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 2015/5485 29 July 2015 (29.07.2015) BE</p> <p>(71) Applicant: ATLAS COPCO AIRPOWER, naamloze vennootschap [BE/BE]; Boomssteenweg 957, 2610 Wilrijk (BE).</p> <p>(72) Inventor: FABRY, Erik, Paul; c/o Atlas Copco Airpower n.v., Boomssteenweg 957, 2610 Wilrijk (BE).</p> | <p>(74) Agents: VAN VARENBERG, Patrick et al.; Arenbergstraat 13, 2000 Antwerpen (BE).</p> <p>(81) Designated States (<i>unless otherwise indicated, for every kind of national protection available</i>): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.</p> <p>(84) Designated States (<i>unless otherwise indicated, for every kind of regional protection available</i>): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,</p> |
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(54) Title: ELECTRIC CENTRIFUGAL COMPRESSOR WITH CHANNELS IN THE IMPELLER HUB FOR BLEEDING AIR FOR COOLING THE MOTOR AND THE BEARINGS

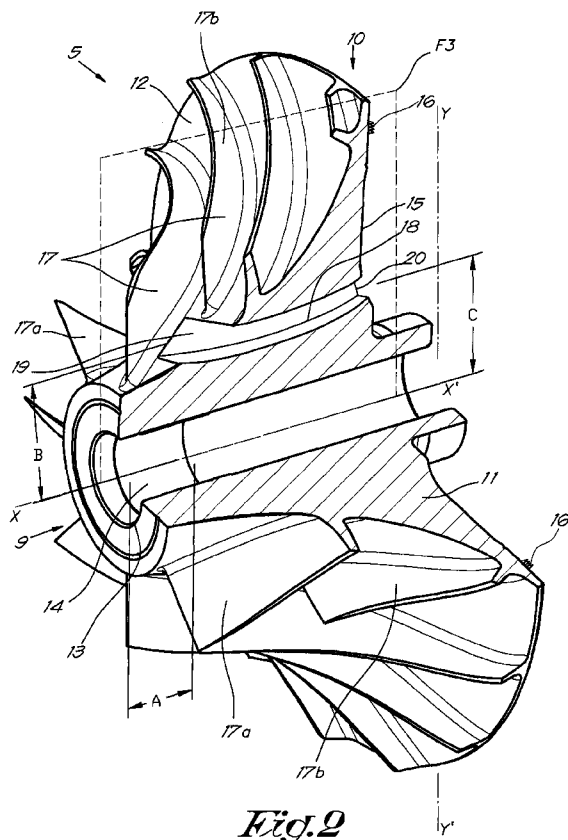


Fig. 2

(57) Abstract: Centrifugal impeller with a hub (11) with a hub surface (12) and a central shaft (13), whereby this hub (11) increases in diameter in the direction from an inlet side (9) to an outlet side (10) of the impeller (5), whereby the hub (11) is provided with a back wall (15) on the outlet side (10), whereby the impeller (5) comprises a number of protruding blades (17) that are provided on the hub surface (12), characterised in that the hub (11) is provided with channels (18) that extend from an input opening (19) in the hub surface (12) to an output opening (20) in the back wall (15), whereby these channels (18) split off a proportion of the gas that is drawn in and guide it to the back wall (15) of the impeller (5).



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ELECTRIC CENTRIFUGAL COMPRESSOR WITH CHANNELS IN THE
IMPELLER HUB FOR BLEEDING AIR FOR COOLING THE MOTOR
AND THE BEARINGS

5

The present invention relates to a centrifugal impeller and a centrifugal machine equipped with such an impeller.

More specifically, the invention is intended for
10 centrifugal machines such as a turbocompressor, turbine or similar.

As is known, a centrifugal compressor element as used in turbocompressors consists of an impeller that is rotatably
15 affixed in a housing with an axial inlet and a radial outlet, whereby the impeller is formed by a type of trumpet-shaped hub to bend the gas drawn in from the axial direction at the inlet to the radial direction at the outlet, and by blades that are provided on the hub and
20 which together with the hub and the housing define channels through which the gas is guided to compress it.

The impeller can be provided with a central borehole to be able to fasten the impeller at one end of a drive shaft,
25 whereby this drive shaft is driven by a motor.

The central borehole does not necessarily have to be present.

30 Such an impeller can also be a closed impeller that is provided with a 'shroud', but this is not necessarily the

case.

It is known that such an impeller is driven at high speeds of many tens of thousands of revolutions per minute whereby
5 the linear peripheral velocity at the outlet of the impeller can reach some hundreds of metres per second.

The motor that is used to drive the impeller will generate heat and heat will also be generated during compression.

10 The motor is a high speed motor for driving the impeller at high speeds of rotation. Consequently this motor has a high energy density and cooling is of great importance.

It will consequently be necessary to cool the
15 turbocompressor, in particular the motor.

Magnetic bearings, air bearings, roller bearings or backup bearings will also have to be cooled when they are used.

20 Backup bearings are roller bearings by which the impeller is mounted on bearings in the housing and will only be used when the magnetic bearings, by which the impeller is mounted on bearings in the housing in normal conditions, are not active, for example due to a power failure, to
25 enable the impeller to come to a stop with these backup bearings.

Solutions are already known whereby the cooling is provided in such compressor elements in the form of cooling fans.

30

They are placed on the housing of the motor and are

provided with their own drive.

Another solution is also already known whereby a second
impeller or fan is affixed on the other end of the drive
5 shaft so that this second impeller or fan can be driven by
the motor.

Such known solutions present a few disadvantages.

10 A disadvantage is that extra means always have to be
provided for the cooling of the motor, impeller and
bearings.

If a second impeller or fan is affixed at the other end of
15 the drive shaft, these extra means consist of an extra fan,
extra filters and similar.

If cooling fans are placed on the housing, these extra
means consist of an extra fan with motor, extra filters,
20 electrical and other connections, control units, control
logic and similar.

This makes such a compressor element not only bulkier but
also more vulnerable to wear and defects in the various
25 components.

An additional disadvantage is that the cooling fan on the
housing with its own drive will switch off if the drive of
the cooling fan fails due to a power failure or similar.

30

If, in the event of such a power failure, the impeller

comes to lie on the backup bearings, they will no longer be cooled while the impeller comes to a stop, such that the its operation will be seriously disturbed. This can lead to damage to the centrifugal machine.

5

For the cooling of air bearings, a small amount of leakage air at a higher temperature is sometimes tapped off from the outside diameter of the impeller, which leads to inadequate cooling. Moreover, the use of leakage air from
10 the outside diameter of the impeller is not energy-efficient as a lot of energy has already been consumed to bring this air to a higher pressure at the outside diameter of the impeller.

15 The purpose of the present invention is to provide a solution to a least one of the aforementioned and other disadvantages.

The object of the present invention is a centrifugal
20 impeller with a hub with a hub surface and a central shaft, whereby this hub increases in diameter in the direction from an inlet side to an outlet side of the impeller, whereby the hub is provided with a back wall on the outlet side, whereby the impeller comprises a number of protruding
25 blades that are provided on the hub surface, whereby the hub is provided with channels that extend from an input opening in the hub surface to an output opening in the back wall, whereby these channels split off a proportion of the gas that is drawn in and guide it to the back wall of the
30 impeller.

An advantage is that a proportion of the gas drawn in can be split off via the channels and can be used as cooling gas to cool the motor and any other components of the centrifugal machine in which the centrifugal impeller is
5 used.

This means that no extra fans, drive motors or other components have to be provided, so that the installation is more robust, cheaper, simpler and more compact.

10

In other words an integration of different functions is obtained in a centrifugal impeller according to the invention.

15 Another advantage is that by correctly positioning the input openings and output openings it can be ensured that the split-off cooling gas is not yet compressed or barely compressed, so that this gas has not been heated up and consequently can cool optimally.

20

Another advantage is that even if there is a power failure, there will still be cooling while the impeller comes to a stop, so that the backup bearings, the motor and the impeller are still cooled.

25

Preferably the hub is at least partially hollow with one or more hollow spaces, whereby the aforementioned channels are formed by one or more of the aforementioned hollow spaces or whereby at least a portion of the channels at least
30 partially coincide or overlap to form a hollow space.

An at least partially hollow hub does not exclude certain structures being provided in the one or more hollow spaces of the hub, such as for example reinforcing ribs and similar.

5

An advantage of this is that the mass of the impeller is reduced so that higher speeds of the impeller are possible, which is useful for an energy-efficient operation of the centrifugal machine in which the impeller is used.

10

Due to a lower mass of the impeller the bearings of the central shaft are also loaded less, such that for the design of a centrifugal machine smaller bearings can be selected resulting in a lower cost price and/or a more compact compressor element or a central shaft with a smaller diameter.

15

Preferably the impeller is produced by means of an additive production method.

20

Additive production refers to a category of production methods, for example powder bed fusion whereby thermal energy is utilised to selectively enable certain regions in a powder bed to fuse together, or by direct energy deposition whereby beamed thermal energy is used to make materials melt while they are deposited.

25

Within the category of powder bed fusion there are a number of technologies such as electron beam melting, whereby powder material is melted by using an electron beam; selective laser melting whereby powder material is melted by means of a laser; selective laser sintering whereby

30

powder material is sintered by using a laser. The category of direct energy deposition includes the technology of laser cladding.

- 5 An advantage of such an additive production method is that it will enable a hollow or at least a partially hollow centrifugal impeller to be produced with channels and/or hollow spaces.
- 10 The invention also concerns a centrifugal machine that is provided with a centrifugal impeller according to the invention.

A centrifugal machine means a turbocompressor or turbine
15 for example, but the invention is not limited to this.

The present invention also concerns a method for cooling a centrifugal machine, whereby use is made of a centrifugal machine according to the invention, whereby a proportion of
20 the gas drawn in is split off via the channels in the centrifugal impeller and guided to the back wall of the impeller so that the split-off gas can be used for cooling the centrifugal machine.

25 The advantages of such a centrifugal machine and method according to the invention are analogous to the advantages of a centrifugal impeller according to the invention cited above.

30 With the intention of better showing the characteristics of the invention, a few preferred variants of a centrifugal

impeller according to the invention, a centrifugal machine according to the invention and a method for cooling a centrifugal machine are described hereinafter by way of an example, without any limiting nature, with reference to the
5 accompanying drawings, wherein:

figure 1 schematically shows a centrifugal machine with one single centrifugal impeller according to the invention;
10 figure 2 schematically shows a perspective view of a centrifugal impeller according to the invention with a partial cutaway;
figure 3 shows an alternative embodiment of the section that is shown in figure 2 by F3;
15 figure 4 shows an alternative embodiment of figure 3;
figure 5 shows two possible cross-sections according to the line V-V in figure 3;
figure 6 shows a variant of a machine with two centrifugal impellers according to the invention.

20

In this case the centrifugal machine 1 shown in figure 1 is a centrifugal compressor element with a housing 2 in which a drive shaft 3 is mounted on bearings 4.

25 The aforementioned bearings 4 can also comprise a pair of backup bearings.

A centrifugal impeller 5 according to the invention is affixed on the drive shaft 3.

30

A motor 6 is provided to drive the drive shaft 3.

An inlet 7 is provided in the housing 2 for the supply of gas to be compressed and an outlet 8 for the outflow of compressed gas.

5

The inlet side 9 of the impeller 5 is located at the aforementioned inlet 7 and the outlet side 10 is located at the aforementioned outlet 8.

10 Figure 2 shows the centrifugal impeller 5 in more detail.

As can be seen in this drawing, the impeller 5 comprises a hub 11 with a hub surface 12 and a central shaft 13 with a borehole 14 that is intended to be coupled to the drive

15 shaft 3.

The hub 11 increases in diameter in the direction from the inlet side 9 to the outlet side 10 of the impeller 5 so that the hub 11 takes on a type of trumpet shape, whereby
20 the hub surface 12 goes slantwise from an essentially axial direction X-X' on the inlet side 9 to an essentially radial direction Y-Y' on the outlet side 10.

The hub 11 is provided with a back wall 15 on the outlet
25 side 10.

A seal 16 is provided on the back wall that will ensure that the hot compressed air remains separated from the motor compartment.

30

A number of protruding blades 17 are provided on the hub surface 12.

In the example shown, two series of blades 17 are provided,
5 i.e. on the one hand main blades 17a that extend over a certain length from the axially oriented inlet side 9 of the hub 5 to the radially oriented outlet side 10 of the hub 5, and 'splitter blades' 17b on the other hand that extend over a shorter length between the main blades 17a,
10 starting at an axial distance from the inlet side 9 of the hub 5 up to the outlet side 10 of the hub 5.

However, the invention is not limited to two series of blades 17, but is also applicable to any number of series
15 of blades 17, whereby for example there are no splitter blades 17b or on the contrary a number of series of splitter blades 17b can be provided.

According to the invention the hub 5 is provided with one
20 or more channels 18 that extend through the hub 5.

The channels 18 extend from an input opening 19 that is located in the hub surface 12 up to an output opening 20 in the back wall 15.
25

The channels 18 will be able to split off a proportion of the gas that is drawn in so that this split-off gas is guided via the input openings 19 and the channel 18 to the output opening 20 and the back wall 15 of the impeller 5.
30

As can be seen in the drawing, the input opening 19 in the hub surface 12 is at an axial distance A from the inlet side 9, at a radial distance B from the shaft 13.

- 5 It is not excluded that this last distance B is almost zero, in other words that the input opening 19 is at the location of the inlet side 9.

10 In this case, the output opening 20 is in the back wall 15 at a radial distance C that is greater than the aforementioned distance B.

15 In other words the channels 18 will bend in the direction from the input opening 19 to the output opening 20 in the radial direction Y-Y', away from the central shaft 13.

20 Due to this bending a slight pressure increase of the split-off gas will be obtained, which is required to ensure that the flow through this channel 18 improves and that the split-off gas can be optimally deployed for the cooling.

As can be seen in the drawings, the channels 18 have an essentially square or rectangular cross-section.

- 25 However, it is not excluded that the channels 18 have a round or oval cross-section.

30 In this case, the cross-section of the channels 18 varies in the direction from the input opening 19 to the output opening 20. The variation of the cross-section of the

channels 18 will ensure that the flow or circulation in the channel 18 is optimum.

In this case, the number and form of the channels 18 and the input openings 19 is such that around 10 percent to 35 percent, for example 25 percent, of the gas drawn in by the centrifugal compressor element 1 can be split off and transported via the input openings 19, the channels 18 and the output opening 20.

10

The operation of the centrifugal compressor element 1 is very simple and as follows.

During the operation of the centrifugal compressor element 15 1, the motor 6 will drive the drive shaft 3 such that the centrifugal impeller 5 will rotate.

As a result of this rotation, ambient air will be drawn in through the inlet 7 for example and will be compressed via 20 the rotating blades 17 on the hub surface 12 and removed via the outlet 8.

A portion of the air drawn in, in this case 25 percent, will be split off via the channels 18 and transported to 25 the back wall 15 of the impeller 5.

Due to the form of the channels 18 it can be ensured that the split-off air can flow through optimally and be transported to the drive shaft 3 and the motor 6 for the 30 cooling thereof.

During the passage through the channels 18, the split-off air can also cool the impeller 5.

In this way an efficient cooling is obtained of the centrifugal compressor element 1 by the split-off cooling
5 air without an extra cooling fan having to be integrated.

If the motor fails due to a fault or failure, the compressor element 1 will come to a stop, whereby the
10 centrifugal impeller 5 will come to a stop in the backup bearings.

Because, while coming to a stop, air can still be split off as cooling air for the cooling of the motor 6, drive shaft
15 3, backup bearings and impeller 5, this can prevent thermal damage occurring when the compressor element 1 comes to a stop.

The channels 18 to the back wall 15 of the impeller 5 for
20 cooling air thus form an internal fan as it were that is integrated in the impeller 5. The cooling air that is blown out by this internal fan along the back wall 15 can be used to cool different components, more specifically the various bearings 4 and the electric motor 6. The cooling air that
25 leaves the impeller 5 can flow freely to the components that are behind the impeller 5 or can be received by fixed cooling channels 21 that guide the cooling air to the specific components and which are schematically shown in figure 1.

These fixed cooling channels 21 can be processed in the housing of the centrifugal machine 1, which in the case of the example of figure 1 is composed of the housing 2 of the compressor element and the stator 6b of the motor.

5

These internal fixed channels 21 can be realised for example by means of 3D printing, casting or by machining techniques, or can be formed by external pipes or channels, or can be formed by assembling different components that
10 form an enclosed space such as the space 22 between the rotor 6a and the stator 6b of the motor 6.

At the inlet of a fixed cooling channel 21 it is possible to provide stator blades, not shown, to reduce the air
15 speeds and build up the pressure to provide the components with cooling air with lower flow losses.

At the inlet of a fixed cooling channel 21 it is also possible to provide adjustable stator blades or an
20 adjustable restriction to control the quantity of cooling air, for example as a function of the motor load.

Moreover, the control of the decrease of the quantity of cooling air is an indirect control of the quantity of air
25 that the impeller will compress. It is thus a capacity control of the centrifugal machine 1 as a centrifugal compressor 1 for example, without other parameters such as speed or similar changing in the centrifugal machine 1.

30 By using this indirect capacity control for operation at low capacity, i.e. if too much cooling air is tapped off

from the impeller 5, a channel 23 or opening will let the surplus quantity of cooling air escape to the environment via a controllable bypass valve 24.

5 Such a capacity control can, alone or together with other controls, guarantee that the centrifugal machine is kept outside the unstable "surge" region (or "pumping") of the centrifugal compressor, for example together with, and without any restriction, a speed control, variable inlet
10 blades, variable outlet blades, etc.

For the cooling of the different components on the back wall 15 of the impeller 5, more specifically the bearings 4 and the electric motor 6, different configurations are
15 possible as described hereinafter on the basis of figure 1.

In a typical configuration as shown in figure 1, there is a set of bearings 4 on either side of the electric motor, when viewed in the axial direction, that can consist of
20 radial bearings only or radial and axial bearings. For functional and durability reasons it is important that the various components remain below an imposed maximum permissible temperature. For example it is important that the motor windings do not exceed a certain temperature in
25 order to prevent degradation of the lacquer on the motor windings.

In the event of limited heating in the bearings 4, as in the case of active magnetic bearings, a simple serial flow
30 of the cooling air is possible, as schematically shown by the arrows P in the bottom half of figure 1, whereby the

fixed cooling channels 21 let the cooling air flow sequentially first through the first set of bearings at the end of the motor 6 on the side of the impeller 5, then through the space 22 of the motor 6 and then through the
5 second set of bearings 4 at the other end of the motor 6.

In the event of strong heating in the bearings 4, for example with air bearings, a parallel flow of the cooling air is to be chosen, as schematically shown by the arrows Q
10 in the top half of figure 1.

In this case the cooling air is divided into separate channels 21 behind the impeller 5 for the first set of bearings 4, the second set of bearings 4 and the electric
15 motor 6. As a result it is possible to bring about the maximum cooling of the components with the coldest possible air.

Alternatively it is also possible to form a combination of
20 a parallel and serial circuit from the fixed cooling channels 21, whereby for example the components with the greatest heating, such as air bearings or the winding heads 25 of the electric motor 6, are first cooled and then this cooling air is used to cool other colder components such as
25 the stator 6b of the motor 6.

In the case of air bearings, large quantities of air are required to limit the strong temperature rise of the air in the bearings 4. In this case, the supply of cooling air
30 originating from the internal channels 18 is preferably directly in the bearing 4. The advantage of this invention

is that large quantities of air at low temperature are introduced compared to a supply of a small amount of leakage air at a higher temperature from the outside diameter of the impeller 5. Moreover, the use of the leakage air from the outside diameter of the impeller 5 is not energy efficient as a lot of energy has already been consumed to bring this air to the higher pressure at the outside diameter of the impeller 5.

10 In the case of roller bearings or ball bearings, as used for the backup bearings, with rollers or balls between an inner race and an outer race, direct cooling by oil-free air such as in the bottom half of figure 1 is not recommended, as such bearings 4 are grease-lubricated or
15 oil-lubricated and cooled oil-free air can dry out these lubricants. In this case it is consequently appropriate for the roller bearings or ball bearings to be cooled by a portion of cooling channels 21 that are in the housing around the outer race of the bearings 4, as in the top half
20 of figure 1.

Figure 3 shows an alternative embodiment of an impeller 5 according to the invention.

25 In this case the hub 11 is hollow with a number of hollow spaces 26.

Because the hub 11 is hollow, the hub 11 will have a lower weight with the aforementioned accompanying advantages.

At least a portion of the aforementioned channels 18 at least partially border one another in the peripheral direction.

- 5 It is also possible that alternatively at least a portion of the channels 18 at least partially coincide or overlap.

As shown in figure 3, the channels 18 that border one another in the peripheral direction are separated from one another by ribs 27 that extend radially or as good as
10 radially. In other words, the ribs 27 act as a separating wall between the various channels 18.

These ribs 27 will also strengthen the hub 11 of the
15 impeller 5.

By applying these ribs 27, the channels 18 can be made larger, without jeopardising the sturdiness of the hub 11.

- 20 In this case the rib 27 is constructed as a fan blade. Such ribs 27 will have a type of compressor action.

In figure 5 the top drawing shows the shape of the cross-section of such a rib 27.

25

The ribs 27 will have the effect that during the operation of the centrifugal impeller 5, the split-off air is compressed so that a good circulation of the split-off cooling air can be obtained.

30

Figure 4 shows an alternative embodiment of figure 3.

In this case the channels 18 do not bend, or hardly bend, in the radial direction Y-Y'. This means that in this case the distance B is approximately equal to the distance C.

5 The cross-section of the channel 18 does not vary either or barely varies.

It is also possible that the distance C is less than the distance B. This means that the channels 18 bend in the radial direction Y-Y' towards the shaft 13. In this last case the split-off air will expand due to the turbine action of the channels 18.

15 In this case the cross-section of the ribs 27 in the channels 18 is shown in the bottom drawing of figure 5.

The ribs 27 are constructed as turbine blades.

This means that they will bring about a certain pressure reduction of the split-off gas in its passage through the channel 18.

Such an application is used for example in the second stage of a two-stage compressor, whereby the air in the inlet 8 is already at a higher pressure and will be expanded by the turbine blades in the channels 18 to ambient pressure or approximately ambient pressure before being guided to the motor 6, the drive shaft 3 and the backup bearings for the cooling thereof.

An advantage of this is that the split-off gas that was compressed will be cooled by the expansion, so that it will be able to cool optimally.

- 5 An additional advantage is that the energy released during the expansion can be recuperated.

According to a particular aspect of the invention, the ribs 27 and/or blades 17 that form the channels 18 are
10 continuously connected to the blades 17 of the impeller 5, this is in contrast to what is described in DE 10.2007.021.934 in which there is a case of a first and a second set of blades that are missing in the case of the invention. Due to the design in the peripheral direction,
15 as illustrated in figure 5, and the axial direction, as shown in figures 3 and 4, it is possible to obtain a fan operation with a pressure increase and to obtain a turbine operation with an expansion with a pressure decrease.

- 20 In the examples shown above it is not excluded that the aforementioned ribs 27 are formed by a radial extension of the blades 17 of the impeller 5 towards the central shaft 13 up to the channels 18 or the hollow spaces 26.

- 25 In other words, the blades 17 as it were run through the channels 18. Of course the form, curvature, etc, of the ribs 27 in the channels 18 will differ from the form, curvature, etc, of the actual blades 17.

It is not excluded that only a portion of the ribs 27 are formed by a radial extension of the blades 17 and that this is not the case for a different portion of the ribs 27.

5 It is not excluded either that in the embodiment shown in figure 2, similar ribs 27 are provided in the channels 18 that extend radially or approximately radially to strengthen the hub 11 of the impeller 5. Note that in this case the ribs 27 do not act as a separating wall between
10 the different channels 18.

In the case of a centrifugal compressor such as in figure 6 with impellers 5 on either side of the electric motor 6, it is possible that one or both impellers 5 have a higher
15 inlet pressure than the ambient pressure. The pressure in the space 22 of the electric motor 6 is preferably close to ambient pressure (lowest pressure) so that the eddy losses due to air friction losses are a minimum. If one impeller draws in from the environment, the cooling air is
20 preferably provided via this impeller 5.

If the inlet pressure is higher than ambient pressure in both impellers, then in this case it is necessary to let the air expand via the internal channels 18 of the impeller
25 5. In order to have the best energy efficiency it is appropriate to start with the lowest pressure as less energy has been needed to reach this pressure. But, to obtain stronger cooling of the components that have the greatest heating, an expansion from a higher pressure is
30 appropriate. The expansion also yields a quantity of motive force that will relieve the electric motor 6.

It is clear that the invention is not only applicable to compressing air, but is also applicable to other gases.

5 The present invention is by no means limited to the embodiments described as an example shown in the drawings, but a centrifugal impeller according to the invention, a centrifugal machine according to the invention and a method for cooling a centrifugal machine can be realised in all
10 kinds of variants without departing from the scope of the invention.

Claims.

1.- Centrifugal impeller with a hub (11) with a hub surface
5 (12) and a central shaft (13), whereby this hub (11)
increases in diameter in the direction from an inlet side
(9) to an outlet side (10) of the impeller (5), whereby the
hub (11) is provided with a back wall (15) on the outlet
side (10), whereby the impeller (5) comprises a number of
10 protruding blades (17) that are provided on the hub surface
(12), characterised in that the hub (11) is provided with
channels (18) that extend from an input opening (19) in the
hub surface (12) to an output opening (20) in the back wall
(15), whereby these channels (18) split off a proportion of
15 the gas that is drawn in and guide it to the back wall (15)
of the impeller (5).

2.- Centrifugal impeller according to claim 1,
characterised in that at least a portion of the channels
20 (18) at least partially coincide or overlap or that at
least a portion of the channels (18) at least partially
border one another in the peripheral direction.

3.- Centrifugal impeller according to claim 1 or 2,
25 characterised in that ribs (27) are provided in the
aforementioned channels (18) that extend radially or
approximately radially to strengthen the hub (11) of the
impeller (5), or that the channels (18) that at least
partially coincide or overlap or border one another in the
30 peripheral direction are separated from one another by ribs
(27) that extend radially or approximately radially.

4.- Centrifugal impeller according to claim 3, characterised in that the aforementioned ribs (27) are constructed or designed as fan blades or as turbine blades.

5

5.- Centrifugal impeller according to claim 3 or 4, characterised in that at least a part of at least a portion of the aforementioned ribs (27) are formed by a radial extension of the blades (17) of the impeller (5) towards
10 the central shaft (13) up to the channels (18) or the hollow spaces (26).

6.- Centrifugal impeller according to any one of the previous claims, characterised in that the input opening
15 (19) in the hub surface (12) is at the location of the inlet side (9) or at a distance (A) from the inlet side (9) of the impeller and at a distance (B) from the central shaft (13).

20 7.- Centrifugal impeller according to claim 6, characterised in that the output opening (20) in the back wall (15) is at a distance (C) from the central shaft (13) that is greater than the aforementioned distance (B) between the central shaft (13) and the input opening (19).

25

8.- Centrifugal impeller according to claim 6, characterised in that the output opening (20) in the back wall (15) is at a distance (C) from the central shaft (13) that is less than the aforementioned distance (B) between
30 the central shaft (13) and the input opening (19).

9.- Centrifugal impeller according to any one of the previous claims, characterised in that the channels (18) have an essentially square or rectangular cross-section.

5 10.- Centrifugal impeller according to any one of the previous claims, characterised in that the cross-section of the channels (18) varies in the direction from the input opening (19) to the output opening (20).

10 11.- Centrifugal impeller according to any one of the previous claims, characterised in that the impeller (5) is produced by means of an additive production method.

12.- Centrifugal impeller according to any one of the
15 previous claims, characterised in that the number and the form of the channels (18) and input openings (19) is such that 10 percent to 35 percent of the gas drawn in can be split off and removed via the input openings (19), the channels (18) and the output openings (20).

20 13.- Centrifugal impeller according to any one of the previous claims, characterised in that the ribs (27) and/or blades (17) that form the channels (18) are such that they are continuously connected to the blades (17) of the
25 impeller (5).

14.- Centrifugal machine, characterised in that the centrifugal machine (1) is provided with a centrifugal impeller (5) according to any one of the previous claims,
30 driven by a motor (6) and mounted on bearings (4).

15.- Centrifugal machine according to claim 14,
characterised in that the proportion of the gas that is
drawn in via the channels (18) when the impeller (5) is
driven is used as a cooling gas for cooling the motor (6)
5 and/or the bearings (4).

16.- Centrifugal machine according to claim 15,
characterised in that for cooling the motor (6) and/or the
bearings (4), fixed cooling channels (21) are provided with
10 an input opposite which the output openings (20) of the
channels (18) open out and which guide the cooling gas to
the motor (6) and/or bearings (4).

17.- Centrifugal machine according to claim 16,
15 characterised in that the cooling gas originating from the
channels (18) in the impeller (5) is distributed over the
motor (6) and the bearings (4) via the aforementioned
cooling channels (21) in series or in parallel or in a
serial/parallel combination.

20

18.- Centrifugal machine according to claim 17,
characterised in that in the case of magnetic bearings,
these bearings (4) and the motor (6) are cooled in series.

25 19.- Centrifugal machine according to claim 17 or 18,
characterised in that in the case of air bearings, these
bearings (4) and the motor (6) are cooled in parallel.

20.- Centrifugal machine according to claim 17 or 18,
30 characterised in that in the case of roller bearings or

ball bearings with an outer race, the cooling channels (21) extend around the outer race.

21.- Centrifugal machine according to any one of the claims
5 14 to 20, characterised in that the cooling channels (21) are internal channels that are realised in the housing of the centrifugal machine (1).

22.- Centrifugal machine according to claim 21,
10 characterised in that the housing or a [missing words] by means of 3D printing, casting or by machining techniques, or by assembling different components that together form a channel.

15 23.- Centrifugal machine according to any one of the claims 14 to 22, characterised in that at the inlet of one or more of the fixed cooling channels (21) a stator blade or a restriction is provided to reduce the air speeds and build up the pressure.

20 24.- Centrifugal machine according to claim 23, characterised in that the aforementioned stator blades or restrictions are adjustable to control the quantity of cooling air, for example as a function of the motor load.

25 25.- Centrifugal machine according to claim 24, characterised in that the aforementioned stator blades or restrictions are adjustable to control the quantity of cooling air as a function of the motor load.

30 26.- Centrifugal machine according to any one of the claims

14 to 25, characterised in that motor (6) is provided at both of its ends with a centrifugal impeller (5) with internal channels (18), whereby each of these impellers (5) provides a part of the cooling of the motor (6) and the
5 bearings (4).

27.- Centrifugal machine according to any one of the claims 14 to 26, characterised in that the motor (6) is a high speed motor.

10

28.- Method for cooling a centrifugal machine (1), characterised in that use is made of a centrifugal machine (1) according to any one of the previous claims 14 to 27, whereby a proportion of the gas drawn in is split off via
15 the channels (18) in the centrifugal impeller (5) and guided to the back wall (15) of the impeller (5) so that the split-off gas can be used for cooling the centrifugal machine (1) via fixed channels (21) that guide the cooling gas to the motor (6) and/or the bearings (4).

20

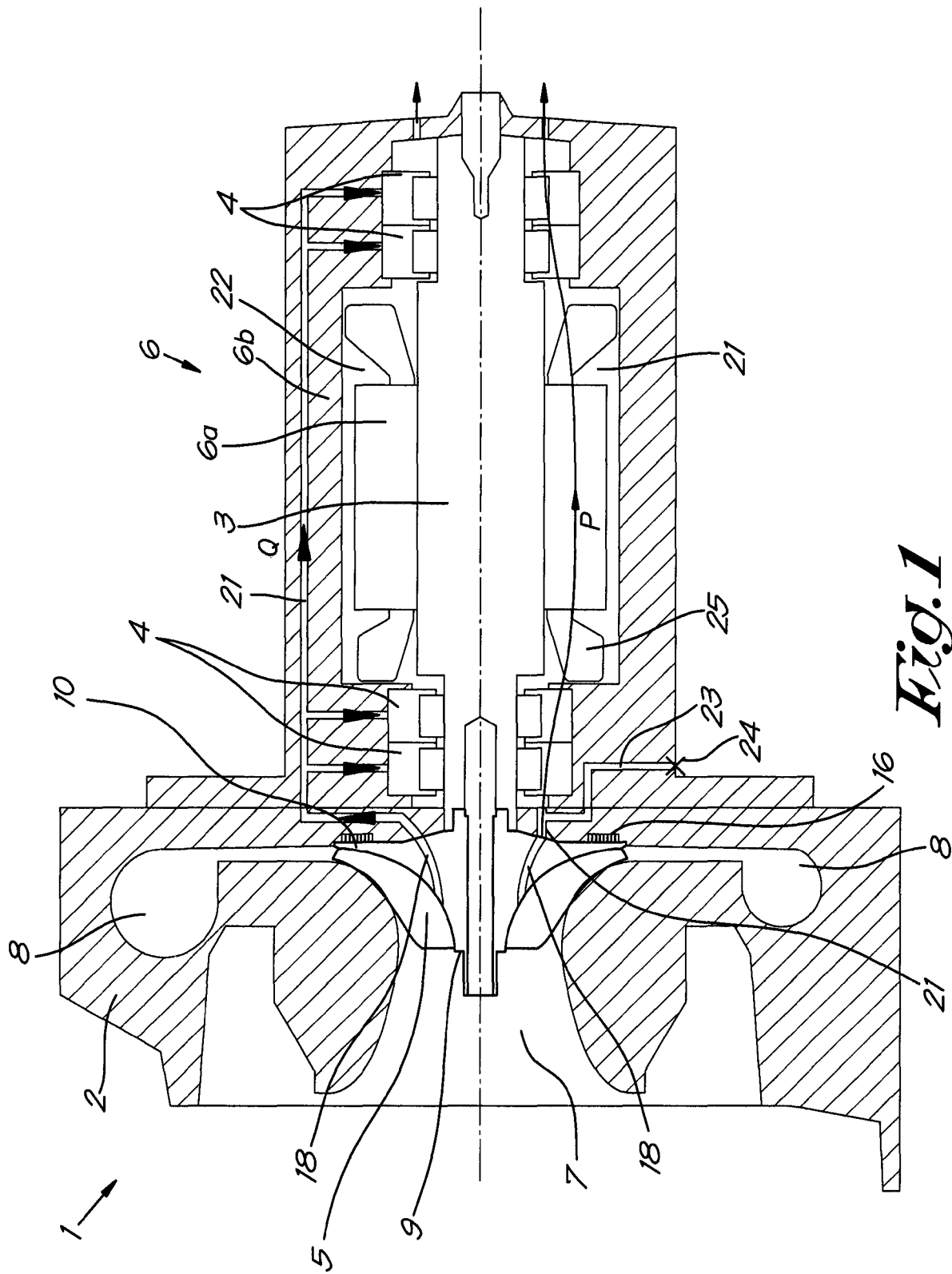
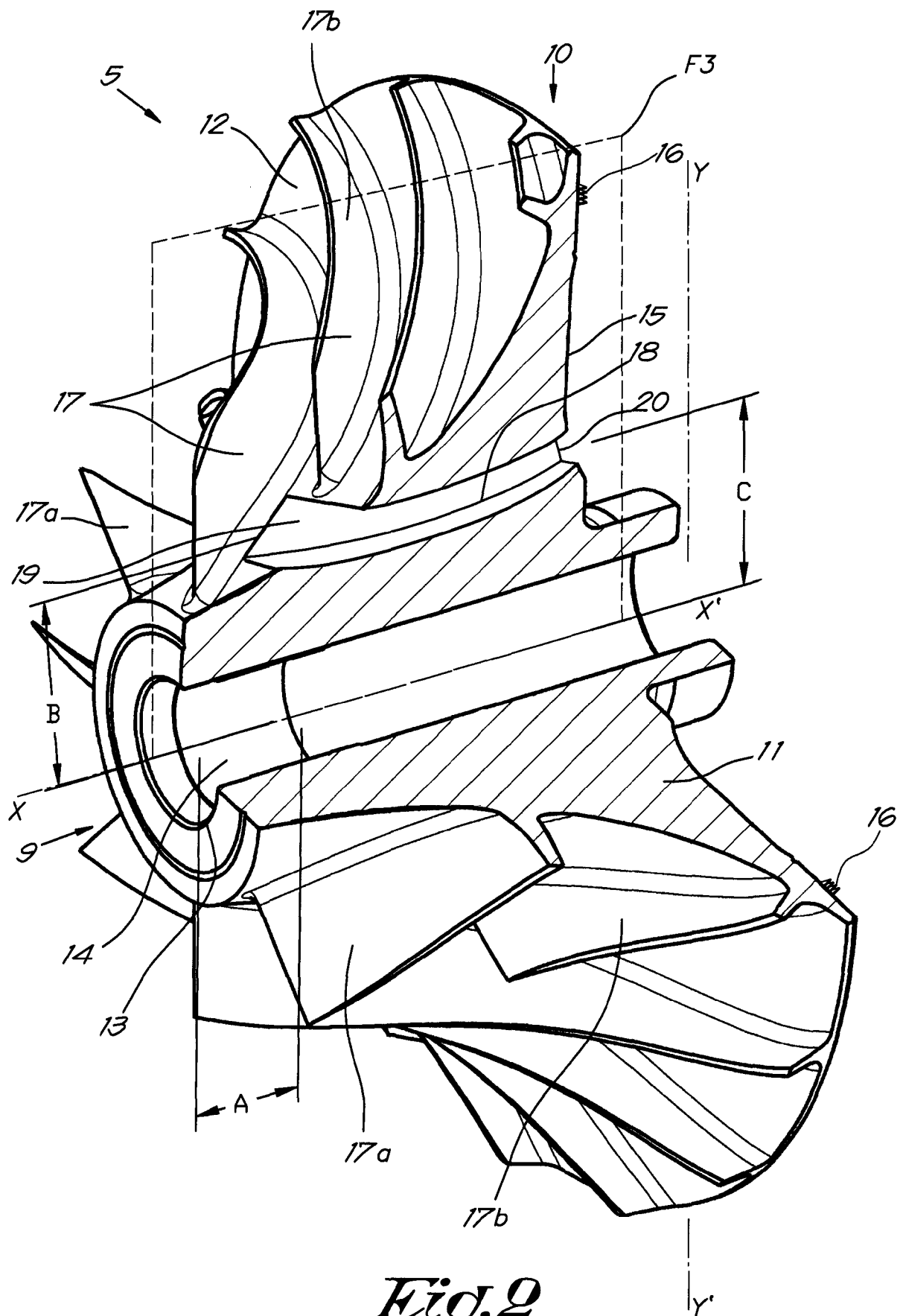
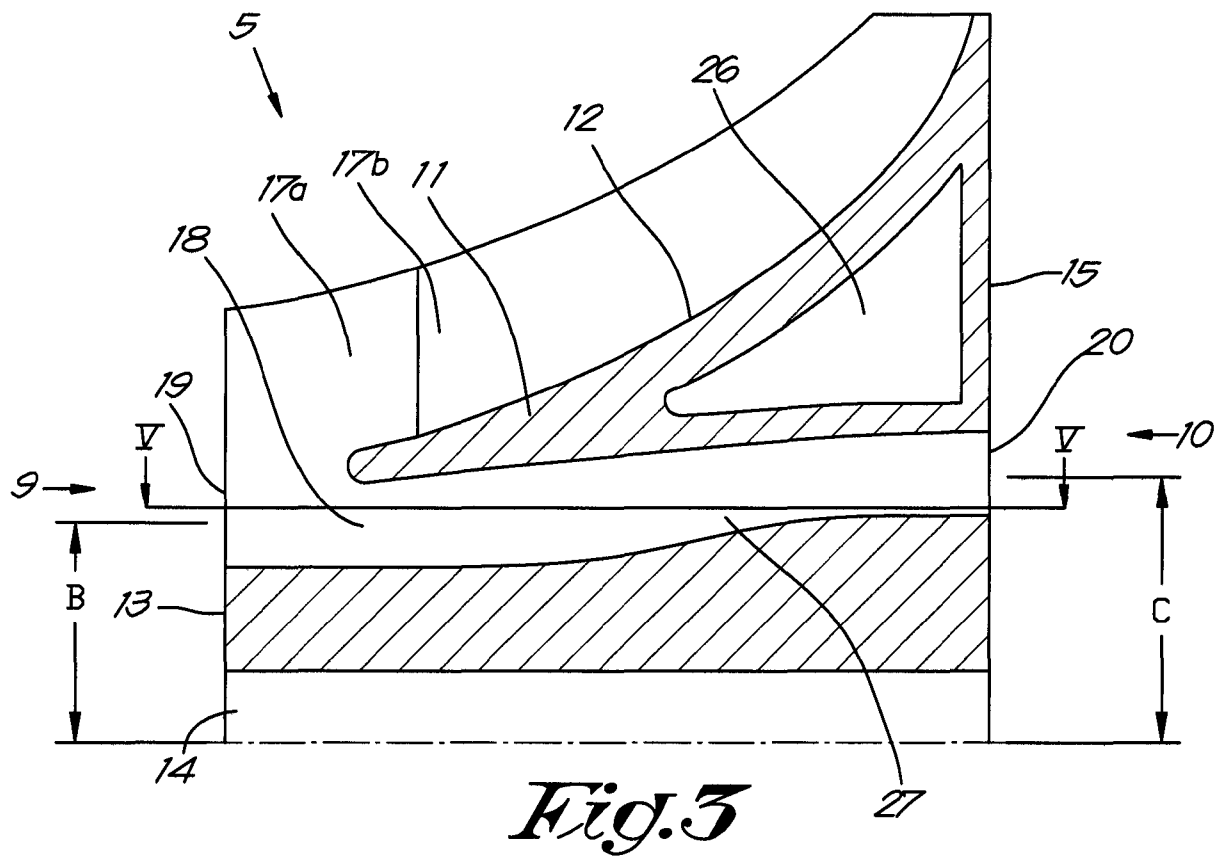
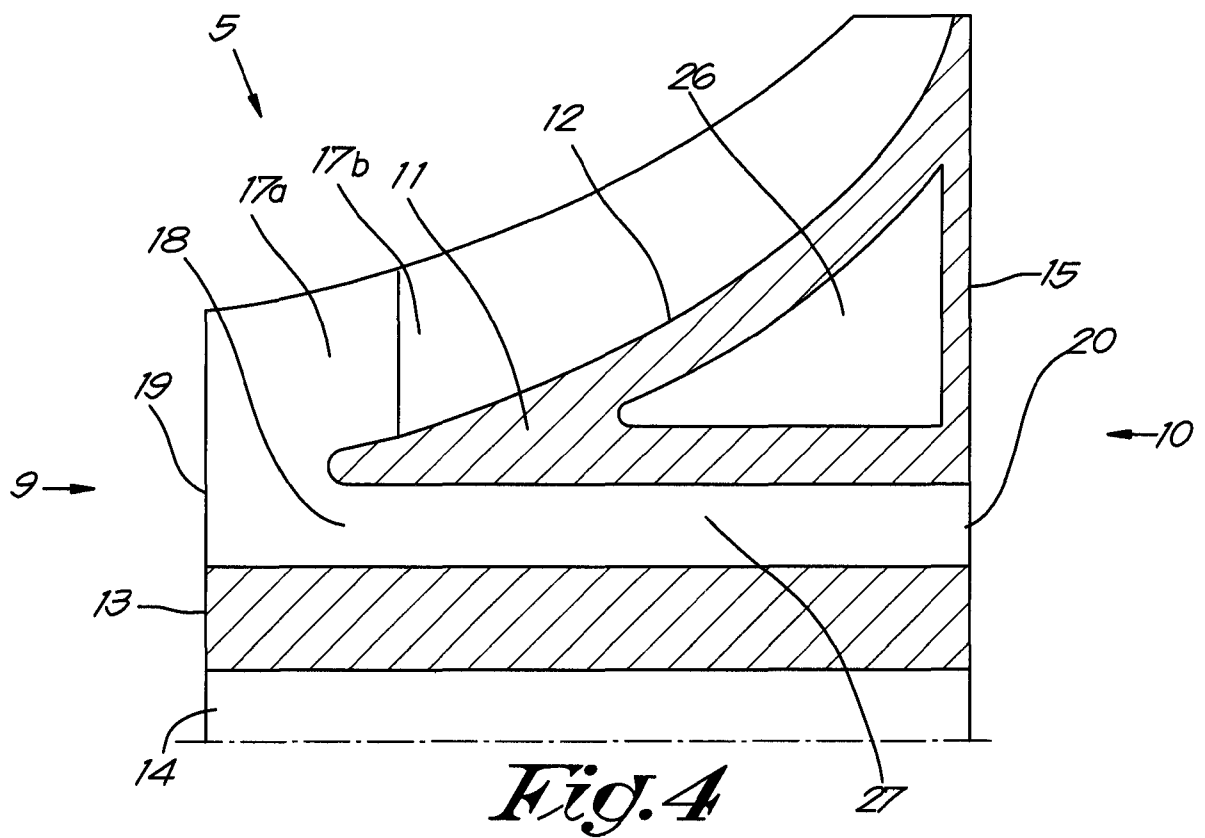


Fig. 1





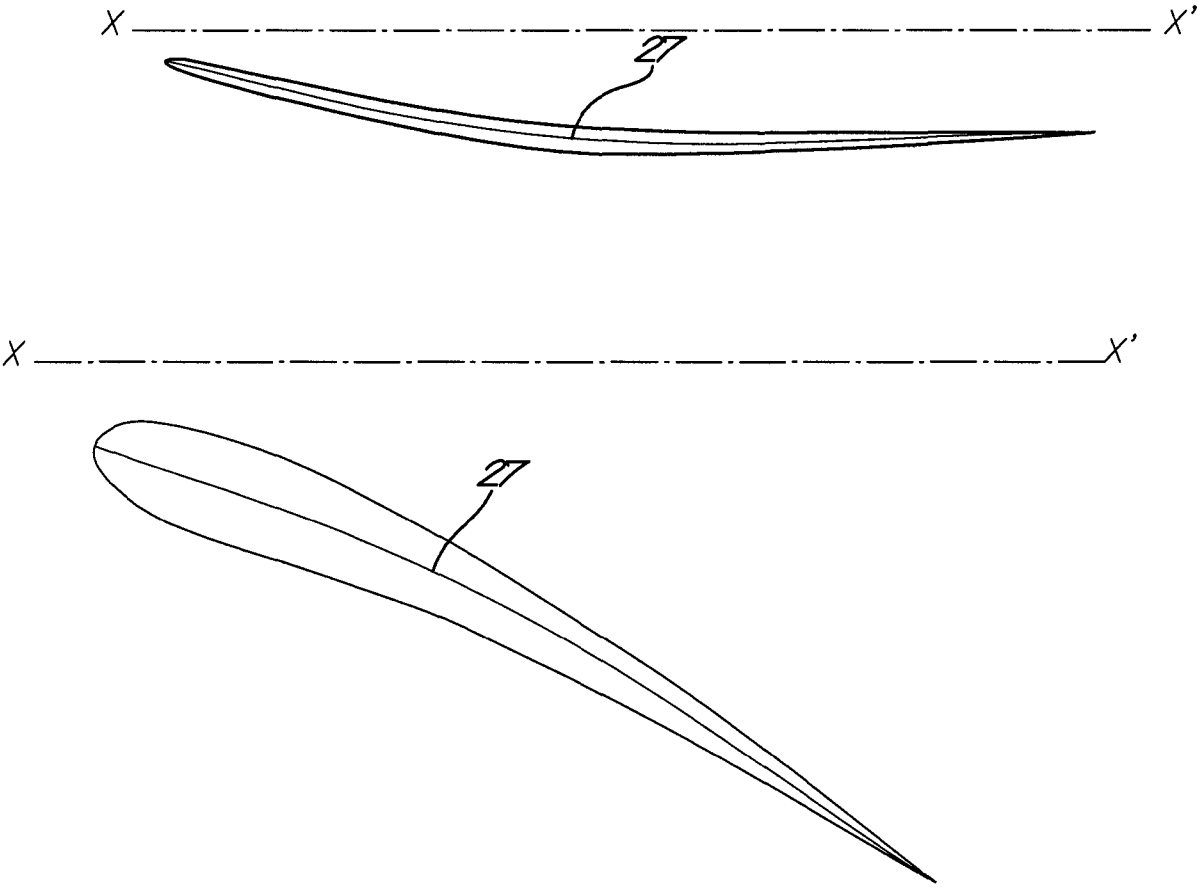


Fig.5

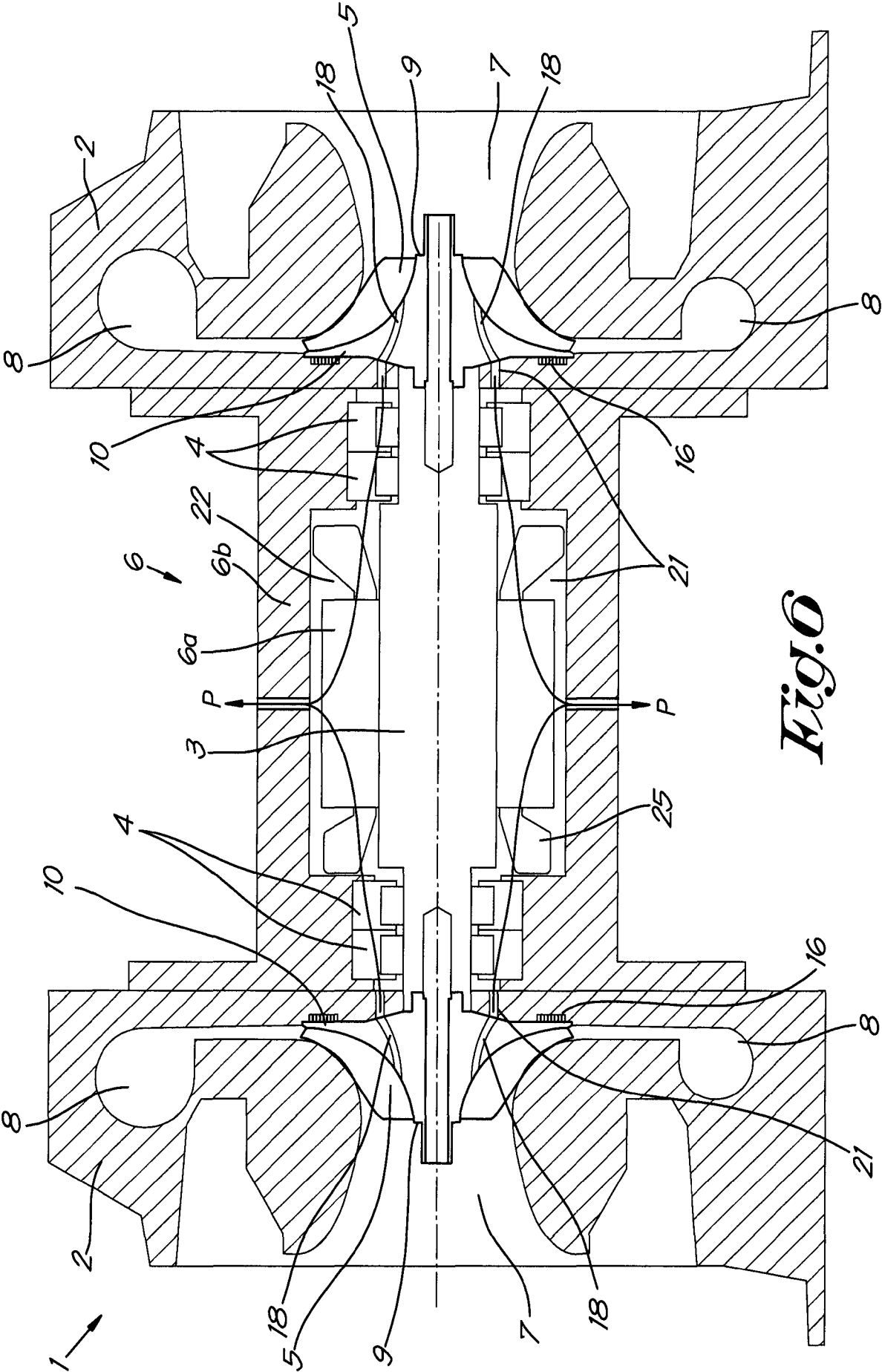


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/BE2016/000034

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04D29/28 F04D29/58 F04D25/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	paragraphs [0050] - [0054]; figure 1 -----	5,11
Y	US 5 108 261 A (RESS JR ROBERT A [US] ET AL) 28 April 1992 (1992-04-28) column 1, line 65 - column 2, line 6; figures 3,4 -----	5
Y	WO 2013/124314 A1 (NUOVO PIGNONE SRL [IT]) 29 August 2013 (2013-08-29) the whole document -----	11
X	US 2 620 123 A (PARDUCCI WILLIAM J) 2 December 1952 (1952-12-02) column 1, lines 39-44; figure 1 ----- -/-	1-3,6,8, 11-23, 27,28



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No

PCT/BE2016/000034

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	paragraph [0055]; figures 1-6 -----	24-26
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