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(54) Device and method for cleaning a gas turbine blade

(57) A device (20) for cleaning a gas turbine blade (1), comprises:
- a vessel (21) suitable for containing a cleaning fluid bath and provided with a header (30); the blade (1) to be cleaned being couplable to the header (30) while the outlet hole (16) of the inner cavity (13) is immersed in the cleaning fluid bath;
- a tank (22) suitable for containing the cleaning fluid;
- a feed line (24) connecting the tank (22) to the vessel (21);
- a return line (25) connecting the header (30) of the vessel (21) to the tank (22);
- a first pump (26) designed to draw the cleaning fluid from the tank (22) and send it to the vessel (21) at such a pressure as to produce a flow of cleaning fluid flowing from the outlet hole (16) of the inner cavity (13) to the inlet opening (15) of the inner cavity (13) of the blade (1).

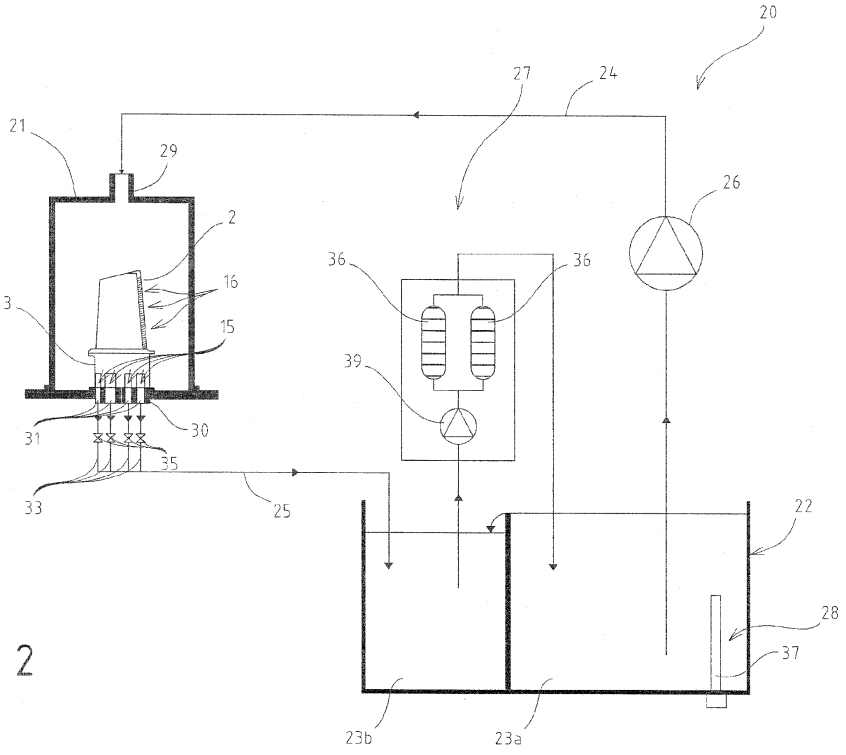

Fig. 2

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Description

[0001] The present invention relates to a device and method for cleaning a gas turbine blade. In particular, the present invention relates to a device and method for cleaning the inner channels of a gas turbine blade.

[0002] Machining residues are commonly accumulated within the inner channels of the blades when manufacturing the gas turbine blades.

[0003] Gas turbine blades, indeed, are provided with inner channels for a cooling fluid to pass. These channels extend into the blade and are connected to a plurality of cooling holes so that the cooling fluid, generally air, flows into the inner channels and exits from the cooling holes lapping the outer surface of the blade.

[0004] Document WO 00/05002 to Siemens describes a device and method for cleaning the inner channels of a gas turbine blade. However, such a method is not particularly effective, especially when machining residues are present inside the channels, which are sized so as to obstruct the cooling holes and the narrow passages of the inner channels of the blades.

[0005] It is thus an object of the present invention to provide a device for cleaning the inner channels of a gas turbine blade which is free from the drawbacks pointed out by the prior art.

[0006] In particular, it is an object of the present invention to provide a device capable of ensuring an optimal, effective removal of the machining residues from the whole blade.

[0007] In accordance with these objects, the present invention relates to a device for cleaning a gas turbine blade; the blade extending along an axis and comprising an elongated main body, an anchoring member coupled with one end of the main body, and at least one inner cavity which is provided with at least one inlet opening arranged on the bottom face of the anchoring member, and with at least one outlet hole arranged along the main body;
the device comprising:

- a vessel suitable for containing a cleaning fluid bath and provided with a header; the blade to be cleaned being couplable to the header so that the outlet hole of the inner cavity is immersed in the cleaning fluid bath, and the inlet opening of the inner cavity is fluidically connected to the header;
- a tank suitable for containing the cleaning fluid;
- a feed line connecting the tank to the vessel;
- a return line connecting the header of the vessel to the tank;
- a first pump arranged along the feed line and designed to draw the cleaning fluid from the tank and send it to the vessel at such a pressure as to produce a flow of cleaning fluid flowing from the outlet hole of the inner cavity to the inlet opening of the inner cavity of the blade.

[0008] It is a further object of the present invention to provide a simple, effective method for cleaning the inner channels of a gas turbine blade.

[0009] In accordance with these objects, the present invention relates to a method for cleaning a gas turbine blade; the blade extending along an axis and comprising an elongated main body, an anchoring member coupled with one end of the main body, and at least one inner cavity which is provided with at least one inlet opening arranged on the bottom face of the anchoring member, and with at least one outlet hole arranged along the main body;
the method comprising the steps of:

- placing the blade in a vessel provided with a header so that the inlet opening of the inner cavity is fluidically connected to the header;
- feeding the cleaning fluid by means of a feed line to the vessel at such a pressure as to produce a flow of cleaning fluid flowing from the outlet hole of the inner cavity to the inlet opening of the inner cavity of the blade; and
- feeding the cleaning fluid exiting from the header by means of a return line to a tank.

[0010] Further features and advantages of the present invention will become apparent from the following description of a non-limitative embodiment thereof, with reference to the figures of the accompanying drawings, in which:

- figure 1 is a diagrammatic view, with parts in section and parts removed for clarity, of a gas turbine blade;
- figure 2 is a diagrammatic view of a device for cleaning the inner channels of a gas turbine blade.

[0011] In figure 1, numeral 1 indicates a gas turbine blade.

[0012] Blade 1 extends along a longitudinal axis A and comprises an elongated main body 2 and an anchoring portion 3 integrally coupled with one end 4 of the main body 2, and a cooling circuit 5.

[0013] Main body 2 substantially extends along axis A and comprises a top section 7, commonly referred to as a "tip", opposite to the end 4, a trailing edge 8 and a leading edge 9.

[0014] The anchoring portion 3 is designed to be inserted, in use, into a respective seat of a rotor disc (not shown in the accompanying figures) of the turbine in a direction parallel to the axis of the rotor disc, substantially orthogonally to axis A of blade 1. In particular, the anchoring portion 3 has a so-called "upside-down pine cone" shape, substantially complementary with the shape of the respective seat of the rotor disc, but has a lower radial height than the radial height of the seat so that, once the seat is engaged, the anchoring portion 3 and the seat of the rotor disc create a channel (not shown for simplicity) for a cooling fluid to pass, preferably air

tapped from a compressor (not shown) of the system comprising the turbine.

[0015] The anchoring portion 3 of each blade 1 is provided with a base face 11, which is suitable for facing the above-described channel for the passage of the cooling fluid in use.

[0016] The cooling circuit 5 comprises one or more inner cavities 13 possibly connected to one another. In the non-limiting example shown in figure 1, the inner cavities 13 are four in number and connected to one another.

[0017] Each inner cavity 13 has at least one inlet opening 15 arranged along the base face 11 of the anchoring portion 3 and at least one outlet hole 16 arranged along the main body 2.

[0018] In the non-limiting example described and illustrated herein, there are four inlet openings 15 while there are many outlet holes 16, mainly arranged along the trailing edge 8 and the tip 7.

[0019] The inner cavities 13 are crossed, in use, by a cooling fluid (generally air), which cools down the blade portions which are most subject to thermal stress, e.g. the trailing edge 8.

[0020] In figure 2, reference numeral 20 indicates a device for cleaning a blade in accordance with the present invention.

[0021] Device 20 comprises a vessel 21, a tank 22, a feed line 24, a return line 25, a pump 26, filtering means 27 and heating means 28.

[0022] Vessel 21 comprises a cleaning fluid bath and is suitable for accommodating the blade 1 to be cleaned.

[0023] Vessel 21 is provided with an inlet 29 and a header 30 which can be coupled to blade 1. In particular, header 30 can be coupled to the anchoring portion 3 of blade 1 so that the inlet opening 15 is fluidically connected to header 30 and the outlet holes 16 are immersed in the cleaning fluid bath.

[0024] In the non-limiting example described and illustrated herein, header 30 comprises four channels 31, one for each inlet opening 15 of the anchoring portion 3.

[0025] Vessel 21 is a pressurized vessel capable of containing a cleaning fluid bath at a pressure equal to the feed pressure of pump 26.

[0026] Tank 22 contains the cleaning fluid to be fed to vessel 21. In the non-limiting example described and illustrated herein, the cleaning fluid is a water-based detergent fluid. It is understood that the cleaning fluid may be any other liquid or possibly gaseous fluid.

[0027] Tank 22 comprises a dirty-fluid container 23a and a clean-fluid container 23b.

[0028] The feed line 24 connects the clean-fluid container 23b to vessel 21 and, in particular, to the inlet 29 of vessel 21, while the return line 25 connects header 30 to the dirty-fluid container 23a. The dirty-fluid container 32b will thus contain the cleaning fluid containing the impurities which were present within blade 1 and which were removed.

[0029] Along the feed line, pump 26 is arranged, which is designed to draw the cleaning fluid from the clean-fluid container 23b and feed it to vessel 21 at such a pressure as to determine a flow of cleaning fluid flowing from the outlet holes 16 to the inlet opening 15 and capable of cleaning the inner cavity 13 of blade 1. Pump 26 is preferably designed to pump the cleaning fluid at a pressure between about 2 and about 20 bars.

[0030] The return line 25 comprises one or more connection branches 33 with header 30. In particular, the return line 25 comprises a branch 33 for each channel 31 of header 30.

[0031] Each branch 33 is provided with a respective on-off valve 35. The on-off valves 35 may be selectively closed or opened to define a flow path of the cleaning fluid in the cavities 13 of blade 1.

[0032] The device 20 for cleaning a blade 1 preferably comprises a filtering assembly 27, which is designed to draw the cleaning liquid from the dirty-fluid container 23b, filter it and send it to the clean-fluid container 23a.

[0033] In the non-limiting example described and illustrated herein, the filtering assembly 27 comprises two filters 36 arranged in parallel and an auxiliary filtering pump 39 which draws the cleaning fluid from the dirty-fluid container 32b.

[0034] Preferably, filters 36 are cartridge filters having a filtering degree between about 30 μm and about 50 μm, so as to prevent all mechanical machining residues from passing (milling chips, grinding scrap, machining residues generated by electro-discharge machining).

[0035] The heating means 28 are designed to heat the cleaning fluid before it is circulated by pump 26.

[0036] The heating means 28 are preferably arranged downstream of the filtering assembly 27 and are designed to heat up the cleaning fluid to a temperature of about 60-70°C.

[0037] The increase of the cleaning fluid temperature determines an increase of the degreasing power of the fluid; thereby, the heated fluid is able to remove all the oil and grease residues which tend to aggregate with the mechanical machining residues (milling chips, grinding scrap, machining residues generated by electro-discharge machining) from the surface of the inner cavity 13 of blade 1.

[0038] In the non-limiting example described and illustrated herein, the heating means 28 comprise an electric resistor 37 arranged in the clean-fluid container 23a.

[0039] In use, the blade 1 to be cleaned is accommodated in vessel 21 (initially open), vessel 21 is closed, and pump 26 is activated to fill vessel 21 with a fluid bath and to adequately pressurize the cleaning fluid within vessel 21 so as to produce a flow of cleaning fluid flowing from the outlet holes 16 of the inner cavity 13 to the inlet opening 15 of the inner cavity 13 of blade 1.

[0040] The forced flow of cleaning liquid from the outlet holes 16 of the inner cavity 13 to the inlet opening 15 of the inner cavity 13 advantageously facilitates the removal of machining residues present in the inner cavities 13 of the blade.

[0041] With traditional cleaning devices, in which the

flow of cleaning fluid is forced in the opposite direction (from the inlet opening 15 to the outlet holes 16), the complete removal of machining residues is practically impossible because residues having dimensions which are larger than the diameter of the outlet holes 16 are not eliminated and remain trapped within the inner cavities 13 of blade 1.

[0042] By virtue of the cleaning method and device 20 according to the present invention, any type of machining residue (oil, grease, machining chips and scrap, machining residues generated by electro-discharge machining, residues generated by adjusting and polishing operations, etc.) can be removed, when deposited on the surfaces of inner cavities 13, outlet holes 16 and inlet holes 15 of the blade.

[0043] By virtue of the cleaning method and device 20 according to the present invention, the operation of cleaning the inner cavities 13 may be advantageously carried out once, only when the machining operations are completed with a consequent reduction of the overall time required to obtain the final cleaning of blade 1.

[0044] It is finally apparent that changes and variations may be made to the method and device 20 for cleaning a blade 1 described herein, without departing from the scope of the appended claims.

Claims

1. A device (20) for cleaning a gas turbine blade (1), the blade (1) extending along an axis (A) and comprising an elongated main body (2); an anchoring member (3) connected to one end (4) of the main body (2); and at least one inner cavity (13) which has at least one inlet opening (15) on a bottom face (11) of the anchoring member (3), and at least one outlet hole (16) along the main body (2);
the device comprising:

- a vessel (21) suitable for containing a cleaning fluid bath and comprising a header (30); the blade (1) to be cleaned being couplable to the header (30) so that the outlet hole (16) of the inner cavity (13) is immersed in the cleaning fluid bath, and the inlet opening (15) of the inner cavity (13) is connected fluidically to the header (30);
- a tank (22) suitable for containing the cleaning fluid;
- a feed line (24) connecting the tank (22) to the vessel (21);
- a return line (25) connecting the header (30) of the vessel (21) to the tank (22); and
- a first pump (26) located along the feed line (24) and designed to draw the cleaning fluid from the tank (22) and pump it to the vessel (21) at such a pressure as to produce a flow of cleaning fluid from the outlet hole (16) of the inner cavity (13) to the inlet opening (15) of the inner cavity (13) of the blade (1).

2. A device as claimed in Claim 1, wherein the first pump (26) is designed to pump the cleaning fluid at a pressure of roughly 2 to 20 bars.

3. A device as claimed in Claim 1 or 2, wherein the vessel (21) is a pressurized vessel resisting to pressure up to 20 bar.

4. A device as claimed in any one of the foregoing Claims, and comprising a filter assembly (27) for filtering the cleaning fluid before it is fed to the vessel (21).

5. A device as claimed in Claim 4, wherein the tank (22) comprises a clean-fluid container (23a) and a dirty-fluid container (23b); the feed line (24) connecting the clean-fluid container (23a) to the vessel (21), and the return line (25) connecting the header (30) to the dirty-fluid container (23b).

6. A device as claimed in Claim 5, wherein the filter assembly (27) is designed to draw the cleaning fluid from the dirty-fluid container (23b), filter it, and feed it into the clean-fluid container (23a).

7. A device as claimed in Claim 6, wherein the filter assembly (27) comprises a second pump (39) for drawing the cleaning fluid from the dirty-fluid container (23b).

8. A device as claimed in any one of the foregoing Claims, and comprising heating means (28) for heating the cleaning fluid before it is fed to the vessel (21).

9. A device as claimed in any one of the foregoing Claims, wherein the return line (25) comprises one or more branches (33) connected fluidically to the header (30).

10. A device as claimed in Claim 9, wherein each branch (33) has at least one on-off valve (35).

11. A device as claimed in Claim 9 or 10, wherein the header (30) comprises one or more channels (31), each connectable to a respective inlet opening (15) of the blade (1), and to a respective branch (33) of the return line (25).

12. A method of cleaning a gas turbine blade (1), the blade (1) extending along an axis (A) and comprising an elongated main body (2); an anchoring member (3) connected to one end (4) of the main body (2); and at least one inner cavity (13) which has at least one inlet opening (15) on a bottom face (11) of the anchoring member (3), and at least one outlet hole

(16) along the main body (2);
the method comprising the steps of:

- placing the blade (1) inside a vessel (21) comprising a header (30) so that the inlet opening (15) of the inner cavity (13) is connected fluidically to the header (30);
- feeding cleaning fluid along a feed line (24) to the vessel (21) at such a pressure as to produce a flow of cleaning fluid from the outlet hole (16) of the inner cavity (13) to the inlet opening (15) of the inner cavity (13) of the blade (1); and
- feeding the cleaning fluid from the header (30) along a return line (25) to a tank (22).

13. A method as claimed in Claim 12, wherein the step of feeding the cleaning fluid to the vessel (21) comprises feeding the cleaning fluid at a pressure of roughly 2 to 20 bars.

14. A method as claimed in Claim 13, wherein the vessel (21) is a pressurized vessel resisting to pressure up to 20 bar.

15. A method as claimed in any one of Claims 12 to 14, and comprising the step of filtering the cleaning fluid before feeding it to the vessel (21).

16. A method as claimed in Claim 15, wherein the tank (22) comprises a clean-fluid container (23a) and a dirty-fluid container (23b); the feed line (24) connecting the clean-fluid container (23a) to the vessel (21), and the return line (25) connecting the header (30) to the dirty-fluid container (23b).

17. A method as claimed in Claim 16, and comprising the step of drawing the cleaning fluid from the dirty-fluid container (23b) prior to the step of filtering the cleaning fluid.

18. A method as claimed in Claim 17, and comprising the step of feeding the cleaning fluid to the clean-fluid container (23a) after the step of filtering the cleaning fluid.

19. A method as claimed in any one of Claims 12 to 18, and comprising the step of heating the cleaning fluid before it is fed to the vessel (21).

20. A method as claimed in any one of Claims 12 to 19, wherein the return line (25) comprises one or more branches (33) connected fluidically to the header (30).

21. A method as claimed in Claim 20, wherein each branch (33) has at least one on-off valve (35).

22. A method as claimed in Claim 20 or 21, wherein the header (30) comprises one or more channels (31), each connectable to a respective inlet opening (15) of the blade (1), and to a respective branch (33) of the return line (25).

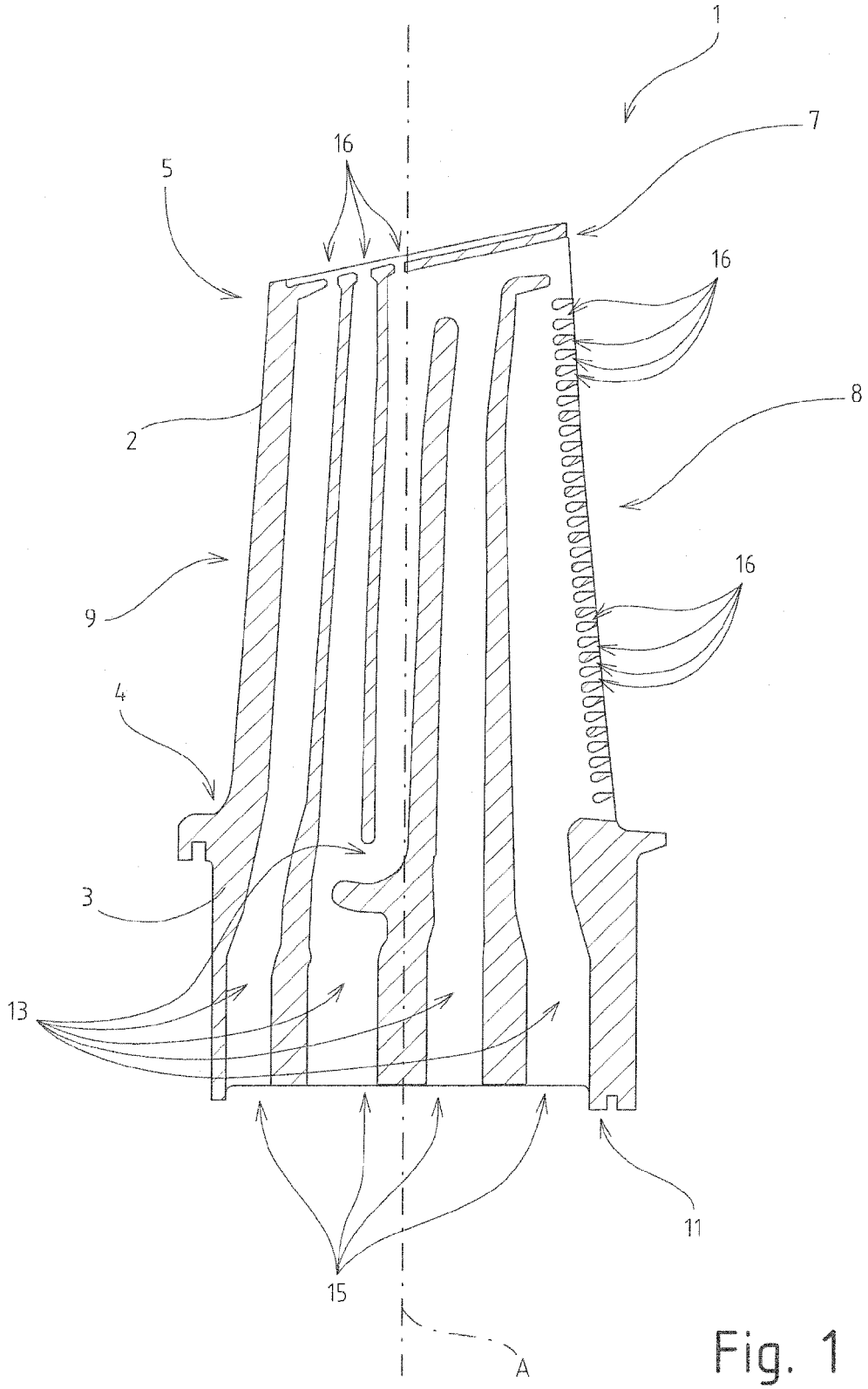

Fig. 1

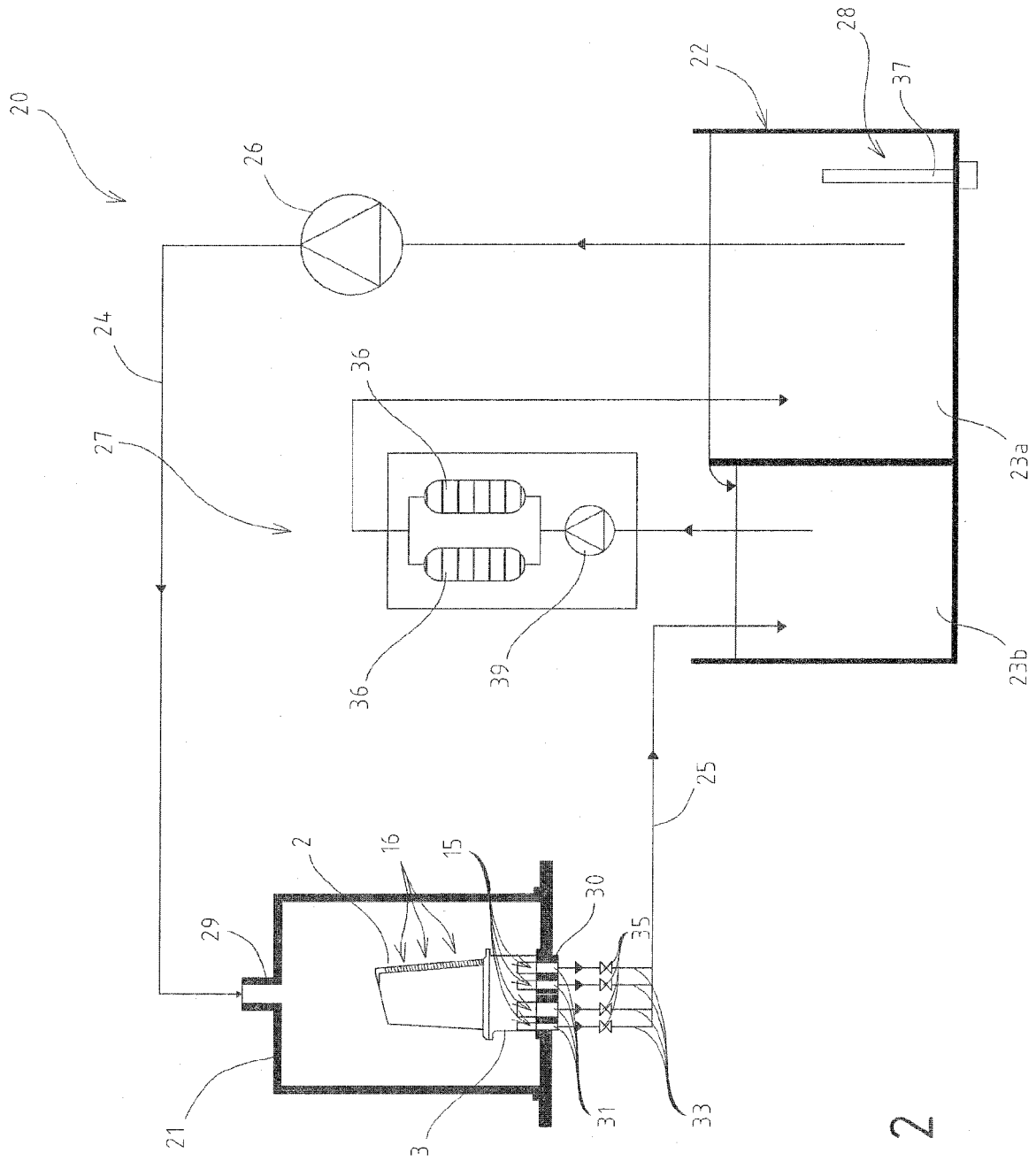

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 3890

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	EP 2 149 404 A1 (SIEMENS AG) 3 February 2010 (2010-02-03) * abstract * * paragraph [0001] - paragraph [0002] * * paragraph [0031] - paragraph [0041] * * claims * * figure * -----	1-4,9, 11-15, 20,22	INV. B08B9/00 F01D25/00
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Y,D	WO 00/05002 A1 (SIEMENS AG ET AL) 3 February 2000 (2000-02-03) * abstract * * page 1, line 3 - line 12 * * page 7, line 24 - page 11, line 9 * * claims * * figures * -----	12,13, 15-22	TECHNICAL FIELDS SEARCHED (IPC) B08B F01D
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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	18 October 2011	van der Zee, Willem

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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