

(19)



(11)

EP 1 520 957 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
23.01.2008 Bulletin 2008/04

(51) Int Cl.:
F01D 5/26 ^(2006.01) **F01D 9/04** ^(2006.01)
F01D 25/24 ^(2006.01)

(21) Application number: **03256262.1**

(22) Date of filing: **03.10.2003**

(54) **Apparatus and method for damping vibrations between a compressor stator vane and a casing of a gas turbine engine**

Apparat und Methode zur Dämpfung von Vibrationen zwischen Kompressorleitschaufeln und dem Gehäuse einer Gasturbine

Dispositif et procédé pour amortir les vibrations entre des aubes turbocompresseur et le boîtier d'une turbine à gaz

(84) Designated Contracting States:
DE FR GB IT

(43) Date of publication of application:
06.04.2005 Bulletin 2005/14

(73) Proprietor: **GENERAL ELECTRIC COMPANY**
Schenectady, NY 12345 (US)

(72) Inventors:
• **Grant, Carl**
Cincinnati,
Ohio 45220 (US)
• **Douglas, David Curr**
Hamilton,
Ohio 45011 (US)

• **Payling, Stephen Rex**
Cincinnati,
Ohio 45244 (US)
• **Vota, James**
Milford,
Ohio 45150 (US)

(74) Representative: **Goode, Ian Roy et al**
London Patent Operation,
General Electric International Inc.,
15 John Adam Street
London WC2N 6LU (GB)

(56) References cited:
EP-A- 1 081 335 **US-A- 4 897 021**
US-A- 5 429 479 **US-A- 5 848 874**

EP 1 520 957 B1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] The present invention relates generally to stator vanes in compressors of a gas turbine engine and, in particular, to the damping of vibrations transmitted to such stator vanes from the case of the engine.

[0002] It has been found that the case of a gas turbine engine vibrates at various modal frequencies during engine operation. These modal vibrations typically have a wide range of mode shapes, as well as different levels of displacements. It will be appreciated that the fixed stator vanes for the low pressure compressor and/or the high pressure compressor of the engine are generally attached to the engine case. This may be accomplished, for example, by sliding the stator vanes into rails supplied on the inner surface of the case or by capturing a flange between a split-line in the case. In both instances, at least some of the vibration energy of the engine case is transmitted to the stator vanes. Since the individual stator vanes and/or the shroud systems for such stator vanes can vibrate at frequency modes which are substantially synchronous with the case modes, the potential for wear damage and/or high cycle fatigue damage is created.

[0003] In order to prevent such potential damage, gas turbine engines in the prior art have employed a variety of solutions. One solution has been to redesign the engine case to remove the potentially damaging modes of vibration. Another solution has been to redesign the stator vanes or the vane/shroud system to remove the vibration modes which are synchronous with the case vibration modes. Damping material and other vibration damping devices have also been added in the shroud/vane tip area to damp the vibrations experienced by such stator vanes, as evidenced in U.S. Patent 4,872,812 to Hendley et al. and U.S. Patent 6,343,912 to Manteiga et al. Still another solution has been to add a mechanical damper spring to the base of the stator vane, as seen in U.S. Patent 5,681,142 to Lewis. None of these solutions, however, has been seen to positively effect a change in the vibrations experienced by the stator vanes from the engine casing.

[0004] US 5, 429,479 describes a stage of vanes where the vanes are embedded in a ring. The stage includes a ferrule concentric with the ring, and may include a plurality of springs that bias blocks against the ferrule.

[0005] Accordingly, it would be desirable for a stator vane assembly to be developed which damps the vibrations from the engine case to the stator vanes of the compressor. It is also desirable for the stator vane assembly to be easily assembled and disassembled to facilitate manufacturing and repair.

[0006] According to a first aspect, the present invention relates to a stator vane assembly as described in claim 1.

[0007] According to a second aspect, the present invention relates to a method for damping vibrations as described in claim 7.

[0008] Embodiments of the invention will now be described, by way of example, with reference to the accom-

panying drawings, in which:

Fig. 1 is a longitudinal cross-sectional view of an exemplary gas turbine engine including a compressor with a stator vane assembly of the present invention;

Fig. 2 is a partial cross-sectional view of a split-line compressor depicted in Fig. 1, where an embodiment of the stator vane assembly according to the present invention is shown;

Fig. 3 is an enlarged cross-sectional view of the stator vane assembly depicted in Fig. 2 including a damping member located in a defined area between the stator vane and the engine casing;

Fig. 4 is an enlarged cross-sectional view of the stator vane assembly depicted in Fig. 2 including an alternative damping member located in a defined area between the stator vane and the engine casing;

Fig. 5 is a partial cross-sectional view of an engine having an alternative casing configuration, where an embodiment of the stator vane assembly according to the present invention is shown;

Fig. 6 is an enlarged cross-sectional view of the stator vane assembly depicted in Fig. 5 including a damping member located in a defined area between the stator vane and the engine casing; and,

Fig. 7 is an enlarged perspective view of the damping member depicted in Figs. 3 and 6.

[0009] Referring now to the drawings in detail, wherein identical numerals indicate the same elements throughout the figures, Fig. 1 depicts an exemplary gas turbine engine identified generally by reference numeral 10. Gas turbine engine 10 is typically utilized in marine and industrial applications, and includes in serial arrangement a low pressure compressor 12, a high pressure compressor 14, a booster compressor 13, a combustor 16, a high pressure turbine 18 and a low pressure turbine 20. It will be seen that a first shaft 22 connects high pressure turbine 18 and high pressure compressor 14 while a second shaft 24 connects low pressure turbine 20 and low pressure compressor 12. A longitudinal axis 25 is provided in Fig. 1 for reference purposes.

[0010] As seen in Fig. 2, gas turbine engine 10 includes a casing 26 which has a split-line configuration at an axial position adjacent high pressure compressor 14. This is evident from a first circumferential flange 28 and a second circumferential flange 30 being connected in abutting relation with a plurality of circumferentially spaced pins 32 or other similar devices connecting such flanges. It will be noted that a particular stage of stator vanes for high pressure compressor 14 (one stator vane 34 being shown) is positioned immediately downstream of the

split-line in casing 26. Due to its proximity to flanges 28 and 30, stator vanes 34 may be more susceptible to the vibrations of casing 26. Such casing vibrations, as explained hereinabove, have a wide range of mode shapes with different levels of displacement. In order to lessen the effect such casing vibrations have on stator vanes 34, a damping member 36 is preferably positioned within an area 38 defined between an outer portion 40 of each stator vane 34 and casing 26.

[0011] More specifically, it will be seen from Figs. 2 and 3 that a tang 41 of an inner portion 42 of each stator vane 34 is retained within a bushing 44 located in a shroud 45, as is known in the art. Outer portion 40 of each stator vane 34 is attached to a platform 47 which is retained by casing 26, where outer platform 47 preferably includes a first or downstream end 46 having a substantially L-shaped design which is sized to fit within a corresponding slot 48 in casing 26. A second or upstream end 50 of each outer platform 47 preferably is a flange which is configured and sized so as to be inserted between first and second circumferential flanges 28 and 30, respectively, of casing 26 in abutting relation. Each flange 50 also includes at least one opening therethrough so as to permit one or more pins 32 to be inserted therethrough. Each outer platform 47 further includes a middle section 52 connecting upstream end 50 and downstream end 46, where middle section 52 extends substantially parallel to casing 26. Because of the respective configurations for each outer platform 47 and casing 26, it will be appreciated that individual open areas 38 are defined therebetween. In order to dampen vibrations experienced by each outer platform 47 (and therefore each stator vane outer portion 40) from casing 26, a damping member 36 is preferably located within each defined open area 38.

[0012] Damping member 36 is preferably constructed of an elastomeric material which preferably is preformed and cured prior to placement within each defined area 38. It will be appreciated that each damping member 36 may be sized to extend within only a portion of each defined area 38 (see Fig. 3) or within substantially all of defined area 38 (see Fig. 4). It will be understood that the elastomeric material will preferably meet certain pre-defined parameters, including the ability to retain its properties under high temperatures. In particular, the elastomeric material of each damping member 36 will preferably retain its properties in temperatures of at least approximately 300°F, more preferably in temperatures of at least approximately 375°F, and optimally in temperatures of at least approximately 450°F. One example of such elastomeric material is known as red oxide RTV (Room Temperature Vulcanized Rubber) made by GE Plastics of Pittsfield, Massachusetts. Accordingly, damping member 36 is able to provide similar functionality to stator vanes and their platforms positioned within the temperature environments of low compressor 12 and/or booster compressor 13.

[0013] When positioning damping member 36 within a

defined area 38, it is preferred that a layer of adhesive 54 be applied thereto so as to maintain it in position while each stator vane 34 and its platform 47 is connected to casing 26. It will be appreciated that adhesive layer 54 may dissolve or burn off once gas turbine engine 10 is in operation, whereby damping member 36 will be either frictionally engaged in defined area 38 or permitted to float therein. As seen in Fig. 7, damping member 36 in a preformed and cured state is shown to be substantially rectangular in shape, although any shape and size may be utilized provided it performs the desired damping function between casing 26 and stator vanes 34. Likewise, a plurality of grooves 56 is preferably formed in damping member 36 in order to provide better flexibility and assembly (see Fig. 7). Orientation of damping member 36 and grooves 56 within each defined area 38, however, is not deemed to be limiting upon the present invention.

[0014] An alternate configuration for the stator vane assembly is depicted in Figs. 5 and 6, where a casing 58 thereof is continuous in an axial direction but has a pair of flanges 60 and 62 which are connected in a clam shell design at opposite radial ends (only one of which is shown). This casing configuration further provides a plurality of spaced rail members 64 along an inner surface thereof into which a plurality of stator vanes 66 are inserted and retained prior to assembly of casing 58. It will also be appreciated that an open area 68 is accordingly defined between casing 58 and an outer platform 70 for each stator vane 66. Each outer platform 70 further includes a pair of end members 71 and 73 which are received within corresponding pockets 75 and 77 of rail member 64. A damping member 72 like that discussed above is preferably positioned within each defined area 68 so as to damp the vibrations experienced by outer platforms 70 and stator vanes 66 from casing 58. Of course, such damping member 72 will preferably be of a size and shape so as to fit within open area 68 and perform its intended function.

[0015] Because access to defined areas 68 between casing 58 and each stator vane outer portion 70 is not as simple as for the stage of stator vanes 34 in the split-line casing 26 previously described, it will be appreciated that elastomeric material may alternatively be squeezed into such areas 68, or "in situ," where it is able to cure in place and perform as damping member 72. By providing the elastomeric material in this manner, damping members 72 are able to be more closely sized to open areas 68. This method may also be utilized with split-line casing 26, as seen in Fig. 4.

[0016] It will be appreciated that damping members 36 and 72 preferably reduce the vibrations experienced by outer platforms 47 and 70 from casings 26 and 58, respectively, by at least approximately 10%. More preferably, damping members 36 and 72 are able to damp the vibrations from casings 26 and 58 by at least approximately 20% and optimally by at least approximately 30%.

[0017] It will further be appreciated that a method of damping vibrations from casing 26 to stator vanes 34 is

presented. More specifically, such method includes the steps of positioning outer platforms 47 of stator vanes 34 with respect to casing 26 so as to define an open area 38 therebetween, providing damping member 36 made of an elastomeric material within such defined open areas 38 of casing 26, and securing damping members 36 therein. Thereafter, stator vanes 34 are attached to casing 26 so that outer platforms 47 are retained adjacent to damping members 36 and vibrations from casing 26 are dampened. Prior to such steps, damping members 36 are preferably preformed and cured, including grooves 56 formed therein, and adhesive layer 54 applied to a surface thereof. Outer platforms 47 are attached to casing 26 and maintained in position by means of flanges 50 which extend therefrom and are positioned between opposite flanges 28 and 30 of casing 26.

[0018] An alternative method of damping vibrations from casing 58 to stator vanes 68 is also demonstrated. This method includes the steps of positioning outer platforms 70 of stator vanes 66 in rail members 64 incorporated into casing 58 so as to define open areas 68 therebetween and providing damping members 72 made of an elastomeric material within each such defined open area 68. Further, damping members 72 may be squeezed into each defined area 68 and permitted to cure.

[0019] Having shown and described the preferred embodiment of the present invention, further adaptations of the stator vane assembly and damping member 36 thereof can be accomplished by appropriate modifications by one of ordinary skill in the art without departing from the scope of the invention. In particular, while damping member 36 is illustrated as being used in a stator vane of high pressure compressor 14 for gas turbine engine 10, it may be utilized with any fixed or stator vane of any compressor. Further, the present invention may be utilized with engine casings have other configurations than that disclosed herein.

Claims

1. A stator vane assembly for a compressor (14) of a gas turbine engine (10), comprising:

- (a) a stator vane (34/66) having an inner portion (42) and an outer portion (40);
- (b) a platform (47/70) attached to said outer portion (40) of said stator vane (34/66);
- (c) a casing (26/58) for said gas turbine engine (10), wherein said outer platform (47/70) of said stator vane (34/66) is attached to said casing (26/58) in a manner so that an open area (38/68) is defined therebetween; and
- (d) a member (36/72) positioned within said defined open area (38/68) for damping vibrations transmitted from said casing (26/58) to said outer platform (47/70), **characterised in that:**

said damping member (36/72) is constructed of an elastomeric material.

2. The stator vane assembly of claim 1, wherein said damping member (36/72) comprises red oxide room temperature vulcanized rubber (RTV).
3. The stator vane assembly of claim 1, wherein said damping member (36/72) is retained within said defined area (38/68) by an adhesive layer (54).
4. The stator vane assembly of claim 1, wherein said damping member (36/72) is preformed and cured prior to placement within said defined area (38/68).
5. The stator vane assembly of claim 1, wherein said damping member (36/72) includes a plurality of grooves (56) formed in a surface thereof.
6. The stator vane assembly of claim 1, wherein said casing (26) has a split-line configuration so that first and second circumferential flanges (28,30) are mated together, said outer platform (47) further comprising a flange (50) located between said first and second circumferential flanges (28,30) of said casing (26).
7. A method of damping vibrations from an engine casing (26/58) to a stator vane (34/66) of a compressor (14) connected to said casing (26/58), comprising the following steps:

- (a) positioning an outer platform (47/70) attached to said stator vane (34/66) with respect to said casing (26/58) so as to define an open area (38/68) therebetween;
- (b) providing a damping member (36/72) within said defined open area (38/68) of said casing (26/58); and,
- (c) attaching said outer platform (47/70) to said casing (26/58),

characterized in that:

said damping member (36/72) is constructed of an elastomeric material.

Patentansprüche

1. Leitschaufelanordnung für einen Verdichter (14) eines Gasturbinenriebwerks (10), umfassend:

- a) eine Leitschaufel (34, 66) mit einem Innenteil (42) und einem Außenteil (40);
- b) eine an dem Außenteil (40) der Leitschaufel (34, 66) angebrachte Plattform (47, 70);
- c) ein Gehäuse (26, 58) für das Gasturbinenriebwerk (10), wobei die Außenplattform (47,

- 70) der Leitschaukel (34, 66) an dem Gehäuse (26, 58) derart befestigt ist, dass ein offener Bereich (38, 68) zwischen ihnen definiert wird, und d) ein in dem offenen Bereich (38, 68) positioniertes Bauteil (36, 72) zur Dämpfung von Schwingungen, die von dem Gehäuse (26, 58) zu der Außenplattform (47, 70) übertragen werden, **dadurch gekennzeichnet, dass** das Dämpfungsbauteil (36, 72) aus einem Elastomermaterial hergestellt ist.
2. Leitschaukelanordnung nach Anspruch 1, wobei das Dämpfungsbauteil (36, 72) bei Zimmertemperatur vulkanisierten Rotoxid-Gummi enthält.
 3. Leitschaukelanordnung nach Anspruch 1, wobei das Dämpfungsbauteil (36, 72) in dem oben erwähnten definierten Bereich (38, 68) durch eine Klebeschicht (54) gehalten wird.
 4. Leitschaukelanordnung nach Anspruch 1, wobei das Dämpfungsbauteil (36, 72) vor seiner Platzierung in dem genannten Bereich (38, 68) vorgeformt und nachbehandelt wird.
 5. Leitschaukelanordnung nach Anspruch 1, wobei das Dämpfungsbauteil (36, 72) eine Anzahl von in einer seiner Oberflächen ausgebildeten Nuten (56) aufweist.
 6. Leitschaukelanordnung nach Anspruch 1, wobei das Gehäuse (26) zweiteilig gestaltet ist, so dass ein erster und ein zweiter sich in Umfangsrichtung erstreckender Flansch (28, 30) miteinander verbunden werden und die Außenplattform (47) ferner einen Flansch (50) aufweist, der zwischen dem ersten und zweiten sich in Umfangsrichtung erstreckenden Flansch (28, 30) des Gehäuses (26) angeordnet ist.
 7. Verfahren zur Dämpfung der Schwingungen eines Triebwerksgehäuses (26, 58), die zu einer mit diesem Gehäuse (26, 58) verbundenen Leitschaukel (34, 66) eines Verdichters (14) übertragen werden, die folgenden Verfahrensschritte umfassend:
 - a) Positionierung einer an der Leitschaukel (34, 66) befestigten Außenplattform (47, 70) mit Bezug auf das Gehäuse (26, 58), um einen offenen Bereich (38, 68) zwischen beiden zu definieren.
 - b) Bereitstellen eines Dämpfungsbauteils (36, 72) in dem definierten offenen Bereich (38, 68) des Gehäuses (26, 58) und
 - c) Befestigung der Außenplattform (47, 70) an dem Gehäuse (26, 58), **dadurch gekennzeichnet, dass:**

das Dämpfungsbauteil (36, 72) aus einem Elastomermaterial hergestellt ist.

Revendications

1. Ensemble d'aubes de stator pour un compresseur (14) de moteur à turbine à gaz (10), comprenant :
 - (a) une aube de stator (34/66) ayant une partie intérieure (42) et une partie extérieure (40) ;
 - (b) une plate-forme (47/70) fixée à ladite partie extérieure (40) de ladite aube de stator (34/66) ;
 - (c) un carter (26/58) pour ledit moteur à turbine à gaz (10), dans lequel ladite plate-forme extérieure (47/70) de ladite aube de stator (34/66) est fixée audit carter (26/58) de manière telle qu'une zone ouverte (38/68) est définie entre eux ; et
 - (d) un élément (36/72) positionné dans ladite zone ouverte définie (38/68) pour amortir les vibrations transmises par ledit carter (26/58) à ladite plate-forme extérieure (47/70),

caractérisé en ce que ledit élément amortisseur (36/72) est fait d'un matériau élastomère.
2. Ensemble d'aubes de stator selon la revendication 1, dans lequel ledit élément amortisseur (36/72) comprend du caoutchouc vulcanisé à température ambiante (RTV) à l'oxyde rouge.
3. Ensemble d'aubes de stator selon la revendication 1, dans lequel ledit élément amortisseur (36/72) est retenu dans ladite zone définie (38/68) par une couche adhésive (54).
4. Ensemble d'aubes de stator selon la revendication 1, dans lequel ledit élément amortisseur (36/72) est préformé et durci avant d'être placé dans ladite zone définie (38/68).
5. Ensemble d'aubes de stator selon la revendication 1, dans lequel ledit élément amortisseur (36/72) comprend une pluralité de rainures (56) formées dans une surface de ce dernier.
6. Ensemble d'aubes de stator selon la revendication 1, dans lequel ledit carter (26) a une configuration à ligne de séparation, de sorte que des première et deuxième brides périphériques (28, 30) sont accouplées l'une à l'autre, ladite plate-forme extérieure (47) comprenant en outre une bride (50) située entre lesdites première et deuxième brides périphériques (28, 30) dudit carter (26).
7. Procédé pour amortir les vibrations transmises par un carter de moteur (26/58) à une aube de stator (34/66) d'un compresseur (14) relié audit carter (26/58), comprenant les étapes suivantes :
 - (a) positionner une plate-forme extérieure

(47/70) fixée à ladite aube de stator (34/66) par rapport audit carter (26/58) de manière à définir une zone ouverte (38/68) entre eux ;
(b) placer un élément amortisseur (36/72) dans ladite zone ouverte définie (38/68) dudit carter (26/58) ; et
(c) fixer ladite plate-forme extérieure (47/70) audit carter (26/58),

caractérisé en ce que ledit élément amortisseur (36/72) est fait d'un matériau élastomère.

15

20

25

30

35

40

45

50

55

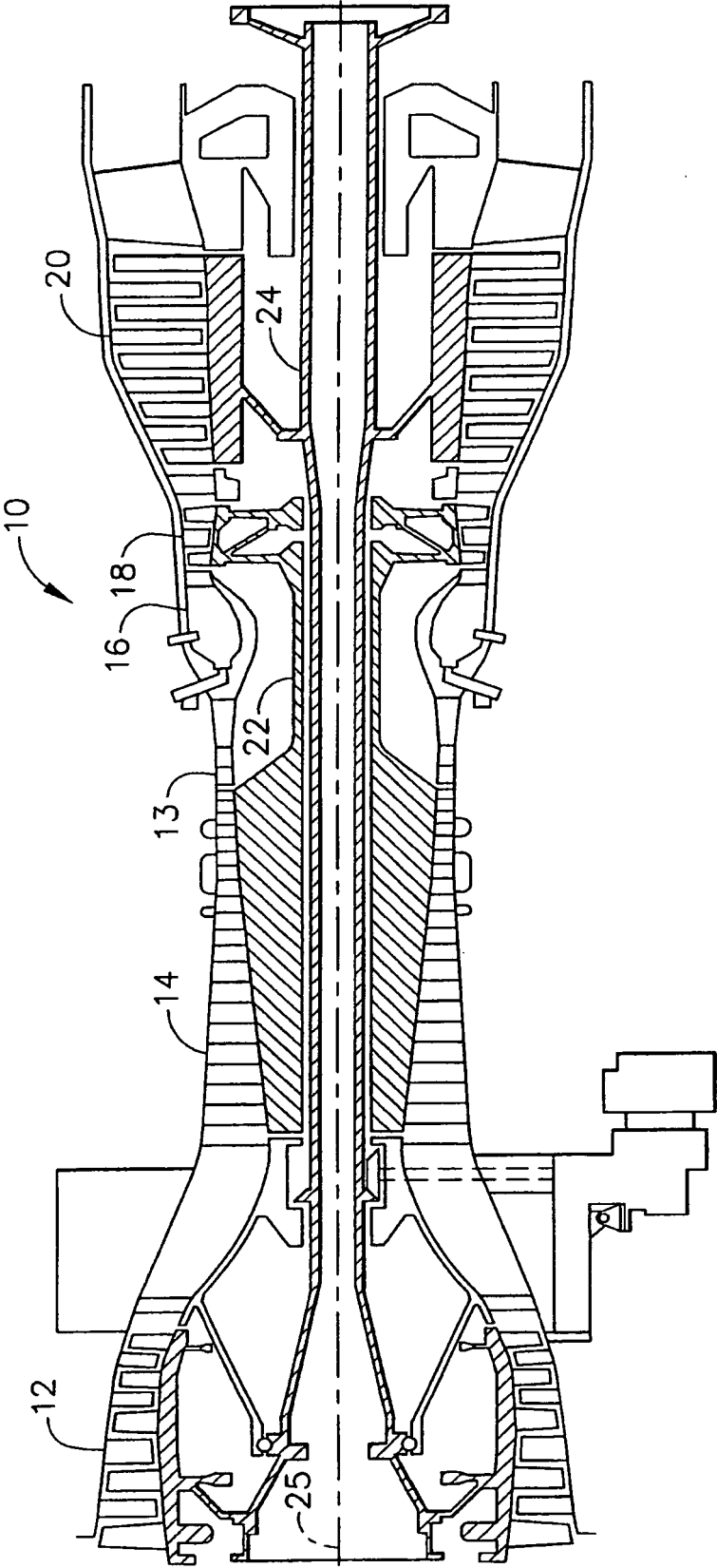


FIG. 1

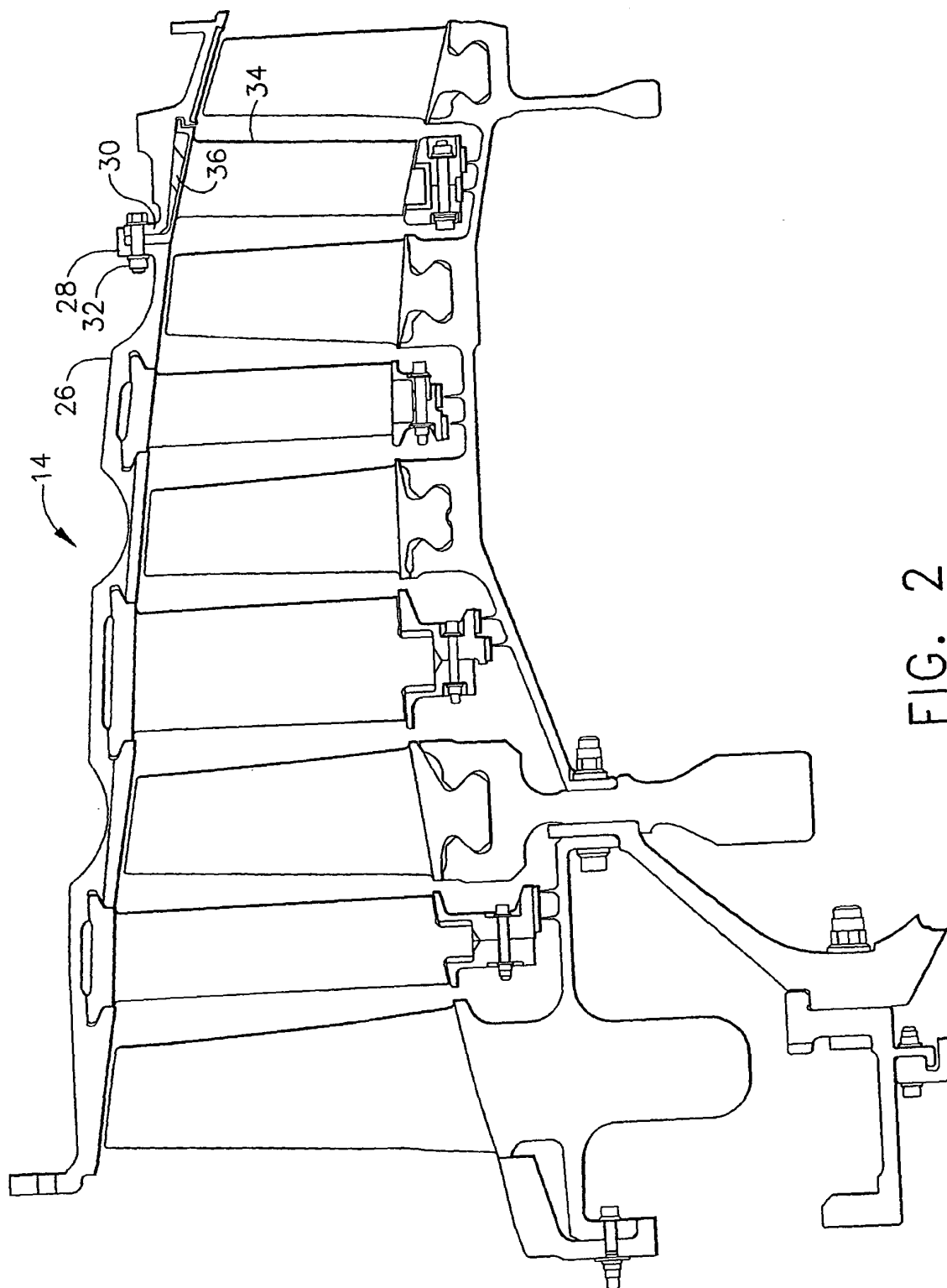
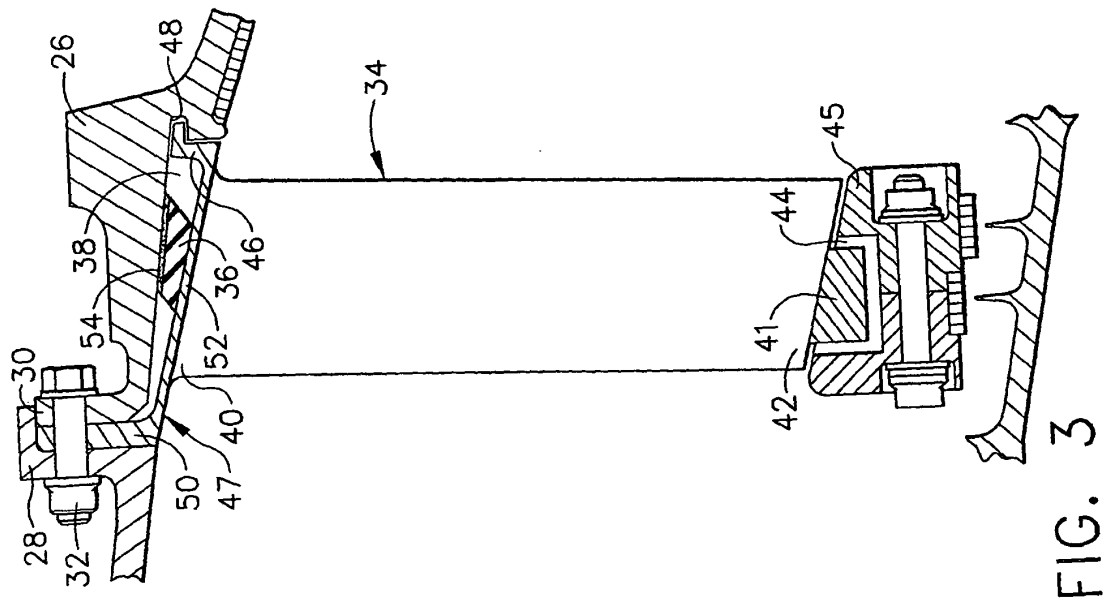
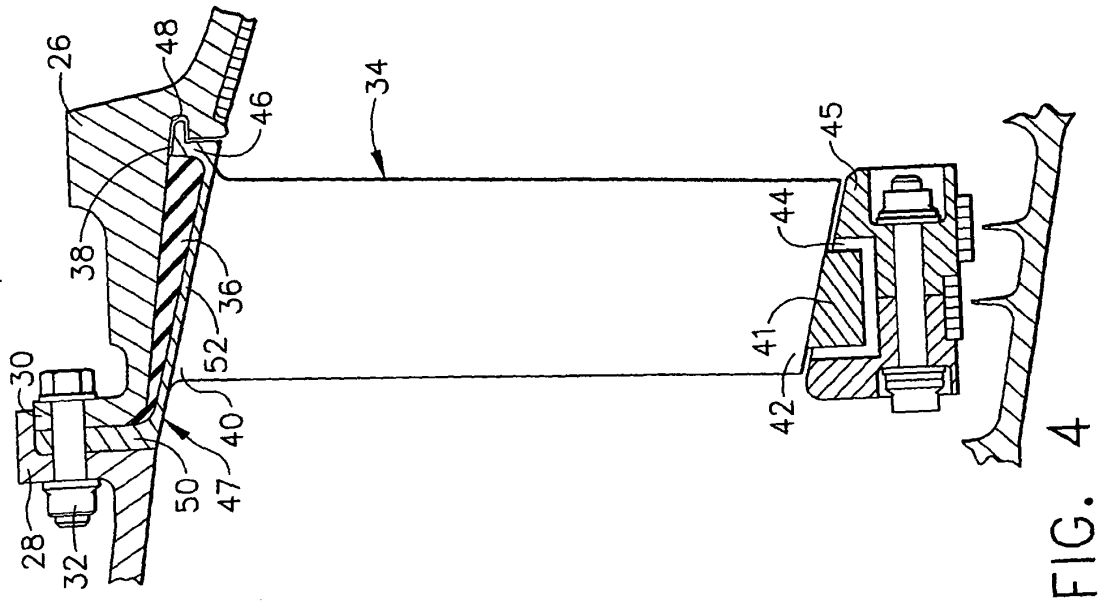


FIG. 2



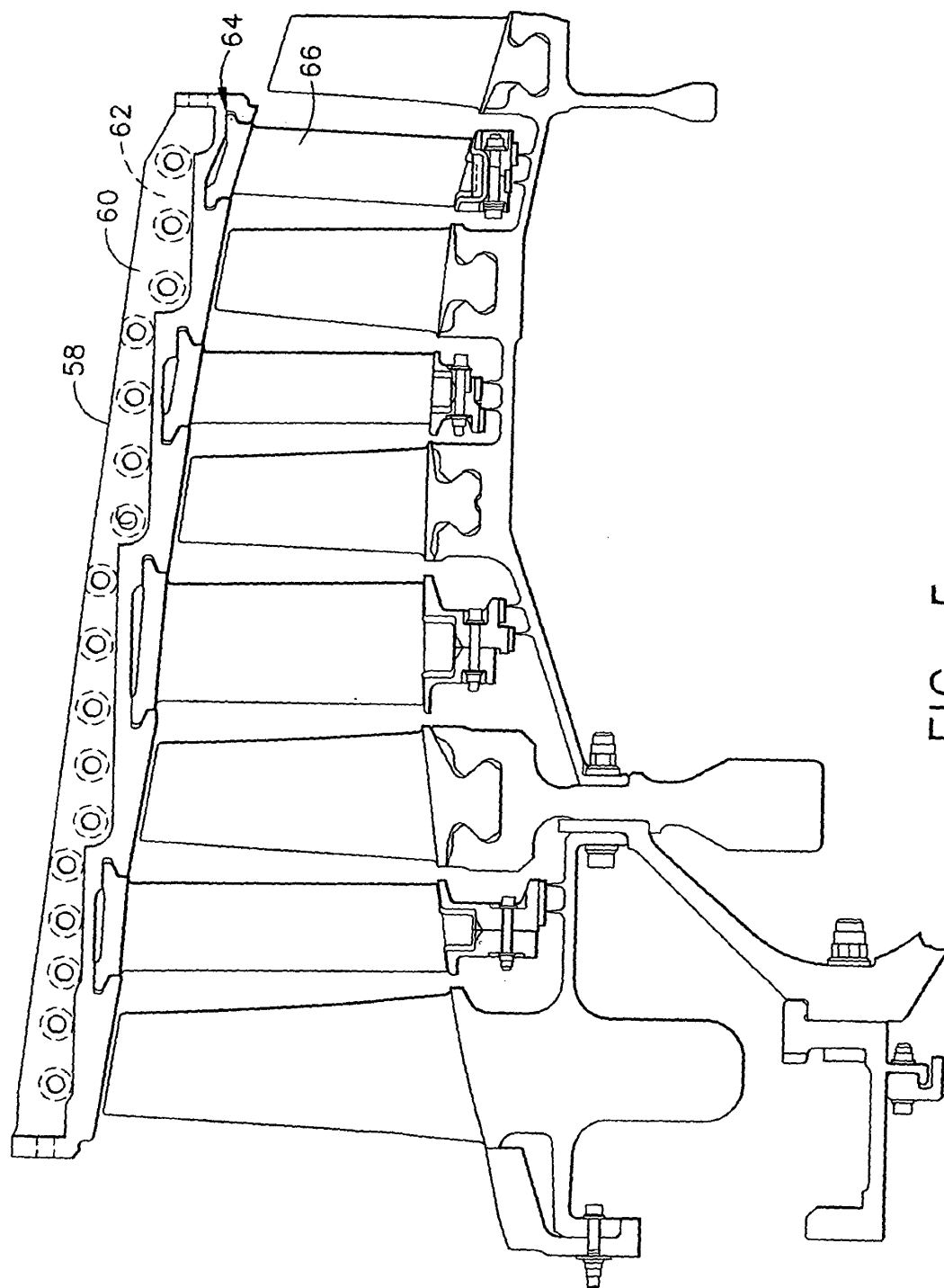


FIG. 5

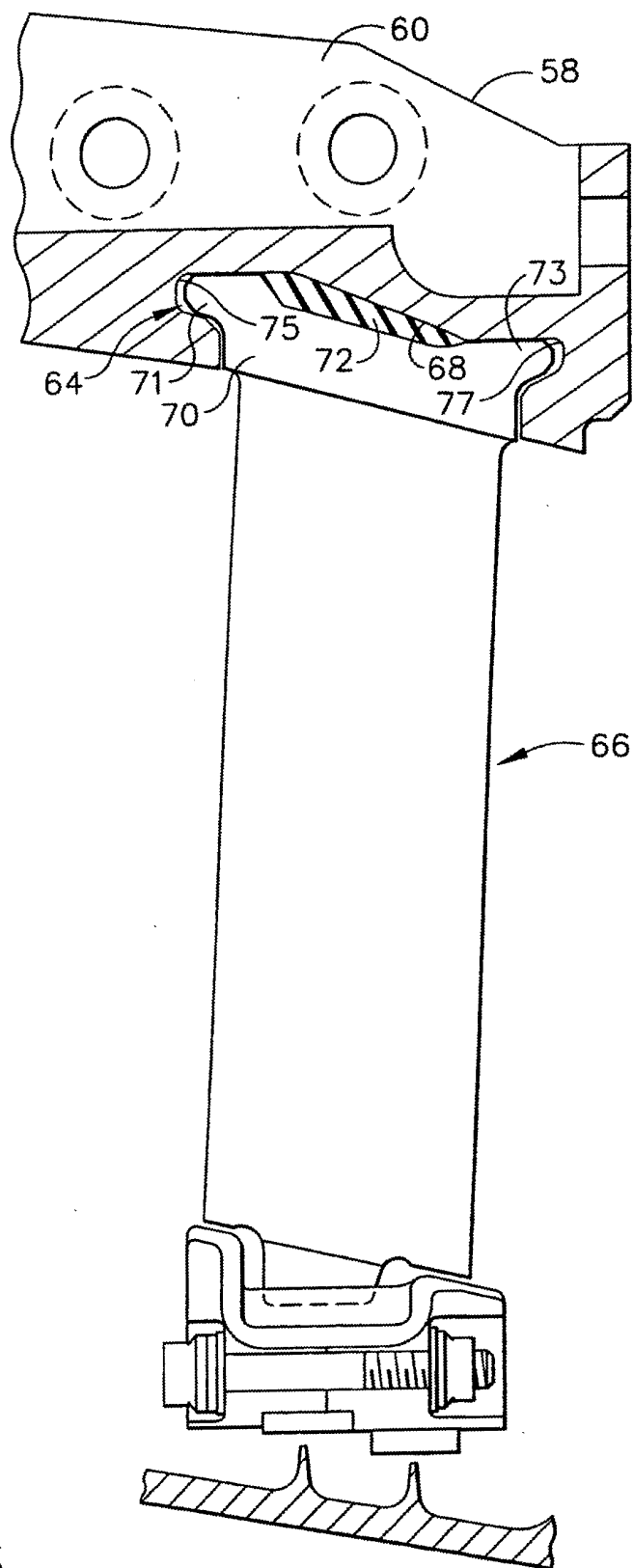


FIG. 6

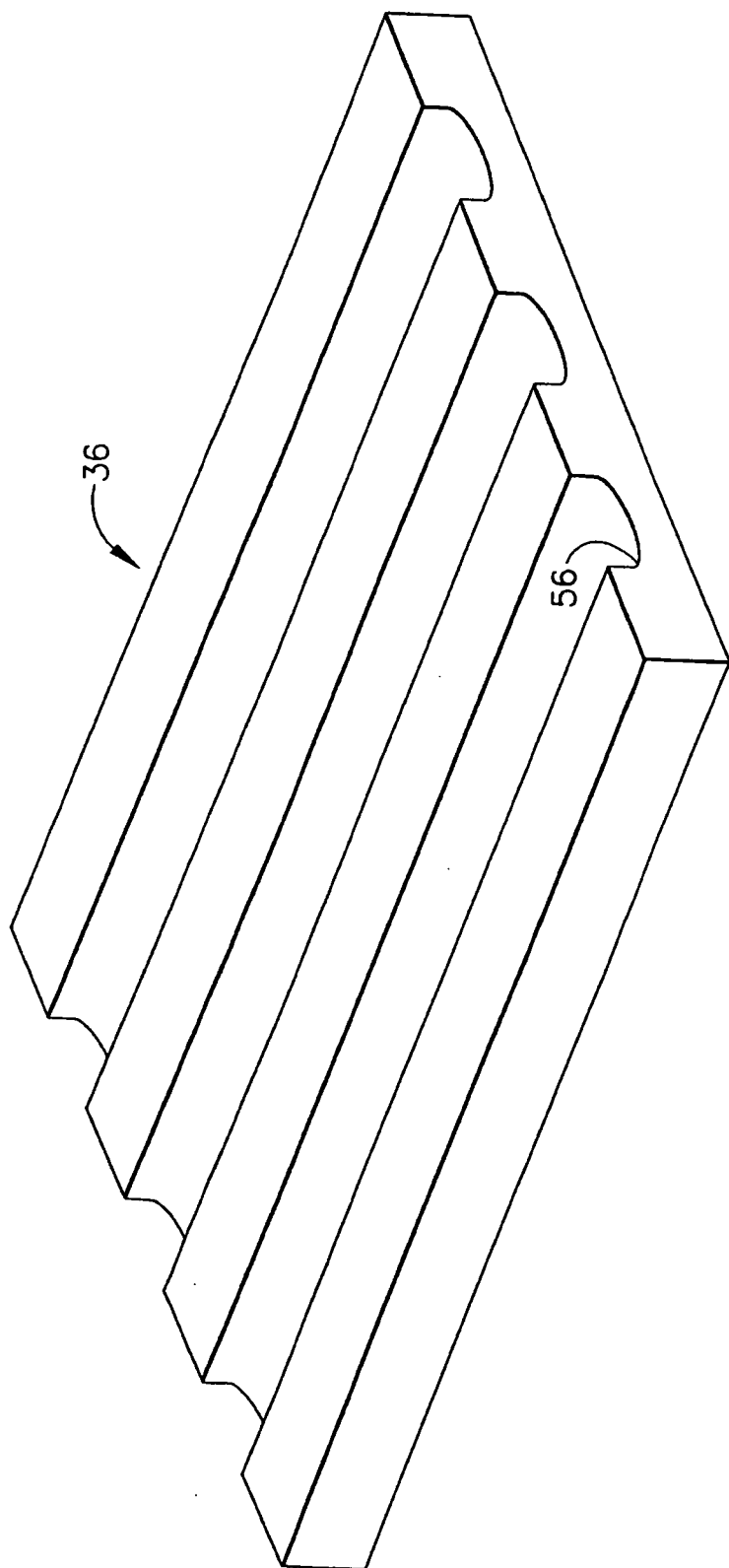


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4872812 A, Hendley [0003]
- US 6343912 B, Manteiga [0003]
- US 5681142 A, Lewis [0003]
- US 5429479 A [0004]