

(19)



(11)

EP 3 495 611 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.06.2019 Bulletin 2019/24

(51) Int Cl.:
F01D 5/08 (2006.01) **F01D 11/00** (2006.01)
F01D 25/08 (2006.01)

(21) Application number: **17205756.4**

(22) Date of filing: **06.12.2017**

(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
 Designated Validation States:
MA MD TN

- **VON ARX, Beat**
4632 TRIMBACH (CH)
- **KOENIG, Marcel**
5430 WETTINGEN (CH)
- **ZIERER, Thomas**
5408 ENNETBADEN (CH)
- **GARBUGLIA, Francesco**
5415 NUSSBAUMEN (CH)

(71) Applicant: **Ansaldo Energia Switzerland AG**
5401 Baden (CH)

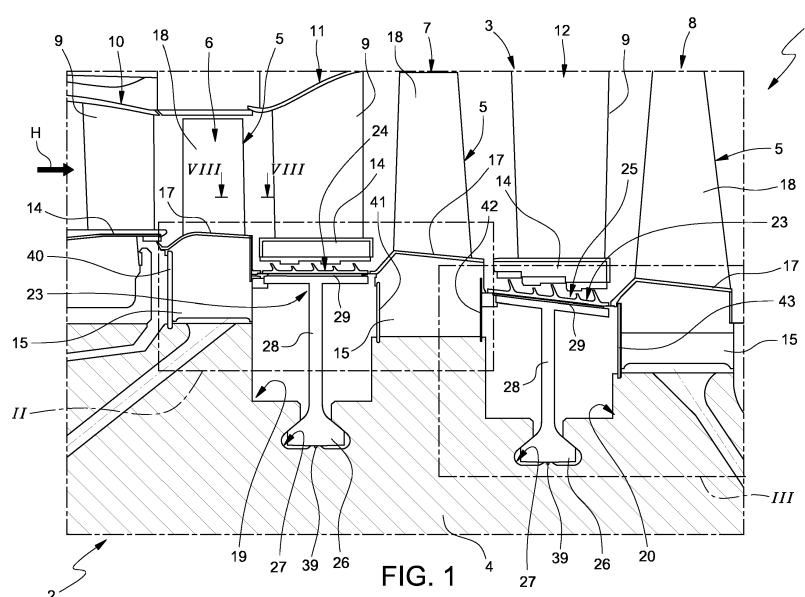
(74) Representative: **Franzolin, Luigi et al**
Studio Torta S.p.A.
Via Viotti, 9
10121 Torino (IT)

(72) Inventors:
 • **SCHNIEDER, Martin**
5408 ENNETBADEN (CH)

(54) **APPARATUS FOR CONTROLLED DELIVERY OF COOLING AIR TO TURBINE BLADES IN A GAS TURBINE**

(57) An apparatus for controlled delivery of cooling air to turbine blades (5) in a gas turbine (1) including a rotor unit (4), at least a first and second row of turbine blades (5), a plurality of rotor heat shield elements (23) disposed in a circumferential row between the first and second rows of turbine blades (5) and configured to define with said rotor unit (4) a rotor heat shield passage

(33, 34, 35, 36) that is fed with cooling air, and a plurality of lock plates (41, 42, 43) disposed in a circumferential row and configured to secure at least one of said first and second rows (6, 7, 8) of turbine blades (5) to the rotor unit (4), wherein a radial portion (28) of the rotor shield elements (23) and/or the lock plates (41, 42, 43) include at least one opening (49) for controlled flow of cooling air.

**FIG. 1****EP 3 495 611 A1**

Description

BACKGROUND OF THE INVENTION

Field of the invention

[0001] The present invention relates to an apparatus for controlled delivery of cooling air to turbine blades in a turbine section of a gas turbine power plant. In particular, the present invention relates to an apparatus for controlling cooling air delivery to rotor heat shield cavities to protect the rotor material against hot gas.

Description of prior art

[0002] As is known, a gas turbine for power plants (in the following, "gas turbine" only) comprises an upstream compressor, a combustor assembly and a downstream turbine. The turbine includes a rotor comprising a compressor section and a turbine section.

[0003] The terms downstream and upstream as used herein refer to the direction of the main gas flow passing through the gas turbine.

[0004] In particular, the compressor comprises an inlet supplied with air and a plurality of blades compressing the passing air. The major part of the compressed air flows into a combustor where the compressed air is mixed with at least one fuel. This mixture is combusted in the combustor leading to a significant temperature rise. The resulting hot gas leaves the combustor and is expanded in the turbine, producing mechanical work on the rotor.

[0005] While the turbine blades are made of a material designed to withstand the hot gas temperatures, and thus costly, the rotor is generally made of a less costly material with a lower resistance to high temperatures. Therefore, a flow of cooling air must be provided in the rotor section, below the hot gas path, to protect the rotor material against the hot gas temperature. Devices called rotor heat shields (RHS) are generally inserted between two adjacent blade rows to form cavities that can be supplied with cooling air.

[0006] In the turbine section, the hot gas pressure decreases from one blade row to the following. It is known in the art that the pressure of the cooling air supplied to the individual blades rows at the root of the blades should be above the hot gas pressure at that blade row to avoid leakage of hot gas into cooling cavities; however, the cooling air pressure should not be too high in order to avoid excessive flow of cooling air into the hot gas path, which would reduce efficiency.

[0007] Controlling cooling air delivery is even more complex when air is supplied to two blade rows from a single source.

SUMMARY OF THE INVENTION

[0008] An object of the present invention is to provide an apparatus for controlled delivery of cooling air to tur-

bine blades in a gas turbine which addresses the above problems.

[0009] According to a first aspect of the present invention, the apparatus includes:

- a plurality of rotor heat shield elements disposed in a circumferential row between a first and a second row of turbine blades, each shield element having a root portion contoured so as to fit in a seat of the rotor unit, an intermediate radial portion and a shroud band configured to be axially interposed between platform portions of the turbine blades of the first and second turbine blade row, the rotor heat shield elements configured to define with a rotor unit of the turbine a rotor heat shield passage that is fed with cooling air; and
- at least a row of lock plates configured to secure axially at least one of said first and second rows of turbine blades to said rotor unit, said lock plates facing said rotor heat shield elements,

wherein at least one of said radial portion of the rotor heat shield elements and the lock plates includes at least one opening for controlled flow of cooling air.

[0010] According to the invention, pressure drop along the different portions of the rotor heat shield passage can be controlled so as to ensure optimum local balance with the pressure of the hot gas.

[0011] According to an embodiment, two portions or cavities of the rotor heat shield passage communicate through the aperture in the radial portion of the rotor heat shield elements, which allows to control pressure in the two portions even though only one of them is supplied with cooling air.

[0012] In an embodiment, the rotor shield elements include at least one feature configured to cooperate with an axial finger extending from the platform portion of the blades of at least one row in order to lock said rotor shield elements circumferentially; the opening is facing the features of the rotor shield elements, so that it can be used to receive the finger of a respective blade.

[0013] Advantageously, lock plates are provided with hooks for coupling with said rotor unit; this makes assembly easy and quick.

[0014] According to a preferred embodiment, the apparatus includes at least one, and preferably all, of:

- a circumferential wire seal between the root portions of the said rotor heat shield elements and said rotor unit,
- a circumferential wire seal between said lock plates and said rotor unit,
- circumferential seals between the shroud bands the said blades, and
- axial seals between each pair of adjacent shroud bands.

[0015] This allows to reduce, and preferably eliminate,

any undesired leaking paths for the cooling air.

[0016] According to another aspect, the invention relates to a gas turbine including:

- a rotor unit;
- at least a first plurality of turbine blades disposed in a first circumferential row around the rotor unit and secured thereto,
- at least a second plurality of turbine blades disposed in a second circumferential row around the rotor unit and secured thereto,
- the first row and the second row being axially spaced with respect to one another,
- a plurality of rotor heat shield elements disposed in a circumferential row between said first and second rows of turbine blades, each shield element having a root portion contoured so as to fit in a seat of the rotor unit, an intermediate radial portion and a shroud band configured to be axially interposed between the first and second row of turbine blades, the rotor heat shield elements defining with said rotor unit a rotor heat shield passage that is fed with cooling air,
- at least a row of lock plates configured to secure at least one of said first and second rows of turbine blades to said rotor unit, said lock plates facing said rotor heat shield elements,

wherein in said lock plates include an opening for controlled flow of cooling air between at least a first portion of said heat shield passage upstream of the lock plates and a second portion of said heat shield passage downstream of the lock plates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] For a better comprehension of the present invention, a preferred embodiment thereof will be described hereafter, by way of a non-limiting example and referring to the attached drawings, where:

Figure 1 is a partial axial cross section of an apparatus for controlled delivery of cooling air to turbine blades according to the present invention;

Figure 2 is an enlarged view of a portion of figure 1;

Figure 3 is a detailed view of another portion of figure 1;

Figure 4 is a side view, partly sectioned, of a turbine blade of a gas turbine including the apparatus;

figure 5 is an axial view from one side of a detail of figure 4;

Figure 6 is an axial view from an opposite side of a detail of figure 4;

Figure 7 is a perspective view of a component of the apparatus of the invention; and

Figure 8 is partial cross-section taken along line VIII-VIII in figure 1.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0018] Referring now to figure 1, a gas turbine 1 (only partially shown) includes a rotor 2 rotatable about a rotor axis (not shown) and a stator 3.

[0019] As is well known in the art, rotor 2 includes a rotor unit 4 and a plurality of turbine blades 5 secured to the rotor unit 4 and disposed in a plurality of circumferential blade rows 6, 7, 8. Three blade rows are shown in figure 1, but the number of blade rows is typically larger than three. Stator 3 is provided with a plurality of turbine vanes 9 disposed in a plurality of circumferential vane rows 10, 11, 12 that precede the respective blade rows 5, 6, 7 in the axial direction of the hot gas flow, indicated by arrow H. Three vane rows are shown in figure 1, but the number of vane rows is typically larger than three. The inner tip of the vane 9 is integrally connected to an inner vane platform 14 that extends circumferentially until the adjacent vane platforms; the gaps between two adjacent vane platforms 14 is sealed with a seal.

[0020] Blades 5 have, each, a firtree shaped shank portion 15 that is inserted in a firtree seat 16 of rotor unit 4 (fig. 6), a platform portion 17 and an airfoil 18.

[0021] Blade rows 6, 7, 8 are axially spaced with respect to one another, and rotor unit 4 has annular recesses 19, 20 in between each pair of rows (5,6; 6,7).

[0022] Turbine 1 also includes a plurality of rotor heat shield elements 23 (hereinafter, for brevity sake, RHS elements) disposed in circumferential RHS rows 24, 25. Two rows only of RHS elements are shown, but the number of rows is obviously dependent on the number of blade rows and typically greater than two.

[0023] Each RHS element 23 (figures 1-3) comprises a mushroom shaped root portion 26 engaged in an undercut mushroom shaped annular seat 27 at the bottom of the respective annular recess 19 or 20, an intermediate radial portion 28 and a circumferential shroud band 29. The shroud bands 29 of the RHS elements 23 in each row are joined to one another by axial seals (not shown) to form a substantially continuous annular band, that is sealed circumferentially to each of the adjacent blade rows by means of circumferential seals 30. Root portions 26 are sealed against the bottom of annular seat 27 by a circumferential wire seal 39.

[0024] A radial small bore 56 in the rotor unit 4, opening into the undercut portion of seat 27 (fig. 3), allows to insert a control wire (not shown) to check whether the circumferential position of RHS elements is correct, as shown e.g. in US 2008/0181778-A.

[0025] Shroud bands 29 have preferably a plurality of inclined sealing fins 31, which are alternately lower and higher and projecting outwardly to cooperate at a short radial distance with a stepped inner sealing contour 32 of inner ring 14 of the stator. This reduces unwanted hot gas leakage between rotor 2 and stator 3.

[0026] As shown in figures 2, 3, the RHS elements 23 of rows 24, 25 delimit, with the adjacent blade rows 6,7

and 7,8 respectively, a plurality of rotor heat shield (RHS) cavities 33, 34, 35, 36 that communicate with one another to define a path for cooling air. Specifically, in the example disclosed, cooling air is fed to RHS cavity 33 via a passage 37 in rotor unit 4 which opens into a passage 38 through blade row 6 (fig. 2).

[0027] Blades 5 are axially blocked by lock plates 40, 41, 42, 43, which are disposed side-by-side in circumferential rows. Lock plates 40-43 have a radially inner edge 44 engaging a corresponding seat 45 on rotor unit 4 and a radially outer edge 46 engaging a corresponding seat 47 in the respective blade 5 (fig. 2).

[0028] As shown in figure 2 and 3, radial portions 28 of RHS elements 23 and/or lock plates 40-43 may include apertures 48, 49 to allow a controlled air flow there-through and thereby define a predetermined pressure drop between adjacent cavities 33, 34 and 35, 36. In this manner, the pressure within each of the cavities can be controlled so as to be greater than the pressure of hot gases at the corresponding axial portion of the hot gas path, so as to avoid leakage of hot gas into the RHS cavities, but not too high so as to avoid excessive leakage of cooling air into the hot gas path. Conveniently, pressure in each section of the RHS path is maintained in the range of 100-150% of the corresponding hot gas pressure. More particularly, apertures 48 in radial portion 28 of RHS elements 23 connect cavity 33 to cavity 34 and cavity 35 to cavity 36. Apertures 49 in lock plates 41 control air flow between cavity 34 and passages 38 through blade row 7.

[0029] RHS elements 23 are locked in a circumferential direction by axial fingers 50 extending from blades 5 and engaging corresponding features 60 of RHS elements 23, as known per se e.g. from US 2008/0181778-A. Such features may include a seat of any kind, e.g. a space between two projections of RHS elements 23.

[0030] As shown in figures 4 and 5, lock plates 42 have the shape of an annulus sector and are placed side by side in a circumferential row. Preferably, inner edges 44 are sealed with respect to seat 45 by means of a wire seal 61 that is housed within a groove 62 in lock plates 52 and cooperates axially with one side of seat 45 (see enlarged detail in fig. 4).

[0031] Lock plates 42 are provided with a preferably rectangular aperture 49 which, in addition to controlling the flow of cooling air as described previously, has the function of allowing a corresponding finger 50 to pass through (fig. 3, 4).

[0032] Lock plates 42 have hooks 51 configured to couple lock plates 42 to rotor unit 4. Preferably, two hooks 51 are arranged at opposite radial edges of the lock plate 42 in the proximity of the outer edge and engage with lugs 52 of the rotor unit located at opposite sides of each first seat 16.

[0033] Lock plates 41 (figures 4 and 6) have preferably a substantially trapezoidal shape with a longer base connected to rotor unit 4 and a shorter base connected to a respective blade 5.

[0034] Lock plates 41 have a central cut-out opening 52 delimiting a flexible tab 53 which is bent axially towards the respective blade 5 so as to exert an elastic force thereon and recover axial play.

[0035] Lock plates 41 also have an opening 54 close to rotor unit 4 so as to allow cooling air flow at the blade roots. Blades 5 of row 6 have platform portions 17 extending radially outwardly of the shroud bands 29 of RHS elements 23 of RHS row 24. Platform portions 17 include shiplap seal features 55 (fig. 8) configured to cooperate with corresponding features of an adjacent blade so as to avoid gas leakage therebetween.

[0036] In use, cooling air is fed through passage 37 into passage 38; part of this flow is used to cool blades 5 of row 6 internally, as known per se.

[0037] The remaining part of cooling air is fed from passage 38 into cavity 33, and hence to cavity 34 through apertures 48 in radial portions 28 of RHS elements 23. Cooling air then flows from cavity 34 through apertures 49 in lock plates into passages 38 through blade row 7; part of the flow cools blades 5 of row 7 internally, as known per se.

[0038] Finally, cooling air flows through apertures 49 of lock plates 42 into cavity 35, and hence into cavity 36 through apertures 48 of RHS elements 23.

[0039] The cross section of apertures 48 and 49 is calibrated to obtain a desired pressure drop at each transition, so as to match the pressure in cavities 33, 34, 35, 36 with the pressure of surrounding hot gas and, preferably, be in the range of 100-150% of the pressure of surrounding hot gas. Although the invention has been explained in relation to its preferred embodiment as mentioned above, it is to be understood that modifications and variations can be made without departing from the scope of the appended claims.

Claims

1. An apparatus for controlled delivery of cooling air to turbine blades (5) in a gas turbine (1) including a rotor unit (4), at least a first plurality of turbine blades (5) disposed in a first circumferential row (6; 7) around the rotor unit (4) and secured thereto, at least a second plurality of turbine blades (5) disposed in a second circumferential row (7; 8) around the rotor unit (4) and secured thereto, the first row (6; 7) and the second row (7; 8) being axially spaced with respect to one another, the apparatus including:

- a plurality of rotor heat shield elements (23) disposed in a circumferential row between said first and second rows of turbine blades (5), each heat shield element (23) having a root portion (26) contoured so as to fit in a seat (27) of the rotor unit (4), an intermediate radial portion (28) and a shroud band (29) configured to be axially interposed between the first and second rows

(6, 7; 7, 8) of turbine blades (5), the rotor heat shield elements (23) configured to define with said rotor unit (4) a rotor heat shield passage (33, 34, 35, 36) that is fed with cooling air;

- a plurality of lock plates (40, 41, 42, 43) disposed in a circumferential row and configured to secure axially at least one of said first and second rows (6, 7, 8) of turbine blades (5) to said rotor unit (4), said lock plates (41, 42, 43) facing said heat shield elements (23),

characterized in that at least one of said radial portion (28) of the rotor shield elements (23) and the lock plates (41, 42, 43) include at least one opening (49; 54) for controlled flow of cooling air.

2. An apparatus as claimed in claim 1, **characterized by** including a first cavity (33) between by the first row (6) of turbine blades (5) and the radial portion (28) of the shield elements (23) and a second cavity (34) between the radial portion (28) of the shield elements (23) and the second row (7) of turbine blades (5), one of said first and second cavity (33) being supplied by a source of cooling air, the other of said first and second cavity (34) being supplied with cooling air through an opening (48) in said radial portion (28) of the shield elements (23).

3. An apparatus as claimed in claim 1, **characterized in that** said rotor shield elements (23) include at least one feature (60) configured to cooperate with an axial finger (50) extending from the blades (5) of at least one row (6, 7, 8) in order to lock said rotor shield elements (23) circumferentially.

4. An apparatus as claimed in claim 3, **characterized in that** said lock plates (42) include an opening (49) facing said features of said rotor shield elements (23), said opening (49) being configured to receive said finger (50) of a respective blade (5).

5. An apparatus as claimed in any of the preceding claims, **characterized in that** the lock plates (42) are provided with hooks (51) for coupling with said rotor unit (4).

6. An apparatus as claimed in any preceding claims, **characterized by** including a circumferential wire seal between the root portions (26) of the said rotor heat shield elements (23) and said rotor unit (4).

7. An apparatus as claimed in any preceding claims, **characterized by** including a circumferential wire seal between said lock plates (41, 42) and said rotor unit (4).

8. An apparatus as claimed in any preceding claims, **characterized by** including circumferential seals

(30) between said shroud bands (29) and said blades (5), and axial seals between each pair of adjacent shroud bands (29).

9. A gas turbine including:

- a rotor unit (4);
- at least a first plurality of turbine blades (5) disposed in a first circumferential row (6, 7) around the rotor unit (4) and secured thereto,
- at least a second plurality of turbine blades (5) disposed in a second circumferential row (7, 8) around the rotor unit (4) and secured thereto,
- the first row and the second row (6, 7; 7, 8) being axially spaced with respect to one another,
- a plurality of rotor heat shield elements (23) disposed in a circumferential row between said first and second rows of turbine blades (5), each rotor shield element (23) having a root portion (26) contoured so as to fit in a seat (27) of the rotor unit (4), an intermediate radial portion (28) and a shroud band (29) configured to be axially interposed between the first and second row of turbine blades (5), the rotor heat shield elements (23) defining with said rotor unit (4) a rotor heat shield passage (33, 34, 35, 36) that is fed with cooling air,
- at least a row of lock plates (40, 41, 42, 43) configured to secure at least one of said first and second rows of turbine blades to said rotor unit (4), said lock plates facing said rotor heat shield elements (23),

characterized in that said lock plates (42) include an opening (49) for controlled flow of cooling air between at least a first portion of said heat shield passage upstream of the lock plates (42) and a second portion of said heat shield passage downstream of the lock plates (42).

10. A gas turbine as claimed in claim 9, **characterized in that** the blades (5) of at least one of said first and second rows (6, 7; 7, 8) have axial fingers (50), the rotor heat elements (23) having mating features (60) cooperating with said axial fingers (50) to lock said rotor shield elements (23) circumferentially, said axial fingers (50) of said blades (5) extending through said openings (49) of said locking plates (42).

11. A gas turbine as claimed in claim 9 or 10, **characterized in that** said lock plates (42) include hooks (51) engaging corresponding seats in the rotor unit (4).

12. A gas turbine as claimed in any of claims 9 to 11, **characterized in that** at least one of said first and second rows (6, 7; 7, 8) of blades (5) have platform portions (17) extending radially outwardly of said

shroud bands (29) of the rotor heat shield elements (23).

13. A gas turbine as claimed in claim 12, **characterized in that** said platform portions (17) include shiplap seal features configured to cooperate with corresponding features (55) of an adjacent blade (5). 5
14. A gas turbine as claimed in any of claims 9 to 13, **characterized in that** the radial portions (28) of the rotor shield elements (23) include at least one opening (48) for controlled flow of cooling air. 10
15. A gas turbine as claimed in any of claims 9 to 14, **characterized in that** shroud bands (29) have a plurality of inclined sealing fins (31) to cooperate at a short radial distance with a stepped inner sealing contour (32) of an inner ring (14) of the stator. 15

20

25

30

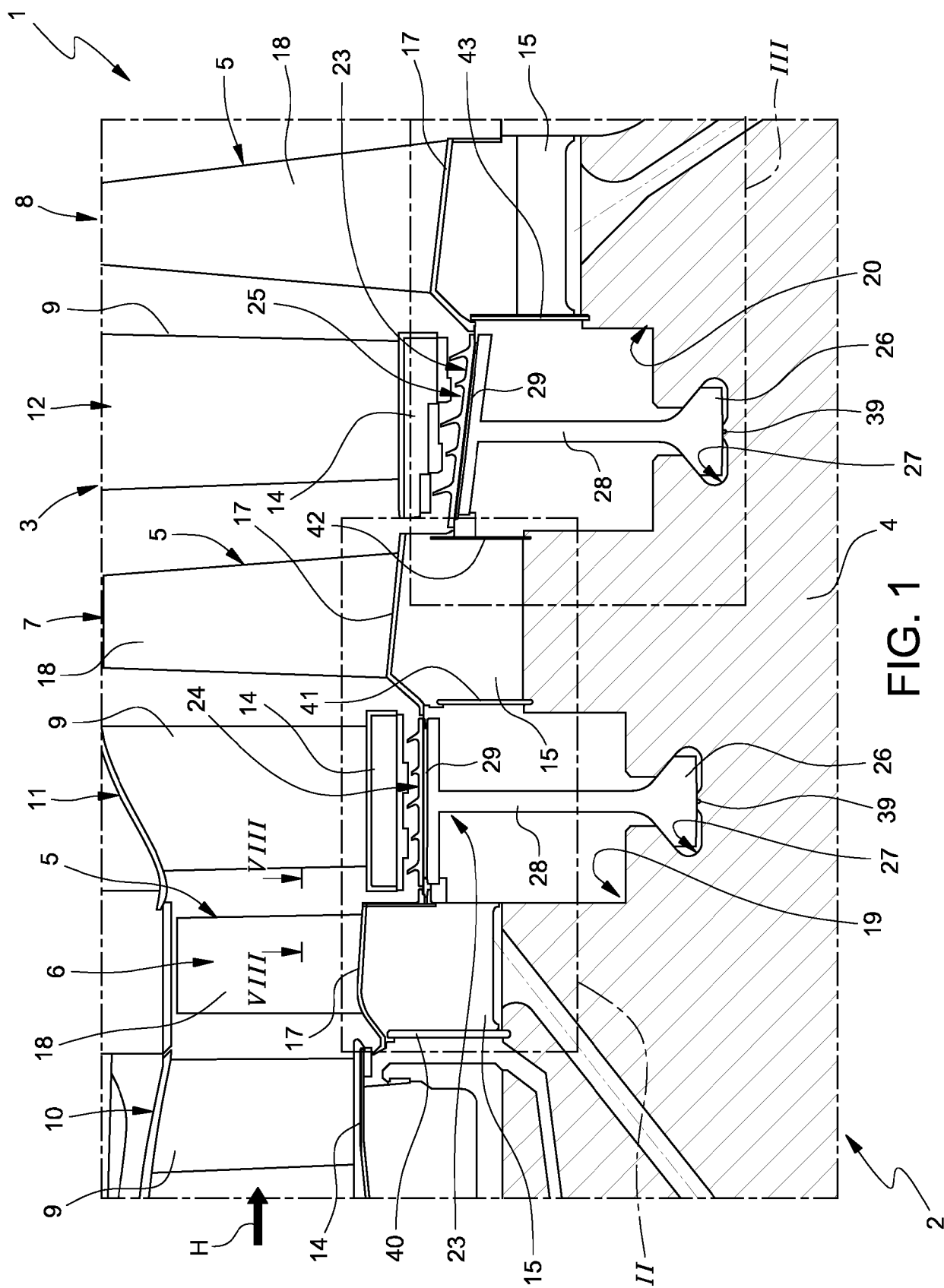
35

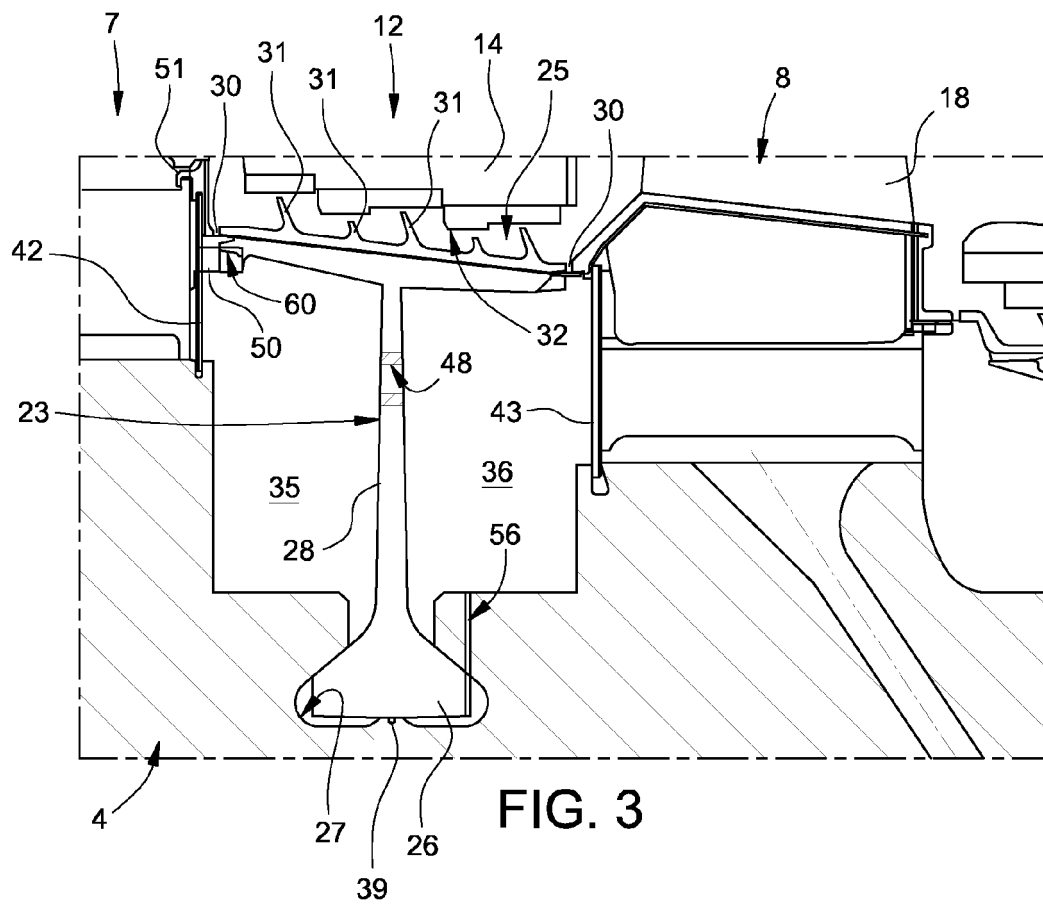
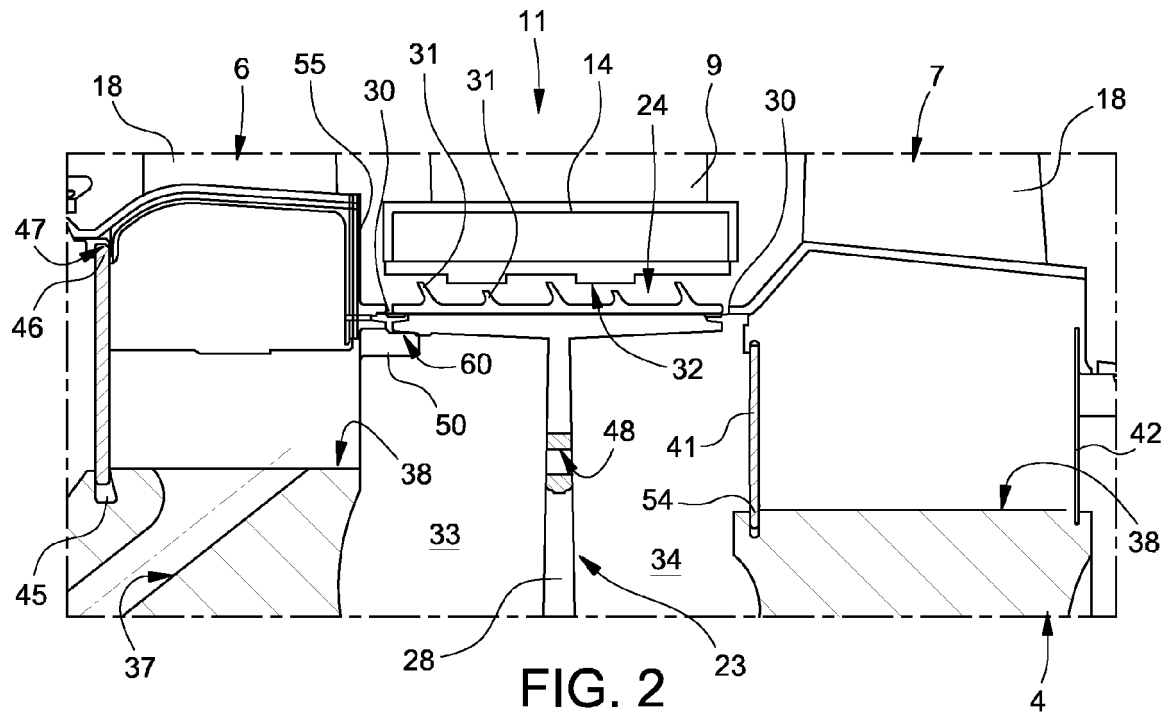
40

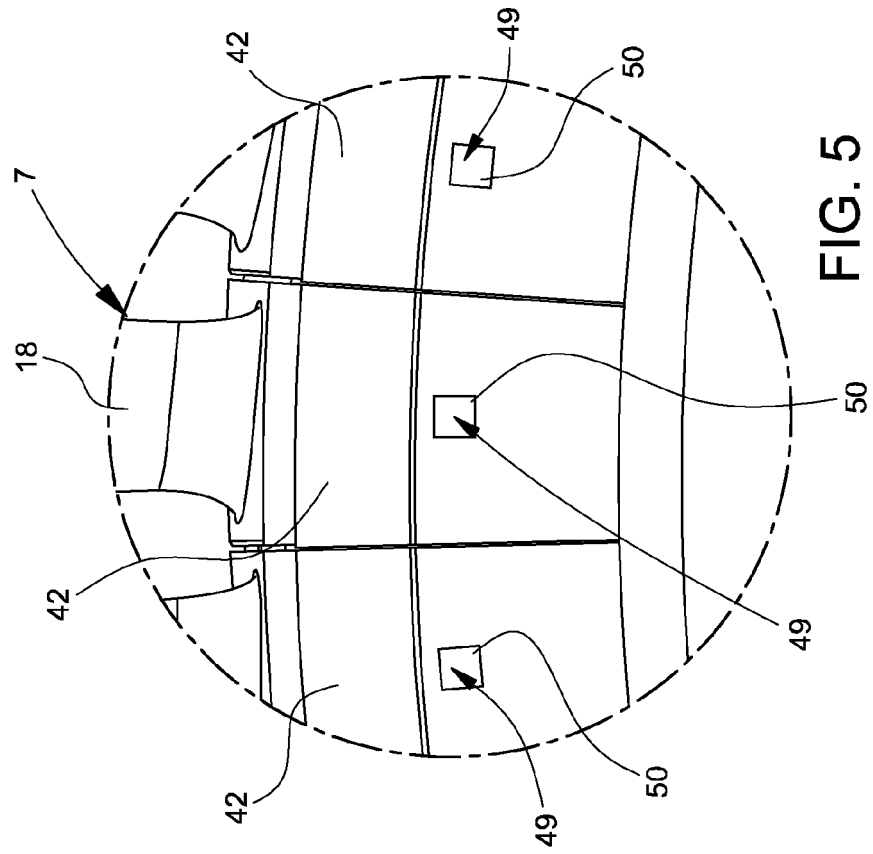
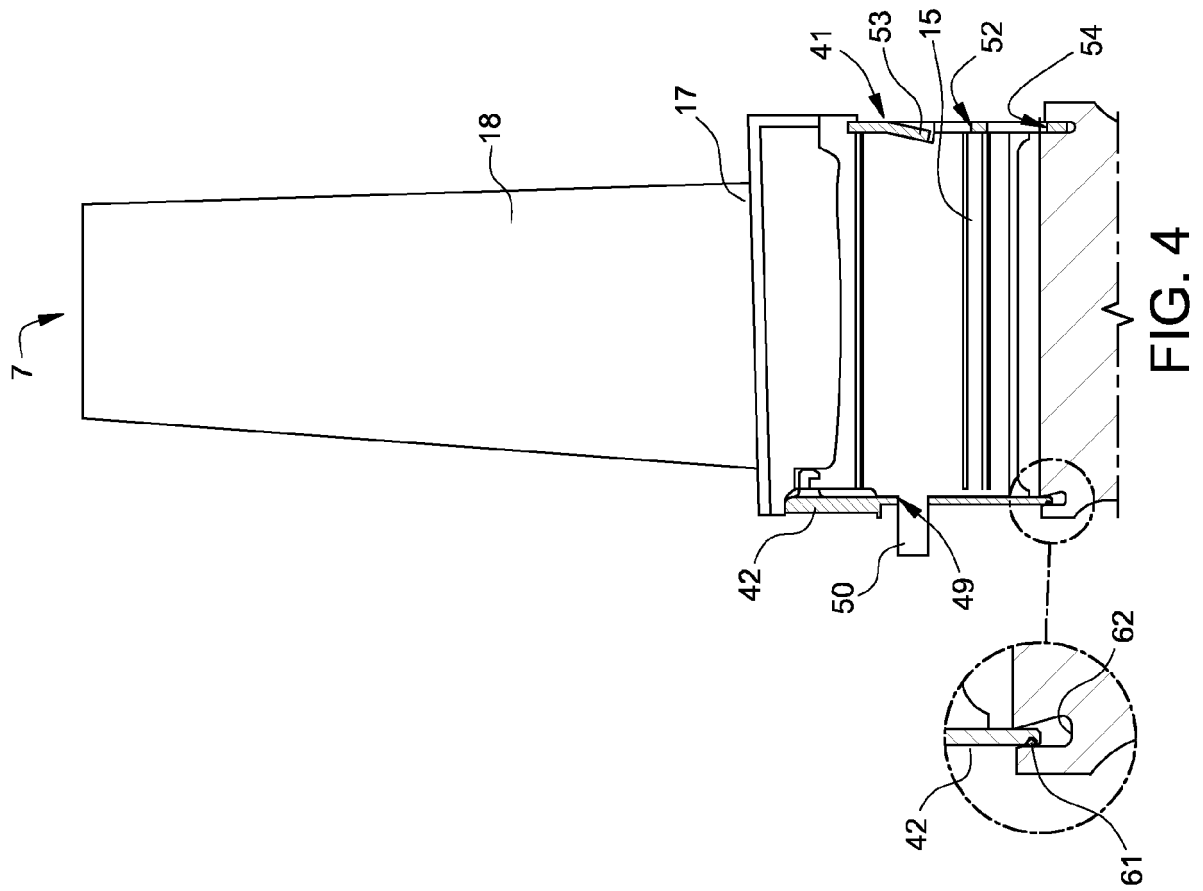
45

50

55







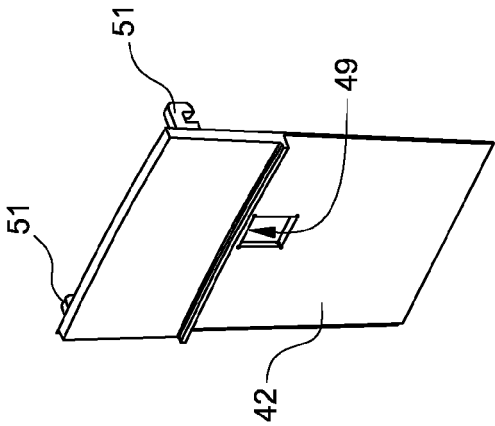


FIG. 7

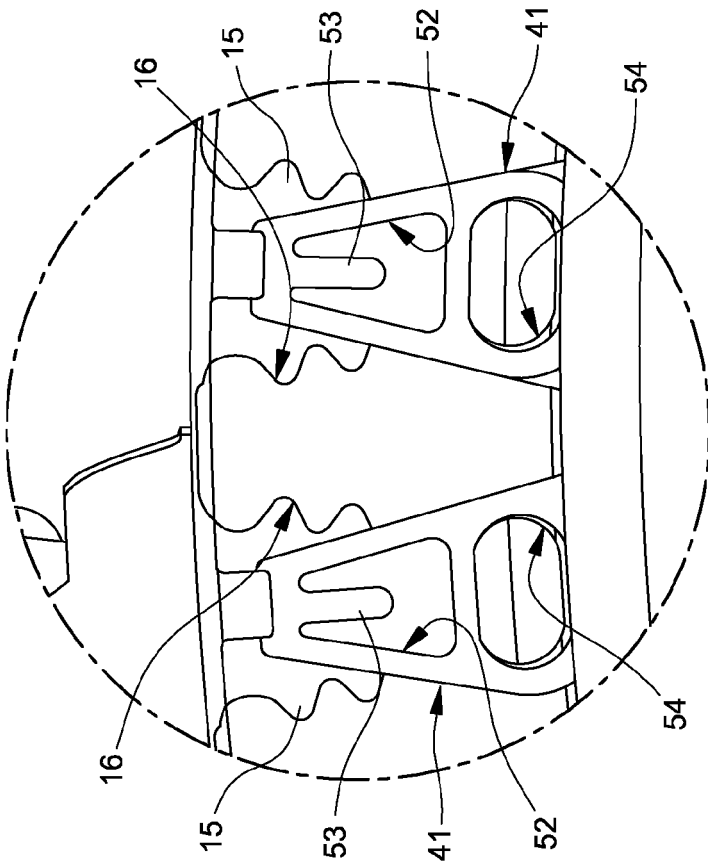


FIG. 6

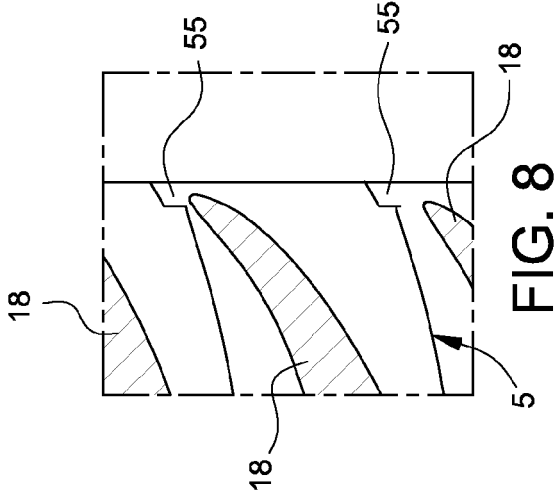


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 17 20 5756

5

10

15

20

25

30

35

40

45

50

55

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 2010/074732 A1 (MARRA JOHN JOSEPH [US] ET AL) 25 March 2010 (2010-03-25) * paragraphs [0025] - [0031], [0063]; figures 1,1A,4,5 *	1-15	INV. F01D5/08 F01D11/00 F01D25/08
X	GB 988 541 A (RUSTON & HORNSBY LTD) 7 April 1965 (1965-04-07) * page 2, line 70 - line 130; figures 1,2 *	1-15	
X	US 4 884 950 A (BRODELL ROBERT F [US] ET AL) 5 December 1989 (1989-12-05) * column 4, line 10 - line 68; figures 1,2 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 May 2018	Examiner Avramidis, Pavlos
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 20 5756

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-05-2018

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010074732 A1	25-03-2010	NONE	
GB 988541 A	07-04-1965	NONE	
US 4884950 A	05-12-1989	FR 2636094 A1	09-03-1990
		GB 2224319 A	02-05-1990
		US 4884950 A	05-12-1989

EPO FORM P0459

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

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 20080181778 A [0024] [0029]