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(54) TURBO MACHINE AND METHOD OF MANUFACTURING

(57) The invention relates to a turbo machine turbo machine comprising an impeller, a bearing, a shaft, an impeller-sided bearing part (150) and a bearing carrier (154), wherein said impeller is arranged on said shaft, wherein said shaft is supported by said bearing and wherein said bearing is supported in and, at least partly, enclosed by said bearing carrier (154), wherein the turbo machine further comprises one or more connecting structures (160), wherein said impeller-sided bearing part (150) and said bearing carrier (154) are spatially spaced apart from each other and connected to each other by said one or more connecting structures (160), and wherein the turbo machine further comprises one or more isolation areas (162) between said impeller-sided bearing part (150) and said bearing carrier (154) and adjoining said one or more connecting structures (160). The invention also relates to a method of manufacturing such a turbo machine.

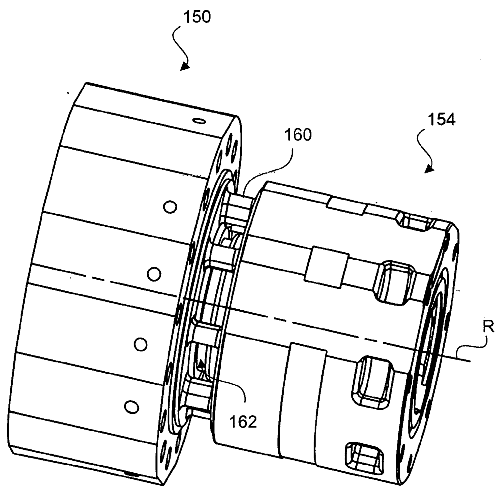

Fig. 3

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Description

[0001] The present invention relates to turbo machine, e.g., a cryogenic turbo machine, with an impeller mounted on a shaft, and to a method of manufacturing such turbo machine.

Background

[0002] Turbo machines can be used in different applications. For example, in cryogenic applications, i.e. applications with process gases at cryogenic temperatures, e.g., plants for air separation or the like, cryogenic turbo machines like turbo expanders and/or compressors are often used. Such turbo machines typically comprise an expander impeller and/or a compressor impeller, which are fixed on a shaft.

[0003] Such turbo machines typically also comprise an inlet or inlet channel configured to guide operating fluid, e.g., gas (or a fluid) like the mentioned process gas, to such impeller, and an outlet or outlet channel configured to guide said operating fluid, e.g., after expansion, from that impeller, e.g., to the outside. While the impeller of the turbo machine and a corresponding impeller-sided bearing part (might be kind of a casing) are subject to very cold temperatures, the shaft, its bearing and a corresponding bearing carrier are typically subject to ambient or at least warmer temperatures; bearings, e.g. can even be warmer than ambient temperature. This can lead to massive heat input from the cold to the warm parts, depending on the specific temperatures. It is therefore an object of the present invention to provide an improved turbo machine.

Disclosure of the invention

[0004] This object is achieved by providing a turbo machine and a method of manufacturing such a turbo machine with the features of the independent claims. Embodiments of the invention are the subject of the dependent claims and of the description that follows.

[0005] The invention relates to turbo machines, in particular cryogenic turbo machines, like turbo compressors or turbo expanders with an impeller arranged or mounted on a shaft. Types of turbomachines are, for example, centrifugal turbo machines and radial turbo machines. Such a turbo machine comprises an impeller, a bearing, a shaft, an impeller-sided bearing part and a bearing carrier. Said impeller is arranged on said shaft and said impeller can, at least partly, be enclosed by said impeller-sided bearing part. Further, said shaft is supported by said bearing and said bearing is supported in and, at least-partly, enclosed by said bearing carrier.

[0006] Further, such a turbo machine typically comprises an inlet (or inlet channel) configured to guide operating fluid, e.g., from an inlet opening, to said impeller, and an outlet or outlet channel configured to guide operating fluid from said impeller, e.g., to an outlet opening. Cryogenic turbo machines are used with operating fluid like gases or process gases (or fluids or process fluids) at cryogenic temperatures, i.e., very low temperatures of, e.g., less than -100°C or even down to -230°C or -250°C at the expander outlet or at the compressor inlet. Depending on the kind of turbo machine, such gases are compressed and/or expanded. Turbo machines in other applications can also be used with operating fluids at higher temperatures.

[0007] In a radial turbo machine, for example, the impeller-sided bearing part (enclosing the expansion impeller) is connected to the bearing carrier and the cold power can be extracted through a compressor impeller or through a generator connected to or arranged on said shaft. Such generator can, for example, also be connected via a gear box. The cold power could, e.g., also be extracted via a brake. In such a radial turbo machine, the fluid is expanded from high-pressure level to low pressure level. This expansion produces a high difference of temperature between the inlet (high-pressure area) and the outlet (low-pressure area). Typical values for hydrogen gas as operating fluid are, for example, an inlet temperature of -230°C and an outlet temperature at -245°C, leading to a very low temperature in the expander impeller-sided bearing part.

[0008] In order to achieve an adequate isentropic efficiency and to maintain a positive temperature at the bearing level, the heat intakes have to be reduced as much as possible.

[0009] It has now been recognized that such heat input can be reduced by providing the turbo machine with one or more connecting structures, e.g., rods or other support structures, and wherein said impeller-sided bearing part and said bearing carrier are spatially spaced apart from each other and connected to each another by said one or more connecting structures. Further, the turbo machine is provided with one or more isolation areas between said impeller-sided bearing part and said bearing, which one or more isolation areas adjoin said one or more connecting structures; said one or more isolation areas can be free of solid material.

[0010] This allows to reduce the cold transfer through the shaft and avoiding hydrogen (or other operating fluid) leakages from the high-pressure part to the low-pressure part (the bearing carrier). This also allows to minimize the heat intakes from the warm bearing carrier side to the cryogenic (expander) side.

[0011] In an embodiment, the turbo machine further comprises an enclosure configured to hermetically enclosing said one or more connecting structures and form said one or more isolation areas. Depending on the configuration of the connecting structures, there can, for example, be a single isolation area also surrounding all connecting structures. Such enclosure can have, for example, two parts, formed as rings and enclosing the connecting structures from the inner and outer side. For a detailed example, please refer to the Figs.

[0012] In an embodiment, said one or more isolation areas are evacuated to a pressure less than ambient pressure, preferably, less than 100 mbar. This further reduces heat transfer due to low heat transfer coefficients of low pressure gas and due to no or almost no convection. Note that an evacuation of said one or more isolation areas, should be as good as possible. A pure vacuum, however, will typically not be achieved. Nevertheless, pressures of, e.g., below 10 mbar or below 1 mbar can be considered a vaccum. Further note that said one or more isolation areas can also be filled with particular gases of low heat transfer coefficients and of low pressure.

[0013] In an embodiment, the turbo machine comprises more of said connecting structures, and said more connecting structure are spaced apart from each other, e.g., equally, and arranged annularly around the shaft. I this way, a stiff and robust connection between the impeller-sided bearing part and the bearing carrier can be provided.

[0014] In an embodiment, said impeller-sided bearing part, said bearing carrier and said one or more connecting structures form parts of a component made of a single piece, e.g. by casting. In this way, potential parts with higher heat transfer coefficients like welding seams or the like can be prevented. In other embodiments, said impeller-sided bearing part, said bearing carrier and said one or more connecting structures can be connected by welding or other means

[0015] The bearing carrier can be equipped with oil bearings, roller bearings, gas bearings or magnetic bearings; depending on the type of bearing, the bearing carrier can be formed or configured correspondingly.

[0016] This invention allows to reduce the heat intakes from the warm bearing carrier side to the cryogenic (expander) side. The impeller (expander) casing which often has a temperature close to -200°C is connected though reduced number of local connecting structures (brackets), to the bearing carrier which is, typically, at ambient temperature. The thermal conduction section is reduced and the heat transfer between the two parts is maintained at a low level.

[0017] In order to reduce also the thermal convection effect, the connection between the impeller-sided bearing part and the bearing carrier can be closed hermetically and a vacuum can be created inside this chamber to avoid any convection. In an embodiment an anti-radiation sheet can be provided in this chamber to further reduce heat transfer.

[0018] This connection system between cryogenic side and warm side of the turbo machine allows to maintain the heat intakes at a low level in order to increase the efficiency of the expansion and to maintain a positive temperature at the -bearing level located on impeller (expander) side.

[0019] Further advantages and embodiments of the invention will be apparent from the description and the accompanying drawing. The invention is illustrated schematically by means of embodiments in the drawing and is described below with reference to the drawing.

[0020] This concept is applicable for cryogenic turbo or rotating machines, like radial cryogenic expanders connected to an oil break or to a generator, turboexpanders, centrifugal compressors, axial turbines, operating at cryogenic temperature and where there is need to minimize the heat transfer from the bearing carrier to the impeller-sided bearing part (machine housing). The concept is, in particular, applicable for cryogenic gases like hydrogen but can also be used for other cryogenic gases like helium or other ones.

[0021] Short description of the figures

Fig. 1 illustrates a turbo machine according to an embodiment of the invention.

Fig. 2 illustrates parts of the turbo machine of Fig. 1.

Fig. 3 illustrates parts of the turbo machine of Fig. 1 in a perspective view.

Fig. 4 illustrates a manufacturing method according to an embodiment of the invention.

Detailed description of the figures

[0022] Fig. 1 schematically illustrates a turbo machine 100 according to an embodiment of the invention. The turbo machine 100, e.g., a cryogenic turbo machine is, by means of example, configured as a compressor and an expander, i.e., both are combined in one turbo machine.

[0023] Turbo machine 100 comprises, hence, two impellers, an impeller 110 and an impeller 120, both mounted on a shaft 130. The turbo machine 100 comprises channels 112 and 114 on the side of the impeller 110, the channels used respectively as inlet channel and outlet channel for the operating fluid to be compressed. The turbo machine 100 further comprises channels 122 and 124 on the side of the impeller 120, the channels used respectively as inlet channel and outlet channel for the operating fluid to be expanded. Thus, the impeller 110 is a compressor impeller and the impeller 120 is an expander impeller. The operating fluid to be compressed and the operating fluid to be expanded can have identical or can have different properties like pressure, temperature, chemical composition etc.

[0024] It is noted that a turbo machine could also have only one impeller mounted on one end of shaft and an electric machine, e.g., a generator or alternator, mounted on the other end of the shaft.

[0025] Further, the turbo machine 100 comprises a bearing 140 and, e.g., further bearing 142, for supporting said shaft 130. In the example shown, bearing 140 is provided on the side of the impeller 110, and bearing 142 is provided on the side of the impeller 120.

[0026] Further, the turbo machine 100 comprises an impeller-sided bearing part 150 (this can be, e.g., in the form of a casing or a plate) and a bearing carrier 154. The impeller-sided bearing part 150 encloses, for example, impeller 110 at least partly. Another impeller-sided bearing part 152, for example, can enclose impeller 120 at least party. The bearing carrier 154 supports said bearing 140 and, e.g., also bearing 142. In addition, said bearing carrier 154 also encloses, at least partly, said bearing 140 and, e.g., also bearing 142.

[0027] The impeller-sided bearing part 150 and the bearing carrier 154 are illustrated only very schematically in Fig. 1. More detailed views are shown in Fig. 2 and Fig. 3.

[0028] Fig. 2 shows parts of the turbomachine 100 in more detail; in particular, the impeller-sided bearing part 150 and the bearing carrier 154 are shown, in addition to the shaft 130, the impeller 110 and the bearing 140. A rotation axis R is shown for better understanding.

[0029] Fig. 3 shows also parts of the turbomachine 100 in more detail and in a perspective view; in particular, the impeller-sided bearing part 150 and the bearing carrier 154 are shown. The rotation axis R is also shown for better understanding.

[0030] The turbo machine further comprises, as shown in Figs. 2 and 3, several connecting structures 160, which are, for example, rod shaped; only one of these connecting structures 160 is visible in the cross-section of Fig. 2, but several of them are visible in Fig. 3. In particular, these connecting structures 160 connecting structures are spaced apart from each other and arranged annularly around the shaft 130 as can be seen in Fig. 3 (the shaft itself is not shown in Fig. 3).

[0031] The impeller-sided bearing part 150 and the bearing carrier 154 are, as can be seen in Figs. 2 and 3, spatially spaced apart from each other (seen along the rotational axis R) and connected to each other by connecting structures 160. The impeller-sided bearing part 160, the bearing carrier 155 and the connecting structures 160 can, for example, form parts of a component made of a single piece, i.e., these parts can be provided integrally.

[0032] Further, the turbo machine comprises one or more isolation areas 162 between the impeller-sided bearing part 150 and the bearing carrier 154, which adjoin the connecting structures 160. These isolation areas can be free of solid material. As can be seen in Fig. 3, the free space (free of solid material) between the connecting structures 160 in the circumferential direction from such isolation areas. As can been in Fig. 2, also part of the free space next the connecting structures 160, in radial direction, can form such isolation areas or part of them.

[0033] Further, the turbo machine comprises an enclosure configured to hermetically enclosing connecting structures 160 and form said isolation areas 162. Such enclosure is shown in Fig. 2, the enclosure comprises, by means of example, an outer part 164 and an inner part 166. Both parts 164, 166 are barrel-shaped. These parts can ensure the connecting structures 160 being hermitically enclosed such that the free space inbetween, i.e., the isolation areas 162, can be evacuated.

[0034] In that these isolation areas 162 are evacuated, e.g., having a pressure of gas therein of less than 100 mbar, the impeller-sided bearing part 150 and the bearing carrier 154 are thermally isolated from each other. The only or main thermal connection is via the connecting structures 160. However, compared to a full connection or the impeller-sided bearing part 150 and the bearing carrier 154 not being spaced apart from each other, the thermal conduction is massively reduced.

[0035] In this way, thermal conduction section is reduced and the heat transfer between the two parts is maintained at a low level. The impeller-sided bearing part can be at temperature close to -200°C and the bearing carrier can be at ambient (room) temperature. The evacuation of the isolation space, in addition, reduces the thermal convection effect. The connecting structure or the entire connection system, respectively, between cryogenic side and warm side of the turbo machine allows to maintain the heat intakes at a low level in order to increase the efficiency of, e.g., expansion and to maintain a positive temperature at the bearing, e.g., oil-bearing, level located on expander side.

[0036] Fig. 4 illustrates, by means of a flow diagram, a manufacturing method according to an embodiment of the invention. The method is for manufacturing a turbo machine as, e.g., shown in Figs. 1 to 3. Such turbo machine comprises an impeller, a bearing, a shaft, an impeller-sided bearing part and a bearing carrier. Said impeller is arranged on said shaft and wherein said impeller is, at least partly, enclosed by said impeller-sided bearing part. Said shaft is supported by said bearing and wherein said bearing is supported in and, at least partly, enclosed by said bearing carrier.

[0037] The method comprises, in a step 400, providing said impeller-sided bearing part and said bearing carrier such that they are spatially spaced apart from each other and connected to each other by one or more connecting structures. This can, for example, comprise, manufacturing these parts as a single piece, e.g., by machining, or by manufacturing said impeller-sided bearing part and said bearing carrier separately and then connecting them by means of the connecting structures.

[0038] In this way, one or more isolation areas are provided between said impeller-sided bearing part and said bearing are provided, and these are adjoining said one or more connecting structures. Said one or more isolation areas can be free of solid material.

[0039] In a step 410, an enclosure to hermetically enclose said one or more connecting structures and form said one or more isolation areas can be provided. This can comprise two parts of such an enclosure as shown in Fig. 2, for example.

[0040] In a step 420, said one or more isolation areas are evacuated to a pressure less than ambient pressure, preferably, less than 100 mbar. In this way, the thermal conduction is drastically reduced. In a further step 430, the remaining components like the shaft, the bearing and the impeller can be provided.

Claims

1. A turbo machine (100) comprising an impeller (110), a bearing (140), a shaft (130), an impeller-sided bearing part (150) and a bearing carrier (154),

   wherein said impeller (110) is arranged on said shaft (130),
   wherein said shaft (130) is supported by said bearing (140) and wherein said bearing (140) is supported in and, at least partly, enclosed by said bearing carrier (154),
   wherein the turbo machine (100) further comprises one or more connecting structures (160), wherein said impeller-sided bearing part (150) and said bearing carrier (154) are spatially spaced apart from each other and connected to each other by said one or more connecting structures (160), and
   wherein the turbo machine (100) further comprises one or more isolation areas (162) between said impeller-sided bearing part (150) and said bearing carrier (154) and adjoining said one or more connecting structures (160).

2. The turbo machine (100) of claim 1, further comprising an enclosure (164, 166) configured to hermetically enclosing said one or more connecting structures (160) and form said one or more isolation areas (162).

3. The turbo machine (100) of claim 1 or 2, wherein said one or more isolation areas (162) are evacuated to a pressure less than ambient pressure, preferably, less than 100 mbar.

4. The turbo machine (100) of any one of the preceding claims, comprising more of said connecting structures (160), and wherein said more connecting structures are spaced apart from each other and arranged annularly around the shaft (130).

5. The turbo machine (100) of any one of the preceding claims, wherein said one or more connecting structures (160) are rod shaped. impeller-sided bearing part

6. The turbo machine (100) of any one of the preceding claims, configured as a cryogenic turbo machine.

7. The turbo machine (100) of any one of the preceding claims, configured as at least one of: a centrifugal turbo machine, a radial turbo machine.

8. The turbo machine (100) of any one of the preceding claims, configured as at least one of: an expander, a compressor.

9. The turbo machine (100) of any one of the preceding claims, wherein the bearing is configured as one of: an oil bearing, a roller bearing, a gas bearing, a magnetic bearing.

10. A method for manufacturing a turbo machine (100), said turbo machine (100) comprising an impeller (110), a bearing (140), a shaft (130), an impeller-sided bearing part (150) and a bearing carrier (154),

    wherein said impeller (110) is arranged on said shaft,
    wherein said shaft (130) is supported by said bearing and wherein said bearing is supported in and, at least partly, enclosed by said bearing carrier,
    comprising:
    Providing (400) said impeller-sided bearing part (150) and said bearing carrier (154) such that they are spatially spaced apart from each other and connected to each other by one or more connecting structures (160), and such that one or more isolation areas (164) between said impeller-sided bearing part and said bearing and adjoining said one or more connecting structures are provided.

11. The method of claim 10, further comprising: Providing (410) an enclosure to hermetically enclose said one or more connecting structures and form said one or more isolation areas.

12. The method of claim 10 or 11, further comprising: Evacuating (420) said one or more isolation areas to a pressure less than ambient pressure, preferably, less than 100 mbar.

13. The method of any one of claims 10 to 12, manufacturing the turbo machine of any one of claims 1 to 9.

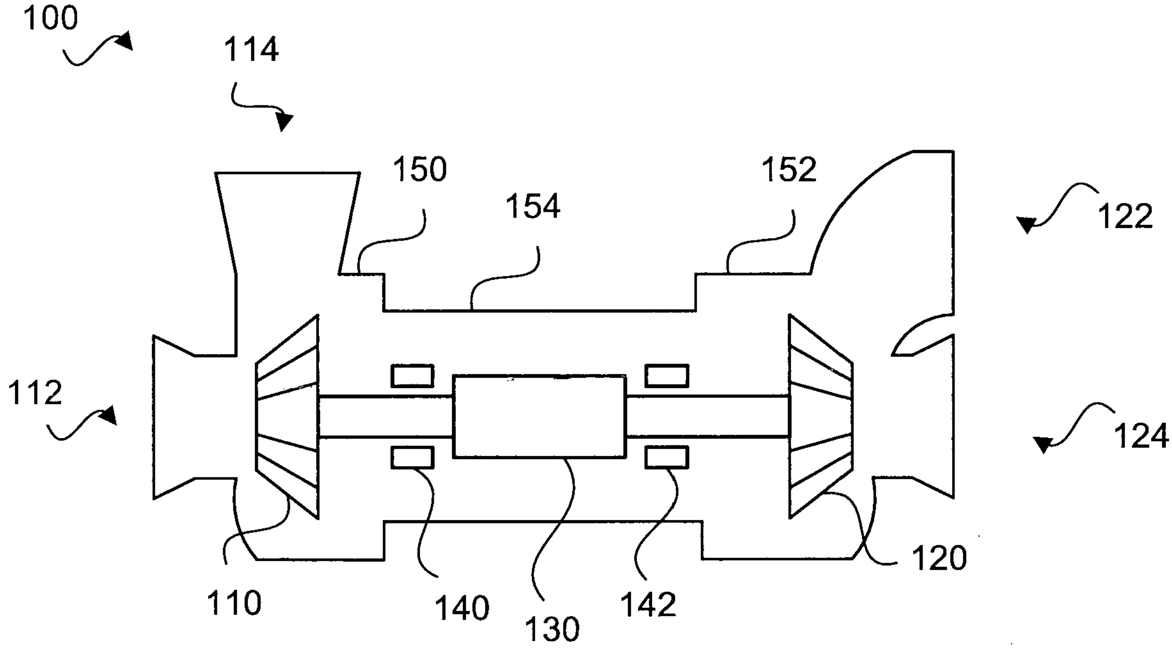

Fig. 1

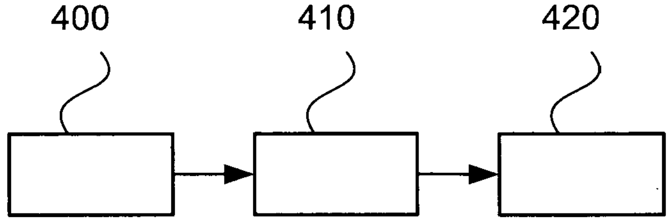

Fig. 4

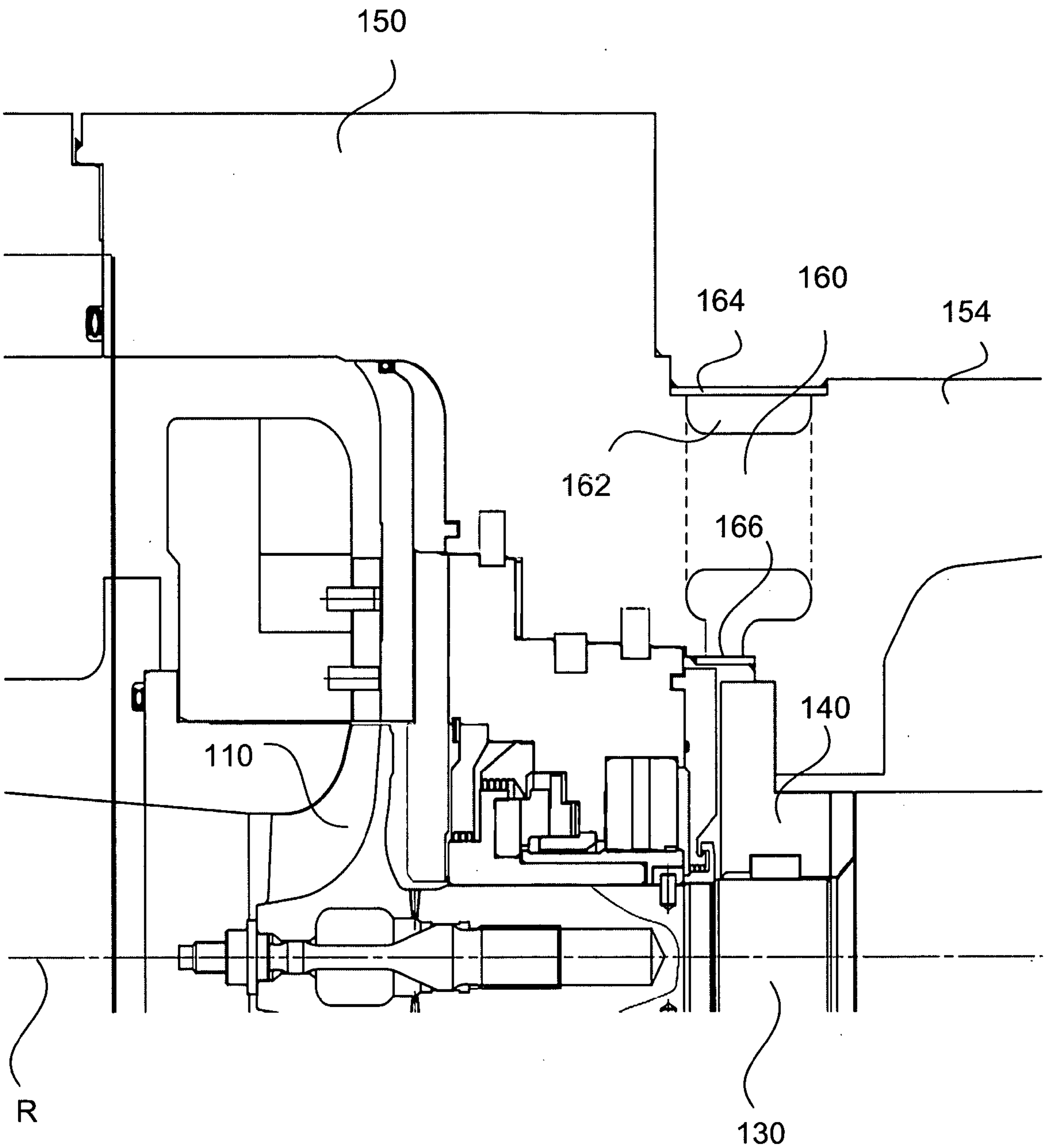

Fig. 2

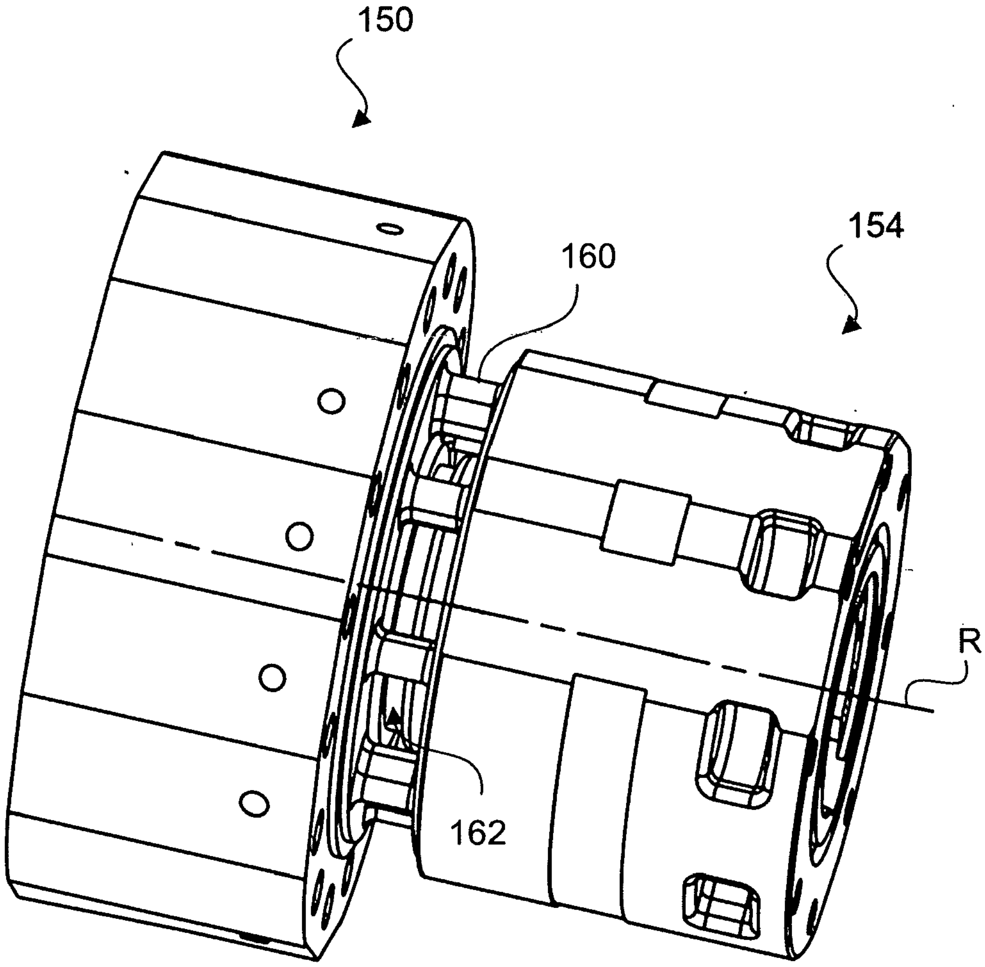

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 31 5411

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			TECHNICAL FIELDS SEARCHED (IPC)
			F04D F01D

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	8 April 2024	Lovergine, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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