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(71) Applicant: **OTICS Corporation**

Nishio-city

Aichi 444-0392 (JP)

(72) Inventor: **Isogai, Tomoyuki**

Nishio-city, Aichi 444-0392 (JP)

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(74) Representative: **Kramer - Barske - Schmidtchen**

Landsberger Strasse 300

80687 München (DE)

(54) **Turbocharger**

(57) According to the present invention, there is provided a turbocharger that can endure high-speed rotation and can be manufactured with high productivity.

The turbocharger including a turbine wheel (20), a compressor wheel (40) and a rotor shaft (10) that couples the turbine wheel and the compressor wheel and is rotatably supported in a bearing housing, which is charac-

terized in that a joint collar (30) having a groove portion on an outer periphery surface thereof, is interposed between the rotor shaft and the turbine wheel and couples the rotor shaft and the turbine wheel, the rotor shaft is made of a material having high rigidity, and the joint collar is made of a material having rigidity lower than that of the rotor shaft.

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a turbocharger.

Description of Related Art

[0002] A turbocharger mounted on a vehicle or the like is configured such that a compressor wheel and a turbine wheel are connected via a rotor shaft, the compressor wheel is forcibly rotated by rotating the turbine wheel with exhaust gas to suck and compress air, and the compressed air is discharged toward an internal combustion engine.

[0003] A joint portion to join the turbine wheel is formed on one end of the rotor shaft. An insertion portion to insert one end of the rotor shaft is formed on the shaft center of the turbine wheel, and the turbine wheel and the rotor shaft are joined to each other by inserting the one end of the rotor shaft into the insertion portion so as to align both shaft centers. Groove portions such as a slinger portion and a seal ring attaching portion are formed on an outer peripheral surface on the one end of the rotor shaft by cutting (Japanese Unexamined Patent Publication No. 2002-235547).

PRIOR ART DOCUMENT

Patent Documents

[0004]

Patent Document 1: JP 2002-235547 A

Patent Document 2: JP 2001-059146 A

SUMMARY OF THE INVENTION

[0005] Recently, high-speed rotation of the compressor wheel and the turbine wheel has been demanded in order to enhance performance of the turbocharger. However, in order to achieve the high-speed rotation, a critical speed has to be considered. The critical speed is defined to a revolution of the rotor shaft at the timing when the revolution of the rotor shaft matches its natural frequency or coincides with an integer multiple of the natural frequency. When the rotor shaft is deformed due to bending or twisting generated during axially rotating, it periodically repeats vibration (deformation), trying to return to the original shape. When the revolution of the rotor shaft becomes close to the critical speed, a resonance state is generated, and its amplitude gradually increases. Along with this, vibration noise also increases. When the amplitude exceeds a level of an elastic limit of the rotor shaft, plastic deformation occurs on the rotor shaft, which damages the turbocharger. Accordingly, in order to achieve

high-speed rotation while preventing the increase in the vibration noise and the damage, it can be proposed to increase the natural frequency of the rotor shaft to increase the critical speed.

[0006] The natural frequency of the rotor shaft is determined based upon its rigidity or mass. Therefore, in order to increase the natural frequency, it can be proposed to use a material having higher rigidity (ultra high rigidity material) in place of a conventional steel such as SCr 40 or SCM 35 as a material of the rotor shaft. The use of such high rigidity material increases the natural frequency of the rotor shaft, whereby the high-speed rotation can be realized.

[0007] As the ultra high rigidity material available for the material of the rotor shaft, Japanese Unexamined Patent Publication No. 2001-59146 describes an iron-base composite material in which a reinforcing phase containing boride of 4A group (titanium group) element as a main component is dispersed in a matrix containing iron as a main component. The ultra high rigidity material described above has rigidity higher than that of the conventional material of the rotor shaft. However, the ultra high rigidity material having excellent rigidity is extremely poor in machinability due to its rigidity. Therefore, the use of the ultra high rigidity material as the material of the rotor shaft causes very poor productivity to the rotor shaft, specifically, a life of a blade in a cutting device becomes extremely short, or much time and labor are needed for cutting, when forming a groove portion on the rotor shaft by cutting or rolling.

[0008] The present invention is accomplished in view of the foregoing background, and aims to provide a turbocharger that can endure high-speed rotation and can be manufactured with high productivity.

[0009] One aspect of the present invention is a turbocharger including a turbine wheel, a compressor wheel and a rotor shaft that couples the turbine wheel and the compressor wheel and is rotatably supported in a bearing housing, which is characterized in that a joint collar having a groove portion on an outer periphery surface thereof, is interposed between the rotor shaft and the turbine wheel and couples the rotor shaft and the turbine wheel, the rotor shaft is made of a material having high rigidity, and the joint collar is made of a material having rigidity lower than that of the rotor shaft.

[0010] In the aforesaid turbocharger, since the rotor shaft is made of a high rigidity material, the natural frequency can be increased. Therefore, the turbine wheel and the compressor wheel can be rotated with high speed, while preventing the vibration noise and the damage. Since the joint collar is made of a material having rigidity lower than that of the rotor shaft, the joint collar has machinability excellent more than that of the rotor shaft. Accordingly, it is possible to easily form the groove portion on the outer peripheral surface of the joint collar and at the same time to achieve high rigidity of the rotor shaft.

[0011] Further, in the aforesaid turbocharger, bending

or twisting of the rotor shaft is suppressed since the rotor shaft is made of the high rigidity material. As a result, the operation noise can be reduced, and further, the dynamic balance for the rotation of each wheel and the rotor shaft can easily be adjusted.

[0012] Furthermore, in the aforesaid turbocharger, the diameter of the rotor shaft can be made smaller than that of the conventional one since the rotor shaft is made of the high rigidity material. Accordingly, friction on the bearing portion of the rotor shaft can be reduced, and inertia (inertia moment) of the rotor shaft can be reduced. The weight of the rotor shaft can also be reduced, and the weight reduction enables to reduce the inertia of the rotor shaft. Consequently, the response of the turbocharger is improved.

[0013] As described above, the present invention can provide a turbocharger that can endure high-speed rotation, and can be manufactured with high productivity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a sectional view of a turbocharger according to an embodiment; and

Fig. 2 is a partially enlarged view of Fig. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0015] The turbocharger can be used to supply compressed air to an internal combustion engine in a vehicle or the like.

[0016] The rigidity of the rotor shaft and the rigidity of the joint collar can be compared based upon longitudinal elastic coefficients (Young's modulus) of the materials forming these members. As a material of the joint collar, a material having Young's modulus smaller than that of the material of the rotor shaft may be employed. As a material of the rotor shaft, a material having Young's modulus of, for example, 300 GPa or more, preferably from 300 GPa to 600 GPa, may be employed. As a material of the joint collar, a material having Young's modulus of, for example, from 180 GPa to 220 GPa, preferably from 190 GPa to 210 GPa, may be employed. Such material enables the high-speed rotation of the turbine wheel and the compressor wheel, and can secure necessary rigidity. The steel such as SCr 40 or SCM 35 used as the material of the conventional rotor shaft may be employed as the material of the joint collar.

[0017] In the turbocharger, the groove portion may be at least one of a slinger portion and a seal ring attaching portion.

[0018] According to this configuration, at least one of the slinger portion and the seal ring attaching portion can be easily formed, resulting in that productivity is enhanced. Both of or either one of the slinger portion and the seal ring attaching portion may be formed on the outer

peripheral surface of the joint collar.

[0019] In the turbocharger, the rotor shaft and the joint collar may be joined by welding.

[0020] According to this configuration, the rotor shaft and the joint collar can surely be joined, compared with the case where the rotor shaft and the joint collar are joined by press fitting or shrink fitting, resulting in that the reliability of the turbocharger is enhanced.

[0021] In the turbocharger, the turbine wheel is coupled to a first end, one end of the rotor shaft, via the joint collar, and the compressor wheel is fitted to a second end, the other end of the rotor shaft by press-fitting or shrink fitting.

[0022] According to this configuration, the joint portion between the rotor shaft and the compressor wheel requires less processing, compared with the case where the rotor shaft made of the high rigidity material with poor machinability is subjected to a threading process and the like, resulting in that the productivity is further enhanced.

[0023] In the turbocharger, the rotor shaft is made of titanium boride dispersed high rigidity steel.

[0024] According to this configuration, the rotor shaft has ultra high rigidity, and therefore, the natural frequency of the rotor shaft is high. Therefore, the turbine wheel and the compressor wheel can be rotated with sufficiently high speed. Further, since the bending and twisting of the rotor shaft can be sufficiently suppressed, the operation noise can be sufficiently reduced, and the dynamic balance for the rotation of each wheel and the rotor shaft can be more easily adjusted. And further, since the diameter of the rotor shaft can be made much smaller, friction on the bearing portion of the rotor shaft or the like can be sufficiently reduced, and inertia of the rotor shaft can be sufficiently reduced. The weight of the rotor shaft can also be reduced, and the weight reduction enables to reduce the inertia of the rotor shaft sufficiently. Consequently, the response of the turbocharger is further enhanced.

[0025] "Titanium boride (TiB₂) dispersed high rigidity steel" is an iron-base composite material in which a reinforcing phase containing boride of 4A group (titanium group) element as a main component is dispersed in a matrix containing iron as a main component. In the titanium boride (TiB₂) dispersed high rigidity steel, the reinforcing phase contains titanium diboride (TiB₂) as a main component, and a non-matrix phase other than the matrix phase contains borides other than the aforesaid titanium diboride (TiB₂) and/or titanium compounds as a main component.

Embodiment

[0026] An embodiment of the turbocharger will be described with reference to Figs. 1 and 2. The turbocharger 1 according to the present embodiment is mounted on a vehicle or the like, and as illustrated in Fig. 1, includes a turbine wheel 20, a compressor wheel 40, and a rotor shaft 10 that couples both wheels and is rotatably supported in a bearing housing 11. The rotor shaft 10 is made

of a high rigidity material. A joint collar 30 provided with a groove 31 on its outer peripheral surface, is interposed between the rotor shaft 10 and the turbine wheel 20 to couple the rotor shaft 10 and the turbine wheel 20. The joint collar 30 is made of a material having rigidity lower than that of the rotor shaft 10.

[0027] The components of the turbocharger 1 will be described below in detail.

[0028] As illustrated in Fig. 1, the rotor shaft 10 is housed in the bearing housing 11. The rotor shaft 10 is a rod member having a circular sectional shape in the shaft direction. As compared with a diameter of a portion (large-diameter portion 10a) from the center of the rotor shaft to a first end 13, one end of the rotor shaft, a diameter of a portion (small-diameter portion 10b) from the center to a second end 14, the other end of the rotor shaft is smaller. The rotor shaft 10 is rotatably supported by the bearing portion 12 on the large-diameter portion 10a. The rotor shaft 10 is made of titanium boride (TiB₂) dispersed high rigidity steel. The reinforcing phase of the steel contains titanium diboride (TiB₂) as a main component, and a non-matrix phase other than a matrix phase contains borides other than the titanium diboride (TiB₂) and/or titanium compounds as a main component.

[0029] The joint collar 30 is made of SCr 40. As illustrated in Fig. 2, the joint collar 30 is a cylindrical member having almost a cylindrical shape, and the inner diameter thereof is slightly larger than the outer diameter of the rotor shaft 10 on the first end 13. The first end 13 of the rotor shaft 10 is inserted into the cylindrical joint collar 30. An end 34 of the joint collar 30 opposite to an insertion side and the first end 13 of the rotor shaft 10 are aligned such that the end faces of both ends 13 and 34 are located on the same plane. The rotor shaft 10 and the joint collar 30 are joined by an electron beam welding applied to a boundary portion 13a positioned between both ends 13 and 34.

[0030] As illustrated in Fig. 2, the joint collar 30 is provided with a groove portion 31, which includes a slinger portion 32 and a seal ring attaching portion 33, on the outer peripheral surface. An insertion portion 36 is formed on one end (close to the turbine wheel 20) of the joint collar 30. As illustrated in Fig. 2, the sectional shape in the shaft direction of the slinger portion 32 is a dome-like curved surface, and the slinger portion is formed as a groove along the circumferential direction of the joint collar 30. With this structure, lubricating oil reaching the slinger portion 32 is scattered outside in the diameter direction by means of centrifugal force generated by the rotation of the rotor shaft 10 applied when the lubricating oil moves along the curved surface.

[0031] The cross section of the seal ring attaching portion 33 perpendicular to the shaft direction of the rotor shaft 10 is rectangle in shape, and the seal ring attaching portion 33 is formed as a groove along the circumferential direction of the joint collar 30. The seal ring attaching portion 33 is formed closer to the first end 13 than the slinger portion 32, and faces a wall face 11a of the bearing

housing 11. An annular member 35 along the groove shape of the seal ring attaching portion 33 is fitted to the seal ring attaching portion 33 to seal the space with the wall face 11a of the bearing housing 11.

[0032] The insertion portion 36 is formed closer to the first end 13 than the seal ring attaching portion 33. The cross section of the insertion portion 36 perpendicular to the shaft direction of the rotor shaft 10 is an L-shape, and the insertion portion 36 is formed along the circumferential direction of the joint collar 30. With this structure, a step is formed on the end 34 of the joint collar 30 in the diameter direction, so that the diameter of the outer periphery is decreased.

[0033] The turbine wheel 20 is a cast member made of nickel alloy. As illustrated in Fig. 2, the turbine wheel 20 is provided with a concave portion 21 along the outer shape of the insertion portion 36 of the joint collar 30. The center of the concave portion 21 matches the shaft center of the turbine wheel 20, and the depth of the concave portion 21 is slightly larger than the length of the insertion portion 36 in the shaft direction. The insertion portion 36 is inserted into the concave portion 21 in such a manner that the shaft center of the turbine wheel 20 and the shaft center of the joint collar 30 match each other. The joint collar 30 and the turbine wheel 20 are welded by the electron beam welding on a boundary portion 22a between an edge 22 of the concave portion 21 and the joint collar 30. Thus, the rotor shaft 10 and the turbine wheel 20 are coupled via the joint collar 30.

[0034] As illustrated in Fig. 1, the turbine wheel 20 is housed in the turbine housing 23. The turbine housing 23 is provided with a scroll chamber 24 that guides exhaust gas discharged from an internal combustion engine (not illustrated) to the turbine wheel 20, and an exhaust port 25 from which the exhaust gas is exhausted to the outside of the turbine housing 23.

[0035] The compressor wheel 40 is a cast member made of aluminum alloy. As illustrated in Fig. 1, the compressor wheel 40 is provided with a shaft hole 42 on the shaft center thereof. The shaft hole 42 is a cylindrical hole with a circular section. The small-diameter portion 10b of the rotor shaft 10, which is positioned close to the second end 14, is inserted into the shaft hole 42, and the small-diameter portion 10b and the shaft hole 42 are bonded with each other by shrink fitting. Specifically, the compressor wheel 40 is formed such that the shaft hole 42 has a diameter slightly smaller than the diameter of the small-diameter portion 10b of the rotor shaft 10 before bonded. Then, the material of the compressor wheel 40 is expanded by heating the compressor wheel 40 to a high temperature, and with this expansion, the diameter of the shaft hole 42 becomes larger than the diameter of the small-diameter portion 10b. Thereafter, the small-diameter portion 10b of the rotor shaft 10 is inserted into the shaft hole 42 the diameter of which has become large. And then, as the compressor wheel 40 is cooled down, the material of the compressor wheel is contracted, and with this contraction, the inner wall of the shaft hole 42

becomes in intimate contact with the small-diameter portion 10b of the rotor shaft 10 so as to be firmly fitted to each other. As a result, the compressor wheel 40 is joined to the second end 14 of the rotor shaft 10.

[0036] In the turbocharger 1 according to the present embodiment, the rotor shaft 10 is made of titanium boride (TiB₂) dispersed high rigidity steel, the Young's modulus of which is about 345 GPa. The joint collar 30 is made of SCr 40, the Young's modulus of which is about 205 GPa. Accordingly, the Young's modulus of the joint collar 30 is smaller than the Young's modulus of the rotor shaft 10, which means the joint collar 30 is made of a material having rigidity lower than that of the rotor shaft 10.

[0037] The outer shape of the rotor shaft 10 can be completed before joining the rotor shaft 10 to the joint collar 30 and the compressor wheel 40. For example, the large-diameter portion 10a and the small-diameter portion 10b of the rotor shaft 10 can be formed by centerless grinding. Accordingly, the rotor shaft 10 made of ultra high rigidity material can be mass-produced with high forming precision. After the outer shape is completed, the rotor shaft 10 is joined to the joint collar 30 to couple with the turbine wheel 20 and is joined to the compressor wheel 40, as described above.

[0038] The operation and effect of the turbocharger 1 will be described next in detail.

[0039] In the turbocharger 1, the rotor shaft 10 is made of a high rigidity material, whereby the natural frequency of the rotor shaft can be increased. Therefore, the turbine wheel 20 and the compressor wheel 40 can be rotated with high speed, while preventing the vibration noise and the damage. The joint collar 30 is made of a material having rigidity lower than that of the rotor shaft 10, and the joint collar 30 made of such a material has more excellent machinability than the rotor shaft 10. Therefore, the groove portion 31 including the slinger portion 32 and the seal ring attaching portion 33, can easily be formed, resulting in that productivity is enhanced. As described above, the turbocharger 1 can endure high-speed rotation, and can be manufactured with high productivity.

[0040] In addition, according to the turbocharger 1, the bending or twisting of the rotor shaft 10 is suppressed, since the rotor shaft 10 is made of the high rigidity material. Consequently, the operation noise can be reduced to a lower level in comparison with the conventional turbocharger, and further, the dynamic balance for the rotation of the turbine wheel 20, the compressor wheel 40, and the rotor shaft 10 can be easily adjusted.

[0041] Since the rotor shaft 10 is made of the high rigidity material, the diameter of the rotor shaft 10 can be made smaller than that of the conventional one. Accordingly, friction on the bearing portion of the rotor shaft 10 can be reduced, and inertia (inertia moment) of the rotor shaft 10 can be reduced. The weight of the rotor shaft 10 can also be reduced, and the weight reduction enables to reduce the inertia of the rotor shaft 10. Consequently, the response of the turbocharger 1 is enhanced.

[0042] In the turbocharger 1, the rotor shaft 10 and the

joint collar 30 are joined by welding. According to this configuration, the rotor shaft 10 and the joint collar 30 can surely be joined, compared with the case where the rotor shaft and the joint collar are joined by press fitting or shrink fitting, resulting in that the reliability of the turbocharger 1 is enhanced.

[0043] In the turbocharger 1, the first end 13, one end of the rotor shaft 10 is coupled to the turbine wheel 20 via the joint collar 30, while the second end 14, the other end of the rotor shaft 10 is bonded to the compressor wheel 40 by shrink fitting. According to this configuration, the joint portion between the rotor shaft 10 and the compressor wheel 40 requires less processing, compared with the case where the rotor shaft 10 made of the high rigidity material with poor machinability is subjected to a threading process and the like, resulting that the productivity is further enhanced.

[0044] In the turbocharger 1, the rotor shaft 10 is made of titanium boride dispersed high rigidity steel. According to this configuration, the rotor shaft 10 has ultra high rigidity, and therefore, has a high natural frequency. Therefore, the turbine wheel 20 and the compressor wheel 40 can be rotated with sufficiently high speed. The bending and twisting of the rotor shaft 10 can be sufficiently suppressed. As a result, the operation noise can be sufficiently suppressed, and the dynamic balance for the rotation of the turbine wheel 20, the compressor wheel 40, and the rotor shaft 10 can be easily adjusted. In addition, the diameter of the rotor shaft 10 can be made smaller, and therefore, friction on the bearing portion of the rotor shaft 10 can be sufficiently reduced, and inertia of the rotor shaft 10 can be sufficiently reduced. The weight of the rotor shaft 10 can also be reduced, and the weight reduction enables to reduce the inertia of the rotor shaft 10 sufficiently. Consequently, the response of the turbocharger 1 is further enhanced.

[0045] In the present embodiment, the rotor shaft 10 and the compressor wheel 40 are joined by shrink fitting. However, instead of the shrink fitting, the second end 14 of the rotor shaft 10 can be press-fitted to the shaft hole 42 of the compressor wheel 40 to join the rotor shaft 10 and the compressor wheel 40. According to this configuration, the joint portion between the rotor shaft 10 and the compressor wheel 40 requires less processing, compared with the case where the rotor shaft 10 made of the high rigidity material with poor machinability is subjected to a threading process and the like, resulting in that the productivity is further enhanced.

It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of re-

stricting the claimed invention, in particular as limits of value ranges

Claims

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1. A turbocharger comprising:

a turbine wheel;
 a compressor wheel; and 10
 a rotor shaft that couples the turbine wheel and the compressor wheel and is rotatably supported in a bearing housing,
characterized in that
 a joint collar having a groove portion on an outer periphery surface thereof, is interposed between the rotor shaft and the turbine wheel and couples the rotor shaft and the turbine wheel, the rotor shaft is made of a material having high rigidity, and 20
 the joint collar is made of a material having rigidity lower than that of the rotor shaft.

2. The turbocharger according to claim 1, wherein the groove portion is at least one of a slinger portion and a seal ring attaching portion. 25

3. The turbocharger according to claim 1 or 2, wherein the rotor shaft and the joint collar are joined by welding. 30

4. The turbocharger according to any one of claims 1 to 3, wherein the turbine wheel is coupled to a first end, one end of the rotor shaft, via the joint collar, and the compressor wheel is fitted to a second end, the other end of the rotor shaft by press-fitting or shrink fitting. 35

5. The turbocharger according to any one of claims 1 to 4, wherein the rotor shaft is made of titanium boride dispersed high rigidity steel. 40

6. The turbocharger according to any one of claims 1 to 5, wherein the rotor shaft is made of a material having Young's modulus of 300 GPa or more. 45

7. The turbocharger according to claim 6, wherein the rotor shaft is made of a material having Young's modulus of from 300 GPa to 600 GPa. 50

8. The turbocharger according to any one of claims 1 to 7, wherein the joint collar 30 is made of a material having Young's modulus of 220 GPa or less.

9. The turbocharger according to claim 8, wherein the joint collar 30 is made of a material having Young's modulus of from 180 GPa to 220 GPa. 55

FIG. 1

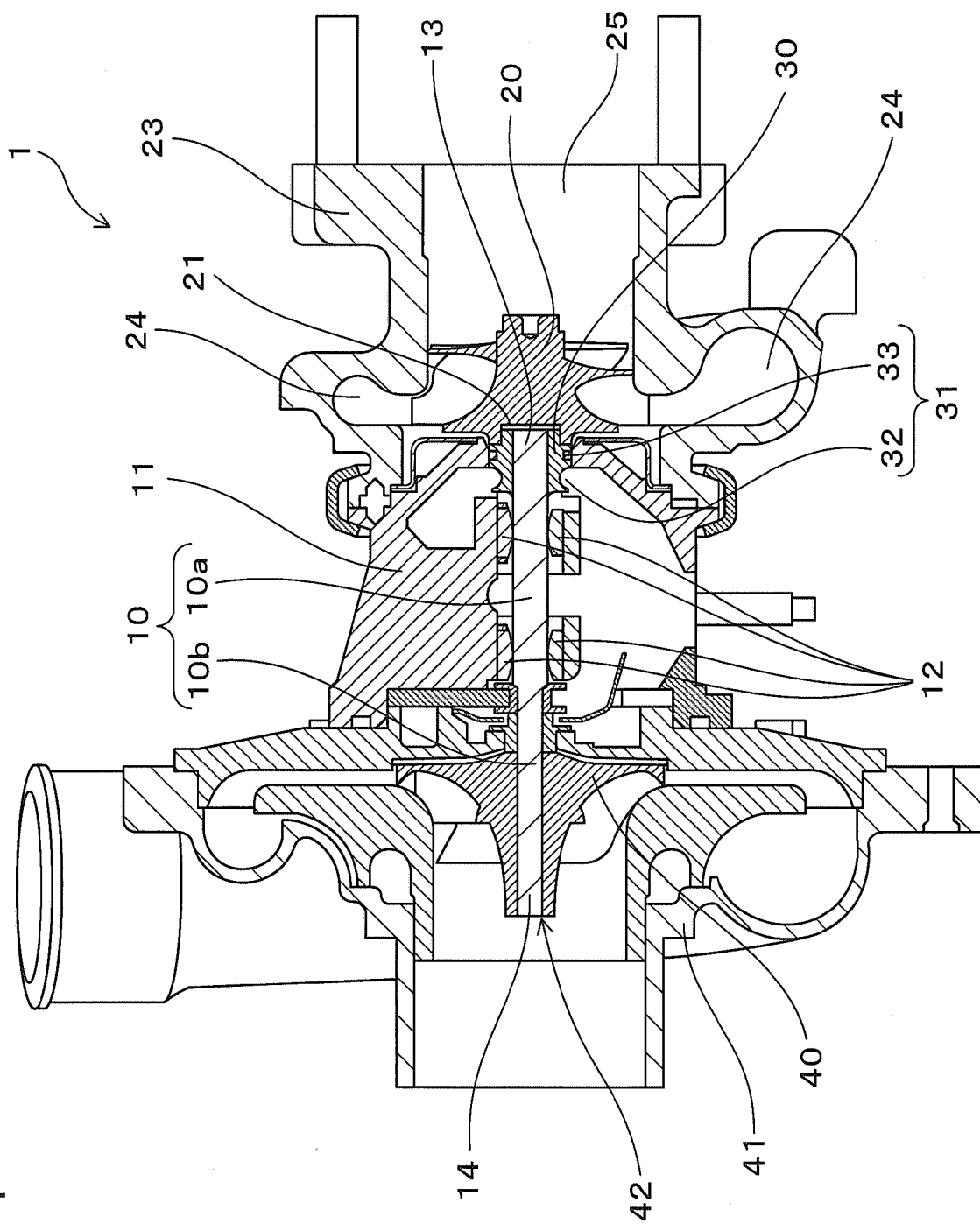
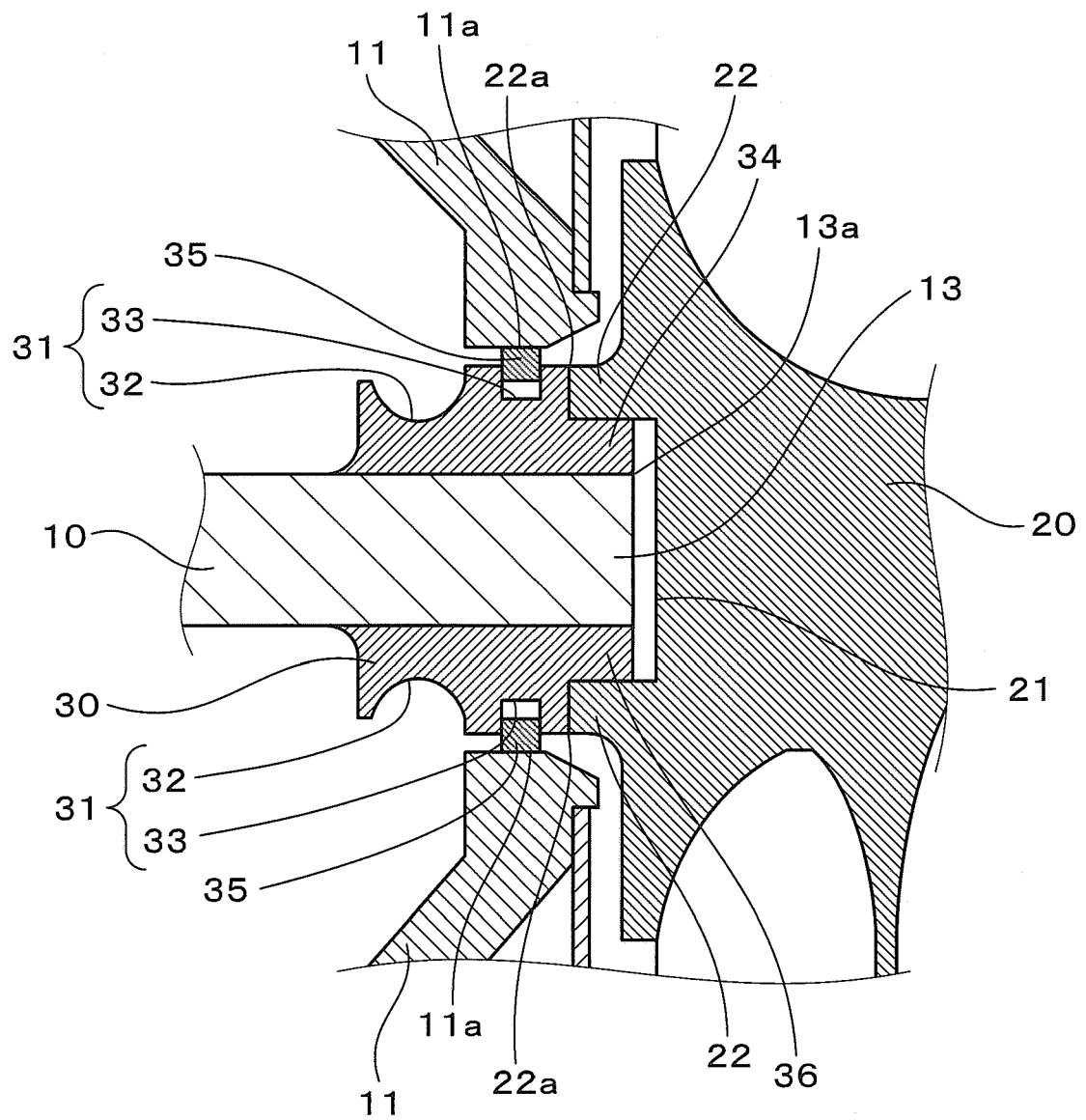


FIG. 2





EUROPEAN SEARCH REPORT

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EP 14 16 3827

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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