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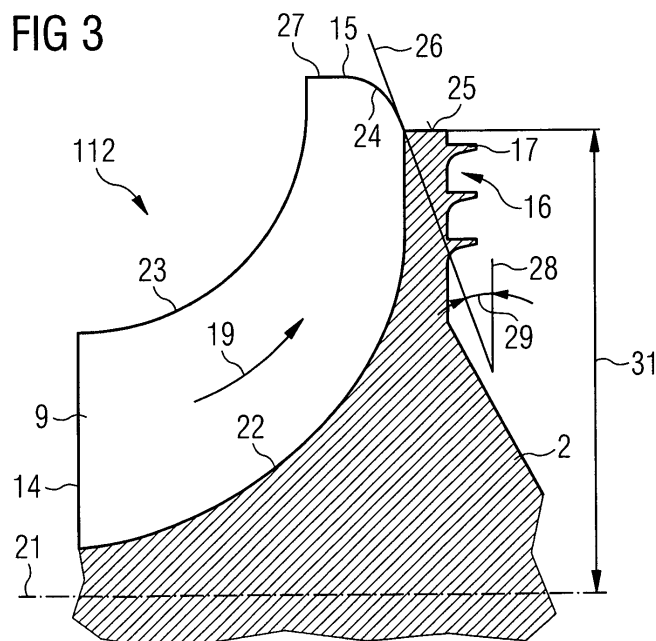
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(54) **Impeller and turbocharger**

(57) An impeller (112, 212) comprising a rotation axis (21), a radial direction, a backplate (2) and a number of vanes (9) which are connected to the backplate (2) at a line of connection (22) is provided. Each vane (9) comprises an upstream side (14), a downstream side (15) and an outer side (23). The downstream side (15) of each

vane (9) comprises an edge portion (27) which is located near the outer side (23). The vanes (9) project radially over the backplate (2) and the downstream side (15) further comprises a connecting portion (24) connecting the edge portion (27) to the backplate (2) and including an angle with the radial direction. Moreover, a turbocharger comprising an inventive impeller (112, 212) is disclosed.



Description

[0001] The present invention relates to an impeller and a turbocharger.

[0002] An industrial turbocharger compressor impeller is typically made from aluminium. This material is relatively cheap, is easy to machine and is light enough so that turbo lag is not a major problem. Current turbocharger impellers for medium speed diesel engines tend not to have a through bore since this minimises the stress in the impeller material and reduces the likelihood of the impeller failing due to fatigue during a typical 50,000 hour life.

[0003] The life of such an impeller tends to be governed by creep of the impeller material, so that maximum operating pressure ratios are limited to around 5:1 for typical industrial duties. Impeller creep failure is associated with areas of high stress and high temperature. The area of highest temperature, and consequently the area which determines the creep life, is on the back of the impeller near the outer diameter. This is an area where typically a labyrinth seal is located to reduce the leakage of compressed air towards the bearings. The high temperature is associated with windage heating in that area.

[0004] The impeller life must typically achieve 50,000 hours. This is achieved traditionally by limiting the operating speed of the turbocharger in line with calculations of the creep life. At lower operating speeds the impeller stresses are lower, the compressed air at the downstream side of the impeller is cooler, and the windage heating is less than at higher operating speed.

[0005] More recently cooled air at high pressure has been fed into the area at the back of the impeller to keep the impeller material cool.

[0006] In US 5,297,928 and US 6,190,123 B1 methods for direct cooling the rear wall of a compressor impeller are disclosed, wherein a gaseous cooling medium is directed onto the rear wall.

[0007] In US 6,257,834 B1 a method for indirect cooling of the flow in radial gaps formed between rotors and stators of turbo machines is provided. The method includes the step of using water as a cooling fluid for stator part adjacent to the radial gap.

[0008] In WO 01/29425 A1 a combination of direct and indirect cooling of the flow in radial gaps formed between rotors and stators of turbine-type machines is disclosed, wherein a first cooling fluid, preferably water, is used for indirect cooling and a second gaseous cooling fluid, preferably air, is used for direct cooling.

[0009] The cooled air is typically taken from the diesel engine air manifold, after the compressed air has been cooled by the charge air cooler. The introduction of this cooled air is a parasitic loss on the turbocharger efficiency, since the turbocharger has to compress the coolant air but the air is not used in the diesel engine. Also this cooled air leaks into the main stream of the compressor flow between impeller and diffuser and will cause a disturbance to the flow which reduces the compressor effi-

ciency. Nevertheless, by cooling the impeller the compressor is allowed to operate at higher speed while still achieving the required 50,000 hours life. Typically, by cooling the impeller by 20°C, an additional 0.2 bar of boost pressure can be achieved with this system and this typically allows the engine rate power to increase by around 5%.

[0010] As well as the parasitic loss in adding this high pressure coolant air, the pressure behind the impeller increases and the thrust load, and consequently parasitic thrust bearing losses, increase.

[0011] It is a first objective of the present invention to provide an advantageous impeller, a second objective to provide an advantageous compressor and a third objective to provide an advantageous turbocharger.

[0012] The first objective is solved by an impeller as claimed in claim 1. The second objective is solved by a compressor as claimed in claim 11. The third objective is solved by a turbocharger as claimed in claim 12. The depending claims define further developments of the invention.

[0013] An inventive impeller comprises a rotation axis, a radial direction, a backplate and a number of vanes which are connected to the backplate at a line of connection. Each vane comprises an upstream side, a downstream side and an outer side. The downstream side of each vane comprises an edge portion which is located near the outer side. The vanes project radially over the backplate and the downstream side further comprises a connecting portion connecting the edge portion to the line of connection between the respective vane and the backplate and including an angle with the radial direction. This means, that part of the inventive impeller's downstream side is removed compared to a conventional impeller's downstream side. The removed area is at high diameter so that stresses are reduced in that area. Also this is the hottest area of the impeller so that the temperature of the impeller is also reduced.

[0014] The edge portion may be orientated perpendicular to the radial direction. The connecting portion may have a convex rounded portion which is located near the connection line. Moreover, the backplate can comprise a radially outer peripheral surface and the connecting portion can be adjacent to the radially outer peripheral surface of the backplate. The radially outer peripheral surface of the backplate may be located in a plane with a normal being locally parallel to the radial direction. This means, that the radially outer surface may run parallel to the rotation axis. Alternatively, the radially outer peripheral surface of the backplate can be located in a plane with a normal which includes an angle between 0° and 45° with the radial direction. Preferably, the angle may have a value between 15° and 25°. This further reduces stress and temperature on the surface of the backplate.

[0015] The radially outer surface of the inventive impeller may especially be located at a radial position closer to the rotation axis than the radially outer surface of a conventional impeller. In other words, the distance be-

tween the radially outer surface and the rotation axis of an inventive impeller is smaller than the distance between the radially outer surface and the rotation axis of a conventional impeller. By removing some of the backplate of the impeller, the aerodynamic performance of the impeller could be reduced. This reduction is associated with leakage around the base of the vanes, which would otherwise be prevented by the presence of the backplate, and a reduction in the diameter of the impeller vanes. Moreover, a removal of part of the backplate could also increase local stresses in the impeller vanes since they will no longer be entirely supported along their entire length.

[0016] To reduce the potential aerodynamic losses and local vane stress the shape of the vane at the impeller tip is carefully chosen: An angle between a tangent located at the connecting portion adjacent to the connection line and the radial direction may have a value between 10° and 45°, preferably between 15° and 25°. This reduces vane leakage losses.

[0017] Moreover, the edge portion of the downstream side can have a length in the direction of the rotation axis of more than 50% of the length of the downstream side in the direction of the rotation axis. This means, that only the part of the vane closest to the backplate is removed, so that the part of the vane that is working most efficiently on the working fluid remains.

[0018] The vane shape can be modified in the area of the downstream side so that the design conforms closely to the so-called "radial element" design. This ensures that the vane stresses are kept to an acceptable low level.

[0019] The inventive compressor comprises an inventive impeller, as previously described and an inventive turbocharger comprises an inventive compressor. The inventive compressor and the inventive turbocharger have the same advantages as the inventive impeller has.

[0020] The inventive impeller has an increased impeller creep life compared to a conventional impeller. Moreover, the necessity for coolant flow is kept to a minimum.

[0021] Further features, properties, and advantages of the present invention will become clear from the following description of an embodiment in conjunction with the accompanying drawings. Each features or a combination of features can be advantageous.

[0022] Fig. 1 schematically shows a turbocharger in a sectional view.

[0023] Fig. 2 schematically shows part of a conventional turbocharger compressor impeller in a sectional view.

[0024] Fig. 3 schematically shows part of an embodiment of the inventive turbocharger compressor impeller in a sectional view.

[0025] Fig. 4 schematically shows part of an alternative embodiment of the inventive turbocharger compressor impeller in a sectional view.

[0026] In the following a first embodiment of the inventive impeller and the inventive turbocharger will be described with reference to Figures 1 to 4. Figure 1 sche-

matically shows a turbocharger in a sectional view. The turbocharger comprises a turbine 11 and a compressor 10. The turbine 11 and the compressor 10 are connected by a shaft 20.

[0027] The turbine 11 includes a rotor 4 which is located inside a turbine casing 3. The turbine casing 3 has an exhaust inlet 5 which leads to the rotor 4 so that the exhaust entering the exhaust inlet 5 activates the rotor 4. Further the turbine casing 3 has an exhaust outlet 6 through which the exhaust coming from the rotor 4 leaves the turbine casing 3. The arrows 18 indicate the exhaust stream entering the turbine casing 3 through the exhaust inlet 5, activating the rotor 4 and leaving the turbine casing 3 through the exhaust outlet 6.

[0028] The compressor 10 includes an impeller 12 which is located inside a compressor casing 1. Moreover, the compressor 10 has an air inlet 7 which air leads to the impeller 12 and an air outlet 8 through which the air coming from the impeller 12 leaves the compressor casing 1. The arrows 19 indicate the air stream entering the compressor casing 1 through the air inlet 7, being compressed by the impeller 12 and leaving the compressor casing 1 through the air outlet 8.

[0029] The impeller 12 comprises a backplate 2 and vanes 9. The backplate 2 is connected to the shaft 20. Further, the backplate 2 is generally conical in shape and a plurality of circumferentially spaced arcuate vanes 9 are formed about its periphery. The back surface 16 of the impeller 12 has radially spaced and axially extended ribs 17. Labyrinth seals 13 are mounted to the compressor casing 1 opposite to the back surface 16 of the impeller 12 so as to mesh with the ribs 17. The labyrinth seals 13 engage the annular ribs 17 to reduce the leakage of compressed air towards the bearings along the back surface 16 of the impeller 12.

[0030] The rotor 4 of the turbine 11 is connected to the shaft 20 so that the activated rotor 4 activates the shaft 20. The shaft 20 is further connected to the impeller 12 inside the compressor 10. Hence, the rotor 4 activates the impeller 12 by means of the shaft 20. The rotation axis is indicated by reference numeral 21.

[0031] In the turbine 11 the exhaust stream 18 entering the exhaust inlet 5 activates the rotor 4 and leaves the turbine through the exhaust outlet 6. The arrows 18 indicate the direction of the exhaust stream. Meanwhile, the impeller 12 in the compressor 10 driven by the rotor 4 sucks atmospherically fresh air into the air inlet 7 and compresses it to precompressed fresh air, which enters the air outlet 8. The compressed air is then used for example in a reciprocating engine like e.g. a diesel engine. The arrows 19 indicate the air stream direction.

[0032] Figure 2 schematically shows part of a conventional turbocharger compressor impeller 12 in a sectional view. The impeller 12 is, for example, made from aluminium. The impeller 12 comprises a backplate 2 and a vane 9. The vane 9 is connected to the backplate 2 at a line of connection 22. Each vane 9 comprises an upstream side 14 and a downstream side 15. The air which is

sucked into the air inlet 7 arrives at the upstream side 14 of the vane 9, passes the vane 9 along the direction 19 and leaves it at the downstream side 15 towards the air outlet 8.

[0033] Opposite to the line of connection 22 an outer side 23 is located. The outer side 23 has a concave shape. The upstream side 14 runs, perpendicular to the rotation axis 21. However, an angle may be present between the upstream side 14 and the rotation axis 21 may have a value between 0° and $\pm 10^\circ$. The downstream side 15 is orientated perpendicular to a radial direction which is defined by the rotation axis 21. Moreover, the backplate 2 comprises a radially outer peripheral surface 25. The radially outer peripheral surface 25 is located in a plane with a normal being locally parallel to the radial direction. The distance between the radially outer peripheral surface 25 and the rotation axis 21 is indicated by reference numeral 30.

[0034] Figure 3 schematically shows part of an inventive turbocharger compressor impeller 112 in a sectional view. Elements which correspond to elements of figure 1 or 2 are designated with the same reference numerals and will not be described again in detail. The conventional impeller 12, as it is shown in figure 2, and the inventive impeller 112, which is shown in figure 3, differ in the shape of the downstream side 15 of the vane 9 and in the radial location of the radially outer peripheral surface 25 of the backplate 2.

[0035] The downstream side 15 of the inventive impeller 112 comprises an edge portion 27 which is located near the outer side 23 and a connecting portion 24 which is located near the line of connection 22 and connects the line of connection 22 to the edge portion 27. The connecting portion 24 in figure 3 has a convex rounded shape. However, it can also have an other shape, for example a linear shape or an S-shape.

[0036] The edge portion 27 which is located near the outer side 23 is further orientated perpendicular to a radial direction which is defined by the rotation axis 21. Furthermore, the edge portion 27 which is located near the outer side 23 may run parallel to the rotation axis 21. This is the case for the vane 9, which is shown in figure 3. The edge portion 27 of the downstream side 15 has a length in the direction of the rotation axis 21 of more than 50% of the length of the downstream side 15 in the direction of the rotation axis 21.

[0037] The edge portion 27 which is located near the outer side 23 adjoins to the connecting portion 24 which is located near the line of connection 22. At the line of connection 22 the connecting portion 24 adjoins to the radially outer peripheral surface 25, which has the same properties as the corresponding radially outer peripheral surface 25 in figure 2. The distance between the radially peripheral outer surface 25 and the rotation axis 21 in figure 3 is indicated by reference numeral 31 and is smaller than the corresponding distance 30 of the conventional impeller 12, which is shown in figure 2. Moreover, the vane 9 of the inventive impeller 112 projects radially over

the backplate 2.

[0038] Figure 3 further shows a tangent 26 of the connecting portion 24 at the point, where the connecting portion 24 is adjacent to the radially outer peripheral surface 25. The angle 29 between the tangent 26 and a line 28 radial to the rotation axis 21 has a value between 10° and 45° , preferably between 15° and 25° .

[0039] Figure 4 schematically shows part of an alternative embodiment of the inventive turbocharger compressor impeller 212 in a sectional view. Elements which correspond to elements of figure 3 are designated with the same reference numerals and are not described again in detail. Unlike figure 3, the impeller 212 which is shown in figure 4 comprises a connecting portion 24 with an S-shape. Moreover, the radially outer peripheral surface 25 in figure 4 includes an angle 32 to the rotation axis 21. The angle 32 has a value between 0° and 45° , preferably between 15° and 25° . This further reduces stress and temperature on the back surface 16. Although the connecting portion has a s-shape in the present embodiment it could as well have other shapes like, e.g., the convex rounded shape of the connecting portion of the first embodiment, a linear shape.

[0040] The improved design of the inventive impeller 112, 212 reduces vane leakage losses and keeps vane stresses to an acceptable low level. This increases the impeller creep life and minimises the necessity for coolant flow.

Claims

1. An impeller (112, 212) comprising a rotation axis (21), a radial direction, a backplate (2) and a number of vanes (9) which are connected to the backplate (2) at a line of connection (22), each vane (9) comprising an upstream side (14), a downstream side (15) and an outer side (23), the downstream side (15) of each vane (9) comprising an edge portion (27) which is located near the outer side (23), **characterised in that** the vanes (9) project radially over the backplate (2) and the downstream side (15) further comprises a connecting portion (24) connecting the edge portion (27) to the line of connection (22) and including an angle with the radial direction.
2. The impeller (112, 212) as claimed in claim 1, **characterised in that** the edge portion (27) is orientated perpendicular to the radial direction.
3. The impeller (112, 212) as claimed in claim 1 or 2, **characterised in that** the connecting portion (24) comprises a convex rounded portion which is located near the line of connection (22).

4. The impeller (112, 212) as claimed in any of the claims 1 to 3,
characterised in that
the backplate (2) comprises a radially outer peripheral surface (25) and the connecting portion (24) is adjacent to the radially outer peripheral surface (25) of the backplate (2). 5

5. The impeller (112, 212) as claimed in claim 4,
characterised in that 10
the radially outer peripheral surface (25) of the backplate (2) is located in a plane with a normal being locally parallel to the radial direction.

6. The impeller (112, 212) as claimed in claim 4, 15
characterised in that
the radially outer peripheral surface (25) of the backplate (2) is located in a plane with a normal which includes an angle (32) between 0° and 45° with the radial direction. 20

7. The impeller (112, 212) as claimed in claim 6,
characterised in that
the angle (32) has a value between 15° and 25°. 25

8. The impeller (112, 212) as claimed in any of the claims 1 to 7,
characterised in that
an angle (29) between the radial direction and a tangent (26) of the connecting portion (24) adjacent to the line of connection (22) has a value between 10° and 45°. 30

9. The impeller (112, 212) as claimed in claim 8,
characterised in that 35
the angle (29) has a value between 15° and 25°.

10. The impeller (112, 212) as claimed in any of the claims 1 to 9,
characterised in that 40
the edge portion (27) of the downstream side (15) has a length in the direction of the rotation axis (21) of more than 50% of the length of the downstream side (15) in the direction of the rotation axis (21). 45

11. A compressor comprising an impeller (112, 212) as claimed in any of the claims 1 to 10.

12. A turbocharger comprising a compressor as claimed in claim 11. 50

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FIG 1

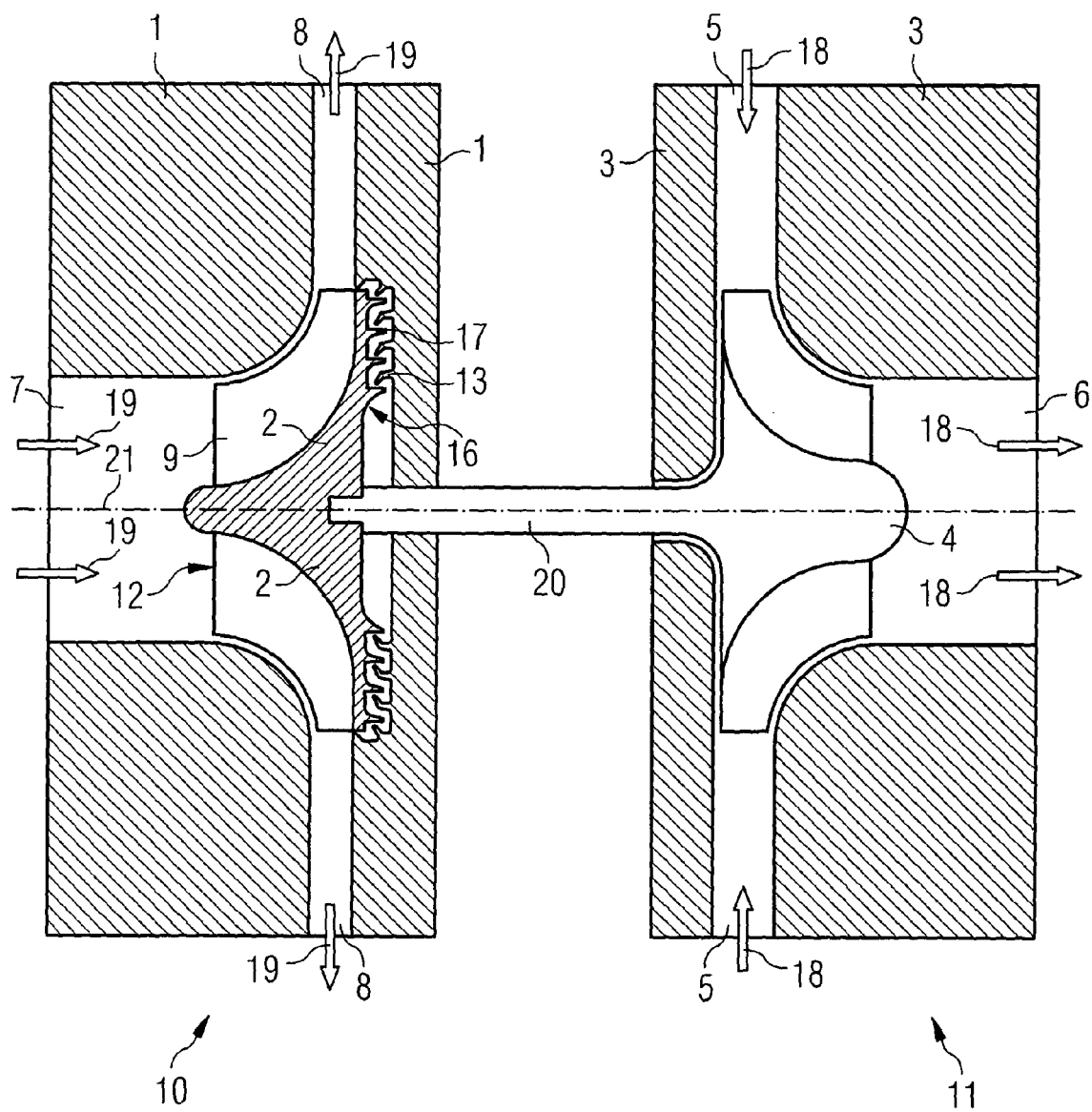


FIG 2

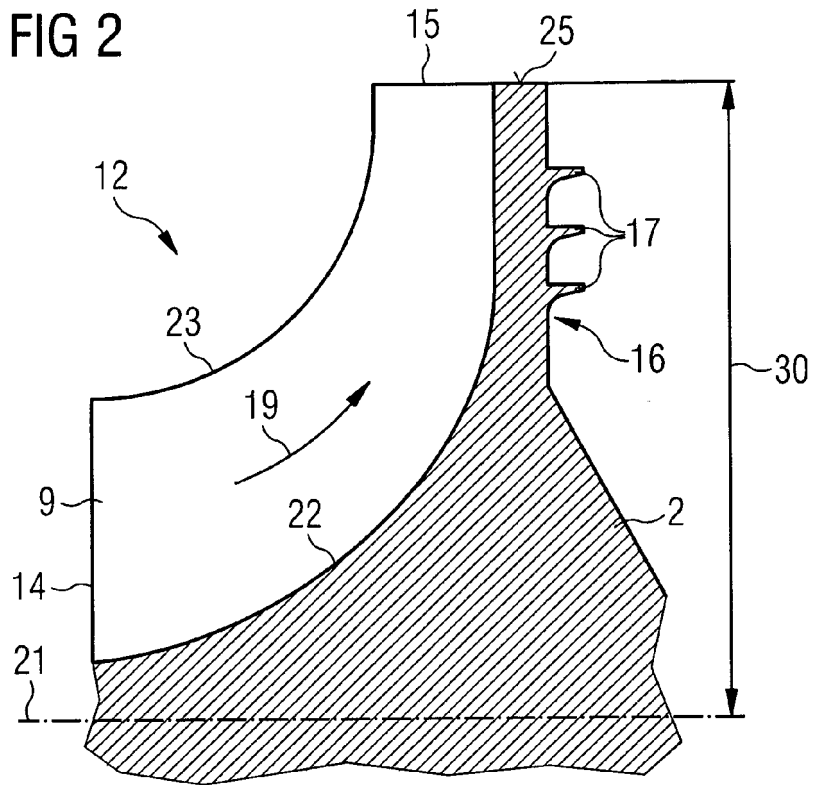


FIG 3

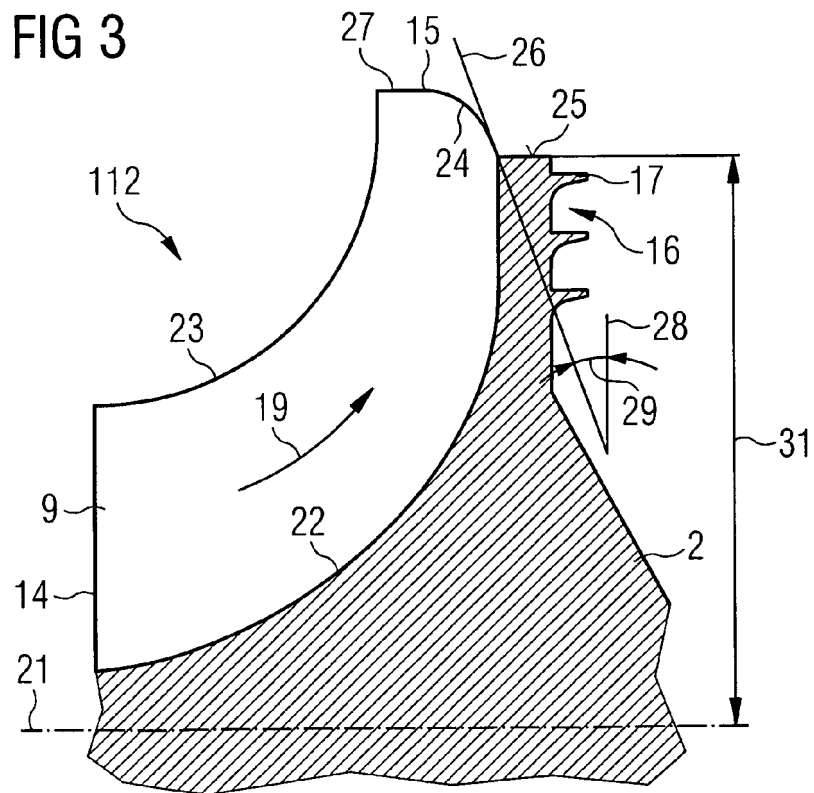
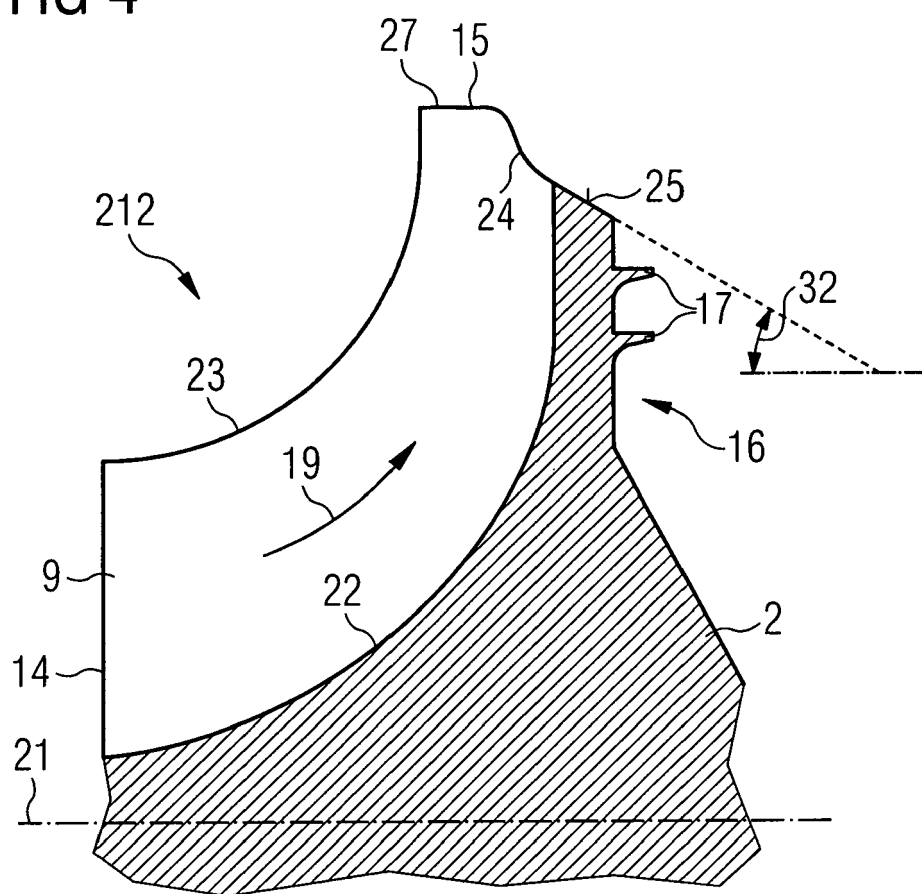


FIG 4





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 00 2766

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			TECHNICAL FIELDS SEARCHED (IPC)
			F04D
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		18 July 2008	Ingelbrecht, Peter
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			

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EPO FORM 1503 03.82 (P04C01)

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

EP 08 00 2766

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
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18-07-2008

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REFERENCES CITED IN THE DESCRIPTION

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