

(19)



(11)

EP 4 155 628 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

29.03.2023 Bulletin 2023/13

(51) International Patent Classification (IPC):

F25B 41/37 ^(2021.01) **F25B 39/02** ^(2006.01)
F25B 43/00 ^(2006.01) **F25B 41/42** ^(2021.01)

(21) Application number: **22196206.1**

(52) Cooperative Patent Classification (CPC):

F25B 41/37; F25B 39/02; F25B 41/42;
F25B 43/003; F25B 2341/062; F25B 2500/18

(22) Date of filing: **16.09.2022**

(84) Designated Contracting States:

**AL 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 RS SE SI SK SM TR**

Designated Extension States:

BA ME

Designated Validation States:

KH MA MD TN

(71) Applicant: **BSH Hausgeräte GmbH**

81739 München (DE)

(72) Inventors:

- **Jimenez Ruiz, Eduardo**
31006 Pamplona (ES)
- **Roitegui Acedo, Ricardo**
31200 Estella (ES)

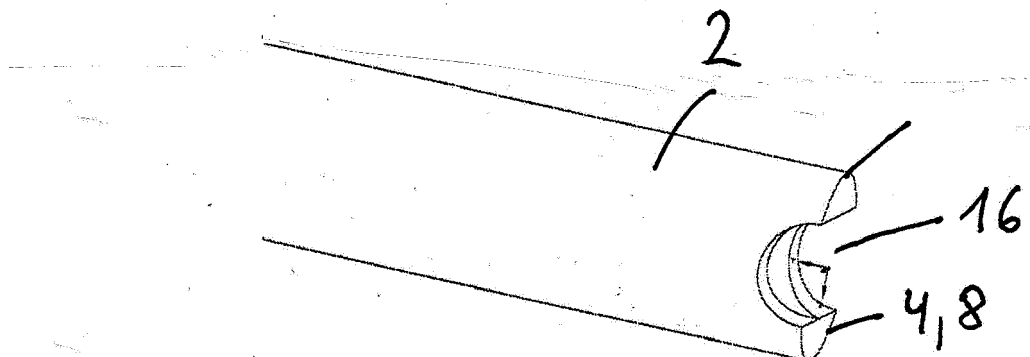
(30) Priority: **24.09.2021 EP 21382859**

(54) **HEAT PUMP HAVING A CAPILLARY, HOME APPLIANCE CONTAINING THE HEAT PUMP AND A PROCESS FOR MANUFACTURING A HEAT PUMP**

(57) The invention relates to a heat pump, including an evaporator 1, a condenser, a compressor for driving and compressing a flow of a refrigerant, a capillary 2 for expanding the refrigerant flow, and a refrigerant channel 3 for circulating the refrigerant flow sequentially through the compressor, the condenser, the filter 14, the capillary 2, the evaporator 1, and the compressor, wherein the

capillary 2 is connected to the evaporator 1 in a gas-tight and fluid-tight manner such that a first end 4 of the capillary 2 intrudes into the evaporator 1, wherein the capillary 2 is a cylindrical tube 5 with a lateral opening 6,7 at its first end 4 and/or at a second end 8 thereof. The invention also relates to a house appliance containing the heat pump.

Fig. 7



EP 4 155 628 A1

Description

[0001] The invention relates to a heat pump having a capillary and a home appliance containing the heat pump. In particular, the invention relates to a heat pump, including an evaporator, a condenser, a compressor for driving and compressing a flow of a refrigerant, a capillary for expanding the refrigerant flow, and a refrigerant channel for circulating the refrigerant flow sequentially through the compressor, the condenser, the filter, the capillary, the evaporator, and the compressor, wherein the capillary is connected to the evaporator in a gas-tight and fluid-tight manner such that a first end of the capillary intrudes into the evaporator; and a home appliance containing the heat pump.

[0002] Heat pumps are used in various fields of technology. A heat pump is a device which takes thermal energy from a reservoir with lower temperature, for example from the environment, and transfers it together with the drive energy as useful heat to a system to be heated with higher temperature. Heat pumps of this type can be used for example for heaters, dryers, washer-dryers, washing machines and dishwashers. A heat pump can also be used for cooling, e.g. in a refrigerator or in an air conditioner. The technical work is usually generated by means of electrical energy. It is desired to reduce the consumption of electrical energy and thus increase the energy efficiency of heat pumps. Another aim is to reduce the manufacturing costs of heat pumps. When heat pumps are used in dryers and washer-dryers, for example, drying times should also preferably be reduced. A known approach to achieve these goals is to reduce the diameter of the pipes carrying the refrigerant of the heat pump circuit. By reducing the diameter of the heat exchanger tubes, energy efficiency can be increased. Furthermore, reducing the diameter of the tubes can save material and thus reduce the manufacturing costs of the heat pump. However, the disadvantage here is that the pressure loss or pressure drop of the tubes can be increased by reducing the diameter of the tubes.

[0003] Dryers and washer dryers with heat pumps usually use a capillary or a regulated expansion valve as a throttle. The capillary must have a correspondingly large length in order to be able to generate a sufficiently high pressure difference between the condenser and the evaporator.

[0004] It is disadvantageous that the capillary has a significantly smaller diameter than the tube of the evaporator, but these two elements must be connected to one another in a fluid-tight or gas-tight manner in order to close the refrigerant circuit of the heat pump. Copper tubes are usually used for both the capillary and the tube of the evaporator, so that the end of the capillary can be inserted into the end of the tube of the evaporator and the end of the tube of the evaporator can be crimped around the end of the capillary by reshaping to establish this connection. This connection is usually also brazed.

[0005] However, since the undefined result of the re-

shaping can make soldering more difficult, leaky soldering points can occur comparatively frequently at these points, so that no reliable gas and fluid-tight connection between the end of the capillary and the tube of the evaporator might be established.

[0006] To avoid this, an adapter piece can be used at this point, which can form the transition between the respective diameters of the end of the capillary and the tube of the evaporator. The adapter piece can each have an opening which corresponds to one of the diameters of the end of the capillary and the end of the tube of the evaporator. The transitions from the end of the capillary to the adapter piece and from the adapter piece to the end of the tube of the evaporator must be brazed, but this can be done without reshaping and thus more defined and safer, so that the risk of leaks at these brazed points can be reduced. However, this requires additional material and manufacturing costs of the adapter piece and an increased number of brazing points.

[0007] The connection between a capillary pipe and an evaporator is currently made with a capillary pipe adapter. On the other hand it is known to connect the capillary pipe directly to an elbow of the evaporator instead of using a capillary pipe adapter. In such a case, however, a blockage of refrigerant flow can occur. For example during an assembly process it might occur that the capillary pipe is introduced too much. The first end of the capillary pipe can then touch the internal wall of the elbow avoiding a correct flow of the refrigerant.

[0008] The publication DE 10 2017 109 065 B4 discloses a connection system for the gas-tight and fluid-tight connection of a condenser of a heat pump to an evaporator of the heat pump, the evaporator having at least two refrigerant passes, with a capillary and with a connecting element which is connected to the capillary in a gas-tight and fluid-tight manner, the connecting element having at least one first tube element, which is designed for connection to the first refrigerant pass of the evaporator, and at least one second tube element, which is designed for connection to the second refrigerant pass of the evaporator, the capillary having a passage for the passage of a refrigerant into the connecting element, wherein the passage of the capillary has at least one first outlet and at least one second outlet, which are arranged within the connecting element. Said publication discloses also a heat pump, with a condenser, with an evaporator with at least two refrigerant passes, and with at least one connection system described above, which connects the condenser to the evaporator in a gas-tight and fluid-tight manner.

[0009] In view of this situation it is an object of the present invention to provide an improved heat pump that does not show a blockage of refrigerant flow and that can be manufactured in an improved assembly process.

[0010] This object is achieved according to the present invention with a heat pump, a process for the manufacture of the heat pump, and a home appliance according to the respective independent claims. Preferred embod-

iments of the heat pump and the process are defined in respective dependent claims, with preferred embodiments of the process and the home appliance corresponding to preferred embodiments of the heat pump, and vice versa, even if not expressly specified elsewhere herein.

[0011] The invention is thus directed to a heat pump, including an evaporator, a condenser, a compressor for driving and compressing a flow of a refrigerant, a capillary for expanding the refrigerant flow, and a refrigerant channel for circulating the refrigerant flow sequentially through compressor, the condenser, the filter, the capillary, the evaporator, and the compressor, wherein the capillary is connected to the evaporator in a gas-tight and fluid-tight manner such that a first end of the capillary intrudes into the evaporator, wherein the capillary is a cylindrical tube with a lateral opening at its first end and/or at a second end thereof.

[0012] In a preferred embodiment of the heat pump, the lateral opening or the lateral openings are obtainable by cutting the first end and/or the second end of the capillary correspondingly. The cut at the end of the capillary can be made by many methods, for example by punching, water jet, laser trimming or a cutting disc. It is moreover possible to have the cut performed through the entire cross section, i.e. through the entire capillary pipe diameter, or through only part of it.

[0013] In a preferred embodiment of the heat pump, the cutting is performed by punching, water jet, laser trimming or a cutting disc.

[0014] Moreover, as stated above, in a preferred embodiment of the heat pump, the lateral opening or the lateral openings extend over the entire inner cross section area A_{cs} of the capillary.

[0015] In another embodiment of the inventive heat pump, the lateral opening or the lateral openings extend over a part of the inner cross section A_{cs} of the capillary.

[0016] The desired shape of the lateral opening can be achieved by the proper use of a cutting device mentioned above.

[0017] It is moreover preferred that a surface area A_{cut} of the lateral opening or the lateral openings is $\geq$ inner cross section A_{cs} of the capillary. In the heat pump of the present invention, the ratio A_{cut} to A_{cs} is preferably in the range of from 1 to 3.

[0018] It is moreover preferred in the heat pump of the present invention that the capillary intrudes into an elbow of the evaporator.

[0019] Preferably the heat pump contains a filter. In a preferred embodiment of the heat pump, the second end of the capillary faces a filter mesh of a filter for the refrigerant. In this regard, a heat pump is preferred wherein the second end of the capillary facing the filter mesh has a lateral opening with an opening area A_{cut}^2 which is $\geq$ inner cross-section area A_{cs} of the capillary.

[0020] In a preferred embodiment of the heat pump, the first end of the capillary also has an opening with an opening area A_{cut}^1 which is $\geq$ inner cross-section area

A_{cs} of the capillary.

[0021] Numerous refrigerants can be used in the invention, for example propane, which is also known by the designation R290 in the field of heat pump technology.

[0022] The capillary of the heat pump preferably contains or is made of copper.

[0023] The invention is moreover directed to a process for the manufacture of a heat-pump including an evaporator, a condenser, a compressor for driving and compressing a flow of a refrigerant, a capillary for expanding the refrigerant flow, and a refrigerant channel for circulating the refrigerant flow sequentially through compressor, the condenser, the filter, the capillary, the evaporator, and the compressor, wherein the capillary is connected to the evaporator in a gas-tight and fluid-tight manner such that a first end of the capillary intrudes into the evaporator, wherein the capillary is a cylindrical tube with an opening at its first end and/or at a second end thereof, comprising the steps

(a) providing a capillary; and

(b) cutting the first end and/or the second end of the capillary.

[0024] In a preferred process, the cutting in step (b) is performed by punching, water jet, laser trimming or a cutting disc.

[0025] In the present invention, a lateral opening is present at least at one end of the capillary pipe. The first end and the second end of the capillary can be also termed first and second edge, respectively.

[0026] The opening can be present over the entire surface of the capillary pipe, first end and/or second end of the capillary pipe.

[0027] In the present invention, a lateral cut is usually performed on the edge of a capillary pipe end. It is preferred that the lateral opening has a surface which is at least equal to the capillary pipe internal cross section. Thus, in the case of the edge of a capillary pipe end touching another surface, at least one capillary pipe internal cross section is open to allow refrigerant flow.

[0028] In a preferred embodiment, the cut is applied at the two ends of the capillary pipe, i.e. for a direct connection to an elbow of the evaporator used in a heat pump and for the other end of the capillary pipe, i.e. the second end, where there is usually a filter that in general contains a filter mesh. Namely, also in the case of a filter, if the capillary pipe is introduced too much, a capillary pipe end can touch the internal filter mesh and it can produce a blockage of refrigerant flow.

[0029] The invention is finally directed to a home appliance comprising a heat-pump according to any of the preceding embodiments.

[0030] The home appliance of the invention is preferably embodied as a laundry dryer for pieces of laundry, a washer-dryer which combines the function of washing laundry with the function of drying. Another embodiment

is a dishwasher that performs drying of tableware by applying a heat pump circuit. In a laundry dryer or a washer-dryer the drying chamber is in general a rotatable drum.

[0031] According to a further aspect of the present invention, the evaporator is connected to the capillary in a gas-tight and fluid-tight manner by means of a material connection, preferably by gluing, welding, brazing or soldering, particularly preferably by brazing.

[0032] The invention has several advantages. The manufacture of the heat pump can be significantly improved. The manufacture can be achieved by applying simple, cheap and quickly assembled means. The tack time in an assembly process can be reduced since it is not necessary to pay attention to the length of the introduced capillary length. The capillary can be produced in a simple and inexpensive manner.

[0033] Further details of the invention will appear from the subsequent description of specific embodiments with references to the following Figures, wherein

Figure 1 shows a perspective view of a section of an evaporator (elbow) of a heat pump to which is connected a capillary tube;

Figure 2 shows a perspective view of the enlarged, vertically cut section shown in Figure 1;

Figure 3 shows a front view of the cut section shown in Figure 2;

Figure 4 shows a perspective view of a filter used in an embodiment of the heat pump to which a capillary tube is attached;

Figure 5 shows a perspective view of a cut through the filter shown in Figure 4 wherein a filter mesh can be seen that is touched by the capillary tube;

Figure 6 shows a front view of a cut through the filter shown in Figure 4 wherein a filter mesh can be seen that is touched by the capillary tube with a lateral opening at its second end;

Figure 7 shows a capillary tube with a lateral opening at an end of the capillary tube that goes through the entire cross-section of the capillary;

Figure 8 shows a capillary tube with a lateral opening at an end of the capillary tube that goes through a part of the cross-section of the capillary;

Figure 9 shows a capillary tube and a cutting disc that is positioned here to provide the capillary tube with a lateral opening at an end of the capillary tube that goes through the en-

tire cross-section of the capillary tube; and

Figure 10 shows a capillary tube and a cutting disc that is positioned here to provide the capillary tube with a lateral opening at an end of the capillary tube that goes through a part of the cross-section of the capillary tube.

[0034] Figure 1 shows a perspective view of a section of an evaporator 1 of a heat pump to which is connected a capillary tube 2. The capillary tube 2 is connected to an elbow 18 of the evaporator. 3 refers to the refrigerant channel within the capillary tube 2.

[0035] Figure 2 shows a perspective view of the enlarged, vertically cut section shown in Figure 1. The reference signs have the same meaning as for Figure 1. The refrigerant channel 3 can be seen here more clearly.

[0036] Figure 3 shows a front view of the cut section shown in Figure 2. The reference signs have the same meaning as for Figure 1.

[0037] Figure 4 shows a perspective view of a filter 14 used in an embodiment of the heat pump to which a capillary tube 2 is attached.

[0038] Figure 5 shows a perspective view of a cut through the filter 14 shown in Figure 4 wherein a filter mesh 13 can be seen that is touched by the capillary tube 2.

[0039] Figure 6 shows a front view of a cut through the filter 14 shown in Figure 4 wherein a filter mesh 13 can be seen that is touched by the capillary tube 2 which has a lateral opening 7 at its second end 8.

[0040] Figure 7 shows a capillary tube 2 with a lateral opening at an end 4, 8 of the capillary tube 2 that goes through the entire cross-section of the capillary 2;

[0041] Figure 8 shows a capillary tube 2 with a lateral opening at an end 4, 8 of the capillary tube 2 that goes through a part of the cross-section of the capillary 2;

[0042] Figure 9 shows a capillary tube 2 and a cutting disc 15 that is positioned here to provide the capillary tube 2 with a lateral opening at an end 4, 8 of the capillary tube 2 that goes through the entire cross-section of the capillary tube 2; and

[0043] Figure 10 shows a capillary tube 2 and a cutting disc 15 that is positioned here to provide the capillary tube 2 with a lateral opening at an end 4, 8 of the capillary tube 2 that goes through a part of the cross-section of the capillary tube 2.

LIST OF REFERENCE NUMERALS

[0044]

- | | |
|---|---|
| 1 | Evaporator |
| 2 | Capillary |
| 3 | Refrigerant channel |
| 4 | First end of the capillary |
| 5 | Cylindrical tube |
| 6 | Lateral opening at the first end of the capillary |

- 7 Lateral opening at the second end of the capillary
- 8 Second end of the capillary
- 9 Inner cross section area A_{cs} of the capillary
- 10 Part of the inner cross section A_{cs} of the capillary over which the opening extends
- 11 Surface area A_{cut}^1 of the opening at the first end of the capillary
- 12 Surface area A_{cut}^2 of the opening at the second end of the capillary
- 13 Filter mesh
- 14 Filter
- 15 Cutting disc
- 16 Lateral opening through the entire capillary
- 17 Lateral opening through part of the capillary
- 18 Elbow of an evaporator

Claims

1. Heat pump, including an evaporator (1), a condenser, a compressor for driving and compressing a flow of a refrigerant, a capillary (2) for expanding the refrigerant flow, and a refrigerant channel (3) for circulating the refrigerant flow sequentially through the compressor, the condenser, the filter (14), the capillary (2), the evaporator (1), and the compressor, wherein the capillary (2) is connected to the evaporator (1) in a gas-tight and fluid-tight manner such that a first end (4) of the capillary (2) intrudes into the evaporator (1), **characterized in that** the capillary (2) is a cylindrical tube (5) with a lateral opening (6,7) at its first end (4) and/or at a second end (8) thereof.
2. Heat pump according to claim 1, wherein the lateral opening (6) or the openings (6,7) are obtainable by cutting the first end (4) and/or the second end (8) of the capillary (2).
3. Heat pump according to claim 1 or 2, wherein the cutting is performed by punching, water jet, laser trimming or a cutting disc.
4. Heat pump according to any of claims 1 to 3, wherein the lateral opening (6) or the lateral openings (6,7) extend over the entire inner cross section area A_{cs} (9) of the capillary (2).
5. Heat pump according to any of claims 1 to 3, wherein the lateral opening (6) or the lateral openings (6,7) extend over a part (10) of the inner cross section A_{cs} (9) of the capillary (2).
6. Heat pump according to any of claims 1 to 5, wherein a surface area A_{cut} (11,12) of the opening (6) or the openings (6,7) is $\geq$ inner cross section A_{cs} (9) of the capillary (2).
7. Heat-pump according to any of claims 1 to 6, wherein the ratio A_{cut} (11,12) to A_{cs} (9) is in the range of from 1 to 3.
8. Heat pump according to any of claims 1 to 7, wherein the capillary (2) intrudes into an elbow (18) of the evaporator (1).
9. Heat pump according to any of claims 1 to 7, wherein the second end (8) of the capillary (2) faces a filter mesh (13) of a filter (14) for the refrigerant.
10. Heat pump according to claim 9, wherein the second end (8) of the capillary (2) facing the filter mesh (13) has an opening (7) with an opening area A_{cut}^2 which is $\geq$ inner cross-section area Q_{cs} of the capillary (2).
11. Heat pump according to any of claims 1 to 10, wherein the first end (4) of the capillary (2) facing the filter mesh (13) has an opening (6) with an opening area A_{cut}^1 which is $\geq$ inner cross-section area A_{cs} of the capillary (2).
12. Heat pump according to any of claims 1 to 11, wherein the capillary (2) contains or is made of copper.
13. Process for the manufacture of a heat pump including an evaporator (1), a condenser, a compressor for driving and compressing a flow of a refrigerant, a capillary (2) for expanding the refrigerant flow, and a refrigerant channel (3) for circulating the refrigerant flow sequentially through the compressor, the condenser, the filter (14), the capillary (2), the evaporator (1), and the compressor, wherein the capillary (2) is connected to the evaporator (1) in a gas-tight and fluid-tight manner such that a first end (4) of the capillary (2) intrudes into the evaporator (1), wherein the capillary (2) is a cylindrical tube (5) with an opening (6,7) at its first end (4) and/or at a second end (8) thereof, comprising the steps
 - (a) providing a capillary (2); and
 - (b) cutting the first end (4) and/or the second end (8) of the capillary (2).
14. Process according to claim 13, wherein the cutting of step (b) is performed by punching, water jet, laser trimming or a cutting disc.
15. A home appliance comprising a heat pump according to any of claims 1 to 12.

Fig. 1

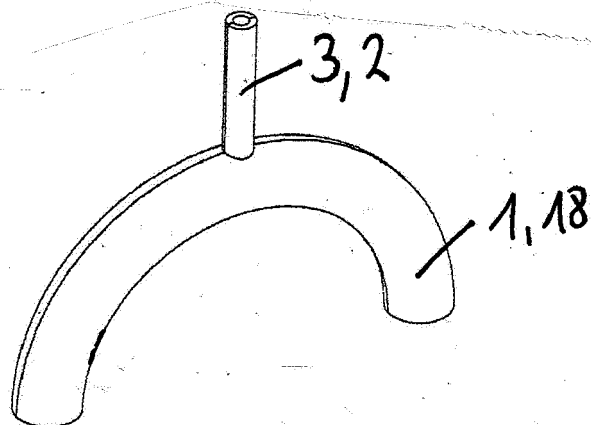


Fig. 2

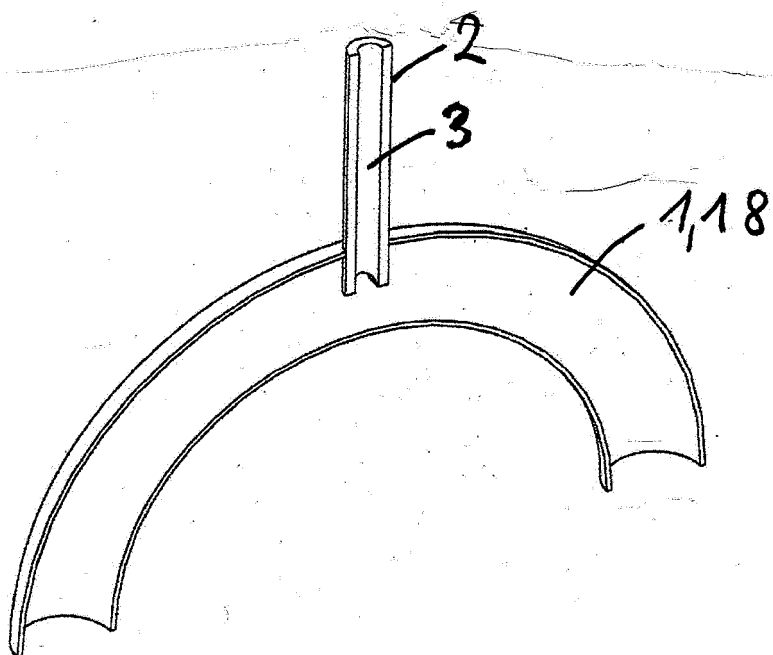


Fig. 3

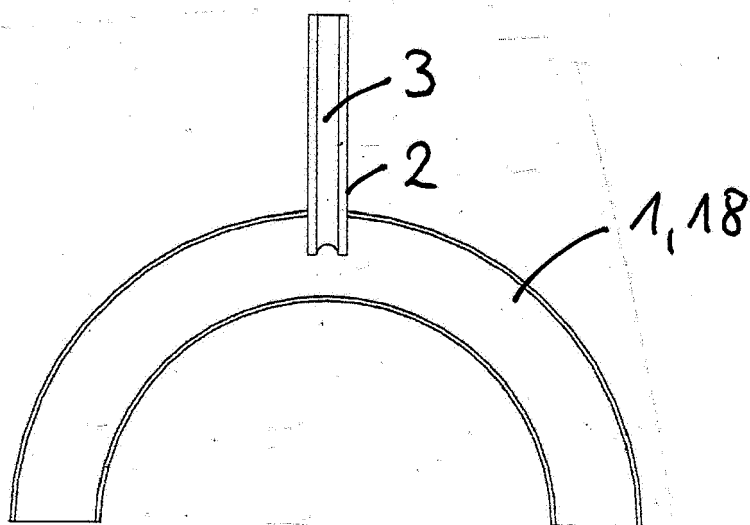


Fig. 4

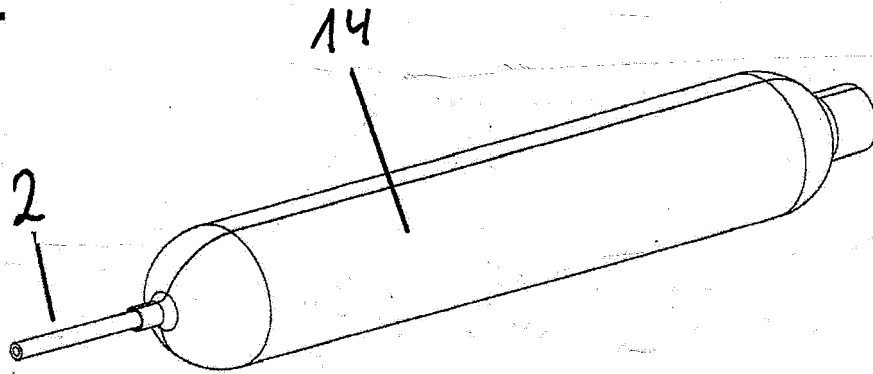


Fig. 5

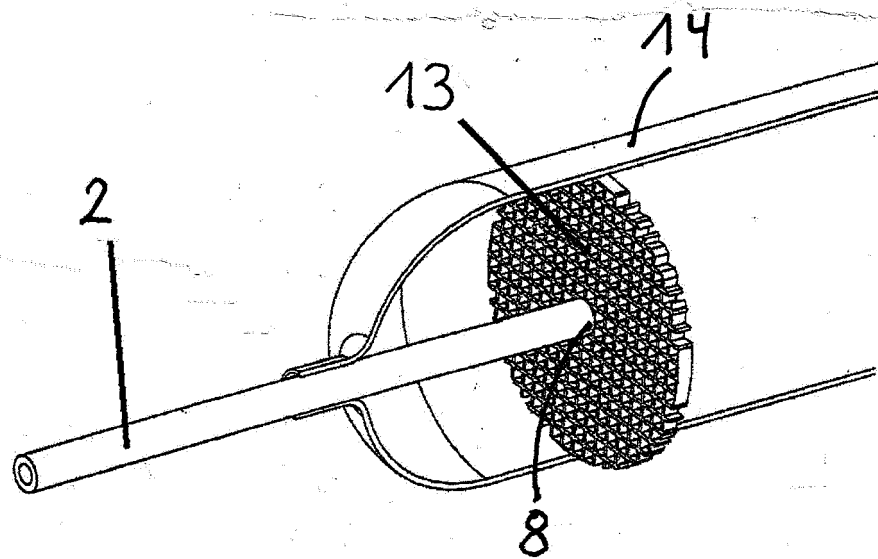


Fig. 6

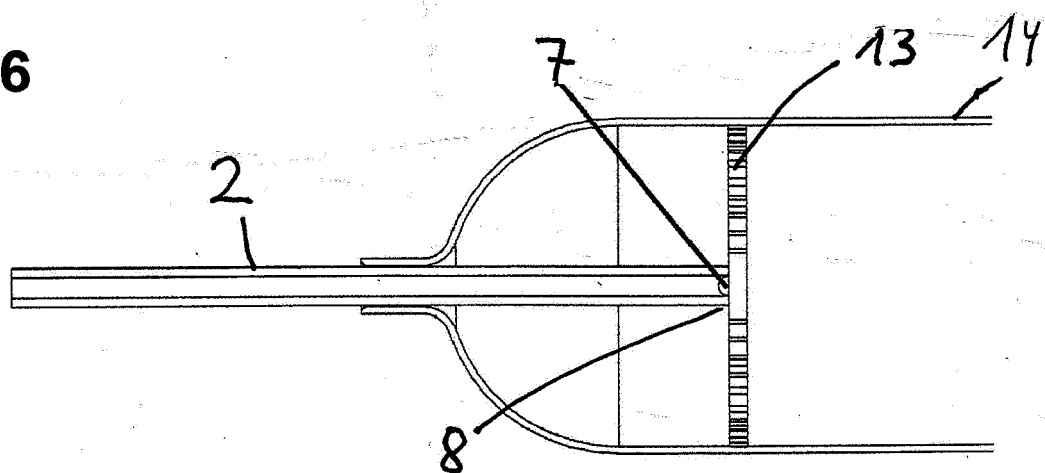


Fig. 7

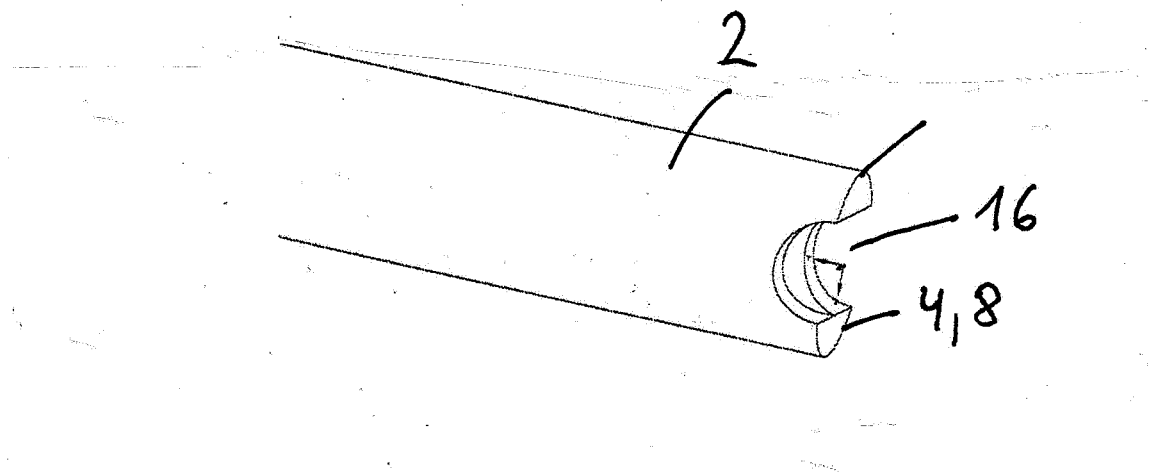


Fig. 8

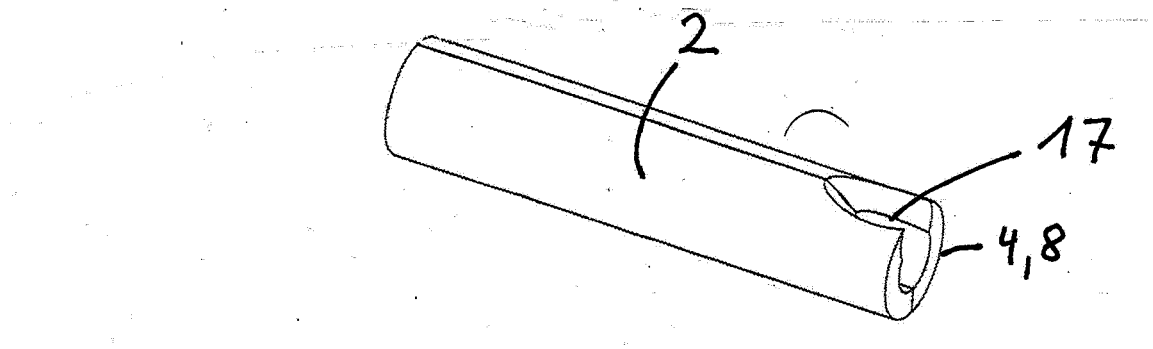


Fig. 9

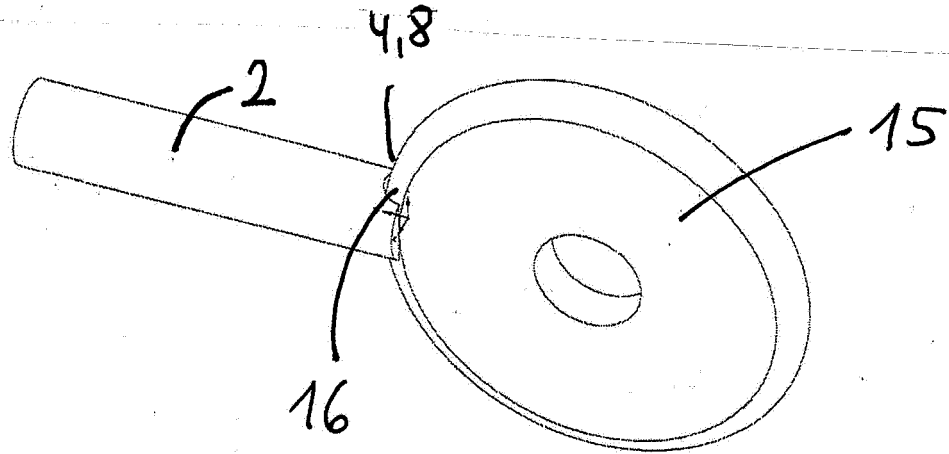
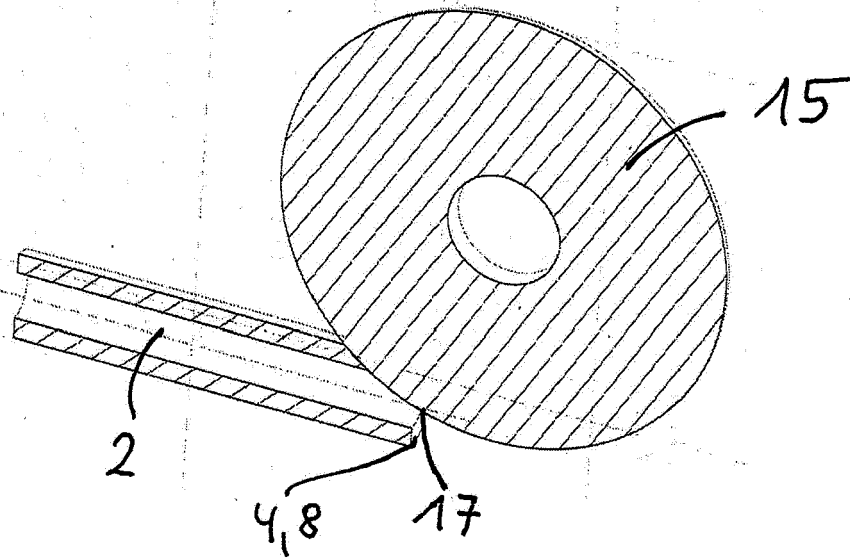


Fig. 10





EUROPEAN SEARCH REPORT

Application Number

EP 22 19 6206

5

10

15

20

25

30

35

40

45

50

55

1

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	DE 10 2017 109065 B4 (MIELE & CIE [DE]) 6 June 2019 (2019-06-06) * paragraphs [0046] - [0063]; figures 1-7 *	1-15	INV. F25B41/37 F25B39/02 F25B43/00 F25B41/42
Y	EP 2 562 490 A1 (PANASONIC CORP [JP]) 27 February 2013 (2013-02-27) * paragraphs [0018] - [0020]; figure 1 *	1-15	
Y	EP 2 667 130 A1 (MARTINEZ AROCA JOSE ANTONIO [ES]) 27 November 2013 (2013-11-27) * paragraphs [0045] - [0054]; figures 1-6 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 January 2023	Examiner Amous, Moez
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	

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

EP 22 19 6206

5 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.

23-01-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102017109065 B4	06-06-2019	NONE	
EP 2562490 A1	27-02-2013	CN 102859300 A	02-01-2013
		EP 2562490 A1	27-02-2013
		JP 2011226729 A	10-11-2011
		WO 2011132362 A1	27-10-2011
EP 2667130 A1	27-11-2013	AU 2012208499 A1	15-08-2013
		BR 112013018232 A2	19-06-2018
		CA 2824995 A1	26-07-2012
		CL 2013002057 A1	23-09-2013
		CO 6781499 A2	31-10-2013
		DK 2667130 T3	20-01-2020
		EA 201391046 A1	30-07-2014
		EP 2667130 A1	27-11-2013
		ES 2763978 T3	01-06-2020
		JP 2014505852 A	06-03-2014
		MA 34843 B1	02-01-2014
		MX 356152 B	16-05-2018
		MY 184995 A	30-04-2021
		PE 20141645 A1	06-12-2014
		PT 2667130 T	15-01-2020
		SG 192020 A1	30-08-2013
		US 2014041408 A1	13-02-2014
		WO 2012098276 A1	26-07-2012
		ZA 201305928 B	30-04-2014

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 102017109065 B4 [0008]