(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 341 180 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.07.2011 Bulletin 2011/27

(51) Int Cl.:
D06F 58/20 *(2006.01)*

(21) Application number: **09180848.5**

(22) Date of filing: **29.12.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

(71) Applicant: **Electrolux Home Products Corporation N.V.**
1130 Brussel (BE)

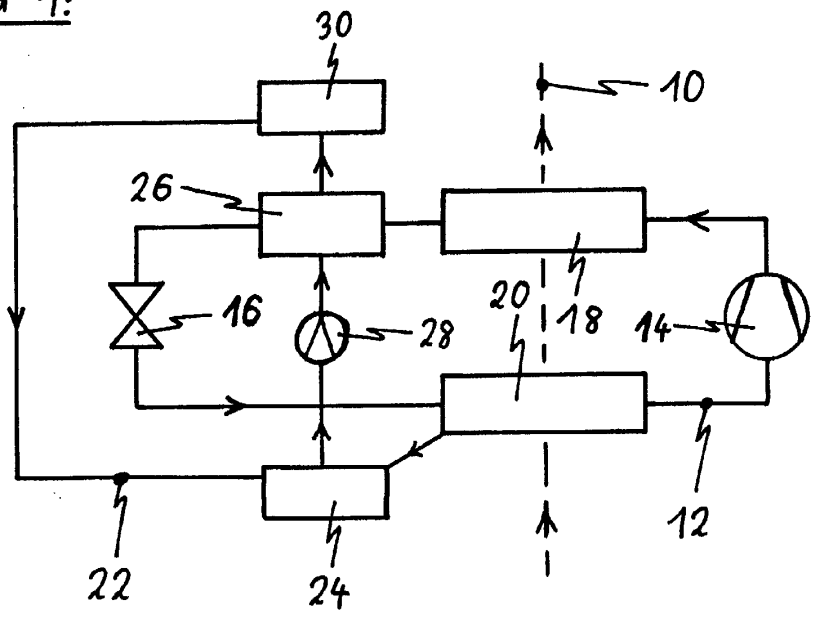
(72) Inventors:
- **Bison, Alberto**
  33080 Porcia (PN) (IT)
- **Zandona', Stefano**
  33080 Porcia (PN) (IT)

(74) Representative: **Nardoni, Andrea et al**
Electrolux Italia S.p.A.
Corso Lino Zanussi, 30
33080 Porcia (PN) (IT)

(54) **A heat pump system for a tumble dryer**

(57) The present invention relates to a heat pump system for a tumble dryer. The heat pump system comprises an air stream circuit (10) including at least one drum for receiving laundry to be dried, at least one fan (34) for generating an air stream, a first heat exchanger (18) and a second heat exchanger (20). The heat pump system comprises a refrigerant circuit (12) including at least one compressor (14), the first heat exchanger (18), at least one expansion valve (16) and the second heat exchanger (20). The heat pump system comprises a collecting sump (24) for collecting condensed water from one of the heat exchangers (20). The air stream circuit (10) and the refrigerant circuit (12) are thermally coupled by a first heat exchanger (18) and a second heat exchanger (20). The heat pump system comprises a closed condensed water circuit (22) for the condensed water with a further heat exchanger (26), wherein the refrigerant circuit (12) and the condensed water circuit (22) are thermally coupled by said further heat exchanger (26). Further, the present invention relates to a method for controlling the heat energy exchange between the refrigerant circuit (12) and the condensed water circuit (22) in the heat pump system.

FIG 1:



EP 2 341 180 A1

Description

A heat pump system for a tumble dryer

[0001] The present invention relates to a heat pump system for a tumble dryer according to the preamble of claim 1.

[0002] It is an efficient way to save energy in a tumble dryer by the heat pump technology. A typical tumble dryer comprises a closed air stream circuit and a closed refrigerant circuit. The air stream circuit and the refrigerant circuit are coupled by at least two heat exchangers. In said air stream circuit hot dry air is blown into the drum containing wet laundry. Then warm humid air leaves the drum and is cooled down in an evaporator. The evaporator is one of the heat exchangers. In the evaporator the water vapour of the humid air is condensed and deposited, while a refrigerant in the refrigerant circuit evaporates and is heated up in the evaporator. Thus, the humid air is dehumidified by the condensation of the water vapour. Then cold dry air in the air stream circuit is blown to a condenser, in which said dry air is heated up, while the refrigerant condenses and is cooled down in the condenser. At last hot dry air is blown into the drum again.

[0003] In the refrigerant circuit the refrigerant is compressed and heated by a compressor. Then the refrigerant condenses and is cooled down in the condenser, in which the air stream is heated up. Between the condenser and the evaporator the refrigerant passes an expansion valve, in which said refrigerant is cooled down. In the evaporator the refrigerant is heated up and the air stream is cooled down, wherein the water vapour of the air stream condenses. Then the refrigerant is compressed and heated again by the compressor.

[0004] DE 44 09 607 C2 discloses a tumble dryer with a heat pump system. The heat pump system comprises an air stream circuit and a refrigerant circuit. The condensed water is used for cooling down the compressor of the refrigerant circuit or a portion of said refrigerant circuit.

[0005] It is an object of the present invention to provide a heat pump system for a tumble dryer, which allows an efficient use of heating and cooling energy resources.

[0006] The object of the present invention is achieved by the tumble dryer according to claim 1.

[0007] According to the present invention the heat pump system comprises a closed condensed water circuit for the condensed water with a further heat exchanger, wherein the refrigerant circuit and the condensed water circuit are thermally coupled by said further heat exchanger.

[0008] The main idea of the present invention is the closed condensed water circuit, which allows a recirculation of the condensed water. The refrigerant is additionally cooled down due to the heat exchange with the condensed water. The condensed water can be cooled down due to a heat exchange with the environment.

[0009] According to a preferred embodiment of the present invention the first heat exchanger is a condenser provided for heating up the air stream and cooling down the refrigerant.

[0010] In a similar way, the second heat exchanger is an evaporator provided for cooling down the air stream and heating up the refrigerant. Thus, the collecting sump is provided for collecting the condensed water from the evaporator.

[0011] Preferably, the further heat exchanger is arranged between the condenser and the expansion valve in the refrigerant circuit. The further heat exchanger may act as an auxiliary condenser.

[0012] For example, the further heat exchanger comprises a serpentine pipe for the refrigerant, wherein said serpentine pipe is immerged in a space provided for the condensed water. This allows an efficient heat exchange between the refrigerant and the condensed water by simple means.

[0013] Further, the condensed water circuit includes a water pump for pumping up the condensed water.

[0014] The condensed water circuit may include a collecting tank for storing the condensed water. Preferably, the collecting tank is arranged in a top portion of the heat pump system, so that the condensed water can flow to the collecting sump by gravity.

[0015] The further heat exchanger may be arranged between the water pump and the collecting tank in the condensed water circuit.

[0016] The condensed water circuit may include an additional heat exchanger arranged between the evaporator and the compressor in the refrigerant circuit. In particular, the additional heat exchanger is arranged between the collecting tank and the collecting sump in the condensed water circuit.

[0017] Alternatively or additionally, the condensed water circuit may comprise at least one fan arranged besides a pipe portion between the collecting tank and the collecting sump.

[0018] Furthermore, the present invention relates to a method for controlling the heat energy exchange between the refrigerant circuit and the condensed water circuit in the heat pump system, wherein said method comprises the steps of:

- detecting the temperature difference of the refrigerant between the inlet and the outlet of the further heat exchanger,
- keeping the condensed water in a collecting space of the further heat exchanger during the temperature difference exceeds a predetermined value, and
- recirculating the condensed water, if the temperature difference decreases.

[0019] This method allows an efficient use of heating and cooling energy resources.

[0020] The novel and inventive features believed to be the characteristic of the present invention are set forth in the appended claims.

[0021] The invention will be described in further detail with reference to the drawings, in which

FIG 1 illustrates a schematic diagram of a heat pump system for a tumble dryer according to a first embodiment of the present invention,

FIG 2 illustrates a schematic diagram of the heat pump system for the tumble dryer according to a second embodiment of the present invention,

FIG 3 illustrates a schematic diagram of the heat pump system for the tumble dryer according to a third embodiment of the present invention,

FIG 4 illustrates a schematic diagram of a portion of a condensed water circuit for the heat pump system according to a fourth embodiment of the present invention,

FIG 5 illustrates a schematic diagram of a portion of the condensed water circuit for the heat pump system according to a fifth embodiment of the present invention, and

FIG 6 illustrates a perspective view of a realisation of the heat pump system for the tumble dryer according to the present invention.

[0022] FIG 1 illustrates a schematic diagram of a heat pump system for a tumble dryer according to a first embodiment of the present invention. The heat pump system comprises an air stream circuit 10, a refrigerant circuit 12 and a condensed water circuit 22.

[0023] The air stream circuit 10 includes a drum, a fan for generating an air stream, a condenser 18 and an evaporator 20. The drum and the fan, which are not shown in FIG 1, are integrated within the air stream circuit 10. The drum is provided for receiving laundry to be dried. The fan is provided for generating the air stream within the air stream circuit 10. The air stream circuit 10 forms a closed loop. In FIG 1 only a portion of the air stream circuit 10 is shown and represented by dashed lines.

[0024] The condenser 18 and the evaporator 20 are heat exchangers. The condenser 18 is provided for heating up the air stream in the air stream circuit 10. The evaporator 20 is provided for cooling down the air stream in the air stream circuit 10 for condensing the water vapour in said air stream.

[0025] The refrigerant circuit 12 includes a compressor 14, the condenser 18, a further heat exchanger 26, an expansion valve 16 and the evaporator 20. The refrigerant circuit 12 forms also a closed loop. The air stream circuit 10 and the refrigerant circuit 12 are thermally coupled by the condenser 18 and the evaporator 20.

[0026] A refrigerant flows in the refrigerant circuit 12. In FIG 1 the refrigerant flows counter-clockwise in the refrigerant circuit 12. The refrigerant is compressed and heated by the compressor 14. The heated refrigerant reaches the condenser 18. In the condenser 18 the refrigerant condenses and is cooled down and the air stream in the air stream circuit 10 is heated up. In the further heat exchanger 26 the refrigerant is additionally cooled down by condensed water. Then the refrigerant is expanded and cooled down by the expansion valve 16. In the evaporator 20 the refrigerant is heated up and the air stream is cooled down. By the compressor 14 the refrigerant is compressed and heated up again.

[0027] The condensed water circuit 22 includes a collecting sump 24, a water pump 28, the further heat exchanger 26 and a collecting tank 30. The collecting sump 24 is arranged at the lowest point of the condensed water circuit 22, while the collecting tank 30 is arranged at the highest point of the condensed water circuit 22. The collecting sump 24 is connected to the evaporator 20 and provided for collecting the condensed water from the evaporator 20. The condensed water is pumped up from the collecting sump 24 through the further heat exchanger 26 to the collecting tank 30. The condensed water can flow down from the collecting tank 30 to the collecting sump 24 again.

[0028] The condensed water allows the additional cooling down of the refrigerant in the further heat exchanger 26. The condensed water is permanently cooled down in the condensed water circuit 22 due to a heat exchange with the environment, while the condensed water flows along said condensed water circuit 22. Preferably, the condensed water circuit 22 is made of a material with a good thermal conductivity. For example, portions of the condensed water circuit 22 may be arranged at or beside the wall of the cabinet of the tumble drier, in order to allow a good heat exchange with the environment. The heat exchange between the refrigerant and the condensed water in the further heat exchanger 26 allows an effective additional cooling down of the refrigerant.

[0029] The further heat exchanger 26 may be considered as an auxiliary condenser. The further heat exchanger 26 may be realized as a continuation of an outlet pipe of the condenser 18. For example, the pipe has a serpentine structure. The serpentine pipe can be immerged in a collecting space under the evaporator, where the condensed water falls down. The condensed water can be kept in this space until the desired energy has been exchanged. Then the condensed water can be recirculated by the water pump 28.

[0030] The exchanged heat can be controlled by the measuring the temperature difference of the refrigerant between the inlet and the outlet of the further heat exchanger 26. Further, the temperature difference of the water and the time development of the temperature differences (of water, of refrigerant or a combination thereof) may be taken into account. The condensed water is kept in the collecting sump 24 during the temperature difference exceeds a predetermined value. If the temperature difference decreases, then the temperature of the condensed water is becoming too high, so that the con-

densed water has to be recirculated.

[0031] Preferably, the collecting tank 30 is removable, so that the user can easily empty the collecting tank 30. When the condensed water reaches a predetermined fill level within the collecting tank 30, then condensed water flows down to the collecting sump 24.

[0032] FIG 2 illustrates a schematic diagram of the heat pump system for the tumble dryer according to a second embodiment of the present invention. The heat pump system according to the second embodiment comprises the same components as the heat pump system of the first embodiment.

[0033] Furthermore, the heat pump system of the second embodiment comprises an additional heat exchanger 32. The additional heat exchanger 32 is a part of the refrigerant circuit 12 as well as of the condensed water circuit 22. Thus, the refrigerant circuit 12 and the condensed water circuit 22 are thermally coupled by the additional heat exchanger 32.

[0034] Within the refrigerant circuit 12 the additional heat exchanger 32 is arranged between the evaporator 20 and the compressor 14. The additional heat exchanger 32 allows the refrigerant to be overheated by the condensed water, so that only gas enters into the compressor 14. This improves the performances of the heat pump system on the one hand and the additional heat exchanger 32 allows the water to be cooled down on the other hand. Within the condensed water circuit 22 the additional heat exchanger 32 is arranged between the collecting tank 30 and the collecting sump 24.

[0035] FIG 3 illustrates a schematic diagram of the heat pump system for the tumble dryer according to a third embodiment of the present invention. The heat pump system according to the third embodiment comprises the same components as the heat pump system of the first embodiment.

[0036] Furthermore, the heat pump system of the third embodiment comprises a fan 34. The fan 34 is arranged besides a pipe connecting the collecting tank 30 to the collecting sump 24. The fan 34 supports the heat exchange between the refrigerant and the environment, so that the cooling down of the refrigerant is improved.

[0037] FIG 4 illustrates a schematic diagram of a portion of a condensed water circuit for the heat pump system according to a fourth embodiment of the present invention.

[0038] In the heat pump system of the fourth embodiment the condensed water circuit 22 includes a water stream sensor 36 and a three-way valve 38. The water stream sensor 36 is arranged in a down-stream pipe 40 between the collecting tank 30 and the collecting sump 24. The three-way valve 38 is arranged in an up-stream pipe 42 to the collecting tank 30. A pipe connection 44 is arranged between the down-stream pipe 40 and the three-way valve 38.

[0039] In this example, the collecting tank 30 is removable and arranged in a tank housing 50. The amount of the condensed water increases during the drying process. The water stream sensor 36 detects a water overflow, when the collecting tank 30 is completely filled and the condensed water flows into the tank housing 50. Then, the tumble dryer is stopped in order to inform the user that the collecting tank needs to be emptied.

[0040] The three-way valve 38 is provided for a selection between two operation modes. In the first operation mode the connection to the collecting tank 30 is closed and the pipe connection 44 is opened, so that the condensed water is recirculated. In the second operation mode the connection to the collecting tank 30 is opened and the pipe connection 44 is closed. The second operation mode may be activated at a predetermined time interval, since the amount of the condensed water increases during the drying process.

[0041] FIG 5 illustrates a schematic diagram of a portion of the condensed water circuit for the heat pump system according to a fifth embodiment of the present invention.

[0042] In the heat pump system of the fifth embodiment the condensed water circuit 22 includes the water stream sensor 36, a recirculation pipe 46 and a recirculation valve 48. The water stream sensor 36 is arranged in the down-stream pipe 40 between the collecting tank 30 and the collecting sump 24. The recirculation pipe 46 extends from the down-stream pipe 40 to the collecting tank 30. The recirculation valve 48 is arranged in the recirculation pipe 46 and is provided for closing said recirculation pipe 46.

[0043] Also in this example, the collecting tank 30 is removable. When the collecting tank 30 is completely inserted, then the recirculation valve 48 is fluidly connected to the bottom part of the collecting tank 30, so that immediately the water is recirculated via the down-stream pipe 40. The condensed water is pumped up to the collecting tank 30. When the water level in the collecting tank 30 reaches a predetermined value, then the recirculation valve 48 is activated, so that the condensed water returns to the collecting sump 24 by gravity.

[0044] The amount of the condensed water increases during the drying process and the collecting tank 30 will be filled. When the collecting tank 30 is completely filled, then the condensed water overflows into the tank housing 50. When, during the drying process, the water accumulated overflows from the collecting tank 30 into the tank housing 50, then the water passes the stream sensor 36 and the tumble dryer is stopped in order to inform the user that the collecting tank needs to be emptied.

[0045] FIG 6 illustrates a perspective view of a realisation of the heat pump system for the tumble dryer according to the present invention. FIG 6 shows the arrangement of the components of the heat pump system within the tumble dryer.

[0046] The collecting tank 30 is arranged in a top portion of the tumble dryer, while the remaining components of the heat pump system are arranged in a bottom portion of the tumble dryer. The collecting tank 30 is removable within the tank housing 50. The collecting tank 30 is con-

nected to the bottom portion of the tumble dryer by the down-stream pipe 40 and the up-stream pipe 42.

[0047] The heat pump system according to the present invention allows in washer dryer a reduction of the temperature of the refrigerant of about 3°C. Thus, the power of the evaporator may increase of about 50 W. In a tumble dryer a reduction of the temperature of the refrigerant of about 6°C can be achieved. This allows a power increase of about 100 W.

[0048] The heat pump system according to the present invention can be realized as a compact arrangement. The inventive heat pump system avoids complicated paths for the pipes outside of the air ducts. The amount of additional material for the closed condensed water circuit, e.g. copper pipes, is very small.

[0049] Although illustrative embodiments of the present invention have been described herein with reference to the accompanying drawings, it is to be understood that the present invention is not limited to those precise embodiments, and that various other changes and modifications may be affected therein by one skilled in the art without departing from the scope or spirit of the invention. All such changes and modifications are intended to be included within the scope of the invention as defined by the appended claims.

List of reference numerals

[0050]

10 air stream circuit

12 refrigerant circuit

14 compressor

16 expansion valve

18 first heat exchanger, condenser

20 second heat exchanger, evaporator

22 condensed water circuit

24 collecting sump

26 (further) heat exchanger

28 water pump

30 collecting tank

32 (additional) heat exchanger

34 fan

36 stream sensor

38 three-way valve

40 down-stream pipe

42 up-stream pipe

44 pipe connection

46 recirculation pipe

48 recirculation valve

50 tank housing

Claims

1. A heat pump system for a tumble dryer comprising:

- an air stream circuit (10) including at least one drum for receiving laundry to be dried, at least one fan for generating an air stream, a first heat exchanger (18) and a second heat exchanger (20),
- a refrigerant circuit (12) including at least one compressor (14), the first heat exchanger (18), at least one expansion valve (16) and the second heat exchanger (20),
- a collecting sump (24) for collecting condensed water from one of the heat exchangers (20), wherein
- the air stream circuit (10) and the refrigerant circuit (12) are thermally coupled by a first heat exchanger (18) and a second heat exchanger (20),

characterized in, that
the heat pump system comprises a closed condensed water circuit (22) for the condensed water with a further heat exchanger (26), wherein the refrigerant circuit (12) and the condensed water circuit (22) are thermally coupled by said further heat exchanger (26).

2. The heat pump system according to claim 1, **characterized in, that**
the first heat exchanger is a condenser (18) provided for heating up the air stream and cooling down the refrigerant.

3. The heat pump system according to claim 1 or 2, **characterized in, that**
the second heat exchanger is an evaporator (20) provided for cooling down the air stream and heating up the refrigerant.

4. The heat pump system according to claim 2 and 3, **characterized in, that**

the collecting sump (24) is provided for collecting the condensed water from the evaporator (20).

5. The heat pump system according to any one of the claims 2 to 4,
characterized in, that
the further heat exchanger (26) is arranged between the condenser (18) and the expansion valve (16) in the refrigerant circuit (12).

6. The heat pump system according to any one of the preceding claims,
characterized in, that
the further heat exchanger (26) comprises a serpentine pipe for the refrigerant, wherein said serpentine pipe is immerged in a space provided for the condensed water.

7. The heat pump system according to any one of the preceding claims,
characterized in, that
the condensed water circuit (22) includes a water pump (28) for pumping up the condensed water.

8. The heat pump system according to any one of the preceding claims,
characterized in, that
the condensed water circuit (22) includes a collecting tank (30) for storing the condensed water.

9. The heat pump system according to claim 8, **characterized in, that**
the collecting tank (30) is arranged in a top portion of the heat pump system, so that the condensed water can flow to the collecting sump (24) by gravity.

10. The heat pump system according to claim 8 or 9, **characterized in, that**
the further heat exchanger (26) is arranged between the water pump (28) and the collecting tank (30) in the condensed water circuit (22).

11. The heat pump system according to any one of the claims 3 to 10,
characterized in, that
the condensed water circuit (22) includes an additional heat exchanger (32) arranged between the evaporator (20) and the compressor (14) in the refrigerant circuit (12).

12. The heat pump system according to claim 11, **characterized in, that**
the additional heat exchanger (32) is arranged between the collecting tank (30) and the collecting sump (24) in the condensed water circuit (22).

13. The heat pump system according to any one of the preceding claims,
characterized in, that
the condensed water circuit (22) comprises at least one fan (34) arranged besides a pipe portion between the collecting tank (30) and the collecting sump (24).

14. A method for controlling the heat energy exchange between the refrigerant circuit (12) and the condensed water circuit (22) in the heat pump system according to any one of the claims 1 to 13,
characterized in, that
the method comprises the steps of:

detecting the temperature difference of the refrigerant between the inlet and the outlet of the further heat exchanger (26), and/or the temperature difference of the condensed water between the inlet and the outlet of the further heat exchanger (26), and/or the time development of the temperature difference of the refrigerant and/or the condensed water,
keeping the condensed water in a collecting space during the temperature difference exceeds a predetermined value, and
recirculating the condensed water, if the temperature difference decreases.

FIG 1:

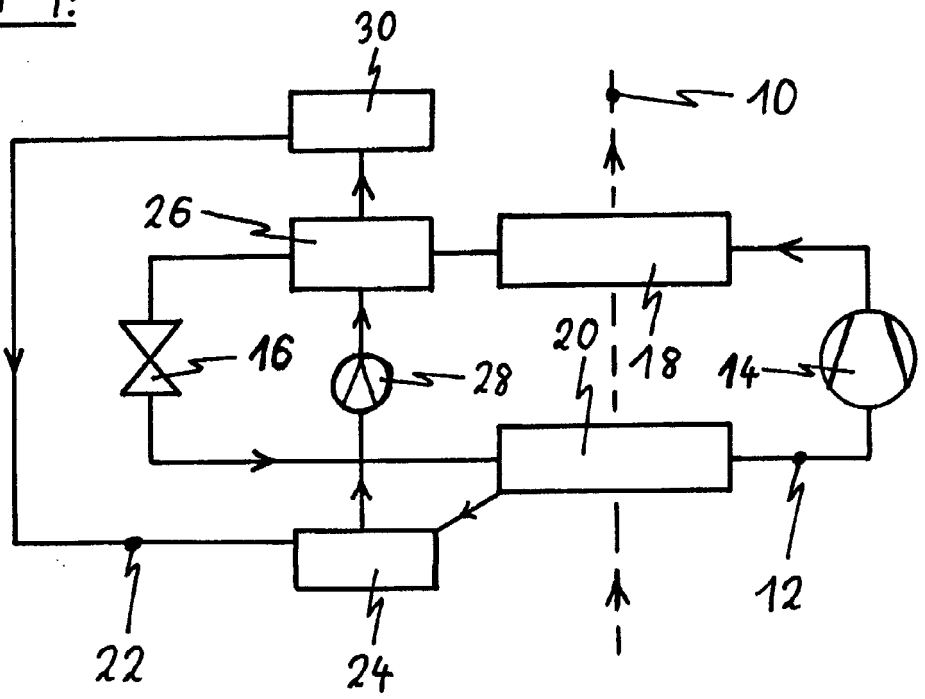


FIG 2:

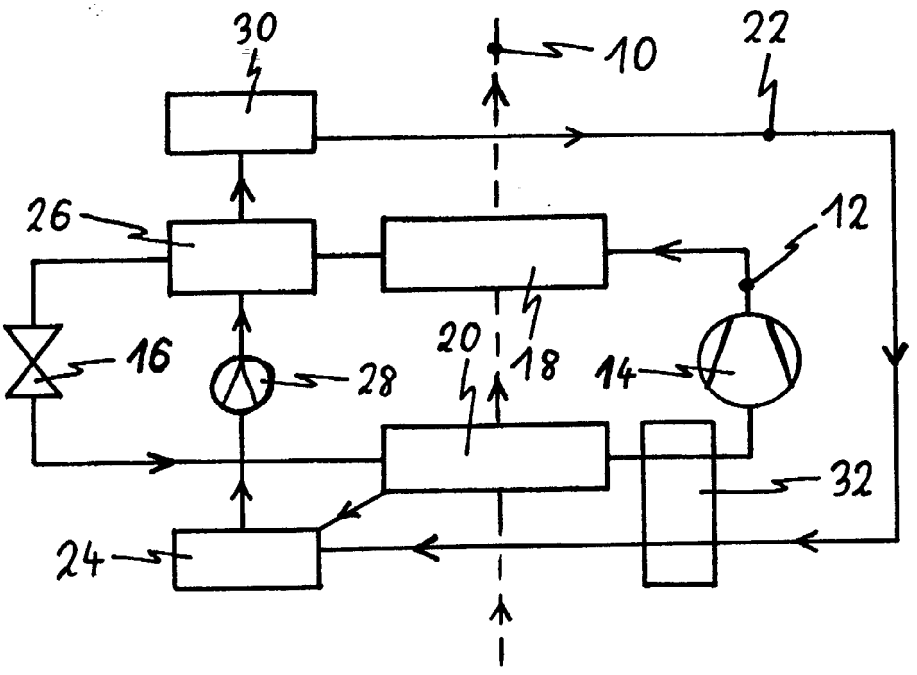


FIG 3:

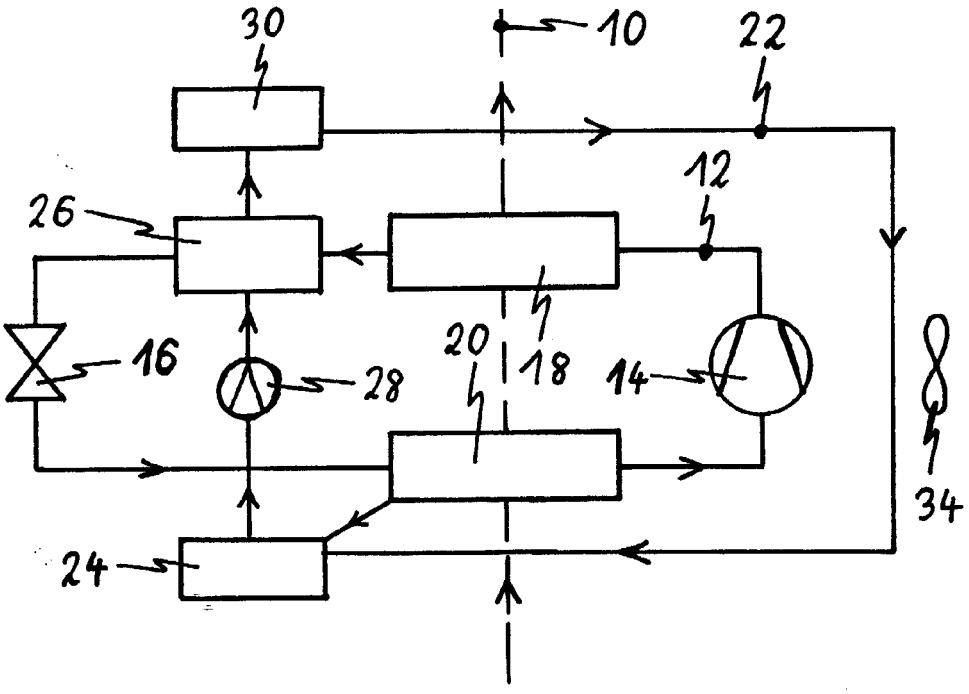


FIG 4:

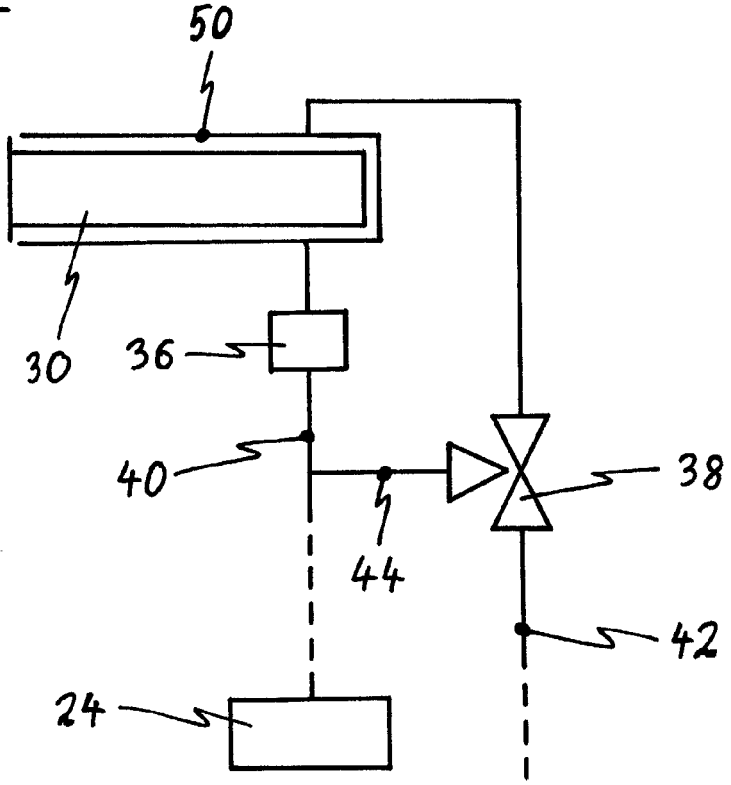


FIG 5:

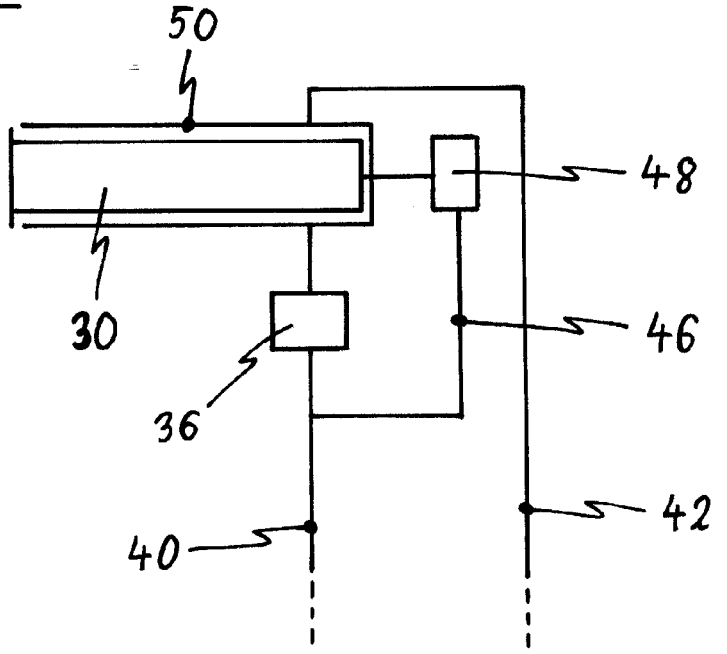
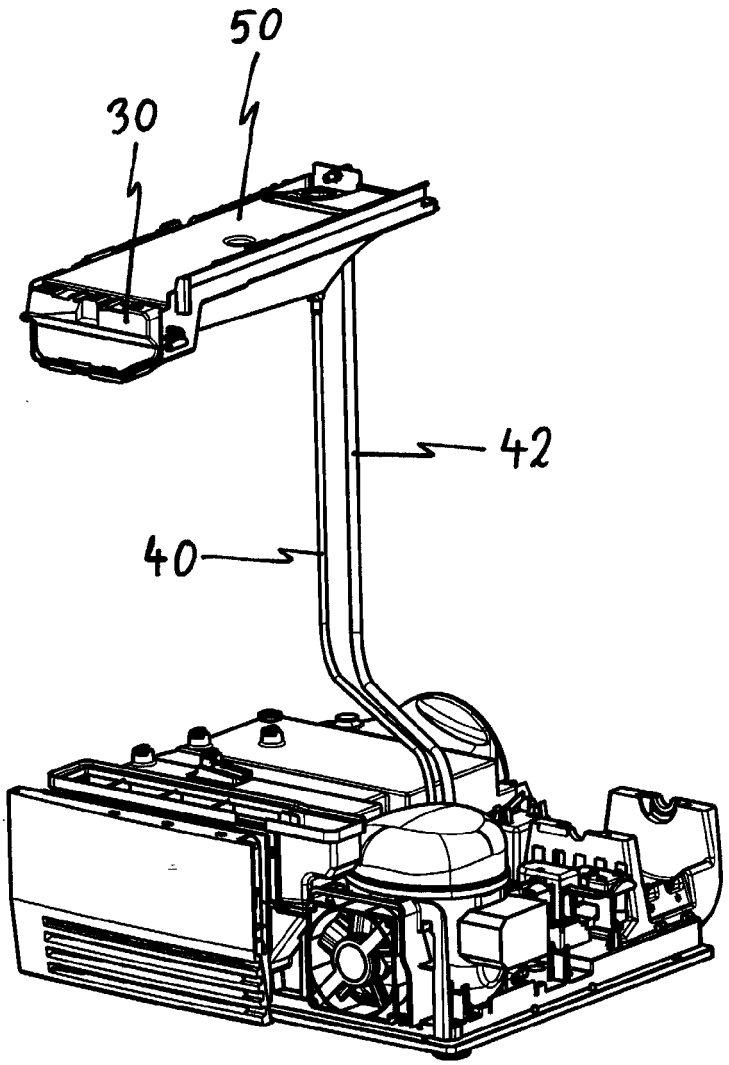


FIG 6:



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 09 18 0848

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D A	DE 44 09 607 A1 (MIELE & CIE [DE]) 27 October 1994 (1994-10-27) * column 2, line 50 - column 3, line 64; claims 1,4,5,11; figures 5-7 *	1-5,7,8,14 6,9-13	INV. D06F58/20
A	DE 10 2007 049060 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]) 16 April 2009 (2009-04-16) * paragraphs [0021] - [0030]; figures *	1-14	
A	DE 33 21 245 A1 (CORDES WILH MASCHF [DE]) 13 December 1984 (1984-12-13) * page 3, line 20 - page 5, line 15; claims; figures *	1-14	
A	DE 20 2006 018205 U1 (V ZUG AG [CH]) 15 February 2007 (2007-02-15) * paragraphs [0015] - [0025]; claims; figures *	1-14	
			TECHNICAL FIELDS SEARCHED (IPC) D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	14 June 2010	Clivio, Eugenio

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

1

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 18 0848

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-06-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 4409607 A1	27-10-1994	NONE	
DE 102007049060 A1	16-04-2009	WO 2009050003 A1	23-04-2009
DE 3321245 A1	13-12-1984	NONE	
DE 202006018205 U1	15-02-2007	DE 202007000648 U1	15-03-2007
		EP 2034084 A1	11-03-2009

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE 4409607 C2 **[0004]**