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(54) **Sealing arrangement of a gas turbine with a cooling air system**

(57) A sealing arrangement for rotating and non-rotating components of a gas turbine is disclosed, which minimizes cooling air losses due to misalignments of an axial seal. The sealing arrangement comprises a circum-

ferential seal (29) and several axial seals (31), and at least one axial seal (31) is positively locked with the circumferential seal (29).

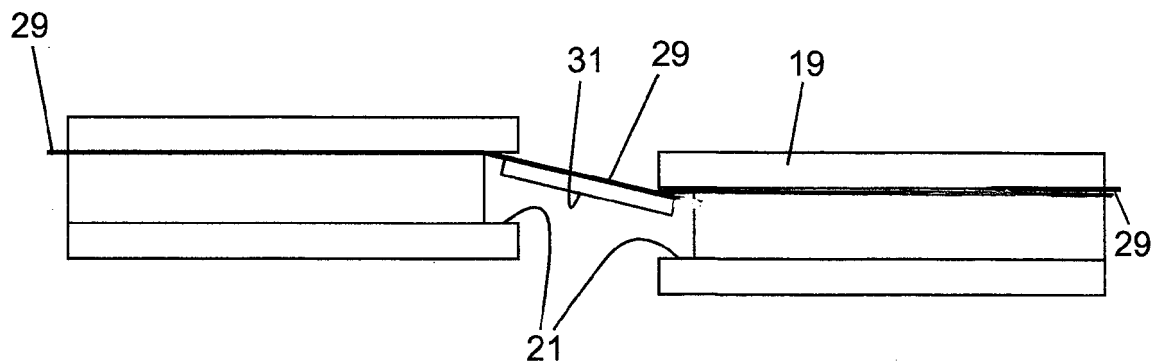


Fig. 11

EP 2 799 667 A1

Description

[0001] The claimed invention relates generally to gas turbines with a cooling air system.

[0002] To avoid that the hot gases derived from the combustion of gas and air are mixed with the cooling air sealing arrangements are known.

[0003] These sealing arrangements close gaps between rotating turbine components like blades that are mounted on the rotor of the gas turbine and the gaps between the rotor and the blades.

[0004] Further, these sealing arrangements are necessary to close gaps between non-rotating turbine components like vanes and heat shields that are directly or indirectly linked with a stator or a housing of the gas turbine.

[0005] To close the above-mentioned gaps, single and multi-layer strip seals of metal are used.

[0006] Since some of these gaps extend in a circumferential direction and some of these gaps, namely the gaps between two adjacent blades, extend more or less in axial direction of the rotor, it is known to use T-shaped seals.

[0007] To more clearly describe the function of these seals in figure 1, a schematic cross-section of a gas turbine 1 is shown.

[0008] The gas turbine 1 comprises a rotor 3 and a stator 5, which is also referred to as housing.

[0009] Connected to the rotor 3 are several rows of blades 7. In figure 1, three rows of blades 7.1, 7.2 and 7.3 are shown. These blades 7 are positively locked with the rotor 3 and rotate if the gas turbine 1 is running.

[0010] Connected to the housing 5 are three rows of vanes 9.1, 9.2 and 9.3. The vanes 9 are connected to the housing 5 and are not rotating.

[0011] The hot gases flow through the gas turbine 1 in the direction of the arrows 11. As can be seen from figure 1, between two adjacent rows of blades (7.1 and 7.2, for example) a first circumferential gap 13.1 exists. Further, between the rows of blades 7.2 and 7.3 a second circumferential gap 13.2 exists.

[0012] Looking now to the left part of figure 1, it can be seen that each row of blades 7 comprises quite a number of blades 7 that are installed one beneath the other around the rotor 3. This means that between two adjacent blades 7.1 in the axial direction of the rotor 3 there are axial gaps 15.

[0013] Looking now to figure 2, that shows a developed view of the row 7.1 of the blades, the circumferential gaps 13 and the axial gaps 15 can be seen. The circumferential gap 13 and the axial gaps 15 do not extend rectangular to each other but nevertheless, one axial gap 15 and two adjacent parts of the circumferential gap 13 are more or less T-shaped.

[0014] To close these gaps 13 and 15, it is known from the prior art to use T-shaped seals 17. The number of these T-shaped seals 17 is similar to the number of blades 7 in one row.

[0015] In figure 3, such a prior art T-shaped seal 17 is shown.

[0016] The branch or part 17.1 closes an axial gap 15 and the branch 17.2 of the T-shaped seal 17 closes a part of the circumferential gap 13.

[0017] Since the operating temperatures of gas turbines 1 are rather high, seals 17 are made of metal strips whose branches 17.1 and 17.2 are welded together resulting in a rather stiff seal. In some cases, the seal 17 is made of two or more layers of metal strips that are welded together, for example.

[0018] In figure 3, it can be seen that the second branch 17.2 is made of two strips of metal being offset a little bit. The offset has the reference numeral 18.

[0019] Since the branches 17.1 and 17.2 are welded together, these T-shaped seals are more or less rigid construction that causes problems or leakage in case that two adjacent blades 7 are misaligned a bit.

[0020] Looking now to figure 4 a) and b), this problem is illustrated in more detail.

[0021] The upper part of figure 4 shows a cross-section through two adjacent blades 7.1 with a focus on the feet or basis 19 of the blades 7.1. The radial outer part of the blades 7 is cut off in figure 4.

[0022] The basis 19 of the blades 7 comprises grooves 21 that extend along the axial gap 13. To close the gap 13, the branch 17.1 of the T-shaped seal 17 is mounted into the grooves 21. The grooves 21 fix the seal 17 and consequently an inner part 23 of the rotor where the cooling air flows is separated from an outer part 25 where hot combustion gases drive the blades 7.

[0023] As can be seen from figure 4a, the adjacent basis 19 of the adjacent blades 7.1.a and 7.2.b are a little bit misaligned, since the basis 19 of the left 7.1 has a position which is a little bit higher than the position of the basis 19 of the right blade 7.1. Consequently, the branch 17.1 is slightly inclined.

[0024] In figure 4b, the impact of this inclination of the branch 17.1 to the branch 17.2 is shown.

[0025] Due to the rigidity of the T-shaped seal at the junction of the branches 17.1 and 17.2 gaps 27 between the seal 17 and the upper part of the groove 21 of both blades 7.1 occur.

[0026] Through this gap 27 cooling air from the area 23 may flow into the area 25, thus, reducing the cooling effect of this cooling air and the efficiency of the turbine.

[0027] It is an object of the claimed invention to provide a sealing solution or a sealing arrangement that does not have gaps 27, even if the basis 19 of two adjacent blades is misaligned.

[0028] This objective is achieved by means of a sealing arrangement for sealing gaps between rotating or non-rotating components of a gas turbine comprising a circumferential seal and several axial seals. In a preferred embodiment the axial seals and the circumferential seal are positively locked.

[0029] This means that the axial seal and the circumferential seal are not welded together and therefore, the

sealing according to the claimed invention is more flexible and less rigid. This allows the claimed sealing arrangement to perfectly seal axial gaps and circumferential gaps even if adjacent blades are misaligned.

[0030] Further, the claimed solution is rather simple to manufacture and easy to install.

[0031] Since under all circumstances the leakage that is allowed by the claimed sealing arrangement is significantly smaller than the leakage of sealing arrangements known from the prior art, the cooling air losses are reduced and the overall efficiency of the gas turbine is increased.

[0032] Further, due to the better cooling efficiency of the claimed solution, the temperature of each component of the gas turbine can be more securely held below certain temperature limits and therefore, the durability and reliability of a gas turbine equipped with the claimed sealing arrangement is raised.

[0033] To make sure that the axial seals do not move during operation of the gas turbine, the circumferential seal comprises at least one hook, that is designed to receive one axial seal.

[0034] To make sure that each of the axial seals is fixed and cannot move in axial direction, in a further embodiment of the claimed sealing arrangement, the circumferential seal comprises one hook for each axial seal; i. e. the number of hooks corresponds to the number of blades.

[0035] In a further advantageous embodiment of the claimed invention, each axial seal comprises a protrusion that fits into a hook of the circumferential seal.

[0036] To make sure that the circumferential seal does not move during operation of the gas turbine in circumferential direction, the circumferential seal comprises at least one lug, and this at least one lug extends in radial and / or axial direction from the circumferential seal.

[0037] This at least one lug fits into a recess of the gas turbine so that the circumferential seal is positively locked against relative movement in circumferential direction.

[0038] This recess in the gas turbine may be arranged between two adjacent vanes or two adjacent blades of the gas turbine.

[0039] To optimize the abilities of the claimed sealing arrangement, the axial seal and / or the circumferential seals may comprise two or more layers. These layers may be of the same or different materials.

[0040] If the seals are made of two layers, it is very easy to build a protrusion or a lug by connecting two layers of the axial seal a little bit offset or to make the one strip of one layer of the axial seal a bit longer than the other.

[0041] In case the radial inner layer of the circumferential seal should comprise a lug, it is easy to build this lug by bending an offset into the one strip of the circumferential seal. After having bent this lug, the two strips of the circumferential seal can be welded together or fixed together in another appropriate way.

[0042] The objective of the claimed invention is also

achieved by a gas turbine comprising a stator with several vanes, a rotor with several blades and at least one sealing arrangement to separate the cooling air stream from the hot gases that drive the blades of the rotor or vanes of the stator by using a sealing arrangement according to one of the foregoing claims.

[0043] Further advantages and features of the claimed invention are illustrated in the following figures 5 to 11 and described in detail below.

Drawings

[0044]

Figure 1 to 4b) show sealing arrangements according to the prior art;

Figure 5 a cut-free sealing arrangement according to the claimed invention with two blades;

Figure 6 a hook in the circumferential branch of an claimed sealing arrangement;

Figure 7 the interaction or the positive locking of a protrusion of an axial seal and a hook in the circumferential seal;

Figure 8 a lug in the circumferential seal;

Figure 9 the interaction of this lug with a recess between two adjacent blades;

Figure 10 an even more detailed illustration of the interaction of a lug and a protrusion of an axial seal and

Figure 11 a front view of the claimed split sealing arrangement.

[0045] Figure 5 illustrates an embodiment of the claimed sealing arrangement comprising a circumferential seal 29 and several axial seals 31. Further, two blades 7 including their basis 19 are also illustrated.

[0046] From this developed view, one axial gap 15 can be seen. In front of the blades 7, the corresponding circumferential gap 13 can be seen, too.

[0047] As can be seen very well in figure 5, the circumferential seal 29 that closes the circumferential gap 13 is basically a long and bended strip of metal. Further details of this circumferential seal 29 are explained in conjunction with figures 6 to 10.

[0048] The axial seals 31 are, compared to the circumferential seal 29, shorter and they are bent to follow the contour of the grooves 21 (cf. figure 4a) in the basis 19 of the blades 7.

[0049] The axial seals 31 and the circumferential seal 29 are positively locked, but not welded together.

[0050] Figure 6 shows an enlarged detail of the circumferential seal 29 that comprises two layers of metal. The upper layer 33 is on the outside of the bent circumferential seal and the layer 35 is on the inside of the circumferential seal 29. As can be seen from figure 6, on the inside of the circumferential seal 29, several hooks 37 are arranged. These hooks 37 are made from the inner layer 35 of the circumferential seal, by making two parallel cuts into the inner layer 35. The piece of metal between these two cuts, is then bent twice to form a hook 37.

[0051] In figure 7, the positive locking of an axial seal 31 with the circumferential seal 29 by means of such a hook 37 is illustrated in detail. The axial seal 31 comprises two layers 39 and 41 of the metal strip, too.

[0052] At the inner layer 41 of the axial seal 31, a protrusion 42 is arranged. This protrusion 42 fits into the recess that is limited by the layer 33 and the hook 37 in radial direction and in circumferential direction by the layer 35. This means, that the axial seal 31 and the circumferential seal 29 are positively locked.

[0053] Due to that positive locking of the axial seal 41, the axial seal 31 cannot move in axial direction and therefore, a safe and lasting connection between axial seal 31 and circumferential seal 29 is established.

[0054] Since the hook 37 and the protrusion 42 are not in direct contact but there is a clearance between them, the axial seal 31 may be inclined a bit and this inclination of the axial seal 31 does not affect the circumferential seal 29.

[0055] This means that even if the axial seal 31 is a bit inclined, the circumferential seal 29 still separates the cooling air from the hot gases and therefore, no cooling air losses occur.

[0056] In figure 9 and 10, a further detail of the circumferential seal is illustrated.

[0057] As can be seen from figure 8 on the radial inner layer 35 a lug 43 is bent. This lug 43 protrudes in radial direction and in axial direction. It is also possible that the lug 43 protrudes only in axial or in radial direction (not shown).

[0058] As can be seen from figure 9, it is also possible, that the lug 43 is made of a separate piece of bent metal and is fitted between the two ends 45 of the inner layer 35. As can be seen from figure 9, the gas turbine, namely the blades 7 comprise recesses 47, which cooperate with the lug 43 in a way that the circumferential seal 29 cannot move relative to the blades 7 in circumferential direction.

[0059] This lug 43 may also serve as a hook for the protrusion 42 of the axial seals. This situation is illustrated in figure 10.

[0060] In figure 10, it is easy to be seen that the protrusion 42 may be inclined without affecting the sealing function of the circumferential seal. This inclined position of the protrusion 42 is illustrated in figure 10 by the hatched lines. The inclined position of the protrusion 42 has the reference numeral 47.

[0061] Figure 11 illustrates the same situations figure 4 b). In figure 11 a sealing arrangement according to the

invention is installed. As can be seen from figure 11, the adjacent basis 19 of the adjacent blades 7.1.a and 7.2.b are misaligned, too.

[0062] Since the axial sealing 31 and the circumferential sealing 29 are positively locked with enough clearance between the protrusion 42 and the hooks 37, the inclination of the axial seal does not affect the circumferential seal and no gap occurs.

10 List of Reference Numbers

[0063]

1	gas turbine
3	rotor
5	stator, housing
7	blade
7.1, 7.2, 7.3	rows of blades
9	vane
9.1, 9.2, 9.3	rows of vanes
13	circumferential gap
13.1	first circumferential gap
13.2	second circumferential gap
15	axial gap
17	T-shaped seal
17.1, 17.2	first and second branch of seal
18	offset
19	feet or basis of blade
21	groove
23	inner part of the rotor
25	outer part of the rotor
27	gap
29	circumferential seal
31	axial seal
33	upper layer of the circumferential seal
35	inner layer of the circumferential seal
37	hook
39	layer of the axial seal
41	layer of the axial seal
42	protrusion for axial seal
43	lug
45	end of inner layer 35
47	recess

Claims

1. Sealing arrangement for sealing gaps between turbine components of a gas turbine **characterized in, that** it comprises a circumferential seal (29) and several axial seals (31), and that at least one axial seal (31) is positively locked with the circumferential seal (29).

2. Sealing arrangement according to claim 1, **characterized in, that** the circumferential seal (29) comprises at least one hook (37), and **in, that** the at least one hook (37) is designed to receive one axial seal(31). 5
3. Sealing arrangement according to claim 2, **characterized in, that** the circumferential seal (29) comprises one hook (37) for each axial seal (31). 10
4. Sealing arrangement according to claim 2, **characterized in, that** each axial seal (31) comprises a protrusion (42) that fits into a hook (37) of the circumferential seal (29). 15
5. Sealing arrangement according to one of the foregoing claims, **characterized in, that** the circumferential seal (29) comprises at least one lug (43) and **in, that** the at least one lug (43) extends in radial direction from the circumferential seal (29). 20
6. Sealing arrangement according to claim 5, **characterized in, that** the at least one lug (43) fits into a recess (47) of the gas turbine. 25
7. Sealing arrangement according to claim 6, **characterized in, that** the recess (47) is arranged between two adjacent vanes (9), or two adjacent blades (7) of the gas turbine. 30
8. Sealing arrangement according to one of the foregoing claims, **characterized in, that** the axial seal (31) and/or the circumferential seal (29) comprises two or more layers (33, 35, 39, 41). 35
9. Sealing arrangement according to one of the claims 3 to 7, **characterized in, that** the at least one hook (37) and/or the at least one lug (43) are cut out and/or bent from one strip (35) of the circumferential seal (29). 40
10. Sealing arrangement according to one of the foregoing claims, **characterized in, that** the axial seal (31) and/or the circumferential seal (29) are made of metal. 45
11. Gas turbine (1) comprising a stator (6) with several vanes (9), a rotor (3) with several blades (7) and at least one sealing arrangement to separate a cooling air stream from hot gases, **characterized in, that** the sealing arrangement is a sealing arrangement (29, 31) according to one of the foregoing claims. 50
12. Gas turbine (1) according to claim 11, **characterized in, that** the stator (5) and/or two adjacent vanes (9) comprise a recess for receiving a lug (43) of the circumferential seal (29). 55
13. Gas turbine (1) according to claim 11 or 12, **characterized in, that** the rotor (3) and/or two adjacent blades (7) comprise a recess (47) for receiving a lug (43) of the circumferential seal (29).

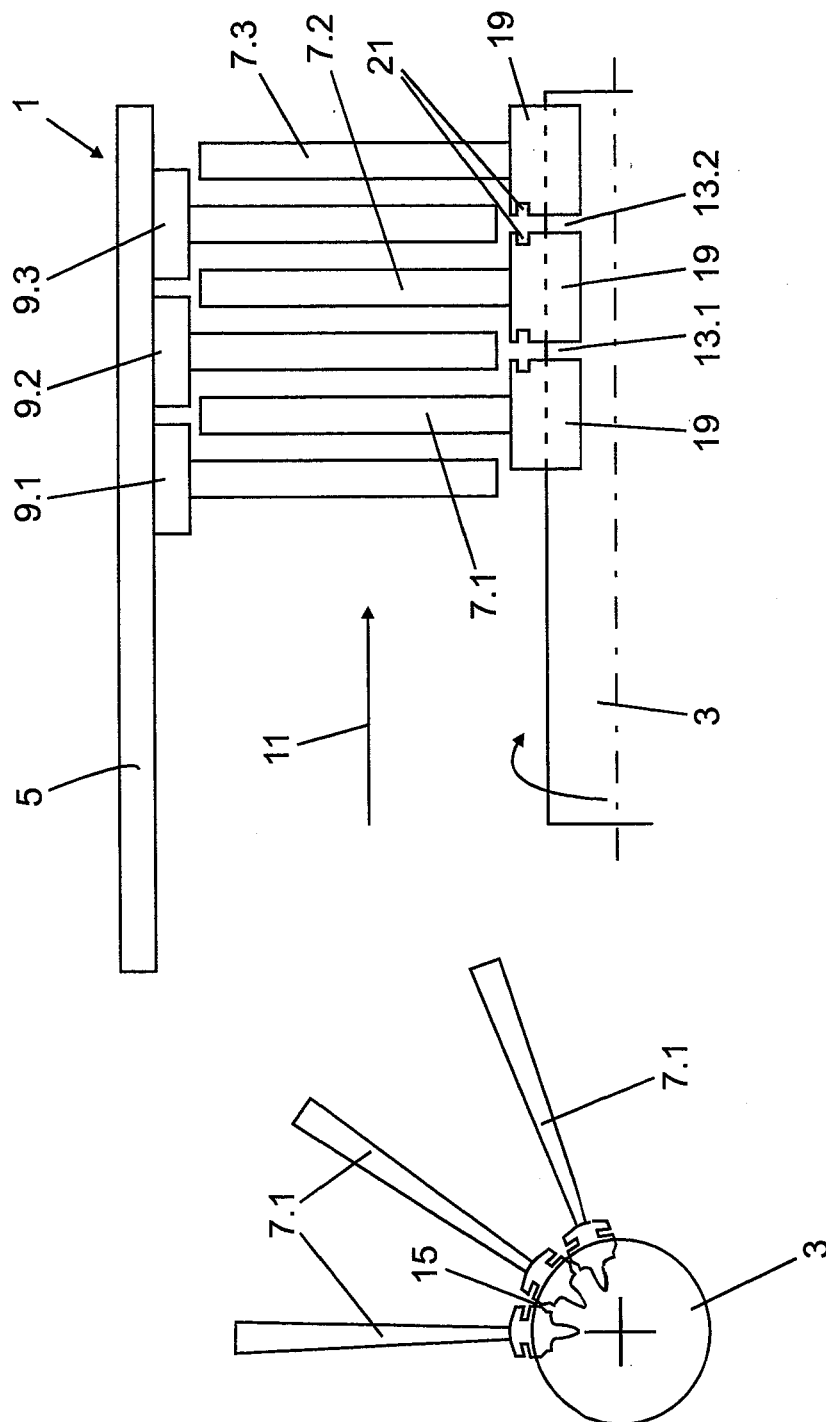


Fig. 1

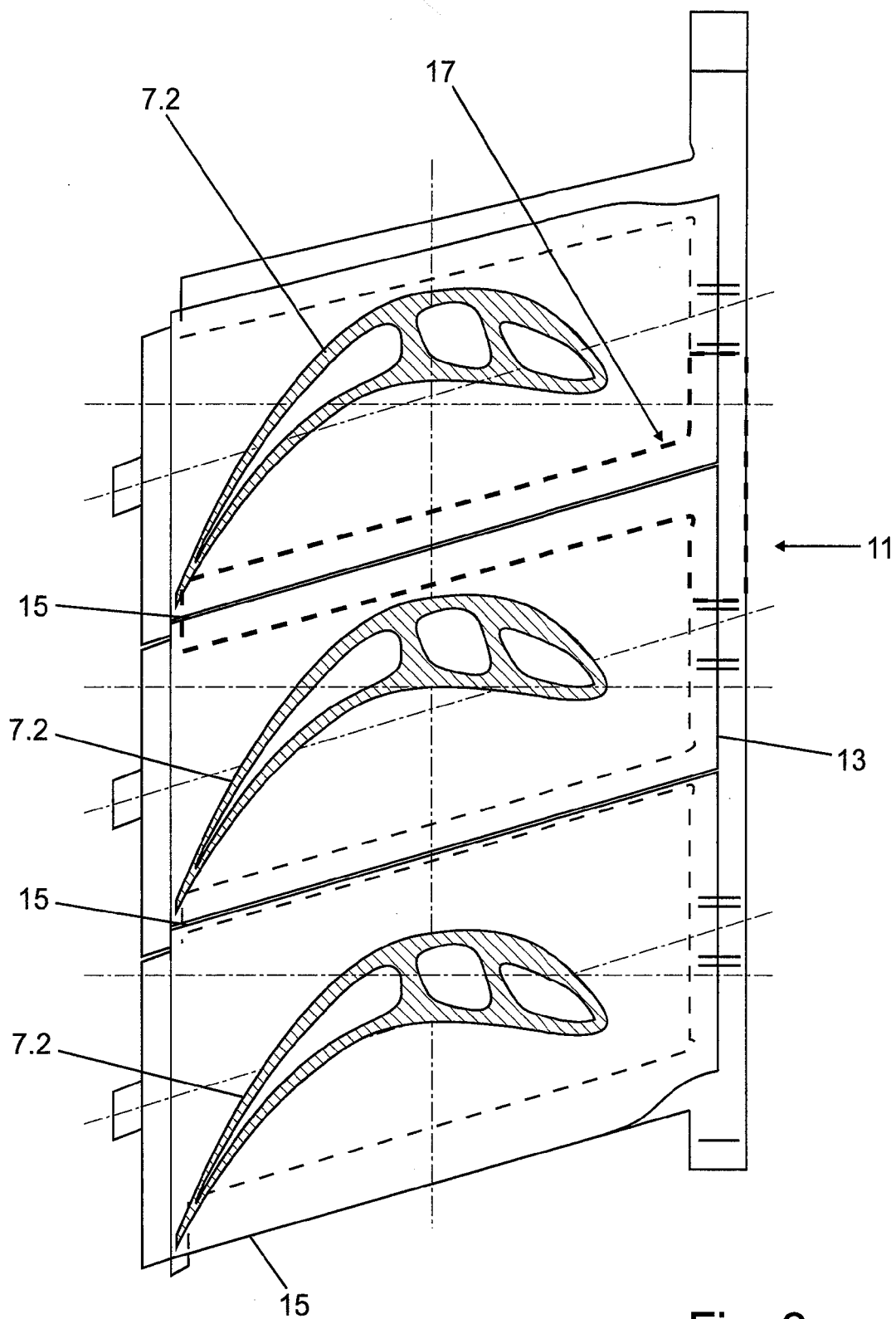


Fig. 2

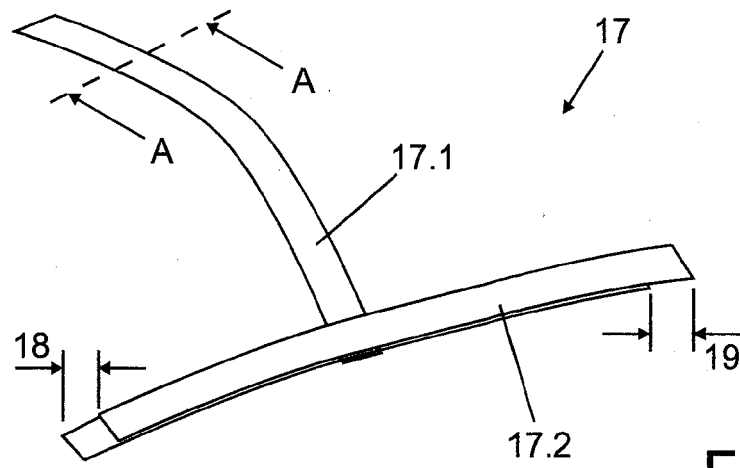


Fig. 3

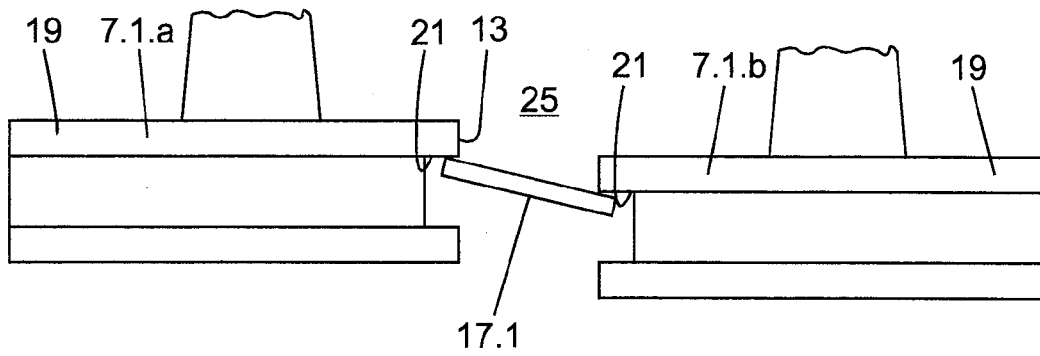


Fig. 4a

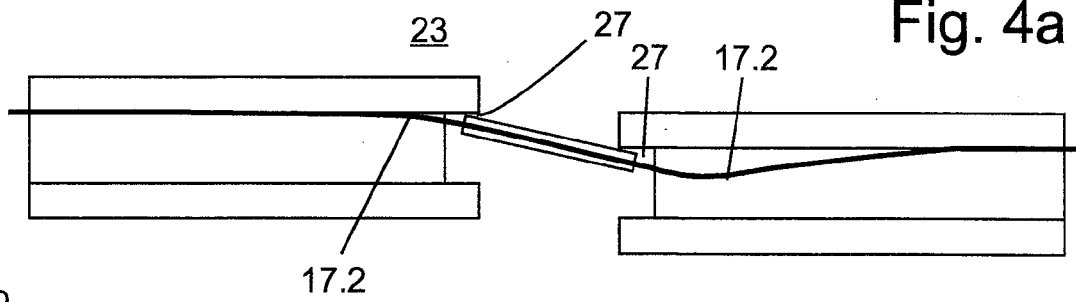


Fig. 4b

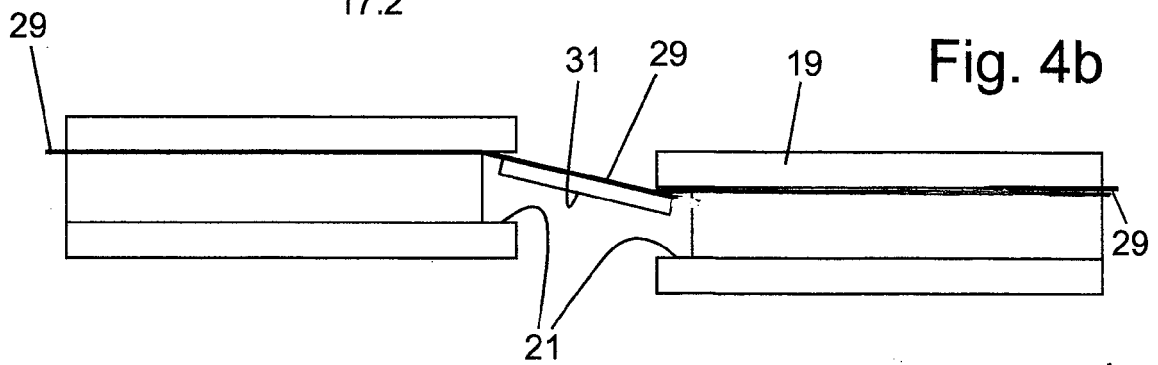


Fig. 11

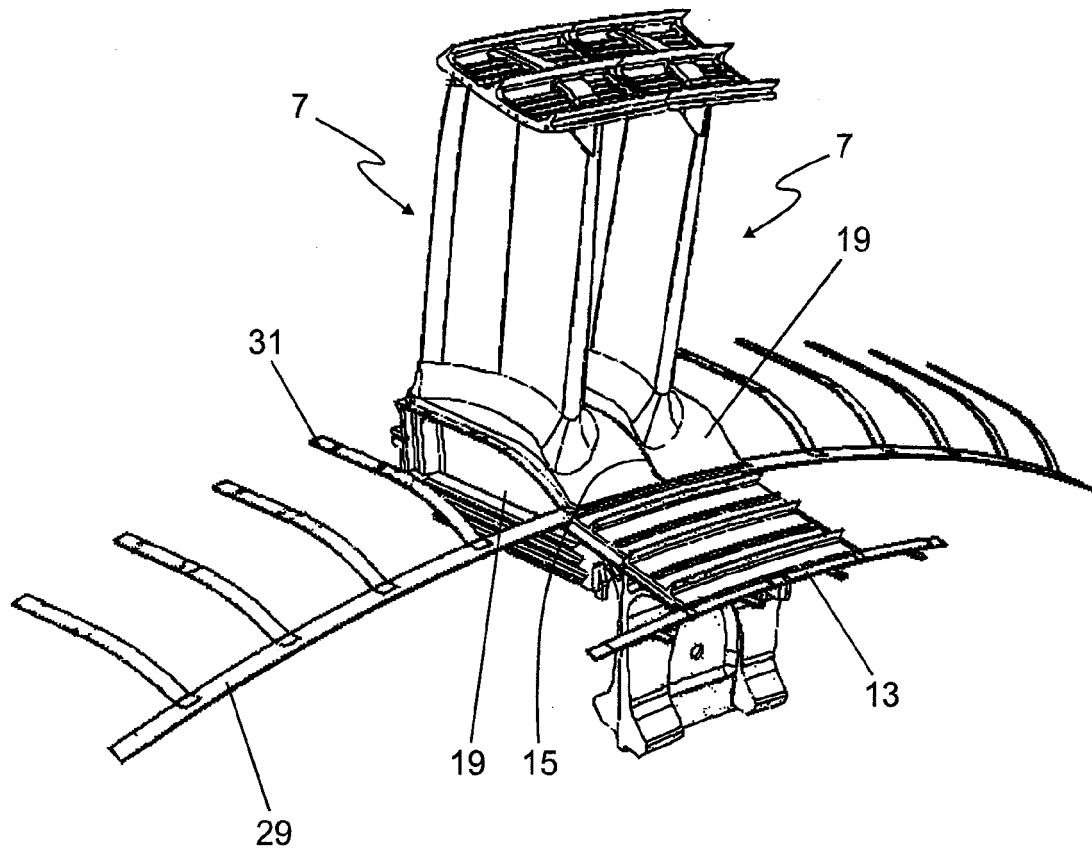


Fig. 5

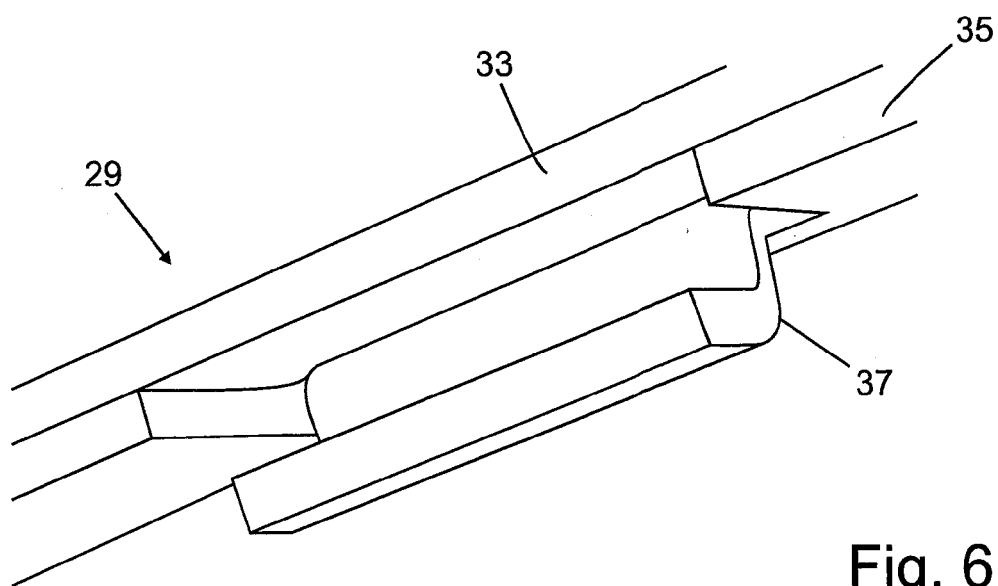


Fig. 6

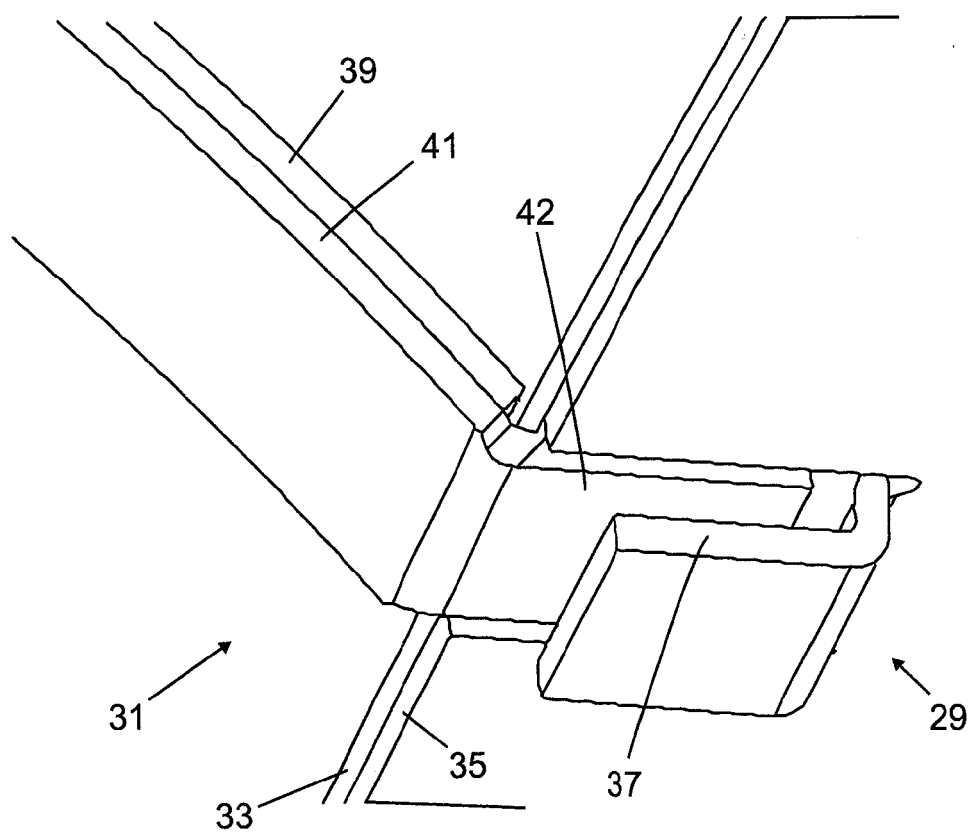


Fig. 7

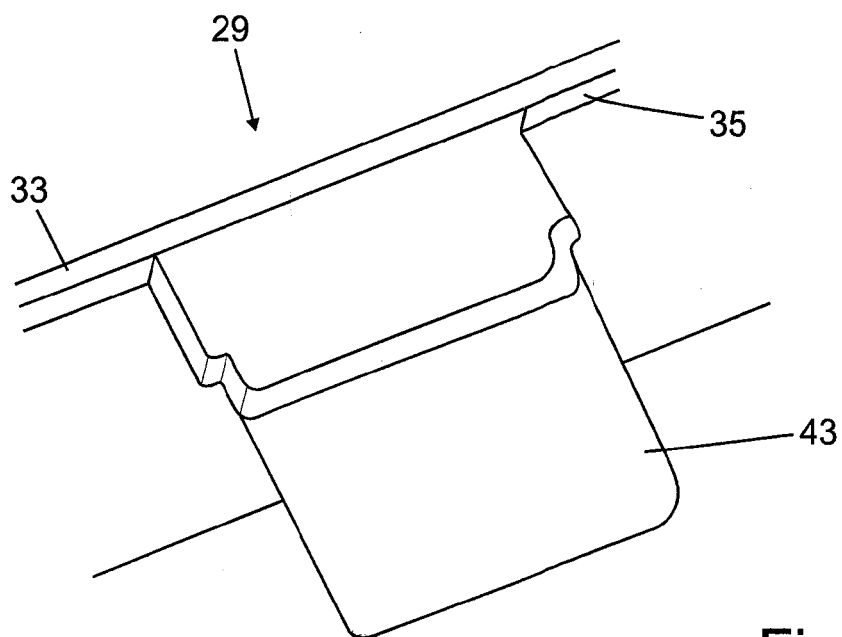


Fig. 8

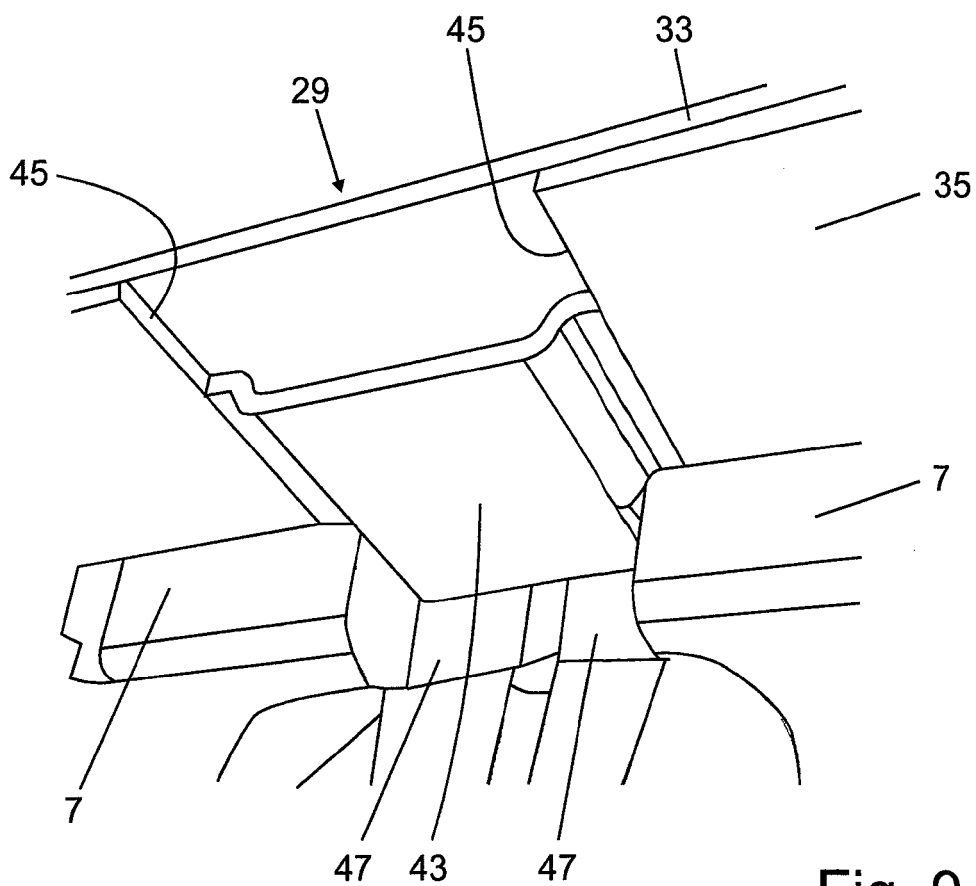


Fig. 9

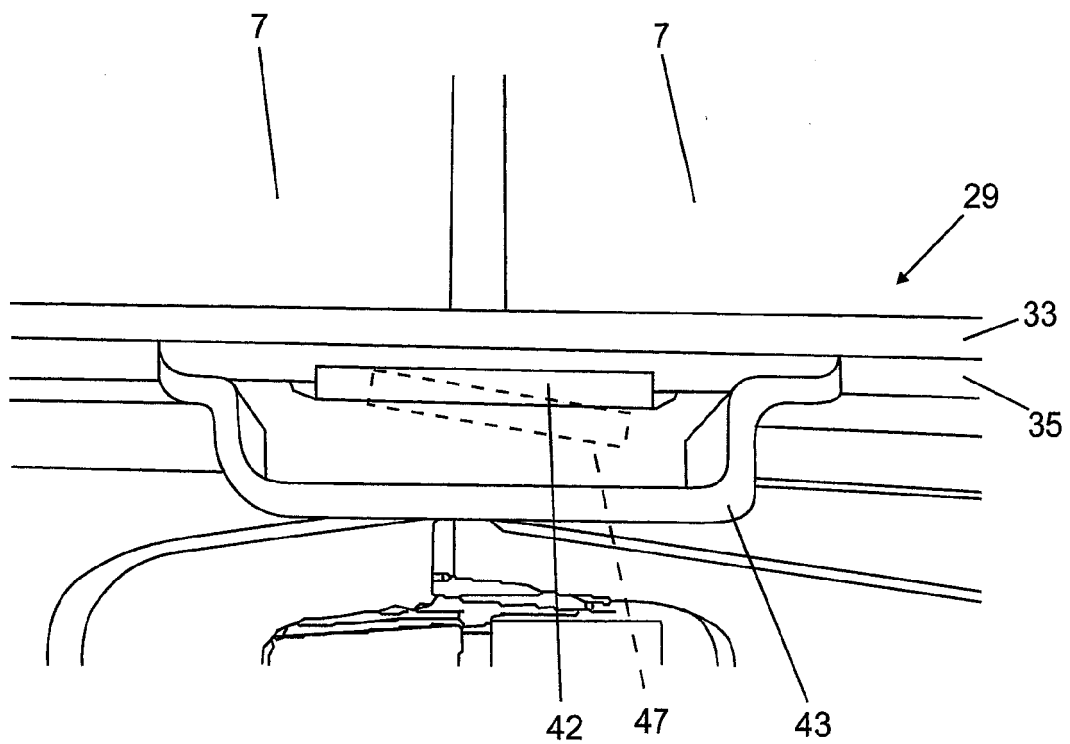


Fig. 10



EUROPEAN SEARCH REPORT

Application Number
EP 13 16 5743

DOCUMENTS CONSIDERED TO BE RELEVANT			
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X	EP 2 039 886 A1 (ALSTOM TECHNOLOGY LTD [CH]) 25 March 2009 (2009-03-25) * paragraphs [0024] - [0028]; figures 3-7 *	1-13	INV. F01D11/00 F16J15/06
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			F01D F16J
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 September 2013	Examiner Oechsner de Coninck
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