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(54) **Condenser**

(57) A condenser (1), comprising a steam inlet (4a, 4b) and an exhaust chamber (6) which are connected via a plurality of cooling tubes (5a,5b) connected in parallel, which exhaust chamber (6) is provided with an exhaust opening which is connected to a pump (13), wherein the condenser (1) is provided with a supplemental barrier (14a,14b) to screen the pump (13) during use from steam breaking through a cooling tube (5a,5b), as well as to screen the other cooling tubes (5a,5b) from steam from a cooling tube (5a,5b) subject to steam breakthrough. A method for condensing steam in a cooler (1), wherein by means of a pump (13) a pressure is maintained in the cooler (1), and wherein the inert gas discharge (12) is screened from steam breaking through the cooler (1).

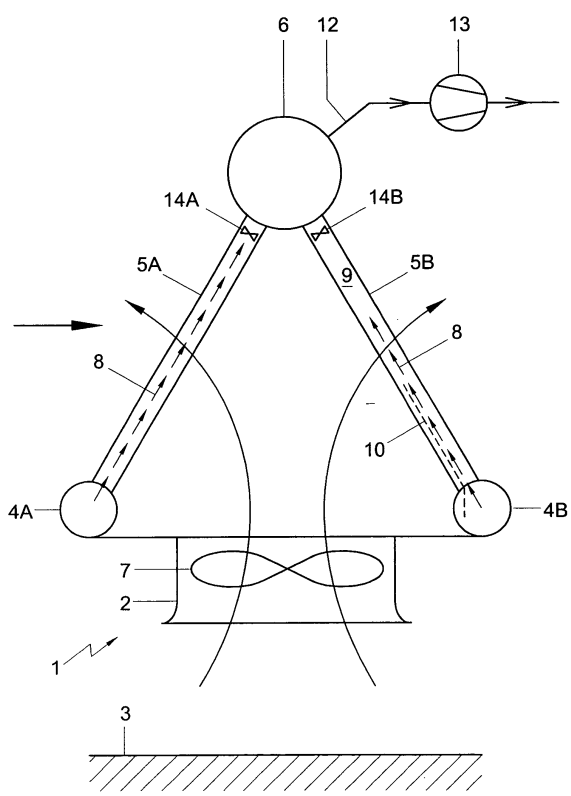

Fig. 1

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Description

[0001] The invention relates to a condenser, in particular a vacuum condenser for condensing expanded steam from a steam turbine.

[0002] Such a condenser is generally known and comprises a steam inlet and an exhaust chamber which are connected with each other via a plurality of cooling tubes connected in parallel, which exhaust chamber is provided with an exhaust opening which is connected to a pump for discharging inert gas, for instance a vacuum pump.

[0003] During use, the steam inlet is connected to the exit of a steam turbine, so that steam expanded in the steam turbine is conducted via the steam inlet into the cooling tubes. Through circumfluence, for instance with a flow of ambient air which may or may not be forced, the cooling tubes, which are typically provided with cooling fins, are cooled. The cooling capacity of the cooling tubes and the flow rate of the circumfluent air have been chosen such that the steam condenses in the cooling tubes, so that in the part of the cooling tube contiguous to the exhaust chamber, and in the exhaust chamber itself, a lower pressure, typically a reduced pressure, is created. With the aid of this lower pressure, the exit pressure of the steam turbine can be maintained. By lowering this pressure, the efficiency of the steam turbine can be increased. The cooling tubes are conventionally arranged at a slope, for instance in an A-frame, so that the condensation can flow downwards under the influence of gravity. To maintain the lower pressure in the exhaust chamber, gas that does not condense in the condenser, here also designated as inert gas, such as any leakage air, is discharged via a pump.

[0004] In practice, a condenser has been found in some cases not to provide the desired low pressure, which adversely affects the efficiency of the steam turbine. The fact that the desired low pressure in the exhaust chamber is not achieved is often imputed to the penetration of leakage air in the condenser or the connection between turbine and condenser, or to insufficient discharge capacity of this leakage air. In practice, it has already occurred a number of times that after fruitless attempts to find the cause, users have resigned themselves to the fact that in practical situations the desired pressure in a particular installation sometimes cannot be attained.

[0005] The object of the invention is to provide a condenser, in particular a vacuum condenser for a steam turbine, with which, while maintaining the advantages mentioned, the disadvantages mentioned can be avoided. To that end, the invention provides a condenser, comprising a steam inlet and an exhaust chamber which are connected with each other via a plurality of cooling tubes connected in parallel, which exhaust chamber is provided with an exhaust opening which is connected to a pump for discharging inert gas, wherein the condenser is provided with a supplemental barrier to screen the pump during use from steam breaking through a cooling tube.

[0006] With the aid of such a supplemental barrier, in practice the desired low pressure in the exhaust chamber can be realized with a greater amount of certainty. The invention is based on the insight that in many cases where the inert gas, such as leakage air, accumulates in the exhaust chamber, it is not the magnitude of the leakage or the design of the condenser that is the causative factor of the desired pressure in the exhaust chamber not being achieved, but that as a result of local disturbance of the cooling action, in one or more cooling tubes steam breakthrough can occur whereas this would not be expected having regard to the ample capacity of the whole cooling system. The local disturbance of the cooling capacity can for instance be caused by fouling of the cooling fins on one of the cooling tubes and/or through local impediment of the throughflow of the cooling air. Such local impediment can for instance be the result of a disturbing sidewind load. When presently, besides the primary measures against breakthrough of steam through the cooling tubes, constituted by the amply dimensioned capacity of the cooling tubes of the condenser, additionally a supplemental barrier against steam breakthrough is included, with which the pump during use can be screened at least partly from steam breaking through a cooling tube, the pump typically has a sufficient flow rate to exhaust the leakage air from the exhaust chamber and the desired low pressure can be preserved in the exhaust chamber of the condenser.

[0007] The supplemental barrier can for instance be designed as a flow resistance which can screen the pump from steam breaking through. Such a flow resistance is preferably placed upstream of the pump and, while leaving clear at least one suction route from steam inlet to pump, closes off at least partly at least one other suction route from steam inlet to pump.

[0008] The barrier does not need to fully prevent steam breaking through, but at least reduces the amount of steam breaking through, so that the pump can fulfill its task longer. The leakage air from pipes not breaking through will be discharged, so that these pipes can fulfill their function. The barrier can be so dimensioned as to entail hardly any pressure drop when only a small amount of leakage air passes, but to give rise to an inhibitory action in case of a larger amount of steam breaking through. This may already be involved in the use in the case of fixed restrictions, such as a restrictor having a fixed passage. Also, such a flow resistance can be designed as a variable valve, for instance a restrictor which impedes the throughflow when a predetermined flow rate is exceeded, or a thermal valve which impedes the throughflow when a predetermined temperature of the passing medium is exceeded. Such a thermal valve is preferably arranged adjacent an exhaust chamber, for instance in the part of a cooling tube contiguous to the exhaust chamber, or in a part of the exhaust line to the pump that is contiguous to the exhaust opening.

[0009] It is noted that different suction routes can already be formed by dividing the cooling tubes into groups and having them terminate per group in a separate exhaust chamber. Such an exhaust chamber can in each case be provided with its own pump. In such a case, the supplemental barrier is formed in that the split into groups has a mutual barrier action; the restriction is then formed by a multiple steam discharge.

[0010] Preferably, however, several exhaust chambers are connected with the same pump. In such an arrangement, a separate exhaust line is present between each exhaust chamber and the pump, while in each exhaust line a flow resistance is included for screening the pump from steam breaking through. In this embodiment, through proper subdivision of the cooler pipes into groups, the disturbing action of, for instance, a sidewind load can be controlled optimally.

[0011] The invention relates to a method for condensing steam in a cooler, wherein by means of a pump, through discharge of inert gas, a low pressure is maintained in the cooler, and wherein the pump is screened from steam breaking through the cooler. Preferably, the pump is then screened in that, while leaving clear at least one suction route between steam inlet and pump, at least one other suction route between steam inlet and pump is closed.

[0012] Further advantageous embodiments are represented in the dependent claims.

[0013] The invention will be further elucidated on the basis of an exemplary embodiment which is represented in a drawing. In the drawing:

Fig. 1 shows a schematic side elevation of a first variant of a condenser according to the invention;
Fig. 2 shows a schematic side elevation of a second variant of a condenser according to the invention;
Fig. 3 shows a schematic side elevation of a third variant of a condenser according to the invention.

[0014] In the figures, the same or corresponding parts are indicated by the same reference numerals. The figures are only schematic representations of preferred embodiments of the invention and are only given by way of non-limiting exemplary embodiment.

[0015] Fig. 1 shows a condenser 1 with a so-called A-frame 2 which is arranged at some height above ground level 3, for instance next to a power plant and in close proximity to the exit of a steam turbine. The condenser 1 is provided with two steam inlets 4a, 4b which are each connected, via a series of cooling tubes 5a, 5b placed at a slope, with an exhaust chamber 6. In this exemplary embodiment, the inclined cooling tubes 5 leaning towards each other give the frame 2 of the condenser 1 the shape of an "A" in side elevation. Arranged at the bottom of the frame 2, between two steam inlets 4a, 4b, are one or more fans 7. By means of the fans 7, ambient air, as represented in the figure, can be drawn in from below and be blown out via the inside of the frame between the cooling tubes 5. In this exemplary embodiment, the cooling tubes 5a, 5b are provided at their outer circumference with fins to enlarge their cooling capacity. If the condenser 1 works correctly, a steam plume 8 passes via the steam inlet 4 into the cooling tube 5, where the steam plume 8, as a result of the cooling, thereby creating a reduced pressure or "vacuum", has condensed in the upper part of the cooling tube 5. This is represented in the right-hand portion of the condenser of Fig. 1. In the figure, the pressure is symbolically represented by 9. This low pressure provides for the suction of new steam from the inlet and thus maintains a low pressure at the turbine exit. As a result of the inclined arrangement of the cooling tubes 5, the condensate 10 flows down and is discharged from the lowermost point of the condenser 1, optionally to a condensate vessel.

[0016] Optionally, prior to the condensation process, inert gas, such as leakage air, is discharged via an air exhaust line which is connected via an opening with the central exhaust chamber 6, here a vacuum chamber, by means of a vacuum pump.

[0017] Should the cooling capacity be insufficient, however, for instance as a result of a wind load and/or local fouling, steam breakthrough can occur. This is shown in the left-hand portion of Fig. 1.

[0018] In the left-hand portion of Fig. 1, it is shown that owing to locally insufficient cooling capacity, steam breakthrough occurs. The steam is insufficiently cooled in the cooling tube 5a and can break through the cooling tube, into the exhaust chamber 6.

[0019] In this case, steam would be discharged from the exhaust chamber 6 via the line 12 to the pump 13. This pump in turn, due to the large volume supply of steam, will no longer be able to provide for a correct discharge of leakage air. The desired pressure then would not be achieved anymore. However, the condenser 1 is provided with a supplemental barrier 14 to screen the pump 13 during use from steam breaking through a cooling tube.

[0020] In this exemplary embodiment, the supplemental barrier is designed as a flow resistance placed upstream of the pump 13, which, while leaving clear one suction route between steam inlet 4B and pump 13, wholly or partly closes off one or a plurality of other suction routes. In this exemplary embodiment, the flow resistance is implemented in that each of the cooling tubes 5 is provided with a thermal valve which closes the cooling tube wholly or partly when steam flows through the valve. The thermal valves are arranged at the top of the cooling tubes 5, at a point which is cool and not exposed to steam during normal functioning of the cooler. The thermal valves are arranged in an exit part of the cooling tubes 5, contiguous to the central exhaust chamber 6. Alternatively, a moisture sensor may be provided, for instance an electrical contact, with which a valve is driven. In the arrangement represented here, upon steam breakthrough, each cooling tube can be individually closed. Likewise as an alternative, fixed restrictions are possible, which, by virtue of their dimensioning, hardly cause a pressure drop upon passage of a small flow of leakage air, but cause a considerable pressure drop upon a greater flow of leakage air.

[0021] In Fig. 2, an alternative embodiment is shown, in which two separate exhaust chambers 6a, 6b are provided. The exhaust chambers are each connected via a separate exhaust line 12A, 12B with the same pump 13. In each line, a thermostatic valve 14A, 14B is included. In this exemplary embodiment, cooling tube 5A breaks through and the valve 14A, through restriction or at least partial closure of the suction route 4A-5A-6A-12A, screens the pump 13 while leaving clear the suction route 4B-5B-6B-12B-13.

[0022] Fig. 3 shows a variant of the invention, in which the condenser is provided with separate exhaust chambers 6A, 6B, each connected with a separate pump 13A, 13B.

[0023] In the embodiment represented here, the A-frame has been placed on end and there is a central steam inlet 4.

[0024] It is noted that here with an arrangement whereby the air is sucked along the cooling tubes 5 from the outside to the inside of the frame 2, a wind load, if any, does not reduce the cooling capacity.

[0025] In this configuration, a sidewind load, instead of having a negative influence, has a positive influence on the amount of cooling air flowing along the cooling tubes on the weather side.

[0026] Due to the invention, this can be utilized advantageously, since breakthrough of steam from the lee side pipes is prevented.

[0027] It will be clear that the invention is not limited to the preferred embodiments represented here. Thus, the condenser 1 can for instance be designed as a half "A", with the cooling tubes situated in one plane surface placed at an inclination. Further, it will be clear that the shape and construction of the condenser, if desired, can be chosen differently, for instance with helically or spirally extending tubes placed horizontally, vertically or at an inclination, with or without joint steam inlets or exhaust chambers. Furthermore, instead of valves having a variable passage, for instance restrictors having a fixed passage can be employed.

[0028] Such variants will be clear to the skilled person and are understood to fall within the scope of the invention as set forth in the following claims.

Claims

1. A condenser, comprising a steam inlet and an exhaust chamber which are connected with each other via a plurality of cooling tubes connected in parallel, which exhaust chamber is provided with an exhaust opening which is connected to a pump for discharging inert gas, wherein the condenser is provided with a supplemental barrier to screen the pump during use from steam breaking through a cooling tube.

2. A condenser according to claim 1, wherein the supplemental barrier is designed as a flow resistance.

3. A condenser according to claim 1 or 2, wherein the supplemental barrier is placed upstream of the pump and, while leaving clear at least one suction route from steam inlet to pump, at least partly closes off at least one other suction route from steam inlet to pump.

4. A condenser according to claim 2 or 3, wherein the flow resistance comprises a restrictor.

5. A condenser according to claim 2 or 3, wherein the flow resistance comprises a variable valve.

6. A condenser according to claim 5, wherein the flow resistance comprises a thermal valve which hampers the throughflow when a predetermined temperature of the passing medium is exceeded.

7. A condenser according to any one of the preceding claims, wherein the cooling tubes are divided into groups and terminate per group in a separate exhaust chamber.

8. A condenser according to claim 7, wherein the exhaust chambers are each provided with their own pump.

9. A condenser according to claim 7, wherein several exhaust chambers are connected with the same pump.

10. A condenser according to claim 9, wherein between each exhaust chamber and pump, a separate exhaust line is present in which a flow resistance is included for screening the pump from steam breaking through.

11. A method for condensing steam in a cooler, wherein by means of a pump, through discharge of inert gas, a low pressure is maintained in the cooler, and wherein the pump is screened from steam breaking through the cooler.

12. A method according to claim 11, wherein the pump is screened in that, upon steam breakthrough, while leaving clear at least one suction route between steam inlet and pump, at least one other suction route between steam inlet and pump is closed off.

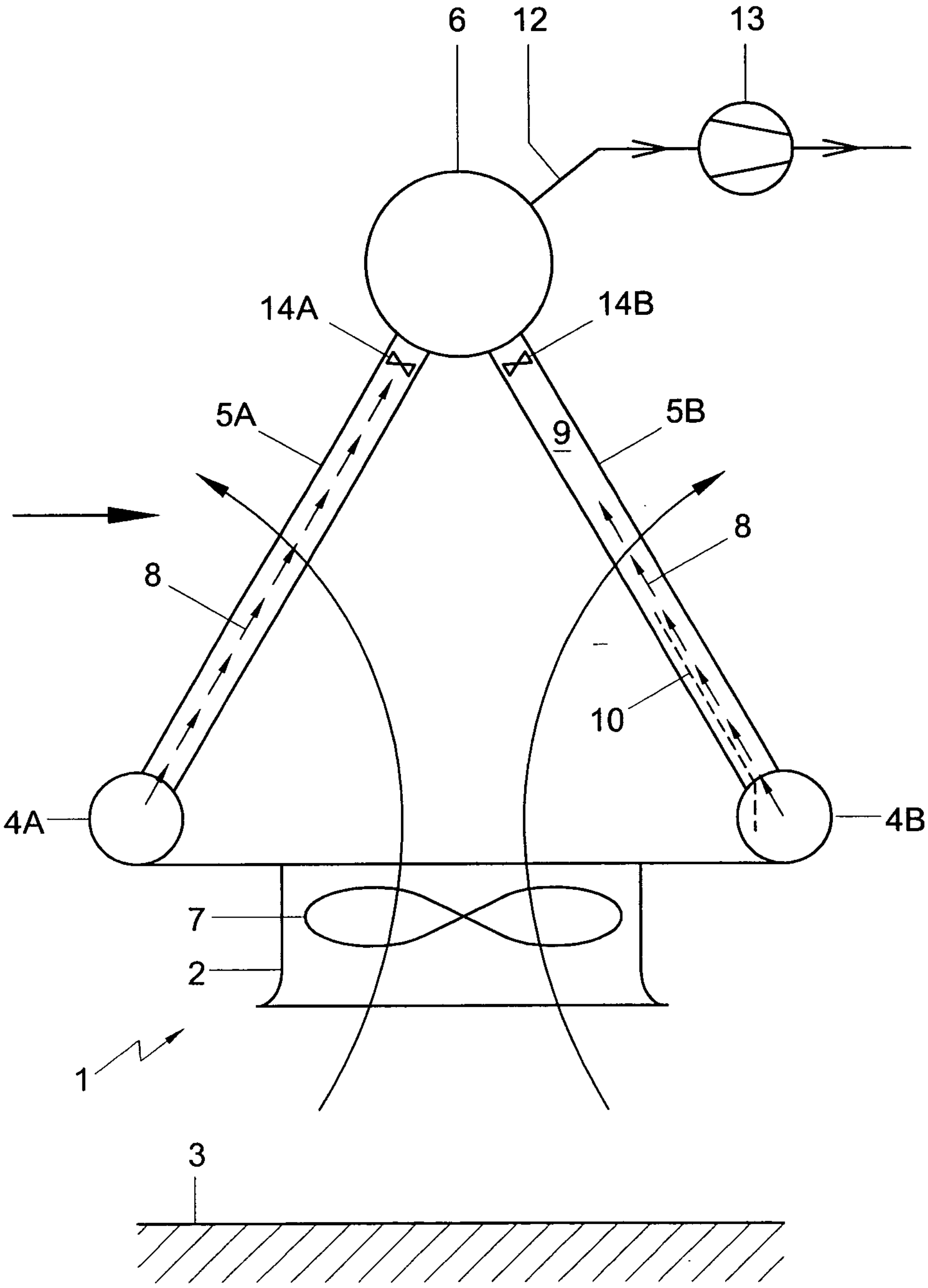

Fig. 1

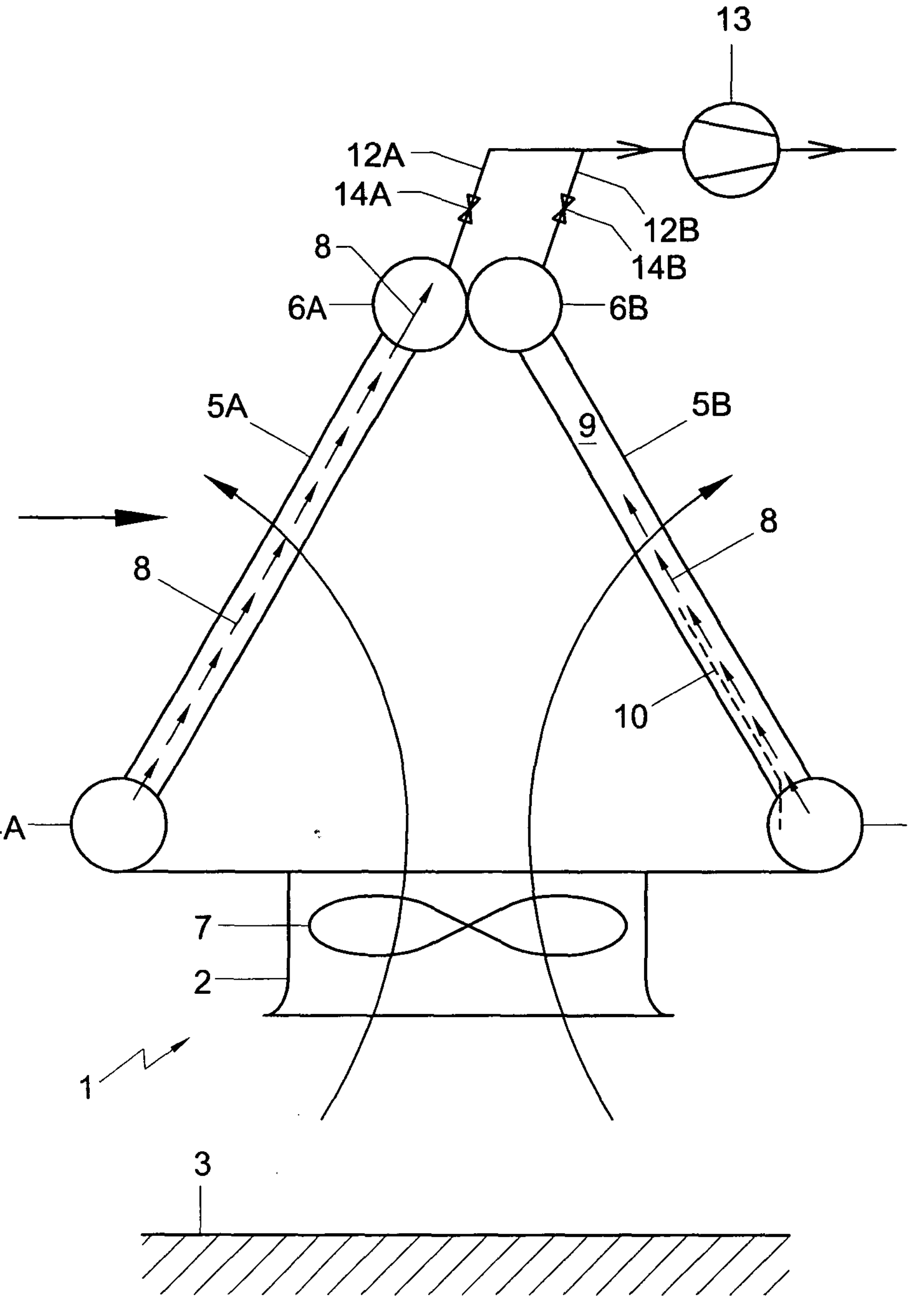

Fig. 2

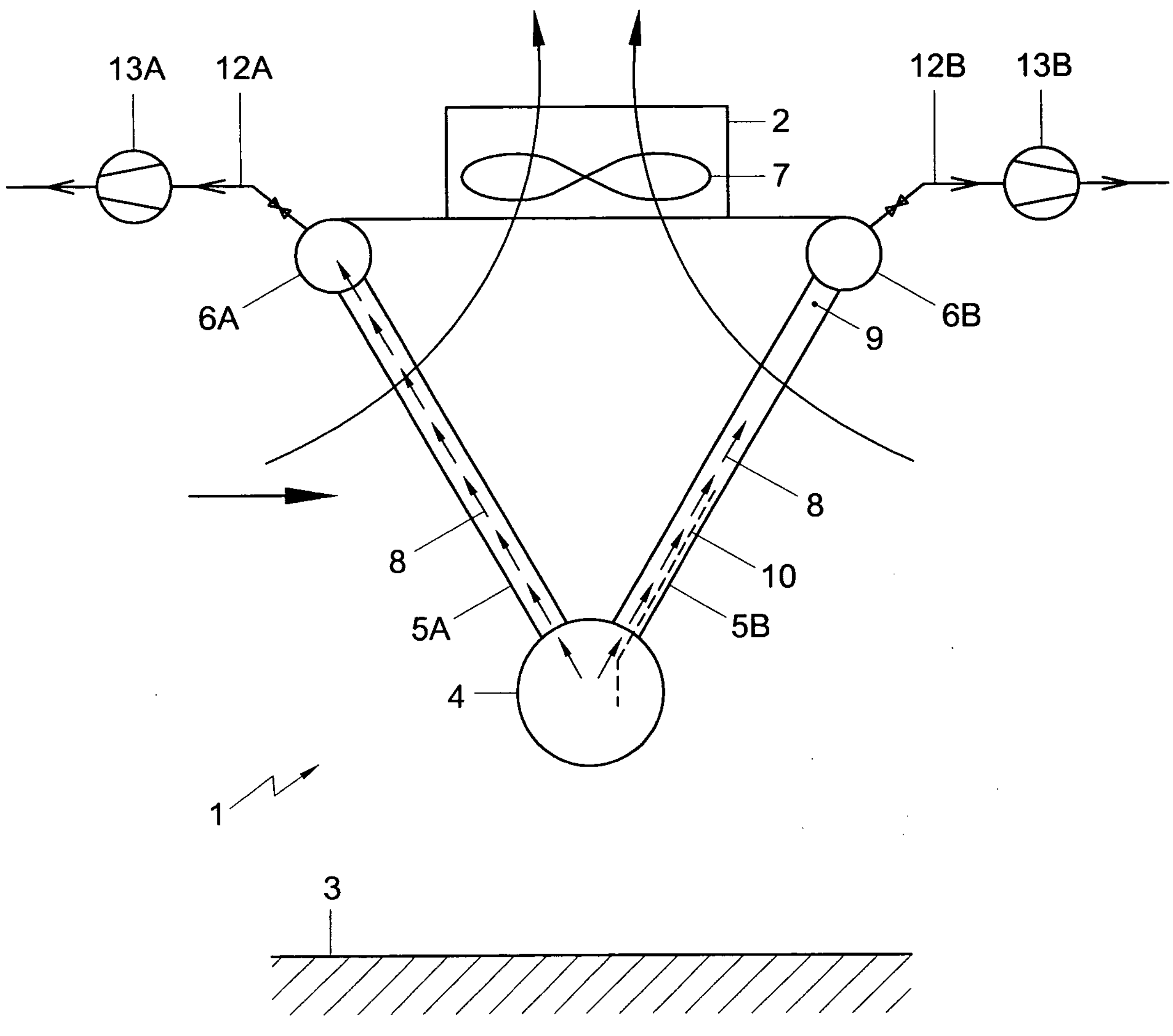

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 04 07 8483

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.7)
X Y	US 5 632 329 A (FAY HERMAN P R) 27 May 1997 (1997-05-27) * column 3, line 7 - line 19 * * column 4, line 37 - line 65 * * column 6, line 13 - column 7, line 63; figures *	1-4,7,9, 11 5,10,12	F28B1/06 F28B9/10
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Y	DATABASE WPI Section Ch, Week 198947 Derwent Publications Ltd., London, GB; Class J08, AN 1989-346498 XP002291605 -& SU 1 456 736 A (AS BELO NUCLEAR POW) 7 February 1989 (1989-02-07) * abstract; figure 1 *	10	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F28B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	21 April 2005	Van Dooren, M

CATEGORY OF CITED DOCUMENTS

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21-04-2005

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