

(19)



Europäisches
Patentamt
European
Patent Office
Office européen
des brevets



(11)

EP 2 282 015 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

09.02.2011 Bulletin 2011/06

(51) Int Cl.:

F01D 11/00 (2006.01)**F01D 11/02** (2006.01)**F01D 11/08** (2006.01)**F01D 5/20** (2006.01)(21) Application number: **09164090.4**(22) Date of filing: **30.06.2009**

(84) Designated Contracting States:

**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 SE SI SK TR**

(71) Applicant: **Alstom Technology Ltd****5400 Baden (CH)**

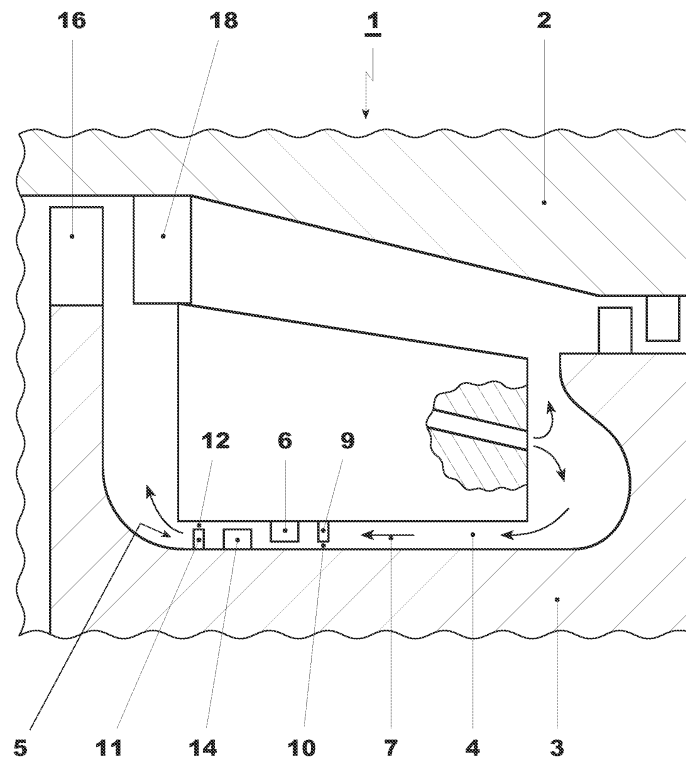
(72) Inventors:

- **Bricaud, Cyrille**
79618 Rheinfelden (DE)
- **Zierer, Thomas**
5408 Ennetbaden (CH)
- **Simon-Delgado, Carlos**
5400 Baden (CH)

(54) **Turbo machine with an Improved Seal**

(57) The rotating machine (1) with improved seal comprises stator parts (2) and rotor parts (3) between which a gap (4) housing at least a seal (5) is provided. The seal (5) comprises a guide vane row (6), that extends from a stator part (2) and is arranged to guide a fluid flow, and/or a rotor blade row (14), that extends from a rotor

part (3) and is arranged to exchange mechanical power with the fluid flow. The guide vane row (6) and/or rotor blade row (14) maintain a differential pressure between areas at opposite ends of the seal (5) and prevent the fluid flow from dissipating its pressure energy generating heat.

**FIG. 13**

Description

TECHNICAL FIELD

[0001] The present invention relates to a rotating machine with an improved seal.

BACKGROUND OF THE INVENTION

[0002] Turbo machines such as gas turbines or steam turbines are provided with a stator (made of a plurality of stator parts) enclosing a rotor (that carries a plurality of rotor parts) rotating within it.

[0003] In a number of places, the stator parts and the rotor parts are usually provided with labyrinth or brush seals, in order to control and limit the leakage between high and low pressure areas.

[0004] These traditional seals (labyrinth or brush seals) generate a controlled fluid flow from the high pressure area to the low pressure area, that dissipates the pressure energy of the fluid, increasing the stator, rotor and fluid temperature.

[0005] This controlled leakage is almost proportional to the smallest clearance between the stator and rotor parts involved, therefore the actual leakage can be hardly controlled according to the particular needs.

SUMMARY OF THE INVENTION

[0006] The technical aim of the present invention is therefore to provide a rotating machine with an improved seal by which the said problems of the known art are eliminated.

[0007] Within the scope of this technical aim, an object of the invention is to provide a rotating machine by which the pressure energy of the fluid is not dissipated and thus wasted. In particular, according to the invention the pressure energy of the fluid is not dissipated as heat.

[0008] Another object of the invention is to provide a rotating machine by which the leakage can be regulated independently from the clearance between the stator and rotor parts.

[0009] The technical aim, together with these and further objects, are attained according to the invention by providing a rotating machine in accordance with the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Further characteristics and advantages of the invention will be more apparent from the description of a preferred but non-exclusive embodiment of the rotating machine according to the invention, illustrated by way of non-limiting example in the accompanying drawings, in which:

Figure 1 is a schematic view of an embodiment of the seal of the invention having a guide vane row

and defining an axial turbine;

Figures 2 through 6 are schematic views of five different embodiments of the seal of the invention defining an axial turbine having a guide vane row followed by a rotor blade row;

Figures 7 through 9 are schematic views of three different embodiments of the invention defining a radial turbine having a guide vane row and a rotor blade row;

Figure 10 is a schematic view of an embodiment of the seal of the invention having a rotor blade row followed by a guide vane row and defining an axial compressor;

Figure 11 is a schematic view of an embodiment of the seal of the invention having a rotor blade row and defining an axial compressor;

Figure 12 is a schematic view of an embodiment of the seal of the invention having a rotor blade row and a guide vane row and defining a radial compressor; and

Figure 13 is an example of a micro-turbine of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0011] With particular reference to figure 13, the rotating machine 1 (such as a gas turbine or a steam turbine) with an improved seal comprises stator parts 2 and rotor parts 3; between the stator parts 2 and rotor parts 3 a gap 4 is defined.

[0012] The gap 4 houses a seal 5 that comprises a guide vane row 6 extending from the stator parts 2 and arranged to guide a fluid flow 7 in the gap 4 and a rotor blade row 14 extending from the rotor part 3 and arranged to exchange mechanical power with the fluid flow 7.

[0013] The guide vane row 6 and rotor blade row 14 maintain the differential pressure between areas at the opposite ends of the seal 5 and prevent the fluid flow 7 from dissipating its pressure energy generating heat.

[0014] Preferably, the seal 5 also comprises an obstruction arranged to limit the fluid flow 7 through the gap 4.

[0015] The obstruction comprises annular plates 9, 11 and, in this respect, a first annular plate 9 extends transversally from a stator part 2, defining an annular passage 10 for the fluid flow 7 having a prefixed thickness.

[0016] In this case, the guide vane row 6 may extend from this stator annular plate 9.

[0017] In addition, a further annular plate 11 extends transversally from a rotor part 3, defining an annular passage 12 for the fluid flow 7 having a prefixed thickness.

[0018] The rotor blade row 14 may extend from the annular plate 11.

[0019] In different embodiments, the seal 5 may define an axial or a radial micro-turbine.

[0020] Advantageously, in these embodiments the pressure energy of the fluid is not dissipated as heat, but is used to provide turbine work thus leading to a decrease

of the total temperature of the air (up to 60K per stage). So the rotor and stator temperature are also reduced.

[0021] In particular figure 13 shows an axial micro-turbine having the guide vane row 6 followed by the rotor blade row 14, nevertheless in different embodiments the rotor blade row 14 may not be provided; in this case the guide vane row 6 drives the fluid flow 7 towards the main rotor blades 16 of the rotating machine 1.

[0022] In further embodiments, the obstructions may not be provided or may be provided in different positions.

[0023] For example the seal 5 could have one or more annular plates 9 extending from a stator part 2 and/or one or more annular plates 11 extending from the rotor part 3; the plates 9 and 11 may be placed partly or totally upstream of and/or between and/or downstream of the guide vane row 6 and rotor blade row 14.

[0024] In further embodiments, the seal of the invention defines an axial or radial micro-compressor.

[0025] In this case the seal has the rotor blade row 14 followed by the guide vane row 6; nevertheless in different embodiments the guide vane row 6 may not be provided.

[0026] Also in this case the obstructions may not be provided or may be provided in different positions.

[0027] For example (as already described for the micro-turbine) the seal 5 could have one or more annular plates 9 extending from the stator part 2 and/or one or more annular plates 11 extending from the rotor part 3; the plates 9 and 11 may be placed partly or totally upstream of and/or between and/or downstream of the guide vane row 6 and rotor blade row 14.

[0028] Moreover, the micro-turbine and the micro-compressor may have one single stage or multiple stages.

[0029] As an example, the micro-turbine can be implemented in the rim seal, at the rotor heat shield/vane, at the stator heat shield/blade, as a radial or axial seal arrangement or in combination with labyrinth or brush seal.

[0030] As a further example the micro-compressor may be implemented in the bearing areas, (no leakage tolerated), as an axial or radial seal arrangement or in combination with labyrinth or brush seal.

[0031] Naturally also other positions are possible for the micro-turbine and micro-compressor.

[0032] Typically the blades of the guide vane row 6 and/or rotor blade row 14 may have a height of some millimetres, such as less than 10 millimetres, preferably less than 5 millimetres and more preferably less than 3 millimetres.

[0033] The blades can be directly machined on the rotor shaft, rotor disk, blade root, casing, honeycomb at the vane hub, stator heat shield or rotor heat shield. Nevertheless the blades can also be designed on the sealing strips, or be separated attached parts.

[0034] In the following particular embodiments of the invention are described.

[0035] Figure 1 shows an embodiment wherein the seal 5 defines an axial micro-turbine.

[0036] In particular figure 1 shows a stator part 2 from which the main stator blades 18 defining a plurality of guide vanes extend (i.e. the stator blades 18 are those of the gas or steam turbine).

5 **[0037]** Figure 1 also shows a rotor part 3 from which the main rotor blades 16 extend (i.e. the rotor blades 16 are those of the gas or steam turbine).

[0038] Between the tip of the stator blades 18 and the rotor part 3 a gap 4 is defined.

10 **[0039]** The stator blades 18 have at their tip the guide vane row 6 extending within the gap 4.

[0040] The hot gases pass through the stator blades 18 and rotor blades 16.

15 **[0041]** A part of the hot gases (i.e. the fluid flow 7) leaks in the gap 4 and passes through the guide vane row 6 that processes it and drives it towards the main rotor blades 16.

[0042] The mass flow through the gap 4 is defined by the thickness of the gap 4 and the shape of the guide vane row 6 (and naturally also the differential pressure upstream and downstream of the guide vane row 6).

[0043] This embodiment lets further mechanical power be collected by the main rotor blades 16 (the power that in traditional seals is dissipated, in the seal according to this embodiment of the invention is collected by the rotor blades 16); thus the local temperatures (in particular those of the air and rotor parts) are reduced with respect to traditional seals, because there is no or less fluid flow pressure energy that is converted into heat.

20 **[0044]** Figure 2 through 6 show different embodiments of axial micro-turbines having a guide vane row 6 and a rotor blade row 14.

[0045] In particular, figure 2 shows an axial micro-turbine having a stator part 2 and a rotor part 3 defining a gap 4; the stator part 2 supports the guide vane row 6 and the rotor part 3 supports the rotor blade row 14.

[0046] In addition upstream of the guide vane row 6 the seal 5 has the annular plate 9.

25 **[0047]** During operation, the fluid flow 7 (i.e. the leakage) passes through the passage 10 between the annular plate 9 and the rotor part 3 and passes through the guide vane row 6; then the fluid flow 7 passes through the rotor blade row 14 and delivers mechanical power to the rotor part 3.

30 **[0048]** The mass flow of the fluid passing through the gap 4 is defined by the passage 10 (i.e. the annular plate 9) and by the geometry and configuration of the guide vane row 6 and rotor blade row 14.

35 **[0049]** In addition, the increase in temperature of the fluid flow and rotor is very limited, because the pressure energy of the fluid is not converted into heat, but is converted into mechanical power collected by the rotor part 3.

[0050] The embodiments of figures 3 through 6 have substantially the same structure and operation of the embodiment of figure 2 and with the same numbers the same or similar elements are indicated.

40 **[0051]** In particular figure 3 shows a seal 5 with two annular plates 9 extending from the stator part 2 respec-

tively one upstream of the guide vane row 6, and the other downstream of the rotor blade row 14.

[0052] Figure 4 shows a seal 5 with an annular plate 11 extending from the rotor part 3 upstream of the guide vane row 6 and a further annular plate 9 extending from the stator part 2 between the guide vane row 6 and the rotor blade row 14.

Figure 5 shows a seal 5 with a guide vane row 6 extending from the stator part 2 and an annular plate 11 extending from the rotor part 3 downstream of the guide vane row 6 and carrying at its border the rotor blade row 14.

Figure 6 shows a seal 5 with an annular plate 9 extending from the stator part 2; from the border of the annular plate 9 the guide vane row 6 extends. Downstream of the guide vane row 6, the rotor blade row 14 extends from a rotor part 3. Moreover, a further annular plate 9 extends from the stator part 2 downstream of the rotor blade row 14. Figures 7 through 9 show three different embodiments of a seal defining a radial micro-turbine; also in this case the same numbers are used for the same or similar elements.

[0053] In particular, figure 7 shows a stator part 2 carrying the main stator blades 18 and a rotor part 3 carrying the main rotor blades 16.

[0054] Between the stator part 2 and the rotor part 3 the radial gap 4 is defined, housing an annular plate 11 extending from the rotor part 3 and downstream of it (with respect to the direction of the fluid flow 7) a guide vane row 6 extending (in this embodiment) from an annular plate 9.

[0055] During operation a fluid flow 7 of compressed air (purge air) is injected through the gap 4 towards the hot gases path 20.

[0056] This fluid flow 7 passes through the passage 12 between the border of the annular plate 11 and the stator part 2 and then passes through the guide vane row 6 that prepares the fluid flow 7 to pass through the main rotor blades 16 and drives it towards it.

[0057] In this embodiment, the mass flow of the fluid flow 7 is limited by the plate 11 (i.e. the thickness of the passage 12) and the shape and configuration of the guide vane row 6 and annular plate 9.

[0058] Moreover the temperature increase is limited because the amount of energy pressure of the fluid flow converted into heat is limited (this energy is gathered as mechanical power by the main rotor blades 16).

[0059] Figures 8 and 9 show two embodiments of a radial micro-turbine having the guide vane row 6 and the rotor blade row 14.

[0060] In particular figure 8 shows a stator part 2 from which the main stator blades 18 extend and a rotor part 3 from which the main rotor blades 16 extend.

[0061] Between the stator part 2 and the rotor part 3 there is the gap 4.

[0062] In the gap 4 an annular plate 9 extending from the stator part 2 and carrying at its border the guide vane row 6 and downstream of it a rotor blade row 14 extending from the rotor part 3 are housed.

[0063] During operation the fluid flow 7 (compressed air) passes through the guide vane row 6 and then through the rotor blade row 14.

[0064] Mechanical power is gathered on the rotor part 3 (this limits the increase of temperature).

[0065] In this case the mass flow through the seal 5 is defined by the configuration of the guide vane row 6 and rotor blade row 14.

Figure 9 shows a further embodiment similar to those already described. This embodiment has a guide vane row 6 extending from an annular plate 9 connected to a stator part 2, a rotor blade row 14 and a further annular plate 9.

Figures 10 through 12 show three seals defining a micro-compressor; also in these cases the reference numbers are the same as those already used to indicate the same or similar elements.

[0066] In particular figure 10 shows a seal 5 defining an axial micro-compressor.

[0067] In this respect, figure 10 shows a stator part 2 and a rotor part 3 defining a gap 4.

[0068] The stator part 2 carries a guide vane row 6 and upstream of it (with respect to the fluid flow 7) the rotor part 3 carries a rotor blade row 14.

[0069] Moreover, upstream of the rotor blade row 14, the seal 5 has an annular plate 9 extending from the stator part 2 and a further annular plate 11 extending from the rotor part 3.

[0070] During operation the fluid flow 7 is drawn from a lower pressure area 22 to a higher pressure area 24.

[0071] In particular, the fluid flow 7 (initially in the lower pressure area 22) overcomes the annular plates 11 and 9 and then passes through the rotor blade row 14 and thus through the guide vane row 6 to be supplied to the higher pressure area 24.

[0072] Nevertheless, at the tip of the blades of the rotor blade row 14 a leakage 25 passes, conveying a flow from the higher pressure area 24 to the lower pressure area 22.

[0073] The seal 5 can thus be designed in order to have a desired flow from the higher pressure area 24 towards the lower pressure area 22, or no flow at all (i.e. the leakage 25 from the higher pressure area 24 towards the lower pressure area 22 is fully compensated by the flow 7 from the lower pressure area 22 towards the higher pressure area 24).

[0074] Moreover, the seal 5 can be designed in order to have a reverse flow, i.e. the fluid flow 7 from the lower pressure area 22 towards the higher pressure area 24 is greater than the leakage 25 from the higher pressure area 24 towards the lower pressure area 22.

[0075] In this embodiment the mass flow of the fluid is defined by the annular plates 11 and 9 and by the configuration and shape of the rotor blade row 14 and guide vane row 6.

[0076] In addition, the temperature increase is limited, because the amount of energy pressure converted into heat is limited (on the contrary the fluid pressure energy

is increased).

[0077] Figure 11 shows a further embodiment of axial micro-compressor having rotor blade row 14.

[0078] In this embodiment, the rotor part 3 carries the rotor blade row 14 and, upstream of it, an annular plate 11; between the rotor blade row 14 and annular plate 11 the stator part 2 carries an annular plate 9.

[0079] Figure 12 shows an embodiment of radial micro-compressor.

[0080] In this embodiment the stator part 2 carries the main stator blades 18 and a rotor part 3 carries the main rotor blades 16.

[0081] Between the stator part 2 and the rotor part 3 the gap 4 is provided.

[0082] In the gap 4 a rotor blade row 14 extends from the rotor part 3 and a guide vane row 6 extends from the stator part 2.

[0083] This embodiment could be used for example to reduce or eliminate the purge air, i.e. the air injected in the gap 4 to prevent the hot gases flowing in the hot gases path 20 from entering the gap 4.

[0084] In this respect, the seal 5 could be designed such that a recirculation occurs that keeps the hot gases in the hot gases path 20.

[0085] In this embodiment the mass flow of the fluid is defined by the configuration and shape of the rotor blade row 14 and guide vane row 6.

[0086] In addition, the temperature increase is limited, because the amount of energy pressure converted into heat is limited (the energy of the fluid is increased).

[0087] The rotating machine conceived in this manner is susceptible to numerous modifications and variants, all falling within the scope of the inventive concept; moreover all details can be replaced by technically equivalent elements.

[0088] In practice the materials used and the dimensions can be chosen at will according to requirements and to the state of the art.

REFERENCE NUMBERS

[0089]

- 1 rotating machine
- 2 stator part
- 3 rotor part
- 4 gap
- 5 seal
- 6 guide vane row
- 7 fluid flow
- 9 annular plate
- 10 annular passage
- 11 annular plate
- 12 annular passage
- 14 rotor blade row
- 16 main rotor blade
- 18 main stator blade
- 20 hot gases path

- 22 lower pressure area
- 24 higher pressure area
- 25 leakage

5

Claims

1. Rotating machine (1) with improved seal comprising stator parts (2) and rotor parts (3) between which a gap (4) housing at least a seal (5) is provided, **characterised in that** said seal (5) comprises a guide vane row (6), that extends from a stator part (2) and is arranged to guide a fluid flow, and/or a rotor blade row (14), that extends from a rotor part (3) and is arranged to exchange mechanical power with the fluid flow, said guide vane row (6) and/or rotor blade row (14) maintaining a differential pressure between areas at opposite ends of the seal (5) and preventing the fluid flow from dissipating its pressure energy generating heat.
2. Rotating machine (1) as claimed in claim 1, **characterised by** comprising an obstruction (9, 11) arranged to limit the fluid flow (7) through said gap (4).
3. Rotating machine (1) as claimed in claim 2, **characterised in that** said obstruction (9, 11) comprises an annular plate.
4. Rotating machine (1) as claimed in claim 3, **characterised in that** said annular plate (9) extends transversally from the stator part (2), defining a prefixed annular passage (10) for the fluid flow (7).
5. Rotating machine (1) as claimed in claim 4, **characterised in that** said guide vane row (6) extends from said annular plate (9).
6. Rotating machine (1) as claimed in claim 3, **characterised in that** said annular plate (11) extends transversally from the rotor part (3), defining a prefixed annular passage (12) for the fluid flow (7).
7. Rotating machine (1) as claimed in claim 6, **characterised in that** said rotor blade row (14) extends from said annular plate (11).
8. Rotating machine (1) as claimed in claim 1, **characterised in that** said seal (5) defines an axial or a radial micro-turbine.
9. Rotating machine (1) as claimed in claim 1, **characterised in that** said seal defines an axial or radial micro-compressor.
10. Rotating machine (1) as claimed in claim 1, **characterised by** being a gas or steam turbine.

11. Rotating machine (1) as claimed in claim 1, **characterised in that** the blades of the guide vane row (6) and/or rotor blade row (14) have a height of less than 10 millimetres, preferably less than 5 millimetres and more preferably less than 3 millimetres.

5

10

15

20

25

30

35

40

45

50

55

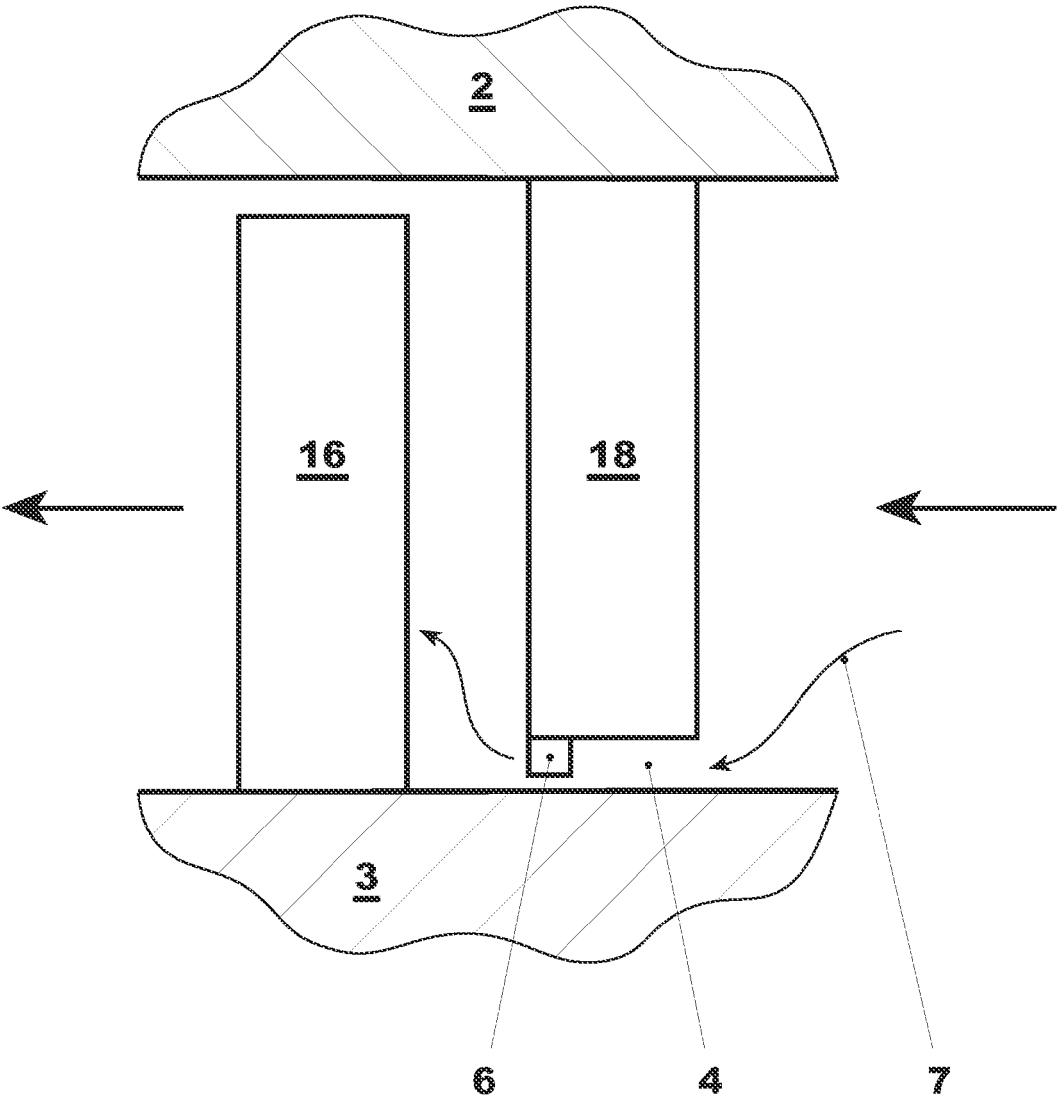


FIG. 1

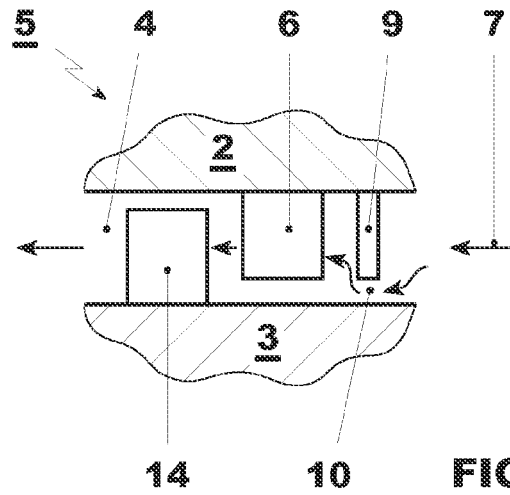


FIG. 2

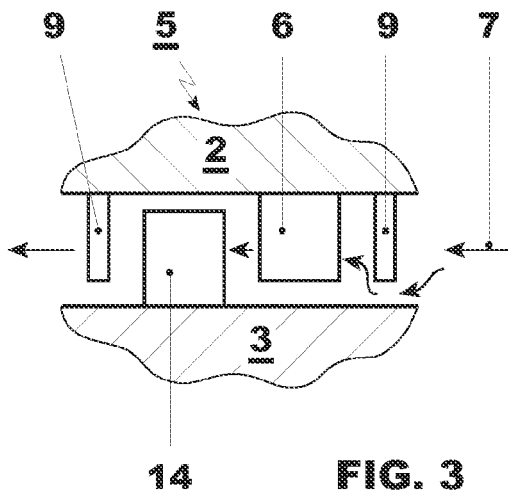


FIG. 3

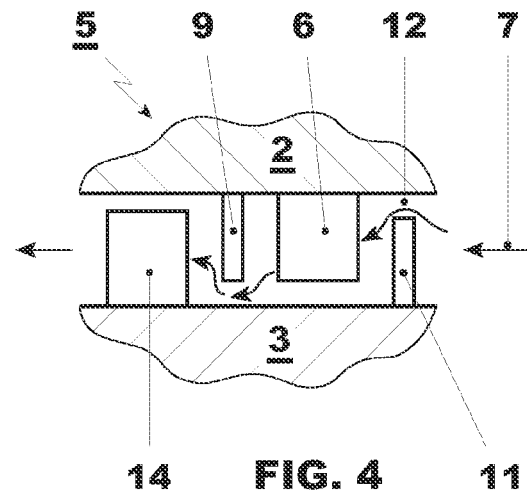


FIG. 4

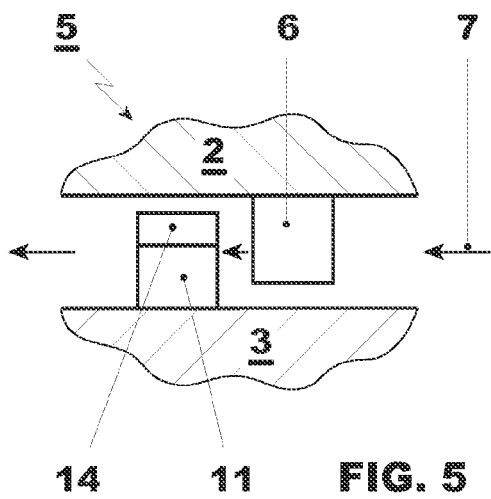


FIG. 5

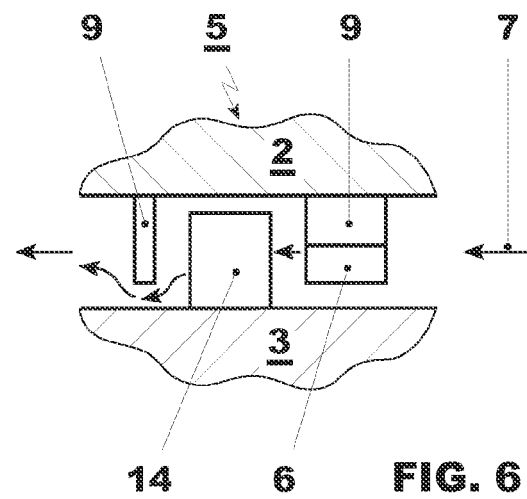
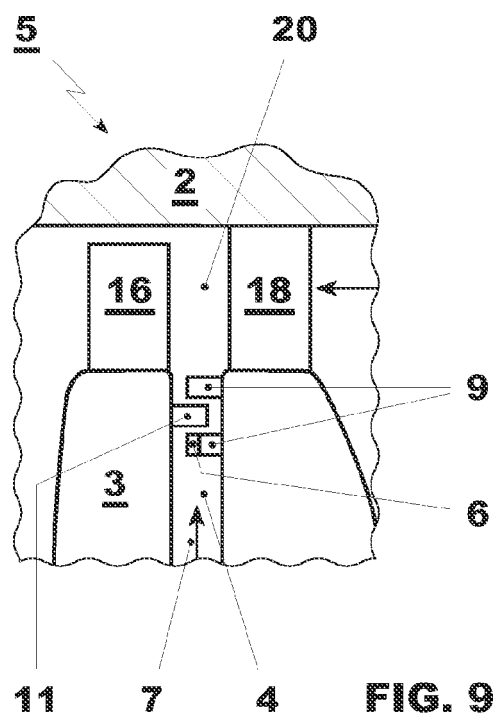
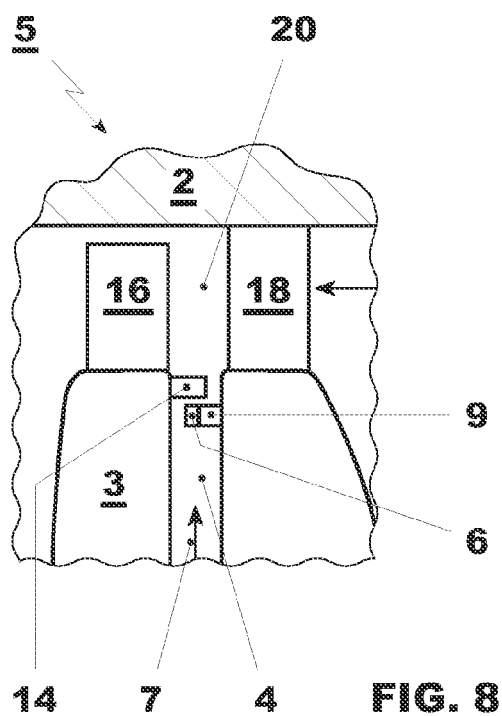
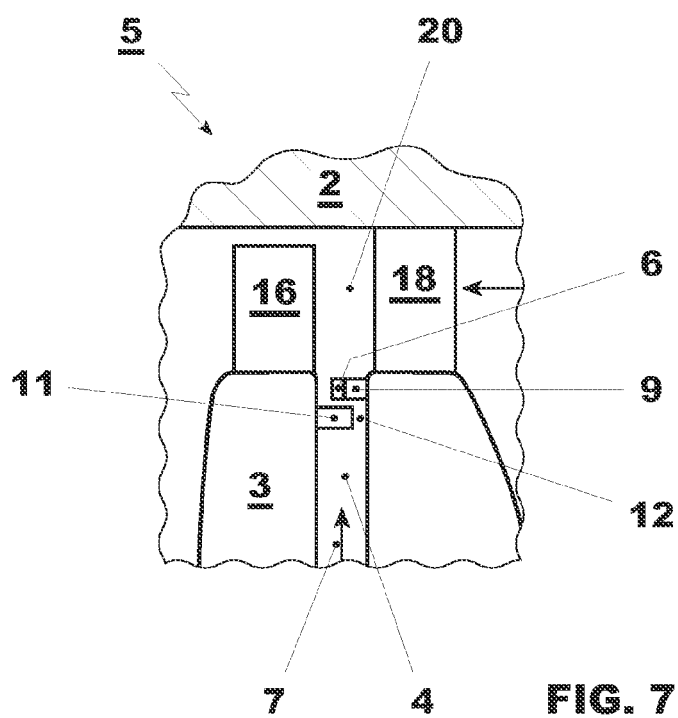


FIG. 6



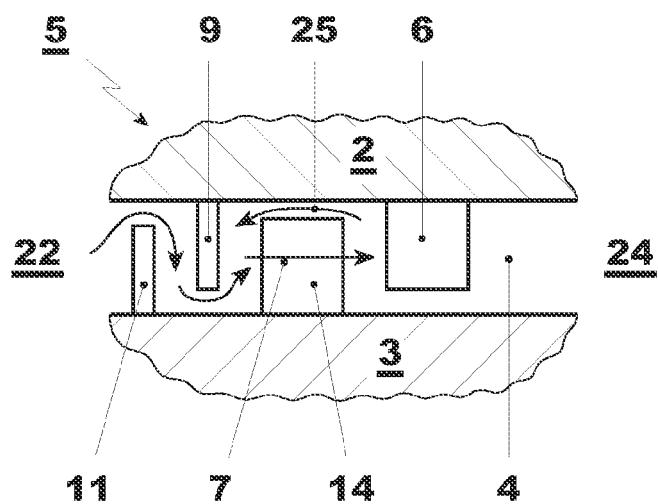


FIG. 10

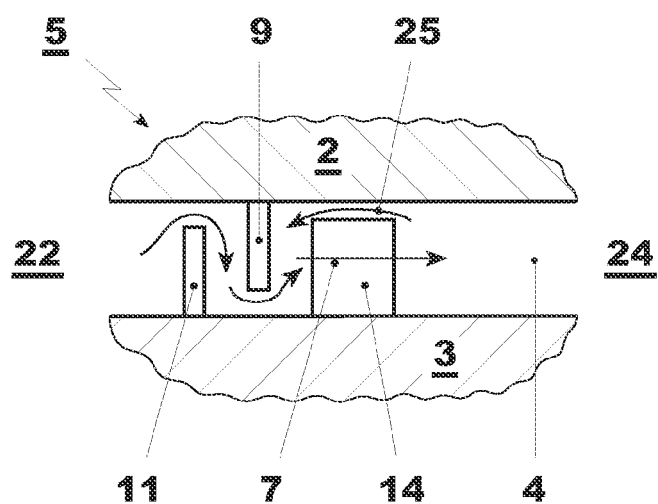


FIG. 11

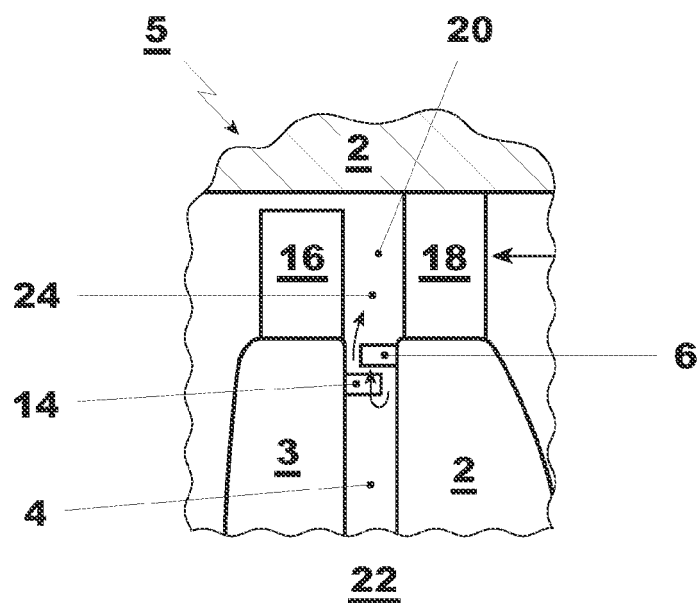


FIG. 12

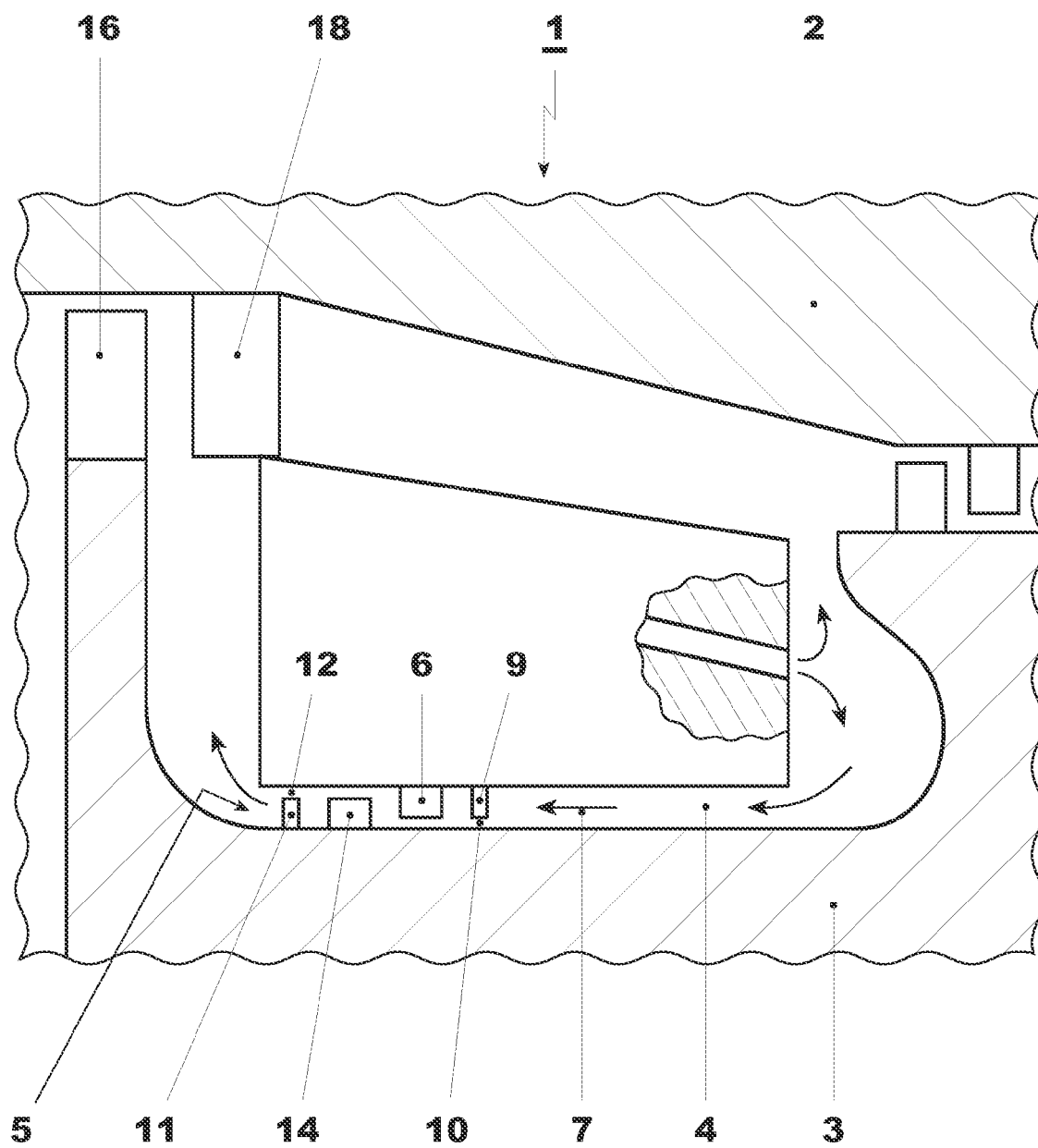


FIG. 13



EUROPEAN SEARCH REPORT

Application Number
EP 09 16 4090

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	US 2005/058533 A1 (BELOKON ALEXANDER [RU] ET AL BELOKON ALEXANDER [RU] ET AL) 17 March 2005 (2005-03-17)	1-3,6, 8-10	INV. F01D11/00 F01D11/02 F01D11/08 F01D5/20
Y	* page 1, paragraph 7 * * page 3, paragraphs 26,28,29 * * page 4, paragraph 33 * * figures 1-5 *	4,11	
Y	----- US 2006/133927 A1 (BRILLERT DIETER [US] ET AL) 22 June 2006 (2006-06-22) * figures 1-7 *	4	
Y	----- US 2007/237627 A1 (BUNKER RONALD S [US]) 11 October 2007 (2007-10-11) * figures 1,2 *	11	
X	----- US 6 059 530 A (LEE CHING-PANG [US]) 9 May 2000 (2000-05-09)	1,2,8-10	TECHNICAL FIELDS SEARCHED (IPC)
Y	* page 7, column 5, lines 33-50 * * page 7, column 8, lines 42-67 * * figures 3-5 *	4,11	
X	----- US 4 875 831 A (FETIVEAU JEAN Y L [FR]) 24 October 1989 (1989-10-24) * page 4, column 1, lines 45-52 *	1,2,8-10	F01D
Y	* figures 1,2,4,4B *	4,11	
X	----- DE 10 2004 050739 A1 (MTU AERO ENGINES GMBH [DE]) 20 April 2006 (2006-04-20)	1,2,8-10	
Y	* figures 1,2 *	4,11	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 December 2009	Examiner Klados, Iason
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	

 5
EPO FORM 1503 03.82 (P04C01)

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

EP 09 16 4090

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.

18-12-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005058533 A1	17-03-2005	AT 413515 T	15-11-2008
		CA 2538749 A1	31-03-2005
		CN 1878931 A	13-12-2006
		DK 1685310 T3	02-03-2009
		EP 1685310 A1	02-08-2006
		ES 2317051 T3	16-04-2009
		JP 2007533888 T	22-11-2007
		KR 20060118432 A	23-11-2006
		MX PA06002860 A	14-06-2006
		WO 2005028813 A1	31-03-2005
US 2006133927 A1	22-06-2006	NONE	
US 2007237627 A1	11-10-2007	NONE	
US 6059530 A	09-05-2000	DE 69922328 D1	05-01-2005
		DE 69922328 T2	15-12-2005
		EP 1013878 A2	28-06-2000
		JP 2000297603 A	24-10-2000
US 4875831 A	24-10-1989	CA 1294558 C	21-01-1992
		DE 3867606 D1	20-02-1992
		EP 0317432 A1	24-05-1989
		FR 2623569 A1	26-05-1989
		JP 1159401 A	22-06-1989
		JP 1955536 C	28-07-1995
		JP 6089647 B	09-11-1994
DE 102004050739 A1	20-04-2006	NONE	