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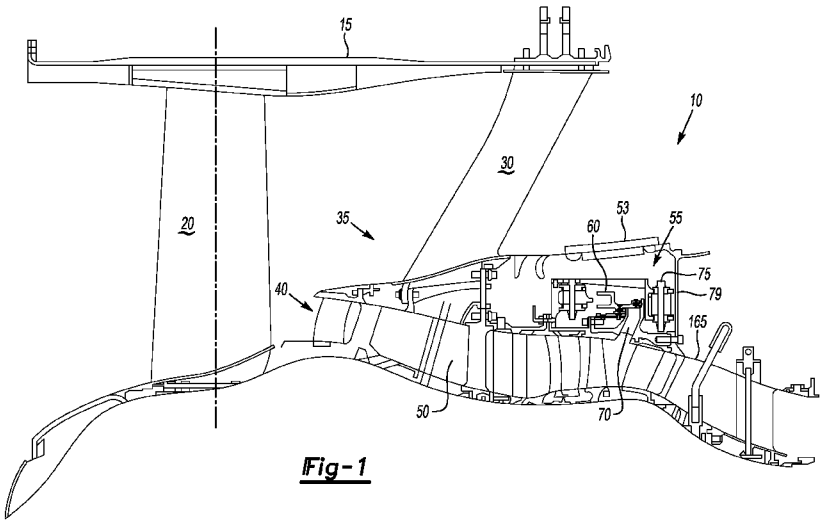

Fig-1

(57) Abstract: A duct assembly for venting flow from an internal portion of a gas turbine engine, has a first piece having a first duct portion extending therethrough, the first piece configured to withstanding backbone loads of the engine, the first piece having a first portion of a duct passing therethrough, and a second piece, the second piece having a second portion of the duct passing therethrough, the second portion and the first portion aligning, the second piece constructed of a lighter material than the first piece.

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TWO-PIECE DUCT ASSEMBLY

BACKGROUND

[0001] Gas turbine engines include one or more compressors for pressurizing a working medium fluid, typically ambient air, which flows through a longitudinally extending compressor flow path. Under some operating conditions, it is desirable to temporarily moderate the pressure at the discharge end of the compressor to prevent or recover from compressor stall or other aerodynamic instabilities. Pressure moderation is usually effected by opening a compressor bleed valve that diverts a portion of the pressurized fluid from the discharge end of the compressor flow path into a lower pressure region.

[0002] An exemplary compressor bleed valve system includes a moveable full hoop valve ring with a pair of ring seal members radially aligned with the bleed duct case seal seats. The compressor bleed duct includes a stationary ring having a pair of resilient seal members adhesively bonded or clamped into respective channels on longitudinally facing surfaces of the ring. A series of circumferentially distributed passages extend through the bleed duct case to join the compressor flow path to a surrounding annular chamber. The compressor bleed duct also includes a moveable valve ring with a cylindrical sleeve and a pair of seal seats radially aligned with the orifice ring seal members. A set of pins extends radially from the valve ring, and each pin includes a roller that engages a carved slot on the orifice ring. A bell crank for operating the valve ring is mounted on a bell crank support bracket by a bell crank pivot. Input and output arrays of the bell crank are connected respectively to an actuator and to the valve ring.

[0003] In operation, the actuator rotates the bell crank about the bell crank pivot so that the bell crank, in turn, drives the valve ring in a spiral motion, positioning the sleeve to cover or uncover the passages. The rollers help guide the valve ring in its spiral path. As the valve ring approaches its fully closed position, the seal members contact the seal seats, compressing them in the longitudinal direction to affect a fluid tight seal.

SUMMARY

[0004] According to an exemplary embodiment disclosed herein, a duct assembly for venting flow from an internal portion of a gas turbine engine, has a first piece having a first duct portion extending therethrough, the first piece configured to withstanding backbone loads of the engine, the first piece having a first portion of a duct passing therethrough, and a second piece, the second piece having a second portion of the duct passing therethrough, the second portion and the first portion aligning, the second piece constructed of a lighter material than the first piece.

[0005] In any of the previous embodiments, the first piece is constructed of titanium.

[0006] In any of the previous embodiments, the second piece is constructed of aluminum.

[0007] In any of the previous embodiments, the aluminum is cast aluminum.

[0008] In any of the previous embodiments, the first piece has a plurality of first portions and the second piece has a plurality of second portions.

[0009] In any of the previous embodiments, the second portions are separated by ligaments that minimize losses flowing through the first portions and aligned second portions.

[0010] In any of the previous embodiments, the ligaments are have an airfoil shape.

[0011] In any of the previous embodiments, a seal is disposed between the first piece and the second piece.

[0012] In any of the previous embodiments, the seal is disposed in a groove in one of the first piece and the second piece.

[0013] In any of the previous embodiments, a flange extends axially from one of the first piece and the second piece and a bracket extends radially from the flange to engage an other of the first piece and the second piece.

[0014] In any of the previous embodiments, the bracket engages a side of the other of the first piece and the second piece.

[0015] In any of the previous embodiments, the first piece forms a radially outer wall of a compressor section of the engine.

[0016] In any of the previous embodiments, the first piece attaches to another portion of a radially outer wall of the compressor section,

[0017] In any of the previous embodiments, a radially extending flange extends from the second portion of the duct for engaging a seal.

[0018] In any of the previous embodiments, a platform is disposed on said first portion of said duct, said platform configured to support a ring assembly thereupon.

[0019] In any of the previous embodiments, a mount is disposed on a radially outer surface of said first piece for mounting a bell crank thereupon.

[0020] According to an exemplary embodiment disclosed herein, a method for minimizing weight of a duct assembly includes the steps of selecting a first material to withstand engine backbone loads, selecting a second material that is lighter than the first material, forming aligning ducts in the first material and in the second material, and mating the first material and the second material to form duct assembly.

[0021] In any of the previous embodiments, the method includes aligning the second material radially outwardly from the first material such that the ducts align.

[0022] In any of the previous embodiments, the method includes creating ligaments that are airfoil shaped between ducts in the first material.

[0023] In any of the previous embodiments, the method includes casting the ligaments of the second material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The various features and advantages of the disclosed examples will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

[0025] Figure 1 is a cross-section of a portion of a gas turbine engine.

[0026] Figure 2 is a portion of the gas turbine engine taken along the lines 2-2 in Figure 1.

[0027] Figure 3A is a perspective view of a bell crank for opening and closing of valves depicted in Figure 2.

[0028] Figure 3B is a cross-sectional view of the four bar linkage as shown in 3A.

[0029] Figure 3C is a side view cutaway of the bell crank four bar configuration of Figure 3A.

[0030] Figure 4A is an isolated view of a portion of the four bar configuration of Figure 3A.

[0031] Figure 4B is a portion of a mounting system for the bell crank of Figure 3A.

[0032] Figure 5A is a side view cutaway of the valve assembly of Figure 1.

[0033] Figure 5B is a side view cutaway of a bulb seal of Figure 5B.

DETAILED DESCRIPTION

[0034] Referring now to Figure 1, an engine 10, such as a gas turbine engine is shown. The engine 10 has a nacelle 15 that extends around blades 20. The blades 20 are attached to a shaft (not shown) passing through the core 25 of the engine 10. The core 25 is held in place by struts 30. The blades 20 provide a first airflow 35 between the core 25 and the nacelle 15, and a second airflow 40 passing through compressor section 45 in the core 25. The core is enclosed by a core casing 53. A bleed assembly 55 is disposed between the core casing 53 and the compressor section 45. The bleed assembly 55 (shown within lines 2-2) includes a ring-shaped bleed valve 60, a ring-shaped bleed duct assembly 65 that acts as a portion of an compressor section outer wall, bleed ducts 70 passing through the bleed duct assembly 65, a linkage assembly 75. A firewall 79 is disposed next to the bleed assembly 55.

[0035] Referring now to Figure 2, the details of the bleed duct assembly 65 are shown. The bleed duct assembly 65 has an inner case 80, which is either forged or cast, load-bearing, high-temperature resistant material such as titanium or the like (including a ceramic), and an outer case 85, which bears less load and stress may be made of lower strength, lighter metal such as aluminum. A duct 90, which has a first portion 95 in the inner case 80, and a second portion 100 in the outer case 85 is separated circumferentially by ligaments such as airfoils 105 between adjacent circumferential ducts 90.

[0036] The inner casing 80 has a body 110 having a central area 115 having a first land 120 on a top portion 125 of the body 110. The top portion 125 has a groove 130 in which an o-ring 135 is disposed to act as a seal to minimize air from escaping between the duct portions 95, 100. Bolt hole 140 is disposed in a side portion 145 of the body 110 for

attaching the outer case 85 to the inner case 80 by means of a bolt 150. The inner casing 80 has an aft extension 155 having an axial attachment hole 160 to attach to an adjacent core segment 165 (see Figure 1). The body 110 also has a fore extension 170 having a flange 175 extending radially outwardly therefrom. The flange 175 has an opening 180 for attaching to another adjacent core segment 185 (see Figure 1).

[0037] On a radially outer surface of the body 110, a platform 190, which supports the bleed valve 60, is disposed thereon. There are a plurality of platforms disposed circumferentially about the body 110 to support the valve 60. The platforms has a cylindrical top 195 that has a flat cross-section and is covered by a low wear material 200 that is somewhat lubricious to allow the bleed valve 60 to slide thereon without snagging.

[0038] The outer case 85 has a body 205 having an aft flange 210 depending radially inwardly from the body 205. The aft flange 210 has a hole 215 aligning with bolt hole 140 through which bolt 150 extends into the bolt hole 140 to attach the outer case 85 to the inner case 80. The outer case body 205 has a flange 220 extending radially outward to mate with the bleed valve 60 as will be discussed infra. The body 205 also has a fore side 225 that mates with the bleed valve 60 as will be discussed infra. The body 205 has a second land 230 that mates with the first land 120 when the bolt 150 is inserted into hole 140. When the bolt 150 is tightened, the first land 120 and the second land 230 secure the 0-ring 135 to minimize any air leakage between the bolts. The o-ring 135 gets compressed when the case halves are installed.

[0039] The airfoils 100, or ligaments disposed between ducts 90 are shaped to direct the flow of air flowing through the duct 90 to enhance flow with minimal losses therethrough so that the air siphoned from the compressor section 45 may be used efficiency downstream of the ducts 90. The outer case 85 is aluminum to allow more complex flow patterns of the duct second portion 100 to be machined or formed to maximize efficiency of the air flowing therethrough. The first portion 95 in the inner case 80 and the second portion 100 in the outer case 85 are smoothed to minimize losses. Furthermore, the outer case 85 is made of aluminum or the like to save weight and the inner case is made of titanium to improve the capability of the bleed duct assembly 65 to handle engine backbone loads. Because the inner case handles the backbone loads, the outer case 85 may be made of aluminum where weight may be saved. Because the outer case 85 is cast, more shaped

airfoils may be used to reduce aerodynamic losses and reduce backflow upon the compressor section 45.

[0040] A user would choose a first material as an inner case 80 to withstand the backbone loads of the engine 10, then choose a lighter material as an outer case 85 to form a lighter bleed duct assembly 65. The user would then form the duct 90 for instance by casting the outer case 85 and forging the inner case 80 and then join the two segments as mentioned hereinabove.

[0041] Referring now to Figures 3A-C and 4A-B, the linkage assembly 75 is shown. The linkage assembly 75 has a fore bell crank assembly 235, an aft bell crank assembly 240, a fore connecting link 245 and a bridge arm 250.

[0042] The aft bell crank 240 has a body 255 from which brackets 260 extend circumferentially and radially inwardly therefrom. A rotation pin 265 extends through the body 255 to hold a bell crank 280. The body 255 has a flange 270 extending radially outwardly therefrom. The upper flange 270 has holes 275 passing axially therethrough for joining with the bridge arm 250. The bell crank 280 is seated within the body 255 and has an upper arm 285 for attaching to the fore connecting link 245 and a lower arm 290 disposed radially inwardly from the upper arm 285 attaching to an aft connecting link 295. The aft connecting link 295 attaches to an actuator (not shown).

[0043] The brackets 260 have a base 300 and webs 305 that attach to the aft bell crank body 255. The brackets 300 sit upon land 310 on the stationary inner case 80. A pin 315 extends radially outwardly from the land 210 for insertion into the locator hole 320 in the base 300. Bolt 323 connects the bracket 260 to the inner case 80.

[0044] The fore bell crank assembly 235 has a body 325. A pin 330 extends through clevis 335 to anchor crank 337 therein (See Fig. 3B). The body has a lower flange 340 that forms a bracket 345 having openings 350. Pin openings 355 (See Fig. 3C) are utilized to locate the bracket 345 in an adjacent core segment 165 (see Figure 1). The body 325 has an upper surface 360 from which locator pin 365 extends. The upper surface has bolt holes 370 that secure bridge arm 250 thereto as will be discussed herein. The crank 337 has a first arm 375 attaching to the bleed valve 60 and a second arm 380 attaching to the fore connecting link 245. The second arm 380 is angularly displaced from the first arm 375 so

that the bleed valve 60 moves an appropriate amount as desired to meter flow through the bleed duct assembly 65.

[0045] The bridge arm 250 has a key-like shape having a flat triangular section 390 that has openings 394 for mating with the bolt holes 370 and an aperture 397 for mating with the pin 365 to attach the bridge arm 385 to the fore bell crank assembly. The bridge arm 250 also has a shank 395 which narrows axially and expands radially from the triangular section 390. A t-shaped assembly 400 is formed by ears 405 that extend circumferentially from an end 407 of the shank 395. The ears have openings 410 through which fasteners 415 extend to mate with the holes 275 in the upper flange 270 of the aft bell crank 240. The openings 394 and aperture 397 may be oversized to allow for circumferential misalignment.

[0046] The webs 305 of the aft bell crank assembly 240 are designed to flex during thermal loading while providing stiffness for operating loads. The bridge arm 250 limits deflection of the cantilevered fore bell crank assembly 235 and aft bell crank assembly 240 and provides more stiffness to the linkage assembly 75. Shims 417 are placed between the t-section 400 and the upper flange 270 to eliminate axial tolerance gaps during assembly.

[0047] Because the area to mount the brackets 260 to the inner case 80 is limited, the required stiffness and deflection of the aft bell crank assembly 240 is provided by providing the bridge arm 250 between the aft bell crank 240 and the fore bell crank assembly 235, which is attached to the flange of the adjacent core segment 165. The bridge arm 250 is designed not to buckle or deflect during excessively unloading. The aft brackets 260 are more flexible to allow for controlled deflection of the fore bell crank assembly 235 and the aft bell crank assembly 240 caused by thermal growth of the inner case 80.

[0048] Referring to Figures 4 and 3C, it can be seen that the aft connecting link 295 and the lower arm 290 (See Fig. 3A) are lower than the upper arm 285 to allow a motive force of the actuator (now shown) to move up and over the radially extending flange 220, which is used by the bleed valve 60 as will be discussed herein. The motive force rotates the bell crank 280 about pin 265, moving the fore connecting link 245 axially and rotationally. The fore connecting link 245 rotates the first arm 375 about the pin 330 thereby causing the rotation of the second arm 380 that moves the bleed valve partially axially and partially in rotation to modulate the degree of air flowing through the bleed duct assembly 65.

[0049] Referring now to Figures 5A and 5B, the bleed valve 60 is shown. The bleed valve 60 has a body 420 having a clevis section 425, a midsection 440 a forward section 430 and an aft section 450. A first seal holder 435 extends radially inward from the midsection 440 of the body 420. A second seal holder 445 extends from the aft section 450 of the body 420.

[0050] Referring now to Figure 5B, a seal 455 is shown in a seal holder 435 or 445. Each seal has a cylindrically extending body 460, a flat cross-section reinforcing strip 465 extending from the extending body 460 and a bulbous section 470 attaching at one end of the body 460. Each bulbous section has an opening 475. In the first seal holder 435, the opening is adjacent and facing the pressure section of the duct 90 so that high pressure air is forced through the opening 495 to allow the bulb to expand. This expansion helps make the seal 455 more effective. Similarly the opening 495 in the second seal holder 445 is also placed so the opening 475 is exposed to the pressure extending through the duct 90 to allow it to be filled with high pressure air as well. The strip 465 extends towards the bulbous section 470.

[0051] A shaft 485 extends upwardly from the flat portion 480 at periodical positions around the seal 455 to attach the seal to the seal holders 435, 445. A shank 490 of a rivet 497 (or other fastener) extends through a center of the shaft 485. The rivet 495 has a head 500, a tail 505, and a bottom 515. The bottom 515 fits within a recess 510 in each seal holder 435, 445. As can be seen in Figure 5, because the bottom 515 slides upon the low wear material 200, the tail 505 must be recessed so as to not damage the low wear material 200. The cylindrical body 460 fits within a groove 520 placed within each seal holder cylindrical 435, 445. There are no sharp edges within the groove 520 to avoid damaging the seal 455. The groove 520 is easy to machine relative to the prior art in which a seal is held within a groove with raised ridges extending towards each other between a cylindrical body and a bulbous section of a seal. The groove 520 presented herein is far more easily machined than in the prior art. Furthermore, because the seal 455 is riveted to the seal holders 435, 445, they are not torn out of their channels as with the prior art bonded seals. The seal is also relatively easy to replace by removing the rivets 495.

[0052] The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. The scope of legal protection given to this disclosure can only be determined by studying the following claims.

CLAIMS

What is claimed is:

1. A duct assembly for venting flow from an internal portion of a gas turbine engine, said duct assembly comprising:
   a first piece having a first duct portion extending therethrough, said first piece configured to withstanding backbone loads of said engine, said first piece having a first portion of a duct passing therethrough, and
   a second piece, said second piece having a second portion of said duct passing therethrough, said second portion and said first portion aligning, said second piece constructed of a lighter material than said first piece.

2. The duct assembly of claim 1 wherein said first piece is constructed of titanium.

3. The duct assembly of claim 1 wherein said second piece is constructed of aluminum.

4. The duct assembly of claim 3 wherein said aluminum is cast .

5. The duct assembly of claim 1 wherein said first piece has a plurality of first portions and said second piece has a plurality of second portions.

6. The duct assembly of claim 5 wherein said second portions are separated by ligaments that minimize losses flowing through said first portions and aligned second portions.

7. The duct assembly of claim 6 wherein said ligaments are have an airfoil shape.

8. The duct assembly of claim 1 wherein a seal is disposed between said first piece and said second piece.

9. The duct assembly of claim 8 wherein said seal is disposed in a groove in one of said first piece and said second piece.

10. The duct assembly of claim 1 further comprising a flange extending axially from one of said first piece and said second piece and a bracket extending radially from said flange to engage another of said first piece and said second piece.

11. The duct assembly of claim 10 wherein said bracket engages a side of said other of said first piece and said second piece.

12. The duct assembly of claim 1 wherein said first piece forms a radially outer wall of a compressor section of said engine.

13. The duct assembly of claim 12 further comprising said first piece attaching to another portion of a radially outer wall of said compressor section,

14. The duct assembly of claim 1 further comprising a radially extending flange extending from said second portion of said duct for engaging a seal.

15. The duct assembly of claim 1 further comprising:
a platform disposed on said first portion of said duct, said platform configured to support a ring assembly thereupon.

16. The duct assembly of claim 1 further comprising:
a mount disposed on a radially outer surface of said first piece for mounting a bell crank thereupon.

17. A method for minimizing weight of a duct assembly comprising:
selecting a first material to withstand engine backbone loads,
selecting a second material that is lighter than said first material,
forming aligning ducts in said first material and in said second material, and
mating said first material and said second material to form duct assembly.

18. The method of claim 17 further comprising:
aligning said second material radially outwardly from said first material such that said ducts align.

19. The method of claim 17 further comprising creating ligaments that are airfoil shaped between ducts in said first material.

20. The method of claim 19 further comprising casting said ligaments.

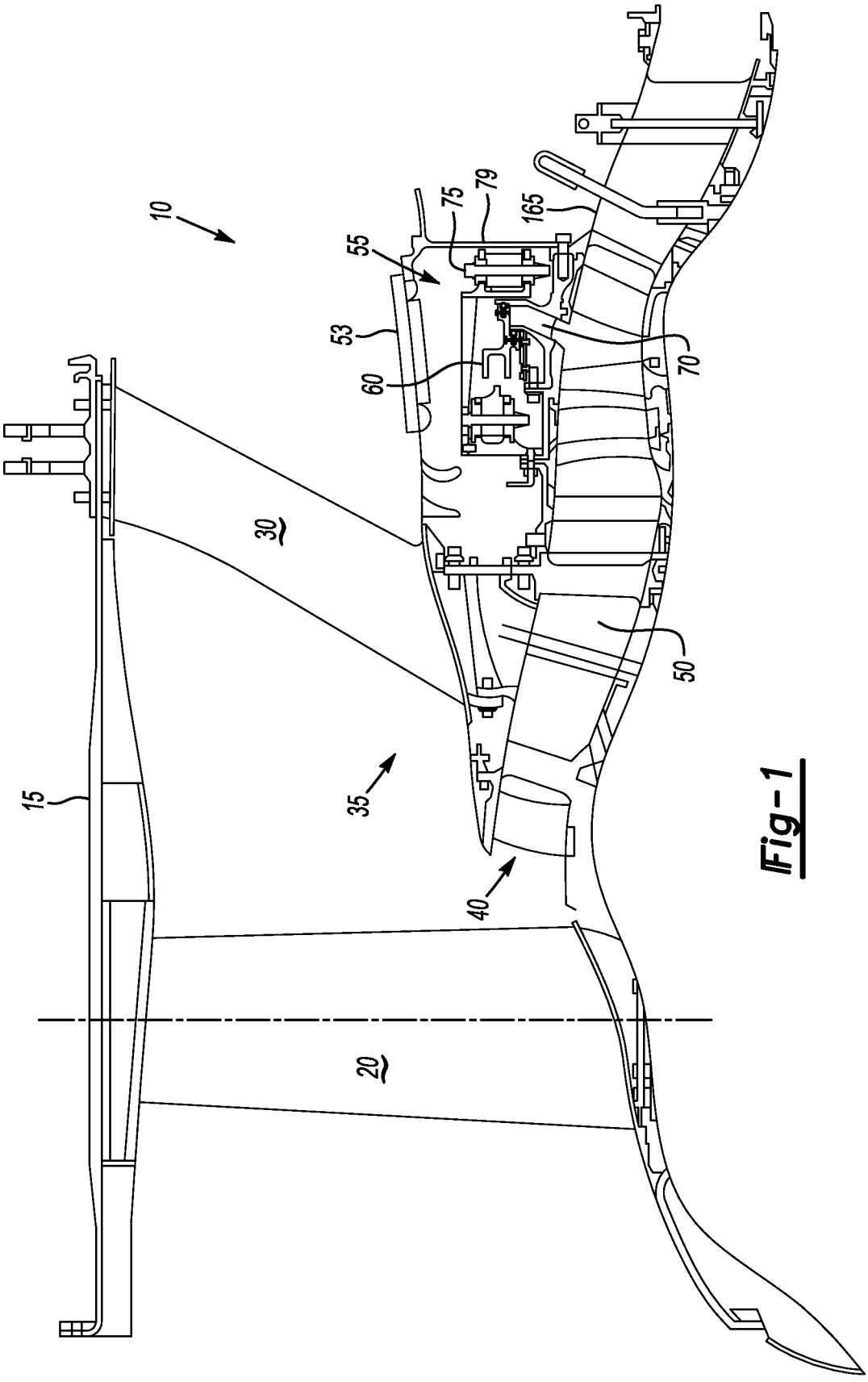

Fig-1

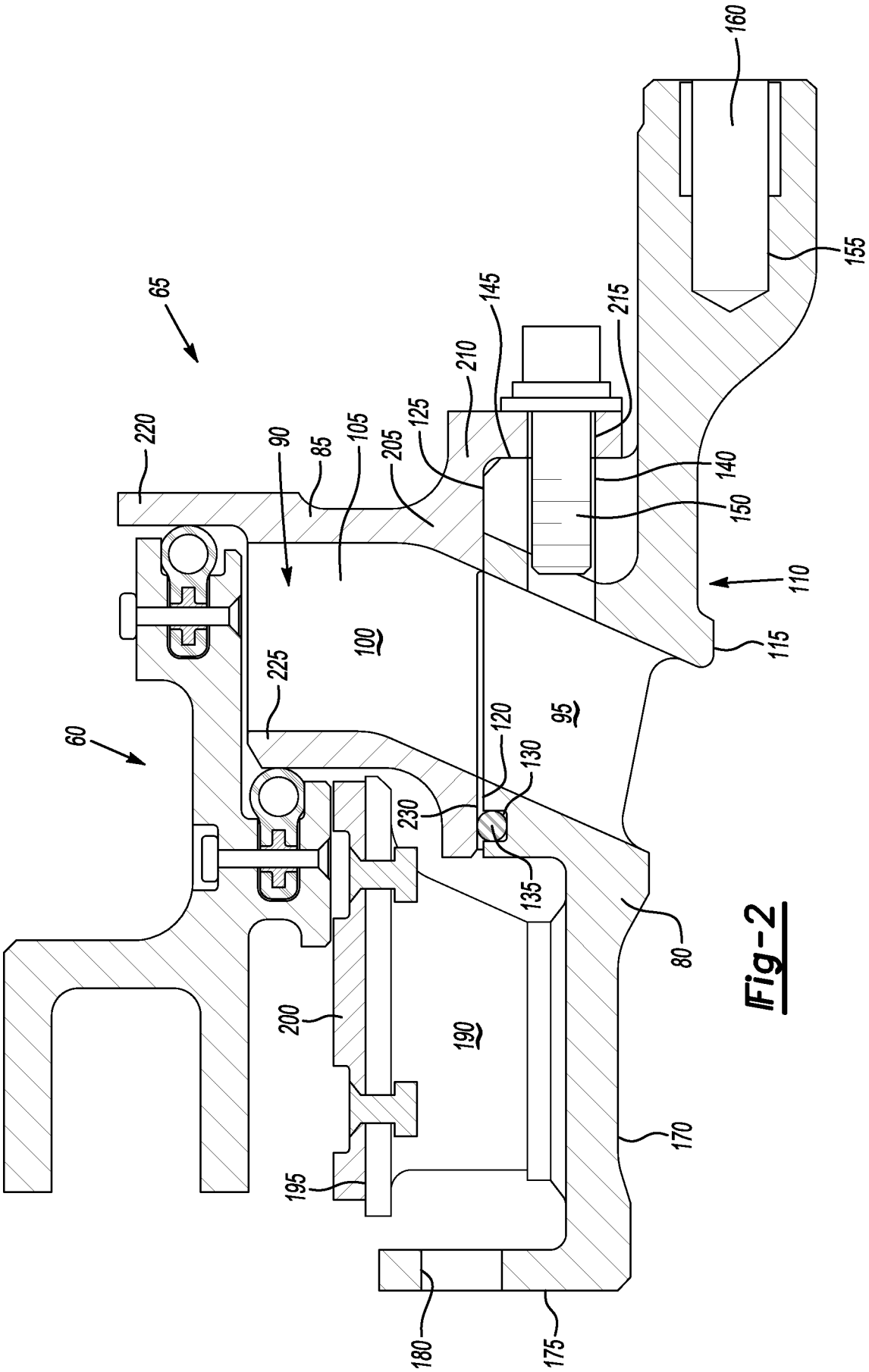
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Fig-2

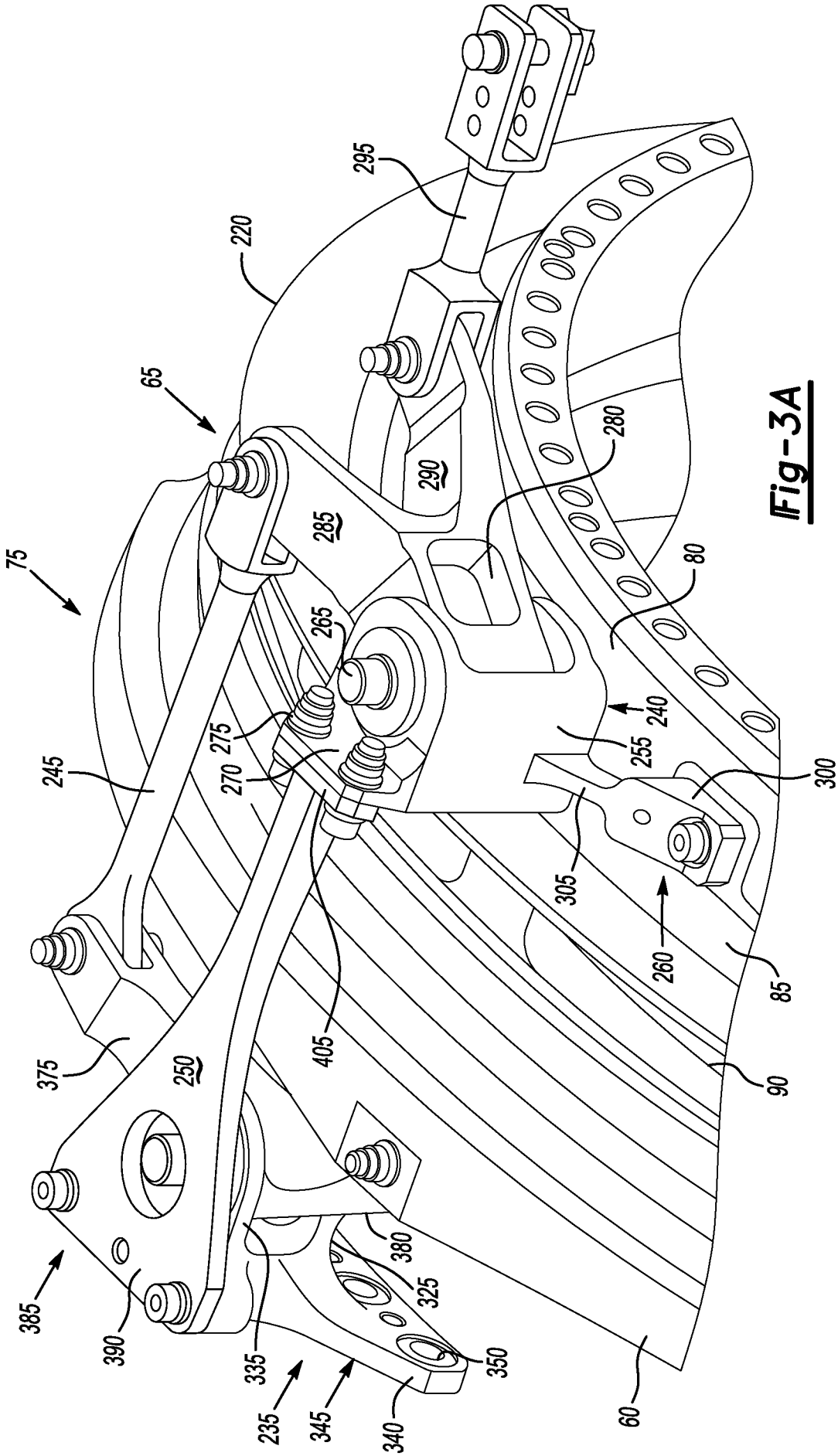
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Fig-3A

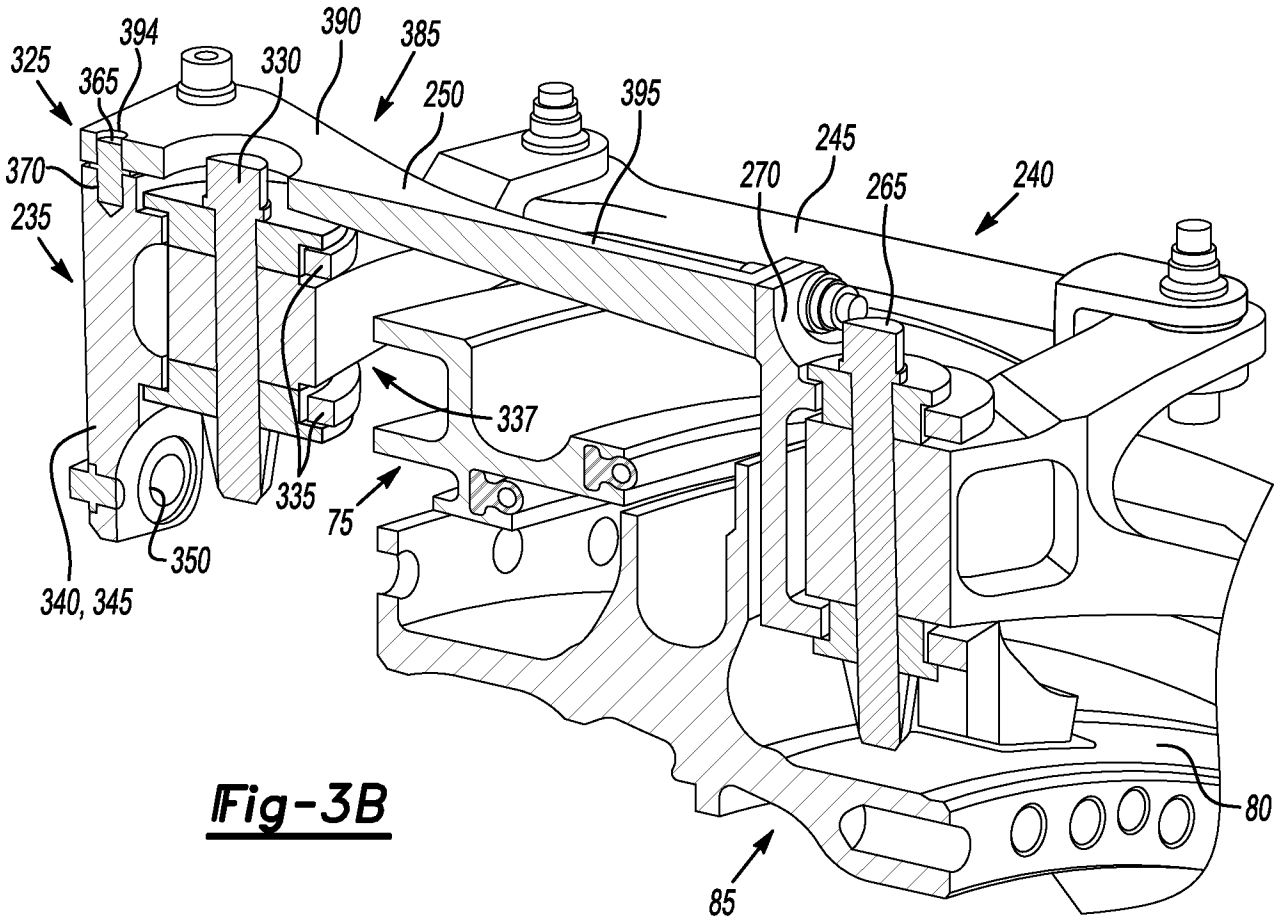
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Fig-3B

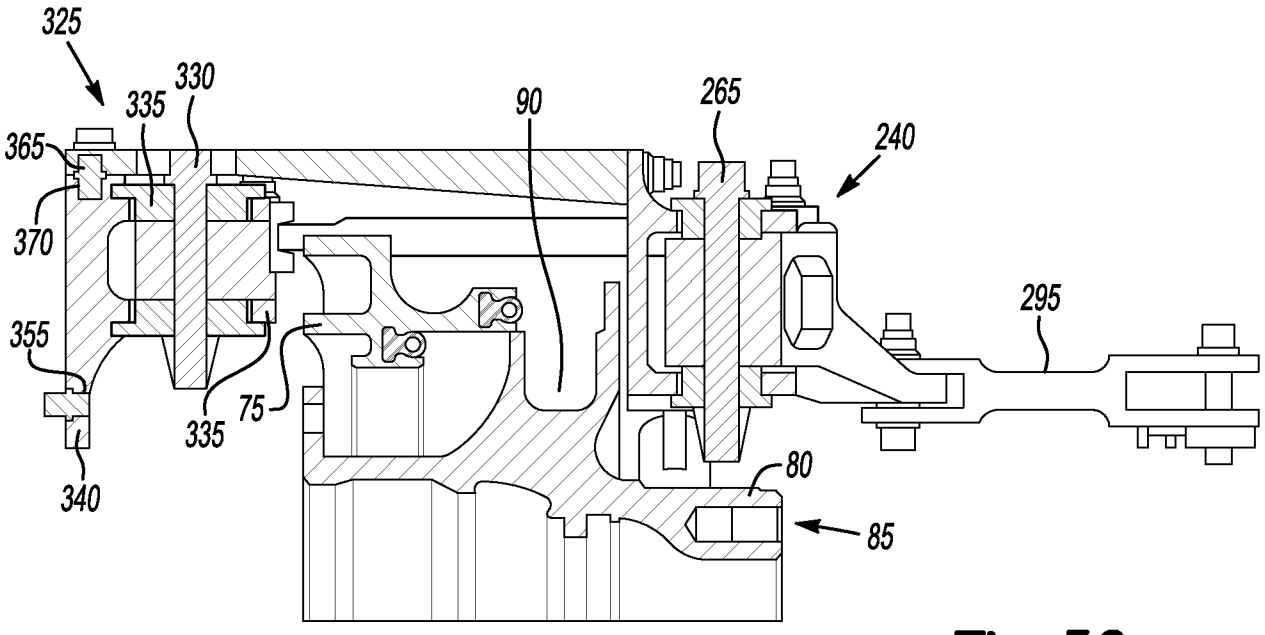
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Fig-3C

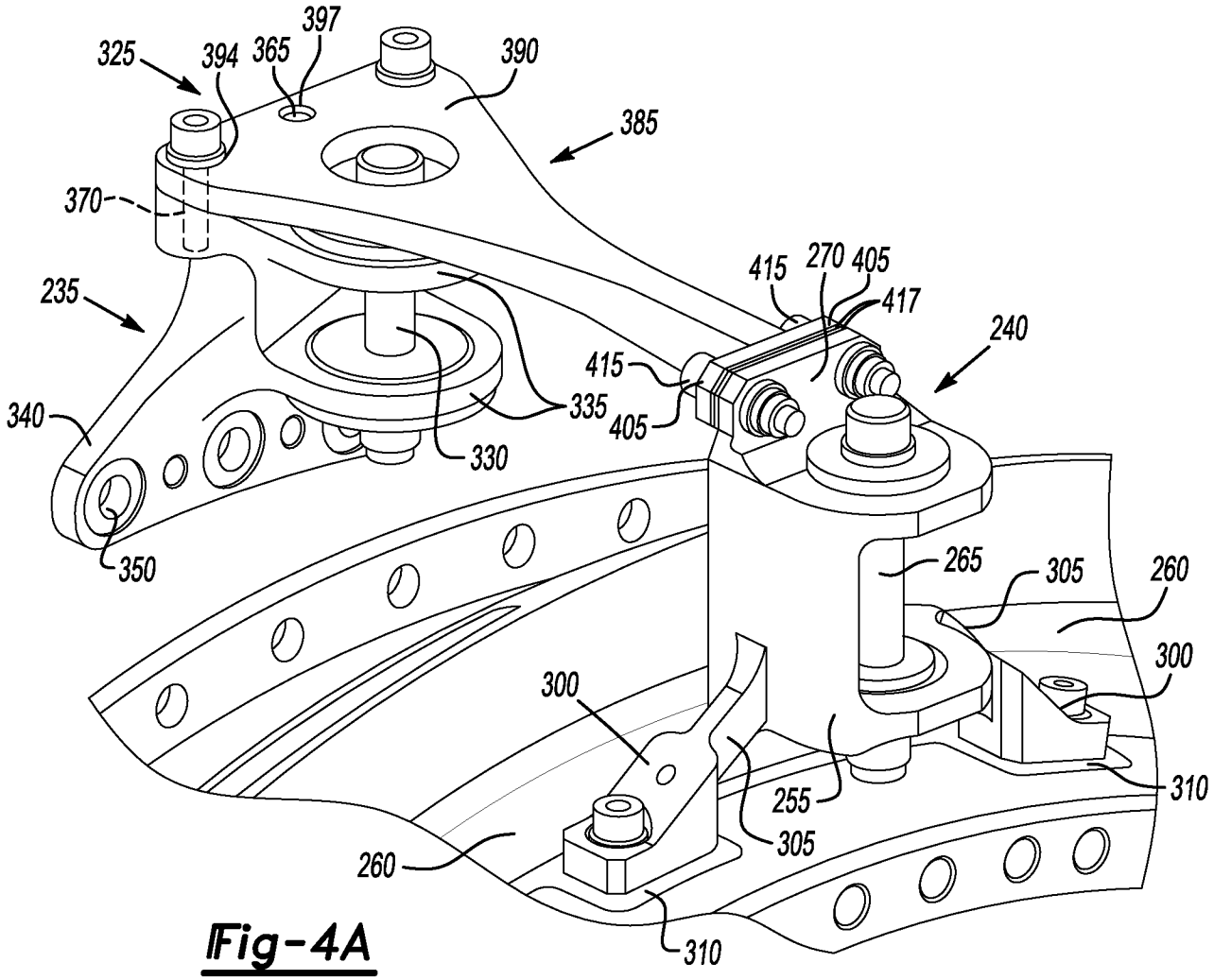
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Fig-4A

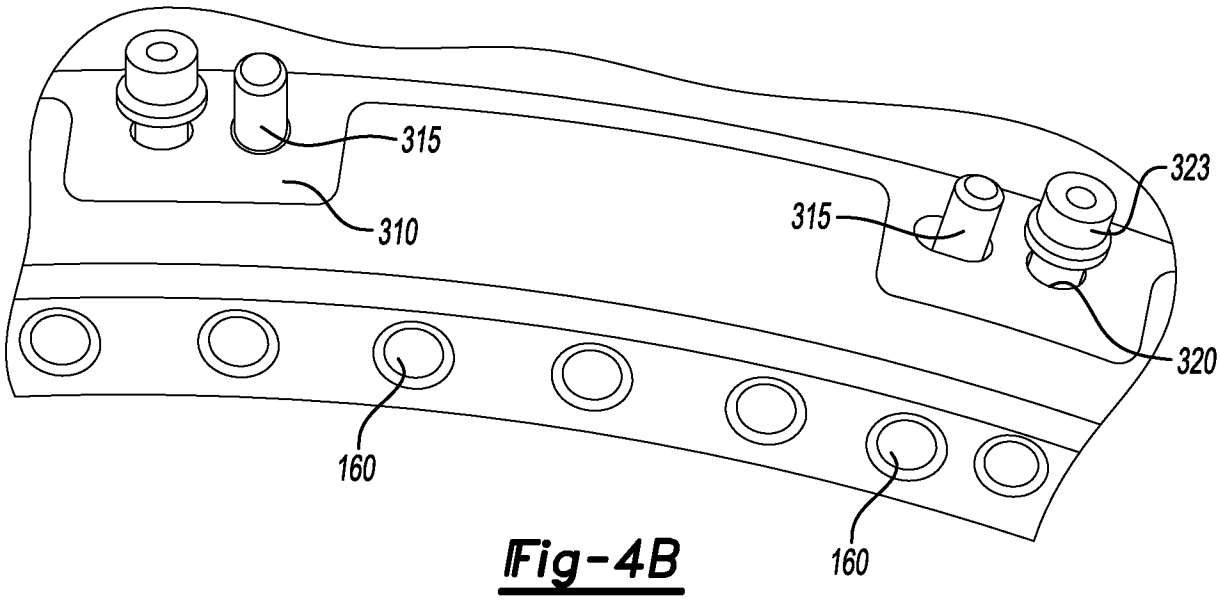
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Fig-4B

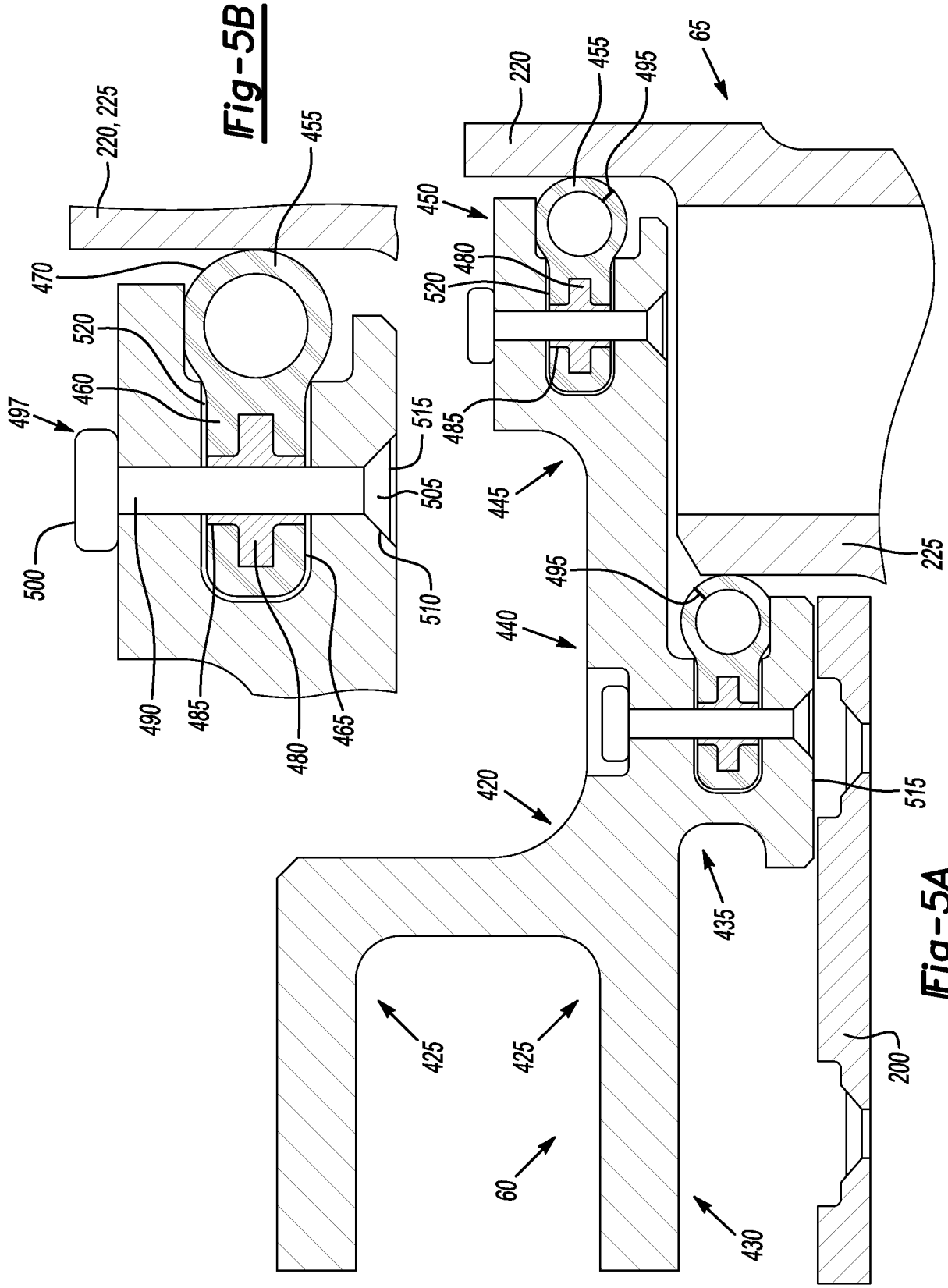
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Fig-5B

Fig-5A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/046063

A. CLASSIFICATION OF SUBJECT MATTER

F02C 7/00(2006.01)i, F02C 7/20(2006.01)i, F02C 7/32(2006.01)i

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)
F02C 7/00; F02C 6/04; F01D 25/14; F01D 1/02; F02K 3/02; F01D 13/00; F02C 7/20; F02C 7/32

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: bleed, duct, compressor, case, shroud, cowl, frame, housing, titanium, and aluminum

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7624581 B2 (MONIZ, THOMAS ORY) 1 December 2009 See abstract, column 5 lines 62-67, column 6 lines 1-8, claims 1,7, and figure 2.	1-5,8-14,17-18
A		6-7,15-16,19-20
Y	US 2005-0135928 A1 (SERVADIO et al.) 23 June 2005 See abstract, paragraph [0005], claim 11, and figure 2.	1-5,8-14,17-18
A		6-7,15-16,19-20
A	US 7249929 B2 (CUMMINGS et al.) 31 July 2007 See abstract, claim 1, and figure 2.	1-20
A	US 6938407 B2 (BEUTIN et al.) 6 September 2005 See abstract, claim 1, and figure 1.	1-20
A	US 6325595 B1 (BREEZE-STRINGFELLOW et al.) 4 December 2001 See abstract, claim 1, and figure 1.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7624581 B2	01/12/2009	CA 2571952 A1	21/06/2007
		CN 1987066 A	27/06/2007
		CN 1987066 B	30/03/2011
		EP 1801403 A2	27/06/2007
		EP 1801403 A3	26/09/2012
		JP 2007-170399 A	05/07/2007
		JP 5028083 B2	19/09/2012
		RU 2006145808 A	27/06/2008
		RU 2433312 C2	10/11/2011
		US 2007-0137175 A1	21/06/2007
US 2005-0135928 A1	23/06/2005	CN 1648417 A	03/08/2005
		EP 1544415 A2	22/06/2005
		EP 1544415 A3	12/11/2008
		EP 1544415 B1	12/12/2012
		IL 165844 D0	15/01/2006
		JP 2005-180428 A	07/07/2005
		JP 4095060 B2	04/06/2008
		KR 10-0706723 B1	13/04/2007
		KR 10-2005-0062375 A	23/06/2005
		US 7025563 B2	11/04/2006
US 7249929 B2	31/07/2007	DE 602004031915 D1	05/05/2011
		EP 1531236 A2	18/05/2005
		EP 1531236 A3	03/09/2008
		EP 1531236 B1	23/03/2011
		JP 2005-147142 A	09/06/2005
		JP 3983242 B2	26/09/2007
		US 2005-0106009 A1	19/05/2005
US 6938407 B2	06/09/2005	CA 2409579 A1	30/04/2003
		CA 2409579 C	26/01/2010
		DE 60200420 D1	03/06/2004
		DE 60200420 T2	19/05/2005
		EP 1308601 A1	07/05/2003
		EP 1308601 B1	28/04/2004
		FR 2831608 A1	02/05/2003
		FR 2831608 B1	02/01/2004
		JP 2003-148164 A	21/05/2003
		JP 4057891 B2	05/03/2008
		RU 2296887 C2	10/04/2007
		US 2003-0079465 A1	01/05/2003
US 6325595 B1	04/12/2001	EP 1136679 A2	26/09/2001
		EP 1136679 A3	03/11/2004
		JP 2001-304194 A	31/10/2001