangement provides for drying cycles with lower, more uniform refrigeration circuit pressures and temperatures than would be possible if the unit operated with no communication with the outside air. Supposing, for example, as is usually the case, that the tempera-

ture in the room where the drier is installed does not vary during the drying cycle. This means there will be no substantial variation in the temperature difference with which heat is exchanged between the air and the refrigerating fluid on the condenser and evaporator. In other words, air pumped in from outside acts as a sort of "brake" on the rise in temperature and the temperature differences in the refrigerating circuit.

Thanks to the principle of the heat pump, a further advantage of the unit according to the present invention is that it also uses the heat content of the outside air.

Supposing the unit, e.g. a clothes-drier, is installed in a room with an air temperature of 20°C, 60% relative humidity and air containing 8.73 gr of water per kilo. The heat content of the air will be 10.10 kcal/kg. If the unit is designed so that air is blown off into the atmosphere, through the cooling passage, at 12°C with 100% relative humidity, with the same 8.73 gr of water per kilo, its heat content will be 8.10 kcal/kg. At the start of the cycle at least, the air pumped in from the outside will supply 2 kcal/kg with consequent saving in energy.

The invention will now be described with reference to the attached drawing, provided by way of a non-limiting example and showing a schematic vertical cross section of a drier, in particular, a clothes-drying cabinet according to the present invention.

The unit shown in the drawing is in the form of

a cabinet with a casing of sheet metal or other suitable material. The casing contains a drying chamber 10 defined by side walls 12, a front door 14, a top 16 and rear dividing wall 18. Walls 12 and 18, top 16 and front door 14 are all lagged.

For the reason given later on, rear dividing wall 18 does not extend as far as top 16. The edge of dividing wall 18, together with top 16, defines a horizontal slot 20.

Drying chamber 10 is fitted inside with hooks and rails on which to hang clothes or other items, an arrangement that turns the unit into a household clothes-drying cabinet. Alternatively, drying chamber 10 may be fitted with grate shelves for drying items other than clothes, e.g. photographs, tobacco leaves, fruit, etc.

Hangers used for another alternative will be described later.

The casing has a rear or outside wall 24 which, together with dividing wall 18, forms a space 26 which, as we shall explain later, acts as a cooling passage. Rear wall 24 is made of sheet metal or other heat-conducting material to act as a cooling means by exchanging heat with the outside air. For even better heat exchange performance, wall 24 may be fitted with fins. The bottom 28 of drying chamber 10 is fitted over another bottom panel 30 so as to form a space 32 which, as we shall see later, acts as a passage for heating and air circulation. The casing or cabinet has yet another horizontal structural panel 33 under bottom

panel 30 which, together with the latter, forms a bottom compartment 34. The latter is defined at the front by wall 36 and at the rear by a bottom extension of dividing wall 18. For reasons explained later, compartment 34 communicates with the outside air through opening 38 (e.g. a slit) in wall 36 fitted with a grate 40.

At the inlet end, heating and circulating passage 32 communicates with both the bottom of chamber 10 and compartment 34. The through openings, preferably slits, are marked 42 and 44.

At the outlet end, passage 32 communicates with the bottom of chamber 10 with circulating means in the form of an electric blower inbetween.

The casing or cabinet has a built-in refrigerating circuit which acts as a heat pump and comprises a known hermetic electric compressor 48, a condenser 50, a trottling element 52 and an evaporator 54.

The hermetic compressor 48 is a normal household refrigerator type situated in compartment 34 and secured to structural wall 33. The trottling element 52 is preferably a capillary tube.

Condenser 50 is in the form of a box heat exchanger which extends right across the heating and circulating passage 32. Evaporator 54 consists of a box heat exchanger, very similar to heat exchanger 50, situated at the bottom of cooling passage 26 and extending right across it.

Under exchanger-evaporator 54 in rear wall 24 is an opening (preferably a slit) 56 through which cooling

passage 26 communicates with the outside air.

A little below the open bottom end of cooling passage 26, there is a receptacle 58 in the form of a gutter which, through drain opening 60, leads to a drip tank or box 62 under structural wall 32. Box 62 slides inside the cabinet for collecting condensed water formed, as we shall see, in cooling passage 26 and exchanger-evaporator 54 during operation of the unit. Condensed water dripping into receptacle 58 is collected in box 62 which can be pulled out of the cabinet. Box 62 is preferably fitted with a transparent (e.g. plastic) front wall so the level of water can be seen for emptying the box periodically. Alternatively, receptacle 58 can be connected directly to a water drain.

The drier described and shown in the drawing operates as follows:

When the clothes or other items for drying have been loaded into drying chamber 10, door 14 is closed and compressor 48 and blower 46 are started up. The refrigerating fluid starts circulating in the refrigerating circuit so as to heat exchanger-condenser 50 and cool exchanger-evaporator 54.

Electric blower 46 circulates the air in a closed circuit, sucking it up from chamber 10 through opening 42, sending it through condenser 50 and blowing it out into the bottom of chamber 10. At the same time, electric blower 46 sucks up air from the outside through opening 38, compartment 34 and opening 44. When it passes into compartment 34, the air sucked up

from the outside flows over the casing of compressor 48, cooling the latter and being heated by it. The air sucked up from the outside also flows through exchanger-condenser 50 and is blown into the bottom of chamber 10 by blower 46. The air circulating in chamber 10 and heated gradually in exchanger-condenser 50 becomes saturated with humidity. The hottest air containing most humidity forms a layer or "dome" at the top of chamber 10 which traps in the heat to improve the efficiency of the unit.

Part of the saturated air flows through slit 20 into cooling passage 26 where it flows down to the bottom and is cooled first upon contact with cold wall 24 and then by heat exchange in evaporator 54.

The air current flowing down into passage 26 is caused by the difference in pressure between the inside of chamber 10 and the outside air as well as by the "reverse drawing" effect created in space 26 by the increasing density of the air as it is cooled.

As the damp air flows down into cooling passage 26, part of the damp condenses on cold wall 24 so that evaporator 54, situated near the bottom end of passage 26, receives air with part of the damp already taken out of it. The remaining damp is then condensed by evaporator 54. The water condensed by cold wall 24 and in evaporator 54 then drips into receptacle 58 and is collected in box 62.

The cooled air is then exhausted to the outside through opening 56. The size of air inlets 38 and 56 and circulation passages 26 and 32 and the power of

air circulating means 46 and heat exchangers 50 and 54 are designed so that the air circulating inside the casing is such that the air flowing over evaporator 54 and condenser 50 is automatically less at the end of the drying cycle than at the beginning.

Operation of the unit is regulated automatically: as the drying cycle proceeds, the temperature of the air in chamber 10 rises while its relative humidity falls. Consequently there is also a fall in the specific weight of the air, in the socalled "reverse drawing" effect and the amount of air exhausted to the outside. The latter fall is an advantage as far as the evaporator is concerned in that it receives less and less heat from the air thus preventing any unwanted rise in temperature. What is more, the smaller the amount of air being supplied to the evaporator, the easier it is to cool down to dew point which provides for better dehumidification.

Sucking up outside air and exhausting it back out by means of blower 46 provides yet another advantage: the load loss in cooling passage 26 creates a certain pressure in chamber 10 which makes the air in the chamber less flexible, so to speak, thus preventing it from finding its own way out through slit 20. This ensures all parts of chamber 10 are swept more or less evenly so as to dry the clothes or other items in the chamber more uniformly.

The scope of the present invention is not limited to the specific arrangement described here. For example, condenser 50 in circulation passage 32 could

be replaced entirely or in part by a coil pipe in drying chamber 10 in the form of horizontal bars on which to hang clothes or other items, as described in Patent Application Nº 67.380-A/82 filed by the present Applicant.

A further variation of the specific arrangement described could be to fit the outside air inlet 38 and outlet 56 with temporary shutters, e.g. controlled by a timer on the unit, which provide for operating the cabinet under airtight conditions during the intermediate drying stage.

The advantages of this arrangement are that it provides for high-speed operation of the drying chamber at the start of the cycle, prevents overheating of the chamber at the end of the cycle and improves drying efficiency during the intermediate stage by making the unit airtight.

CLAIMS:

1. Drier consisting of a drying chamber in a casing with closed-circuit air circulating means in the chamber itself; means for heating the circulating air; an air cooling passage for condensing humidity, situated next to the drying chamber with a top inlet communicating with the top of the drying chamber and a bottom outlet; and a refrigerating circuit which acts as a heat pump and comprises, among other things, a compressor, a condenser acting as the above mentioned heating means, and an evaporator in the form of a heat exchanger situated in the cooling passage, characterised by the fact that the casing comprises an outside air inlet (38) which communicates with the bottom of the drying chamber (10) via the above mentioned circulating means (46) and that the bottom end of the cooling passage (26) comes out into the outside air.

2. Drier according to Claim 1, characterised by the fact that it comprises a circulating passage (32) situated under the drying chamber (10) with which it communicates by means of an inlet and outlet at opposite ends, the circulating means (46) being situated in the said passage, and that the outside air inlet (38) communicates with the inlet in the circulating passage (32).

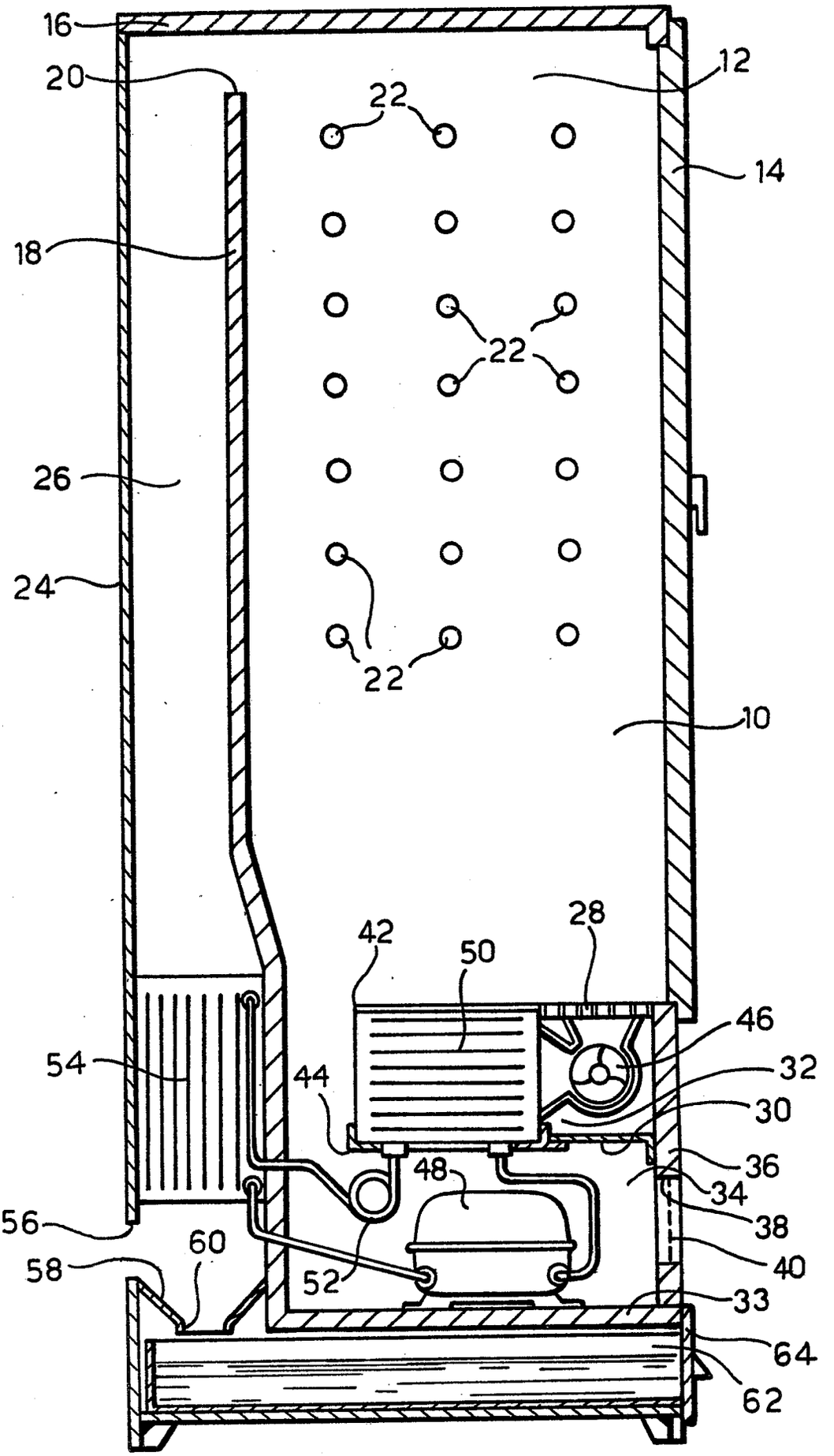
3. Drier according to Claim 1, characterised by the fact that the size of the air inlets (38 and 56) and circulating passages (26 and 32) and the power of the air circulating means (46) and heat exchangers (50 and 54) are designed so that the air circulating inside the

casing is such that the air flowing over the evaporator (54) and condenser (50) is automatically less at the end of the drying cycle than at the beginning.

4. Drier according to Claim 2, characterised by the fact that the condenser (50) is at least partly in the form of a heat exchanger situated in the circulation passage (32).

5. Drier according to any one of the previous Claims, characterised by the fact that the casing comprises a bottom compartment (34) in which is installed the compressor (48) and via which the air inlet (38) communicates with the drying chamber (10).

6. Drier according to any one of the previous Claims, characterised by the fact that the said outside air inlet (38) and the said bottom end of the cooling passage (26) that comes out into the outside air are fitted with shutters for preventing air being exchanged between the cabinet and outside atmosphere during part of the operating cycle of the unit.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EUROPEAN SEARCH REPORT

Application number

EP 83 83 0088

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. ³)
A	US-A-3 064 358 (GIUFFRE) * Column 2, lines 19-72; column 3, lines 1-9; column 4, lines 37-63 *	1,2,4, 6	D 06 F 58/10 D 06 F 58/20
A	GB-A-1 133 098 (RANDELL) * Page 3, lines 3-41 *	1	
A	FR-A-1 390 083 (GEOFFROY, BONSIGNORE)		
A	FR-A-1 370 792 (BONSIGNORE, GEOFFROY)		
A	DE-B-2 218 440 (LEPPER)		TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	FR-A-1 598 605 (BELLEVILLE)		D 06 F
A	FR-A-1 439 185 (RICHALET)		
A	FR-A-1 458 677 (DEOUST)		
A	FR-A-1 562 056 (DIELA)		

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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	04-08-1983	D HULSTER E.W.F.

CATEGORY OF CITED DOCUMENTS

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

Application number

EP 83 83 0088

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. ³)
A	FR-A-1 542 480 (CHARDON)		

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	04-08-1983	D HULSTER E.W.F.

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