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(54) ROTATING SEAL ASSEMBLY WITH AXIAL PUMP

(57) A rotating seal assembly (24) of a gas turbine engine (14) includes a rotating seal element (34) and a rotationally stationary seal support (36) positioned radially outboard of the rotating seal element (34). The rotating seal element (34) and the seal support (36) are configured to define a seal interface therebetween.

The seal element (34) includes an axial pump portion (54) defined by one or more axially and circumferentially extending grooves (56) to urge an airflow (50) there-through. The airflow (50) is configured to prevent a fluid from entering the seal interface.

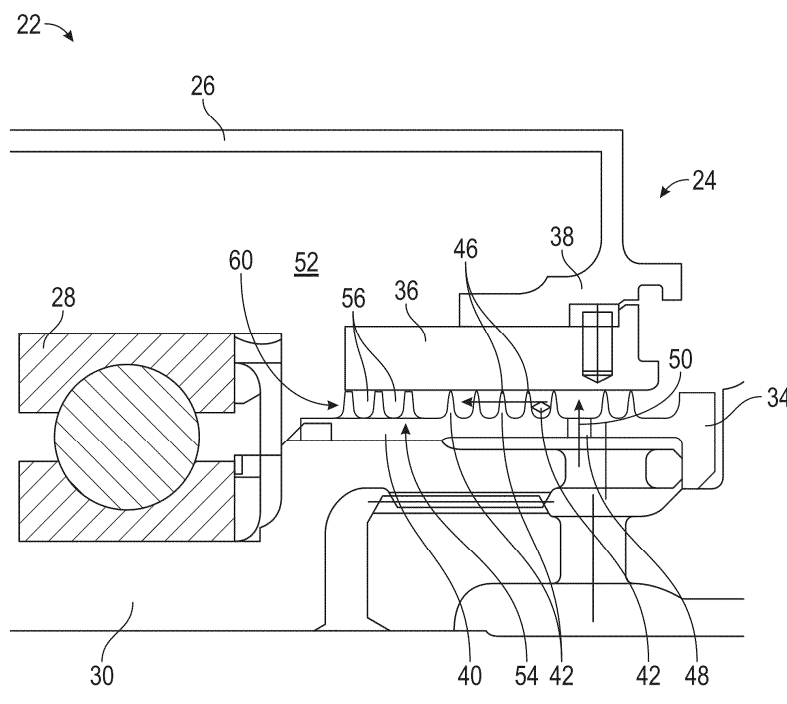


FIG. 2

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Description

TECHNICAL FIELD

[0001] The present invention pertains to the art of aircraft propulsion, and more particularly to thermal engines of aircraft propulsion systems.

BACKGROUND

[0002] Hybrid aircraft applications, such as aircraft that have a combination of electrically-driven propellers and thermal engine, such as a gas turbine engine, - driven propellers on wing can require the thermal engines to be shut down during extended periods of the mission. During this windmilling operation of the thermal engine, rotating engine components such as bearings, gears, and the like need to have a certain amount of lubrication to prevent damage. Utilizing an oil system via pressure & scavenge pumps can accomplish normal required lubrication. However, the secondary air system at sub-idle conditions may not sufficiently pressurize the bearing compartment seal to prevent oil from leaking outside the bearing cavities.

[0003] These leaks can lead to oil smell in the cabin, bleed valve contamination, coking of engine core components, smoke on start and shutdown or oil in the exhaust duct. Typical air seals consist of a rotating and stationary component, with a small clearance maintained between the components in operation. Air pressure (secondary air system) blowing between them to draw air inside the bearing cavity, preventing oil to exit through the seals. Without these typical air pressures, a novel solution is required to improve the sealing at the bearing cavities at low RPM.

BRIEF DESCRIPTION

[0004] In one aspect of the present invention, a rotating/rotational seal assembly of a gas turbine engine includes a rotating/rotational seal element and a rotationally stationary seal support positioned radially outboard of the rotating/rotational seal element. The rotating/rotational seal element and the seal support are configured to define a seal interface therebetween. The seal element includes an axial pump portion defined by one or more axially and circumferentially extending grooves to urge an airflow therethrough. The airflow is configured to prevent a fluid from entering the seal interface.

[0005] In an embodiment according to the above, the seal element is one of a carbon seal element or includes a plurality of knife edge elements extending radially outwardly from an element base toward the seal support.

[0006] In an embodiment according to any of the previous embodiments, one or more airflow openings extend through the seal element to supply the axial pump portion with the airflow.

[0007] In an embodiment according to any of the pre-

vious embodiments, at least a portion of the seal interface is positioned axially between the one or more airflow openings and the axial pump portion.

[0008] In an embodiment according to any of the previous embodiments, a radial running clearance is defined between the axial pump portion and the seal support.

[0009] In an embodiment according to any of the previous embodiments, the fluid is lubricant from a bearing arrangement.

[0010] In an embodiment according to any of the previous embodiments, the airflow is directed circumferentially in a first direction opposite a second direction of the rotation of the seal element.

[0011] In another aspect of the present invention, a bearing and seal arrangement of a gas turbine engine includes a bearing positioned in a bearing housing. The bearing is supportive of a rotating/rotational component of the gas turbine engine. A seal assembly is positioned at the bearing housing to seal the bearing housing. The seal assembly includes a seal element operably connected to the rotating component/rotational and rotatable therewith and a rotationally stationary seal support positioned radially outboard of the seal element. The seal element and the seal support are configured to define a seal interface therebetween. The seal element includes an axial pump portion defined by one or more axially and circumferentially extending grooves to urge an airflow therethrough, the airflow configured to prevent migration of a lubricant inside the bearing housing into the seal interface.

[0012] In an embodiment of the above, the axial pump portion is located axially between the seal interface and the bearing.

[0013] In an embodiment according to any of the previous embodiments, the seal element is one of a carbon seal element or includes a plurality of knife edge elements extending radially outwardly from an element base toward the seal support.

[0014] In an embodiment according to any of the previous embodiments, one or more airflow openings extend through the seal element to supply the axial pump portion with the airflow.

[0015] In an embodiment according to any of the previous embodiments, at least a portion of the seal interface is positioned axially between the one or more airflow openings and the axial pump portion.

[0016] In an embodiment according to any of the previous embodiments, a radial running clearance is defined between the axial pump portion and the seal support.

[0017] In an embodiment according to any of the previous embodiments, the airflow is directed circumferentially in a first direction opposite a second direction of the rotation of the seal element.

[0018] In an embodiment according to any of the previous embodiments, the rotating component is a shaft of the gas turbine engine.

[0019] In another aspect of the present invention, a propulsion arrangement of an aircraft includes a propeller

and a gas turbine engine operably connected to the propeller to drive rotation of the propeller. The gas turbine engine includes a rotating/rotational shaft and a bearing and seal arrangement supportive of the shaft. The bearing and seal arrangement includes a bearing positioned in a bearing housing. The bearing is supportive of the rotating/rotational shaft. A seal assembly is positioned at the bearing housing to seal the bearing housing. The seal assembly includes a seal element operably connected to the shaft and rotatable therewith, and a rotationally stationary seal support positioned radially outboard of the seal element. The seal element and the seal support are configured to define a seal interface therebetween. The seal element includes an axial pump portion defined by one or more axially and circumferentially extending grooves to urge an airflow therethrough. The airflow is configured to prevent migration of a lubricant inside the bearing housing into the seal interface.

[0020] In an embodiment of the above, the axial pump portion is located axially between the seal interface and the bearing.

[0021] In an embodiment according to any of the previous embodiments, the seal element is one of a carbon seal element or includes a plurality of knife edge elements extending radially outwardly from an element base toward the seal support.

[0022] In an embodiment according to any of the previous embodiments, one or more airflow openings extend through the seal element to supply the axial pump portion with the airflow.

[0023] In an embodiment according to any of the previous embodiments, the airflow is directed circumferentially in a first direction opposite a second direction of the rotation of the seal element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

FIG. 1 is a schematic illustration of an exemplary embodiment of an aircraft;

FIG. 2 is a partial cross-sectional view of an exemplary embodiment of a bearing and bearing seal arrangement of a gas turbine engine;

FIG. 3 is a perspective view of an exemplary embodiment of a rotating seal element including an axial pump portion; and

FIG. 4 is a partial cross-sectional view of another exemplary embodiment of a bearing and bearing seal arrangement of a gas turbine engine.

DETAILED DESCRIPTION

[0025] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0026] Referring now to FIG. 1, illustrated is an embodiment of an aircraft 10. Aircraft 10 includes, for example, a hybrid propulsion aircraft 10, including at least one first propeller 12 driven by a thermal engine, such as a gas turbine engine 14, and at least one second propeller 16 driven by an electric motor 18. The propellers 12, 16, gas turbine engine 14 and electric motor 18 are all mounted on or in an aircraft body 20. In some operating conditions during flight of the aircraft 10, operation of the gas turbine engine 14 may be stopped, and only the electric motor 18 and second propeller 16 are utilized to propel the aircraft 10.

[0027] During such operations, the aerodynamic forces will continue to rotate the first propeller 12, even though the gas turbine engine 14 is not operating. During this rotation, referred to as "windmilling", rotating components, such as bearing systems or the like, require lubrication, with lubricant, such as oil, retained in bearing compartments via air pressure.

[0028] Shown in FIG. 2 is an embodiment of an exemplary bearing arrangement 22 and bearing compartment seal 24 of the gas turbine engine 14 for driving the first propeller 12. The bearing arrangement 22 includes a bearing housing 26 in which a bearing 28, for example, a roller bearing is located. The bearing 28 is supportive of a rotating component, such as a shaft 30. In some embodiments, the shaft 30 may be a propeller shaft supportive of the first propeller 12. A volume of lubricant, such as oil, is located inside the bearing housing 26 to lubricate the components inside the bearing housing 26.

[0029] The bearing seal 24 is disposed at an interface of the bearing housing 26 and shaft 30, where the shaft 30 extends outside of the bearing housing 26. The bearing seal 24 includes a rotating seal element 34 secured to the shaft 30 and configured to rotate therewith. A rotationally static seal support 36 is fixed to a rotationally static element, such as a bearing housing wall 38 of the bearing housing 26. In some embodiments, such as shown in FIG. 2, the rotating seal element 34 is labyrinth seal element 34, having an element base 40 and a plurality of knife edge elements 42 extending radially outwardly from the element base 40 toward the static seal support 36. The knife edge elements 42 are axially spaced apart by an element pitch 44, which in some embodiments is equal between all of the knife edge elements 42, or in other embodiments may be varied such that a first element pitch 44 separates two adjacent knife edge elements 42, while a second element pitch 44, different from the first element pitch 44 separates another two adjacent knife edge elements 42. In some embodiments, a knife edge tip 46 of the knife edge elements 42 may contact the seal support 36 during rotation of the seal element 34,

while in other embodiments a small radial clearance is defined between the seal element 34 and the knife edge tip 46. The seal element 34 and the seal support 36 define a tortuous path therebetween to act as a seal during normal operation of the gas turbine engine 14 to retain the lubricant inside the bearing housing 26.

[0030] The element base 40 includes one or more airflow openings 48 therein through which an airflow 50 is directed toward an interior 52 of the bearing housing 26 to discourage lubricant flow out of the bearing housing 26. In some embodiments, the one or more airflow openings 48 are disposed axially between two adjacent knife edge elements 42 of the seal element 34. To aid in inducing this airflow during windmilling operation of the gas turbine engine 14, the element base 40 further includes an axial pump portion 54, defined by a plurality of axial and circumferentially-extending grooves 56 formed in the element base 40, as best shown in FIG. 3. In the embodiment illustrated, the axial pump portion 54 is disposed on the seal element 34 axially between the knife edge elements 42 and the bearing 28, with at least one of the knife edge elements 42 disposed axially between the axial pump portion 54 and the one or more airflow openings 48. As shown in FIG. 3, as the seal element 34 is rotated with the shaft 30 in a first direction 58, the airflow 50 is urged along the grooves 56 circumferentially and axially toward the bearing 28, thus stopping or preventing lubricant from the interior 52 of the bearing housing 26 toward the knife edge elements 42 and through the bearing compartment seal 24.

[0031] The operation of the axial pump portion 54 creates the air pumping effect in rotation, set by a defined running clearance 60 between the axial pump portion 54 and the seal support 36. Additionally, the axial pump portion 54 will mechanically push back any lubricant toward the interior 52. While this embodiment utilizes a labyrinth seal element 34, the axial pump portion 54 may be utilized with other seal configurations, such as brush seals, washer seals, spring back seals, or a carbon seal element 62, as in the embodiment of FIG. 4.

[0032] In addition to the benefits realized during windmilling operation of the gas turbine engine 14, the use of the axial pump portion 54 may lead to a better overall sealing efficiency of the bearing seal 24. This may allow for reducing the required pressurized airflow during normal operation, and further improvements to the oil/air system and their components.

[0033] The term "about" is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

[0034] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when

used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

[0035] While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

Claims

1. A rotating seal assembly (24) for a gas turbine engine (14), comprising:
 - a rotating seal element (34) rotatable about an axis; and
 - a rotationally stationary seal support (36) positioned radially outboard of the rotating seal element (34), the rotating seal element (34) and the seal support (36) configured to define a seal interface therebetween;
 - wherein the seal element (34) includes an axial pump portion (54) defined by one or more axially and circumferentially extending grooves (56) to urge an airflow (50) therethrough, the airflow (50) configured to prevent a fluid from entering the seal interface.
2. The rotating seal assembly (24) of claim 1, wherein the seal element (34) is a carbon seal element (62) or includes a plurality of knife edge elements (42) extending radially outwardly from an element base (40) toward the seal support (36).
3. The rotating seal assembly (24) of claim 1 or 2, further comprising one or more airflow openings (48) extending through the seal element (34) to supply the axial pump portion (54) with the airflow (50).
4. The rotating seal assembly (24) of claim 3, wherein at least a portion of the seal interface is disposed axially between the one or more airflow openings (48) and the axial pump portion (54).
5. The rotating seal assembly (24) of any preceding

claim, wherein a radial running clearance (60) is defined between the axial pump portion (54) and the seal support (36).

6. The rotating seal assembly (24) of any preceding claim, wherein the fluid is lubricant from a bearing arrangement (22). 5

7. The rotating seal assembly (24) of any preceding claim, wherein the seal element (34) is configured such that the airflow (50) is directed circumferentially in a first direction (58) opposite a second direction of the rotation of the seal element (34). 10

8. A bearing and seal arrangement (22) for a gas turbine engine (14) comprising: 15

a bearing (28) disposed in a bearing housing (26), the bearing (28) configured to be supportive of a rotating component (30) of the gas turbine engine (14); and 20
the seal assembly (24) of any preceding claim disposed at the bearing housing (26) to seal the bearing housing (26), the seal element (34) configured to be operably connected to the rotating component (30) and rotatable therewith. 25

9. The bearing and seal arrangement (22) of claim 8, wherein the axial pump portion (54) is located axially between the seal interface and the bearing (28). 30

10. The bearing and seal arrangement (22) of claim 8 or 9, wherein the rotating component (30) is a shaft (30) of the gas turbine engine (14). 35

11. A propulsion arrangement of an aircraft (10), comprising:

a propeller (12); and
a gas turbine engine (14) operably connected to the propeller (12) to drive rotation of the propeller (12), the gas turbine engine (14) including: 40

a rotating shaft (30); and
a bearing and seal arrangement (22) supportive of the shaft (30), the bearing and seal arrangement (22) including: 45

a bearing (28) disposed in a bearing housing (26), the bearing (28) supportive of the rotating shaft (30); and
the seal assembly (24) of any of claims 1 to 7 disposed at the bearing housing (26) to seal the bearing housing (26), the seal element (34) operably connected to the shaft (30) and rotatable therewith. 50
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12. The propulsion arrangement of claim 11, wherein the axial pump portion (54) is located axially between the seal interface and the bearing (28).

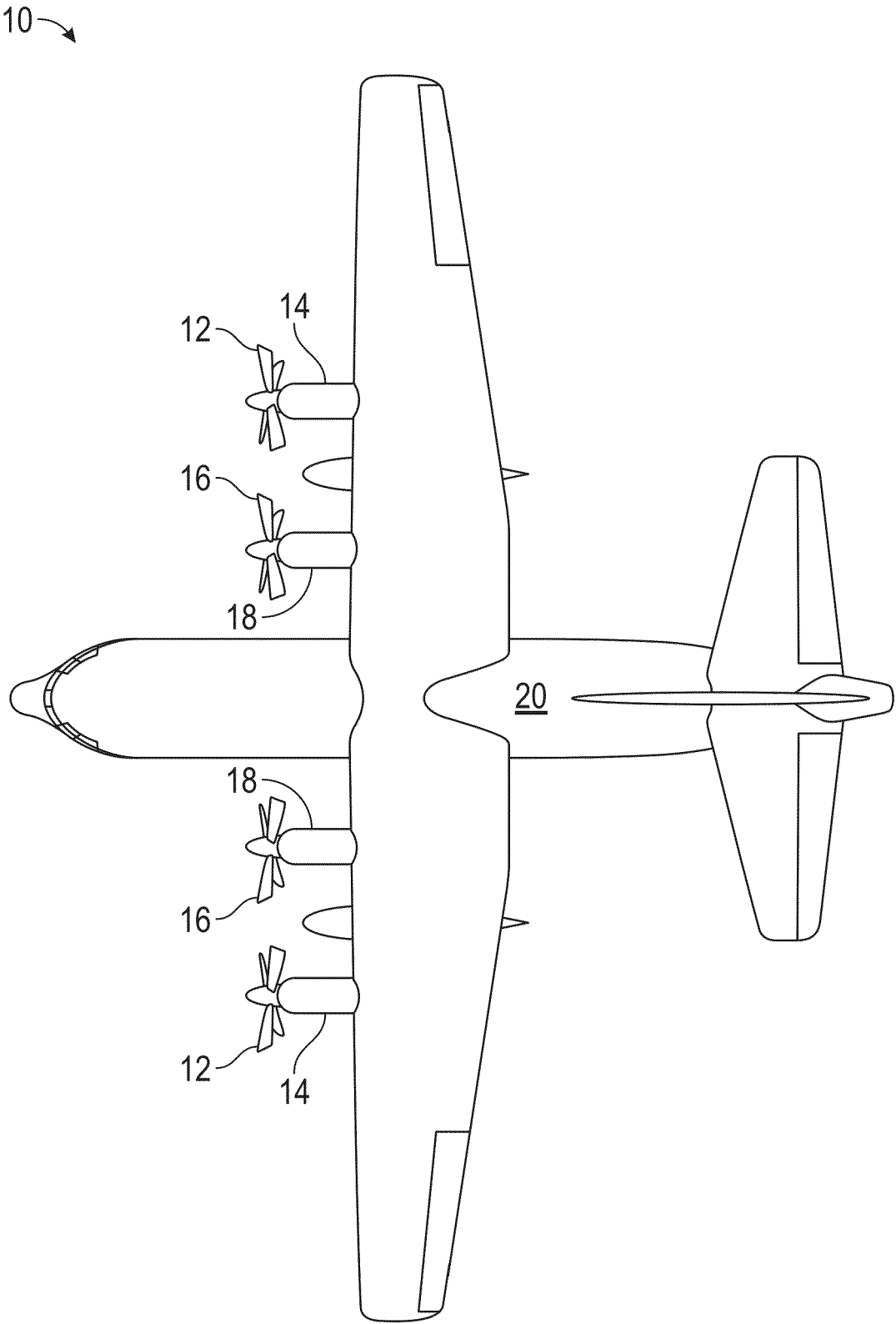


FIG. 1

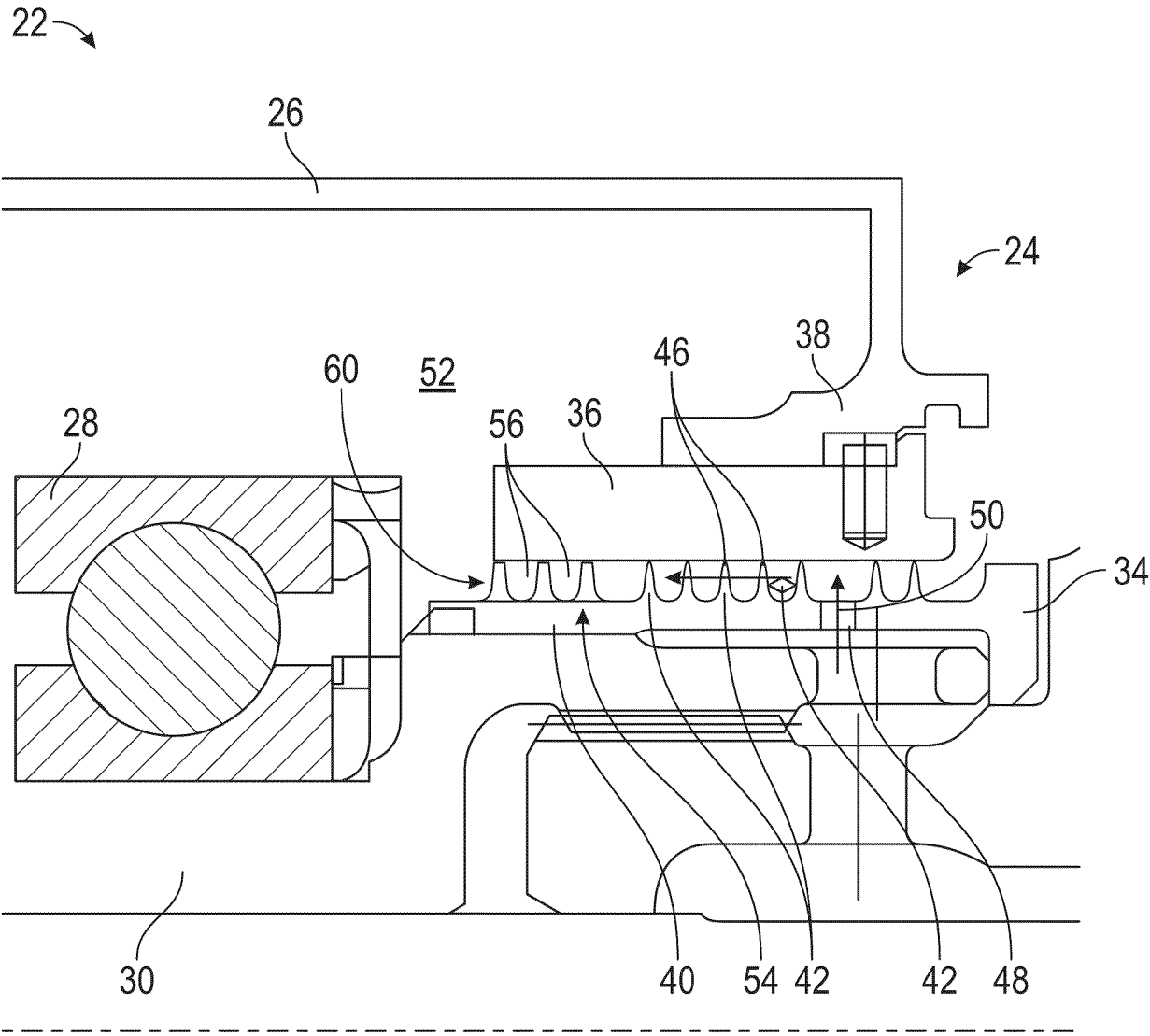


FIG. 2

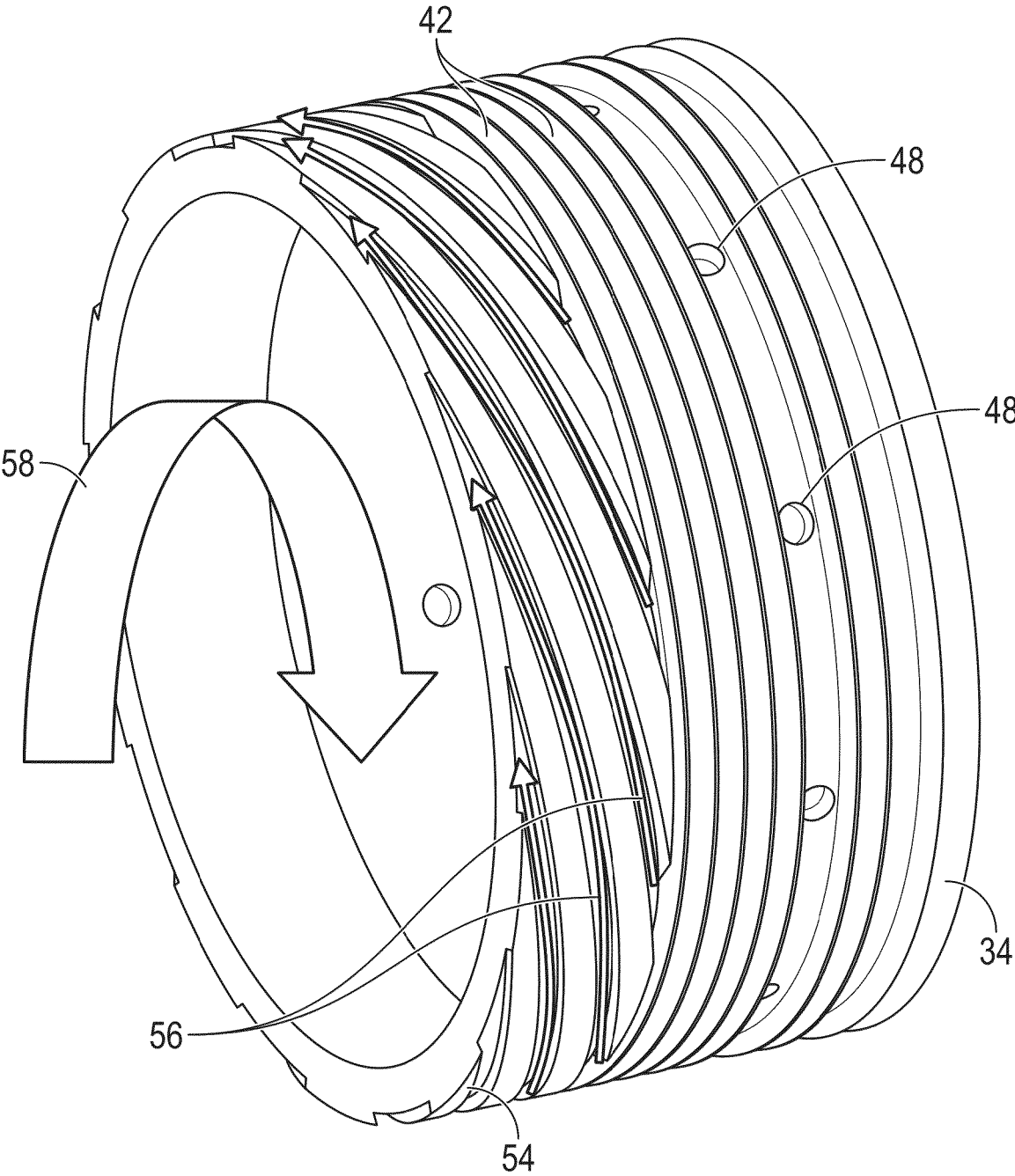


FIG. 3

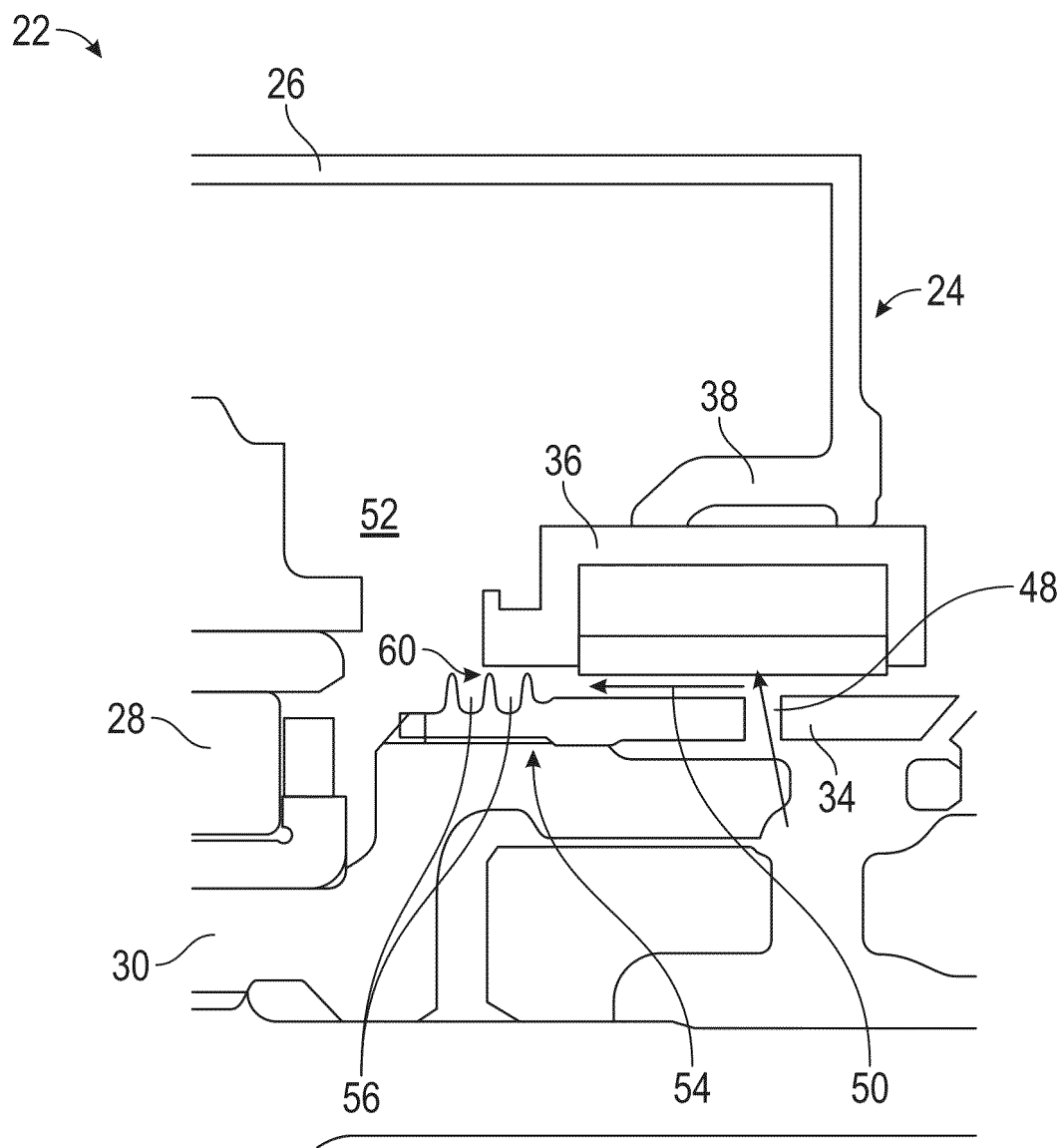


FIG. 4



EUROPEAN SEARCH REPORT

Application Number

EP 26 17 0026

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			TECHNICAL FIELDS SEARCHED (IPC)
			F01D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 July 2026	Examiner de la Loma, Andrés
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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