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Lubrication system for aircraft engine reduction gearbox

Abstract

A method of performing maintenance on an aircraft engine includes removing a propeller shaft of the aircraft engine to form an access volume at a center of the aircraft engine. The access volume extends axially and radially relative to a center axis of the aircraft engine. The method includes performing maintenance on a lubricant strainer positioned at a location of the access volume where a carrier of the aircraft engine engages an output of the aircraft engine.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. patent application Ser. No. 17/203,902 filed on Mar. 17, 2021, the entire contents of which are incorporated by reference herein. Reference is made to U.S. patent application Ser. No. 16/360,297 filed Mar. 21, 2019, the entire contents of which are incorporated by reference herein.

TECHNICAL FIELD
(1) The application relates generally to aircraft engines and, more particularly, to aircraft engines with reduction gearboxes.
BACKGROUND
(2) Aircraft engines may include a reduction gearbox (RGB) which provides a speed reduction while carrying the torque increase at lower speed.
(3) RGBs contribute to the weight, cost and size of the engine, and may also impose oil flow requirements for lubrication and cooling, which in turn impact the oil system components of the engine.
SUMMARY
(4) There is disclosed a gas turbine engine, comprising: a power input and a power output; and an epicyclic gear train engaged with the power input and with the power output, the epicyclic gear train comprising: a sun gear defining a center axis and engaged with the power input; a plurality of planet gears mounted to a carrier and engaged to the sun gear, the plurality of planet gears rotatable about respective planet gear axes, the plurality of planet gears and the carrier rotatable about the center axis, the carrier engaged with the power output at a carrier-output engagement location; one or more ring gears in meshed engagement with the plurality of planet gears; a plurality of planet gear bearings, each planet gear bearing disposed between one of the plurality of planet gears and the carrier, a lubrication interface defined between each planet gear bearing and the one of the plurality of planet gears; and a bearing lubrication system including a lubricant supply conduit extending between a conduit inlet at the carrier-output engagement location and conduit outlets at the lubrication interfaces of the plurality of planet gear bearings, the bearing lubrication system including a lubricant strainer mounted about the conduit inlet at the carrier-output engagement location.
(5) There is disclosed a method of operating a reduction gearbox of an aircraft engine, the reduction gearbox having an epicyclic gear train with a sun gear, planet gears mounted to a carrier,

and one or more ring gears, the method comprising: filtering a lubricant at a location where the carrier engages an output of the aircraft engine; and lubricating interfaces between the planet gears and the carrier with the filtered lubricant.
(6) There is disclosed a gas turbine engine, comprising: a power input and a power output; and an epicyclic gear train engaged with the power input and with the power output, the epicyclic gear train comprising: a sun gear defining a center axis and engaged with the power input; a plurality of planet gears mounted to a carrier and engaged to the sun gear, the plurality of planet gears rotatable about respective planet gear axes; one or more ring gears in meshed engagement with the plurality of planet gears and rotatable about the center axis, the one or more ring gears engaged with the power output at an engagement location; a plurality of planet gear bearings, each planet gear bearing disposed between one of the plurality of planet gears and the carrier, a lubrication interface defined between each planet gear bearing and the one of the plurality of planet gears; and a bearing lubrication system including a lubricant supply conduit extending between a conduit inlet at the engagement location and conduit outlets at the lubrication interfaces of the plurality of planet gear bearings, the bearing lubrication system including a lubricant strainer mounted about the conduit inlet at the engagement location.
(7) There is disclosed a method of performing maintenance on an aircraft engine, the method comprising: removing a propeller shaft of the aircraft engine to form an access volume at a center of the aircraft engine, the access volume extending axially and radially relative to a center axis of the aircraft engine; and performing maintenance on a lubricant strainer positioned at a location of the access volume where a carrier of the aircraft engine engages an output of the aircraft engine.
(8) There is disclosed a lubricant strainer mountable within an aircraft engine at a location where an epicyclic gear train of the aircraft engine engages with a power output of the aircraft engine, the lubricant strainer comprising: an annular body disposed about a center axis, the annular body extending along the center axis between a first end and a second end, the annular body having a mesh for filtering lubricant.

Description

DESCRIPTION OF THE DRAWINGS
(1) Reference is now made to the accompanying figures in which:
(2) FIG. **1** is a schematic cross-sectional view of a gas turbine engine;
(3) FIG. **2**A is a cross-sectional view of part of a reduction gearbox of the gas turbine engine in FIG. **1**;
(4) FIG. **2**B is an enlarged view of area IIB-IIB in FIG. **2**A;
(5) FIG. **2**C is an enlarged view of area IIC-IIC in FIG. **2**A;
(6) FIG. **2**D is an enlarged view of area IID-IID in FIG. **2**A;
(7) FIG. **3** is a perspective view of an epicyclic gear train of the reduction gearbox of FIG. **2**A;
(8) FIG. **4** is a perspective view of an epicyclic gear train of a reduction gearbox of the gas turbine engine in FIG. **1**;
(9) FIG. **4**A is a cross-sectional view of part of a reduction gearbox of the gas turbine engine in FIG. **1**, having the epicyclic gear train of FIG. **4**;
(10) FIG. **4**B is an enlarged view of area IVB-IVB in FIG. **4**A;
(11) FIG. **5**A is a partial cross-sectional view of the part of the reduction gearbox of FIG. **4**A;
(12) FIG. **5**B is an enlarged perspective view of an output shaft of FIG. **5**A;
(13) FIG. **5**C is another partial cross-sectional view of the part of the reduction gearbox of FIG. **4**A;
(14) FIG. **6** is a perspective view of a lubricant strainer of FIG. **5**A;
(15) FIG. **7** is a graphical representation of a disclosed method; and
(16) FIG. **8** is another graphical representation of a disclosed method.

DETAILED DESCRIPTION

(17) FIG. **1** illustrates a gas turbine engine **10** commonly referred to as a “turboprop”, and of a type preferably provided for use in subsonic flights, generally comprising in serial flow communication an intake **11** through which air is drawn to subsequently be compressed by compressors **12**. Fuel is added to the compressed air in a combustor **13** for the combustion of the fuel and air mixture. Combustion gasses then expand to drive turbines **14**. A power shaft **15** connected to one of the turbines **14** projects to transmit a rotatable driving force to a propeller shaft **16**. Although the engine **10** shown in FIG. **1**A is configured for driving a propeller of an aircraft, the engine **10** in an alternate embodiment is a turboshaft engine configured to drive the rotor of a helicopter, or the fan of a “turbofan” engine. Any suitable engine may be employed.

(18) The engine **10** has a transmission, including a reduction gearbox **20**, engaged with the power and propeller shafts **15**,**16**. The reduction gearbox **20** (sometimes referred to herein as “RGB **20**”) allows for the controlled application of power from the power shaft **15** to the propeller shaft **16**. As will be explained in greater detail below, the RGB **20** includes gears, gear trains, and other gear arrangements to provide speed and torque conversions from the rotating power and propeller shafts **15**,**16**.

(19) Referring to FIG. **2**A, the RGB **20** has a power input **22** and a power output **24**. The power input **22** and the power output **24** are both rotatable about a longitudinal center axis **17** of the engine **10**. The power input **22** is any mechanical object or coupling which links the RGB **20** to a power source of the engine **10** and through which motive power is provided to the RGB **20**. The power output **24** is any mechanical object or coupling which links the RGB **20** to a driven component of the engine **10** and through which motive power is conveyed from the RGB **20**. The power output **24** is a rotatable driven member that functions to drive a rotatable load such as the propeller of an aircraft, the rotor of a helicopter, a fan of the engine, or the reduction gearboxes associated with the aircraft propeller and helicopter rotor. For example, in FIG. **2**A, the power input **22** includes a coupling **22**A mounted to the power shaft **15** to receive a rotational input therefrom, and the power output **24** includes a spline **24**A mounted to the propeller shaft **16** to convey thereto a torque output of the RGB **20**. In FIG. **2**A, the coupling **22**A and the spline **24**A are rotatable and coaxial about the center axis **17** of the engine **10** and axially spaced apart from each other. In alternate embodiments, the power input **22** and the power output **24** are radially offset. In an alternate embodiment, the power input **22** is embodied as a gearing arrangement which is engaged to, and driven by, the power shaft **15**. In the depicted embodiment, the power output **24** is the sole or single source of power for the main load of the engine **10**, namely, the propeller, the rotor, or their respective reduction gearboxes. The power output **24** in the depicted embodiment is therefore the only power output to drive the propeller, the rotor, or their respective reduction gearboxes.

(20) Referring to FIG. **2**A, the engine **10** has an output shaft, which is the propeller shaft **16** in the illustrated embodiment. The propeller shaft **16** defines, and is rotatable about, an output shaft axis **16**A. The output shaft axis **16**A is parallel to the center axis **17** of the engine **10**. The output shaft axis **16**A may be collinear with the center axis **17** of the engine **10**. The propeller shaft **16** extends axially between a first end **16**B of the propeller shaft **16** that is engaged to the power output **24** of the RGB **20**, and a second end **16**C that is spaced axially apart from the first end **16**B. The second end **16**C is spaced axially apart from the first end **16**B in a direction away from the RGB **20**. The second end **16**C may be engaged directly with the propeller, or indirectly with the propeller via a propeller gearbox. The first end **16**B is the portion of the propeller shaft **16** that is spaced axially furthest from the propeller. The propeller shaft **16** is a hollow annular body that defines an inner volume or shaft interior **16**D. Referring to FIG. **2**A, the propeller shaft **16** is hollow along its entire axial length between the first and second ends **16**B,**16**C, such that the shaft interior **16**D extends axially between the first and second ends **16**B,**16**C. In an alternate embodiment, the output shaft of the engine **10** is another shaft, and may be another rotatable load such as the rotor of a helicopter, a fan of the engine **10**, or the reduction gearboxes associated with the aircraft propeller and helicopter

rotor.

(21) Referring to FIG. **2**A, the RGB **20** also includes an epicyclic gear train **30**. The epicyclic gear train **30**, which in the depicted embodiment is a "planet" type gear train, is engaged with the power input **22** to be driven thereby, and is engaged with the power output **24** to drive the power output **24**. By "engaged", it is understood that the rotation of components of the epicyclic gear train **30** allows power from the power input **22** to be transferred to the power output **24**.

(22) In FIG. **2**A, the epicyclic gear train **30** is the only epicyclic gear train of the RGB **20**. In FIG. **2**A, the epicyclic gear train **30** is the only epicyclic gear train positioned between the power input **22** of the RGB **20** and the power output **24** of the RGB **20**. In FIG. **2**A, only one epicyclic gear train **30** engages both the power input **22** of the RGB **20** and the power output **24**. The RGB **20** is therefore a "single stage" RGB **20**, and uses only one epicyclic gear train **30** to achieve speed reduction and torque conversion. In contrast, some conventional reduction gearboxes have multiple epicyclic gear systems, which may be arranged in series such that the output of one of the epicyclic gear systems is the input for another of the epicyclic gear systems, in order to achieve the desired speed reduction and torque conversion. The use of multiple epicyclic gear systems may create weight and space penalties.

(23) The epicyclic gear train **30** includes a sun gear **34**. The sun gear **34** is centrally disposed in the epicyclic gear train **30**, and defines a center axis **32** of the epicyclic gear train **30**. The center axis **32** in FIG. **2**A is collinear with the center axis **17** of the engine **10**. The outer circumferential periphery of the sun gear **34** is located closer to the center axis **32** of the epicyclic gear train **30** than all other rotating components of the epicyclic gear train **30**. The sun gear **34** is engaged with the power input **22** to be driven thereby about the center axis **32**. In FIG. **2**A, the sun gear **34** is coupled to the coupling **22**A of power input **22** to receive rotational input from the power shaft **15**. The sun gear **34** has sun gear teeth **34**A. As shown in FIG. **2**A, the power input **22** is coaxial with the sun gear **34**.

(24) The epicyclic gear train **30** also has multiple compound planet gears **36** which mesh with the sun gear **34**, and are driven thereby. The compound planet gears **36** mesh with the inside of ring gears **38** of the epicyclic gear train **30**. The compound planet gears **36** therefore mesh with both the sun gear **34** and the ring gears **38**. The compound planet gears **36** are mounted to a carrier **37** which extends between and connects the center of the compound planet gears **36**. Each compound planet gear **36** is rotatable about its own planet gear axis **36**A. In FIG. **2**A, the planet gear axes **36**A are radially spaced apart from center axis **32**. The planet gear axes **36**A are parallel to each other, and to the center axis **32**. It will therefore be appreciated that the power provided by the sun gear **34** to the compound planet gears **36** may cause them to rotate about themselves and their planet gear axes **36**A.

(25) Each compound planet gear **36** includes differently-sized gear engaging elements for engaging different components of the epicyclic gear train **30**. Each compound planet gear **36** may thus be referred to as a "stepped-planet" gear. The presence of the compound planet gears **36** may allow the RGB **20** to achieve the desired speed reduction and torque conversion using only the single epicyclic gear train **30** shown in FIG. **2**A, thus avoiding the need for two stages of epicyclic gear reduction. Each compound planet gear **36** includes an input gear **36**B and output gears **36**C. Each input and output gear **36**B,**36**C is a portion of the compound planet gear **36** with teeth, splines, or other similar elements which mesh with the teeth of another gear separate from the same compound planet gear **36**. The input and output gears **36**B,**36**C are coaxial and concentric.

(26) The input gear **36**B is in meshed engagement with the sun gear **34** to receive a rotational drive from the sun gear **34**, thereby causing the compound planet gear **36** to rotate about its planet gear axis **36**A. In FIG. **2**A, the sun gear teeth **34**A are meshed with the input gear teeth **36**D of each compound planet gear **36** to transmit rotation from the sun gear **34** to the compound planet gears **36**. The output gears **36**C are spaced from the input gear **36**B along the direction of the planet gear axis **36**A. The output gears **36**C are axially spaced apart from each other. The input gear **36**B is

positioned axially between the output gears **36**C along the direction of the planet gear axis **36**A. The compound planet gear **36** shown in FIG. **2**A has two output gears **36**C, but more are possible.

(27) For the compound planet gear **36** shown in FIG. **2**A, the input gear **36**B is positioned axially between the output gears **36**C. The output gears **36**C are thus positioned on the compound planet gear **36** on opposite axial sides of the input gear **36**B. The two output gears **36**C are axially spaced equidistantly from the input gear **36**B. A diameter of the input gear **36**B is greater than a diameter of the output gears **36**C. The radial distance of the input gear teeth **36**D from the planet gear axis **36**A is greater than the radial distance of output gear teeth **36**E of the output gears **36**C from the planet gear axis **36**A. This arrangement of the differently-sized gears **36**B,**36**C may help achieve speed reduction and torque conversion in a relatively compact volume, as described in greater detail below. The output gears **36**C in FIG. **2**A have the same diameter. The input and output gears **36**B,**36**C are rigidly connected together and rotate at the same rotational speed about the planet gear axis **36**A. The input and output gears **36**B,**36**C are integral with one another. Each compound planet gear **36** in the depicted embodiment is a unitary structure. Each compound planet gear **36** in the depicted embodiment is a single-piece structure or a single part. Each compound planet gear **36** in the depicted embodiment includes a pair of concentric output gears **36**C rigidly connected to each side of the larger input gear **36**B. Such a compound planet gear **36** may offer an additional speed reduction when compared to a conventional star-type gear system which does not have compound planet gears.

(28) Each compound planet gear **36** may have any suitable structure with the input and output gears **36**B,**36**C, an example of which is described with reference to FIGS. **2**A and **2**D. The compound planet gears **36** have a central body **36**F or shaft being coaxial with the planet gear axis **36**A. The central body **36**F is annular, and hollow along at least part of its axial length. Referring to FIG. **2**D, an inner journal surface **36**G of the body **36**F delimits a central cavity **36**H of the body **36**F which is also coaxial with the planet gear axis **36**A. Referring to FIG. **2**A, the input gear **36**B includes an input gear web **36**B′ extending radially outwardly from the body **36**F to a peripheral end having the input gear teeth **36**D. The output gears **36**C are positioned at axially opposite ends of the body **36**F, and include the output gear teeth **36**E. Other structures and arrangement of components for the compound planet gear **36** are possible.

(29) Still referring to FIG. **2**A, the ring gears **38** are axially spaced apart from each another along the direction of the center axis **32** of the epicyclic gear train **30**. The ring gears **38** are rotatable about the center axis **32**. The ring gears **38** are engaged, directly or indirectly, with the power output **24** to transmit the torque and reduced speed from the RGB **20** to a component to be driven, such as the propeller shaft **16**. FIG. **2**A shows two ring gears **38**, but more may be used, the number of ring gears **38** typically corresponding to the number of output gears **36**B.

(30) The ring gears **38** receive a rotational input from the compound planet gears **36**. Each ring gear **38** is in meshed engagement with one of the output gears **36**C. It will thus be appreciated that the input gears **36**B of the compound planet gears **36** receive a rotational input from the sun gear **34**, and the output gears **36**C of the compound planet gears **36** output a rotational input to the ring gears **38**. The epicyclic gear train **30** in FIG. **2**A is thus an epicyclic star gear system having compound planet gears **36** with concentric gears **36**B,**36**C, and axially spaced-apart output ring gears **38** engaging the axially spaced-apart sets of the output gear teeth **36**E of the compound planet gears **36**. The epicyclic gear train **30** with its arrangement of compound planet gears **36** engaging different ring gears **38** may provide an additional speed reduction when compared to a conventional star type gear system.

(31) One possible configuration for the ring gears **38** is shown in FIGS. **2**A, **2**B and **2**D. Each ring gear **38** includes an outer meshing member **38**A engaged with the power output **24** (see FIG. **2**B), and an inner meshing member **38**B disposed radially inwardly of the outer meshing member **38**A and in meshed engagement with one of the output gears **36**C (see FIG. **2**D). The inner meshing member **38**B includes teeth, splines, etc. meshed with the output gear teeth **36**E to receive a

rotational input from the output gears **36**C. The ring gears **38** in FIG. **2**A are annular bodies with radially outer and inner meshing members **38**A,**38**B. Each ring gear **38** in FIG. **2**A includes a ring gear web **38**C extending radially between the outer and inner meshing members **38**A,**38**B. The outer and inner meshing members **38**A,**38**B of each ring gear **38** are axially offset from one another. Other configurations for the ring gears **38** are possible.
(32) The ring gears **38** in the illustrated embodiment indirectly engage the power output **24**. The spline **24**A of the power output **24** extends between the power shaft **16** and the ring gears **38**, so as to convey a rotational output from the ring gears **38** to the power shaft **16**. The spline **24**A is a rotatable, annular component having a first end **24**A′ coupled to the propeller shaft **16** and a radially-outer second end **24**A″ in meshed engagement with the ring gears **38** (see FIGS. **2**A, **2**B and **2**C). The second end **24**A″ of the spline **24**A is in meshed engagement with the outer meshing members **38**A of the ring gears **38**. In FIG. **2**A, the ring gears **38** are separate gears that are axially spaced apart from each other, and which are connected by the common spline **24**, so that the ring gears **38** and the spline **24**A rotate together about the center axis **32** of the epicyclic gear train **30** and output to the propeller shaft **16**. As shown in FIG. **2**A, the spline **24** is in meshed engagement with the ring gears **38** at a first axial position P**1** that is axially spaced from axial positions P**2**,P**3** of the meshed engagement of the ring gears **38** with the output gears **36**C. In FIG. **2**A, the first axial position P**1** is located axially between the axial positions P**2**,P**3** of the meshed engagement of the inner meshing members **38**B with the output gear teeth **36**E of the output gears **36**C. The axially-spaced apart ring gears **38** thus have a common output location that is axially offset from where the ring gears **38** are engaged to the output gears **36**C.
(33) The spline **24**A and ring gears **38** may have any suitable meshing structure to achieve the functionality described above. For example, and referring to FIGS. **2**A, **2**B and **2**C, the spline **24**A has a spline web **25**A extending between the first and second ends **24**A′,**24**A″. Referring to FIG. **2**B, one of the ring gears **38**′ has an axial extension **38**D at the radially outer end which has an orientation being substantially parallel to the center axis **32**. The axial extension **38**D extends from a first end at the radially outer end of the ring gear **38**′ to a second end which includes the teeth **38**F of the outer meshing member **38**A. The teeth **38**F of the ring gear **38**′ mesh with the teeth of the second end **24**A″ of the spline **24**A, and with the teeth of the other ring gear **38**″, such that the rotation of both the ring gears **38**′,**38**″ drives the rotation of the spline **24**A about the center axis **32**. In an alternate embodiment, the ring gears **38** directly engage the power output **24** to provide a rotational output thereto.
(34) One possible manner for operating the epicyclic gear train **30** is now described with reference to FIG. **2**A. The sun gear **34** is engaged, via the coupling **22**A, with the power input **22** to be driven thereby. The carrier **37** is fixed and made immobile, such that it does not rotate about the center axis **32**. The carrier **37** can be fixed in place by, among other things, being mounted to surrounding structure or by using a brake of the epicyclic gear train **30**. Since the carrier **37** is fixed in place, the compound planet gears **36** are prevented from rotating about the center axis **32**. The rotational input provided by the sun gear **34** to the input gears **36**B of the compound planet gears **36** causes the compound planet gears **36** to rotate about their respective planet gear axes **36**A. The rotation of the output gears **36**C of the compound planet gears **36** in turn causes the meshed ring gears **38** to rotate about the center axis **32**. The ring gears **38** in the depicted embodiment engage the power output **24** via the spline **24**A to rotate the propeller shaft **16**. The epicyclic gear train **30** in the depicted embodiment may therefore be referred to as a “star” gear system, in which the carrier **37** is braked to slow and/or stop rotation thereof, while the compound planet gears **36** can still rotate about each of their respective axis **36**A. The compound planet gears **36** in such a star gear configuration thus do not revolve around the sun gear **34** (i.e. the axes **36**A of rotation of each compound planet gear **36** is fixed in space), but the compound planet gears **36** still individually rotate. It is possible to operate the gear train **30** differently than as described above. For example, reference is made to U.S. patent application Ser. No. 16/360,297 which describes an arrangement of the epicyclic gear

train **30** which operates as a "star"-type gear system where the carrier **37** is immobile and where the ring gears rotate about the center axis **32**.

(35) Still referring to FIG. **2**A, the sun gear **34** is driven in a first rotational direction R**1** about the center axis **32**, and the star type arrangement of the compound planet gears **36** means that they will cause the ring gears **38**, and thus the power output **24** and the propeller shaft **16**, to rotate in a second rotational direction R**2** opposite to the first rotational direction R**1**. The epicyclic gear train **30** of FIG. **2**A therefore reverses the rotation direction of the output relative to the input. In contrast, in a conventional planetary type gear system, the ring gear is normally fixed in place, and the planet gears rotate about their own axes and about the axis of the planetary gear system, such that the rotational direction of the input is the same as the rotational direction of the output.

(36) Referring to FIGS. **2**A and **2**D, each of the compound planet gears **36** is mounted about an oil-film bearing **40**. The bearing **40** is fixed to surrounding support structure, such as the casing or the carrier **37**, so that it does not displace during rotation of the compound planet gears **36** about their respective planet gear axes **36**A. The bearings **40** are coaxial with each of the compound planet gears **36** about their planet gear axes **36**A. In the illustrated embodiment, the bearings **40** are journal or rotary bearings, which support the compound planet gears **36** during their rotation. In FIGS. **2**A and **2**D, the oil-film bearing **40** is mounted within the central cavity **36**H of the annular body **36**F of each compound planet gear **36**, and releases a thin film of oil or other suitable fluid along the inner journal surface **36**G of the body **36**F for lubrication. The oil-film bearing **40** may help the arrangement of the compound planet gears **36** in the epicyclic gear train **30** to occupy less space or volume.

(37) Thus the axial spacing apart of the output gears **36**C allows for the "split" ring gears **38** shown in FIG. **2**A, where both are disposed symmetrically on each axial side of the bearings **40**, so that load is applied uniformly through the planetary gear axes **36**A, and load asymmetry may be avoided. The epicyclic gear train **30** is thus an arrangement of a star epicyclic system, combining compound planet gears **36** and oil film bearing **40** with balanced load from two ring gears **38**. This contrasts with some conventional planetary gear systems, in which an unequal planet radial load is applied longitudinally.

(38) FIG. **3** is a perspective view of the epicyclic gear train **30** showing the sun gear **34**, the compound planet gears **36**, and the ring gears **38**. The carrier **37** is omitted from FIG. **3** for clarity. The sun gear teeth **34**A are meshed with the input gear teeth **36**D of the input gear **36**B of each of the compound planet gears **36** to transmit rotation from the sun gear **34** to the compound planet gears **36**. The inner meshing members **38**B of the ring gears **38** are meshed with the output gear teeth **36**E of the output gears **36**C of each of the compound planet gears **36** to receive a rotational input from the output gears **36**C in one possible embodiment of the epicyclic gear train **30**. In another embodiment of the epicyclic gear train **30** described below, the inner meshing members **38**B of the ring gears **38** are meshed with the output gear teeth **36**E of the output gears **36**C of each of the compound planet gears **36** so that the compound planet gears **36** can displace along the inner meshing members **38**B of the ring gears **38**. The outer meshing members **38**A of the ring gears **38** are shown. In FIG. **3**, the ring gear **38**′ is shown without the axial extension **38**D for clarity. Each compound planet gear **36** is mounted about the oil-film bearing **40**.

(39) Referring to FIG. **2**A, there is also disclosed a method of operating the RGB **20**. The method includes driving the sun gear **34** to rotate the input gear **36**B of the compound planet gears **36**, and to rotate the axially spaced-apart output gears **36**C. Rotation of the output gears **36**C rotates the ring gears **38** about the center axis **32** of the epicyclic gear train **30**.

(40) Another possible configuration of the epicyclic gear train **30** is now described with reference to FIG. **4**. The description of the epicyclic gear train **30** in FIGS. **2**A-**3** applies mutatis mutandis to the description of the epicyclic gear train **30** in FIG. **4**. Any features, functionalities or advantages attributed to the epicyclic gear train **30** or its components in FIGS. **2**A-**3** applies mutatis mutandis to the epicyclic gear train **30** in FIG. **4**. Reference numbers indicated in FIGS. **1-3** are applicable to

similar elements shown in FIG. **4**. FIG. **4** is a perspective view of the epicyclic gear train **30** showing the sun gear **34**, the compound planet gears **36**, and the ring gears **38**. The carrier **37** is omitted from FIG. **4** for clarity. The sun gear teeth **34**A are meshed with the input gear teeth **36**D of the input gear **36**B of each of the compound planet gears **36** to transmit rotation from the sun gear **34** to the compound planet gears **36**. The inner meshing members **38**B of the ring gears **38** are meshed with the output gear teeth **36**E of the output gears **36**C of each of the compound planet gears **36** so that the compound planet gears **36** can displace along the inner meshing members **38**B of the ring gears **38**.

(41) Another possible configuration of the RGB **20** having the epicyclic gear train **30** of FIG. **4** is now described with reference to FIGS. **4**A to **8**. The description of the RGB **20** in FIGS. **2**A-**3** applies mutatis mutandis to the description of the RGB **20** in FIGS. **4**A to **8**. Any features, functionalities or advantages attributed to the RGB **20** or its components in FIGS. **2**A-**3** applies mutatis mutandis to the RGB **20** in FIGS. **4**A to **8**. Reference numbers indicated in FIGS. **1-3** are applicable to similar elements shown in FIGS. **4**A to **8**.

(42) Referring to FIG. **4**A, the RGB **20** is engaged to both the power input **122** and the power output **124** of the engine **10**. The power input **122** and the power output **124** are both rotatable about the longitudinal center axis **17** of the engine **10**. The power input **122** is any mechanical object or coupling which links the RGB **20** to a power source of the engine **10** and through which motive power is provided to the RGB **20**. The power output **124** is any mechanical object or coupling which links the RGB **20** to a driven component of the engine **10** and through which motive power is conveyed from the RGB **20**. The power output **124** is a rotatable driven member that functions to drive a rotatable load such as the propeller of an aircraft, the rotor of a helicopter, a fan of the engine, or the reduction gearboxes associated with the aircraft propeller and helicopter rotor. For example, in FIG. **4**A, the power input **122** is, or is mounted to, the power shaft **15** to receive a rotational input therefrom. For example, in FIG. **4**A, the power output **124** is an output shaft of the engine **10**. For example, in FIG. **4**A, the power output **124** is, or includes, an output shaft such as the propeller shaft **16** to convey thereto a torque output of the RGB **20**. In an alternate embodiment, the power input **122** is embodied as a gearing arrangement which is engaged to, and driven by, the power shaft **15**. In the depicted embodiment, the power output **124** is the sole or single source of power for the main load of the engine **10**, namely, the propeller. The power output **124** in the depicted embodiment is therefore the only power output to drive the propeller.

(43) Referring to FIG. **4**A, the epicyclic gear train **30** of the RGB **20**, which in the depicted embodiment is a “planet” type gear train, is engaged with the power input **122** to be driven thereby, and is engaged with the power output **124** to drive the propeller shaft **16**. By “engaged”, it is understood that the rotation of components of the epicyclic gear train **30** allows power from the power input **122** to be transferred to the propeller shaft **16**.

(44) Referring to FIG. **4**A, the sun gear **34** is engaged with the power input **122** to be driven thereby about the center axis **32**. In FIG. **4**A, the sun gear **34** is coupled to the power shaft **15** to receive rotational input from the power shaft **15**. The sun gear **34** has sun gear teeth **34**A which mesh with the input gear teeth **36**D of each compound planet gear **36**. In another possible configuration, a spline rotatably couples the sun gear **34** to the compound planet gears **36**.

(45) The ring gears **38** are axially spaced apart from each another along the direction of the center axis **32** of the epicyclic gear train **30**. In the epicyclic gear train **30** of FIG. **4**A, the ring gears **38** are fixed in position. In the epicyclic gear train **30** of FIG. **4**A, the ring gears **38** do not rotate about the center axis **32** of the epicyclic gear train **30**. FIG. **4**A shows two ring gears **38**, but more may be used, the number of ring gears **38** typically corresponding to the number of output gears **36**C of each compound planet gear **36**. The inner meshing members **38**B of each ring gear **38** is in meshed engagement with the output gear teeth **36**E of the output gears **36**C (see FIG. **4**). The ring gears **38** in FIG. **4**A are annular bodies with radially inner meshing members **38**B. Other configurations for the ring gears **38** are possible.

(46) The compound planet gears **36** rotate along the inner meshing members **38**B of the ring gears **38** about the center axis **32**. It will thus be appreciated that the input gears **36**B of the compound planet gears **36** receive a rotational input from the sun gear **34**, and the output gears **36**C of the compound planet gears **36** circumferentially displace along inner teeth of the ring gears **38** about the center axis **32**. The epicyclic gear train **30** in FIG. **4**A is thus an epicyclic "planet" gear system having compound planet gears **36** with concentric gears **36**B,**36**C, and axially spaced-apart ring gears **38** engaging the axially spaced-apart sets of the output gear teeth **36**E of the compound planet gears **36**.

(47) The compound planet gears **36** are mounted to a carrier **37** which extends between and connects the center of the compound planet gears **36**. The compound planet gears **36** and the carrier **37** rotate about the center axis **32** of the epicyclic gear train **30**. More specifically, the rotational input provided by the sun gear **34** to the compound planet gears **36** causes them to drive the carrier **37** to rotate with the compound planet gears **36** about the sun gear **34** and about the center axis **32**. The carrier **37** is engaged, directly or indirectly, with the power output **124** to transmit the torque and reduced speed from the RGB **20** to a component to be driven, which in FIG. **4**A, is the propeller shaft **16**. The carrier **37** and the propeller shaft **16** rotate together, such that there is no slip between the carrier **37** and the propeller shaft **16**.

(48) Referring to FIG. **4**A, the carrier **37** is an annular body. The carrier **37** includes a carrier output shaft **37**A that is meshed with the propeller shaft **16**. The carrier output shaft **37**A directly engages the first end **16**B of the propeller shaft **16** so as to convey a rotational output from the compound planet gears **36** to the propeller shaft **16**. The carrier output shaft **37**A is an annular body that is coaxial with, and rotates about, the center axis **32**. The carrier output shaft **37**A has an axial length defined along the center axis **32**. The carrier output shaft **37**A is axially positioned between the sun gear **34** and the second end **16**C of the propeller shaft **16**. The carrier **37** includes multiple carrier arms **37**B which extend radially outwardly from the carrier output shaft **37**A to the compound planet gears **36**. The carrier arms **37**B are spaced circumferentially from each other about the center axis **32**. The number of carrier arms **37**B corresponds to the number of compound planet gears **36**. In the illustrated embodiment, there are three carrier arms **37**B. The carrier output shaft **37**A is engaged with propeller shaft **16** so that the carrier **37** is able to transmit torque to the propeller shaft **16** and thus drive the propeller.

(49) Referring to FIGS. **4**A and **4**B, the carrier **37** engages the propeller shaft **16** at an interface between the two components. More particularly, the carrier output shaft **37**A has carrier output meshing members **37**C, which may be gear teeth or spline teeth, along a radially inner wall of the carrier output shaft **37**A. The carrier output meshing members **37**C mesh with propeller input meshing members **16**M on a radially outer wall of the propeller shaft **16** and its first end **16**B, to convey a rotational output from the carrier output shaft **37**A to the propeller shaft **16**. The carrier **37** is thus engaged with the propeller shaft **16** at a carrier-output engagement location **39**. The carrier-output engagement location **39** is an area or region within the engine **10** at which the drive from the carrier **37** is transmitted to the first end **16**B of the propeller shaft **16**. Referring to FIGS. **4**A and **4**B, the carrier-output engagement location **39** is located along the longitudinal center axis **17** of the engine **10** at a position that is axially between the sun gear **34** and the second end **16**C of the propeller shaft **16**. Referring to FIGS. **4**A and **4**B, the carrier-output engagement location **39** is located along the longitudinal center axis **17** of the engine **10** at a position that is axially between the sun gear **34** and a mid-axial span position of the propeller shaft **16**. Referring to FIGS. **4**A and **4**B, the carrier-output engagement location **39** is located along the longitudinal center axis **17** of the engine **10** at a position that is axially adjacent to the first end **16**B of the propeller shaft **16**. Referring to FIGS. **4**A and **4**B, the carrier-output engagement location **39** is located relative to the longitudinal center axis **17** of the engine **10** at a position that is radially inward of the output gears **36**C of the compound planet gears **36**. Referring to FIGS. **4**A and **4**B, the carrier-output engagement location **39** is located relative to the longitudinal center axis **17** of the engine **10** at a

position that is radially inward of the radially-outermost surface of the carrier output shaft **37**A. Referring to FIGS. **4**A and **4**B, the carrier-output engagement location **39** is composed of, or includes, the carrier output shaft **37**A and the first end **16**B of the propeller shaft **16**.

(50) Referring to FIG. **2**D, the central body **36**F of each compound planet gear **36** is annular, and hollow along at least part of its axial length. A journal **136**G or sleeve is an annular body that extends along a circumferential inner surface of the central body **36**F and about the planet gear axis **36**A, and delimits the central cavity **36**H of the body **36**F which is also coaxial with the planet gear axis **36**A. The journal **136**G defines the inner journal surface **36**G. The journal **136**G and the central body **36**F rotate together (i.e. no slip) about the planet gear axis **36**A. The oil-film bearing **40** is positioned within the central cavity **36**H. Each of the bearings **40** are located between one of the compound planet gears **36** and the carrier **37**. Since the bearings **40** support the rotation of the compound planet gears **36**, they are sometimes referred to herein as "planet gear bearings **40**".

(51) Referring to FIG. **2**D, each bearing **40** is fixed to surrounding support structure, such as to a radially-outer end of one of the carrier arms **37**B of the carrier **37**, so that it does not displace about the planet gear axis **36**A during rotation of the compound planet gears **36** about their respective planet gear axes **36**A. The bearings **40** are coaxial with each of the compound planet gears **36** about their planet gear axes **36**A. In the illustrated embodiment, the bearings **40** are journal or rotary bearings, which support the compound planet gears **36** during their rotation. Referring to FIG. **2**D, each of the bearings **40** includes a bearing shaft **42** positioned within the central cavity **36**H about the planet gear axis **36**A. The bearing shaft **42** is engaged directly with the journal **136**G and disposed within the journal **136**G. The bearing shaft **42** is an annular body which defines a bearing shaft interior **42**A that is coaxial with the planet gear axis **36**A. Each bearing shaft **42** has an annular groove **42**C at its axially outer ends. The annular groove **42**C is coaxial with the planet gear axis **36**A and extends axially inwardly into the body of the bearing shaft **42**. The bearing shaft **42** in FIG. **2**D is thus a compliant shaft having axially outer ends which permit more deflection in a radial direction at both ends due to the structural compliance added by the annular grooves **42**C. Each bearing shaft **42**, and each bearing **40** itself, is secured to one of the carrier arms **37**B with a bolt **44** that extends through the bearing shaft interior **42**A and through axially opposed ends of the carrier arm **37**B. The bolt **44** rotates with the bearing shaft **42** (i.e. no slip) and the carrier **37** about the center axis **32**, such that the bolts **44** and the bearing shafts **42** are "stationary" with respect to the compound planet gears **36**.

(52) The oil-film bearing **40** releases a thin film of oil or other suitable lubricant along the radially-inner surface **36**G of the journal **136**G. The radially-inner surface **36**G of the journal **136**G therefore forms a lubrication interface **41** between the bearing **40** and the compound planet gear **36**, which is lubricated to allow the compound planet gear **36** and the journal **136**G to rotate relative to, and about, the bearing **40** and about the planet gear axis **36**A. The lubrication interface **41** is a radial gap between radially opposed surfaces, that is much smaller in magnitude than the radial dimensions of the components it is defined between. In FIG. **2**D, the radial gap of the lubrication interface **41** is defined between an inner diameter of the journal **136**G and an outer diameter of the bearing shaft **42**. The lubrication interface **41** in FIG. **2**D extends along most or all of the axial extent of the journal **136**G and the bearing shaft **42**. In an alternate embodiment, the lubrication interface **41** is along a radially-inner surface of the central body **36**F of the compound planet gear **36**, such that bearing shaft **42** directly supports the compound planet gear **36** (e.g. the journal sleeve **136**G is omitted from the assembly), which may require some surface treatment of the planet gear **36** internal diameter such as a coating.

(53) One possible manner for operating the epicyclic gear train **30** is now described with reference to FIGS. **4**A and **4**B. The sun gear **34** is engaged to the power shaft **15** to be driven thereby. The ring gears **38** are fixed and made immobile, such that they do not rotate about the center axis **32**. The ring gears **38** may be fixed in place by, among other things, being mounted to surrounding structure or by using a brake of the epicyclic gear train **30**. Since the ring gears **38** are fixed in

place, the compound planet gears **36** rotate about the center axis **32**. The rotational input provided by the sun gear **34** to the input gears **36**B of the compound planet gears **36** causes the compound planet gears **36** to rotate about their respective planet gear axes **36**A and about the center axis **32**. The rotation of the compound planet gears **36** about the center axis **32** in turn causes the carrier arms **37**B and the carrier output shaft **37**A to rotate about the center axis **32**. The carrier output meshing members **37**C of the carrier output shaft **37**A engage the propeller input meshing members **16**M at the first end **16**B of the propeller shaft **16** to provide the output of the epicyclic gear train **30** and rotate the propeller shaft **16**. The epicyclic gear train **30** in the depicted embodiment may therefore be referred to as a “planetary” gear system, in which the ring gears **38** are braked to slow and/or stop rotation thereof, while the compound planet gears **36** and the carrier **37** rotate about the center axis **32**. The compound planet gears **36** in such a planetary gear configuration thus revolve around the sun gear **34** (i.e. the axes **36**A of rotation of each compound planet gear **36** rotates about the center axis **32**). It is possible to operate the gear train **30** differently than as described above. For example, reference is made to U.S. patent application Ser. No. 16/360,297 which describes an arrangement of the epicyclic gear train **30** which operates as a “star”-type gear system where the carrier **37** is immobile and where the ring gears rotate about the center axis **32**, the entirety of which is incorporated by reference herein. The rotational direction of the input of the epicyclic gear train **30** is the same as the rotational direction of the output epicyclic gear train **30**.

(54) Referring to FIGS. **4**A and **4**B, a bearing lubrication system **50** is now described in greater detail. The bearing lubrication system **50** is a grouping of components which form part of the RGB **20** to supply a lubricant, such as oil, to the oil film bearings **40**, and possibly other components of the RGB **20** requiring lubrication. In one possible operating mode for the epicyclic gear train **30**, the bearings **40** are constantly fed with pressurized oil to continuously lubricate the lubrication interfaces **41**, so as to support rotation of the compound planet gears **36** about their planet gear axes **36**A.

(55) The bearing lubrication system **50** includes a lubricant supply conduit **52** to convey the lubricant to the lubrication interfaces **41**. More particularly, and as explained in greater detail below, the lubricant supply conduit **52** allows the lubricant to be conveyed from the carrier-output engagement location **39** to the lubrication interfaces **41** for each compound planet gear **36**. During operation of the engine **10**, the lubricant supply conduit **52** defines a lubricant flow path, along which the lubricant is supplied under pressure into a conduit inlet **54**A of the lubricant supply conduit **52** and travels along the lubricant flow path of the lubricant supply conduit **52** to multiple conduit outlets **54**B that are in fluid communication with the lubrication interfaces **41** (see FIG. **2**D). The lubricant supply conduit **52** may therefore be any suitable object, or take any suitable form, to achieve such functionality. As described in greater detail below, the lubricant supply conduit **52** includes interconnected through passages that extend through components of the epicyclic gear train **30**. The lubricant supply conduit **52** may also or alternatively include external tubes, pipes, lines or other fluid-enclosing bodies running along the outside of one or more components of the epicyclic gear train **30**.

(56) Referring to FIGS. **4**A and **4**B, the conduit inlet **54**A is any suitable opening, passage or volume which admits lubricant into the lubricant supply conduit **52**. The conduit inlet **54**A is positioned at the carrier-output engagement location **39**. By “at”, it is understood that the conduit inlet **54**A is located in the immediate vicinity of where the carrier output shaft **37**A engages the first end **16**B of the propeller shaft **16**. This may be expressed in different forms. For example, in one possible configuration, such as the one shown in FIG. **4**B, the conduit inlet **54**A is positioned immediately radially inwardly of the location where the carrier output meshing members **37**C of the carrier output shaft **37**A engage the propeller input meshing members **16**M at the first end **16**B of the propeller shaft **16**. In another possible configuration, the conduit inlet **54**A is positioned immediately axially adjacent to the location where the carrier output shaft **37**A engages the first end **16**B of the propeller shaft **16**. In another possible configuration, the conduit inlet **54**A is

positioned in the same location, or collocated, where the carrier output shaft **37**A engages the first end **16**B of the propeller shaft **16**. Referring to FIGS. **4**A and **2**D, each of the conduit outlets **54**B supplies the lubricant to one of the lubrication interfaces **41**. The conduit outlets **54**B therefore define, or are in fluid communication with, the lubrication interfaces **41**.

(57) Referring to FIGS. **4**A and **4**B, the bearing lubrication system **50** includes a lubricant strainer **56**. The lubricant strainer **56** is a filter, sieve or other similar device of any suitable size and density to remove solid or semisolid debris from the lubricant while allowing passage of the lubricant through the lubricant strainer **56**, before the lubricant is conveyed, via the conduit inlet **54**A, into the lubricant supply conduit **52**. The lubricant strainer **56** thus prevents any undesirable solid debris from being entrained with the lubricant to the lubrication interfaces **41**. The lubricant strainer **56** therefore helps prevent or reduce debris from entering the bearing **40**, where such debris might otherwise cause overheating, damage and/or failure of the bearing **40**.

(58) Referring to FIG. **4**B, the lubricant strainer **56** is mounted about the conduit inlet **54**A. By "about", it is understood that the lubricant strainer **56** is mounted in relation to the conduit inlet **54**A such that the lubricant strainer **56** is positioned upstream of the conduit inlet **54**, so that the lubricant must first travel through the lubricant strainer **56** before entering the conduit inlet **54**A. Different configurations of this mounting are possible. For example, and referring to FIGS. **4**B and **5**C, the conduit inlet **54**A includes one or more openings **55** in the propeller shaft **16**. The openings **55** are circumferentially spaced apart from each other along the inner annular wall of the propeller shaft **16** that delimits the shaft interior **16**D (see FIG. **5**C). The lubricant strainer **56** covers or overlaps the openings **55** to filter the lubricant upstream of the openings **55** by forcing the lubricant to transit through the lubricant strainer **56** before going into the openings **55**. The lubricant strainer **56** has a mesh **56**A which is spaced apart from the openings **55**. The mesh **56**A is spaced apart radially inwardly from the openings **55**. The mesh **56**A has a frusto-conical shape. The lubricant strainer **56** is a singular body. The lubricant strainer **56** is only one of the parts of the engine **10**. In another possible configuration, the lubricant strainer **56** is mounted closer or further to the conduit inlet **54**A. In another possible configuration, the lubricant strainer **56** is a cylindrical mesh. In another possible configuration, the lubricant strainer **56** is a disc-shaped axial flow membrane.

(59) Referring to FIGS. **4**A and **4**B, the lubricant strainer **56** is positioned within the shaft interior **16**D and protects the openings **55** from potential debris in the lubricant. In FIGS. **4**A and **4**B, only one lubricant strainer **56** is positioned within the shaft interior **16**D. The lubricant strainer **56** in the illustrated embodiment has an annular body **56**B that is coaxial with the longitudinal center axis **17** of the engine **10**. Referring to FIGS. **4**B and **6**, the annular body **56**B has an axial extent, and extends between a first end **56**B**1** and a second end **56**B**2**. When the lubricant strainer **56** is mounted at the carrier-output engagement location **39**, the first end **56**B**1** is axially closer to the propeller than the second end **56**B**2**. The diameter of the annular body **56**B is greater at the first end **56**B**1** than at the second end **56**B**2**. The annular body **56**B has a frusto-conical shape. The first and second ends **56**B**1**,**56**B**2** are defined by rings of different diameter each of which supports the mesh **56**A. The first and second ends **56**B**1**,**56**B**2** are mounted to any suitable portion of the inner annular wall of the propeller shaft **16** that defines the shaft interior **16**D so that the lubricant strainer **56** rotates with the propeller shaft **16** about the longitudinal center axis **17**. In an alternate embodiment, the lubricant strainer **56** is not annular or does not include the annular body **56**B. In an alternate embodiment, the conduit inlet **54**A is along an outer wall of the carrier output shaft **37**A at the carrier-output engagement location **39**, and the lubricant strainer **56** is mounted about the carrier output shaft **37**A like a sleeve so that the mesh **56**A covers the conduit inlet **54**A.

(60) The lubricant strainer **56** is located at the carrier-output engagement location **39**. By "at", it is understood that the lubricant strainer **56** is located in the immediate vicinity of where the carrier output shaft **37**A engages the first end **16**B of the propeller shaft **16**. This may be expressed in different forms. For example, in one possible configuration, such as the one shown in FIG. **4**B, the lubricant strainer **56** is positioned immediately radially inwardly of the location where the carrier

output meshing members **37**C of the carrier output shaft **37**A engage the propeller input meshing members **16**M at the first end **16**B of the propeller shaft **16**. In another possible configuration, the lubricant strainer **56** is positioned immediately axially adjacent to the location where the carrier output shaft **37**A engages the first end **16**B of the propeller shaft **16**. In another possible configuration, the lubricant strainer **56** is positioned in the same location, or collocated, where the carrier output shaft **37**A engages the first end **16**B of the propeller shaft **16**.

(61) In some configurations of the components of the epicyclic gear train **30**, size constraints or the arrangement of the components may make it difficult or impossible to filter the lubricant within the RGB **20** at, or immediately prior to, the lubrication interfaces **41**. Thus, placing the lubricant strainer **56** at the inlet **54**A of the lubricant supply conduit **52** allows for filtering any debris and preventing it from entering the lubricant supply conduit **52** before the lubricant gets to the lubrication interfaces **41**. Placing the lubricant strainer **56** at the carrier-output engagement location **39** provides a “last chance” for filtering the lubricant before it enters the small and difficult-to-access portions of the lubricant supply conduit **52** that lead to the lubrication interfaces **41**. Thus, the position of the lubricant strainer **56** at the carrier-output engagement location **39** helps to prevent comprising the reliability of the bearing **40** or the lubrication feed system. Furthermore, the position of the lubricant strainer **56** at the carrier-output engagement location **39** may facilitate maintenance, cleaning, replacement, inspection, or repair of the lubricant strainer **56**, because the lubricant strainer **56** may be easily accessed during maintenance of engine **10** by removing the propeller shaft **16** to create an axially and radially extending access volume to an interior of the carrier shaft **37**A. Further, by removing the propeller, access is provided to the lubricant strainer **56** via the interior of the propeller shaft **16** in one possible configuration of the lubricant strainer **56**. There may thus be no need to disassemble the whole epicyclic gear train **30** to access the lubricant strainer **56** because it is positioned at the carrier-output engagement location **39**.

(62) Positioning the lubricant strainer **56** at the carrier-output engagement location **39** helps to locate the lubricant strainer **56** as close as possible to the lubrication interfaces **41** without being within the components of the epicyclic gear train **30**, and removes any design requirement for the bearings **40** or the body **36**F of the compound planet gears **36** to filter the lubricant. This allows the bearings **40** and the compound planet gears **36** to be optimized for their primary load carrying function, rather than for lubricant filtration, and contributes to a stable and compact design for the bearings **40** allowing high power/weight ratio and reliability. This also provides more options when selecting the size and shape of the lubricant strainer **56** for a given epicyclic gear train **30**. By using a single lubricant strain **56** is some configurations upstream of the lubrication interfaces **41**, it is possible to avoid using multiple filters within the compound planetary gears **36** and thus reduce the engine part count.

(63) In an alternate embodiment, the lubricant strainer **56** is positioned at another location of the epicyclic gear train **30**. For example, in the configuration of the RGB **20** where the epicyclic gear train **30** is a “star” type gear train as described above, the lubricant strainer **56** is positioned at a location where the rotatable output from the ring gear **38** engages an output shaft like the propeller shaft **16**.

(64) Referring to FIGS. **5**A to **5**C, the lubricant supply conduit **52** is described in greater detail. In the depicted configuration, the lubricant supply conduit **52** includes interconnected through passages that extend through components of the epicyclic gear train **30**. The lubricant supply conduit **52** includes multiple first segments **52**A that are through passages through the annular body of the propeller shaft **16**. Each first segment **52**A extends radially outwardly from one of the openings **55** and is in fluid communication with the shaft interior **16**D. The orientation of each first segment **52**A is radial to the longitudinal center axis **17**, and is inclined relative to a radial line by an angle greater than 0 degrees and less than 90 degrees. The lubricant supply conduit **52** includes multiple second segments **52**B downstream of the first segments **52**A and in fluid communication with the first segments **52**A to receive the lubricant therefrom. The second segments **52**B are

through passages through the body of the carrier **37**, and extend downstream from the first segments **52**A through the carrier **37** to the conduit outlets **54**B at the lubrication interfaces **41**. The lubricant supply conduit **52** is thus formed of interconnected passages through the propeller shaft **16** and through the carrier **37** to ultimately deliver the lubricant to the bearings **40** and the interfaces **41**.

(65) Referring to FIGS. **5**A to **5**C, each of the second segments **52**B includes multiple portions. A first portion **52**B**1** of each second segment **52**B extends substantially axially (i.e. an axial vector of the first portion **52**B**1** is greater in magnitude than a radial vector) through the carrier output shaft **37**A from the corresponding first segment **52**A. The upstream end of the first portion **52**B**1** of the second segments **52**B and the downstream end of the first segments **52**A meet at an annular lubricant cavity **53** defined between a radially-inner surface of the carrier output shaft **37**A and a radially-outer surface of the propeller shaft **16**. The annular lubricant cavity **53** may form a manifold for collecting the previously-filtered lubricant from the openings **55**. A second portion **52**B**2** of each second segment **52**B extends substantially radially (i.e. a radial vector of the second portion **52**B**2** is greater in magnitude than an axial vector) through each of the carrier arms **37**B from the first portion **52**B**1**. A third portion **52**B**3** of each second segment **52**B extends through one of the carrier arm **37**B toward the planet gear bearing **40**. A fourth portion **52**B**4** of each second segment **52**B is defined within the planet gear bearing **40**. The fourth portion **52**B**4** extends through the bolt **44** and through the bearing shaft **42** and is in fluid communication with the third portion **52**B**3**. Referring to FIG. **2**D, the fourth portion **52**B**4** has an upstream end defined by an opening **44**A in the bolt **44** which is in fluid communication with the third portion **52**B**3**. The fourth portion **52**B**4** extends along an inner passage **44**B of the bolt **44**, and provides the lubricant to a radially-extending bearing shaft passage **42**B extending through the bearing shaft **42**. Each bearing shaft passage **42**B terminates at, and is in fluid communication with, the lubrication interface **41** to supply the lubricant to the lubrication interface **41**. The fourth portion **52**B**4** may be referred to herein as a “planet gear passage **52**B**4**” because it allows lubricant to be supplied to lubricate the rotation of the compound planet gear **36**. Referring to FIGS. **5**A and **5**B, the carrier arms **37**B include one or more machining passages **52**C which are used to form, or to facilitate, the creation of the portions **52**B**1**,**52**B**2**,**52**B**3**,**52**B**4** of the second segment **52**B. The machining passages **52**C may be partially or fully filled in once the machining operation has been completed. Although the first and second segments **52**A,**52**B may be described above using singular language, it will be appreciated that the lubricant supply conduit **52** includes multiple pairs of the first and second segments **52**A,**52**B, where each pair of the first and second segments **52**A,**52**B may be circumferentially spaced apart from another pair. Referring to FIGS. **5**A and **5**B, the second segment **52**B of the lubricant supply conduit **52** includes multiple sun gear passages **52**B**5**, each of which terminates at one or more sun gear passage outlets **52**B**5**O to lubricate an engagement between the compound planet gears **36** and the sun gear **34**. Each of the sun gear passages **52**B**5** is a spur line extending from the first portion **52**B**1** of the second segment **52**B, downstream of the location where the second portion **52**B**2** of the second segment **52**B intersects the first portion **52**B**1**. Each of the sun gear passages **52**B**5** has a substantially radial orientation relative to the center axis **32**. The sun gear passage outlets **52**B**5**O are spaced apart radially inwardly of the first portions **52**B**1**.

(66) During operation of the engine **10**, the flow of a lubricant **58** along the lubricant flow path defined by the lubricant supply conduit **52** may be described as follows with reference to FIGS. **5**A to **5**C. The lubricant **58** is supplied under pressure to the shaft interior **16**D of the propeller shaft **16** and travels in an axial direction through the shaft interior **16**D toward the lubricant strainer **56**. The lubricant **58** is then conveyed under pressure through the mesh **56**A of the lubricant strainer **56** which filters the lubricant **58** by removing debris which may be entrained in the lubricant **58**. Once the lubricant **58** is screened or filtered by the mesh **56**A, it enters the openings **55** in the propeller shaft **16** at the conduit inlet **54**A. The lubricant **58** is then conveyed through the first segments **52**A

of the lubricant supply conduit **52** in a radially outward direction. The lubricant **58** is then conveyed through the second segments **52**B of the lubricant supply conduit **52**. More particularly, the lubricant **58** is conveyed along the first portions **52**B**1**, then the second portions **52**B**2**, then the third portions **52**B**3** and then into the opening **44**A of the fourth portions **52**B**4** of the second segments **52**B. Referring to FIG. **2**D, from the opening **44**A, the lubricant **58** is conveyed along the inner passage **44**B of the bolt **44**, and through the radially-extending bearing shaft passage **42**B extending through the bearing shaft **42**. The lubricant **58** then arrives at the lubrication interfaces **41** to supply the lubricant to the lubrication interfaces **41**. During conveyance of the lubricant **58** to the lubrication interfaces **41**, the propeller shaft **16**, the carrier output shaft **37**A, and the carrier arms **37**B are rotating about one or more of the axes **16**A,**17**,**32**.
(67) Referring to FIGS. **5**A to **5**C and **7**, there is disclosed a method of operating the RGB **20**. The method includes filtering the lubricant **58** at a location **39** where the carrier **37** engages an output **16** of the aircraft engine **10**. The method includes lubricating interfaces **41** between the planet gears **36** and the carrier **37** with the filtered lubricant **58**.
(68) Referring to FIGS. **5**A to **5**C and **8**, there is disclosed a method of performing maintenance on an aircraft gas turbine engine **10**. The method includes removing the propeller shaft **16** of the engine **10** to form an axially and radially extending access volume at the center of the engine **10**. The method includes performing maintenance (e.g. inspection, cleaning, replacement, repair, etc.) on a lubricant strainer **56** mounted at the carrier-output engagement location **39**. The method may further include not disassembling the epicyclic gear train **30** of the engine **10**. The method may include removing a casing for the RGB **20**.
(69) The embodiments described in this document provide non-limiting examples of possible implementations of the present technology. Upon review of the present disclosure, a person of ordinary skill in the art will recognize that changes may be made to the embodiments described herein without departing from the scope of the present technology. For example, although described herein as “compound”, the planet gears **36** may be other types of gears which do not have compound stages, such as gears where the meshing members receive input from the sun gear **34** and also engage with the one or more ring gears **38**. Yet further modifications could be implemented by a person of ordinary skill in the art in view of the present disclosure, which modifications would be within the scope of the present technology.

Claims

1. A method of performing maintenance on an aircraft engine including an epicyclic gear train having a sun gear a carrier mounted about a center axis, and a plurality of planet gears mounted to the carrier, the carrier engaged with a propeller shaft at a carrier-output engagement location, the method comprising: removing the propeller shaft of the aircraft engine to form an access volume at a center of the aircraft engine, the access volume extending axially and radially relative to the center axis at the carrier-output engagement location; and performing maintenance on a lubricant strainer positioned at the carrier-output engagement location.
2. The method of claim 1, wherein performing maintenance on the lubricant strainer includes removing the lubricant strainer from inside the propeller shaft and cleaning the lubricant strainer.
3. The method of claim 2, wherein cleaning the lubricant strainer includes removing debris from the lubricant strainer and returning the lubricant strainer inside the propeller shaft.
4. The method of claim 1, wherein performing maintenance on the lubricant strainer includes replacing the lubricant strainer with a new lubricant strainer, and positioning the new lubricant strainer at the carrier-output engagement location.
5. The method of claim 1, wherein performing maintenance on the lubricant strainer includes performing at least one of inspecting, cleaning, replacing and repairing the lubricant strainer at the carrier-output engagement location or after having removed the lubricant strainer from the carrier-

output engagement location.

6. The method of claim 1, comprising accessing the lubricant strainer via the access volume.

7. The method of claim 1, wherein removing the propeller shaft and performing maintenance include leaving the epicyclic gear train of the aircraft engine assembled.

8. The method of claim 1, comprising removing a casing of the epicyclic gear train of the aircraft engine.