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

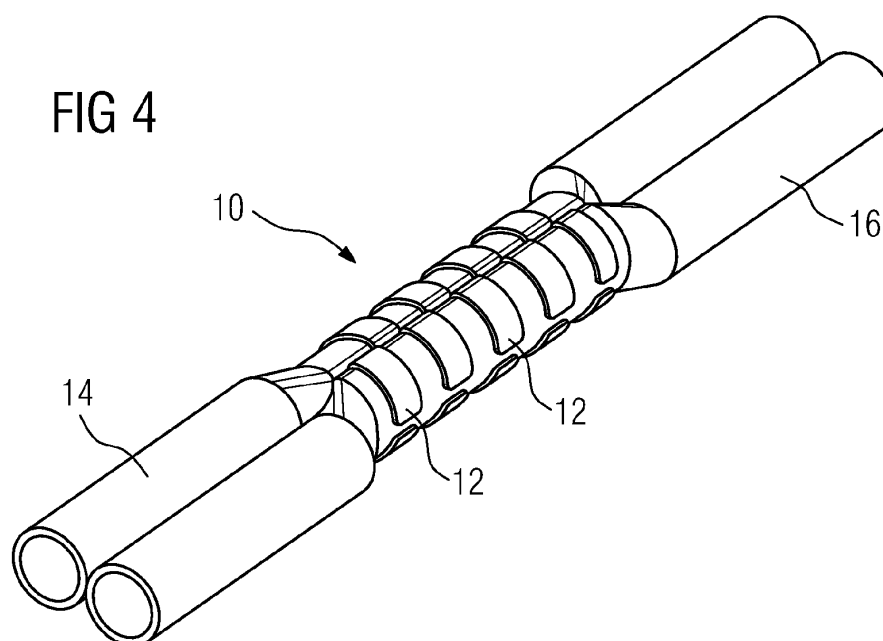
(72) Inventors:
• **Pillot, Sergio**
33080 Porcia (PN) (IT)
• **Sartor, Luciano**
33080 Porcia (PN) (IT)
• **Zandona', Stefano**
33080 Porcia (PN) (IT)

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

(54) **A heat exchanger for a heat pump system in a household appliance**

(57) The present invention relates to a heat exchanger for a heat pump system in a household appliance. The heat exchanger includes at least two pipes (14, 16) arranged side-by-side and parallel to each other. The pipes (14, 16) are thermally and mechanically coupled by at least one connecting device (10). The connecting device (10) includes at least two parallel series of a plurality of

connecting elements (12). Each series of connecting elements (12) corresponds with one of the pipes (14, 16). Each connecting element (12) encloses at least partially one of the pipes (14, 16). The connecting elements (12) are crimped onto the pipes (14, 16). Further, the present invention relates to a household appliance with a heat pump system. In particular, the present invention relates to a laundry dryer with a heat pump system.



Description

[0001] The present invention relates to a heat exchanger for a heat pump system in a household appliance. Further, the present invention relates to a household appliance with a heat pump system. In particular, the present invention relates to a laundry dryer with a heat pump system.

[0002] In a heat exchanger a sufficient heat transfer between the both sides of said heat exchanger is required. For this purpose long pipes or other voluminous means are necessary. Otherwise the dimensions of the heat exchanger should not be too large in order to install the heat exchanger and further components inside a casing, which size is limited.

[0003] Especially in a heat pump system the heat exchanger should have a maximum heat transfer on the one hand and small dimensions on the other hand. In particular, a laundry dryer with a heat pump system requires a heat exchanger with a sufficient heat transfer in order to obtain a good heat pump performance. Further, the space inside the casing of the laundry dryer is limited.

[0004] It is an object of the present invention to provide a heat exchanger for a heat pump system, which heat exchanger comprises an improved heat transfer, wherein the dimensions and the complexity of said heat exchanger are relative small.

[0005] The object of the present invention is achieved by the heat exchanger according to claim 1.

[0006] The present invention relates to a heat exchanger for a heat pump system in a household appliance, wherein

- the heat exchanger includes at least two pipes arranged side-by-side and parallel to each other,
- the pipes are thermally and mechanically coupled by at least one connecting device,
- the connecting device includes at least two parallel series of a plurality of connecting elements,
- each series of connecting elements corresponds with one of the pipes,
- each connecting element encloses at least partially one of the pipes, and
- the connecting elements are crimped onto the pipes.

[0007] The core of the present invention is the crimping of the connecting device on the pipes. Since no further components are required, the heat exchanger can be realized by only a few elements. Since the pipes are arranged side-by-side, the thermal coupling between the pipes and a sufficient heat transfer is guaranteed.

[0008] According to a preferred embodiment of the present invention the pipes are crimped onto each other at least within the portion of the connecting device and/or the connecting elements. This increases the heat transfer between the pipes.

[0009] For example, the connecting element has a U-shaped form and/or the form of a horseshoe. These forms

are optimal for enclosing the pipe.

[0010] In particular, the connecting device with the connecting elements is formed as a single-piece part. In this case, the heat exchanger can be realized by only three elements, i.e. the two pipes and the connecting device.

[0011] Further, the connecting device may be made of a sheet, wherein a plurality of parallel cuts is made and a resulting plurality of tongues is bent to the connecting elements.

[0012] Preferably, the plurality of parallel cuts is made on two opposite sides of the sheet, wherein the resulting tongues extend perpendicular to said opposite sides.

[0013] In particular, two diametrically opposed tongues are bent to the connecting element in each case.

[0014] According to a preferred embodiment of the present invention the heat exchanger is provided as a counterflow heat exchanger.

[0015] Preferably, the connecting device and/or the pipes are made of at least one material with a high thermal conductivity. In particular, the connecting device and/or the pipes are made of metal.

[0016] The present invention relates further to a household appliance with a heat pump system, wherein the household appliance comprises at least one heat exchanger as described above.

[0017] Moreover, the present invention relates further to a laundry dryer comprising at least one heat exchanger mentioned above.

[0018] The novel and inventive features believed to be the characteristic of the present invention are set forth in the appended claims.

[0019] The invention will be described in further detail with reference to the drawings, in which

FIG 1 shows a three-side view of a connecting device for a heat exchanger according to a preferred embodiment of the present invention,

FIG 2 shows a perspective view of the connecting device for the heat exchanger according to the preferred embodiment of the present invention,

FIG 3 shows a perspective view of the heat exchanger in a semi-finished state according to the preferred embodiment of the present invention,

FIG 4 shows a perspective view of the heat exchanger in a finished state according to the preferred embodiment of the present invention, and

FIG 5 shows a schematic diagram of a heat pump system for a laundry dryer according to a preferred application of the heat exchanger according to the present invention.

[0020] FIG 1 illustrates a three-side view of a connecting device 10 for a heat exchanger according to a preferred embodiment of the present invention. The three-

side view includes a front view, a side view and a top view of said connecting device 10.

[0021] The connecting device 10 is formed as a single-piece part. Preferably, the connecting device 10 is made of metal. The connecting device 10 comprises a plurality of connecting elements 12. Each connecting element 12 has a U-shaped form and/or the form of a horseshoe. The connecting device 10 includes two series of the connecting elements 12.

[0022] The connecting device 10 is made of a rectangular sheet, in particular a metal sheet. In a first step, a plurality of parallel cuts is made on two opposite edges of said metal sheet. The cuts extend perpendicular to the edges. The distances of neighboured cuts are equal. As a result, the metal sheet gets two series of parallel tongues. Each tongue of the one series corresponds with an according tongue of the other series. The corresponding tongues have a common axis and are directed outwardly. Between the both series of tongues, the metal sheet remains uncut and comprises a plane sheet portion.

[0023] In a second step, the tongues are bent, so that each pair of corresponding tongues form the connecting element 12. Each connecting element 12 has a U-shaped form and/or the form of a horseshoe. As a result, two parallel series of the plurality of U-shaped connecting elements 12 are formed. The parallel series of the U-shaped connecting elements 12 form two parallel elongated channels. The open longitudinal sides of said two parallel channels are diametrically opposed.

[0024] FIG 2 shows a perspective view of the connecting device 10 for the heat exchanger according to the preferred embodiment of the present invention. FIG 2 clarifies the structure of the connecting device 10.

[0025] The two parallel elongated channels formed by the U-shaped connecting elements 12 are provided for receiving pipes 14 and 16. The connecting device 10, a first pipe 14 and a second pipe 16 form the heat exchanger.

[0026] FIG 3 shows a perspective view of the heat exchanger in a semi-finished state according to the preferred embodiment of the present invention. The heat exchanger comprises the connecting device 10, the first pipe 14 and the second pipe 16.

[0027] In FIG 3 the first pipe 14 is inserted in the one channel formed by the plurality of connecting elements 12. The second pipe 16 is inserted in the other channel formed by the plurality of connecting elements 12. The first pipe 14 and the second pipe 16 are arranged in parallel and side-by-side.

[0028] FIG 4 shows a perspective view of the heat exchanger in a finished state according to the preferred embodiment of the present invention. In FIG 4 the U-shaped connecting elements 12 are compressed, so that each connecting element 12 encloses the first pipe 14 or the second pipe 16, respectively. Further, the first pipe 14 and the second pipe 16 are also compressed, so that a good heat transfer between the first pipe 14 and the

second pipe 16 is provided. The connecting device 10, the first pipe 14 and the second pipe 16 are made of materials with a high thermal conductivity.

[0029] Since the first pipe 14 and the second pipe 16 are compressed onto each other, the heat transfer between the first pipe 14 and the second pipe 16 increases. The good heat transfer between the first pipe 14 and the second pipe 16 allows a smaller dimension of the whole heat exchanger.

[0030] In particular, the heat exchanger of the present invention can be used as a counterflow heat exchanger. In the counterflow heat exchanger the gas or liquid, respectively, flows through the first pipe 14 and the second pipe 16 in opposite directions. The counterflow heat exchanger allows an increased heat transfer between the first pipe 14 and the second pipe 16.

[0031] The heat exchanger of the present invention can be used as a gas/gas heat exchanger, as a gas/liquid heat exchanger and as a liquid/liquid heat exchanger. In general, the inventive heat exchanger can be used for arbitrary applications. For example, the heat exchanger of the present invention can be used for heat pump systems.

[0032] According to a preferred application of the inventive heat exchanger, said heat exchanger is provided for a heat pump system of a laundry dryer.

[0033] FIG 5 shows a schematic diagram of the heat pump system for the laundry dryer according to a preferred application of the heat exchanger according to the present invention. The heat pump system includes a closed refrigerant circuit 20 and a closed air stream circuit 22.

[0034] The refrigerant circuit 20 includes a compressor 24, a first heat exchanger 26, lamination means 28, a second heat exchanger 30 and an internal heat exchanger 32. The refrigerant circuit 20 is subdivided into a low pressure portion and a high pressure portion. The low pressure portion and the high pressure portion are thermally connected by the internal heat exchanger 32. The internal heat exchanger 32 is preferably realized as the heat exchanger of FIG 4.

[0035] The compressor 24, the first heat exchanger 26, a high pressure side 36 of the internal heat exchanger 32, the lamination means 28, the second heat exchanger 30 and a low pressure side 34 of the internal heat exchanger 32 are switched in series and form a closed loop of the refrigerant circuit 20.

[0036] The high pressure portion extends from an outlet of the compressor 24 via the first heat exchanger 26 and the high pressure side 36 of the internal heat exchanger 32 to an inlet of the lamination means 28. The low pressure portion extends from an outlet of the lamination means 28 via the second heat exchanger 30 and the low pressure side 34 of the internal heat exchanger 32 to an inlet of the compressor 24.

[0037] The first heat exchanger 26 and the second heat exchanger 30 form the thermal interconnections between the refrigerant circuit 20 and the air stream circuit 22. The

air stream circuit 22 includes the second heat exchanger 30, the first heat exchanger 26, a laundry drum 40 and a fan 42. In the air stream circuit 22 the second heat exchanger 30 cools down and dehumidifies the air stream, after the air stream has passed the laundry drum 40. Then the first heat exchanger 26 heats up the air stream, before said air stream is re-inserted into the laundry drum 40. The air stream is driven by the fan 42.

[0038] The first heat exchanger 26 and the second heat exchanger 30 do not always condense and evaporate, respectively, the refrigerant. For example, if CO₂ is used as refrigerant and said refrigerant operates at the supercritical mode, i.e. at least at the critical pressure and always in the gas phase, then the refrigerant is neither condensed nor evaporated. In this case, the first heat exchanger 26 and the second heat exchanger 30 operate factually as a gas cooler and a gas heater, respectively.

[0039] In the refrigerant circuit 22 a refrigerant is compressed by the compressor 24, condensed in the first heat exchanger 26, cooled down in the high pressure side 36 of the internal heat exchanger 32, laminated in the expansion means 28, vaporised in the second heat exchanger 30 and in the low pressure side 34 of the internal heat exchanger 32.

[0040] The high pressure side 36 of the internal heat exchanger 32 is used to cool down the refrigerant between the first heat exchanger 26 and the lamination means 28. The low pressure side 34 of the internal heat exchanger 32 is used to heat up the refrigerant at the outlet of the second heat exchanger 30. The internal heat exchanger 32 allows the refrigerant to enter the second heat exchanger 30 in more favourable conditions. The vapour quality is lower and a part of the refrigerant is in the liquid phase, wherein the cooling capacity of the second heat exchanger 30 is increased. Otherwise the temperature of the refrigerant at an outlet of the low pressure side 34 of the internal heat exchanger 32, which enters the inlet of the compressor 24, is higher, and the power required to the compressor 24 increases as well. If cooling capacity increases more than the power required by the compressor 24, then the internal heat exchanger 32 improves heat pump efficiency.

[0041] The internal heat exchanger 32 in the heat pump system of the laundry dryer allows a shorter warm-up phase on the one hand and an improved heat pump performance during a steady state phase on the other hand. The internal heat exchanger 32 can additionally improve the heat pump performance more than usual, if said internal heat exchanger 32 is used to flood the second heat exchanger 30, so that a part of the refrigerant flowing through the second heat exchanger 30 is maintained in the liquid phase. This occurs, if the superheating phase in the second heat exchanger 30 is provided at the low pressure side 34 of the internal heat exchanger 32.

[0042] Condensed refrigerant is cooled down as usual in the high pressure side 36 of the internal heat exchanger 32, while in the low pressure side 34 of the internal heat

exchanger 32 the vaporization of the refrigerant is completed and the superheating is performed. Therefore the second heat exchanger 30 improves its cooling performance, because the flooding allows a big heat exchange coefficient of the refrigerant in the liquid phase and the internal heat exchanger 32 can improve the refrigerant sub-cooling at the high pressure side 36, since at the low pressure side 34 of the internal heat exchanger 32 the refrigerant can exchange both latent and sensible heat, so that more energy is available.

[0043] In order to optimize the internal heat exchanger for the warm-up phase as well as for the steady state phase, at least one by-pass line may be arranged. Said by-pass line may be provided for bypassing at least a part of the low pressure side 34 and/or high pressure side 36 of the internal heat exchanger 32. In particular, the by-pass line is at least partially closable by one or more regulation devices.

[0044] Although an illustrative embodiment of the present invention has been described herein with reference to the accompanying drawings, it is to be understood that the present invention is not limited to this precise embodiment, 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

[0045]

10	connecting device
12	connecting element
14	first pipe
16	second pipe
20	refrigerant circuit
22	air stream circuit
24	compressor
26	first heat exchanger
28	lamination means
30	second heat exchanger
32	internal heat exchanger
34	low pressure side of the internal heat exchanger 32
36	high pressure side of the internal heat exchanger

32

40 laundry drum

42 fan

Claims

1. A heat exchanger for a heat pump system in a household appliance, wherein

- the heat exchanger includes at least two pipes (14, 16) arranged side-by-side and parallel to each other,
- the pipes (14, 16) are thermally and mechanically coupled by at least one connecting device (10),
- the connecting device (10) includes at least two parallel series of a plurality of connecting elements (12),
- each series of connecting elements (12) corresponds with one of the pipes (14, 16),
- each connecting element (12) encloses at least partially one of the pipes (14, 16), and
- the connecting elements (12) are crimped onto the pipes (14, 16).

2. The heat exchanger according to claim 1, **characterized in, that** the pipes (14, 16) are crimped onto each other at least within the portion of the connecting device (10) and/or the connecting elements (12).

3. The heat exchanger according to claim 1 or 2, **characterized in, that** the connecting element (12) has a U-shaped form and/or the form of a horseshoe.

4. The heat exchanger according to any one of the preceding claims, **characterized in, that** the connecting device (10) with the connecting elements (12) is formed as a single-piece part.

5. The heat exchanger according to any one of the preceding claims, **characterized in, that** the connecting device (10) is made of a sheet, wherein a plurality of parallel cuts is made and a resulting plurality of tongues are bent to the connecting elements (12).

6. The heat exchanger according to claim 5, **characterized in, that** the plurality of parallel cuts is made on two opposite sides of the sheet, wherein the resulting tongues extend perpendicular to said opposite sides.

7. The heat exchanger according to claim 5 or 6, **characterized in, that** two diametrically opposed tongues are bent to the connecting element (12) in each case.

8. The heat exchanger according to any one of the preceding claims, **characterized in, that** the heat exchanger is provided as a counterflow heat exchanger.

9. The heat exchanger according to any one of the preceding claims, **characterized in, that** the connecting device (10) and/or the pipes (14, 16) are made of at least one material with a high thermal conductivity.

10. The heat exchanger according to claim 9, **characterized in, that** the connecting device (10) and/or the pipes (14, 16) are made of metal.

11. A household appliance with a heat pump system, **characterized in, that** the household appliance comprises at least one heat exchanger according to any one of the claims 1 to 10.

12. A laundry dryer with a heat pump system, **characterized in, that** the laundry dryer comprises at least one heat exchanger according to any one of the claims 1 to 10.

FIG 1

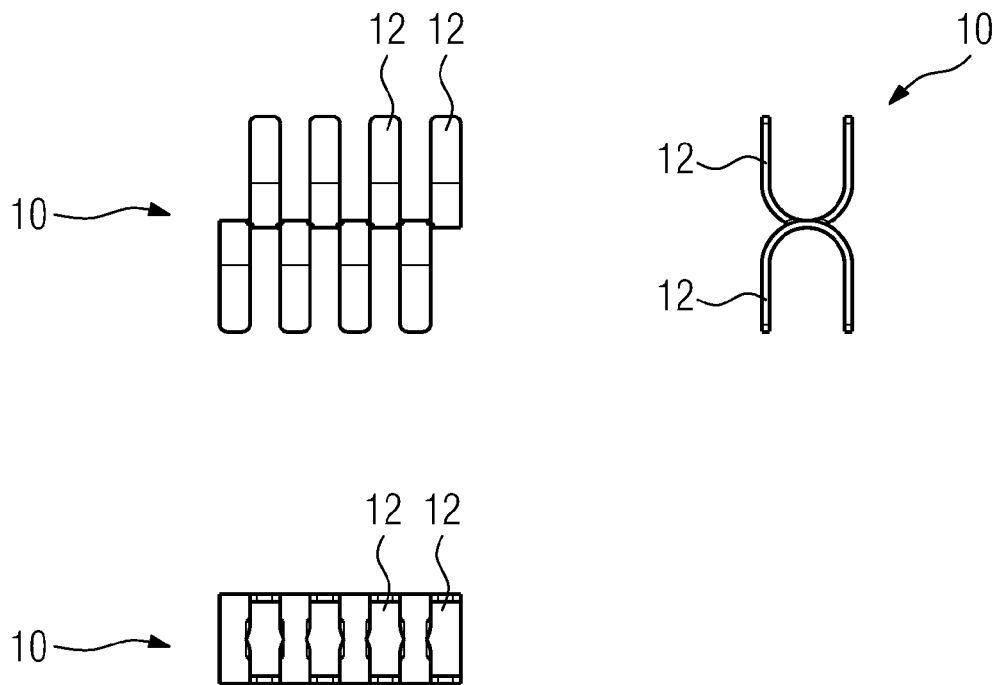


FIG 2

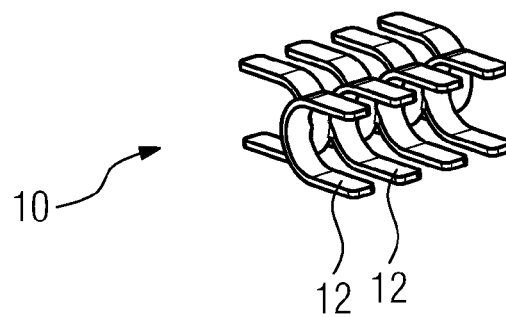


FIG 3

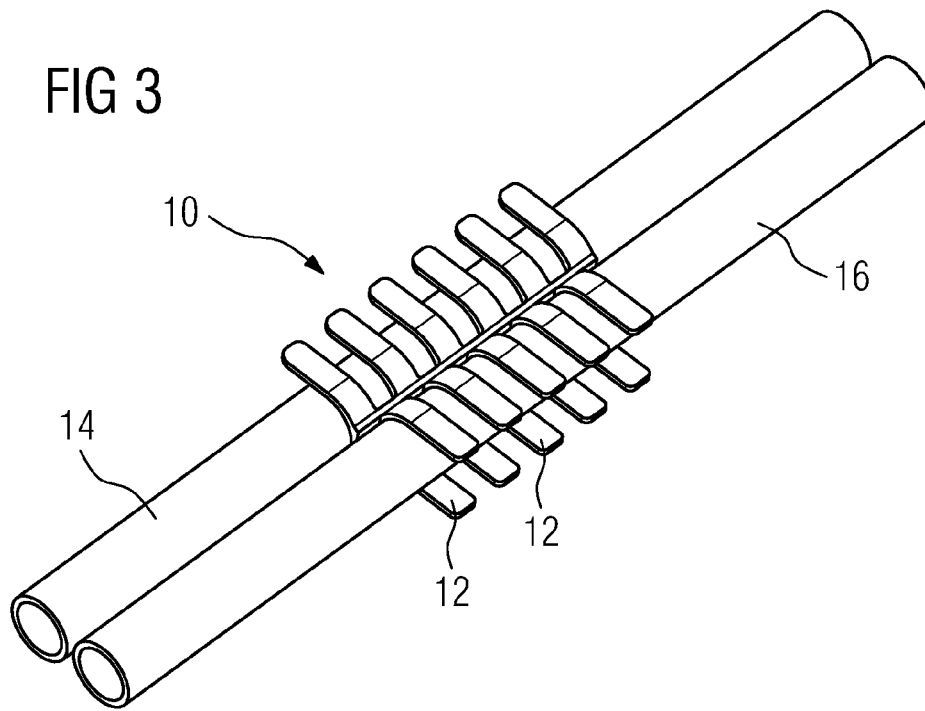


FIG 4

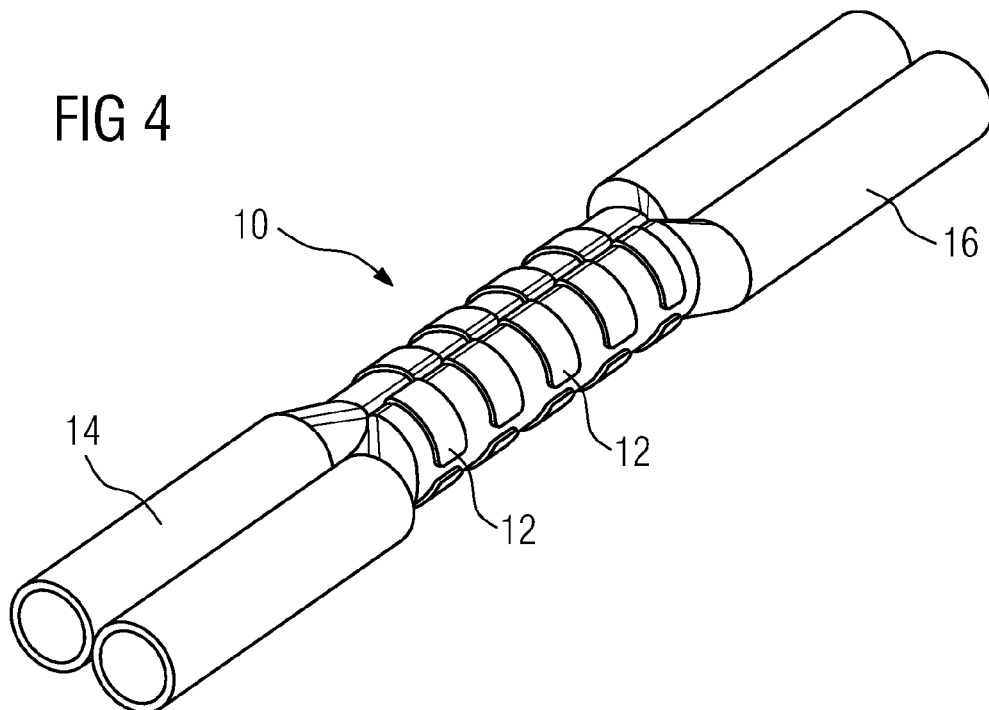
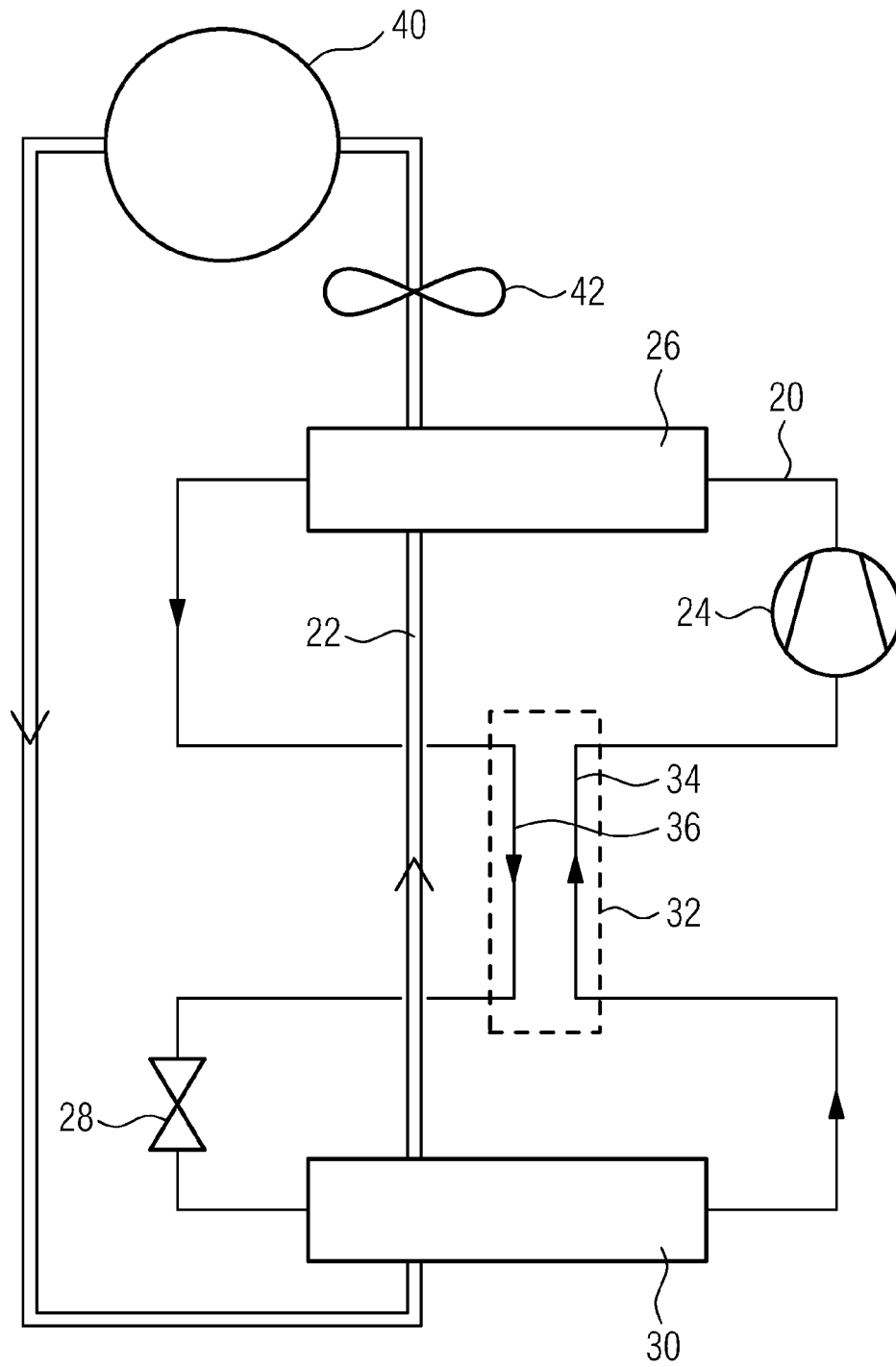


FIG 5





EUROPEAN SEARCH REPORT

Application Number
EP 11 17 2263

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 5 279 047 A (JANECKE WERNER [DE]) 18 January 1994 (1994-01-18) * column 14, line 24 - column 15, line 8; figures 9-11 *	1	INV. D06F58/24 F28F1/06 F28F1/02
A	JP 58 213193 A (TOKYO SHIBAURA ELECTRIC CO) 12 December 1983 (1983-12-12) * abstract *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			D06F F28F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 January 2012	Examiner Stroppa, Giovanni
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			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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26-01-2012

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5279047	A	18-01-1994	NONE	

JP 58213193	A	12-12-1983	NONE	
