disclosed herein according to one non-limiting embodiment is less than about 1150 ft / second.

[0035] Referring to Figures 2 and 3, a geared turbofan architecture with a counter-rotating low pressure compressor (LPC) 60 and counter-rotating low pressure turbine (LPT) 62 is provided, which significantly reduces a length of the low speed or inner shaft 40 as compared to a non-counter-rotating configuration, an example of which is shown in Figure 1 and in the upper half of Figure 2. This non-rotating configuration in the upper half of Figure 2 is included for the purposes of a length comparison to the counter-rotating LPC and counter-rotating LPT configurations shown in the lower half of Figure 2. The engine has a high pressure core, schematically indicated at 64. It is to be understood that the high pressure core 64 includes the combustor 56 and the high spool 32 (i.e., the high pressure compressor 52, the high pressure turbine 54, and the high shaft 50) shown in Figure 1. The high pressure compressor 52 has a high pressure core ratio of 23:1, for example. To retain this ratio, as well as providing a desired low shaft diameter and speed, a combination of the counter-rotating LPC 60 and LPT 62 is utilized as shown in the lower half of Figure 2.

[0036] One example of the LPC 60 is found in United States Patent No. 7,950,220, which is assigned to the same assignee as the subject invention, and which is hereby incorporated by reference. In this example, which is shown in Figure 2, the LPC 60 includes a counter-rotating compressor hub 70 with blade stages 72, 74, and 76 interspersed with blade stages 78 and 80 of the low speed spool 30. The counter-rotating compressor hub 70 may be driven by a transmission 82. The transmission 82 is also schematically illustrated in Figure 5. In one example, the transmission 82 is an epicyclic transmission having a sun gear 84 mounted to the low shaft 40. A circumferential array of externally-toothed star gears 86 are in meshing engagement with the sun gear 84. The star gears 86 are carried on journals 88 carried by a carrier 90. The carrier 90 is fixedly mounted relative to an engine static structure 92. The static structure 92 is coupled to the low shaft 40 via multiple bearing systems 94 and 96 to permit rotation of the low shaft 40.

[0037] The transmission 82 further includes an internally-toothed ring gear 98 encircling and in meshing engagement with the star gears 86. The ring gear 98 is supported relative to the static structure 92 by one or more bearing systems 100 and 102. The transmission 82 causes a counter-rotation of ring gear 98. As the compressor hub 70 is

CLAIMS

What is claimed is:

1. A gas turbine engine comprising:

a shaft defining an axis of rotation;

a turbine section comprising:

an outer rotor directly driving the shaft, the outer rotor including an outer set of blades; and

an inner rotor having an inner set of blades interspersed with the outer set of blades, the inner rotor configured to rotate in an opposite direction about the axis of rotation from the outer rotor; and

a gear system coupling the inner rotor to the shaft and configured to rotate the inner set of blades at a faster speed than the outer set of blades.

2. The gas turbine engine according to claim 1, wherein the gear system is mounted to a turbine exhaust case.

3. The gas turbine engine according to claim 2, wherein the gear system includes a sun gear engaged to the inner rotor, a plurality of star gears in meshing engagement with the sun gear, and a ring gear in meshing engagement with the star gears.

4. The gas turbine engine according to claim 3, wherein the sun gear is fixed for rotation with an aft end of the inner rotor.

5. The gas turbine engine according to claim 3, wherein the star gears are supported within a carrier that is fixed to the turbine exhaust case.

6. The gas turbine engine according to claim 3, wherein an aft end of the shaft includes a portion that extends radially outward from the axis to be coupled to the ring gear.

7. The gas turbine engine according to claim 2, including a first bearing supporting a fore end of the inner rotor for rotation relative to the shaft and a second bearing supporting an aft end of the inner rotor for rotation relative to the shaft.

8. The gas turbine engine according to claim 7, including a third bearing supporting the shaft for rotation relative to a mid-turbine frame structure.

9. The gas turbine engine according to claim 8, wherein the first, second, and third bearings are axially spaced apart from each other parallel to axis of rotation with the third bearing being located forward of the first bearing.

10. The gas turbine engine according to claim 2, including a low pressure turbine static case having an aft end connected to the turbine exhaust case and a fore end connected to a mid-turbine frame case.

11. The gas turbine engine according to claim 1, wherein a fore end of the shaft is associated with a counter-rotating low pressure compressor.

12. A gas turbine engine comprising:

a core air flowpath;

a shaft supporting a compressor section and a turbine section arranged within the core flow path; and

wherein the turbine section includes a counter-rotating low pressure turbine comprising

an outer rotor directly driving the shaft, the outer rotor including an outer set of blades,

an inner rotor having an inner set of blades interspersed with the outer set of blades, the inner rotor configured to rotate in an opposite direction about the axis of rotation from the outer rotor, and

a gear system coupling the inner rotor to the shaft and configured to rotate the inner set of blades at a faster speed than the outer set of blades.

13. The gas turbine engine according to claim 12, wherein the compressor section includes a high pressure compressor section that has a pressure ratio of approximately 23:1.

14. The gas turbine engine according to claim 12, wherein the compressor section includes a counter-rotating low pressure compressor driven by the shaft.

15. The gas turbine engine according to claim 12, wherein the gear system is mounted to a turbine exhaust case.

16. The gas turbine engine according to claim 15, wherein the gear system includes a sun gear engaged to the inner rotor, a plurality of star gears in meshing engagement with the sun gear, and a ring gear in meshing engagement with the star gears.

17. The gas turbine engine according to claim 16, wherein the sun gear is fixed for rotation with an aft end of the inner rotor, the star gears are supported within a carrier that is fixed to the turbine exhaust case, and an aft end of the shaft includes a portion that extends radially away from the axis of rotation to be coupled to the ring gear.

18. The gas turbine engine according to claim 12, including a first bearing supporting a fore end of the inner rotor for rotation relative to the shaft, a second bearing supporting an aft end of the inner rotor for rotation relative to the shaft, and a third bearing supporting the shaft for rotation relative to a mid-turbine frame structure.

19. The gas turbine engine according to claim 18, wherein the first, second, and third bearings are axially spaced apart from each other parallel to the axis of rotation with the third bearing being located upstream from the first bearing.

20. The gas turbine engine according to claim 18, wherein the first and third bearings are roller bearings and the second bearing is a ball bearing.

disclosed herein according to one non-limiting embodiment is less than about 1150 ft / second.

[0035] Referring to Figures 2 and 3, a geared turbofan architecture with a counter-rotating low pressure compressor (LPC) 60 and counter-rotating low pressure turbine (LPT) 62 is provided, which significantly reduces a length of the low speed or inner shaft 40 as compared to a non-counter-rotating configuration, an example of which is shown in Figure 1 and in the upper half of Figure 2. This non-counter-rotating configuration in the upper half of Figure 2 is included for the purposes of a length comparison to the counter-rotating LPC and counter-rotating LPT configurations shown in the lower half of Figure 2. The engine has a high pressure core, schematically indicated at 64. It is to be understood that the high pressure core 64 includes the combustor 56 and the high spool 32 (i.e., the high pressure compressor 52, the high pressure turbine 54, and the high shaft 50) shown in Figure 1. The high pressure compressor 52 has a high pressure core ratio of 23:1, for example. To retain this ratio, as well as providing a desired low shaft diameter and speed, a combination of the counter-rotating LPC 60 and LPT 62 is utilized as shown in the lower half of Figure 2.

[0036] One example of the LPC 60 is found in United States Patent No. 7,950,220, which is assigned to the same assignee as the subject invention, and which is hereby incorporated by reference. In this example, which is shown in Figure 2, the LPC 60 includes a counter-rotating compressor hub 70 with blade stages 72, 74, and 76 interspersed with blade stages 78 and 80 of the low speed spool 30. The counter-rotating compressor hub 70 may be driven by a transmission 82. The transmission 82 is also schematically illustrated in Figure 5. In one example, the transmission 82 is an epicyclic transmission having a sun gear 84 mounted to the low shaft 40. A circumferential array of externally-toothed star gears 86 are in meshing engagement with the sun gear 84. The star gears 86 are carried on journals 88 carried by a carrier 90. The carrier 90 is fixedly mounted relative to an engine static structure 92. The static structure 92 is coupled to the low shaft 40 via multiple bearing systems 94 and 96 to permit rotation of the low shaft 40.

[0037] The transmission 82 further includes an internally-toothed ring gear 98 encircling and in meshing engagement with the star gears 86. The ring gear 98 is supported relative to the static structure 92 by one or more bearing systems 100 and 102. The transmission 82 causes a counter-rotation of ring gear 98. As the compressor hub 70 is

Claims

1. A gas turbine engine comprising:

a shaft defining an axis of rotation;

a turbine section comprising:

an outer rotor directly driving the shaft, the outer rotor including an outer set of blades; and

an inner rotor having an inner set of blades interspersed with the outer set of blades, the inner rotor configured to rotate in an opposite direction about the axis of rotation from the outer rotor;

a first bearing supporting a fore end of the inner rotor;

a second bearing supporting an aft end of the inner rotor, wherein the first and second bearings are mounted on the shaft; and

a gear system coupling the inner rotor to the shaft and configured to rotate the inner set of blades at a faster speed than the outer set of blades.

2. The gas turbine engine according to claim 1, wherein the gear system is mounted to a turbine exhaust case.

3. The gas turbine engine according to claim 2, wherein the gear system includes a sun gear engaged to the inner rotor, a plurality of star gears in meshing engagement with the sun gear, and a ring gear in meshing engagement with the star gears.

4. The gas turbine engine according to claim 3, wherein the sun gear is fixed for rotation with an aft end of the inner rotor.

5. The gas turbine engine according to claim 3, wherein the star gears are supported within a carrier that is fixed to the turbine exhaust case.

6. The gas turbine engine according to claim 3, wherein an aft end of the shaft includes a portion that extends radially outward from the axis to be coupled to the ring gear.

7. The gas turbine engine according to claim 1, including a third bearing supporting the shaft for rotation relative to a mid-turbine frame structure.

8. The gas turbine engine according to claim 7, wherein the first, second, and third bearings are axially aligned with each other and spaced apart from each other parallel to axis of rotation with the third bearing being located forward of the first bearing.

9. The gas turbine engine according to claim 2, including a low pressure turbine static case having an aft end connected to the turbine exhaust case and a fore end connected to a mid-turbine frame case.

10. The gas turbine engine according to claim 1, wherein a fore end of the shaft is associated with a counter-rotating low pressure compressor.

11. A gas turbine engine comprising:

a core air flowpath;

a shaft supporting a compressor section and a turbine section arranged within the core flow path; and

wherein the turbine section includes a counter-rotating low pressure turbine comprising

an outer rotor directly driving the shaft, the outer rotor including an outer set of blades, an inner rotor having an inner set of blades interspersed with the outer set of blades, the inner rotor configured to rotate in an opposite direction about the axis of rotation from the outer rotor, a first bearing supporting a fore end of the inner rotor, a second bearing supporting an aft end of the inner rotor wherein the first and second bearings are mounted on the shaft, and a gear system coupling the inner rotor to the shaft and configured to rotate the inner set of blades at a faster speed than the outer set of blades.

12. A gas turbine engine comprising:

a core air flowpath;

a shaft supporting a compressor section and a turbine section arranged within the core flow path wherein the compressor section includes a high pressure compressor section that has a pressure ratio of approximately 23:1; and

wherein the turbine section includes a counter-rotating low pressure turbine comprising an outer rotor directly driving the shaft, the outer rotor including an outer set of blades, an inner rotor having an inner set of blades interspersed with the outer set of blades,

the inner rotor configured to rotate in an opposite direction about the axis of rotation from the outer rotor, and

a gear system coupling the inner rotor to the shaft and configured to rotate the inner set of blades at a faster speed than the outer set of blades.

13. The gas turbine engine according to claim 11, wherein the compressor section includes a counter-rotating low pressure compressor driven by the shaft.

14. The gas turbine engine according to claim 11, wherein the gear system is mounted to a turbine exhaust case.

15. The gas turbine engine according to claim 14, wherein the gear system includes a sun gear engaged to the inner rotor, a plurality of star gears in meshing engagement with the sun gear, and a ring gear in meshing engagement with the star gears.

16. The gas turbine engine according to claim 15, wherein the sun gear is fixed for rotation with an aft end of the inner rotor, the star gears are supported within a carrier that is fixed to the turbine exhaust case, and an aft end of the shaft includes a portion that extends radially away from the axis of rotation to be coupled to the ring gear.

17. The gas turbine engine according to claim 11, including a third bearing supporting the shaft for rotation relative to a mid-turbine frame structure.

18. The gas turbine engine according to claim 17, wherein the first, second, and third bearings are axially aligned with each other and spaced apart from each other parallel to the axis of rotation with the third bearing being located upstream from the first bearing.

19. The gas turbine engine according to claim 17, wherein the first and third bearings are roller bearings and the second bearing is a ball bearing.

20. The gas turbine engine according to claim 11, wherein the first and second bearings are axially aligned with each other and are positioned directly between the shaft and the inner rotor.

21. The gas turbine engine according to claim 1, wherein the first and second bearings are axially aligned with each other and are positioned directly between the shaft and the inner rotor.

22. A gas turbine engine comprising:

at least one shaft defining an axis of rotation;

a compressor section including a counter-rotating low pressure compressor driven by the at least one shaft and a high pressure compressor section that has a pressure ratio of approximately 23:1;

a turbine section comprising

an outer rotor directly driving the shaft, the outer rotor including an outer set of blades; and

an inner rotor having an inner set of blades interspersed with the outer set of blades, the inner rotor configured to rotate in an opposite direction about the axis of rotation from the outer rotor; and

a gear system coupling the inner rotor to the shaft and configured to rotate the inner set of blades at a faster speed than the outer set of blades.

23. The gas turbine engine according to claim 22, including a first bearing supporting a fore end of the inner rotor and a second bearing supporting an aft end of the inner rotor, wherein the first and second bearings are positioned directly between the shaft and the inner rotor.