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

(11) EP 0 826 937 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.03.1998 Bulletin 1998/10

(51) Int. Cl.[6]: **F25D 3/10**

(21) Application number: **97114434.0**

(22) Date of filing: **21.08.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **29.08.1996 NL 1003915**

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(54) Cooling unit

(57) Autonomously operating cooling unit for cooling a storage space (9) during a certain time. The cooling unit (1) contains a container (2) for a coolant and a number of pipes (14) and is provided with means (13) for making the air in the storage space circulate by using the increase in pressure caused by the evaporation of the coolant; the storage space (9) is equipped for the transport of foods in a frozen or cooled condition. The evaporation of a coolant causes:

- the cooling of the storage space (9);
- the circulation of the ambient air in the storage space (9);
- the drying of the ambient air; and
- thermally controlled cooling.

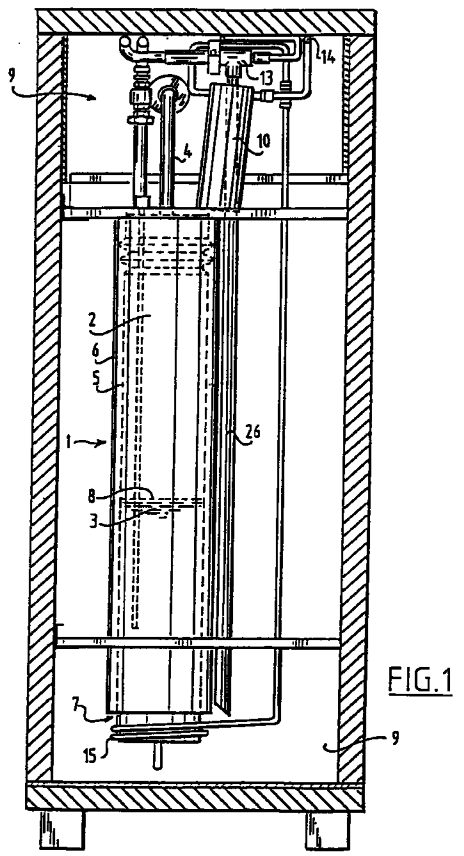

FIG.1

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Description

The invention relates to an autonomously operating cooling unit for cooling a storage space during a certain time. The cooling unit consists of a container for a coolant and a number of pipes.

Such cooling units are familiar and are used in particular for cooling frozen foods during transport and distribution. This familiar cooling unit contains a container for a coolant, e.g., liquid nitrogen or carbon dioxide in the solid state. Heat is exchanged because of the evaporation of the coolant and the storage space is cooled.

These familiar units have many disadvantages. The most important relate to the irregular cooling pattern caused by such a unit. Because the evaporation decreases in the course of time and because of the lack of suitable circulation of the ambient air in the storage space, considerable differences in temperature are observed in the storage space. The temperature increases over time and from the floor to the ceiling.

New EU Directives on the storage and transport of frozen foods prescribe a temperature of -18°C during the entire process of storage and transport. The familiar cooling units are unable to ensure such a stable cooling temperature.

The invention envisages overcoming these objections and to this end provides an autonomously operating cooling unit because such a cooling unit is fitted with means for making the air in the storage space circulate by using the increase in pressure caused by the evaporation of the coolant. Because circulation is effected, a good mixture of the ambient air and the evaporated coolant ensues and hence a homogeneous temperature in the storage space.

For preference, the means for causing the ambient air to circulate contain a pipe connected to a venturi to cause suction of the ambient air. Because of the acceleration of the evaporated coolant through a constriction - the venturi - ambient air is sucked in through a pipe, e.g., a T-piece.

To protect the venturi against freezing, an element is fitted between the pipe and the ambient air. This element has matching volume. The moisture present in the ambient air is frozen solid through the cooling of the evaporated coolant.

Hence, the coolant fulfils three functions:

- the cooling of the storage space through heat exchange with the evaporated or liquid coolant,
- freezing the moisture from the air that is drawn in by an element with a matching volume, termed the moisture trap, and
- circulating the ambient air by the suction caused by the acceleration of the evaporated coolant by way of the venturi. In the familiar cooling units, the evaporated coolant performs only the first function.

Furthermore, temperature measurements make it possible to cause an additional direct influx of evaporated coolant by way of pressure-regulating elements and pipes. This provides thermally controlled cooling. In this way the cooling unit provides thermally controlled cooling and the temperature in the storage space will remain constant independent of the external ambient temperature. Moreover, the influx of this additional flow of evaporated coolant will cause a better mix with the cooled ambient air which is drawn in and returns to the storage space.

Preferred designs in accordance with the invention will be described in greater detail in the final conclusions.

The invention also relates to a storage space fitted with a mobile or stationary cooling unit according to the invention. Such a storage space is suitable for the transport of frozen foods.

Finally, the invention also relates to an autonomous cooling procedure. The preferred design for this cooling procedure allocates four functions to the evaporated coolant. These four functions are:

- cooling the storage space;
- causing the circulation of the ambient air in the storage space;
- causing the moisture in the circulated ambient air to freeze solid; and
- providing thermally controlled cooling by means of temperature and pressure sensors.

The invention will be described in greater detail on the basis of the following descriptions of the figures illustrating a number of preferred specimen designs of the cooling unit according to the invention.

Figure 1 shows a front view in cross-section of a preferred design of a cooling unit in accordance with the present invention;
Figure 2 shows the same preferred design as in Figure 1 in a side view;
Figure 3 contains a flow diagram of the ambient air and the evaporated coolant in a cooling unit according to the invention;
Figure 4 contains a flow diagram similar to that of Figure 3, in which an additional flow of evaporated coolant causes thermostatic operation.
Figure 5 contains a diagrammatic cross-section, in which the operation of the moisture trap and the venturi is shown in a T-piece connector.

Figure 1 shows the cooling unit 1 in which a container 2 for a coolant 3 is connected to a number of pipes. The container 2 is filled with a coolant by way of a filling tube 4. Since the wall 5 of the container 2 is largely insulated by a vacuum sheath 6, the base 7 of the container 2 functions as a heat exchanger. This base 7 of the container 2 is not insulated, so that evaporation of the coolant is caused by way of the difference in temperature, so that pressure is built up. This overpressure is caused by the evaporation of the liquid nitrogen 8 Since the container 2 has not been closed off to the liquid nitrogen 8, nitrogen in the gaseous phase flows from the container 2 because of the overpressure into an element with a matching volume 10, hereinafter to be termed a moisture trap, after which this gas flows through a heat exchanger and a venturi connection. This results in acceleration of the flow, so that underpressure is caused in the T-piece connection, which causes the ambient air to be drawn in through the pipe 12 to the base 7 of the container 2.

The venturi 13 is protected against freezing by the moisture trap 10. The ambient air which is drawn in is collected in the moisture trap and the moisture in the ambient air is frozen solid by the evaporated coolant. The moisture trap may be regarded as a heat exchanger, by means of which moisture in the ambient air is temporarily frozen solid so that the operation of the venturi is not impaired.

The most important function of the evaporated coolant 3 (here nitrogen gas 8) is to cool the storage space 9 by ensuring the air flow which is drawn in, together with the nitrogen gas 9 which is accelerated by the venturi 13, is forced into the storage space.

After the heat exchange in the moisture trap 10, the nitrogen gas 8 is compelled to exchange heat by way of a heat exchanger 14 which comprises the storage space: cooling the storage space on the one hand and heating the nitrogen gas on the other hand.

Another heat exchanger 15 is connected to the container at the base and provides additional cooling, e.g., if this is necessary in warmer periods.

The design according to the invention has the same cooling power because of an adaptation of the pressure-regulating elements, irrespective of the level of the coolant in the container 2.

Because the venturi 13 causes the ambient air to be drawn in, circulation is caused as long as evaporation takes place, so that the temperature in the storage space is homogeneous.

Figure 2 shows a lateral cross-section view of the preferred design of the cooling unit shown in Figure 1. The uppermost 14 and the lowest 15 heat exchangers can be clearly seen; the latter is an additional heat exchanger. The uppermost one reaches to the ceiling of the storage space 9. Cooling is obtained in the heat exchangers by the transfer of heat by way of the evaporated nitrogen. The level in the container 2 can be determined by a probe 15.

Figure 3 contains a flow diagram of the preferred design of Figures 1 and 2. There are two types of flows: that of the evaporated coolant 16 (completely black triangle) and that of the ambient air 17 (triangle with O). The liquid nitrogen 3 in the container 2 evaporates and provides cooling of the storage space by way of the first heat exchanger 18 and also provides for the ambient air to be drawn in. The ambient air is drawn in through a venturi 13, so that circulation is created in the storage space, with the ambient air mixing with the evaporated coolant which has passed through the first heat exchanger. This mixture is returned to the environment, which constitutes a second heat exchanger 19. A third heat exchanger 20 is fitted to the base of the container 2.

Figure 4 contains a flow diagram comparable to that of Figure 3. A different pressure-regulating system is used in this design, in which pressure-regulating elements 21 and a cut-off valve 22 are switched in series or in parallel. A further flow of liquid nitrogen is introduced into the storage space by other pressure-regulating elements 24 and temperature measurements 23 by way of pipe 25. Thermally controlled cooling of the storage space is caused in this way. The additional flow may cause additional mixing with the output flow - ambient air - of the evaporated nitrogen.

Figure 5 contains a diagram of the moisture trap and the venturi according to the invention. The moisture trap 27 consists of a pipe 30 for the ambient air; the low temperature T_E dominates the moisture trap 27 is caused by the presence in direct or counter-flow of evaporated coolant, through which the moisture in the ambient air is frozen solid to the wall of the pipe 30. In this way ice 29 is formed on this wall 30. The flow of evaporated coolant is then led to the input of the venturi 28 by way of heat exchangers. The temperature T_{HE} is the temperature of the coolant after exchanging heat with the storage space and for preference is lower than the temperature T_{AA} of the ambient air from the moisture trap in order to exclude all phenomena of freezing from the venturi. Ambient air is drawn in through the constriction and mixing with the evaporated coolant and the ambient air which has been drawn in takes place; this is released into the storage space at point 31.

A cooling unit according to the invention is used for preference in a storage space, e.g., a container or the body of a lorry used for the transport and distribution of foods. A calculation using the logistical data, such as transport time and ambient temperature and the volume of the storage space will enable the coolant level in the container to be adjusted. This level can be read off by means of a probe determining the level, for example. In this way regular cooling over time and in the storage space which satisfies all European standards for the transport of cooled and frozen foods.

Claims

1. Autonomously operating cooling unit for cooling a storage space for a certain time. The cooling unit contains a container for the coolant and a number of pipes, **with the feature** that the cooling unit is provided with means for making the air in the storage space circulate by using the increase in pressure caused by the evaporation of the coolant.

2. Cooling unit according to Conclusion 1, **with the feature** that the means for causing the ambient air to circulate contain a pipe connected to a venturi to cause the ambient air to be drawn in.

3. Cooling unit according to Conclusion 2, **with the feature** that the cooling unit contains an element with a matching volume between the pipe and the venturi to protect the venturi against freezing because the moisture in the ambient air is frozen solid in this element.

4. Cooling unit according to one of Conclusions 1-3, **with the feature** that the unit is constructed for the dosed introduction of coolant into the storage space; the unit is designed to carry out the dosage depending on the ambient temperature in the storage space.

5. Cooling unit according to Conclusions 1, 2, 3 or 4, **with the feature** that the container is connected at its base to another heat exchanger.

6. Cooling unit according to one of the preceding conclusions, **with the feature** that part of the container is insulated.

7. Cooling unit according to Conclusion 6, **with the feature** that the container is designed to contain a coolant in its liquid state.

8. Cooling unit according to Conclusion 7, **with the feature** that the container is constructed to hold liquid nitrogen or liquid carbon dioxide.

9. Cooling unit according to one of the preceding Conclusions 1-8, **with the feature** that the unit is provided with means of pressure regulation.

10. Cooling unit according to one of Conclusions 1-9, **with the feature** that the unit is fitted with temperature sensors.

11. Cooling unit according to one of the preceding conclusions, **with the feature** that the unit contains an element for indicating the level of the coolant in the container.

12. Cooling unit according to one of Conclusions 1-11, **with the feature** that the unit is designed as an independent unit.

13. Cooling unit according to one of Conclusions 1-12, **with the feature** that the cooling unit is provided with means, e.g., wheels underneath the cooling unit, for moving the cooling unit simply from one storage space to another.

14. Cooling unit according to one of Conclusions 1-13, fitted with an external source for powering the components of the cooling unit, e.g., for powering a protection element.

15. Storage space fitted with a cooling unit according to Conclusions 1-14.

16. Storage space according to Conclusion 15, **with the feature** that the storage space is suitable for transport.

17. Storage space according to Conclusion 15 or 16, **with the feature** that the storage space is equipped for the transport of frozen foods for at least the duration of the transport.

18. Autonomously operating cooling process for cooling a storage space; because of the evaporation of a coolant:

- the storage space is cooled; and
- the ambient air in the storage space is caused to circulate.

19. Cooling process according to Conclusion 18 in which the moisture in the circulating ambient air is caused to freeze solid by the evaporated coolant.

20. Cooling procedure according to Conclusion 18 or 19, in which thermally controlled cooling is created by the evaporation of the coolant and by means of pressure and temperature sensors.

21. Cooling procedure according to Conclusions 18-20 implemented in a unit according to 1-14.

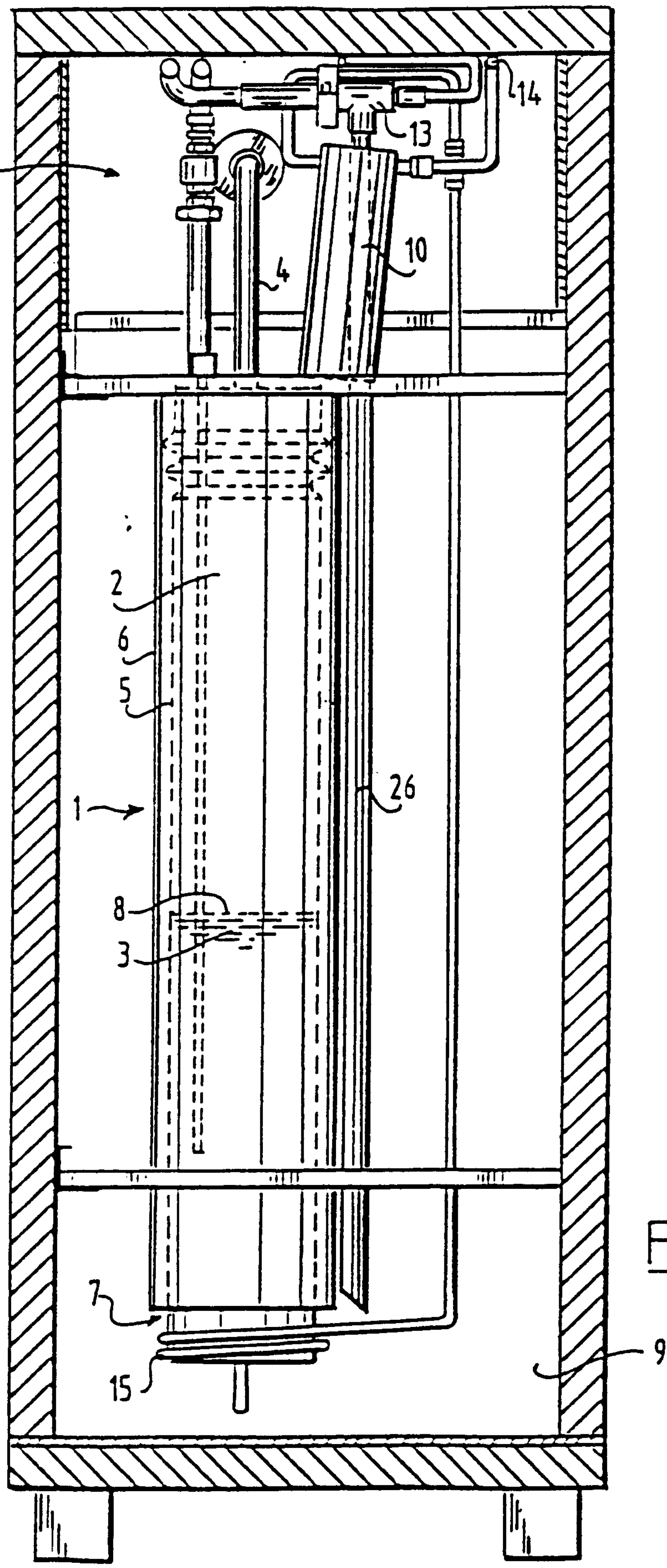

FIG.1

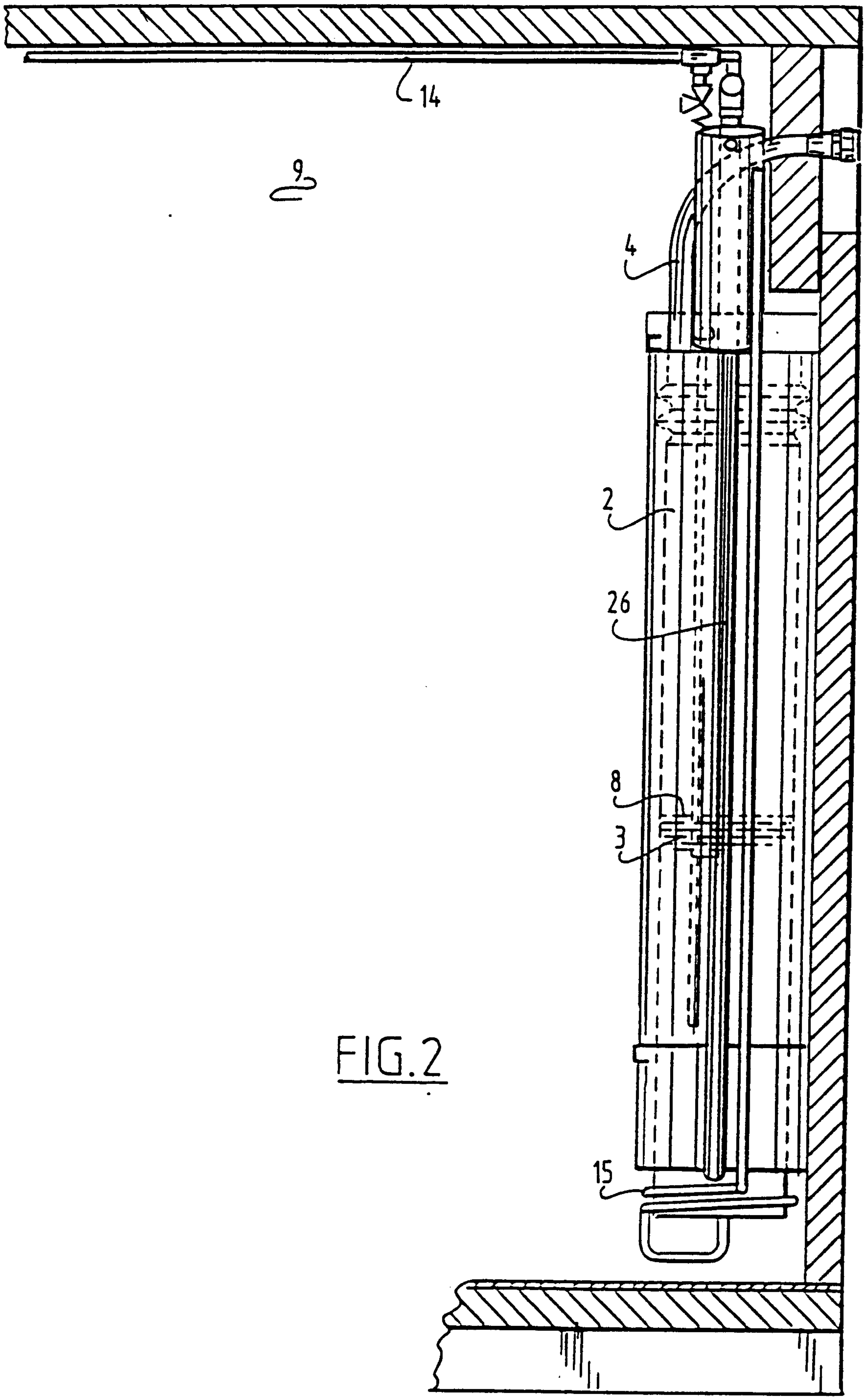

FIG.2

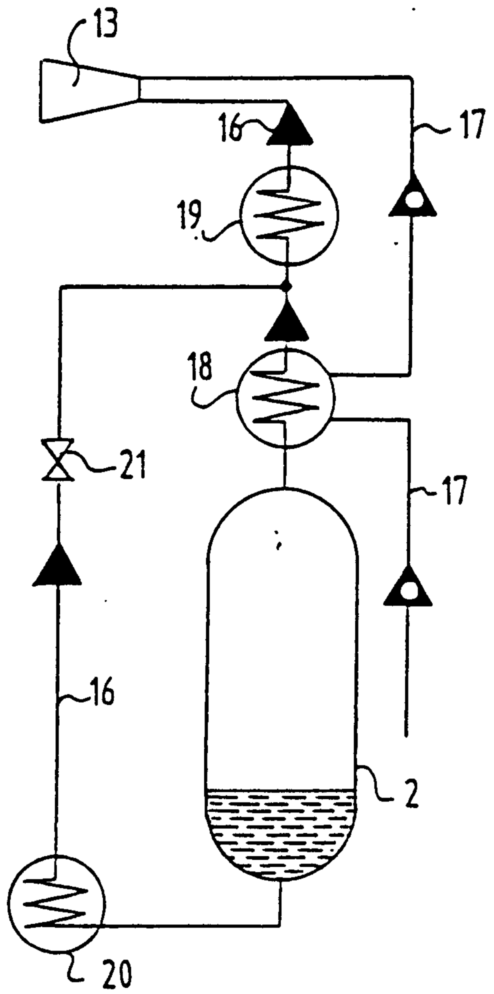

FIG.3

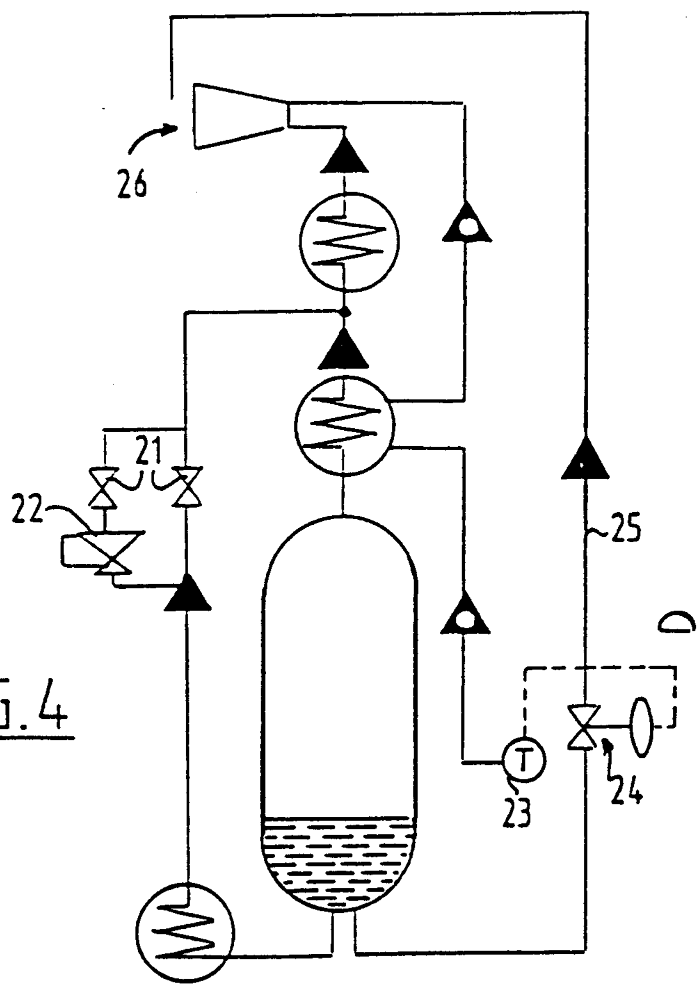

FIG.4

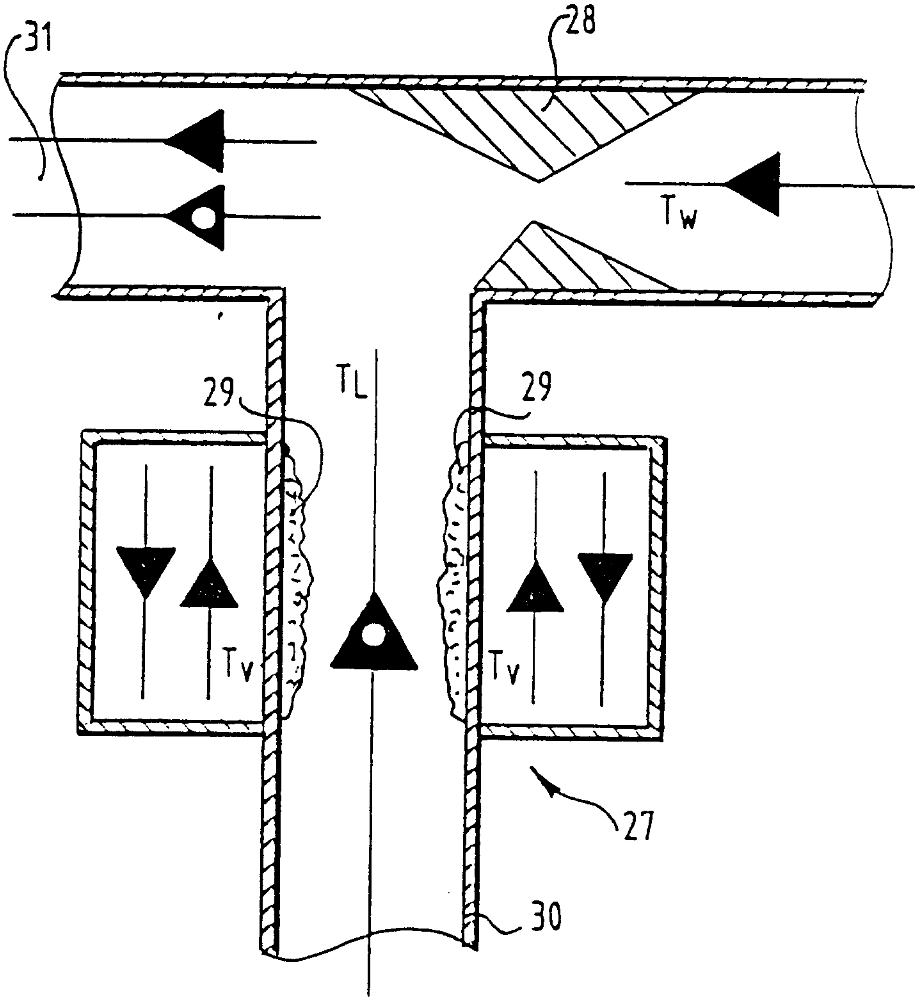

FIG.5

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EUROPEAN SEARCH REPORT

Application Number
EP 97 11 4434

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.6)
X	US 3 447 336 A (GRAMSE) 3 June 1969	1-4,9, 10,12, 15-21	F25D3/10
Y	* column 5, line 5 - line 56 *	13	
A	* figures 1,3,4 *	7,8	
Y	GB 1 594 576 A (BOC) 30 July 1981	13	
A	* page 2, line 1 - line 14; figure 2 *	6-8	
X	US 4 576 010 A (WINDECKER) 18 March 1986	1,2,4,5, 9-12, 14-21	
A	* column 2, line 66 - line 68 * * column 4, line 17 - line 19 * * column 5, line 31 - column 6, line 6 * * column 7, line 15 - line 25 * * figure 2 *	6-8	
X	EP 0 576 134 A (BOC) 29 December 1993	1,2,6-8, 11,12, 15-19,21	
A	* column 4, line 10 - line 35 * * column 10, line 39 - column 11, line 17 * * figures 1,2 *	3,4,9, 10,13,20	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F25D
X	US 3 163 022 A (HOTTENROTH) 29 December 1964	1,2,4,9, 10,12, 15,16, 18-21	
A	* column 1, line 62 - column 2, line 54 * * column 3, line 66 - line 75 * * figures *	3,6-8,17	

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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	25 November 1997	Goeman, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application Number
EP 97 11 4434

DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 3 447 334 A (KIMBALL) 3 June 1969	1,2,4,5, 9-12, 15-21	
A	* column 2, line 26 - line 63 * * column 3, line 47 - column 4, line 29 * * figure 4 * ---	7,8	
A	US 3 271 970 A (BERNER) 13 September 1966 * figure 5 * -----	1,2,6-8, 12, 15-19,21	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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