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Inventor(s)	Jacquemard; Christophe Paul et al.

Auxiliary oil tank for an aircraft turbine engine

Abstract

An auxiliary tank for an aircraft turbine engine is provided, and in conjunction with a pump and associated auxiliary lubrication circuit, supplies oil to a reducer when, for example, a phase of free rotation of the fan is detected. Thus, the reducer is always lubricated, even during the phases of free rotation of the fan, thus ensuring a longer life of the reducer gears. The auxiliary tank is arranged with respect to the reducer so that oil is recovered from the reducer at least in part by the auxiliary tank.

Inventors: **Jacquemard; Christophe Paul (Moissy-Cramayel, FR), Desombre; Didier Gabriel Bertrand (Moissy-Cramayel, FR)**

Applicant: **SAFRAN AIRCRAFT ENGINES** (Paris, FR)

Family ID: **1000008767415**

Assignee: **SAFRAN AIRCRAFT ENGINES (Paris, FR)**

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Primary Examiner: Riegelman; Michael A

Attorney, Agent or Firm: Christensen O'Connor Johnson Kindness PLLC

Background/Summary

CROSS-REFERENCES TO RELATED APPLICATIONS (1) This application is a divisional of U.S. application Ser. No. 17/278,257, filed Mar. 19, 2021, which is a National Stage of international application number PCT/FR2019/052163, filed Sep. 17, 2019, which claims foreign priority to French application number 1858629, filed Sep. 24, 2018, the contents of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD
(1) The field of the present disclosure is that of aircraft turbomachines, in particular that of the storage of lubrication oil for such turbomachines.
BACKGROUND
(2) A turbomachine, such as a dual flow turbofan engine of an aircraft, typically comprises an air inlet comprising a shrouded fan whose outlet airflow divides into an airflow that enters the engine section and forms a hot flow (or primary flow), and an airflow that flows around the engine section and forms a cold flow (or secondary flow).
(3) The engine part typically comprises, from upstream to downstream in the direction of gas flow, at least one compressor, a combustion chamber, at least one turbine, and an exhaust nozzle in which the combustion gases leaving the turbine (primary flow) are mixed with the secondary flow. A turbomachine may also be of the “double-body” type, which means that it comprises two rotors arranged coaxially. A first body is called a low pressure body and a second body is called a high pressure body. In this case, as is well known, the engine part comprises, from upstream to downstream, a low-pressure compressor, a high-pressure compressor, the combustion chamber, a high-pressure turbine and a low-pressure turbine.
(4) In the case of a turbomachine with reducer, the turbine shaft drives the fan shaft via a speed reducer which reduces the speed of rotation of the fan shaft in relation to that of the turbine shaft.
(5) Depending on the type of reducer used, planetary or epicyclic, the fan shaft will rotate in the same direction or in the opposite direction to the turbine shaft. A planetary or epicyclic reducer comprises each at least one epicyclic gear train (comprising at least one sun gear, one planet carrier,

planets and one ring gear) arranged in a defined configuration.
(6) More precisely, an epicyclic reducer comprises, in particular, a fixed ring gear and a planet carrier integral with the fan shaft, each planet gear thus comprising a movable axis of rotation.
(7) The turbine shaft, which is the low-pressure turbine shaft in the case of a double-body turbomachine, is usually coupled to a low-pressure compressor shaft, which in turn is coupled to an input shaft of the reducer. This input shaft is rotationally coupled to the sun gear of the reducer to drive it in rotation.
(8) The fan shaft is, for example, guided in rotation relative to a fixed structure via two bearings which are spaced apart and located upstream of the speed reducer. The input shaft is guided in rotation relative to the fixed structure via a bearing located downstream of the speed reducer.
(9) The reducer is housed in an annular lubrication enclosure and, in the current technology, its operation to ensure the lubrication and the cooling of its pinions and bearings is guaranteed by a supply circuit and a main lubrication circuit of the turbomachine, which requires the turbomachine to operate.
(10) However, during the phases of free rotation of the fan due to the effect of air flows flowing through the fan (called windmilling), the engine does not operate and the supply circuit and the main lubrication circuit does not ensure the lubrication of the reducer, which can lead to seizure or breakage of the toothing of the reducer.
SUMMARY
(11) This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.
(12) The disclosure aims to solve these drawbacks by offering a solution compatible with all the operating phases of the turbomachine, and in particular those in which the engine does not operate.
(13) For this purpose, the disclosure concerns an auxiliary oil tank and associated auxiliary lubrication circuit for an aircraft turbomachine. In accordance with an aspect of the present disclosure, a method is provided for lubricating a reducer of an aircraft turbomachine, comprising a step of activating the pump so that oil arrives from the auxiliary tank to the reducer as soon as a phase of free rotation of the fan is detected.
(14) Thus, the reducer is always lubricated, even during the phases of free rotation of the fan, thus ensuring a longer life of the reducer gears.

Description

DESCRIPTION OF THE DRAWINGS
(1) The foregoing aspects and many of the attendant advantages of the claimed subject matter will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:
(2) FIG. **1** is a schematic sectional view of a turbomachine;
(3) FIG. **2** is a perspective view of an auxiliary tank according to an embodiment of the disclosure;
(4) FIG. **3** is a front view of the auxiliary tank;
(5) FIG. **4** is a perspective view of the auxiliary tank provided with a lubrication pump;
(6) FIG. **5** is a perspective view of the rear side of a turbomachine casing according to an embodiment of the disclosure;
(7) FIG. **6** is a detailed perspective view of the turbomachine casing;
(8) FIG. **7** is a perspective view of the front side of the casing equipped with an auxiliary tank;
(9) FIG. **8** is a detailed view of an auxiliary tank mounted on the casing of the turbomachine;

(10) FIG. **9** is a sectional view along the axis A-A of FIG. **7**;
(11) FIG. **10** is a view analogous to FIG. **8** illustrating the lubrication oil path in a turbomachine casing according to an embodiment of the disclosure; and
(12) FIG. **11** is a detailed perspective view illustrating the lubrication pump mounted on the turbomachine casing.

DETAILED DESCRIPTION

(13) The detailed description set forth below in connection with the appended drawings, where like numerals reference like elements, is intended as a description of various embodiments of the disclosed subject matter and is not intended to represent the only embodiments. Each embodiment described in this disclosure is provided merely as an example or illustration and should not be construed as preferred or advantageous over other embodiments. The illustrative examples provided herein are not intended to be exhaustive or to limit the claimed subject matter to the precise forms disclosed.
(14) In this specification, the terms “upstream” and “downstream” are used to refer to the direction of gas flow in an aircraft turbomachine. The terms “inner”, “outer”, “radial”, “axial” are defined in relation to an axis of the centres of curvature of the walls constituting the auxiliary tank according to the disclosure.
(15) FIG. **1** shows a turbomachine **1** which comprises, conventionally centred on a longitudinal axis X, a fan S, a low-pressure compressor **1***a*, a high-pressure compressor **1***b*, an annular combustion chamber **1***c*, a high-pressure turbine **1***d*, a low-pressure turbine **1***e* and an exhaust nozzle **1***h*. The high-pressure compressor **1***b* and the high-pressure turbine **1***d* are connected by a high-pressure shaft **2** and form with it a high-pressure body (HP). The low-pressure compressor **1***a* and the low-pressure turbine **1***e* are connected by a low-pressure shaft **3** and form with it a low-pressure body (LP).
(16) The fan S is driven by a fan shaft **4** which is coupled to the LP shaft **3** by means of an epicyclic gear reducer **10**, shown here schematically.
(17) The reducer **10** is positioned in the front part of the turbomachine. A fixed structure, here schematically comprising an upstream part **5***a* and a downstream part **5***b*, is arranged to form an enclosure E**1** surrounding the reducer **10**. This enclosure E**1** is closed upstream by seals at a bearing allowing to pass through the fan shaft **4** and downstream by seals at the passing through of the LP shaft **3**.
(18) Such a reducer **10** must be lubricated to maintain its gears in good working condition and to guarantee an acceptable service life of the reducer **10** for an aircraft turbomachine. This means that the reducer **10** must be lubricated even when the fan is freely rotating, e.g. due to windmilling caused by the wind through the fan.
(19) The present disclosure therefore proposes to add, on an aircraft turbomachine, for example in the vicinity of the reducer **10**, an auxiliary oil tank **20** in addition to a main oil tank known per se. This auxiliary tank could however equip a turbomachine not equipped with a reducer.
(20) Referring to FIG. **2**, the auxiliary tank **20** has a curved general or circumferential shape with the radius of curvature centred on an axis Y which is intended to coincide with the longitudinal axis X of the turbomachine **1**. This tank comprises one radially outer cylindrical or frustoconical wall **210** and three radially inner cylindrical or frustoconical walls **220**, **230**.
(21) The radially inner walls **220**, **230** are arranged opposite the radially outer wall **210**. The three radially inner walls comprise a middle wall **220** and two side walls **230** arranged on either side of the middle wall **220**. The middle wall **220** has a larger average radius of curvature D**1** than the average radius of curvature D**2** of the side walls **230**.
(22) The auxiliary tank **20** comprises walls at the circumferential ends **240**. Each of these circumferential end walls **240** connects a radially inner side wall **230** to the radially outer wall **210** and forms the side edges of the tank **20**.
(23) The auxiliary tank **20** comprises further intermediate radial walls **250**. Each of these

intermediate radial walls **250** connects a lateral radially inner wall **230** to the middle radially inner wall **220**.
(24) The auxiliary tank **20** comprises further walls **260**, **270** at the axial ends.
(25) The tank **20** is made of any material with the necessary robustness, it can be flexible or rigid.
(26) This means that the inner volume of the auxiliary tank **20** is approximately U-shaped. Each branch of the U is formed by lateral volume portions between one of the side walls **230**, the radially outer wall **210**, one of the walls at the circumferential ends **240** and one of the intermediate radial walls **250** extended fictitiously to the radially outer wall **210**. The base of the U is formed by a middle volume portion between the middle wall **220**, the radially outer wall **210** and a fictitious extension of the intermediate radial walls **250** to the radially outer wall **210**.
(27) The auxiliary tank **20** comprises an oil inlet located on the middle wall **220**. As illustrated, but by no means limited to, the oil inlet comprises a substantially cylindrical neck **24** protruding from the middle wall **220** and comprising an outer annular groove **25** for receiving a seal, such as an O-ring (not shown).
(28) The lateral volume portions V**1** are advantageously connected to gas outlets. According to an embodiment, the gas outlets are formed by curved general shape vent conduits **26**, e.g. with the same average radius of curvature D**3** as the side walls **230**. These vent conduits **26** communicate with the enclosure E**1** to ensure the gas flushing when the auxiliary tank **20** is filled with oil.
(29) To enable the auxiliary tank **20** to be attached to an aircraft turbomachine **1** casing, the auxiliary tank **20** also further comprises mounting brackets **28** comprising holes **29** for screw passage. These brackets **28**, for example two, are respectively arranged on walls at the circumferential ends **240** and extend circumferentially.
(30) FIG. **5** shows a casing **40** of a turbomachine **1**. This casing **40** comprises two coaxial annular walls **41**, **42** extending one **41** inside the other **42**, and connected together by an annular row of arms **43** which are intended to be swept by a gas flow during operation. At least one **43′** of these arms **43** is hollow and comprises fluid passages **44** and **45** defined below. The inner annular wall **41** defines the inner casing **41** of the turbomachine **1** and the outer annular wall **42** defines the inter-duct casing **42** of the turbomachine **1**. The inner casing **41** and the inter-duct casing **42** define the entire upstream casing of the turbomachine **1**, also referred to as casing **40** in this presentation.
(31) As shown in FIG. **6**, the inter-duct casing **42** of the casing **40** comprises two radially outer annular rims **42***a* connected by stiffening ribs **42***b*.
(32) The auxiliary tank **20** is mounted between the two radially outer annular rims **42***a* and between two adjacent stiffening ribs **42***b* (see FIGS. **7** and **8**). The middle wall **220** of the auxiliary tank **20** is then located perpendicularly to the hollow arm **43′** and the side walls **230** are located perpendicularly to inter-arm spaces.
(33) In an embodiment, the auxiliary tank **20** according to the disclosure partly takes the shape of the inter-duct casing **42** of the turbomachine **1** and therefore has an adapted shape allowing its integration into the inter-duct casing **42** of the turbomachine **1**.
(34) The ribs **42***b* are provided with circumferentially extending mounting brackets **42***c* on their faces intended to be arranged opposite the walls **240** of the auxiliary tank **20**, when the latter is mounted on the casing **40**. The tank **20** is then connected to the casing **40**, e.g. by screwing the mounting brackets **28** of the auxiliary tank **20** to the mounting brackets **42***c* of the casing **40**. In another embodiment, not shown, the auxiliary tank **20** is integrated into the casing **40**.
(35) Advantageously, as shown in FIG. **7**, the tank is angularly positioned at 6 o'clock, with reference to a time dial, (i.e. in the low position) when the casing **40** is mounted on an aircraft turbomachine.
(36) The hollow arm **43′** ensures the overall recovery by gravity of lubrication oil from the reducer **10** of the enclosure E**1**. Referring to FIGS. **9** and **10**, the hollow arm **43′** comprises a first inner passage **44** of oil recovery and a second inner passage **45** of oil recovery. The first and second passages **44**, **45** of oil recovery are formed in the inter-duct casing **42** of the casing **40**. They are for

example formed by two channels separated by a partition **46** and arranged side by side in a plane passing through the axis of revolution of the inner casing **41** and the inter-duct casing **42**.
(37) The first passage **44** is, in a manner known per se, connected to a main oil tank (not shown) and ensures the passage of oil to various parts of the turbomachine such as, for example, the rolling elements of the line shafts of the turbine, the compressor, the fan, etc.
(38) The main oil tank is connected to a main lubrication circuit which provides lubrication for the reducer **10** when the turbomachine is active.
(39) The second passage **45** of oil recovery has a non-rectilinear shape, e.g. V-shaped. It comprises an opening **45***a* and a base **45***b* comprising a hole **45***c* for engaging the neck **24** of the tank **20**.
(40) The second inner passage **45** of oil recovery is configured to allow the recovered oil to be conveyed from the enclosure E**1** to the auxiliary tank **20**.
(41) Specifically, after lubricating the reducer **10**, for example, during normal operation of the turbomachine in which the engine is running, the lubrication oil is drained into the hollow arm **43′**, it then flows into the passage **45** as shown in FIG. **10** by the arrow F**1**. In this way, the tank is supplied continuously and spontaneously. When the auxiliary tank **20** is filled, the passage **45** is filled with lubrication oil, which then overflows into the passage **44** to be discharged through the hole **47** to a general oil recovery as shown by the arrows F**2** and the main oil tank known per se (not shown).
(42) Advantageously, the opening **45***a* of the second passage **45** is opposite to the auxiliary tank **20** and extends in a plane P which is intended to be inclined from upstream to downstream downwards when the turbomachine **1** is substantially horizontal.
(43) The tank **20** and the casing **40** thus configured, and in particular the recovery passage **45**, make it possible to maintain a sufficient oil level in the auxiliary tank **20**, even under the effect of a negative inclination of the turbomachine **1**, or under the effects of rolling of the latter.
(44) The auxiliary tank **20** is associated with an auxiliary lubrication circuit (not shown). Thus, the auxiliary tank **20** together with the auxiliary lubrication circuit is an independent unit from the main lubrication circuit and allows the reducer **10** to be lubricated when the main lubrication circuit is not active, for example during particular windmilling operating phases with the turbomachine switched off and the main lubrication circuit not active, thus not requiring the main lubrication circuit to be activated specifically in these particular operating phases of the turbomachine.
(45) The dimensions of the auxiliary tank **20** are such that it contains a sufficient volume of oil to meet the lubrication requirements of the reducer **10** according to the turbomachine during the operating phases of the auxiliary tank **20**.
(46) The tank also comprises an oil outlet connected by a hose **27** to a pump **30** powered for example by an electric motor (not shown). As shown in FIG. **11**, the pump **30** is attached to the casing **40**.
(47) The present disclosure also relates to a method for lubricating a reducer **10** of a turbomachine **1** comprising a casing **40** equipped with an auxiliary tank **20**.
(48) When a free rotation phase of the fan S is detected, the pump **30** is activated, for example by the electric motor. The lubrication oil is then taken from the auxiliary tank **20** via the oil outlet hose **27** and is conveyed to the reducer **10** or other components requiring lubrication, for example such as bearings, via a hose **31** at the outlet of the pump **30** and via the auxiliary lubrication circuit.
(49) The auxiliary tank **20**, the casing **40** and the lubrication method according to the disclosure are thus configured so that the reducer **10** is always lubricated, regardless of the flight altitudes and the operating phases of the turbomachine.
(50) The principles, representative embodiments, and modes of operation of the present disclosure have been described in the foregoing description. However, aspects of the present disclosure which are intended to be protected are not to be construed as limited to the particular embodiments disclosed. Further, the embodiments described herein are to be regarded as illustrative rather than restrictive. It will be appreciated that variations and changes may be made by others, and

equivalents employed, without departing from the spirit of the present disclosure. Accordingly, it is expressly intended that all such variations, changes, and equivalents fall within the spirit and scope of the present disclosure, as claimed.

Claims

1. A method of lubricating a reducer of an aircraft turbomachine, the aircraft turbomachine having a main tank and a main lubrication circuit configured to lubricate the reducer when the turbomachine is active and having an auxiliary tank and an auxiliary lubrication circuit configured to lubricate the reducer when the turbomachine is not active, the method comprising: detecting a phase of free rotation of a fan of the turbomachine; and thereafter, activating a pump associated with the auxiliary lubrication circuit so that oil is supplied to the reducer from the auxiliary tank, and filling the auxiliary tank with oil recovered from the reducer when the turbomachine is active, and when the auxiliary tank is full, filling the main tank with oil that overflows from the auxiliary tank.
2. The method of claim 1, further comprising lubricating, via the main lubrication circuit, the reducer with oil when the turbomachine is active.
3. The method of claim 2, further comprising filling the auxiliary tank with oil from the main lubrication circuit when the turbomachine is active.
4. The method of claim 1, wherein the reducer is connected in fluid communication with the auxiliary tank and the auxiliary lubrication circuit, and wherein the reducer is connected in fluid communication with the main lubrication tank and the main lubrication circuit.
5. The method of claim 1, further comprising recovering oil from the reducer into the auxiliary tank and into the main lubrication tank.
6. The method of claim 5, wherein when the auxiliary tank is filled with oil recovered from the reducer, the oil overflows into a passage connected in fluid communication with the main lubrication tank.
7. A method of lubricating a reducer of an aircraft turbomachine, comprising: lubricating, via a main lubrication circuit, the reducer when the turbomachine is active; and lubricating, via an auxiliary lubrication circuit, the reducer when the turbomachine is not active, the main lubrication circuit comprising a main lubrication tank and the auxiliary lubrification circuit comprising an auxiliary lubrication tank, filling the auxiliary tank with oil recovered from the reducer when the turbomachine is active, and when the auxiliary tank is full, filling the main tank with oil that overflows from the auxiliary tank.
8. The method of claim 7, wherein the reducer is connected in fluid communication with the auxiliary tank and the auxiliary lubrication circuit, and wherein the reducer is connected in fluid communication with the main lubrication tank and the main lubrication circuit.
9. The method of claim 8, further comprising detecting a phase of free rotation of a fan of the turbomachine; and thereafter, activating a pump associated with the auxiliary lubrication circuit so that oil is supplied to the reducer from the auxiliary tank.
10. A method of lubricating a reducer of an aircraft turbomachine having an auxiliary tank having a curved shape with a radius of curvature centered on a centering axis corresponding to a longitudinal axis of the turbomachine, the turbomachine further having a reducer, a main lubrication oil tank, a main lubrication circuit, an auxiliary lubrication circuit, and an oil outlet connected to a pump, the method comprising: lubricating, via the main lubrication circuit, the reducer when the turbomachine is active; and lubricating, via the auxiliary lubrication circuit, the reducer when the turbomachine is not active by activating the pump so that oil is supplied from the auxiliary tank to the reducer as soon as a phase of free rotation of a fan of the turbomachine is detected, and filling the auxiliary tank with oil recovered from the reducer when the turbomachine is active, and when the auxiliary tank is full, filling the main tank with oil that overflows from the auxiliary tank.

11. The method of claim 1, wherein the auxiliary tank has a curved shape with a radius of curvature centered on a centering axis corresponding to a longitudinal axis of the turbomachine, the auxiliary tank comprising: a cylindrical or frustroconical radially outer wall, three cylindrical or frustroconical radially inner walls arranged opposite said radially outer wall, and an inner volume forming a U-shape enclosed by the radially outer wall and the radially inner walls.
12. The method of claim 11, wherein the radially inner walls comprise a middle wall and two side walls arranged on either side of the middle wall, the middle wall has a mean radius of curvature greater than a mean radius of curvature of the two side walls.
13. The method of claim 12, the U-shape of the inner volume has a base and a plurality branches, the plurality of branches are formed by lateral volume portions between the two side walls and the radially outer wall, and wherein the base is formed by a middle volume portion between the middle wall and the radially outer wall.