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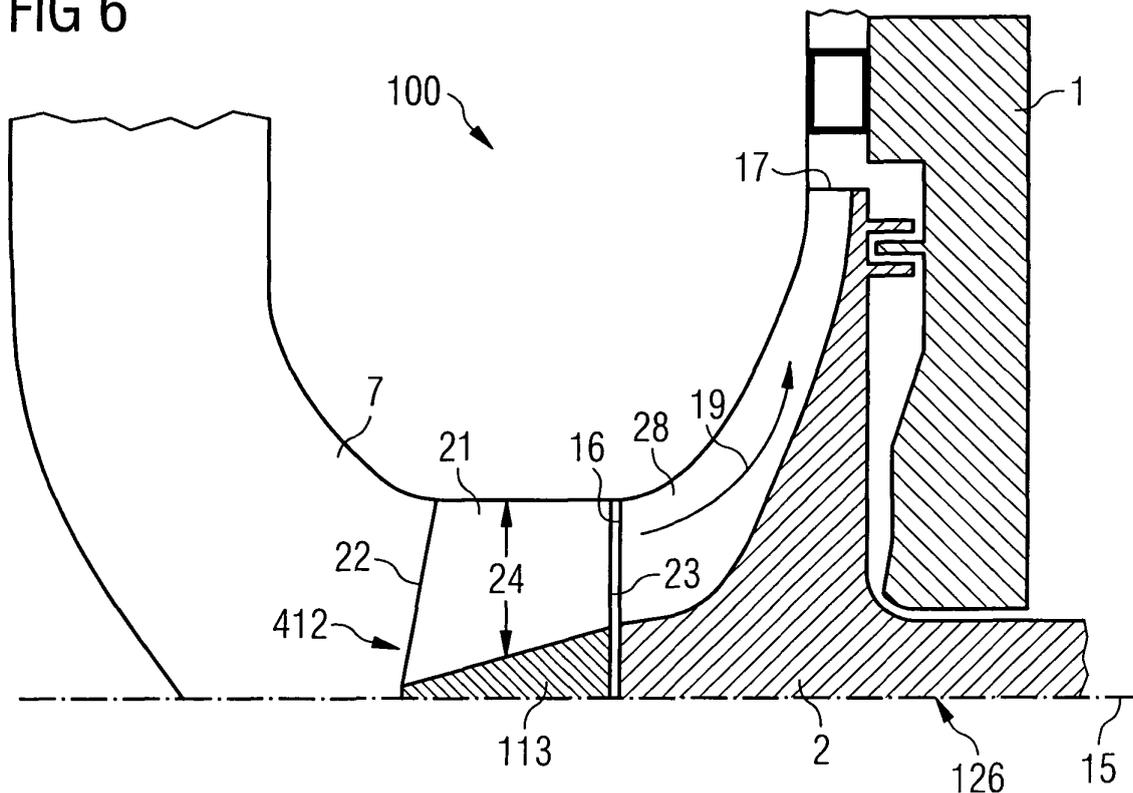
(54) **Impeller and turbocharger**

(57) An impeller (412), comprising a hub (2) and a number of vanes (21, 28), which are connected to the hub (2) is described.

Each vane (21, 28) comprises a leading edge (16, 22) and a trailing edge (17, 23). The impeller (412) comprises long vanes and short vanes where the long vanes have

a longer distance between the centre of the leading edge and the centre of the trailing edge. The impeller (412) comprises a bluff body portion, and at least the long vanes extend onto the bluff body portion. Furthermore, a turbocharger comprising an inventive impeller (412) is described.

FIG 6



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Description

[0001] The present invention relates to an impeller of a turbocharger, to a bluff body element for an impeller and to a turbocharger.

[0002] A turbocharger compressor impeller is typically made of aluminium. This material is relatively cheap, it is easy to machine and it is light enough so that turbo lag is not a major problem. The life and geometry of such an impeller tends to be restricted by the material property of aluminium. The specific flow of an impeller is determined by the inlet area and the velocity at the leading edge of the impeller vane. Too high velocities per mach numbers, particularly at the outer radius of the flow passage, may cause difficulties for the performance of the turbocharger. At the same time high velocities means small dimensions for a given flow. Small dimensions of the turbocharger means that costs and space can be saved.

[0003] In order to achieve a good performance, the outer corner of the impeller vane is often swept in the tangential direction. This increases the load to be transferred through the vane to the hub. As a result of the interacting factors a bluff body, in particular a so-called bullet-nose, is used in the centre of the impeller. This bluff body or bullet-nose does not take part in the compression work. A turbocharger compressor impeller which is equipped with such a bluff body is, for instance, shown in figure 2 of US 5,461,860. Furthermore, in US 1,931,692 and US 2,941,780 compressor impellers with a separate nose piece which comprises vanes are disclosed.

[0004] In US 1,959,703, US 1,097,729 and US 2,664,240 impellers are described which comprises inlet vanes separate from the main impeller vanes. The inlet vanes are connected to the main impeller vanes.

[0005] It is an objective of the present invention to provide an improved impeller. It is another objective of the present invention is to provide an improved turbocharger. The first objective is solved by an impeller, as claimed in claim 1. The second objective is solved by a turbocharger, as claimed in claim 15. The depending claims define further developments of the invention.

[0006] The inventive impeller comprises a hub and a number of vanes. The vanes are connected to the hub. Each vane comprises a leading edge and a trailing edge. The impeller further comprises long vanes and short vanes where the long vanes have a longer distance between the centre of the leading edge and the centre of the trailing edge. The inventive impeller comprises a bluff body portion. At least the long vanes extend onto the bluff body portion. The bluff body portion may have in upstream direction an aerodynamical shape, like a bullet-nose curve.

[0007] The use of at least two different lengths of impeller vanes makes it possible to extend the impeller vanes in upstream direction further towards the centreline of the rotor. This increases the efficiency of the

impeller because nearly the whole cross section of the inventive impeller may take part in the compression work.

[0008] The bluff body portion may be an integral part of the impeller. Alternatively, the impeller may comprise an impeller base element and a separate bluff body element. In this case the bluff body element can be fixed to the impeller base element to form a bluff body portion. The bluff body element can preferably be fixed to the impeller base element in upstream direction near the centreline of the impeller base element. For instance, the bluff body element can be connected to a flat portion of the hub of the impeller base element. Especially, the bluff body element may be bolted onto the impeller base element or shrunk onto a stub protruding from the impeller base element. The bluff body element may, for example, be bolted onto the impeller base element by means of a centre bolt arrangement or by radial screws.

[0009] Moreover, the bluff body element may comprise at least one bluff body vane which is connected to an impeller base vane and elongates this impeller base vane. In this case, the elongated impeller base vane and the elongating bluff body vane can be regarded as one vane. This vane has a longer distance between the centre of its leading edge and the centre of its trailing edge than other vanes of the impeller base element, which are not elongated by bluff body vanes.

[0010] The bluff body vane may comprise a trailing edge and the impeller base vanes may each comprise a leading edge. Preferably, the trailing edge of the bluff body vane is connected to the leading edge of the impeller base vane. The bluff body vane may be connected to the impeller base vane by means of a positive connexion. The positive connexion may especially be a plug-and-socket connexion. The trailing edge of the bluff body vane may comprise a slot into which the leading edge of the impeller base vane can be inserted. Furthermore, the trailing edge of the bluff body vane may comprise a reinforced portion extending along the slot to strengthen the trailing edge of the bluff body vane. This arrangement allows for using a slot with a larger width without compromising the stability of the connexion.

[0011] At least one vane, especially the bluff body vane, may comprise in upstream direction a step-wise or conically increasing span width. This increases the efficiency of the impeller because also the bluff body vanes take effectively part in the compression work.

[0012] Generally, the impeller can be made of aluminium. Preferably, the bluff body element or the bluff body portion can be made of a different material than the impeller base element. In particular, the bluff body element or the bluff body portion may made of a material stronger than and/or cheaper than aluminium, like for example titanium, a fibre-reinforced composite or steel. Generally, the bluff body element or the bluff body portion can be made of aluminium, titanium, a fibre-reinforced composite, or steel.

[0013] The inventive turbocharger comprises an impeller as previously described.

[0014] Extending the impeller towards the centreline of the rotor using the inventive bluff body element or the described bluff body portion provides the possibility to utilize the advantages of stronger than aluminium materials to obtain a higher specific flow. Furthermore, compared to the case if the entire impeller is made of another material than aluminium, increasing costs and weight can at least partially be avoided.

[0015] 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.

[0016] Fig. 4 schematically shows a turbocharger in a sectional view.

[0017] Fig. 2 schematically shows part of a turbocharger compressor impeller in sectional view.

[0018] Fig. 3 schematically shows a conventional impeller in a perspective view.

[0019] Fig. 4 schematically shows an alternative conventional impeller in a perspective view.

[0020] Fig. 5 schematically shows part of a conventional compressor of a turbocharger in a sectional view.

[0021] Fig. 6 schematically shows part of an inventive turbocharger compressor in a sectional view.

[0022] Fig. 7 schematically shows a connexion between an impeller vane and a bluff body vane in a sectional view.

[0023] Fig. 8 schematically shows an alternative connexion between an impeller vane and a bluff body vane in a sectional view.

[0024] Fig. 9 schematically shows a further alternative connexion between an impeller vane and a bluff body vane in a sectional view.

[0025] Fig. 10 schematically shows a still further alternative connexion between an impeller vane and a bluff body vane in a sectional view.

[0026] Fig. 11 schematically shows a still further alternative connexion between an impeller vane and a bluff body vane in a sectional view.

[0027] Fig. 12 schematically shows a still further alternative connexion between an impeller vane and a bluff body vane in a sectional view.

[0028] At first a conventional turbocharger and a conventional impeller will be described with reference to figures 1 to 4. Figure 1 schematically shows a turbocharger in a sectional view while figure 2 shows a sectional part of the turbocharger shown in figure 1. The turbocharger comprises a turbine 11 and a compressor 10 which are connected to each other by a shaft 20.

[0029] The turbine 11 comprises 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 18A indicate the exhaust stream entering the turbine casing 3 through the exhaust inlet 5 and activating the rotor 4. The exhaust stream

leaving the turbine casing 3 through the exhaust outlet 6 is indicated by arrows 18B.

[0030] The compressor 10 comprises an impeller 12 which is located inside a compressor casing 1. Moreover, the compressor 10 has an air inlet 7 which leads air 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 19A indicate the air stream entering the compressor casing 1 through the air inlet 7 and being compressed by the impeller 12. The compressed air then leaves the compressor casing 1 through the air outlet 8, as indicated by arrows 19B.

[0031] The rotor 4 of the turbine 11 is connected to the shaft 20 so that the activated rotor 4 activates the shaft 20 in an operating turbocharger. The shaft 20 is further connected to the impeller 12 inside the compressor 10. Hence, the rotor activates the impeller 12 by means of the shaft 20.

[0032] In the turbine 11 the exhaust stream 18A entering the exhaust inlet 5 activates the rotor 4 and leaves the turbine through the exhaust outlet 6. 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 compressed fresh air, which enters the air outlet 8. The compressed air is then used, for example, in a motor. The arrows 19A, 19B indicate the air stream direction.

[0033] The impeller 12 comprises an impeller base element 26 and a bluff body element 13. The impeller base element 26 comprises a hub 2 and vanes 9, 25. The bluff body element 13 is connected to the hub 2 of the impeller base element 26 in upstream direction by means of a screw 14. It has an aerodynamical shape, comparable to a bullet-nose curve.

[0034] The hub 2 of the impeller base element 26 is connected to the shaft 20. Further, the hub 2 is generally conical in shape and a plurality of circumferentially spaced, arcuate vanes 9, 25 are formed about its periphery. Each vane 9, 25 comprises a leading edge 16 and a trailing edge 17. The air coming from the air inlet 7 arrives the vanes 9, 25 at their leading edges 16, flows along the vanes 9, 25 and leaves the vanes 9, 25 at their trailing edges 17.

[0035] Figure 2 schematically shows a sectional view of part of the impeller base element 26 including the hub 2 and the vanes 9, 25. The centreline of the impeller base element 26 is indicated by reference numeral 15.

[0036] A centre 33 of a leading edge 16 of a vane 9, 25 is defined as a position at the leading edge 16 at half of the length of the leading edge 16. In the same way a centre 34 of a trailing edge 17 is defined as a position at half of the length of the trailing edge 17. The distance 35 between the centre of the leading edge 33 and the centre of the trailing edge 34 of the vane 9 along the flow path is longer than the distance 36 between the centre of the leading edge 33 and the centre of the trailing edge 34 of the vane 25. Hence, the vane 9 can be regarded as a long vane and the vane 25 can be regarded as a short

vane. The use of vanes of at least two different lengths, which means different distances between the centre of the leading edge 33 and the centre of the trailing edge 34, increases the efficiency of the impeller 12, because an increased part of the cross section of the impeller in flow direction can take part in the compression work. Of course, also vanes 9, 25 of more than two different lengths can be used.

[0037] Figures 3 and 4 schematically show two alternative conventional impellers 112, 212 in a perspective view. In both figures the impeller 112, 212 comprises a hub 2. The hub 2 comprises in upstream direction a bluff body portion 27. This bluff body portion 27 has the same characteristics as the bluff body element 13, which was described in conjunction with figure 1. The impeller 12 in the figures 3 and 4 further comprises vanes 9, 25 of two different lengths, namely are long vanes 9, and short vanes 25, where the long vanes 9 have a longer distance from their leading edge to their trailing edge along the flow path.

[0038] The vanes 9, 25 are arranged circumferentially at the hub 2 such that the long vanes 9 and the short vanes 25 alternate. This means that a long vane 9 is followed by a short vane 25, which is followed again by a long vane 9, and so on. All vanes 9, 25 are rotated around the radial direction of the impeller axis 15 so that they are inclined in circumferential direction of the impeller 112, 212.

[0039] The impeller 212 which is shown in figure 4 comprises more vanes 9, 25 than the impeller 112 which is shown in figure 3. Furthermore, all vanes 9, 25 of the impeller 212 shown in figure 4 are rotated around the radial direction of the impeller axis 15 to a greater extent than the vanes 9, 25 of the impeller 112 shown in figure 3. Moreover, the difference in the lengths between the long vanes 9 and the short vanes 25 is higher in figure 4 than the difference in figure 3. Length again means the distance between the centre of the leading edge 33 and the centre of the trailing edge 34 of the particular vane 9, 25 along the flow path.

[0040] In the following, an embodiment of the present invention will be described with reference to figures 5 to 12. Elements corresponding to elements of the previously described figures will be designated with the same reference numerals and will not be described again.

[0041] Figure 5 schematically shows part of a standard turbocharger compressor 100 in a sectional view. The figure shows the compressor casing 1 and the impeller 312. The impeller axis is indicated by reference numeral 15. The impeller 312 comprises a hub 2 and a vane 28, which corresponds to a vane of the impeller base element 26 of an inventive impeller 12. The leading edge 16 of the vane 28 covers only a fraction of the cross section of the air inlet 7. The fraction which is not covered by the leading edge 16 is occupied by the front end of the hub 2 in upstream direction. This means that this fraction, which is occupied by the surface of the hub 2, does not take part in the compression work of the impeller 12.

[0042] Figure 6 schematically shows part of an inventive impeller 412 inside a turbocharger compressor 10 in a sectional view. The impeller 412 comprises a bluff body element 113 and an impeller base element 126. The impeller base element 126 corresponds to the standard impeller 312, which is shown in figure 5. The impeller 412 is located inside a compressor casing 1.

[0043] The bluff body element 113 comprises vanes 21, which have a leading edge 22 and a trailing edge 23. The span width of the vanes 21 is indicated by reference numeral 24. The span width 24, which defines the dimension of the vane 21 in radial direction, increases from the trailing edge 23 to the leading edge 22, where the span width reaches its maximum value. At the leading edge 22 the vane 21 covers nearly the whole cross section of the air inlet 7. This means that nearly the whole cross section of the air inlet 7 takes part in the compression work of the compressor 100. The bluff body element 113 is connected to the impeller base element 126 in upstream direction. The bluff body element 113 can, for instance, be bolted onto the hub 2 of the impeller base element 126 or it can be shrunk onto a stub protruding from the hub 2 of the impeller base element 126. For example, a centre bolt arrangement or radial screws can be used to fix the bluff body element 113 to the impeller base element 126.

[0044] The vanes 21 of the bluff body element 113 can be connected to some of the vanes 28 of the impeller base element 126 by different means. Preferably the trailing edge 23 of a bluff body vane 21 is connected to the leading edge 16 of an impeller base vane 28. In this case the bluff body vane 21 elongates the impeller base vane 28 resulting in a long vane, as has been described, for example, with reference to figure 2. Impeller base vanes 28 which are not elongated by a bluff body vane 21 are short vanes (as described with reference to figure 2) of this arrangement.

[0045] Generally the bluff body element 13, 113 can be made of a different material than the impeller base element 26, 126, which is typically made of aluminium. Preferably, the bluff body element 13, 113 is made of titanium, fibre-reinforced composite, or steel.

[0046] The figures 7 to 12 show different possibilities for a connexion between a bluff body vane 21 and a vane 28 of the impeller base element 126 in a sectional view. In figure 7 the trailing edge 23 of the bluff body vane 21 is connected to the leading edge 16 of the impeller base vane 28 at a face which is perpendicular to the direction of the air stream 19.

[0047] Figure 8 shows an alternative arrangement for a connexion between a bluff body vane 21 and an impeller base vane 28 in a sectional view. The arrow 29 in figure 8 indicates the direction of rotation of the impeller 412. In figure 8 the leading edge 16 of the impeller base vane 28 overlaps the trailing edge 23 of the bluff body vane 21 in upstream direction. The contact face 37 where the bluff body vane 21 and the impeller base vane 28 are in contact is orientated such that the angle 39 between

the orientation 38 of the contact face 37 and the direction of the rotation 29 or the air stream direction 19 has a value between 0° and 90°. Preferably, the angle 39 between the orientation 38 of the contact face 37 and the direction of the rotation 29 has a value of 45°, as it is shown in figure 8.

[0048] In figure 9 the bluff body vane 21 is thicker than the impeller base vane 28. The bluff body vane 21 comprises a slot 30 at its trailing edge 23. The slot 30 has a width so that at least the leading edge 16 of the impeller base vane 28 can be inserted into the slot 30, as it is shown in figure 9.

[0049] In figure 10 a reinforced portion 31 is present in the bluff body vane 21. This reinforced portion 31 extends along the trailing edge 23 of the bluff body vane 21. Compared to figure 9, the bluff body vane 21 shown in figure 10 is only a little thicker than the impeller base vane 28. Nevertheless, the reinforced portion 31 which extends along the slot 30 makes it possible to use a slot 30 of a width that corresponds to the thickness of the leading edge 16 of the impeller base vane 28. The use of a reinforced portion 31 increases the stability around the slot 30, while the rest of the vane 21 can be relatively thin.

[0050] An alternative is shown in figure 11. In this alternative, the bluff body vane 21 has a conically increasing thickness from its leading edge 22 towards its trailing edge 23. Figure 12 shows an alternative arrangement to figure 11. In figure 12 also the impeller base vane 28 has a conically increasing width from its trailing edge 17 towards its leading edge 16. The leading edge 16 of the impeller base vane 28 comprises a stub 32, which fits into the slot 33 extending along the trailing edge 23 of the bluff body vane 21.

[0051] Generally the connexion between the bluff body vane 21 and the impeller base vane 28 can be any type of positive connexion, for instance a plug-and-socket connexion.

[0052] In summary, elongating some of the vanes of an impeller, for example by means of a bluff body element or a bluff body portion which comprises vanes, increases the efficiency of the impeller, because the cross section of the air inlet can optimally be exploited.

Claims

1. An impeller (412), comprising a hub (2) and a number of vanes (21, 28), which are connected to the hub (2), each vane (21, 28) comprising a leading edge (16, 22) and a trailing edge (17, 23), the impeller (412) comprising long vanes and short vanes where the long vanes have a longer distance between the centre of the leading edge and the centre of the trailing edge,
characterised in that
the impeller (412) comprises a bluff body portion, and at least the long vanes extend onto the bluff body

portion.

2. The impeller (412) as claimed in claim 1,
characterised in that
the bluff body portion is an integral part of the impeller (412).
3. The impeller (412) as claimed in claim 1,
characterised in that
the impeller (412) comprises an impeller base element (126) and a separate bluff body element (113) fixed to the impeller base element (126) to form a bluff body portion.
4. The impeller (412) as claimed in claim 3,
characterised in that
the bluff body element (113) is bolted onto the impeller base element (126) or shrunk onto a stub protruding from the impeller base element (126).
5. The impeller (412) as claimed in claim 4,
characterised in that
the bluff body element (113) is bolted onto the impeller base element (126) by means of a centre bolt arrangement or by radial screws.
6. The impeller (412) as claimed in any of the claims 3 to 5,
characterised in that
the bluff body element (113) comprises at least one bluff body vane (21) which is connected to an impeller base vane (28) and elongates this impeller base vane (28).
7. The impeller (412) as claimed in claim 6,
characterised in that
the bluff body vane (21) comprises a trailing edge (23) and the impeller base vanes (28) each comprise a leading edge (16), and the trailing edge (23) of the bluff body vane (21) is connected to the leading edge (16) of an impeller base vane (28).
8. The impeller (412) as claimed in claim 6 or 7,
characterised in that
the bluff body vane (21) is connected to the impeller base vane (28) by means of a positive connexion.
9. The impeller (412) as claimed in claim 8,
characterised in that
the bluff body vane (21) is connected to the impeller base vane (28) by means of a plug-and-socket connexion.
10. The impeller (412) as claimed in claim 9,
characterised in that
the trailing edge (23) of the bluff body vane (21) comprises a slot (30) into which the leading edge (16) of the impeller base vane (28) is inserted.

11. The impeller (412) as claimed in claim 10,
characterised in that
the trailing edge (23) of the bluff body vane (21) comprises a reinforced portion (31) extending along the slot (30). 5
12. The impeller (412) as claimed in any of the claims 1 to 11,
characterised in that
at least one vane (21, 28) comprises in upstream direction a stepwise or conically increasing span width (24). 10
13. The impeller (412) as claimed in any of the claims 1 to 12,
characterised in that
the bluff body element (113) or the bluff body portion (27) is made of a different material than the impeller base element (126). 15
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14. The impeller (412) as claimed in claim 13,
characterised in that
the bluff body element (113) or the bluff body portion (27) is made of aluminium, titanium, a fibre reinforced composite or steel. 25
15. A turbocharger, comprising an impeller (412) as claimed in any of the claims 1 to 14. 30

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FIG 1

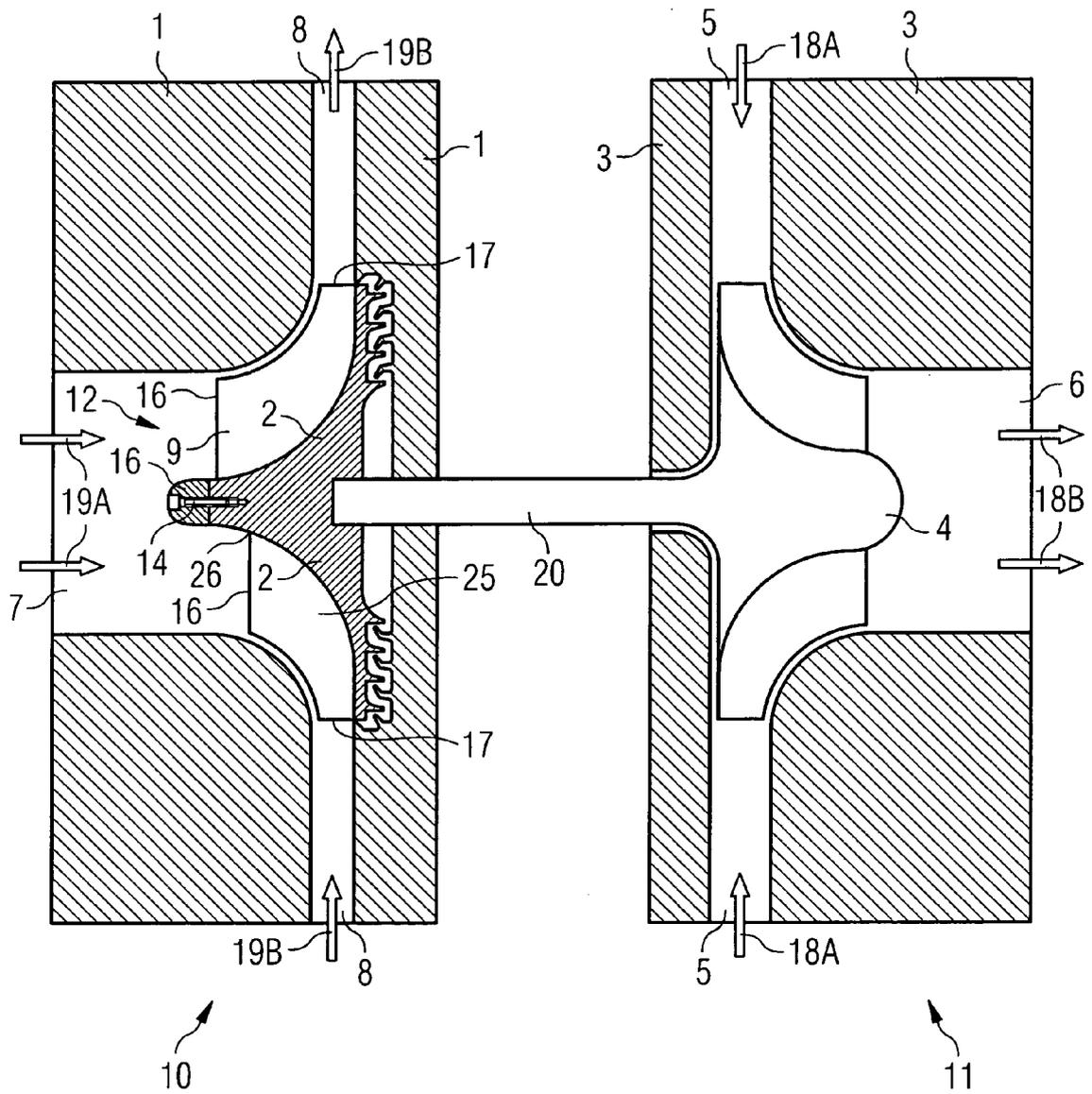


FIG 2

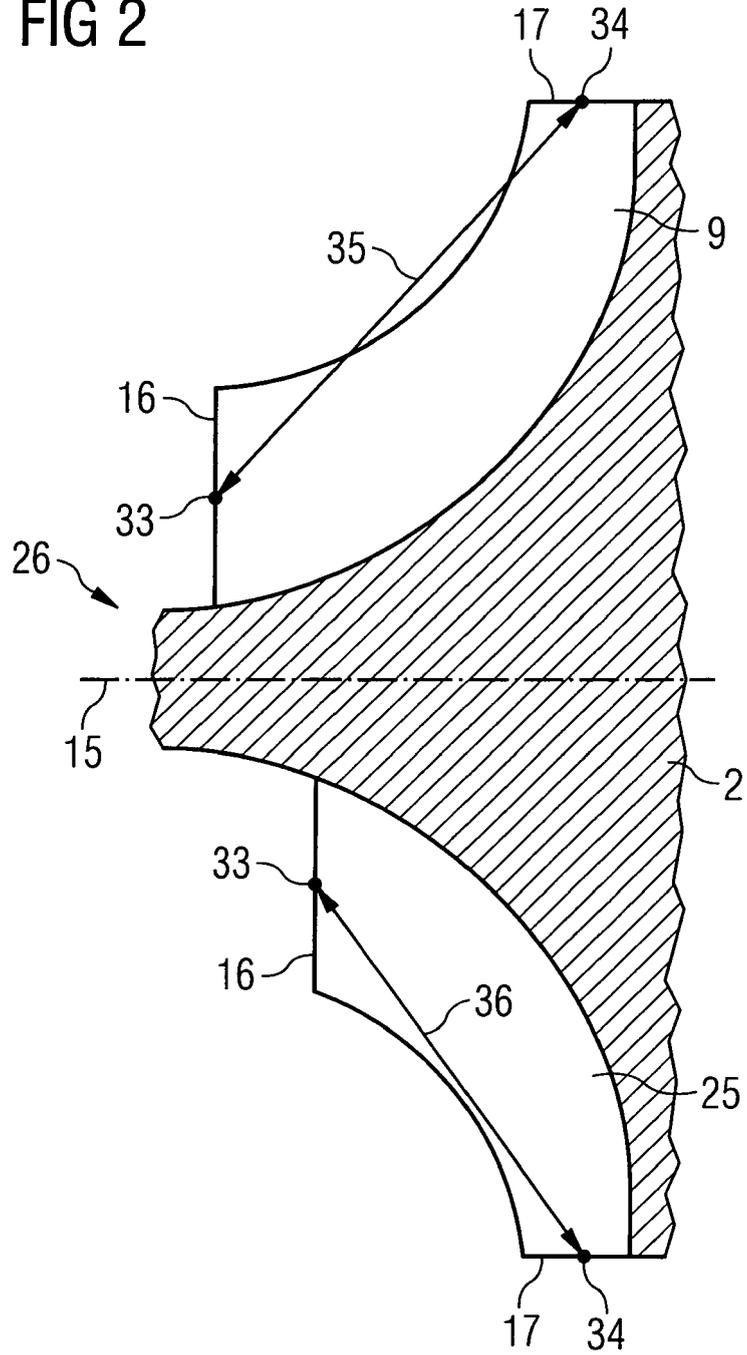


FIG 3

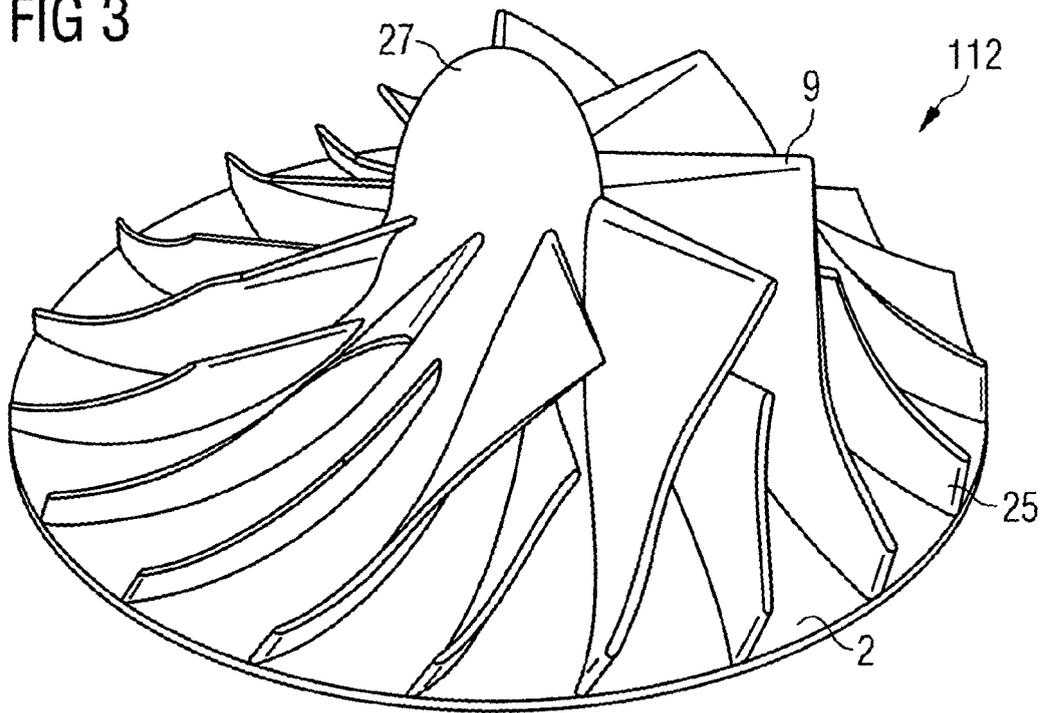


FIG 4

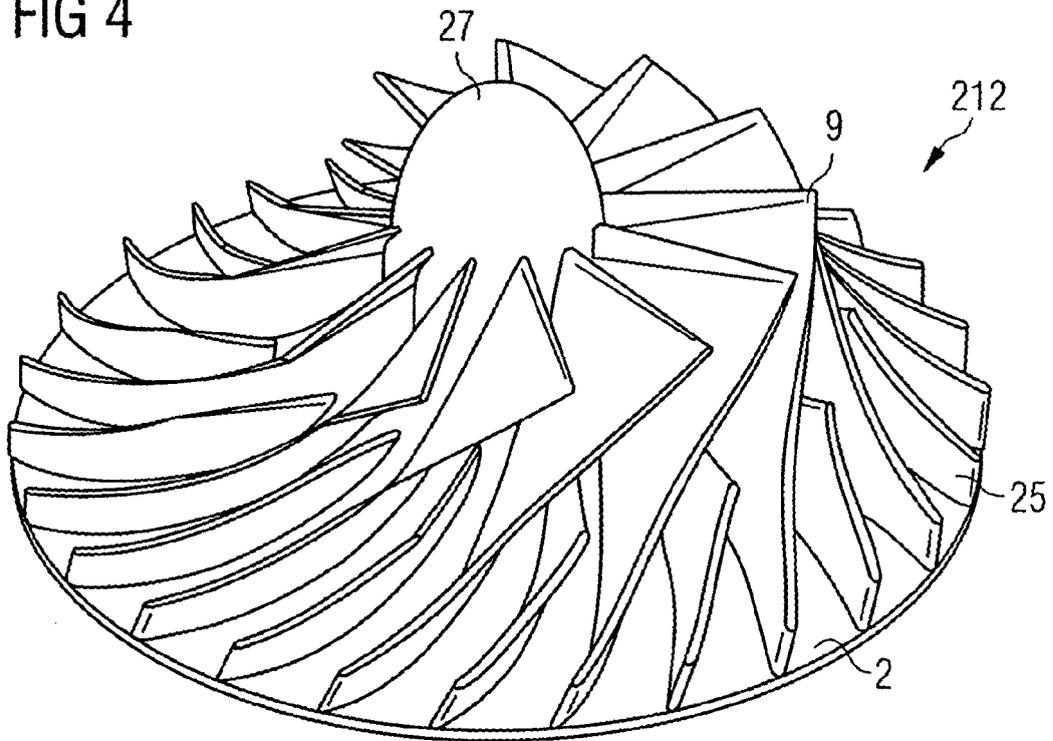


FIG 5

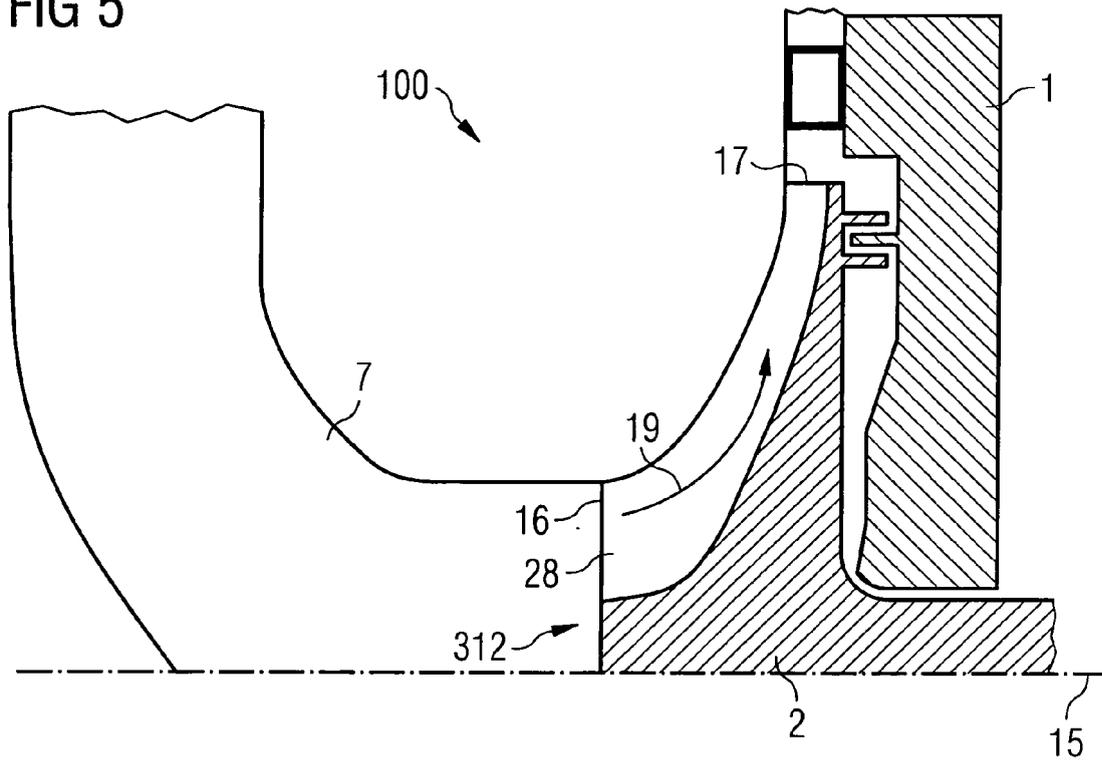


FIG 6

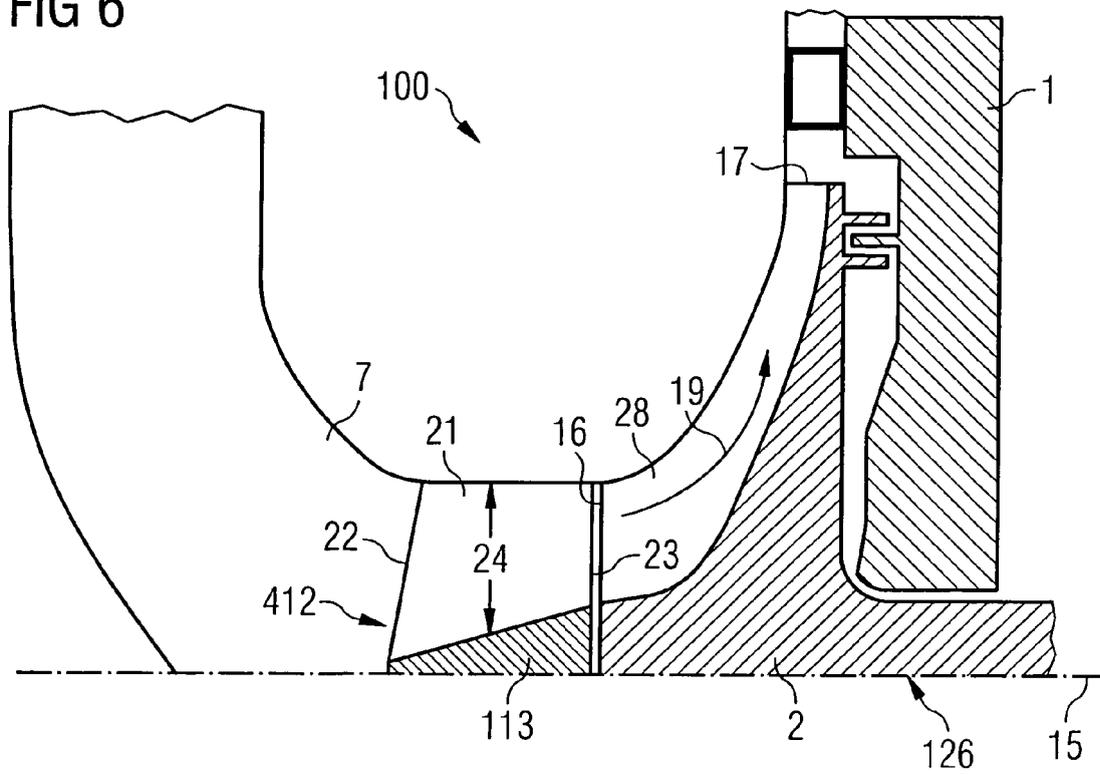


FIG 7

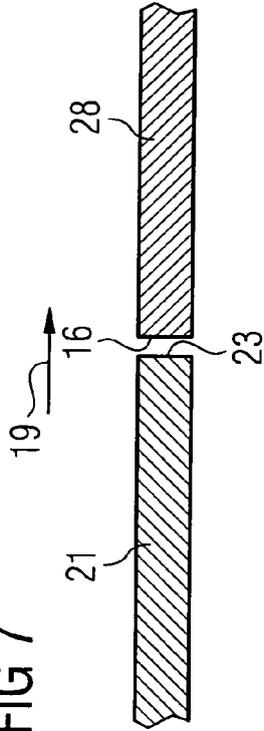


FIG 10

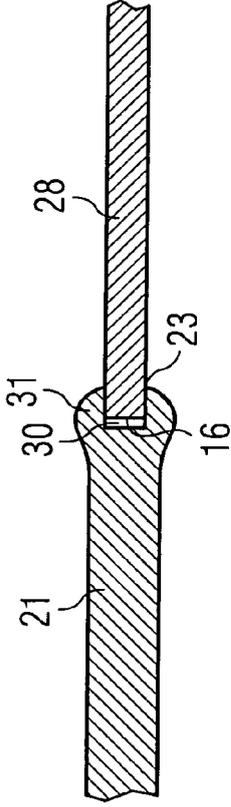


FIG 8

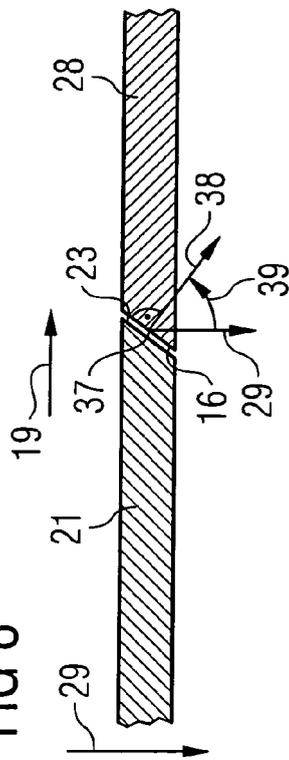


FIG 11

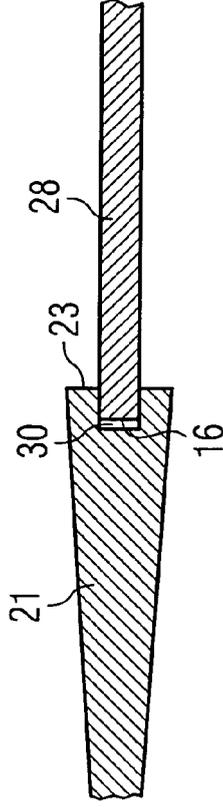


FIG 9

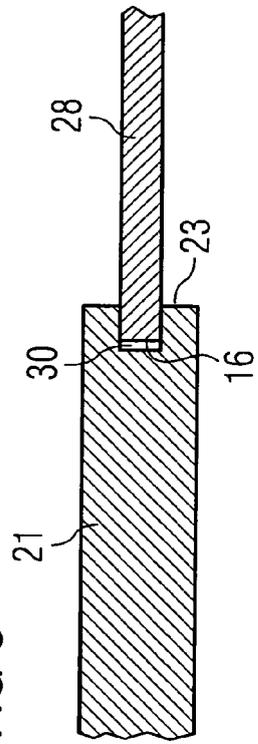
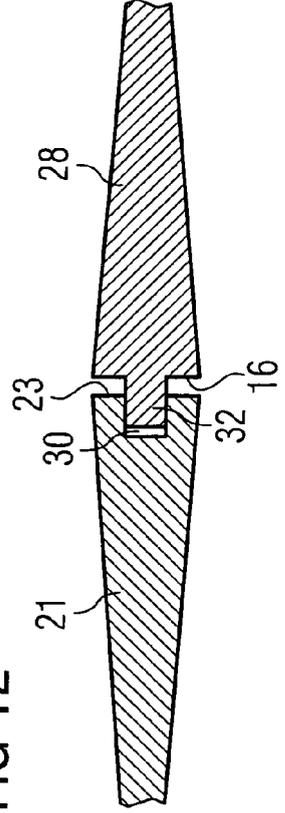


FIG 12





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 2005/063825 A1 (YANG SHENG-AN [TW]) 24 March 2005 (2005-03-24)	1,2	INV. F04D29/28
Y	* paragraph [0019] - paragraph [0020]; figure 1 *	10,12-15	F04D29/62
X	* paragraph [0021] - paragraph [0022]; figures 2,3 *	3,4,6-8	ADD. F04D25/04

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	* column 2, line 8 - line 30; figures 1,2 *		

The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		15 April 2008	Di Giorgio, F
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone		T : theory or principle underlying the invention	
Y : particularly relevant if combined with another document of the same category		E : earlier patent document, but published on, or after the filing date	
A : technological background		D : document cited in the application	
O : non-written disclosure		L : document cited for other reasons	
P : intermediate document		& : member of the same patent family, corresponding document	

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

EP 07 02 2516

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