(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 703 606 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**05.03.2014 Bulletin 2014/10**

(51) Int Cl.:
***F01D 17/16*** *(2006.01)*

(21) Application number: **13180525.1**

(22) Date of filing: **15.08.2013**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**

(30) Priority: **29.08.2012 US 201213598059**

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(54) **System and method to control variable stator vanes in gas turbine engines**

(57) Embodiments of the present application include a variable stator vanes control mechanism (100) for a gas turbine engine. The control mechanism (100) includes a moveable actuation rod (102) in operative communication with a first unison ring (104) such that movement of the actuation rod (102) drives the first unison ring (104). The control mechanism (100) also includes a linkage (114) in operative communication with the first unison ring (104) and a second unison ring (116) such that movement of the first unison ring (104) drives the second unison ring (116).

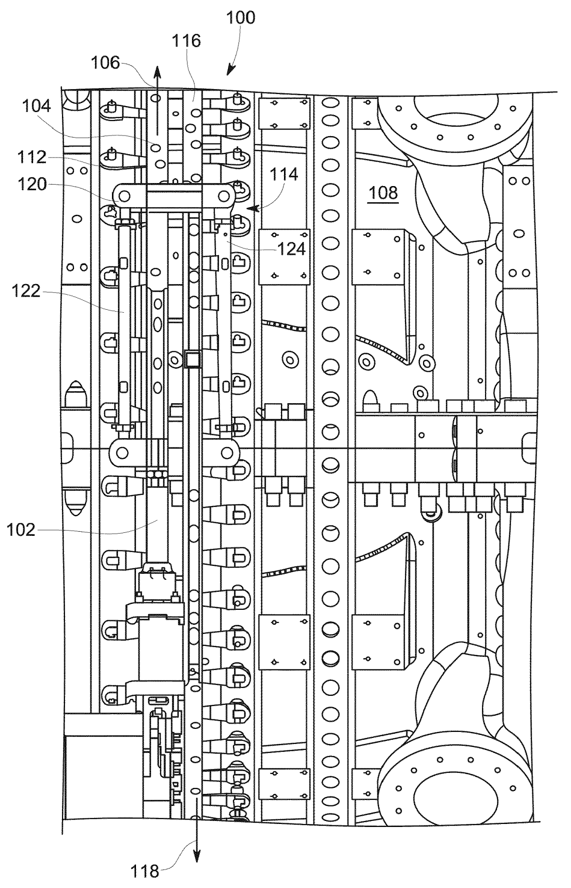


FIG. 3

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## Description

### FIELD OF THE INVENTION

**[0001]** Embodiments of the present application relate generally to gas turbine engines and more particularly to systems and methods to control variable stator vanes in gas turbine engines.

### BACKGROUND OF THE INVENTION

**[0002]** During operation of a gas turbine engine using a multi-stage axial compressor, a turbine rotor is turned at high speeds by a turbine so that air is continuously induced into the compressor. The air is accelerated by rotating blades and swept rearwards onto adjacent rows of variable stator vanes. Each rotor blade/variable stator vane stage increases the pressure of the air.

**[0003]** In addition to translating the kinetic energy of the air into pressure, the variable stator vanes also serve to correct the deflection given to the air by the rotor blades and to present the air at the correct angle to the next stage of rotor blades. Pivoting the variable stator vanes permits the flow capacity of the compressor or turbine to be changed, thereby ensuring that the flow capacity is always at an optimum value for the particular operating conditions of the gas turbine engine. Accordingly, there is a need to control the angle of the variable stator vanes.

### BRIEF DESCRIPTION OF THE INVENTION

**[0004]** Some or all of the above needs and/or problems may be addressed by certain embodiments of the present application. According to a first aspect of the invention, there is provided a variable stator vanes control mechanism for a gas turbine engine. The control mechanism includes a moveable actuation rod in operative communication with a first unison ring such that movement of the actuation rod drives the first unison ring. The control mechanism also includes a linkage in operative communication with the first unison ring and a second unison ring such that movement of the first unison ring drives the second unison ring.

**[0005]** According to another aspect, there is provided a method to control variable stator vanes in a gas turbine engine. The method includes actuating a moveable actuation rod in operative communication with a first unison ring such that movement of the actuation rod drives the first unison ring. The method also includes driving a linkage in operative communication with the first unison ring and a second unison ring such that movement of the first unison ring drives the second unison ring.

**[0006]** Further, according to another aspect, there is provided a variable stator vanes control mechanism for a gas turbine engine. The gas turbine engine may include a compressor having a compressor casing. The control mechanism may include a moveable actuation rod in operative communication with a first unison ring such that movement of the actuation rod drives the first unison ring about the compressor casing. The control mechanism may also include a linkage in operative communication with the first unison ring and a second unison ring such that movement of the first unison ring about the compressor casing drives the second unison ring about the compressor casing.

**[0007]** Other embodiments, aspects, and features of the invention will become apparent to those skilled in the art from the following detailed description, the accompanying drawings, and the appended claims.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** Reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

FIG. 1 is a schematic of an example diagram of a gas turbine engine with a compressor, a combustor, and a turbine, according to an embodiment.

FIG. 2 is a schematic of an example portion of a compressor assembly, according to an embodiment.

FIG. 3 is a perspective view of a portion of a compressor assembly, according to an embodiment.

FIG. 4 is a perspective view of a portion of a compressor assembly, according to an embodiment.

FIG. 5 is a perspective view of a portion of a compressor assembly, according to an embodiment.

FIG. 6 is a perspective view of a portion of a compressor assembly, according to an embodiment.

FIG. 7 is a perspective view of a portion of a compressor assembly, according to an embodiment.

FIG. 8 is a perspective view of a portion of a compressor assembly, according to an embodiment.

FIG. 9 is a perspective view of a portion of a compressor assembly, according to an embodiment.

FIG. 10 is a perspective view of a portion of a compressor assembly, according to an embodiment.

### DETAILED DESCRIPTION OF THE INVENTION

**[0009]** Illustrative embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments are shown. The present application may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Like numbers refer to like elements throughout.

**[0010]** Illustrative embodiments are directed to, among other things, systems and methods to control variable stator vanes in gas turbine engines. Fig. 1 shows a schematic view of a gas turbine engine 10 as may be used herein. As is known, the gas turbine engine 10 may include a compressor 12. The compressor 12 compresses an incoming flow of air 14. The compressor 12 delivers the compressed flow of air 14 to a combustor 16. The combustor 16 mixes the compressed flow of air 14 with a pressurized flow of fuel 18 and ignites the mixture to create a flow of combustion gases 20. Although only a single combustor 16 is shown, the gas turbine engine 10 may include any number of combustors 16. The flow of combustion gases 20 is in turn delivered to a turbine 22. The flow of combustion gases 20 drives the turbine 22 so as to produce mechanical work. The mechanical work produced in the turbine 22 drives the compressor 12 via a shaft 24 and an external load 26 such as an electrical generator and the like.

**[0011]** The gas turbine engine 10 may use natural gas, various types of syngas, and/or other types of fuels. The gas turbine engine 10 may be any one of a number of different gas turbine engines offered by General Electric Company of Schenectady, New York, including, but not limited to, those such as a 7 or a 9 series heavy duty gas turbine engine and the like. The gas turbine engine 10 may have different configurations and may use other types of components.

**[0012]** Other types of gas turbine engines also may be used herein. Multiple gas turbine engines, other types of turbines, and other types of power generation equipment also may be used herein together.

**[0013]** Fig. 2 depicts a section of the compressor 12 of the gas turbine engine 10 of Fig. 1. The compressor 12 includes a tubular casing 28. Sets of variable stator vanes 30 are mounted within the casing 28 circumferentially about the central axis of the compressor 12. Corresponding sets of rotor vanes 32 are mounted downstream of each set of variable stator vanes 30. Each variable stator vane 30 terminates at the casing 28 in a stem 34. The stem 34 is rotatable in a bush bearing 36 on the outside of the casing 28.

**[0014]** Located externally of the casing 28 and adjacent to each set of variable stator vanes 30 are unison rings 38 extending circumferentially about the casing 28. The vane stems 34 of each set of variable stator vanes 30 are connected to the corresponding unison ring 38 by a respective lever 40. One end of the lever 40 is clamped to the end of the vane stem 34 by a bolt 42 so that there is no relative movement between the stem 34 and the lever 40. The other end of the lever 40 is connected to the unison ring 38 by a pin 44 rotatable in a bush bearing located in the unison ring 38.

**[0015]** The unison ring 38 is arranged so that it may be rotated about the central axis of the compressor section 12 in either direction of arrow 9. Consequently, rotation of the unison ring 38 causes rotation of each variable stator vane 30 via the levers 40 and thus enables the variable stator vanes 30 to assume required angles of incidence to the incoming air.

**[0016]** Figs. 3 and 4 depict an embodiment of a variable stator vanes control mechanism 100. The variable stator vanes control mechanism 100 enables the transfer of motion from one unison ring to another using only one actuator. The variable stator vanes control mechanism 100 may include a moveable actuation rod 102. The moveable actuation rod 102 may be in operative communication with a first unison ring 104 such that movement of the actuation rod 102 drives the first unison ring 104 in a first direction 106 about the central axis of the casing 108. Rotation of the first unison ring 104 causes rotation of each variable stator vane 110 connected to the first unison ring by the levers 112.

**[0017]** The variable stator vanes control mechanism 100 may also include a bell crank mechanism 114. The bell crank mechanism 114 may be in operative communication with the first unison ring 104. The bell crank mechanism 114 may also be in operative communication with a second unison ring 116 such that movement of the first unison ring 104 in the first direction 106 translates movement, by way of the bell crank mechanism 114, to the second unison ring 116 in a second direction 118 that is opposite the first direction 106 of the first unison ring 104. Rotation of the second unison ring 116 causes rotation of each variable stator vane 110 connected to the second unison ring 116 by the levers 112.

**[0018]** Still referring to Figs. 3 and 4, the bell crank mechanism 114 may include a pivot 120, a first turnbuckle 122, and a second turnbuckle 124. The first turnbuckle 122 operatively connects the first unison ring 104 to the pivot 120. Similarly, the second turnbuckle 124 operatively connects the second unison ring 116 to the pivot 120. The first turnbuckle 122 and the second turnbuckle 124 are attached to the pivot 120 such that rotation of the pivot 120 drives the first turnbuckle 122 and the second turnbuckle 124 in opposite directions.

**[0019]** In operation, the movable actuator rod 102 actuates the first unison ring 104 thereby rotating the first unison ring 104 in the first direction 106 about the casing 108. As the first unison ring 104 rotates about the casing 108 in the first direction 106, it drives the first turnbuckle 122. The first turnbuckle 122 then applies a pivoting force to the pivot 120. The pivoting of the pivot 120 causes the second turnbuckle 124 to drives the second unison ring 116 thereby causing the second unison ring 116 to rotate in the second direction 118 about the casing 108. In this embodiment, the second direction 118 and the first direction 106 are opposite of each other. The rotation of the first unison ring 104 and the second unison ring 116 causes the respective variable stator vanes 110 attached to each unison ring to rotate in opposite directions due to the movement of the levers 112. Accordingly, the angle of the variable stator vanes 110 may be adjusted with the variable stator vanes control mechanism 100.
As described above, the first direction 106 and the second direction 118 are relative to each other. Accordingly,

the first direction 106 and the second direction 118 may be any direction about the casing 108. Moreover, the moveable actuation rod 102 may be in operative communication with the first unison ring 104, the second unison ring 106, or the bell crank mechanism 114.

**[0020]** In certain embodiments, the bell crank mechanism 114 may be at least partially secured to the casing 108 of the compressor. In other embodiments, the moveable actuator rod 102 may be at least partially secured to the casing 108 of the compressor. One will appreciate, however, that the bell crank mechanism 114 and the moveable actuator rod 102 may be at least partially secured at any location on or about the gas turbine engine.

**[0021]** A relative movement between the first unison ring 104 and the second unison ring 116 and the angle of the variable stator vanes 110 may be adjusted by varying the dimensions of the pivot 12, the first turnbuckle 122, and the second turnbuckle 124. Moreover, the angle of the variable stator vanes 110 may be varied by varying the length of the levers 112.

**[0022]** In an embodiment, as depicted in Fig. 5, the variable stator vanes control mechanism 100 may enable the transfer of motion from one unison ring to another using only one actuator. In this embodiment, however, the first unison ring and the second unison ring may rotate in the same direction. For example, the bell crank mechanism 114 may include a pivot 120, a first turnbuckle 122, and a second turnbuckle 124. The first turnbuckle 122 operatively connects the first unison ring 104 to the pivot 120. Similarly, the second turnbuckle 124 operatively connects the second unison ring 116 to the pivot 120. The first turnbuckle 122 and the second turnbuckle 124 may be attached to the pivot 120 such that rotation of the pivot 120 drives the first turnbuckle 122 and the second turnbuckle 124 in the same direction. Accordingly, in operation, the movable actuator rod actuates the first unison ring 104 thereby rotating the first unison ring 104 in a first direction 106 about the casing 108. As the first unison ring 104 rotates about the casing 108 in the first direction 106, it drives the first turnbuckle 122. The first turnbuckle 122 then applies a pivoting force to the pivot 120. The pivoting of the pivot 120 causes the second turnbuckle 124 to drive the second unison ring 116 thereby causing the second unison ring 116 to rotate in the first direction about the casing 108. The rotation of the first unison ring 104 and the second unison ring 116 causes the respective variable stator vanes 110 attached to each unison ring to rotate in the same direction due to the movement of the levers 112.

The embodiments as depicted in Figs. 3-5 may include one or more additional unison rings in operative communication with the bell crank mechanism such that movement of the first unison ring in the first direction drives the one or more additional unison rings in the first or second direction respectively.

**[0023]** Fig. 6 depicts an embodiment of a variable stator vanes control mechanism 200. The variable stator vanes control mechanism 200 enables the transfer of motion from one unison ring to another using only one actuator. The variable stator vanes control mechanism 200 may include a moveable actuation rod 202 in operative communication with a first unison ring 204. The moveable actuation rod 202 may actuate the first unison ring 204. The variable stator vanes control mechanism 200 may also include a linkage 206 in operative communication with the first unison ring 204 and a second unison ring 208 such that movement of the first unison ring 204 drives the second unison ring 208. This embodiment is similar to the previously described embodiments, except that it does not include the bell crank mechanism. Instead, this embodiment provides a direct linkage 206 between the unison rings 204 and 208. Accordingly, in this embodiment, the linkage 206 translates movement from the actuated first unison ring 204 to the second unison ring 208 in the same direction. In certain aspects, the linkage 206 may pull the second unison ring 208. In other aspects, the linkage 206 may push the second unison ring 208.

**[0024]** Still referring to Fig. 6, in operation, the movable actuator rod 202 is attached to the casing 210 and actuates the first unison ring 204 thereby rotating the first unison ring 204 about the casing 210. As the first unison ring 204 rotates about the casing 210, it drives the linkage 206. The linkage 206 may be a turnbuckle. The linkage 206 then applies a force to the second unison ring 208 thereby causing the second unison ring 208 to rotate about the casing 210. In this embodiment, the first unison ring 204 and the second unison ring 206 rotate in the same direction about the casing 210. The rotation of the first unison ring 204 and the second unison ring 206 causes the respective variable stator vanes attached to each unison ring by way of the respective levers 212 to rotate. Accordingly, the angle of the variable stator vanes may be adjusted with the variable stator vanes control mechanism 200.

**[0025]** The embodiment as depicted in Fig 6 may include one or more additional unison rings in operative communication with one or more additional linkages such that movement of the first unison ring in the first direction drives the one or more additional unison rings respectively.

**[0026]** Figs. 7 and 8 depict an embodiment of a variable stator vanes control mechanism 300. The variable stator vanes control mechanism 300 enables the actuation of multiple unison rings using only one actuator. The variable stator vanes control mechanism 300 may include a moveable actuation rod 302. The moveable actuation rod 302 may be in operative communication with a torque shaft 304 such that the movable actuation rod 302 rotates the torque shaft 304. A first unison ring 306 may be in operative communication with the torque shaft 304 via a turnbuckle 305 such that rotation of the torque shaft 304 drives the first unison ring 306 in a first direction 308 about a central axis of the casing 310. Rotation of the first unison ring 306 causes rotation of each variable stator vane 312 connected to the first unison 306 ring by the levers 314. Similarly, a second unison ring 316 may be in operative communication with the torque shaft 304 via a turnbuckle 307 such that rotation of the torque shaft 304 drives the second unison ring 316 in a second direction 318 about the central axis of the casing 310. Rotation of the second unison ring 316 causes rotation of each variable stator vane 312 connected to the second unison 316 ring by the levers 314.

**[0027]** As described above, the first direction 308 and the second direction 318 are relative. The first direction 308 and the second direction 318 may be the same direction or different directions about the casing 310. For example, in embodiments where the first direction and the second direction are the same, the turnbuckles 305 and 307 may be attached on the same side of the torque shaft. Conversely, in embodiments where the first direction and the second direction are different, the turnbuckles 305 and 307 may be attached on opposite sides of the torque shaft. The first direction 308 and the second direction 318 may be any direction about the casing 310. Moreover, the moveable actuation rod 302 may be in operative communication with the first unison ring 306, the second unison ring 316, or the torque shaft 304.

**[0028]** In operation, the movable actuator rod 302 is attached to the casing 310 and actuates the torque shaft 304 thereby rotating the torque shaft 304. The turnbuckle 305 connects the first unison ring 306 to the torque shaft 304, and the turnbuckle 307 connects the second unison ring 316 to the torque shaft 304. As the torque shaft 304 rotates, the turnbuckles 305 and 307 drive the first unison ring 306 and the second unison ring 316 about the compressor casing 310. The rotation of the first unison ring 306 and the second unison ring 316 causes the respective variable stator vanes attached to each unison ring by the respective levers 314 to rotate. Accordingly, the angle of the variable stator vanes may be adjusted with the variable stator vanes control mechanism 300. One will appreciate that one or more additional unison rings may be in communication with the torque shaft by one or more respective turnbuckles.

**[0029]** In certain embodiments, the moveable actuator rod 302 may be at least partially secured to the casing 310 of the compressor. One will appreciate, however, that the moveable actuator rod 302 may be at least partially secured at any location on or about the gas turbine engine. Moreover, the torque shaft 304 may be rotatably supported about the casing 310 of the compressor by a support structure 320. The support structure 320 may be any configuration that facilitates the rotation of the torque shaft about the compressor casing 310.

**[0030]** Figs. 9 and 10 depict an embodiment of a variable stator vanes control mechanism 400. The variable stator vanes control mechanism 400 enables the actuation of two variable stator vanes stages using only one actuator and a system of gears. The actuator engages the gear system which engages the two stages of variable stator vanes thereby adjusting the variable stator vanes.

**[0031]** The variable stator vanes control mechanism 400 may include a moveable actuation rod 402. The moveable actuation rod 402 may be attached to the casing 404 or any other location on or about the gas turbine engine. The moveable actuation rod 402 may also be attached to a gear ring 406. The gear ring 406 may be disposed about the compressor casing 404 such that the gear ring 406 rotates about the compressor casing 404 when actuated by the moveable actuation rod 402. A rub block 408 may be disposed between the casing 404 and the gear ring 406 to facilitate smooth rotation of the gear ring 406 about the casing 404.

**[0032]** A number of variable stator vanes 410 may be disposed on a first side 412 and a second side 414 of the gear ring 406. The variable stator vanes 410 form a first compressor stage and a second compressor stage respectively on each side of the gear ring 406. The variable stator vanes 410 may include gear stems 416. The gear stems 416 may be in operative communication with the gear ring 406.

**[0033]** In operation, the movable actuation rod 402 is attached to the casing 404 and actuates the gear ring 406 thereby rotating the gear ring 406 about the casing 404. The gear stems 416 of the variable stator vanes 410 are in operative communication with the gear ring 406 such that as the gear ring 406 rotates about the casing 404, the gear stems 416 of the variable stator vanes 410 are rotated. The rotation of the gear stems 416 adjusts the angle of the variable stator vanes 410.

**[0034]** In certain embodiments, the rotation of the variable stator vanes 410 may be controlled by the addition of gears or gear train type mechanisms operatively disposed between the gear stems and the gear ring. For example, as depicted in Figs. 9 and 10, additional gears 418 are operatively disposed between the gear ring 406 and the respective gear stems 416 of the first compressor stage. The addition of additional gears 418 enables the first compressor stage of variable stator vanes and the second compressor stage of variable stator vanes to rotate in the same direction. In contrast, if the gear stems 416 of the variable stator vanes 410 were in direct communication with the gear ring 406, the variable stator vanes 410 would rotate in opposite directions.

**[0035]** One will appreciate that any number of additional gears or gear train type mechanisms may be operatively disposed between the gear ring and the gear stems to facilitate a desired rotation. Moreover, the gear ratio and the number of gear teeth may be adjusted to control the schedule between variable stator vane stages.

**[0036]** Although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that the disclosure is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as illustrative forms of implementing the embodiments.

## Claims

1. A variable stator vanes control mechanism (100) for a gas turbine engine (10), comprising:

   a first unison ring (104);
   a second unison ring (116);
   a moveable actuation rod (102) in operative communication with the first unison ring (104) such that movement of the actuation rod (102) drives the first unison ring (104); and
   a linkage (114) in operative communication with the first unison ring (104) and the second unison ring (116) such that movement of the first unison ring (104) drives the second unison ring (116).

2. The control mechanism of claim 1, wherein the linkage (114) pulls the second unison ring (116).

3. The control mechanism of claim 1, wherein the linkage (114) pushes the second unison ring (116).

4. The control mechanism of any of claims 1 to 3, wherein the linkage (114) comprises a turnbuckle (122,124).

5. The control mechanism of any of claims 1 to 4, wherein the first unison ring (104) is in operative communication with a plurality of variable stator vanes (110).

6. The control mechanism of any of claims 1 to 5, wherein the second unison ring (116) is in operative communication with a plurality of variable stator vanes (110).

7. The control mechanism of any preceding claim, wherein the moveable actuator rod (102) is at least partially secured to a casing (108) of a compressor.

8. The control mechanism of any preceding claim, wherein an angle variation between stages of variable stator vanes (110) is achieved by adjusting lever arm lengths (112).

9. The control mechanism of any preceding claim, further comprising:

   one or more additional unison rings (116); and
   one or more additional linkages (114) in operative communication with the one or more additional unison rings (116) such that movement of the first unison ring (104) drives the one or more additional unison rings (116).

10. A gas turbine engine comprising:

    a compressor having a compressor casing (108); and the variable stator vanes control mechanism of any preceding claim wherein:

    the first unison ring (104) is disposed about the compressor casing (108);
    the second unison ring (116) is disposed about the compressor casing (108);
    and wherein movement of the actuation rod (102) drives the first unison ring (104) about the compressor casing (108); and
    movement of the first unison ring (104) about the compressor casing (108) drives the second unison ring (116) about the compressor casing (108).

11. A method to control variable stator vanes (100) in a gas turbine engine, comprising:

    actuating a moveable actuation rod (102) in operative communication with a first unison ring (104) such that movement of the actuation rod drives (102) the first unison ring (104); and
    driving a linkage (114) in operative communication with the first unison ring (104) and a second unison ring (116) such that movement of the first unison ring (104) drives the second unison ring (116).

12. The method of claim 11, wherein the linkage (114) pulls the second unison ring (116).

13. The method of claim 11, wherein the linkage (114) pushes the second unison ring (116).

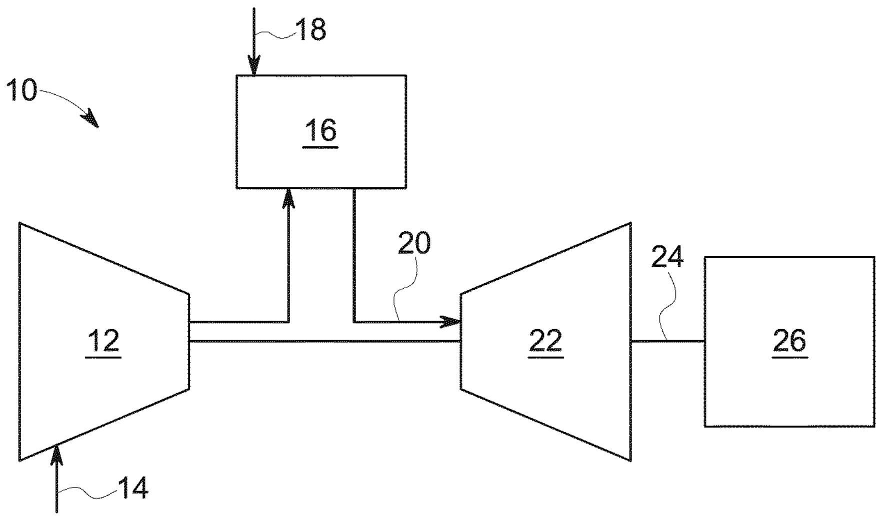


FIG. 1
(PRIOR ART)

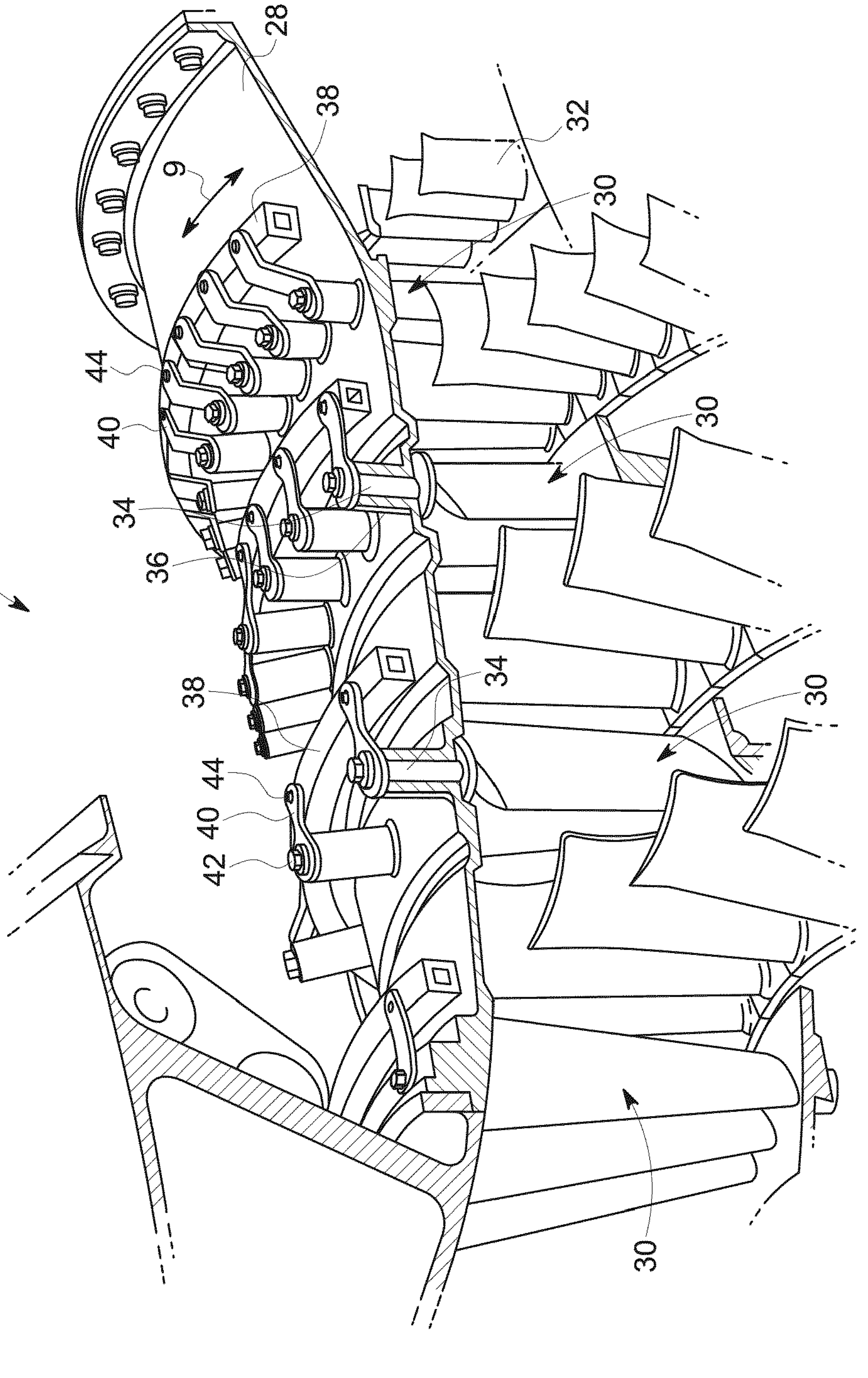


FIG. 2
(PRIOR ART)

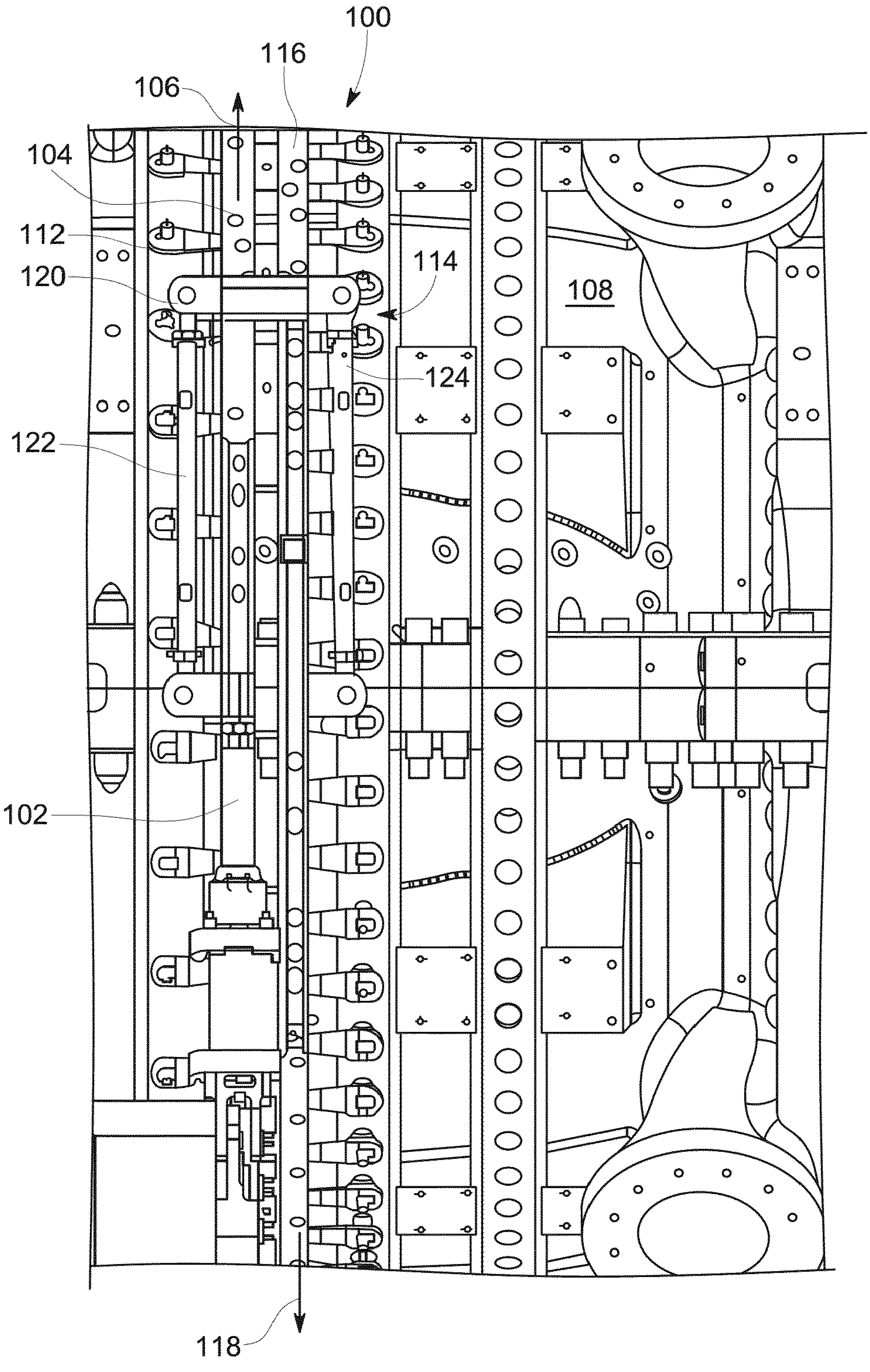


FIG. 3

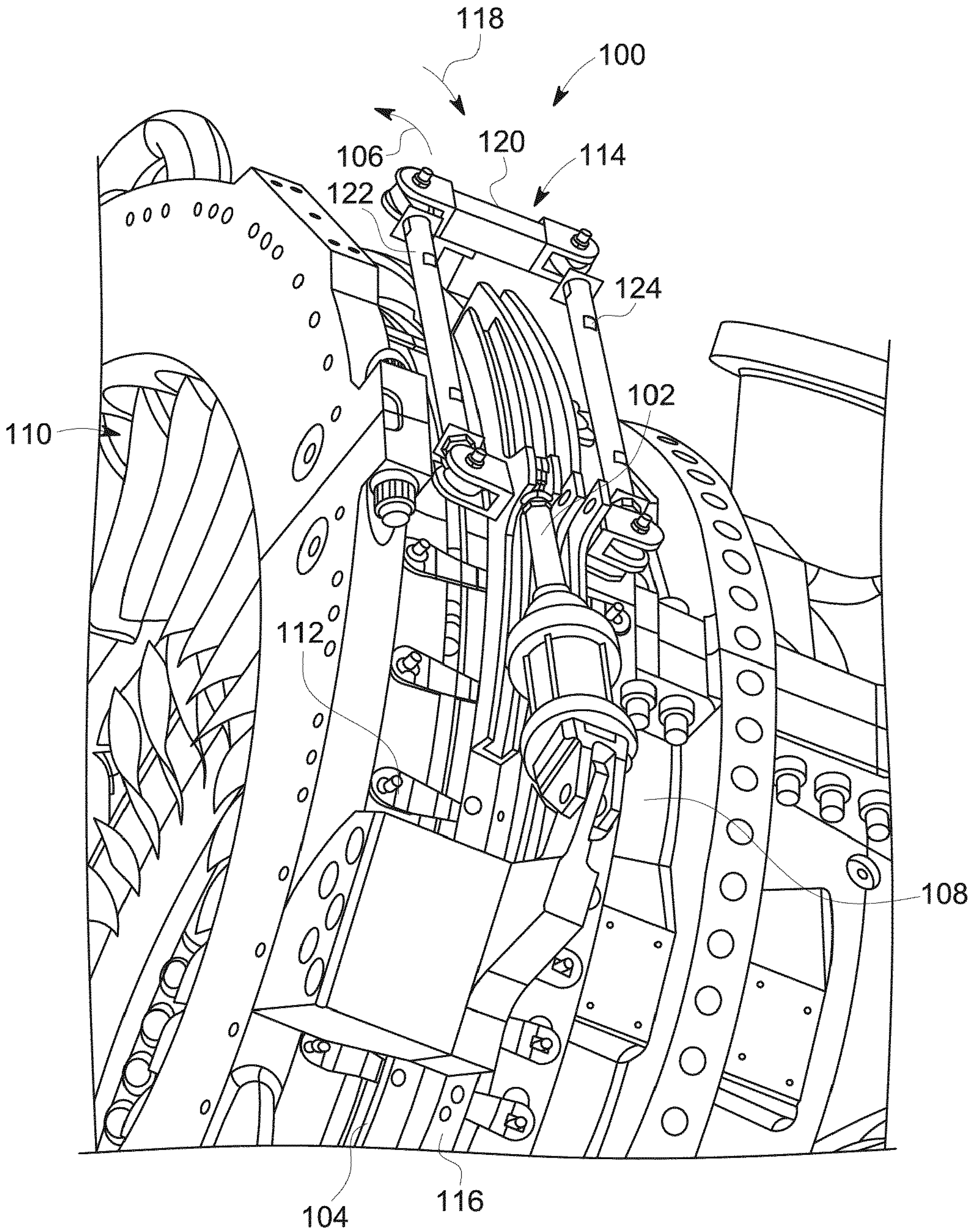


FIG. 4

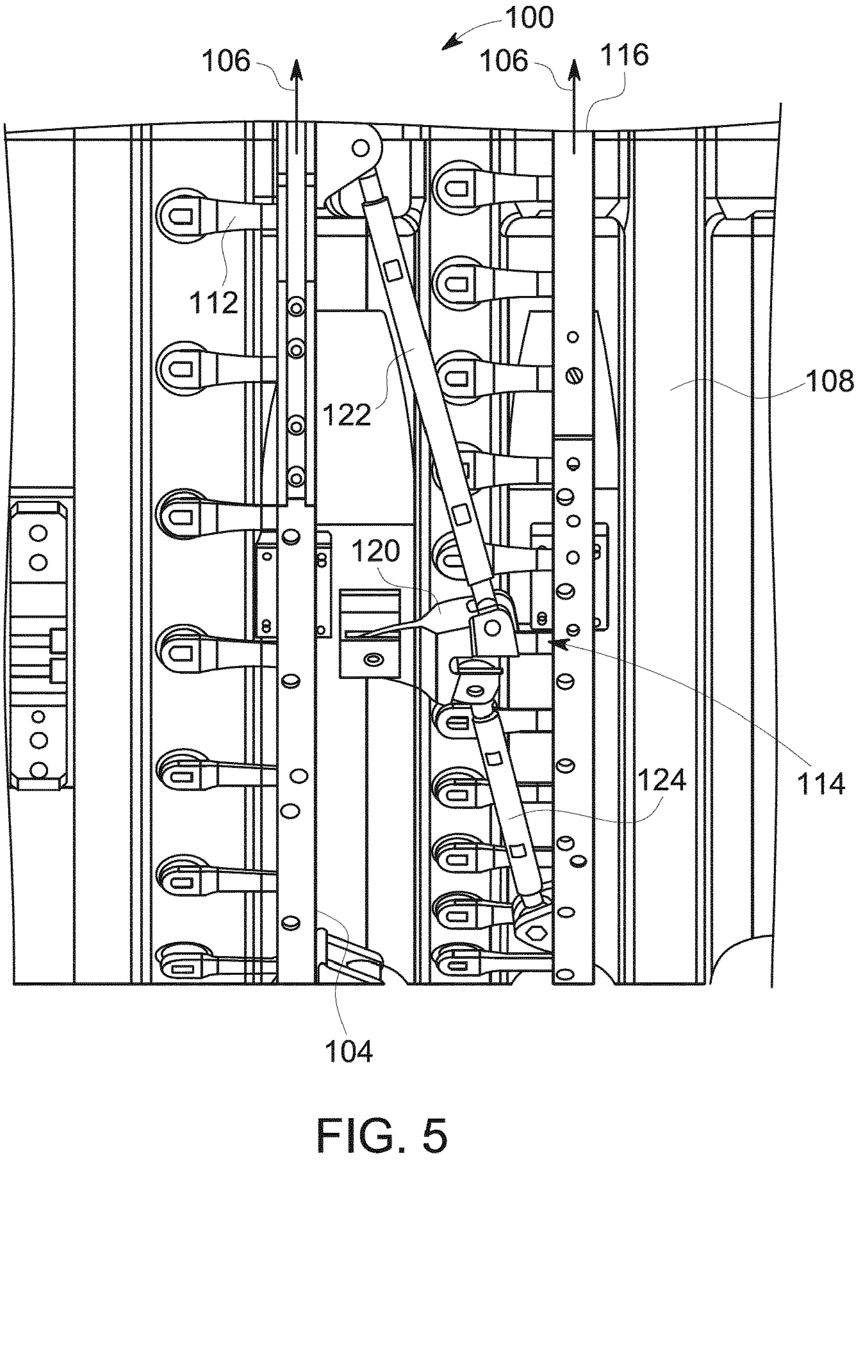


FIG. 5

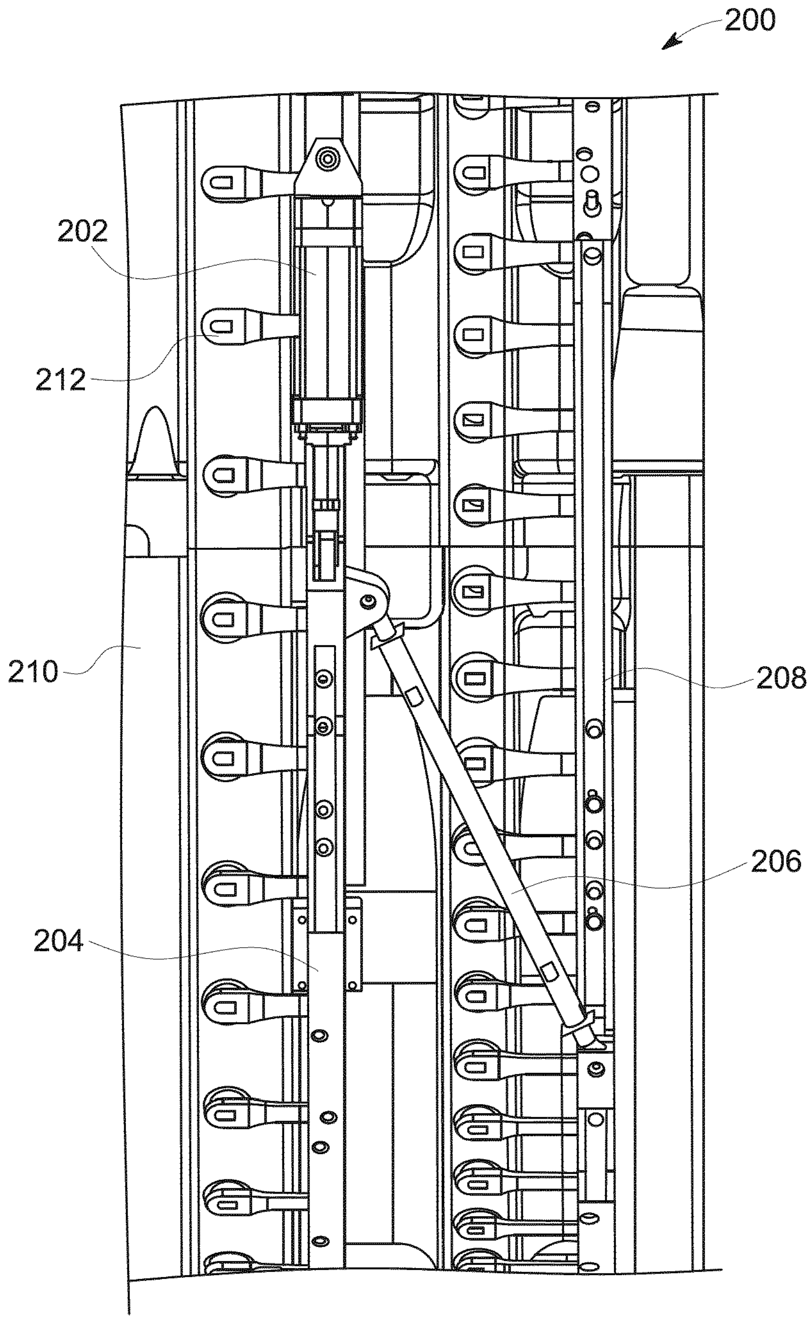


FIG. 6

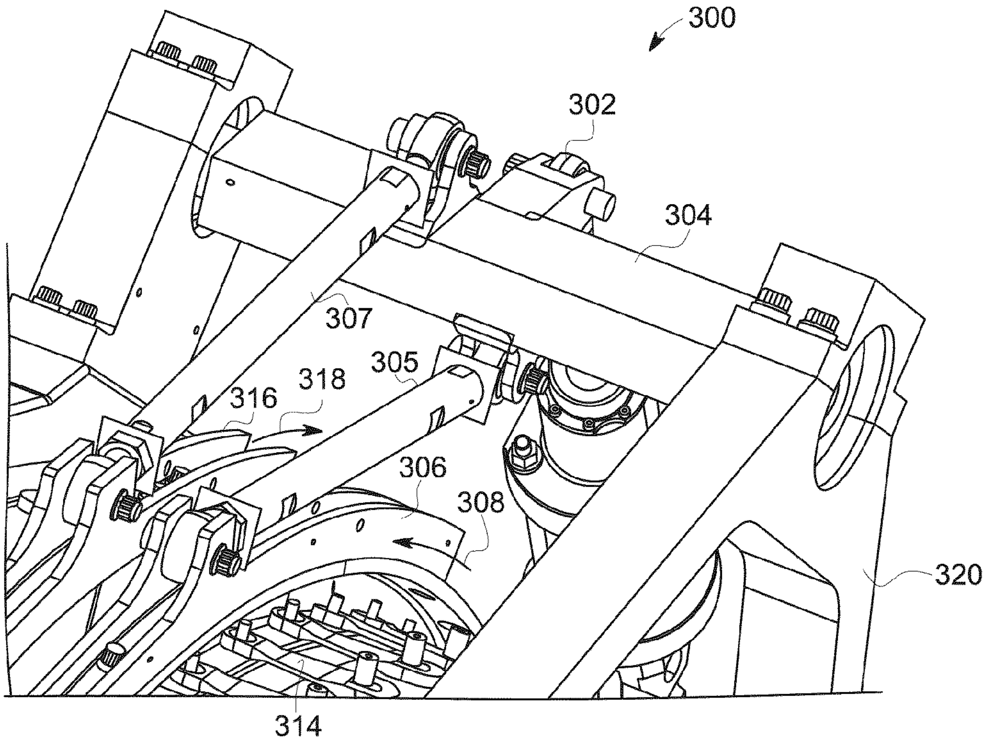


FIG. 7

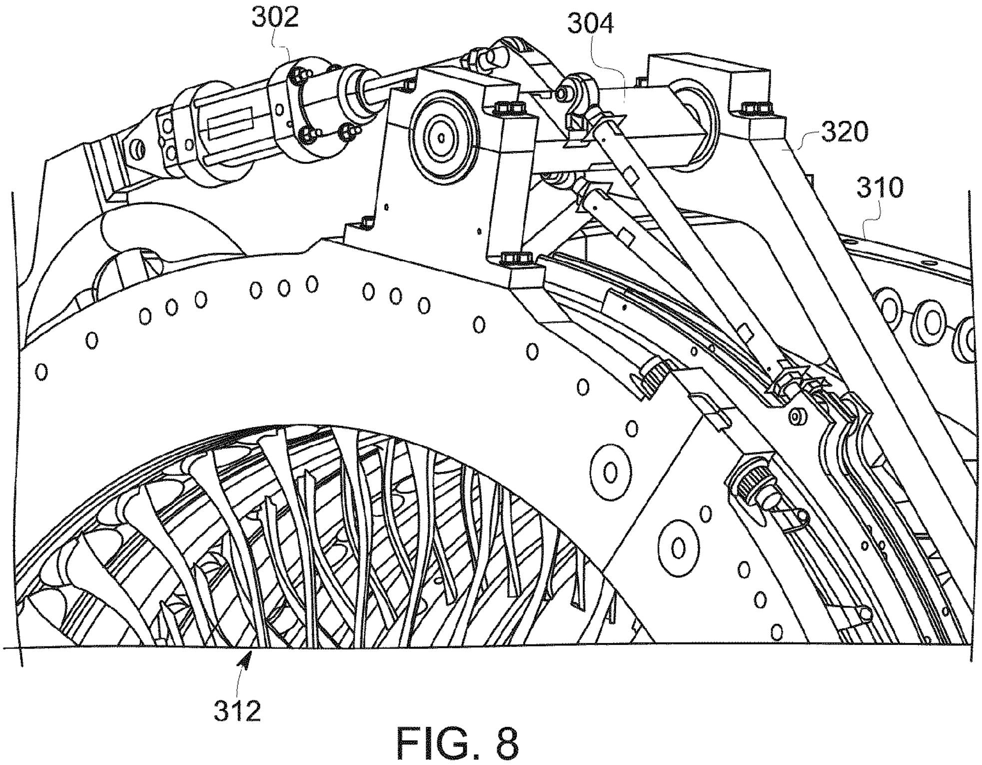


FIG. 8

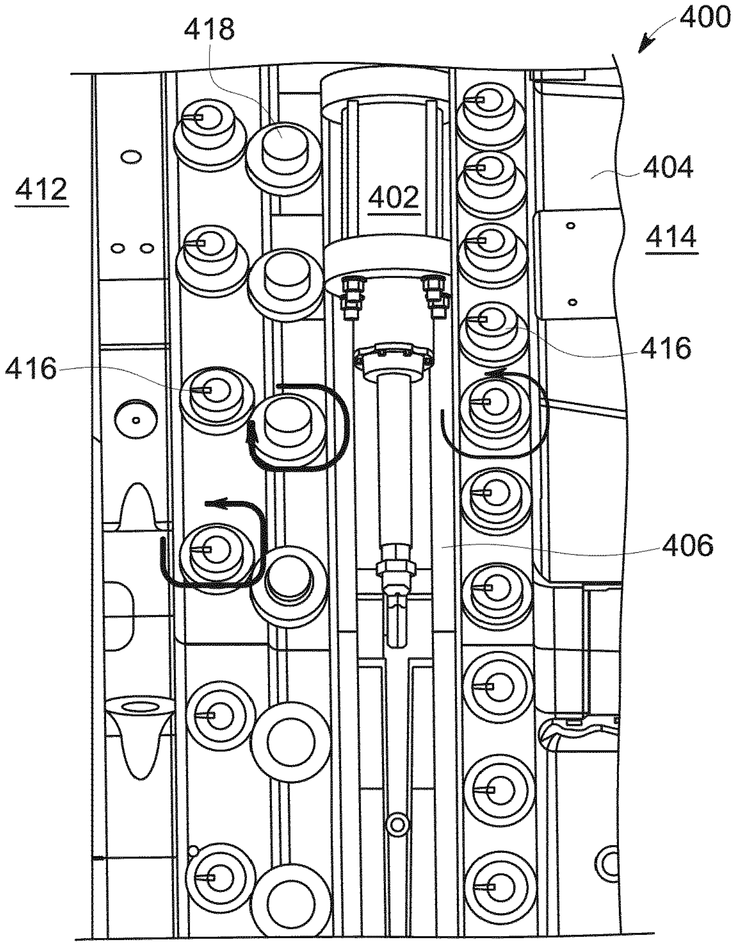
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FIG. 9

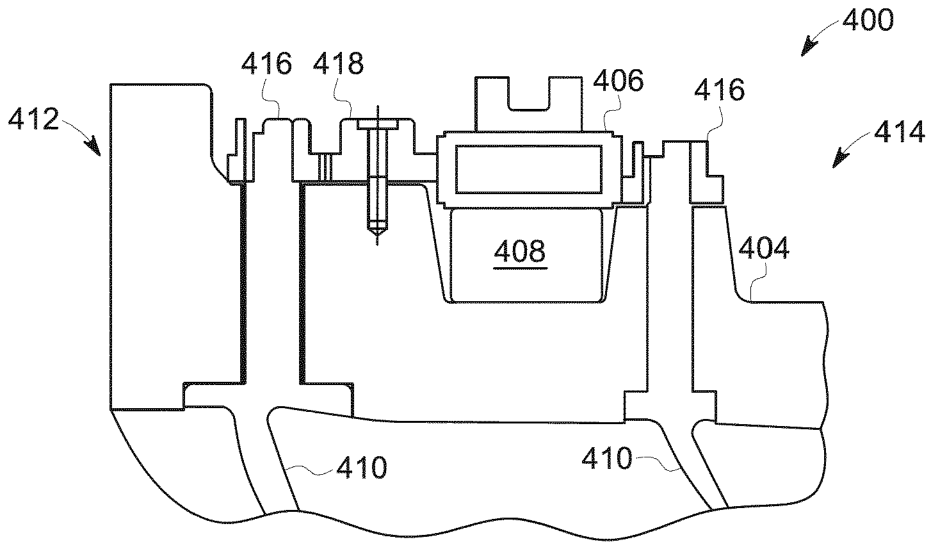
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FIG. 10

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# EUROPEAN SEARCH REPORT

Application Number
EP 13 18 0525

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | EP 1 207 271 A2 (GEN ELECTRIC [US]) 22 May 2002 (2002-05-22) * paragraph [0010] - paragraph [0015] * * paragraph [0019] - paragraph [0025]; claim 1; figures 1-6,15,16 * ----- | 1-13 | INV. F01D17/16 |
| X | EP 1 724 472 A2 (SNECMA [FR]) 22 November 2006 (2006-11-22) * paragraph [0018] - paragraph [0033]; claims 1-3; figures 1-3 * ----- | 1-13 | |
| X | EP 1 724 471 A2 (SNECMA [FR]) 22 November 2006 (2006-11-22) * paragraph [0016] - paragraph [0030]; claims 1,5; figures 1,2 * ----- | 1-13 | |

TECHNICAL FIELDS SEARCHED (IPC)

F01D

The present search report has been drawn up for all claims

1

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 5 November 2013 | Balice, Marco |

CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 18 0525

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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP 1207271 A2 | 22-05-2002 | EP 1207271 A2 | 22-05-2002 |
| | | JP 5148031 B2 | 20-02-2013 |
| | | JP 2002147387 A | 22-05-2002 |
| | | KR 20020036663 A | 16-05-2002 |
| | | US 6457937 B1 | 01-10-2002 |
| EP 1724472 A2 | 22-11-2006 | CA 2547026 A1 | 17-11-2006 |
| | | EP 1724472 A2 | 22-11-2006 |
| | | FR 2885969 A1 | 24-11-2006 |
| | | JP 4773876 B2 | 14-09-2011 |
| | | JP 2006322457 A | 30-11-2006 |
| | | US 2006263206 A1 | 23-11-2006 |
| EP 1724471 A2 | 22-11-2006 | CA 2547025 A1 | 17-11-2006 |
| | | EP 1724471 A2 | 22-11-2006 |
| | | FR 2885968 A1 | 24-11-2006 |
| | | JP 4653013 B2 | 16-03-2011 |
| | | JP 2006322456 A | 30-11-2006 |
| | | US 2006260307 A1 | 23-11-2006 |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82