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Epicyclic gear train

Abstract

A gas turbine engine according to an example of the present disclosure includes a propulsor section including a propulsor supported on a propulsor shaft, a turbine section including a turbine shaft, a compressor section having a plurality of compressor hubs with blades driven by the turbine shaft about an engine axis, and an epicyclic gear train interconnecting the propulsor shaft and the turbine shaft. The epicyclic gear train includes a sun gear coupled to the turbine shaft, intermediary gears arranged circumferentially about and meshing with the sun gear, a carrier and a ring gear including first and second portions. The first and second portions have axially opposed faces abutting one another at a radial interface.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) The present disclosure is a continuation of U.S. patent application Ser. No. 18/196,048 filed May 11, 2023, which is a continuation of U.S. patent application Ser. No. 17/711,177 filed Apr. 1, 2022, now U.S. Pat. No. 11,680,492, granted Jun. 20, 2023, which is a continuation of U.S. patent application Ser. No. 17/145,766 filed Jan. 11, 2021, now U.S. Pat. No. 11,319,831, granted May 3, 2022, which is a continuation of U.S. patent application Ser. No. 16/805,917 filed Mar. 2, 2020, now U.S. Pat. No. 10,890,245, granted Jan. 12, 2021, which is a continuation of U.S. patent application Ser. No. 15/984,494, filed May 21, 2018, now U.S. Pat. No. 10,577,965 granted Mar. 3, 2020, which is a continuation of U.S. patent application Ser. No. 14/824,351, filed Aug. 12, 2015, now U.S. Pat. No. 9,976,437, granted May 22, 2018, which is a continuation-in-part of U.S. patent application Ser. No. 13/486,766, filed Jun. 1, 2012, which is a continuation of U.S. patent application Ser. No. 13/340,735, filed Dec. 30, 2011, now U.S. Pat. No. 8,708,863, granted Apr. 29, 2014, which is a continuation-in-part of U.S. patent application Ser. No. 11/504,220, filed Aug. 15, 2006, now U.S. Pat. No. 8,753,243, granted Jun. 17, 2014.

BACKGROUND OF THE INVENTION
(1) This invention relates to a ring gear used in an epicyclic gear train of a gas turbine engine.
(2) Gas turbine engines typically employ an epicyclic gear train connected to the turbine section of the engine, which is used to drive the turbo fan. In a typical epicyclic gear train, a sun gear receives rotational input from a turbine shaft through a compressor shaft. A carrier supports intermediate gears that surround and mesh with the sun gear. A ring gear surrounds and meshes with the

intermediate gears. In arrangements in which the carrier is fixed against rotation, the intermediate gears are referred to as "star" gears and the ring gear is coupled to an output shaft that supports the turbo fan.

(3) Typically, the ring gear is connected to the turbo fan shaft using a spline ring. The spline ring is secured to a flange of the turbo fan shaft using circumferentially arranged bolts. The spline ring includes splines opposite the flange that supports a splined outer circumferential surface of the ring gear. The ring gear typically includes first and second portions that provide teeth facing in opposite directions, which mesh with complimentary oppositely facing teeth of the star gears.

(4) An epicyclic gear train must share the load between the gears within the system. As a result, the splined connection between the ring gear and spline ring is subject to wear under high loads and deflection. Since the spline connection requires radial clearance, it is difficult to get a repeatable balance of the turbo fan assembly. Balance can also deteriorate over time with spline wear.

SUMMARY OF THE INVENTION

(5) In a featured embodiment, a turbine engine has a fan shaft. At least one tapered bearing is mounted on the fan shaft. The fan shaft includes at least one passage extending in a direction having at least a radial component, and adjacent the at least one tapered bearing. A fan is mounted for rotation on the tapered bearing. An epicyclic gear train is coupled to drive the fan. The epicyclic gear train includes a carrier supporting intermediate gears that mesh with a sun gear. A ring gear surrounds and meshes with the intermediate gears. Each of the intermediate gears are supported on a respective journal bearing. The epicyclic gear train defines a gear reduction ratio of greater than or equal to about 2.3. A turbine section is coupled to drive the fan through the epicyclic gear train. The turbine section has a fan drive turbine that includes a pressure ratio that is greater than about 5. The fan includes a pressure ratio that is less than about 1.45, and the fan has a bypass ratio of greater than about ten (10).

(6) In another embodiment according to the previous embodiment, the fan shaft is coupled to the ring gear.

(7) In another embodiment according to any of the previous embodiments, the at least one tapered bearing includes a first tapered bearing and the at least one passage includes a first passage and a second passage. The first passage is located at an axially forward side of the first tapered bearing and the second passage is located at an axially aft side of the first tapered bearing.

(8) In another embodiment according to any of the previous embodiments, the fan shaft includes, on a radially inner surface, at least one well extending between axial sides and a radial side, and the at least one passage opens at the radial side.

(9) In another embodiment according to any of the previous embodiments, the fan shaft includes, on a radially inner surface, a plurality of wells each extending between axial side walls and a radial side wall, and the at least one passage includes a plurality of passages that open at respective ones of the radial side walls of the plurality of wells.

(10) In another embodiment according to any of the previous embodiments, two wells of the plurality of wells are axially adjacent such that the two wells share a common axial side wall.

(11) In another embodiment according to any of the previous embodiments, the axial side walls are gradually sloped.

(12) In another embodiment according to any of the previous embodiments, the epicyclic gear train has a gear reduction ratio of greater than or equal to 2.3.

(13) In another embodiment according to any of the previous embodiments, the epicyclic gear train has a gear reduction ratio of greater than or equal to about 2.5.

(14) In another embodiment according to any of the previous embodiments, the epicyclic gear train has a gear reduction ratio of greater than or equal to 2.5.

(15) In another embodiment according to any of the previous embodiments, the fan defines a bypass ratio of greater than about 10.5:1 with regard to a bypass airflow and a core airflow.

(16) In another embodiment according to any of the previous embodiments, there are three

turbines, with the fan drive turbine being a lowest pressure turbine, and there being a high pressure turbine and an intermediate pressure turbine, with the high pressure turbine and the intermediate pressure turbine each driving a compressor rotor.
(17) Although different examples have the specific components shown in the illustrations, embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components of another of the examples.
(18) These and other features disclosed herein can be best understood from the following specification and drawings, the following of which is a brief description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a partial cross-sectional view of a front portion of a gas turbine engine illustrating a turbo fan, epicyclic gear train and a compressor section.
(2) FIG. **2** is an enlarged cross-sectional view of the epicyclic gear train shown in FIG. **1**.
(3) FIG. **3** is an enlarged cross-sectional view of an example ring gear similar to the arrangement shown in FIG. **2**.
(4) FIG. **4** is a view of the ring gear shown in FIG. **3** viewed in a direction that faces the teeth of the ring gear in FIG. **3**.
(5) FIG. **5** shows another embodiment.
(6) FIG. **6** shows yet another embodiment.
DETAILED DESCRIPTION
(7) A portion of a gas turbine engine **10** is shown schematically in FIG. **1**. The turbine engine **10** includes a fixed housing **12** that is constructed from numerous pieces secured to one another. A compressor section **14** having compressor hubs **16** with blades are driven by a turbine shaft **25** about an axis A. A turbo fan **18** is supported on a turbo fan shaft **20** that is driven by a compressor shaft **24**, which supports the compressor hubs **16**, through an epicyclic gear train **22**.
(8) In the example arrangement shown, the epicyclic gear train **22** is a star gear train. Referring to FIG. **2**, the epicyclic gear train **22** includes a sun gear **30** that is connected to the compressor shaft **24**, which provides rotational input, by a splined connection. A carrier **26** is fixed to the housing **12** by a torque frame **28** using fingers (not shown) known in the art. The carrier **26** supports star gears **32** using journal bearings **34** that are coupled to the sun gear **30** by meshed interfaces between the teeth of sun and star gears **30**, **32**. Multiple star gears **32** are arranged circumferentially about the sun gear **30**. Retainers **36** retain the journal bearings **34** to the carrier **26**. A ring gear **38** surrounds the carrier **26** and is coupled to the star gears **32** by meshed interfaces. The ring gear **38**, which provides rotational output, is secured to the turbo fan shaft **20** by circumferentially arranged fastening elements, which are described in more detail below.
(9) As shown, each of the star gears **32** is supported on one of the journal bearings **34**. Each journal bearing **34** has an internal central cavity **34***a* that extends between axial ends **35***a* and **35***b*. In this example, as shown, the internal central cavity **34***a* is axially blind in that the axial end **35***a* is closed. At least one passage **37** extends from the internal central cavity **34***a* to a peripheral journal surface **39**. In the example, the at least one passage **37** includes a first passage **37***a* and a second passage **37***b* that is axially spaced from the first passage **37***a*. As shown, the first and second passages **37***a* and **37***a* are non-uniformly spaced with regard to the axial ends **35***a* and **35***b* of the internal central cavity **34***a*.
(10) In operation, lubricant is provided to the internal central cavity **34***a*. The lubricant flows through the internal central cavity **34***a* and then outwardly through the at least one passage **37** to the peripheral journal surface **39**. The arrangement of the internal central cavity **34***a* and at least

one passage **37** thereby serves to cool and lubricate the journal bearing **32**.
(11) The gas turbine engine **10** is a high-bypass geared architecture aircraft engine. In one disclosed, non-limiting embodiment, the engine **10** has a bypass ratio that is greater than about six (6) to ten (10), the epicyclic gear train **22** is a planetary gear system or other gear system with a gear reduction ratio of greater than about 2.3 or greater than about 2.5, and a low pressure turbine of the engine **10** has a pressure ratio that is greater than about 5. In one disclosed embodiment, the engine **10** bypass ratio is greater than about ten (10:1) or greater than about 10.5:1, the turbofan **18** diameter is significantly larger than that of the low pressure compressor of the compressor section **14**, and the low pressure turbine has a pressure ratio that is greater than about 5:1. In one example, the epicyclic gear train **22** has a gear reduction ratio of greater than about 2.3:1 or greater than about 2.5:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present invention is applicable to other gas turbine engines including direct drive turbofans.
(12) A significant amount of thrust is provided by a bypass flow B due to the high bypass ratio. The fan **18** of the engine **10** is designed for a particular flight condition—typically cruise at about 0.8 M and about 35,000 feet. The flight condition of 0.8 M and 35,000 ft, with the engine at its best fuel consumption—also known as "bucket cruise TSFC"—is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. "Low fan pressure ratio" is the pressure ratio across the fan blade alone. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45. "Low corrected fan tip speed" is the actual fan tip speed in ft/sec divided by an industry standard temperature correction of [(Tambient deg R)/518.7){circumflex over ( )}0.5]. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1150 ft/second.
(13) Referring to FIGS. **3** and **4**, the ring gear **38** is a two-piece construction having first and second portions **40**, **42**. The first and second portions **40**, **42** abut one another at a radial interface **45**. A trough **41** separates oppositely angled teeth **43** (best shown in FIG. **4**) on each of the first and second portions **40**, **42**. The arrangement of teeth **43** forces the first and second portions **40**, **42** toward one another at the radial interface **45**. The back side of the first and second portions **40**, **42** includes a generally S-shaped outer circumferential surface **47** that, coupled with a change in thickness, provides structural rigidity and resistance to overturning moments. The first and second portions **40**, **42** have a first thickness T**1** that is less than a second thickness T**2** arranged axially inwardly from the first thickness T**1**. The first and second portions **40**, **42** include facing recesses **44** that form an internal annular cavity **46**.
(14) The first and second portions **40**, **42** include flanges **51** that extend radially outward away from the teeth **43**. The turbo fan shaft **20** includes a radially outwardly extending flange **70** that is secured to the flanges **51** by circumferentially arranged bolts **52** and nuts **54**, which axially constrain and affix the turbo fan shaft **20** and ring gear **38** relative to one another. Thus, the spline ring is eliminated, which also reduces heat generated from windage and churning that resulted from the sharp edges and surface area of the splines. The turbo fan shaft **20** and ring gear **38** can be rotationally balanced with one another since radial movement resulting from the use of splines is eliminated. An oil baffle **68** is also secured to the flanges **51**, **70** and balanced with the assembly.
(15) Seals **56** having knife edges **58** are secured to the flanges **51**, **70**. The first and second portions **40**, **42** have grooves **48** at the radial interface **45** that form a hole **50**, which expels oil through the ring gear **38** to a gutter **60** that is secured to the carrier **26** with fasteners **61** (FIG. **2**). The direct radial flow path provided by the grooves **48** reduces windage and churning by avoiding the axial flow path change that existed with splines. That is, the oil had to flow radially and then axially to exit through the spline interface. The gutter **60** is constructed from a soft material such as aluminum so that the knife edges **58**, which are constructed from steel, can cut into the aluminum if they interfere. Referring to FIG. **3**, the seals **56** also include oil return passages **62** provided by first

and second slots **64** in the seals **56**, which permit oil on either side of the ring gear **38** to drain into the gutter **60**. In the example shown in FIG. **2**, the first and second slots **64**, **66** are instead provided in the flange **70** and oil baffle **68**, respectively.
(16) FIG. **5** shows an embodiment **200**, wherein there is a fan drive turbine **208** driving a shaft **206** to in turn drive a fan rotor **202**. A gear reduction **204** may be positioned between the fan drive turbine **208** and the fan rotor **202**. This gear reduction **204** may be structured and operate like the gear reduction disclosed above. A compressor rotor **210** is driven by an intermediate pressure turbine **212**, and a second stage compressor rotor **214** is driven by a turbine rotor **216**. A combustion section **218** is positioned intermediate the compressor rotor **214** and the turbine section **216**.
(17) FIG. **6** shows yet another embodiment **300** wherein a fan rotor **302** and a first stage compressor **304** rotate at a common speed. The gear reduction **306** (which may be structured as disclosed above) is intermediate the compressor rotor **304** and a shaft **308** which is driven by a low pressure turbine section.
(18) Although embodiments of this invention have been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

Claims

1. A gas turbine engine comprising: a propulsor section including a propulsor supported on a propulsor shaft; a turbine section including a turbine shaft; a compressor section having a plurality of compressor hubs with blades driven by the turbine shaft about an engine axis; and an epicyclic gear train interconnecting the propulsor shaft and the turbine shaft, the epicyclic gear train comprising: a sun gear coupled to the turbine shaft; intermediary gears arranged circumferentially about and meshing with the sun gear; a carrier and support means for supporting each of the intermediate gears relative to the carrier; and a ring gear including first and second portions, the first and second portions each having an inner periphery with teeth intermeshing with the intermediate gears, the first and second portions having axially opposed faces abutting one another at a radial interface, the ring gear including discharge means for expelling lubricant from the radial interface outwardly of the ring gear, and the discharge means including facing recesses of the first and second portions that form an internal annular cavity along the radial interface; wherein the first and second portions including respective flanges extending along the radial interface radially outward from the teeth, the epicyclic gear train defines a gear reduction ratio of greater than or equal to 2.5, and the ring gear includes engagement means for forcing the first portion and the second portion toward one another at the radial interface.
2. The gas turbine engine as recited in claim 1, wherein the epicyclic gear train is a planetary gear system.
3. The gas turbine engine as recited in claim 1, wherein the ring gear includes attachment means for securing the first and second portions of the ring gear to the propulsor shaft.
4. The gas turbine engine as recited in claim 1, wherein the first and second portions of the gear train includes means for resisting overturning moments.
5. The gas turbine engine as recited in claim 1, wherein the ring gear includes accumulation means for capturing lubrication expelled toward the radial interface.
6. The gas turbine engine as recited in claim 1, wherein the support means includes journal bearings that support the respective intermediate gears, and each journal bearing includes lubrication means for conveying lubricant through the journal bearing to a peripheral journal surface of the journal bearing.
7. The gas turbine engine as recited in claim 1, wherein the gear train includes a torque frame

having securement means for fixing the carrier to a fixed housing.
8. The gas turbine engine as recited in claim 1, wherein: the gear train includes collection means for receiving lubricant expelled by the discharge means through the radial interface; the discharge means inhibits an axial flow of lubricant passing along the radial interface prior to being expelled toward the collection means; and the gear train includes return means for communicating lubricant from an outer periphery of the respective first and second portions of the ring gear outwardly to the collection means.
9. The gas turbine engine as recited in claim 1, further comprising: an input shaft that interconnects the sun gear and the turbine shaft, the input shaft including an undulation that extends radially outward relative to the engine axis.
10. The gas turbine engine as recited in claim 1, wherein the discharge means includes grooves at the radial interface that form a hole.
11. The gas turbine engine as recited in claim 10, wherein the hole provides a direct radial path through the ring gear.
12. The gas turbine engine as recited in claim 1, wherein the propulsor is a turbo fan, and the propulsor shaft is a fan shaft supporting the fan.
13. A gas turbine engine comprising: a propulsor section including a propulsor supported on a propulsor shaft; a turbine section including a turbine shaft; a compressor section having a plurality of compressor hubs with blades driven by the turbine shaft about an engine axis; and an epicyclic gear train interconnecting the propulsor shaft and the turbine shaft, the epicyclic gear train comprising: a sun gear coupled to the turbine shaft; intermediary gears arranged circumferentially about and meshing with the sun gear; a carrier and support means for supporting each of the intermediate gears relative to the carrier; and a ring gear including first and second portions, the first and second portions each having an inner periphery with teeth intermeshing with the intermediate gears, the first and second portions having axially opposed faces abutting one another at a radial interface, the ring gear including discharge means for expelling lubricant from the radial interface outwardly of the ring gear, and the discharge means including facing recesses of the first and second portions that form an internal annular cavity along the radial interface; wherein the propulsor is a turbo fan, and the propulsor shaft is a fan shaft supporting the fan.
14. The gas turbine engine as recited in claim 13, wherein the ring gear includes attachment means for securing the first and second portions of the ring gear to the propulsor shaft.
15. The gas turbine engine as recited in claim 13, wherein the first and second portions of the gear train includes means for resisting overturning moments.
16. The gas turbine engine as recited in claim 13, wherein the ring gear includes accumulation means for capturing lubrication expelled toward the radial interface.
17. The gas turbine engine as recited in claim 13, wherein the gear train includes a torque frame having securement means for fixing the carrier to a fixed housing.
18. The gas turbine engine as recited in claim 13, wherein: the gear train includes collection means for receiving lubricant expelled by the discharge means through the radial interface; the discharge means inhibits an axial flow of lubricant passing along the radial interface prior to being expelled toward the collection means; and the gear train includes return means for communicating lubricant from an outer periphery of the respective first and second portions of the ring gear outwardly to the collection means.
19. A gas turbine engine comprising: a propulsor section including a propulsor supported on a propulsor shaft; a turbine section including a turbine shaft; a compressor section having a plurality of compressor hubs with blades driven by the turbine shaft about an engine axis; and an epicyclic gear train interconnecting the propulsor shaft and the turbine shaft, the epicyclic gear train comprising: a sun gear coupled to the turbine shaft; intermediary gears arranged circumferentially about and meshing with the sun gear; a carrier and support means for supporting each of the intermediate gears relative to the carrier; a ring gear including first and second portions, the first

and second portions each having an inner periphery with teeth intermeshing with the intermediate gears, the first and second portions having axially opposed faces abutting one another at a radial interface, the ring gear including discharge means for expelling lubricant from the radial interface outwardly of the ring gear, and the discharge means including facing recesses of the first and second portions that form an internal annular cavity along the radial interface; and sealing means along an outer periphery of the respective first and second portions.

20. The gas turbine engine as recited in claim 19, wherein: the gear train includes collection means for receiving lubricant expelled by the discharge means through the radial interface; the gear train includes return means for communicating lubricant from the outer periphery of the respective first and second portions of the ring gear outwardly to the collection means.