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

(72) Inventors: LORD, Wesley K.; 62 Blueberry Lane, South Glastonbury, Connecticut 06073 (US). SUCIU, Gabriel L.; 27 Tanglewood Drive, Glastonbury, Connecticut 06033 (US). EPSTEIN, Alan H.; 5 Cedarwood Ter., Lexington, Massachusetts 02421 (US). MCCUNE, Michael E.; 43 Hunters Court, Colchester, Connecticut 06415 (US). MERRY, Brian D.; 220 Bear Swamp Road, Andover, Connecticut 06232 (US).

(74) Agent: OLDS, Theodore W.; Carlson, Gaskey & Olds/Pratt & Whitney, c/o CPA Global, P.O. Box 52050, Minneapolis, Minnesota 55402 (US).

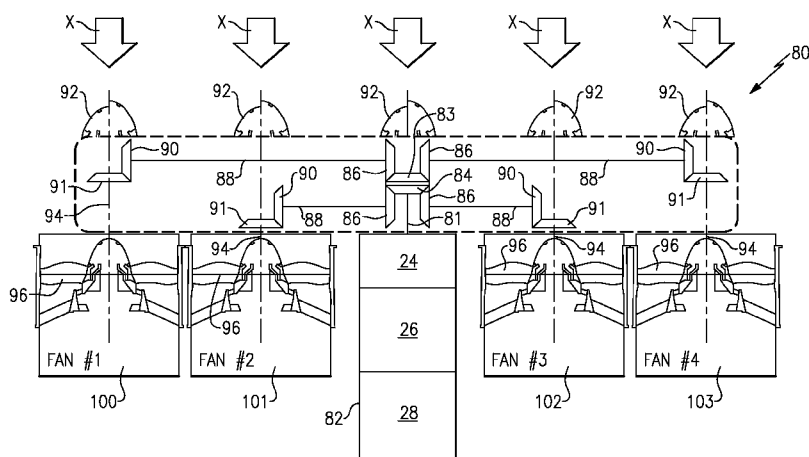
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(54) Title: GAS TURBINE ENGINE DRIVING MULTIPLE FANS

**FIG.2**

(57) Abstract: A gas turbine engine includes a core engine with a compressor section, a combustor and a turbine. The turbine drives an output shaft, and the output shaft drives at least four gears. Each of the at least four gears extends through a drive shaft to drive an associated fan rotor.

GAS TURBINE ENGINE DRIVING MULTIPLE FANS

BACKGROUND

[0001] Gas turbine engines are known, and typically include a fan delivering air into a compressor. The air is compressed in the compressor, and delivered into a combustion section where it is mixed with fuel and ignited. Products of the combustion pass downstream over turbine rotors, which in turn drive the compressor and fan.

[0002] Fan rotors are becoming increasingly large in diameter. This increase presents challenges with regard to operation and packaging. Thus, it has been proposed to drive a plurality of fan rotors from a single gas turbine engine core. The enlargement of fan diameter has increased with the recent development of a gear reduction driving the fan from the turbine rotor. The fans typically drive air through both a bypass duct, and into the compressor. A bypass ratio is defined as the volume of air delivered into the bypass duct as propulsion, compared to the volume of air delivered into the compressor. The bypass ratio has become larger as the fan diameter has become larger.

[0003] It has been proposed to drive a plurality of smaller fan rotors from a single core engine. Typically these proposals have only driven two fan rotors. One proposal has been to drive as many as four fan rotors from a single core engine, however, the transmission for doing so would not share the power to the fan rotors in an efficient manner.

SUMMARY

[0004] In a featured embodiment, a gas turbine engine has a core engine including a compressor section, a combustor and a turbine. The turbine drives an output shaft. The output shaft drives at least four gears, each of the at least four gears extending through a drive shaft to drive an associated fan rotor.

[0005] In another embodiment according to the previous embodiments, the output of the core engine drives a pair of bevel gears. Each of the at least four gears are driven by at least one of the pair of bevel gears.

[0006] In another embodiment according to the previous embodiments, the pair of bevel gears rotate together. Each of the pair of bevel gears drives at least two of the at least four gears.

[0007] In another embodiment according to the previous embodiments, the at least four gears are bevel gears.

[0008] In another embodiment according to the previous embodiments, the output shafts drive an output shaft bevel gear. The output shaft bevel gears engage fan rotor bevel gears which in turn drive fan rotors.

[0009] In another embodiment according to the previous embodiments, the output shaft of the gas turbine engine also drive a fifth fan delivering air into the compressor section.

[0010] In another embodiment according to the previous embodiments, the fifth fan is driven by a shaft upstream of the pair of bevel gears.

[0011] In another embodiment according to the previous embodiments, the at least four gears and shafts are positioned downstream of the fan rotors.

[0012] In another embodiment according to the previous embodiments, the output shafts are positioned upstream of the fan rotors.

[0013] In another embodiment according to the previous embodiments, an exhaust of the core engine exhausts air through a duct. An exhaust from the at least four fan rotors is maintained substantially separate of the exhaust from the core engine.

[0014] In another embodiment according to the previous embodiments, the exhaust of the core engine is positioned upstream of the fan rotors.

[0015] In another embodiment according to the previous embodiments, the exhaust of the core engine is positioned downstream of the fan rotors.

[0016] In another embodiment according to the previous embodiments, an exhaust of the core engine exhausts air through a duct. An exhaust from the at least four fan rotors is maintained substantially separate of the exhaust from the core engine.

[0017] In another embodiment according to the previous embodiments, the output shafts are positioned upstream of the fan rotors.

[0018] In another embodiment according to the previous embodiments, the at least four gears and shafts are positioned downstream of the fan rotors.

[0019] In another embodiment according to the previous embodiments, the output shaft of the gas turbine engine also drives a fifth fan delivering air into the compressor section.

[0020] In another embodiment according to the previous embodiments, the fifth fan is driven by a shaft upstream of the pair of bevel gears.

[0021] In another embodiment according to the previous embodiments, the output shaft drives an output shaft bevel gear. The output shaft bevel gear engages fan rotor bevel gears which in turn drive fan rotors.

[0022] In another embodiment according to the previous embodiments, an exhaust of the core engine is positioned upstream of the fan rotors.

[0023] In another embodiment according to the previous embodiments, an exhaust of the core engine is positioned downstream of the fan rotors.

[0024] These and other features of the invention will be better understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0025] Figure 1 schematically shows a prior art gas turbine engine.
- [0026] Figure 2 shows a first embodiment.
- [0027] Figure 3 shows a second embodiment.
- [0028] Figures 4A – 4D show various direction of rotation options for either of the foregoing embodiments.
- [0029] Figure 5 shows a third embodiment.
- [0030] Figure 6A shows a feature of any of these embodiments.
- [0031] Figure 6B shows an alternative to the Figure 6A arrangement.
- [0032] Figure 6C shows a feature of either the Figure 6A or 6B embodiment.

DETAILED DESCRIPTION

[0033] 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 an augmentor section (not shown), among other systems or features. The fan section 22 drives air along a bypass flowpath B while the compressor section 24 drives air along a core flowpath C 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 including three-spool architectures.

[0034] 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.

[0035] The low speed spool 30 generally includes an inner shaft 40 that interconnects a fan 42, a low pressure (or first) compressor 44 and a low pressure (or first) turbine 46. 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 (or second) compressor 52 and high pressure (or second) turbine 54. A combustor 56 is arranged between the high pressure

compressor 52 and the high pressure turbine 54. 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. As used herein, a “high pressure” compressor or turbine experiences a higher pressure than a corresponding “low pressure” compressor or turbine.

[0036] 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 turbines 46, 54 rotationally drive the respective low speed spool 30 and high speed spool 32 in response to the expansion.

[0037] Figure 2 shows a gas turbine engine 80 having a single core engine 82 shown schematically. The core engine includes at least a compressor 44, a combustor 26 and a turbine 28 of the type shown in Figure 1, as may be generally known. The core 82 drives a shaft 81 which in turn drives a gear combination 83 and 84. Gears 83 and 84 are shown as bevel gears which rotate together to drive four bevel gears 86. Each of the bevel gears 86 drives a shaft 88 that in turn drives a bevel gear 90. The bevel gears 90 drive bevel gears 91, which in turn drive shafts 94. Nose cones 92 are positioned forwardly in front of four fans 100, 101, 102 and 103. In addition, a cone 92 is positioned forwardly of an intake into a compressor section of the gas turbine engine 82. Airflow in this embodiment flows in the direction X across fan rotors 96 in each of the fans 100, 101, 102 and 103. By utilizing the direct drive taken from the bevel gears, and delivered to each of the four fan rotors, this embodiment efficiently and adequately drives each of the fan rotors 96. It should be understood that the drive is shown schematically and would typically include bearings, supports, etc.

[0038] Figure 3 shows an embodiment 290 that is somewhat similar to the embodiment 80 of Figure 2. However, the gas turbine engine 290 takes air in the direction X into its compressor section 24 and drives the output shaft 181 to drive the fans 200, 201, 202 and 203 through a gear transmission 110, which is shown to be quite similar to that of Figure 2. However, in this embodiment the transmission 110 and fan rotors 200, 201, 202, and 203 are provided at the downstream (with respect to airflow) of the core 190. For example, the transmission 110 and fan rotors 200, 201, 202, and 203 may be provided adjacent the low pressure turbine 46 of the turbine section 28. Essentially, this embodiment simply reverses

the location of the gear transmission relative to the fan rotors. As shown in Figure 3, the transmission 110 is on an opposed side of the fan rotor, or in the path of the air downstream of the fan rotor. In contrast, as shown in Figure 2, the transmission is positioned intermediate the nose cones 92 and the fan rotors, and upstream of the fan rotors in the airflow direction.

[0039] Figures 4A-4D shows the feature that the fans 100/200, 101/201, 102/202, and 103/203 can rotate in directions R1 or R2 as shown. However, a worker of ordinary skill in the art would recognize how to achieve a desired rotation for the fan rotors by selectively arranging the gear transmissions.

[0040] Figure 5 shows an embodiment 250 wherein the output 254 from a gas turbine engine core 255 drives bevel gears 256 and 258 to drive a gear transmission 252 which is similar to the Figure 1 or Figure 2 embodiments. The gear transmission 252 in turn drives five fan rotors 301, 302, 303, 304 and 305. The fan rotor 305 delivers the air into the core engine 255 in the direction X, and is shown schematically. As shown, the fan rotor 305 is driven by a shaft 311, upstream of the bevel gears 256/258.

[0041] The arrangements as set forth above will be operable to drive each of the fan rotors with a shared power, and such that the speed of the fan rotors can be controlled.

[0042] Figure 6A shows a feature wherein the core engine 400 delivers its exhaust gas through a duct 402 as exhaust flow 401. The four or more fans 404 deliver propulsion air as flow 403, which is separate from the exhaust flow 401.

[0043] Figure 6A shows the core 400 being upstream of the fan 404.

[0044] Figure 6B shows the four or more fans 500 being upstream of the core 502. Again, the propulsive flow 501 from the fans 500 is separate from the exhaust flow 503 from the core 502.

[0045] Figure 6C shows one possible arrangement of the core exhaust duct 600 relative to the fan rotors 100/200, 101/201, 102/201 and 103/203. As shown, the core exhaust may be maintained separate from the bypass output of the fans 100/200, 101/201, 102/202 and 103/203.

[0046] 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

What is claimed is:

1. A gas turbine engine comprising:
a core engine including a compressor section, a combustor and a turbine, said turbine driving an output shaft; and
said output shaft driving at least four gears, each of said at least four gears extending through a drive shaft to drive an associated fan rotor.
2. The gas turbine engine as set forth in claim 1, wherein said output of said core engine drives a pair of bevel gears, and each of said at least four gears being driven by at least one of said pair of bevel gears.
3. The gas turbine engine as set forth in claim 2, wherein said pair of bevel gears rotate together, with each of said pair of bevel gears driving at least two of said at least four gears.
4. The gas turbine engine as set forth in claim 3, wherein said at least four gears are bevel gears.
5. The gas turbine engine as set forth in claim 4, wherein said output shafts drive an output shaft bevel gear, and said output shaft bevel gears engage fan rotor bevel gears which in turn drive fan rotors.
6. The gas turbine engine as set forth in claim 5, wherein said output shaft of said gas turbine engine also driving a fifth fan delivering air into the compressor section.
7. The gas turbine engine as set forth in claim 6, wherein said fifth fan is driven by a shaft upstream of said pair of bevel gears.

8. The gas turbine engine as set forth in claim 5, wherein said at least four gears and said shafts are positioned downstream of the fan rotors.
9. The gas turbine engine as set forth in claim 5, wherein said output shafts are positioned upstream of the fan rotors.
10. The gas turbine engine as set forth in claim 5, wherein an exhaust of said core engine exhausts air through a duct, and an exhaust from said at least four fan rotors is maintained substantially separate of said exhaust from said core engine.
11. The gas turbine engine as set forth in claim 10, wherein said exhaust of said core engine is positioned upstream of said fan rotors.
12. The gas turbine engine as set forth in claim 10, wherein said exhaust of said core engine is positioned downstream of said fan rotors.
13. The gas turbine engine as set forth in claim 1, wherein an exhaust of said core engine exhausts air through a duct, and an exhaust from said at least four fan rotors is maintained substantially separate of said exhaust from said core engine.
14. The gas turbine engine as set forth in claim 1, wherein said output shafts are positioned upstream of the fan rotors.
15. The gas turbine engine as set forth in claim 1, wherein said at least four gears and said shafts are positioned downstream of the fan rotors.
16. The gas turbine engine as set forth in claim 1, wherein said output shaft of said gas turbine engine also driving a fifth fan delivering air into the compressor section.
17. The gas turbine engine as set forth in claim 16, wherein said fifth fan is driven by a shaft upstream of said pair of bevel gears.

18. The gas turbine engine as set forth in claim 1, wherein said output shaft drives an output shaft bevel gear, and said output shaft bevel gear engages fan rotor bevel gears which in turn drive fan rotors.

19. The gas turbine engine as set forth in claim 1, wherein an exhaust of said core engine is positioned upstream of said fan rotors.

20. The gas turbine engine as set forth in claim 1, wherein an exhaust of said core engine is positioned downstream of said fan rotors.

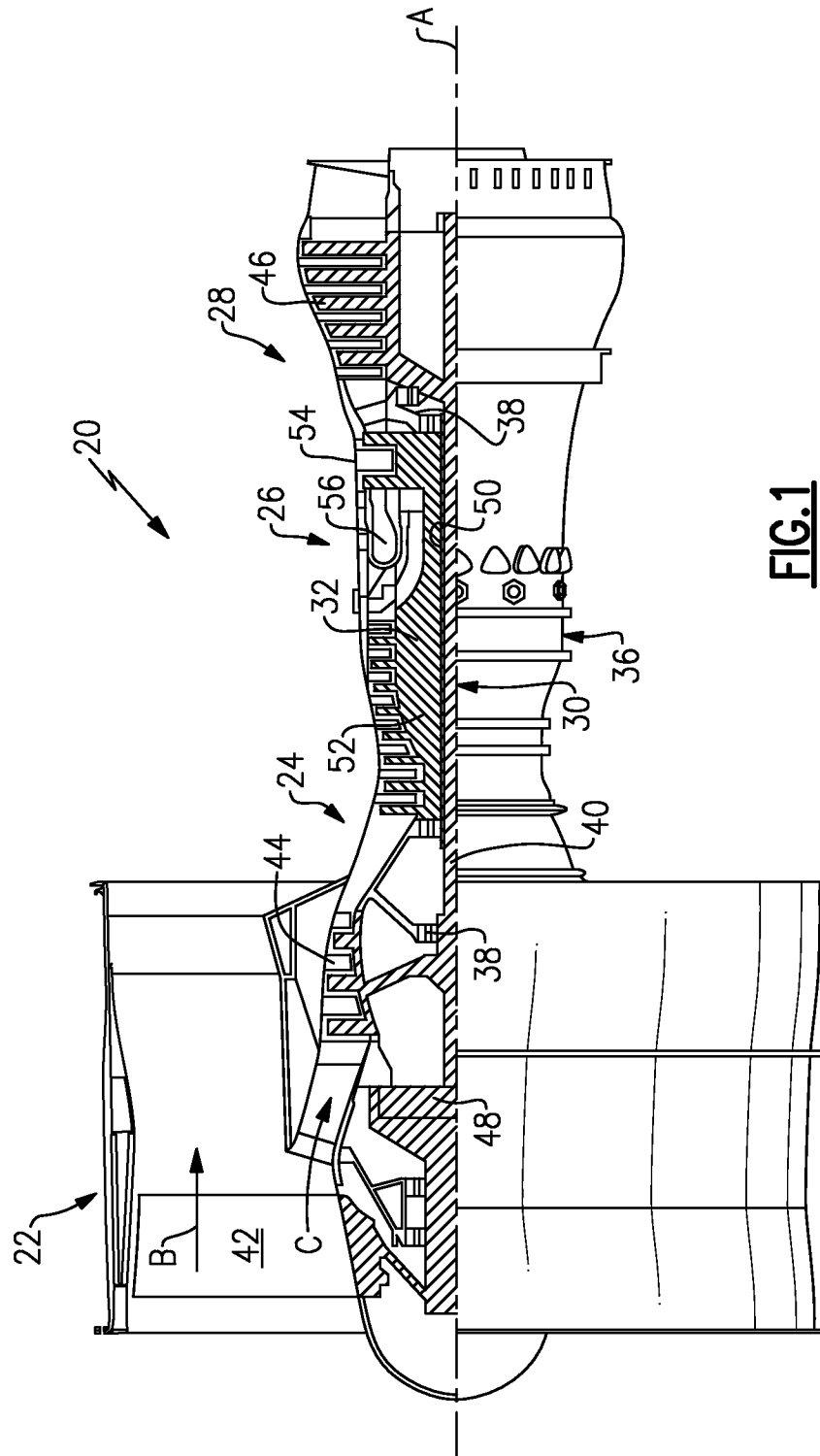


FIG. 1

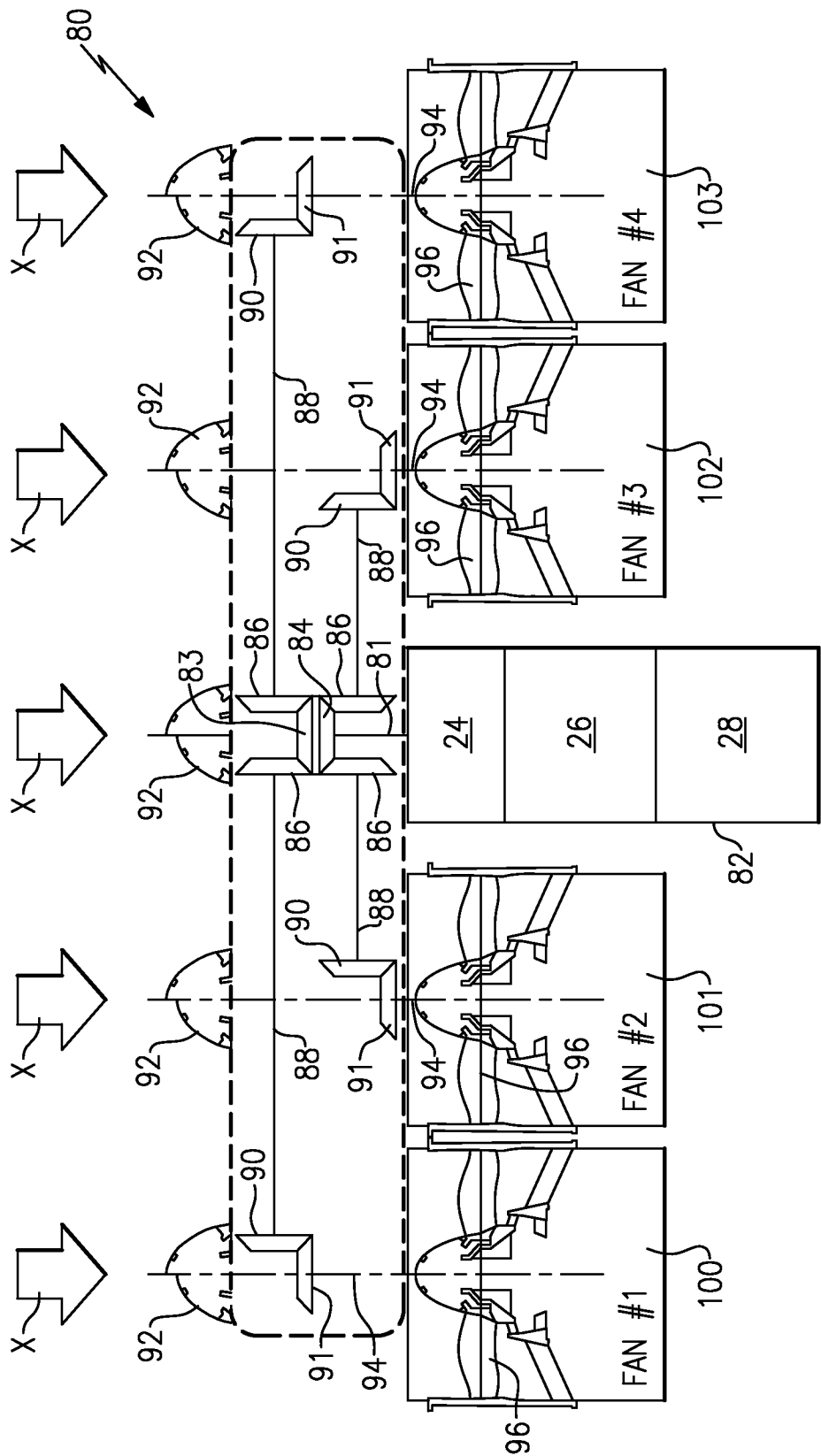


FIG. 2

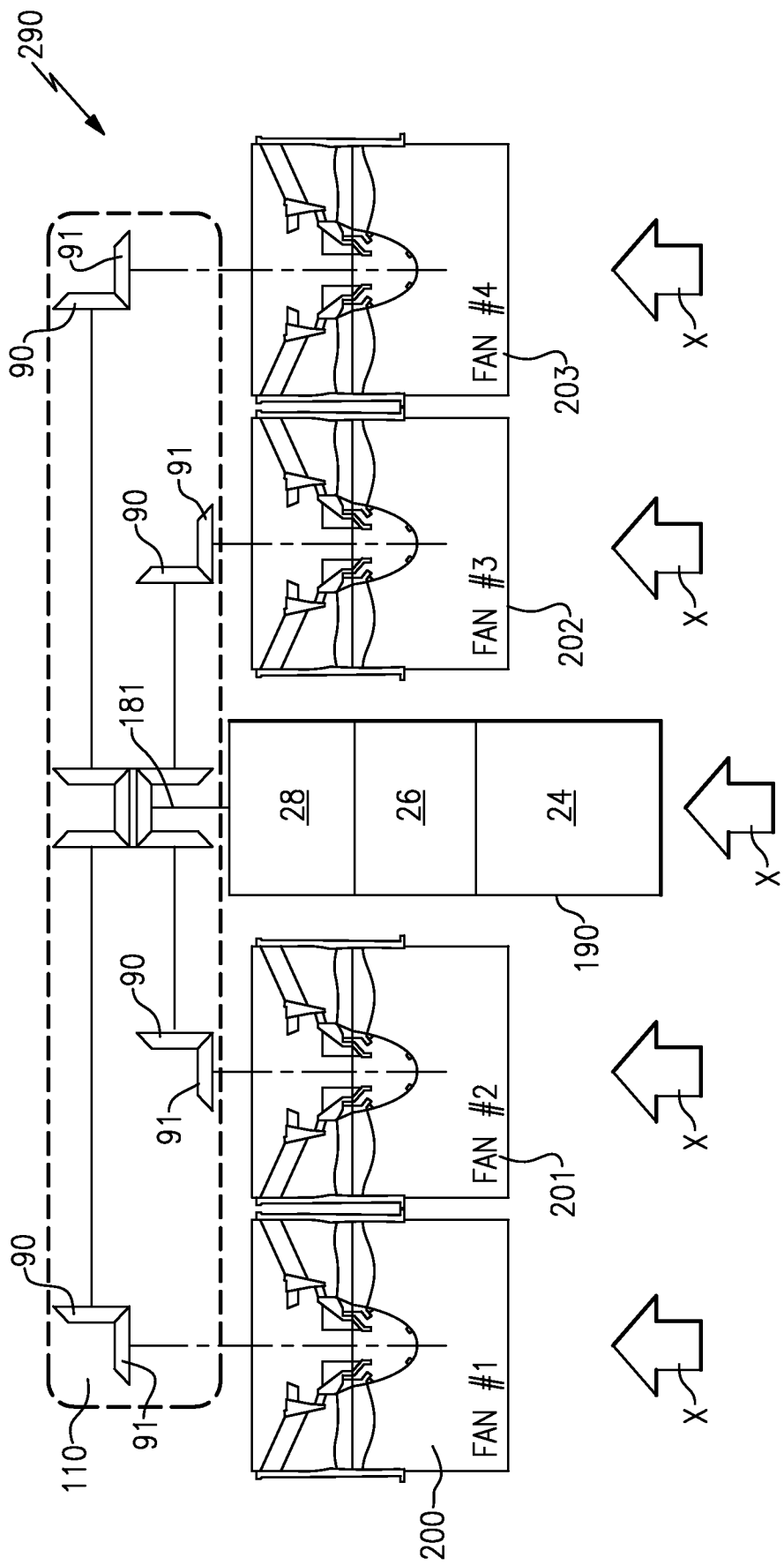
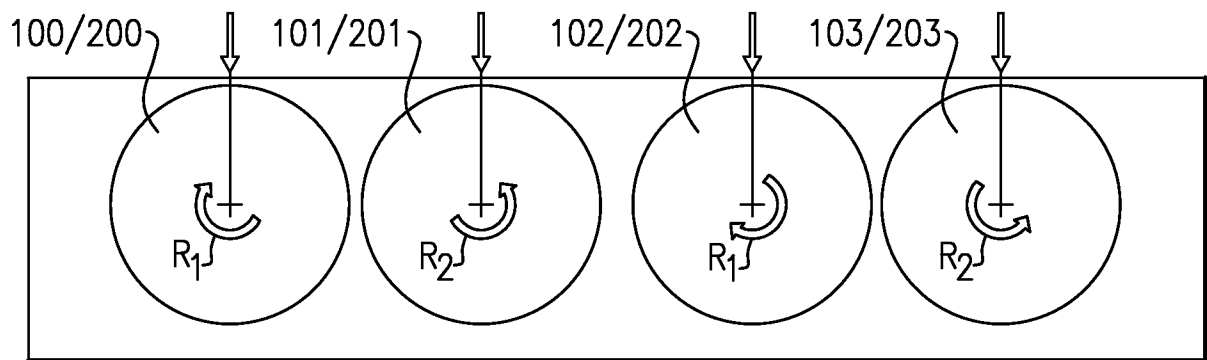
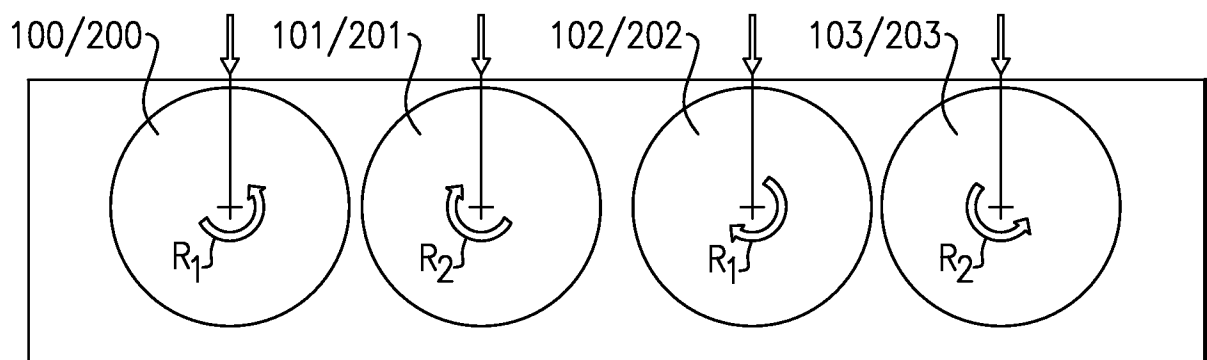
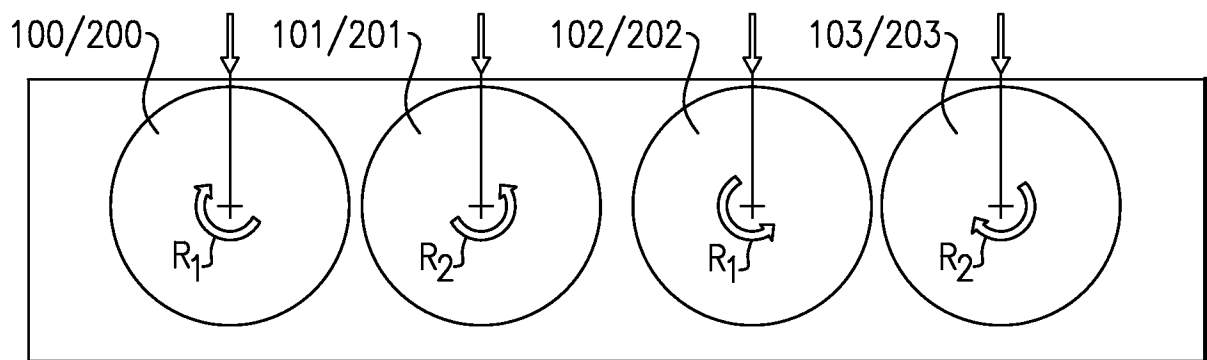
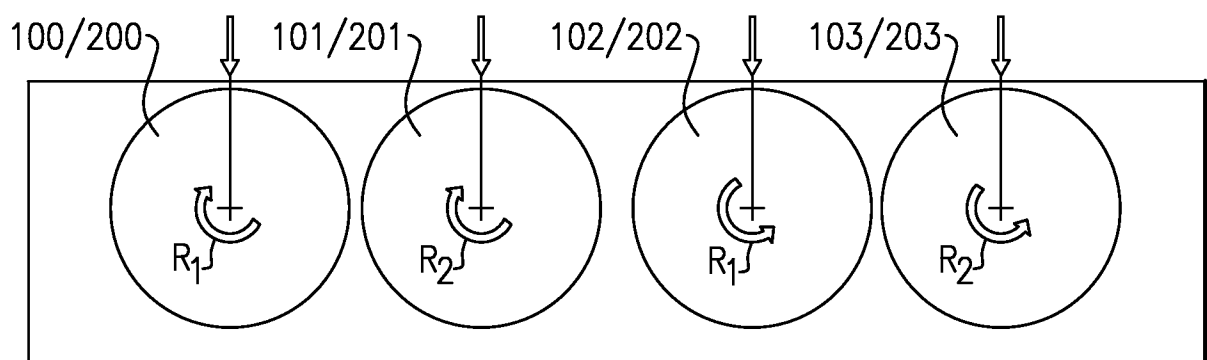


FIG. 3

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**FIG. 4A****FIG. 4B****FIG. 4C****FIG. 4D**

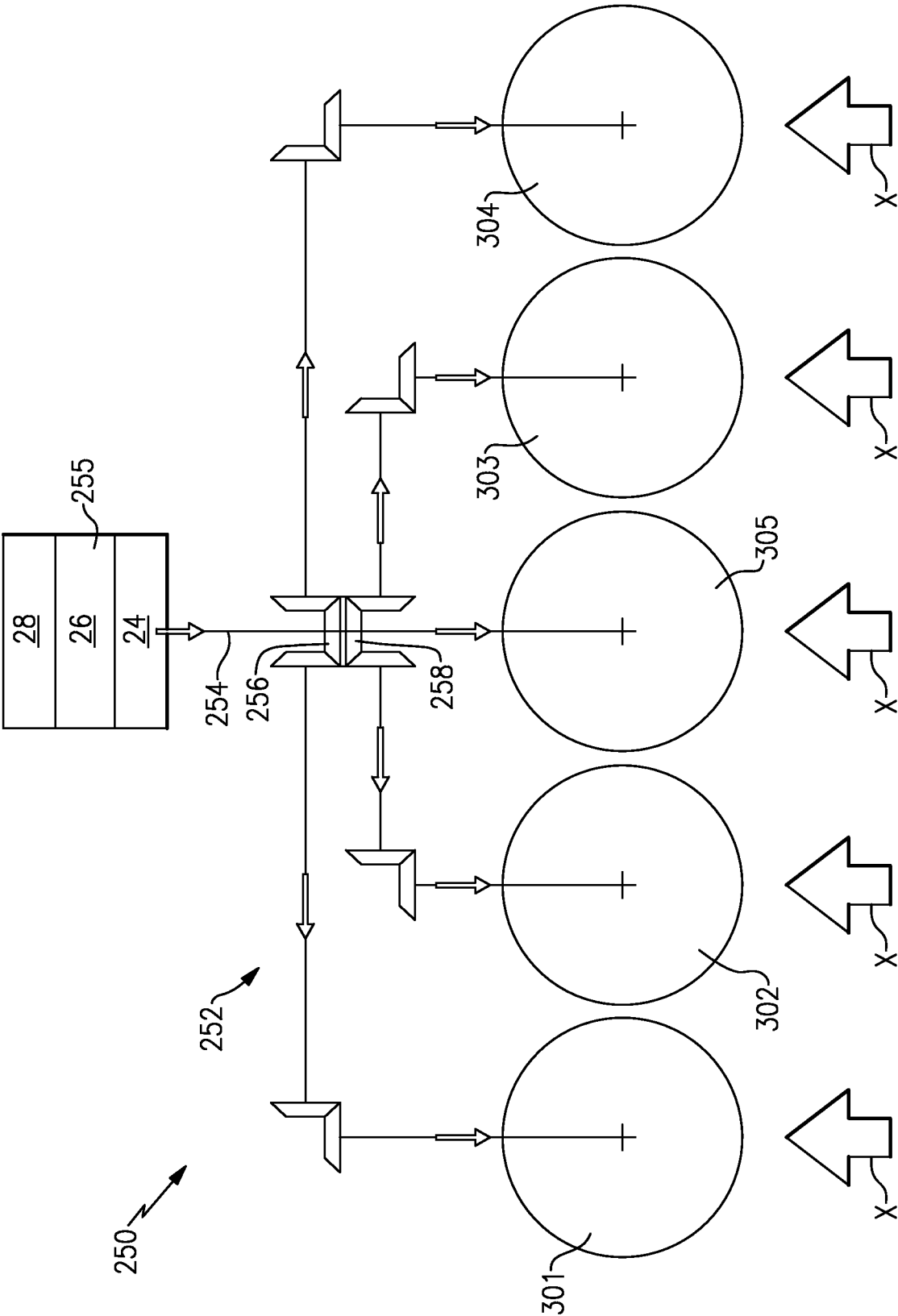


FIG.5

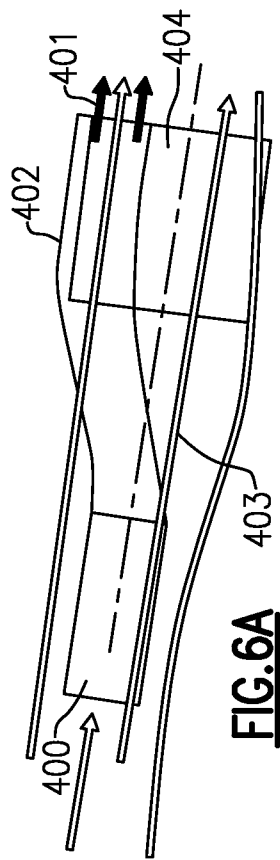


FIG. 6A

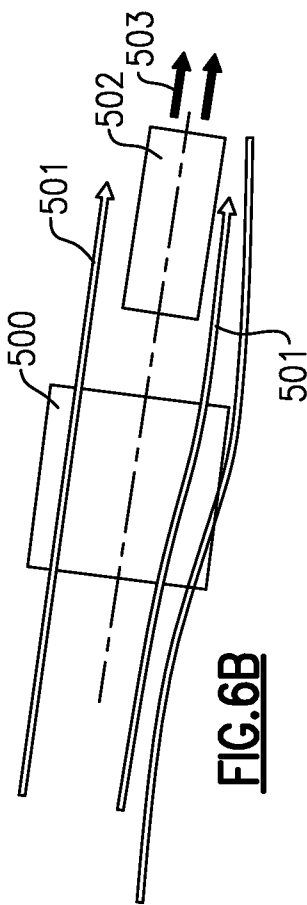


FIG. 6B

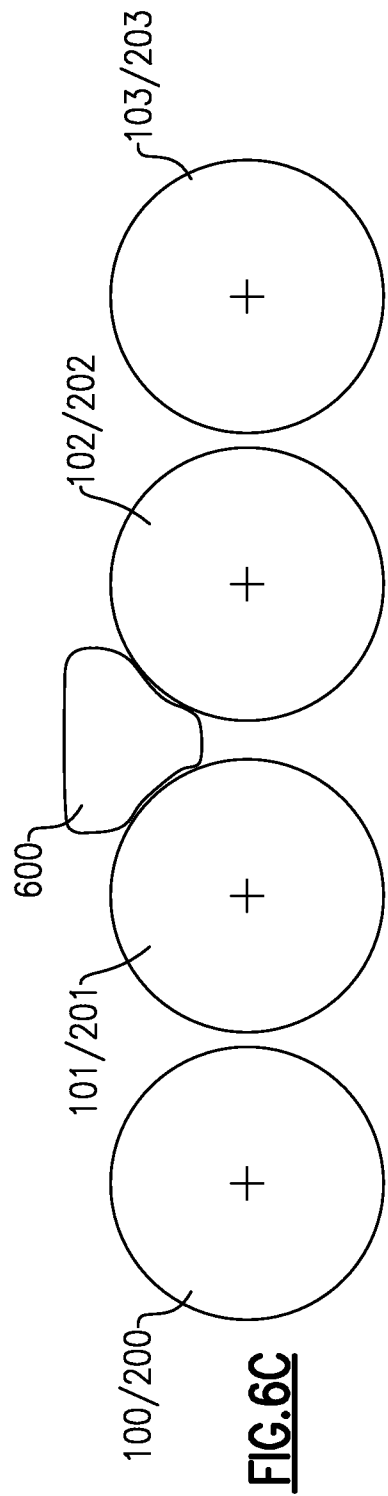


FIG. 6C

A. CLASSIFICATION OF SUBJECT MATTER**F02C 7/32(2006.01)i, F02K 3/04(2006.01)i, F02C 7/36(2006.01)i, F02C 3/04(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 7/32; F02K 3/00; F02K 3/02

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: gas, turbine, engine, multi fans, and bevel gear

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0229243 A1 (GUEMMER, VOLKER) 17 September 2009 See paragraphs [0033], [0038]-[0041], [0047]-[0048], [0055], [0058]; claim 1 and figures 2b, 5a-5d.	1-5, 8-15, 18-20
Y		6, 7, 16, 17
Y	US 8,015,796 B2 (BABU et al.) 13 September 2011 See column 1 line 6 - column 2 line 47; claim 1 and figure 1.	6, 7, 16, 17
A	US 6,792,745 B2 (WOJCIECHOWSKI, PAUL M.) 21 September 2004 See column 2 line 66 - column 3 line 52; figures 1, 2.	1-20
A	US 7,752,834 B2 (ADDIS, MARK) 13 July 2010 See column 4 line 48 - column 5 line 32; figure 7.	1-20
A	US 5,161,369 A (WILLIAMS, GREGG G.) 10 November 1992 See abstract; column 1 lines 5-50; claim 1.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

24 June 2013 (24.06.2013)

Date of mailing of the international search report

25 June 2013 (25.06.2013)

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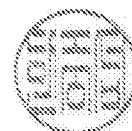
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/026576

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0229243 A1	17.09.2009	DE 102008011643 A11 EP 2096293 A2 EP 2096293 A3 US 8402740 B2	03.09.2009 02.09.2009 30.05.2012 26.03.2013
US 8015796 B2	13.09.2011	EP 2000656 A1 EP 2014901 A2 EP 2014901 A3 US 2010-0011741 A1	10.12.2008 14.01.2009 04.01.2012 21.01.2010
US 6792745 B2	21.09.2004	US 2004-025493 A1	12.02.2004
US 7752834 B2	13.07.2010	EP 1916406 A2 EP 1916406 A3 US 2008-0098719 A1	30.04.2008 05.10.2011 01.05.2008
US 5161369 A	10.11.1992	EP 0497472 A1	05.08.1992