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(71) **Applicant**: **UNITED TECHNOLOGIES CORPORATION** [US/US]; One Financial Plaza, Hartford, Connecticut 06101 (US).

(72) **Inventors**: **BRILLIANT, Lisa I.**; 123 Greenview Terrace, Middletown, Connecticut 06457 (US). **ROSE, Becky E.**; 161 Shadbush Drive, Colchester, Connecticut 06415 (US). **DONG, Yuan**; 66 Broad Moor, Glastonbury, Connecticut 06033 (US). **BALAMUCKI, Stanley J.**; 2866 Bernay Court, The Villages, Florida 32163 (US).

(74) **Agent**: **BURCH, Stephen A.**; c/o CPA Global, P.O. Box 52050, Minneapolis, Minnesota 55402 (US).

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(54) **Title**: COMPRESSOR FLOWPATH

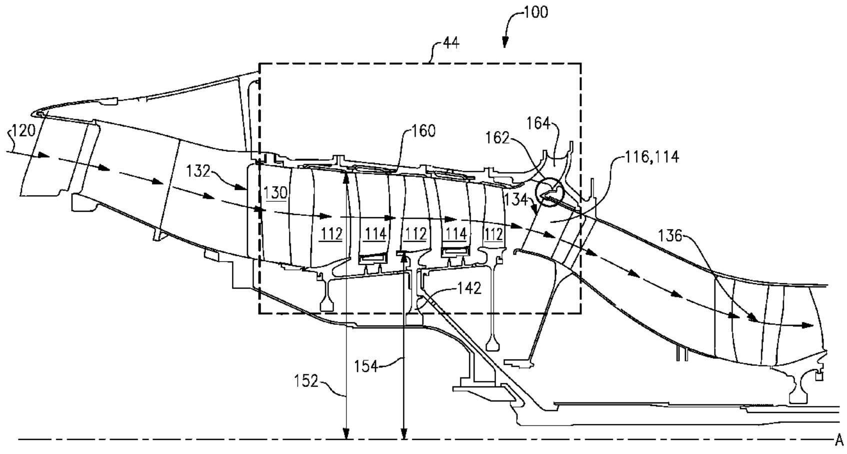

FIG.2

(57) **Abstract**: A core flowpath through a low pressure compressor section of a gas turbine engine includes an outer diameter, which has a slope angle relative to an axis defined by the core flowpath. The slope angle is a slope angle that is operable to prevent flow separation of a fluid passing through the core flowpath.

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COMPRESSOR FLOWPATH

TECHNICAL FIELD

[0001] The present application relates generally to gas turbine engines, and more particularly to a low pressure compressor flowpath for a gas turbine engine.

BACKGROUND OF THE INVENTION

[0002] Commercial turbofan engines use low pressure compressors coupled to a fan. Advances in coupling the fan to the low pressure compressor have allowed the compressor to operate at higher speeds and to decrease the number of compressor stages required of the compressor. Decreasing the number of stages and increasing the rotational speed of the low pressure compressor causes existing flowpath designs to be non-optimal and results in decreased performance when the existing flowpath designs are used.

SUMMARY OF THE INVENTION

[0003] A turbine engine according to an exemplary aspect of the present disclosure includes, among other things, a compressor section having at least a low pressure compressor, and a core flowpath passing through the low pressure compressor, the core flowpath having an inner diameter and an outer diameter. The outer diameter has a slope angle of between approximately 0 degrees and approximately 15 degrees relative to an engine central longitudinal axis. The turbine engine may also include a combustor in fluid communication with the compressor section, and a turbine section in fluid communication with the combustor.

[0004] In a further non-limiting embodiment of the foregoing turbine engine, the turbine engine may include a fan.

[0005] In a further non-limiting embodiment of either of the foregoing turbine engines, the turbine engine may include a fan connected to at least a low speed spool through a geared architecture.

[0006] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a slope angle in the range of approximately 0 degrees to approximately 10 degrees relative to the engine central longitudinal axis.

[0007] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a slope angle that is approximately 6 degrees relative to the engine central longitudinal axis.

[0008] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a slope angle in the range of approximately 5 degrees to 7 degrees, relative to the engine central longitudinal axis.

[0009] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a slope angle that slopes toward the engine central longitudinal axis along a fluid flow direction of the core flowpath.

[0010] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a low pressure compressor that comprises at least one variable vane.

[0011] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a low pressure compressor further comprising an exit guide vane, wherein the exit guide vane is located in a low pressure compressor outlet section of the core flowpath.

[0012] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a low pressure compressor further comprising a low pressure bleed located between a low pressure compressor rotor and the exit guide vane.

[0013] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a low pressure bleed further comprising a bleed trailing edge. The bleed trailing edge may extend into the core flowpath beyond the outer diameter of the core flowpath.

[0014] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include a low pressure compressor that is a multi-stage compressor.

[0015] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include an inner diameter of the core flowpath that increases through the low pressure compressor along a fluid flow direction.

[0016] In a further non-limiting embodiment of any of the foregoing turbine engines, the turbine engine may include an outer diameter slope angle that is operable to reduce a tip clearance of a compressor rotor, and thereby reduce flow separation.

[0017] A low pressure compressor for a turbine engine according to an exemplary aspect of the present disclosure includes, among other things, a core flowpath, wherein the core flowpath has an inner diameter and an outer diameter. The outer diameter has a slope angle of between approximately 0 degrees and approximately 15 degrees relative to an engine central longitudinal axis about which the low pressure compressor rotates.

[0018] In a further non-limiting embodiment of the foregoing low pressure compressor, the low pressure compressor may include a slope angle that is between approximately 0 degrees and approximately 10 degrees.

[0019] In a further non-limiting embodiment of either of the foregoing low pressure compressor, the low pressure compressor may include a slope angle that is approximately 6 degrees.

[0020] In a further non-limiting embodiment of any of the foregoing low pressure compressor, the low pressure compressor may include at least one variable vane.

[0021] In a further non-limiting embodiment of any of the foregoing low pressure compressor, the low pressure compressor may include an outlet section of the core flowpath. The outlet section may include an exit guide vane.

[0022] In a further non-limiting embodiment of any of the foregoing low pressure compressor, the low pressure compressor may include a low pressure bleed located between a low pressure compressor rotor and the exit guide vane.

[0023] In a further non-limiting embodiment of any of the foregoing low pressure compressor, the low pressure compressor may include a low pressure bleed comprising a bleed trailing edge, and a bleed trailing edge extending into the core flowpath beyond the outer diameter of the core flowpath.

[0024] In a further non-limiting embodiment of any of the foregoing low pressure compressor, the low pressure compressor may include a multi-stage compressor.

[0025] In a further non-limiting embodiment of any of the foregoing low pressure compressor, the low pressure compressor may include an inner diameter of the core flowpath that increases through the low pressure compressor along a fluid flow direction.

[0026] In a further non-limiting embodiment of any of the foregoing low pressure compressor, the low pressure compressor may include an outer diameter slope angle that is operable to reduce a tip clearance of a compressor rotor, and thereby reduces flow separation.

[0027] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Figure 1 schematically illustrates a gas turbine engine.

[0029] Figure 2 contextually illustrates an example core flowpath through a low pressure compressor of the gas turbine engine of Figure 1.

[0030] Figure 3 contextually illustrates another example core flowpath through a low pressure compressor of the gas turbine engine of Figure 1.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0031] Figure 1 schematically illustrates a gas turbine engine 20. The gas turbine engine 20 is disclosed herein as a two-spool turbofan that generally incorporates a fan section 22, a compressor section 24, a combustor section 26 and a turbine section 28. Alternative engines might include, for example, a three-spool design, an augmentor section, and different arrangements of sections, among other systems or features. The fan section 22 drives air along a bypass flowpath while the compressor section 24 drives air along a core flowpath for compression and communication into the combustor section 26 then expansion through the turbine section 28. Although depicted as a turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with turbofans as the teachings may be applied to other types of turbine engines.

[0032] The engine 20 generally includes a low speed spool 30 and a high speed spool 32 mounted for rotation about an engine central longitudinal axis A relative to an engine static structure 36 via several bearing systems 38. It should be understood that various bearing systems 38 at various locations may alternatively or additionally be provided.

[0033] The low speed spool 30 generally includes an inner shaft 40 that interconnects a fan 42, a low pressure compressor 44 and a low pressure turbine 46. The low pressure compressor 44 is the first compressor in the core flowpath relative to the fluid flow through the core flowpath. The inner shaft 40 is connected to the fan 42 through a geared architecture 48 to drive the fan 42 at a lower speed than the low speed spool 30. The high speed spool 32 includes an outer shaft 50 that interconnects a high pressure compressor 52 and high pressure turbine 54. The high pressure compressor 52 is the compressor that connects the compressor section to a combustor 56, and is the last illustrated compressor 52 in the illustrated example of Figure 1 relative to the core flowpath. The combustor 56 is arranged between the high pressure compressor 52 and the high pressure turbine 54. A mid-turbine frame 57 of the engine static structure 36 is arranged generally between the high pressure turbine 54 and the low pressure turbine 46. The mid-turbine frame 57 further supports bearing systems 38 in the turbine section 28. The inner shaft 40 and the outer shaft 50 are concentric and rotate via bearing systems 38 about the engine central longitudinal axis A which is collinear with their longitudinal axes.

[0034] The core airflow is compressed by the low pressure compressor 44 then the high pressure compressor 52, mixed and burned with fuel in the combustor 56, then expanded over the high pressure turbine 54 and low pressure turbine 46. The mid-turbine frame 57 includes airfoils 59 which are in the core airflow path. The turbines 46, 54 rotationally drive the respective low speed spool 30 and high speed spool 32 in response to the expansion.

[0035] The engine 20 in one example a high-bypass geared aircraft engine. In a further example, the engine 20 bypass ratio is greater than about six (6), with an example embodiment being greater than ten (10), the geared architecture 48 is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.25 and the low pressure turbine 46 has a pressure ratio that is greater than about 5. In one disclosed embodiment, the engine 20 bypass ratio is greater than about ten (10:1), the fan diameter is significantly larger than that of the low pressure compressor 44, and the low pressure turbine 46 has a pressure ratio that is greater than about 5:1. Low pressure turbine 46 pressure ratio is pressure measured prior to inlet of low pressure turbine 46 as related to the pressure at the outlet of the low pressure turbine 46 prior to an exhaust nozzle. 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.

[0036] A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section 22 of the engine 20 is designed for a particular flight condition -- typically cruise at about 0.8 Mach and about 35,000 feet. The flight condition of 0.8 Mach and 35,000 ft, with the engine at its best fuel consumption - also known as "bucket cruise

Thrust Specific Fuel Consumption ('TSFC')" - is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. "Fan pressure ratio" is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane ("FEGV") system present. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.6. "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)^0.5]. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1250 ft / second.

[0037] With continued reference to Figure 1, Figure 2 is a sectional view of the gas turbine engine 20 of Figure 1, contextually illustrating a low pressure compressor 44 of the gas turbine engine 20. The core flowpath, identified herein as flowpath 120 or core flowpath 120, passes through the low pressure compressor 44 of the gas-turbine engine 20. The low pressure compressor 44 includes multiple rotor 112/stator 114 pairs that serve to drive air through the core flowpath 120. The rotors 112 are connected to an inner shaft 40 via a compressor frame 142. Interspersed between each of the rotors 112 is a stator 114. The stators 114 are connected to an outer frame 160. The illustrated low pressure compressor 44 is referred to as a three stage compressor as three rotor 112/stator 114 pairs are included. Additional stages can be added or removed depending on design constraints via the addition or removal of rotor 112/stator 114 pairs. A variable guide vane 130 is located at an inlet 132 of the low pressure compressor 44. Alternately, one or more of the stators 114 could also be a variable vane 130. An exit guide vane 116 is located at a fluid outlet 134 of the low pressure compressor 44. In the illustrated example of Figure 2, the exit guide vane 116 also acts as a stator 114 corresponding to the last rotor 112 of the low pressure compressor 44. The core flowpath 120 has an inner diameter 154 and an outer diameter 152 measured with respect to the engine longitudinal axis A.

[0038] As the core flowpath 120 passes through the low pressure compressor 44, the outer diameter 152 slopes inward relative to the engine central longitudinal axis A toward the engine central longitudinal axis A. The inner diameter 154 of the core flowpath 120 slopes outward relative to the engine central longitudinal axis A away from the engine central longitudinal axis A resulting in an increasing inner diameter 154 as the core flowpath 120 progresses along the direction of fluid flow. As a result of the inward sloping outer diameter 152 and the increasing inner diameter 154, the core flowpath 120 has a lower cross sectional area at the fluid outlet 134 than at the fluid inlet 132, and air passing through the low pressure compressor 44 is compressed.

[0039] A steeper slope angle of the outer diameter 152, relative to the engine central longitudinal axis A, results in a greater average tip clearance between the rotor blade 112 and the engine case during flight. The additional tip clearance increases flow separation in the air flowing through the core flowpath 120. By way of example, undesirable amounts flow separation can occur when the outer diameter 152 exceeds 15 degrees relative to the engine central longitudinal axis A.

[0040] Flow separation occurs when the air flow separates from the core flowpath 120 walls. By ensuring that the outer diameter 152 includes a sufficiently low slope angle, relative to the engine central longitudinal axis A, the flow separation resulting from the additional tip clearance is eliminated, and the total amount of flow separation is minimized. In some example embodiments, a slope angle of the outer diameter 152 is less than approximately 10 degrees relative to the engine central longitudinal axis A. In another example embodiment, the slope angle of the outer diameter 152 is approximately 6 degrees relative to the engine central longitudinal axis A.

[0041] With continued reference to Figures 1 and 2, Figure 3 illustrates an example core flowpath 120. In some example engine embodiments, air flow passing through the core flowpath 120 is not sufficiently stable. In order to increase the stability of the fluid flow, and improve the pressure ratio of the low pressure compressor 44, one or more variable guide vanes 130 are included in the flow path 120. In a three stage geared turbofan compressor 44, such as the one illustrated in Figure 2, a single variable guide vane 130 can be utilized to sufficiently stabilize the air flow. However, alternate embodiments, such as those utilizing additional compressor stages, may require additional variable guide vanes 130. In such an embodiment, one or more of the stators 114 can be the additional variable guide vanes 130. In alternate examples, the air flow can be sufficiently stable without the inclusion of a variable guide vane 130, and the variable guide vane 130 can be omitted.

[0042] In some example embodiments the exit guide vane 116 is incorporated into a low pressure compressor outlet 134 section of the core flowpath 120 the low pressure compressor 44, and to the high pressure compressor 52. The low pressure compressor outlet 134 section of the core flowpath 120 is sloped inward (toward the engine central longitudinal axis A).

Placing the exit guide vane 116 in the inward sloping low pressure compressor outlet 134 section of the core flowpath 120 cants the exit guide vane 116 and provides space for a low pressure bleed 164. The low pressure bleed 164 and allows for dirt, rain and ice to be removed from the compressor 44. The low pressure bleed 164 additionally improves the stability of the fluid flowing through the core flowpath 120. The low pressure bleed 164 is positioned between the rotors 112 and the exit guide vane 116. In some example embodiments a bleed trailing edge 162 of the low pressure bleed 164 can extend inward toward the engine central longitudinal axis A, beyond the outer diameter 152 of the core flowpath 120. In such an embodiment the outer diameter of the bleed trailing edge 162 of the low pressure bleed 164 is smaller than the outer diameter 152. Extending the bleed trailing edge 162 inwards allows the bleed 164 to scoop out more of the dirt, rain, ice or other impurities that enter the core flowpath 120.

[0043] Although a preferred embodiment of this invention has 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 turbine engine comprising:

a compressor section having at least a low pressure compressor, and a core flowpath passing through said low pressure compressor, said core flowpath having an inner diameter and an outer diameter, wherein said outer diameter has a slope angle of between approximately 0 degrees and approximately 15 degrees relative to an engine central longitudinal axis;

a combustor in fluid communication with the compressor section; and

a turbine section in fluid communication with the combustor.

2. The turbine engine of claim 1, further comprising a fan.

3. The turbine engine of claim 2, wherein said fan is connected to at least a low speed spool through a geared architecture.

4. The turbine engine of claim 1, wherein said slope angle is in the range of approximately 0 degrees to approximately 10 degrees relative to said engine central longitudinal axis.

5. The turbine engine of claim 4, wherein said slope angle is approximately 6 degrees relative to said engine central longitudinal axis.

6. The turbine engine of claim 4, wherein said slope angle is in the range of approximately 5 degrees to 7 degrees, relative to said engine central longitudinal axis.

7. The turbine engine of claim 1, wherein said slope angle slopes toward said engine central longitudinal axis along a fluid flow direction of said core flowpath.

8. The turbine engine of claim 1, wherein said low pressure compressor comprises at least one variable vane.

9. The turbine engine of claim 1, wherein said low pressure compressor further comprises an exit guide vane, wherein said exit guide vane is located in a low pressure compressor outlet section of said core flowpath.

10. The turbine engine of claim 9, wherein said low pressure compressor further comprises a low pressure bleed located between a low pressure compressor rotor and said exit guide vane.

11. The turbine engine of claim 10 wherein said low pressure bleed further comprises a bleed trailing edge, and wherein said bleed trailing edge extends into said core flowpath beyond said outer diameter of said core flowpath.

12. The turbine engine of claim 1, wherein said low pressure compressor is a multi-stage compressor.

13. The turbine engine of claim 1, wherein said inner diameter of said core flowpath increases through the low pressure compressor along a fluid flow direction.

14. The turbine engine of claim 1, wherein said outer diameter slope angle is operable to reduce a tip clearance of a compressor rotor, and thereby reduce flow separation.

15. A low pressure compressor for a turbine engine comprising a core flowpath, wherein said core flowpath has an inner diameter and an outer diameter, and wherein said outer diameter has a slope angle of between approximately 0 degrees and approximately 15 degrees relative to an engine central longitudinal axis about which said low pressure compressor rotates.

16. The low pressure compressor of claim 15, wherein said slope angle is between approximately 0 degrees and approximately 10 degrees.

17. The low pressure compressor of claim 16, wherein said slope angle is approximately 6 degrees.

18. The low pressure compressor of claim 15, further comprising at least one variable vane.

19. The low pressure compressor of claim 15, further comprising an outlet section of said core flowpath, wherein said outlet section includes an exit guide vane.

20. The low pressure compressor of claim 19, further comprising a low pressure bleed located between a low pressure compressor rotor and said exit guide vane.

21. The low pressure compressor of claim 20, wherein said low pressure bleed comprises a bleed trailing edge, and wherein said bleed trailing edge extends into said core flowpath beyond said outer diameter of said core flowpath.

22. The low pressure compressor of claim 15, wherein said low pressure compressor is a multi-stage compressor.

23. The low pressure compressor of claim 15, wherein said inner diameter of said core flowpath increases through the low pressure compressor along a fluid flow direction.

24. The low pressure compressor of claim 15, wherein said outer diameter slope angle is operable to reduce a tip clearance of a compressor rotor, and thereby reduce flow separation.

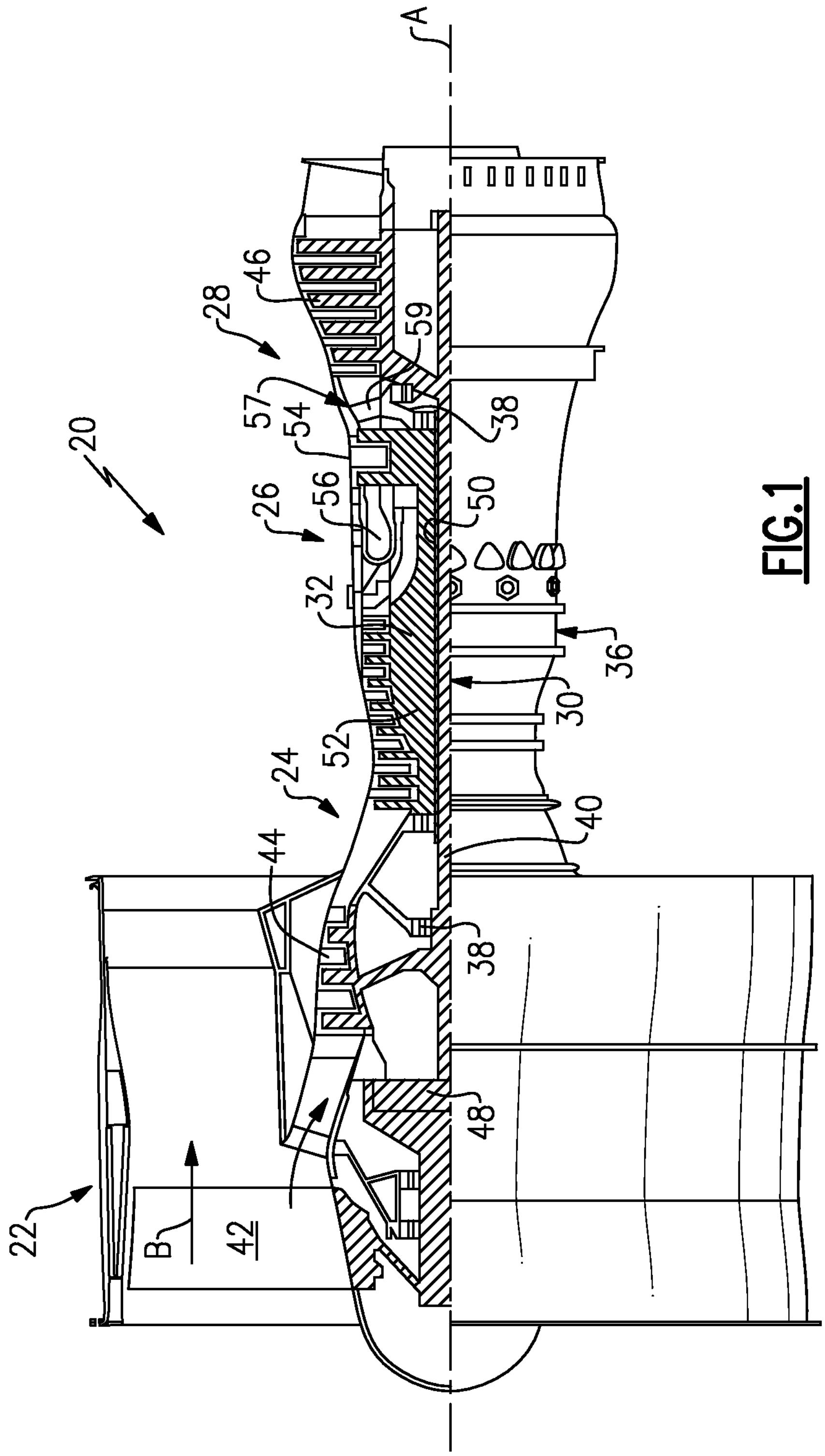
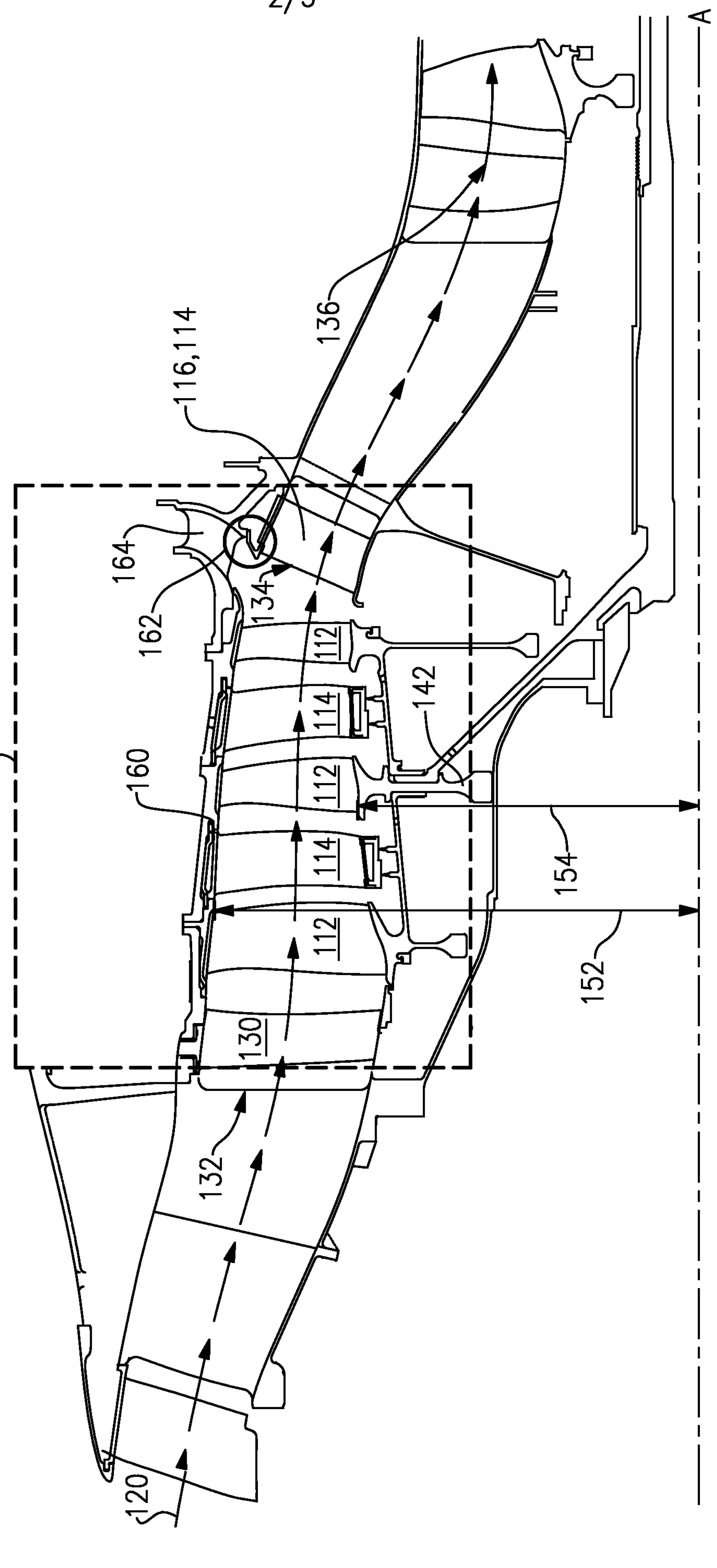


FIG.1


100
44
116,114
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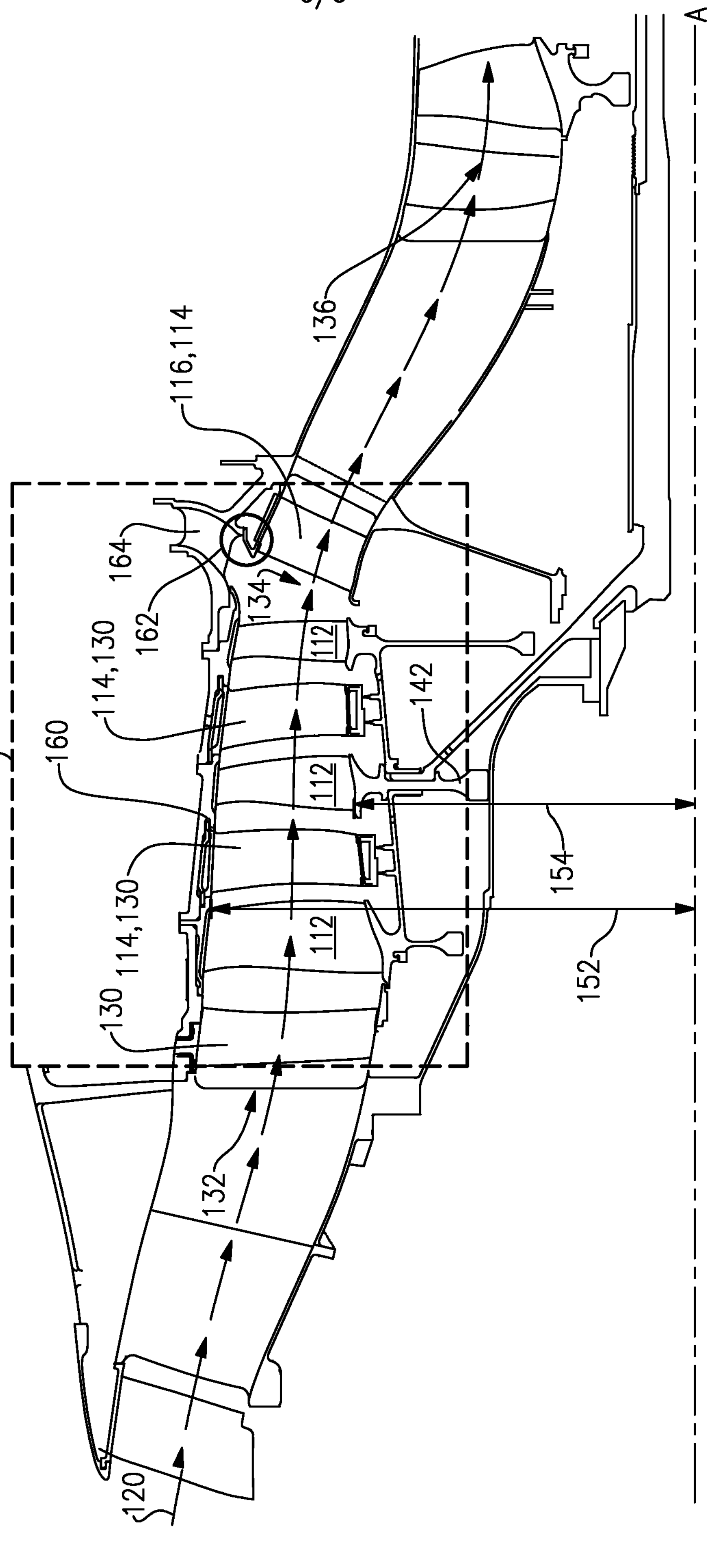
132
120
A

FIG.2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136
116,114
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164
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114,130
152
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132
120

FIG.3

INTERNATIONAL SEARCH REPORT	International application No. PCT/US13/22020

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **F02K 3/02**(2006.01),**3/00**(2006.01);**F02C 9/00**(2006.01)

USPC: 60/226.1,268,795
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 60/226.1, 268, 795

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
US-PGPUB; USPAT; USOCR: gear, planetar, fan, bleed, bled, variable, vary, adjust, vane, blade, stator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/0223903 A1 (STARR) 09 September 2010 (09.09.2010), see entire document.	1-2, 4-24
X --- Y	US 2008/0098715 A1 (ORLANDO et al.) 01 May 2008 (01.05.2008), see entire document.	1-2, 4-9, 12-19, 22-24 ----------- 9-11, 19-21
X	US 2008/0053062 A1 (TUTTLE) 06 March 2008 (06.03.2008), see entire document.	1-2, 4-9, 12, 14-17, 19, 22, 24
X	US 2007/0251210 A1 (CERIC et al.) 01 November 2007 (01.11.2007), see entire document.	1, 4, 9, 12-16, 19, 22-24
X	US 2006/0196164 A1 (DONOHUE) 07 September 2006 (07.09.2006), see entire document.	1-2, 4-9, 12-19, 22-24
X	US 5,127,794 A (BURGE et al.) 07 July 1992 (07.07.1992), see entire document.	1-2, 4-7, 9, 12, 14-17, 19, 22, 24

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search 07 September 2013 (07.09.2013)	Date of mailing of the international search report 10 SEP 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	Authorized officer William Krynski Telephone No. 571-272-1700

INTERNATIONAL SEARCH REPORT	International application No. PCT/US13/22020

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/0130456 A1 (SUCIU et al.) 22 June 2006 (22.06.2006), see entire document.	1-9, 12-19, 22-24
X --- Y	US 2009/0056306 A1 (SUCIU et al.) 05 March 2009 (05.03.2009), see entire document.	1-24 ----------- 8-11, 18-21
X --- Y	US 3,761,042 A (DENNING) 25 September 1973 (25.09.1973), see entire document.	1-7, 9, 12, 14, 15-17, 19, 22, 24 ----------- 9-11, 19-21
X	US 7,883,315 B2 (SUCIU et al.) 08 February 2011 (08.02.2011), see entire document.	1-9, 12-19, 22-24
X	US 3,673,802 a (KREBS et al.) 04 July 1972 (04.07.1972), see entire document.	1-2, 4-6, 12-17, 22-24
X --- Y	US 3,680,309 A (WALLACE, JR.) 01 August 1972 (01.08.1972), see entire document.	1, 4-7, 9, 12-17, 19, 22-24 ----------- 9-11, 19-21

INTERNATIONAL SEARCH REPORT	International application No. PCT/US13/22020

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.