



**EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**23.10.2013 Bulletin 2013/43**

(51) Int Cl.:  
**F01D 17/16** <sup>(2006.01)</sup> **F04D 29/56** <sup>(2006.01)</sup>

(21) Application number: **13158889.9**

(22) Date of filing: **13.03.2013**

(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**

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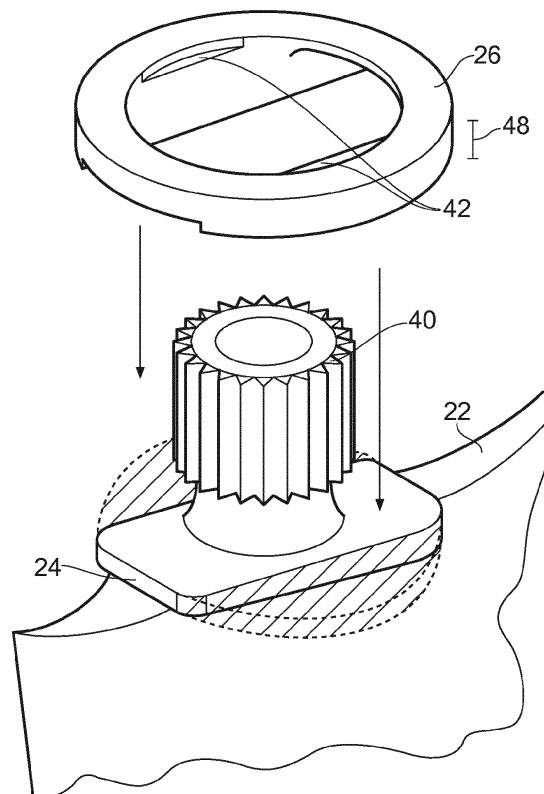
(30) Priority: **16.04.2012 GB 201206603**

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(54) **Variable stator vane arrangement**

(57) A variable guide vane assembly comprising a variable guide vane having an aerofoil and a spindle at one end of the aerofoil; wherein the vane further comprises a platform positioned between the aerofoil and the

spindle, the platform having a surface facing in the direction of the spindle and at least one side face; the assembly also having a washer with an aperture through which the spindle extends, the washer having a portion which overhangs the at least one side face.



**FIG. 3**

## Description

### Technical Field of Invention

[0001] The invention relates to turbine engines and variable guide vanes and / or inlet guide vanes for turbine engines in particular.

### Background of Invention

[0002] In a gas turbine engine having a multi-stage axial compressor the rotor is turned at high speed so that air introduced into the compressor is accelerated by the rotating blades and swept rearwards onto an adjacent row of stator vanes. Each rotor stage increases the pressure of the air passing through the stage and at final stage of the compressor the air is many times that of the inlet air pressure.

[0003] In addition to converting the kinetic energy of the air into pressure the 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 the rotor blades.

[0004] As compressor pressure ratios have increased it has become more difficult to ensure that the compressor will operate efficiently over the operational speed of the engine. This is because the inlet to exit area ratios of the stator vanes required for high pressure operation can result in aerodynamic inefficiency and flow separation at low operational speeds and pressures.

[0005] In applications where high pressure ratios are required from a single compressor spool the above problem can be overcome by using variable stator vanes which permit the angle of one or more rows of stator vanes in a compressor to be adjusted while the engine is running in accordance with the rotational and mass flows of the engine.

[0006] Existing designs for variable inlet guide vanes typically incorporate an integral outer platform which provides for an interface between the aerofoil and also that of the outer spindle. Often known as a "penny", these platforms are round in geometry and positioned within a counterbore incorporated into a suitable casing to provide for a continuous aerodynamic profile at the casing / penny interface as the vane rotates.

[0007] A non metallic thrust washer may be sandwiched between the penny and the inner base surface of the counterbore to prevent metal to metal contact.

[0008] The counterbore must be sufficiently robust to accommodate the penny and platform and not distort in use. With large vanes the size and depth of the counterbore significantly increases the machining time and cost of the casing. Alternative manufacturing methods, such as forging, to form the casing can exhibit high levels of distortion in manufacture.

[0009] It is an object of the present invention to seek to address these and other problems.

## Statements of Invention

[0010] According to a first aspect of the invention there is provided a variable guide vane assembly comprising a variable guide vane having an aerofoil and a spindle at one end of the aerofoil; wherein the vane further comprises a platform having a non-circular plan positioned between the aerofoil and the spindle, the platform having a surface facing in the direction of the spindle and at least one side face; the assembly also having a washer having a circular plan with an aperture through which the spindle extends, the washer having a portion which overhangs the at least one side face. Preferably the washer is supported by the platform surface and portion overhangs one or more of the side faces of the platform. Preferably the plan of the washer is circular. The plan of the platform may be non-circular and may be rectangular, fluted or lobed.

[0011] Advantageously, the washer may be secured to the platform by its positioning between the platform and a further component or by an interference fit between the platform and the washer. Adhesive, or another coating, may be used to further secure the platform with the washer.

[0012] Preferably the washer is formed from plastic. An exemplary plastic is polyimide.

[0013] The washer may be formed from metal having a surface coating.

[0014] The variable guide vane assembly may further comprise a casing having a chamber containing the platform and the washer. Preferably the chamber is stepped from a casing surface wherein a surface of the platform opposing the spindle facing surface is flush with the casing surface.

## Description of Drawings

[0015] Fig. 1 is a schematic of a VIGV and a rotor;

[0016] Fig. 2 is a cross-section of a VIGV mounting arrangement 10;

[0017] Fig. 3 is a partially exploded view of a vane platform and thrust washer;

[0018] Fig. 4 is a top view of a vane platform and thrust washer;

[0019] Fig. 5a to 5d are plan views (5a-5b) and side views (5c-5d) of alternative washer arrangements.

## Detailed Description of Invention

[0020] Figure 1 shows a schematic of a variable inlet guide vane (VIGV) or variable stator vane (VSV) 2 in relation to an associated rotor 4. The VIGV is upstream of the rotor and is rotatable about the axis 6 to change the angle of flow onto the rotor in accordance with the desired operating conditions to improve performance and stability particularly where high pressure ratios are required.

[0021] In the arrangement shown in Figure 1, each in-

dividual vane in a VIGV row is supported by bearings 8, 10 at the radially inner and outer ends of the vane aerofoil section. The bearings permit the VIGV to rotate or pivot about its spanwise axis 12 which is typically radial, or nearly radial, relative to the compressor or engine axis 14. The angular position of the vane is controlled by an actuating lever 16, which is attached to a spigot type extension at the radially outer end of the vane. The actuating lever of each vane in a row is connected to an actuating ring 18, commonly known as a unison ring which rotates about the axis of the engine 14.

**[0022]** Figure 2 depicts the radially outer bearing arrangement 10 in more detail. The vane spindle 20 is integrally formed with the vane aerofoil 22 and has a platform 24 which has at least one side face which engages a thrust washer 26. The thrust washer has a circular outer profile, an inner profile that compliments the profile of the platform, and is positioned within an outwardly stepped chamber 28 in the casing 30 carrying the vane. The radially inner surface of the thrust washer provides, with the inner surface of the casing and the radially inner surface of the platform, a substantially flush continuous aerodynamic profile. The radially outer surface of the thrust washer engages the shoulder 32 of the stepped chamber 28 and provides a bearing surface which prevents direct engagement of the aerofoil platform with the casing.

**[0023]** The actuating lever 16 has a mount which surrounds the vane spindle 20 and has an inner profile which engages the driving teeth 40 on the spindle (Fig. 3). A cylindrical bush 34 separates the outer surface of the actuating lever from the casing whilst permitting the mount to rotate within the casing about the axis 12. A lever retention feature e.g. a nut, screw or other mechanical fastener secures the actuating lever to the spindle.

**[0024]** The thrust washer 26 is shown in more detail in Figure 3. The platform 24 in this embodiment has a rectangular shape with an upper surface supporting the underside of the thrust washer and side walls arranged such that the longer sides of the platform engage with the inside surfaces of the washer. Preferably the washer is formed of a suitably formed plastic such as polyimide or a metal provided with a suitable coating which gives an acceptable interface with the platform and / or the casing which offers a combination of low friction and low wear at all contact points with the platform or casing. The upper surface of the thrust washer may be provided with one or more sections 42 which provide relief for the local overhang of the actuating lever. The washer is carried by the upper surface of the platform 24 which faces the spindle. By facing it is meant that it is the surface from which the spindle protrudes. The surface may be sloped towards the spindle, rather than perpendicular as shown in Figure 3, but it will be appreciated that this increases the depth of the platform in the axial direction and may be undesirable.

**[0025]** A top view of the vane 22, washer 26 and platform 24 is shown in Figure 4 and depicts the profiles of the vane platform and the interior and exterior surface of

the thrust washer.

**[0026]** It will be appreciated that the invention offers a number of advantages. The overhang of the thrust washer, when presented to the platform of the vane, forms a full circular aerodynamic surface at the vane interface with the casing. For large stator vanes in particular the arrangement provides a significant reduction to the time and cost required to machine the vane by virtue of a more efficient utilisation of the aerofoil initial material envelope as machining a platform with a circular cross-section requires significantly more material. By contrast the thrust washer can be made of both cheaper and lighter material which also leads to an overall reduction in the weight of the engine.

**[0027]** The depth of the washer 26 has a significantly lower profile 48 than the conventional combinations of platform and washer. Accordingly, the manufacturing costs of the casing is reduced.

**[0028]** The use of a thrust washer can also reduce the profile of the vane which allows the vane, if forged, to be manufactured from smaller stock which results in reduced manufacturing cost of the aerofoil as less material is used with reduced machining time.

**[0029]** Figure 5a and 5b are top views of alternative washer arrangements. In 5a the washer has a star-shaped feature which engages a complementary star shaped platform. In 5b the washer has a cross-shaped feature which engages a complementary cross shaped platform. Figure 5c is a side view of an embodiment of washer which does not have a portion that engages a spindle facing surface of the platform. The washer relies upon an interference fit and / or an adhesive to secure it in position against the platform. A coating can be provided on the top surface of the washer and platform to prevent damage to the casing by the platform when the vane is assembled thereto. In the embodiment of 5d the washer has a shoulder 52 which prevents the washer from becoming detached from the platform and entering the air flow through the engine. The arrangement of Figure 5d has the advantage of being more robust but is thicker than the arrangement of Figure 5c.

**[0030]** Although aspects of the invention have been described with reference to the embodiments shown in the accompanying drawings it is to be understood that the invention is not limited to those precise embodiments and that various changes and modifications may be effected without further inventive skill and effort. For example, the platform 24 is shown as rectangular but may be any other appropriate shape provided the thrust washer may fit around it.

## Claims

1. A variable guide vane assembly comprising a variable guide vane having an aerofoil (22) and a spindle (20) at one end of the aerofoil; wherein the vane further comprises a platform (24)

having a non-circular plan positioned between the aerofoil and the spindle, the platform having a surface facing in the direction of the spindle and at least one side face;

the assembly also having a washer (26) having a circular plan with an aperture through which the spindle extends, the washer having a portion which overhangs the at least one side face. 5

2. A variable guide vane assembly according to claim 1, wherein the washer is supported by the platform surface. 10
3. A variable guide vane assembly according to claim 1 or claim 2, wherein the plan of the platform is rectangular. 15
4. A variable guide vane assembly according to claim 1 or claim 2, wherein the plan of the platform is fluted. 20
5. A variable guide vane assembly according to any preceding claim, wherein the washer is formed from plastic.
6. A variable guide vane assembly according to claim 5, wherein the washer is formed from polyimide. 25
7. A variable guide vane assembly according to any of claims 1 to 4, wherein the washer is formed from metal having a surface coating. 30
8. A variable guide vane assembly further comprising a casing having a chamber (28) containing the platform and the washer. 35
9. A variable guide vane assembly according to claim 8, wherein the chamber is stepped from a casing surface wherein a surface of the platform opposing the spindle facing surface is flush with the casing surface. 40

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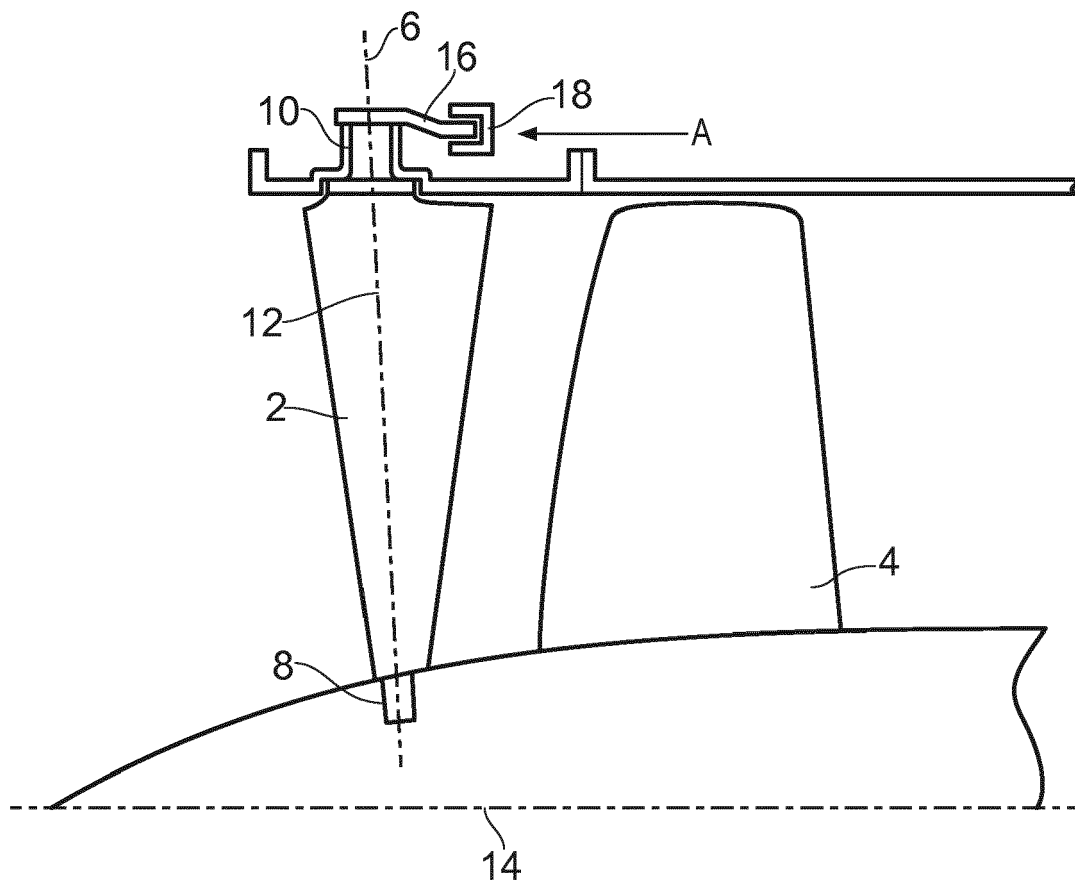


FIG. 1

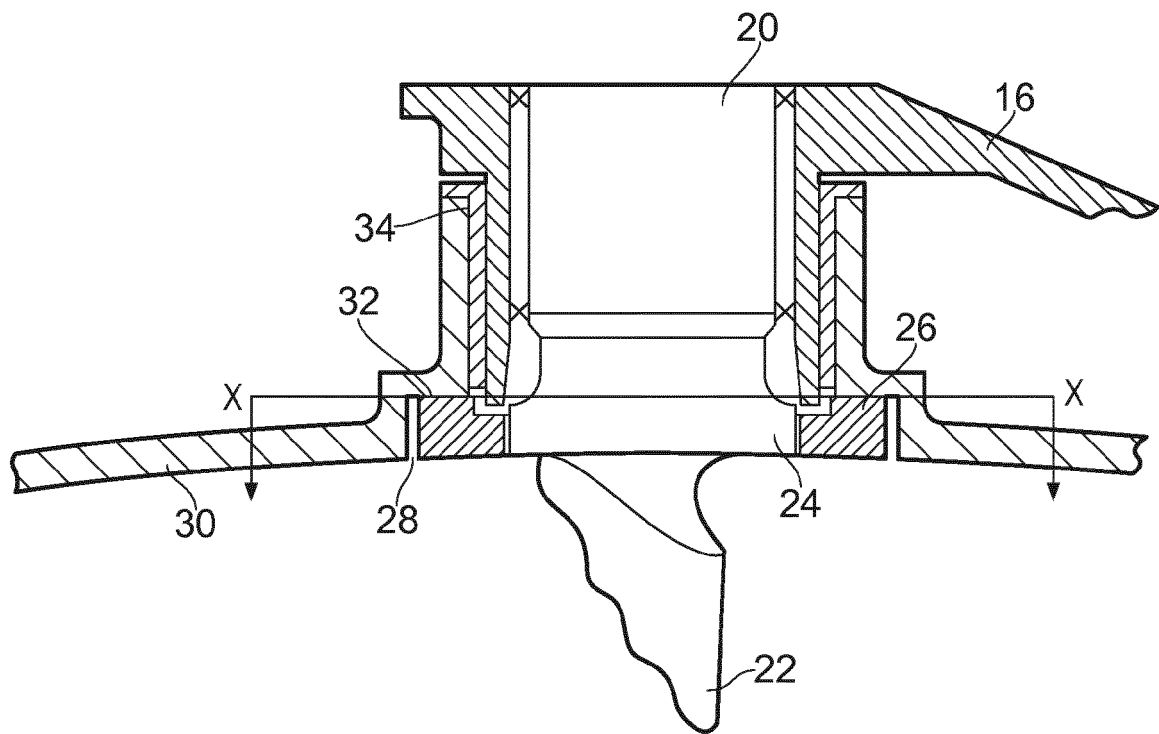


FIG. 2

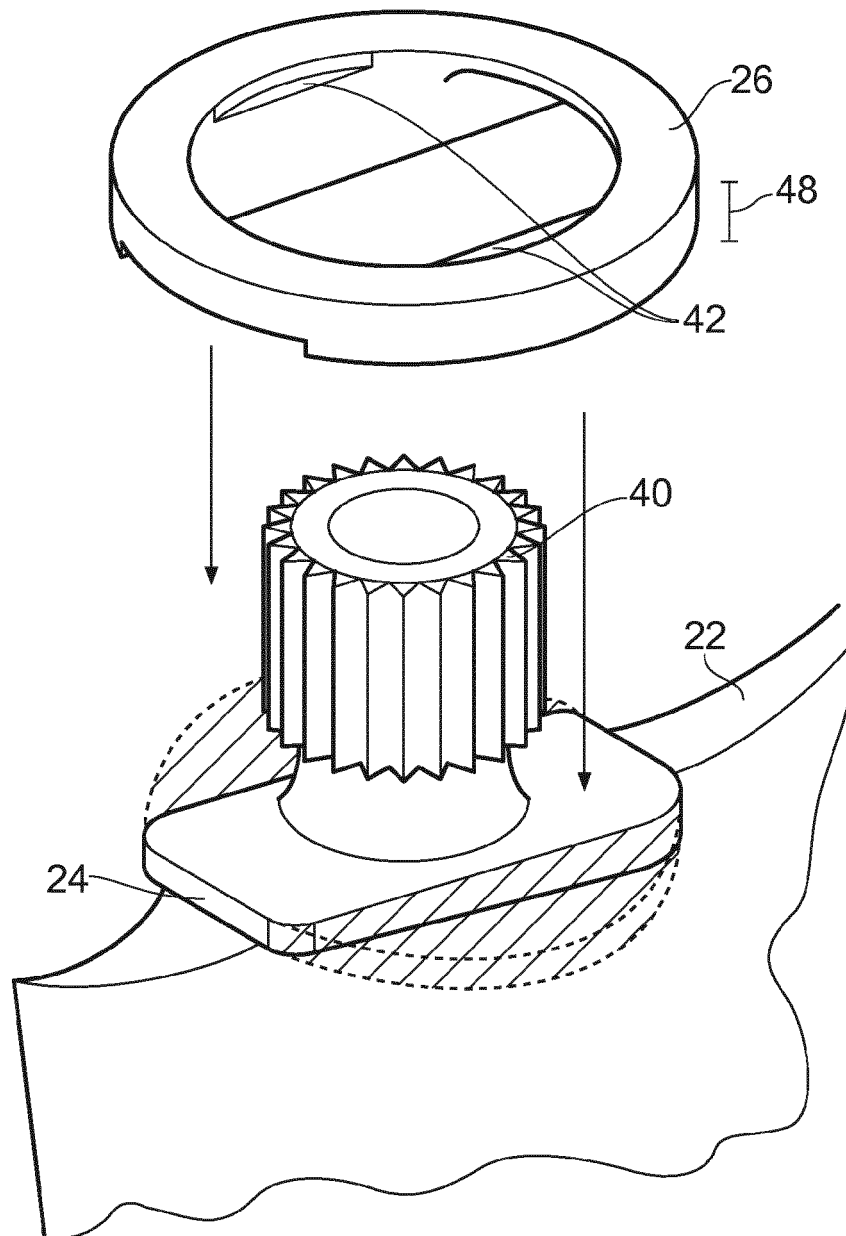


FIG. 3

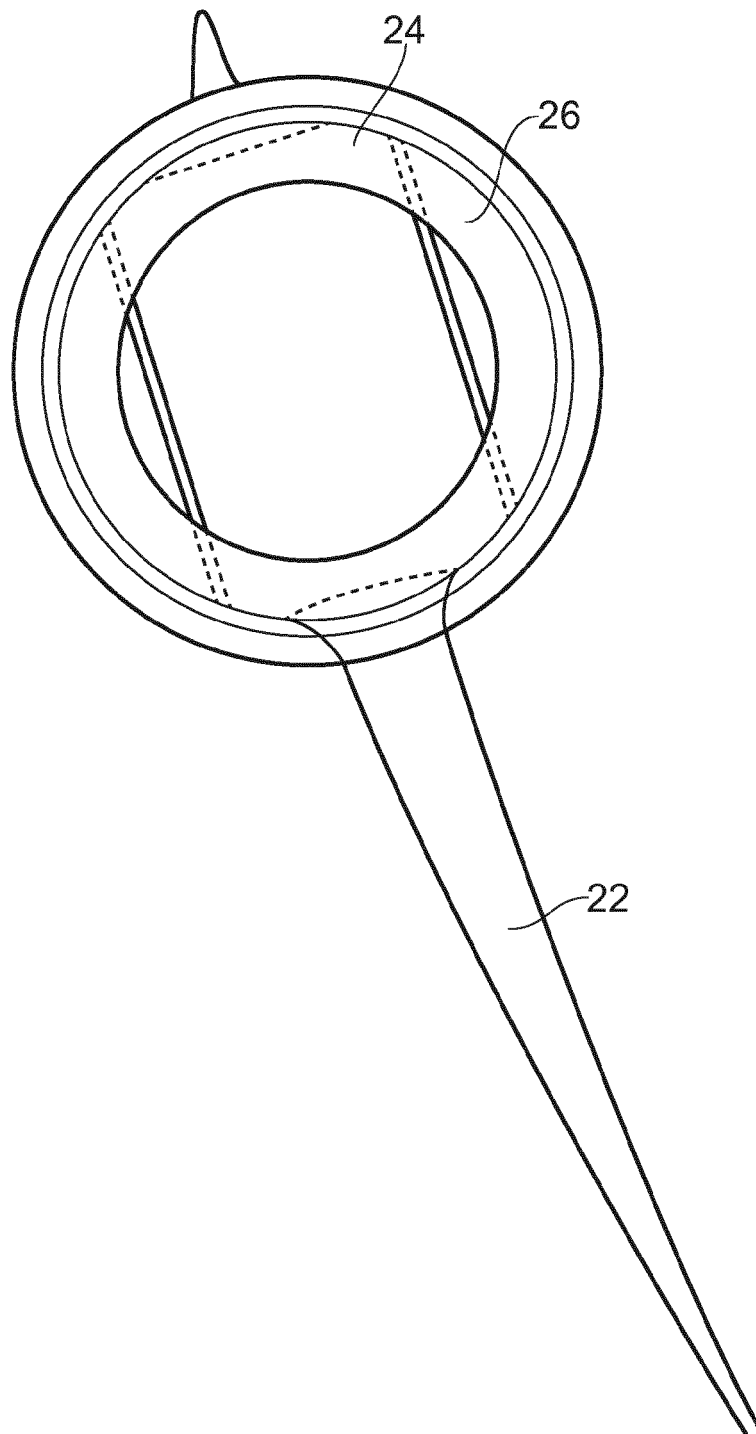


FIG. 4



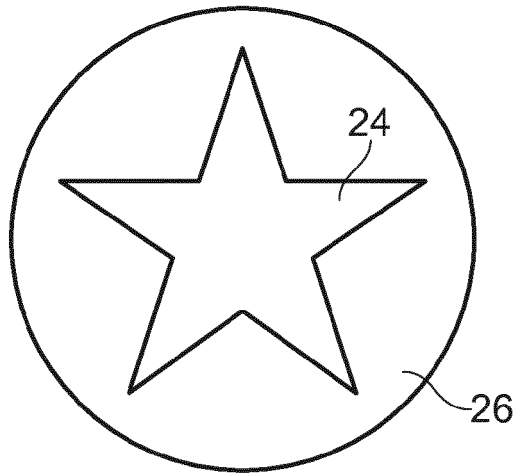


FIG. 5a

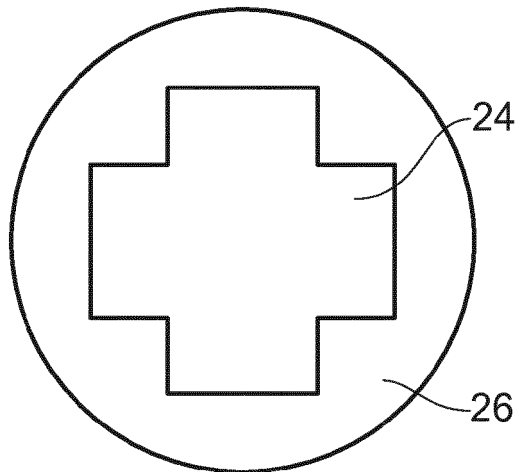


FIG. 5b



FIG. 5c

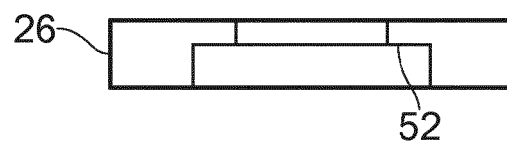


FIG. 5d



## EUROPEAN SEARCH REPORT

Application Number  
EP 13 15 8889

| 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                                                                                                                                                                                                                                                      | US 5 039 277 A (NAUDET JACKY [FR])<br>13 August 1991 (1991-08-13)<br>* the whole document *<br>* column 2, lines 26-56 *<br>* column 3, lines 13-40 *<br>* figures 3,4,6 *        | 1-9                                                                                                                                                                                                                                                                          | INV.<br>F01D17/16<br>F04D29/56                  |
| X                                                                                                                                                                                                                                                      | US 2006/245916 A1 (FOUCHER CHRISTELLE [FR]) 2 November 2006 (2006-11-02)<br>* the whole document *<br>* paragraphs [0021], [0022], [0025] - [0029] *<br>* figures 1,4-6,9-11 *    | 1-9                                                                                                                                                                                                                                                                          |                                                 |
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| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                                                                   |                                                                                                                                                                                                                                                                              |                                                 |
| Place of search<br>The Hague                                                                                                                                                                                                                           |                                                                                                                                                                                   | Date of completion of the search<br>26 July 2013                                                                                                                                                                                                                             | Examiner<br>Gombert, Ralf                       |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                                                                   | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                 |

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
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26-07-2013

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