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

(11) EP 2 915 957 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.09.2015 Bulletin 2015/37

(51) Int Cl.:
F01D 9/02 *(2006.01)* ***F02C 7/18*** *(2006.01)*

(21) Application number: **14157781.7**

(22) Date of filing: **05.03.2014**

(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

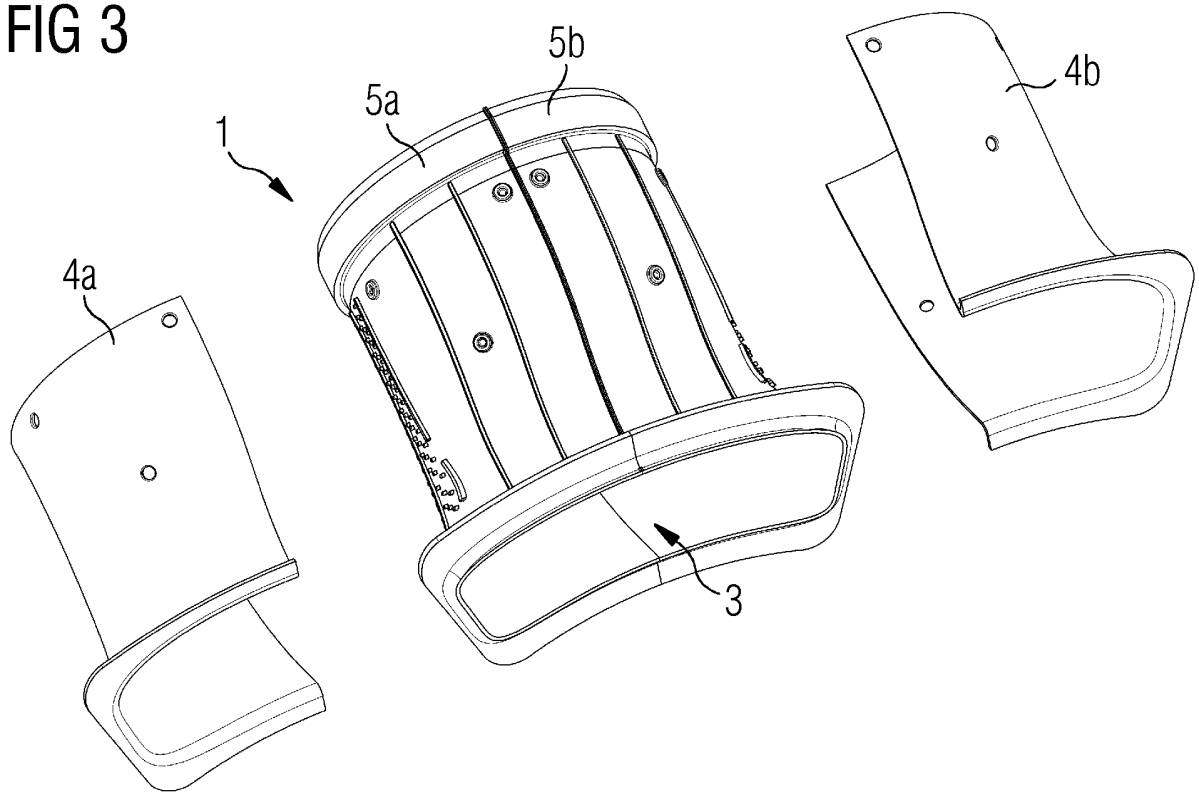
(71) Applicant: **Siemens Aktiengesellschaft**
80333 München (DE)

(72) Inventors:
- **Hasselqvist, Magnus**
  61213 Finspong (SE)
- **Szijarto, Janos**
  61295 Finspong (SE)

(54) Cast tubular duct for a gas turbine and manufacturing method thereof

(57) It is described a tubular duct (1) for connecting a combustion chamber (14) and a turbine (15) of a gas turbine (12), comprising a first opening (2) designed to face said combustion chamber (14) and a second opening (3) designed to face said turbine (15). According to the invention, said duct (1) is cast by means of precision casting technology. Furthermore, a gas turbine (12) with such a duct (1) and a manufacturing method thereof is disclosed.

FIG 3



EP 2 915 957 A1

Description

Field of invention

[0001] The present invention relates to a tubular duct for connecting a combustion chamber and a turbine of a gas turbine - i.e. a gas turbine engine -, comprising a first opening designed to face said combustion chamber and a second opening designed to face said turbine. Furthermore, the invention relates to a manufacturing method for a tubular duct of the kind above. Finally, the present invention relates to a gas turbine, comprising a compressor, a turbine, a burning chamber and duct of the kind above.

Art Background

[0002] A tubular duct and a gas turbine as presented above are generally known. Usually, such a duct is made of a number of metal sheets, which are reshaped into three-dimensional parts by means of plastic deformation and then welded together. However, such a manufacturing method suffers from imprecision of the reshaped parts, on the one hand, and from the limitation to a more or less constant thickness of the parts over the whole curved plane, on the other hand.

[0003] Another problem of prior art gas turbines is the cooling of the turbine parts, which in particular counts for the vane platforms, which are generally more difficult to cool than airfoils. Cooling air released as film (or as jets) into the hot gas stream has a strong tendency to be swept up by the residual swirl from the burner and aggregate in cold streaks. When this happens, the cold streaks can cause thermal stresses, which result in premature crack initiation. Furthermore, the positions of said cold streaks are difficult to predict and may to some extent change with loading conditions (pilot flow, fuel, mass flow etc.). Accordingly, the associated crack initiation life is difficult to assess.

[0004] Accordingly, there is a need to provide a duct, a gas turbine and a manufacturing method, which overcome the drawbacks mentioned above.

Summary of the Invention

[0005] This need may be met by the subject matter according to the independent claims. Advantageous embodiments of the present invention are described by the dependent claims.

[0006] According to a first aspect of the invention, there is provided a tubular duct as disclosed in the opening paragraph, wherein said duct is cast by means of precision casting technology.

[0007] Moreover, there is provided a method of manufacturing a duct as disclosed in the opening paragraph, wherein said duct is cast by means of precision casting technology.

[0008] Finally, there is provided a gas turbine, comprising a compressor, a turbine, a burning chamber and a duct of the kind above.

[0009] These aspects of the invention are based on the idea that cast parts may be produced with high precision, so that the duct can easily be integrated into a gas turbine without reworking. Furthermore, cast ducts allow for a variable thickness and complex shapes, in particular embossments. In this way the inner (concave) duct surface may be even and smooth so as to provide for beneficial flow conditions for the hot burnt gas, whereas the outer (convex) duct surface may be uneven and structured. Thus, a highly effective convective cooling system may be realized also causing a beneficial temperature profile in the turbine by reducing/eliminating cold streaks. For example, IN939 may be chosen as a material for the duct respectively parts of the duct.

[0010] According to a further embodiment of the invention, said duct comprises a plurality of parts. In this way assembly of the duct may be eased.

[0011] In this context it is advantageous, if said duct comprises an outer tube and an inner tube with a gap in-between, wherein the outer tube and the inner tube are cast in separate molds. In the same way it is advantageous, if the manufacturing method comprises the steps of molding an outer tube and an inner tube in separate molds and mounting the outer tube to the inner tube, whereby a gap between the outer tube and the inner tube is created. Accordingly, not just assembly of the duct is eased, but also a channel for cooling air is provided, so that the temperature of the duct may be kept low.

[0012] According to another embodiment of the invention, the outer tube and/or the inner tube is/are split into separate tube parts in an axial plane of the duct. Accordingly, the manufacturing method comprises the steps of

- molding two parts of the outer tube split in an axial plane of the duct in separate molds,
- molding two parts of the inner tube split in an axial plane of the duct in separate molds and
- assembling said parts.

[0013] In this way, manufacturing of the parts of the duct as well as assembly of the same is eased even more.

[0014] According to yet another embodiment of the invention, the gap is connected to a first vent in the outer tube situated in the region of the first opening and to a second vent in the inner tube situated in the region of the second opening. In this way, cooling air is drawn into the gap from the outside by means of the first vent and then drawn into the inner tube by means of the second vent. Accordingly, the temperature of the duct can be kept low.

[0015] According to yet another embodiment of the invention, the outer tube and/or the inner tube comprise(s) assembly points and/or bumps and/or fins facing the gap. In this way, spacers are provided so that the gap is created in a predetermined way when the outer tube is mounted to the inner tube. For example, said assembly points or bumps may be ring shaped or dot shaped. The

bumps and spacers may also be used for guiding the cooling air in the gap in a desired way. In particular, bumps may be used to cause turbulences, which in turn increase cooling in this area. Accordingly, the local cooling effect in a particular area of the duct may be influenced by the design of the bumps/fins. Particularly, a pin can be welded onto an assembly point on the inner tube and to the outer tube. Alternatively, a screw can be screwed into a (ring shaped and threaded) assembly point. In turn, the outer tube can be mounted to the screws by means of screw nuts. Of course, also a threaded pin can be welded onto an assembly point on the inner tube and used for mounting the outer tube to the inner tube by means of screw nuts.

[0016] It has to be noted that embodiments of the invention have been described with reference to different subject matters. In particular, some embodiments have been described with reference to method type claims whereas other embodiments have been described with reference to apparatus type claims. However, a person skilled in the art will gather from the above and the following description that, unless other notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters, in particular between features of the method type claims and features of the apparatus type claims is considered as to be disclosed with this document.

[0017] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Brief Description of the Drawing

[0018]

Figure 1 shows a back view of an exemplary tubular duct;

Figure 2 shows a cross section of the duct of Fig. 1;

Figure 3 shows an exploded view of the duct of Fig. 1;

Figure 4 shows an oblique view of a part of the inner tube of the duct shown in Fig. 1;

Figure 5 shows an oblique view of the inner tube of the duct shown in Fig. 1 and

Figure 6 shows a exemplary gas turbine with the duct of Fig. 1.

Detailed Description

[0019] The illustration in the drawing is schematically. It is noted that in different figures, similar or identical elements or features are provided with the same reference signs or with reference signs, which are different from the corresponding reference signs only within the first digit. In order to avoid unnecessary repetitions elements or features which have already been elucidated with respect to a previously described embodiment are not elucidated again at a later position of the description.

[0020] Fig. 1 and 2 show a tubular duct 1 for connecting a combustion chamber and a turbine of a gas turbine (Fig. 1 shows a back view and Fig. 2 shows a cross section) The duct 1 is cast by means of precision casting technology and comprises a first opening 2 designed to face said combustion chamber and a second opening 3 designed to face said turbine.

[0021] In this particular example, said duct 1 comprises an outer tube 4 and an inner tube 5 with a gap 6 in-between, wherein the outer tube 4 and the inner tube 5 are cast in separate molds. The gap 4 is connected to a first vent 7 in the outer tube 2 situated in the region of the first opening 2 and to second vents 8 in the inner tube 3 situated in the region of the second opening 3. In this way, cooling air is drawn into the gap 6 from the outside by means of the first vent 7 and then drawn into the inner tube 5 (and as a consequence into the turbine) by means of the second vents 8.

[0022] In this example there is just a single ring shaped circumferential vent 7. However, the duct 1 may also comprise a number of separate vents 7. Accordingly, there may also be a single second vent 8 instead of the plurality of second vents 8 shown in Figs. 1 and 2.

[0023] Fig. 3 now shows an exploded view of the duct 1 disclosing that it comprises a plurality of parts 4a, 4b, 5a, 5b. Concretely, the outer tube 4 is split into separate tube parts 4a, 4b, and the inner tube 5 is split into separate tube parts 5a, 5b in this example. Both the outer tube 4 and the inner tube 5 are split an axial plane of the duct 1 in Fig. 3.

[0024] Preferably, the outer tube 4 and the inner tube 5 respectively their parts 4a, 4b, 5a, 5b are cast in separate molds and are assembled in a further step. Concretely, the part 5a is mounted to part 5b and the parts 4a and 4b are mounted to the resulting inner tube 5.

[0025] Fig. 4 shows the part 5a of the inner tube 5, and Fig. 5 shows the inner tube 5 separate from the outer tube 4. On the part 5a respectively on the inner tube 5, assembly points 9, bumps 10 and fins 11 are arranged. Because of these assembly points 9, bumps 10 and fins 11, the gap 6 is created when the outer tube 4 is mounted to the inner tube 5. Moreover, cooling air is guided within the gap 6 in a desired way. In particular, the bumps 10 cause turbulences which in turn increase cooling in this area. Accordingly, the local cooling effect in a particular area of the duct 1 may be influenced by the density of said bumps 10 or generally by the design of the emboss-

ments 9, 10 and 11.

[0026] Generally, the inner tube 5 and the outer tube 4 respectively their parts 4a, 4b, 5a and 5b may be welded together, in particular by means of the assembly points 9, which have the form of ring shaped bumps and face holes in the outer tube 4 in this example. A pin can be welded onto respectively into the ring shaped bump 9 on the inner tube 5 and into the hole of the outer tube 4 to keep the tubes 4 and 5 at distance. Alternatively, a screw can be screwed into the ring shaped bump 9 if this is threaded on its inside. In turn, the outer tube 4 can be mounted to the screws by means of screw nuts.

[0027] To show how and where the duct 1 may be applied, Fig. 6 finally discloses an exemplary gas turbine 12 - i.e. a exemplary gas turbine engine -, comprising a compressor 13, a burning chamber 14, a turbine 15 and a duct 1 as presented before. The duct 1 is situated between the combustion chamber 14 and the turbine 15 and connects the same. A fluid flow will be guided by the duct 1 from the combustion chamber 14 to the turbine 15.

[0028] Generally, the temperature profile in the duct 1 and in particular in the turbine 15 benefits from the inventive measures. Cooling air, which is released as film into the hot gas stream close to the combustor outlet is beneficial in particular for the first vane of the turbine 15 since it decreases the hot gas temperature on the vane platforms. Consequently, it is beneficial for the first vane, which is always a very critical part of a gas turbine 12, that most of the cooling air used in the combustor is released into the hot gas stream close to the outlet of said combustor. This is realized by this invention since the combustor walls are essentially convectively cooled and said convection cooling air is then released close to the combustor outlet where it provides a beneficial effect for the first vane platforms, while the problem with thermal stresses due to cold streaks is significantly reduced.

[0029] Finally, it should be noted that the term "comprising" does not exclude other elements or steps and the use of articles "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

Claims

1. Tubular duct (1) for connecting a combustion chamber (14) and a turbine (15) of a gas turbine (12), comprising a first opening (2) designed to face said combustion chamber (14) and a second opening (3) designed to face said turbine (15),
   wherein
   said duct (1) is cast by means of precision casting technology.

2. Duct (1) as claimed in claim 1,
   characterised in that
   said duct (1) comprises a plurality of parts (4a, 4b, 5a, 5b).

3. Duct (1) as claimed in claim 2,
   characterised in that
   said duct (1) comprises an outer tube (4) and an inner tube (5) with a gap (6) in-between and wherein the outer tube (4) and the inner tube (5) are cast in separate molds.

4. Duct (1) as claimed in claim 3,
   characterised in that
   the outer tube (4) and/or the inner tube (5) is/are split into separate tube parts (4a, 4b, 5a, 5b) in an axial plane of the duct (1).

5. Duct (1) as claimed in claim 3 or 4,
   characterised in that
   the gap (4) is connected to a first vent (7) in the outer tube (2) situated in the region of the first opening (2) and to a second vent (8) in the inner tube (3) situated in the region of the second opening (3).

6. Duct (1) as claimed in any one of the claims 3 to 5,
   characterised in that
   the outer tube (4) and/or the inner tube (5) comprise(s) assembly points (9) and/or bumps (10) and/or fins (11) facing the gap (6).

7. Gas turbine (12) comprising a compressor (13), a burning chamber (14), a turbine (15) and a duct (1) as claimed in claims 1 to 6 connecting said combustion chamber (14) and said turbine (15).

8. Method of manufacturing a duct (1) for connecting a combustion chamber (14) and a turbine (15) of a gas turbine (12), comprising a first opening (2) designed to face said combustion chamber (14) and a second opening (3) designed to face said turbine (15),
   wherein
   said duct (1) is cast by means of precision casting technology.

9. Method as claimed in claim 8, comprising the steps of molding an outer tube (4) and an inner tube (5) in separate molds and mounting the outer tube (4) to the inner tube (5), whereby a gap (6) between the outer tube (4) and the inner tube (5) is created.

10. Method as claimed in claim 9, comprising the steps of

    - molding two parts (4a, 4b) of the outer tube (4) split in an axial plane of the duct (1) in separate molds,
    - molding two parts (5a, 5b) of the inner tube (5) split in an axial plane of the duct (1) in separate molds and
    - assembling said parts (4a, 4b, 5a, 5b).

FIG 1

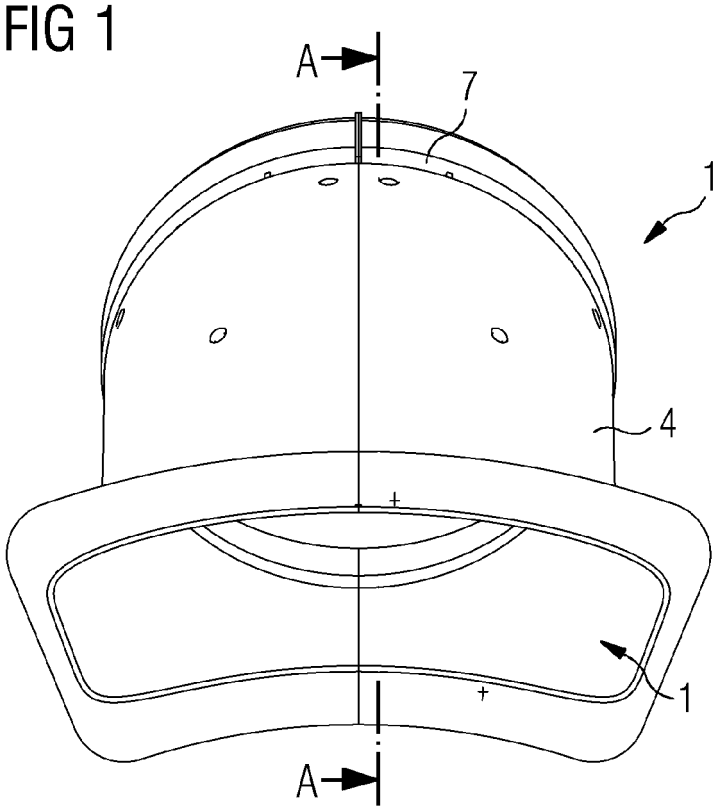


FIG 2

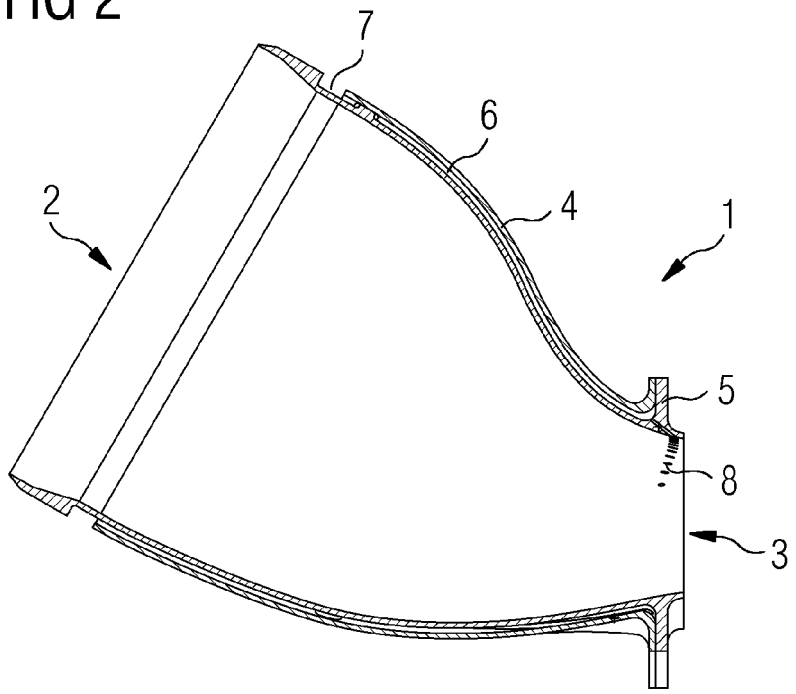


FIG 3

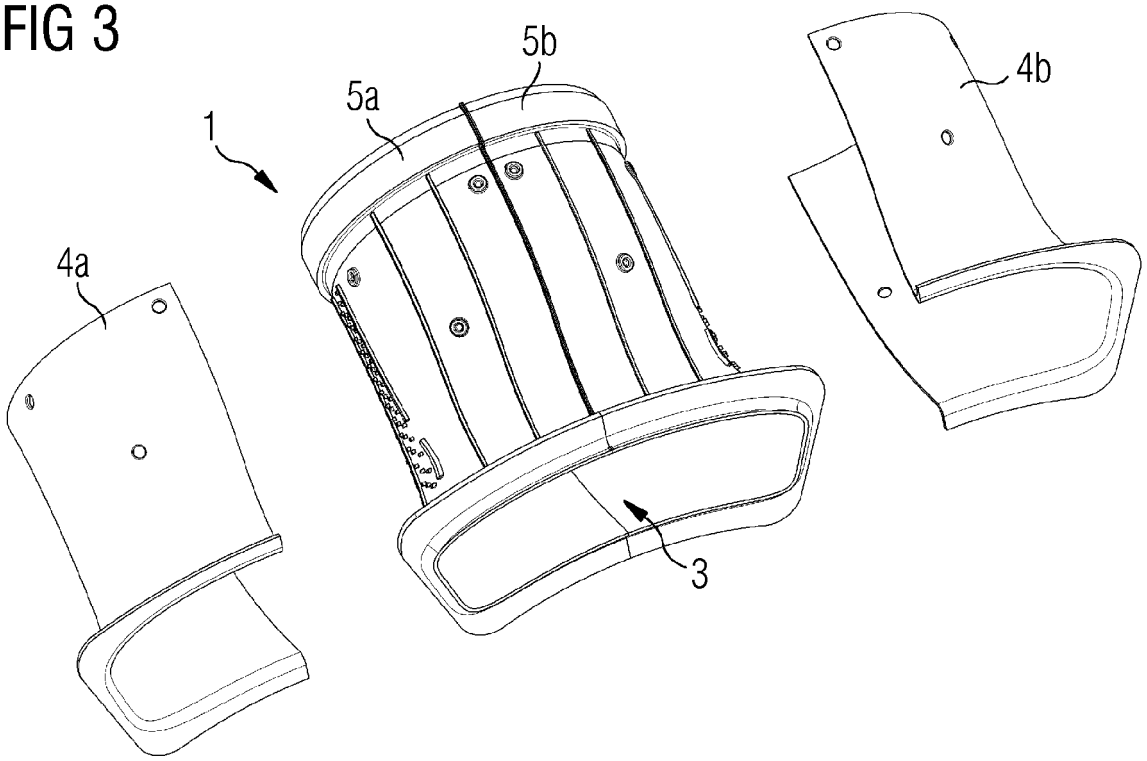


FIG 4

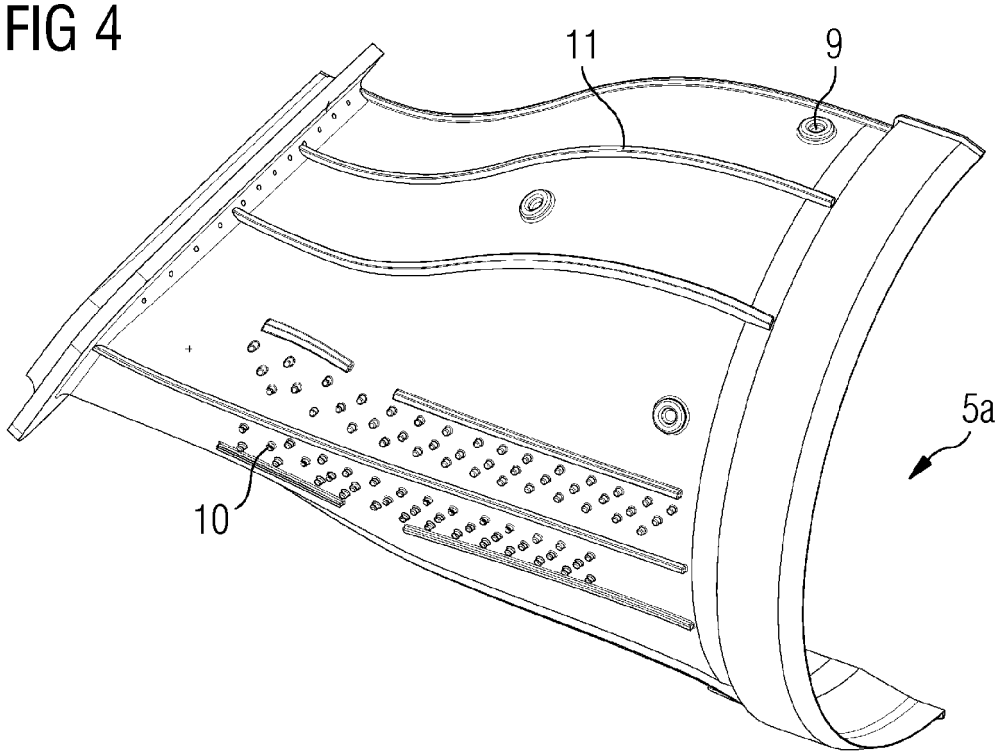


FIG 5

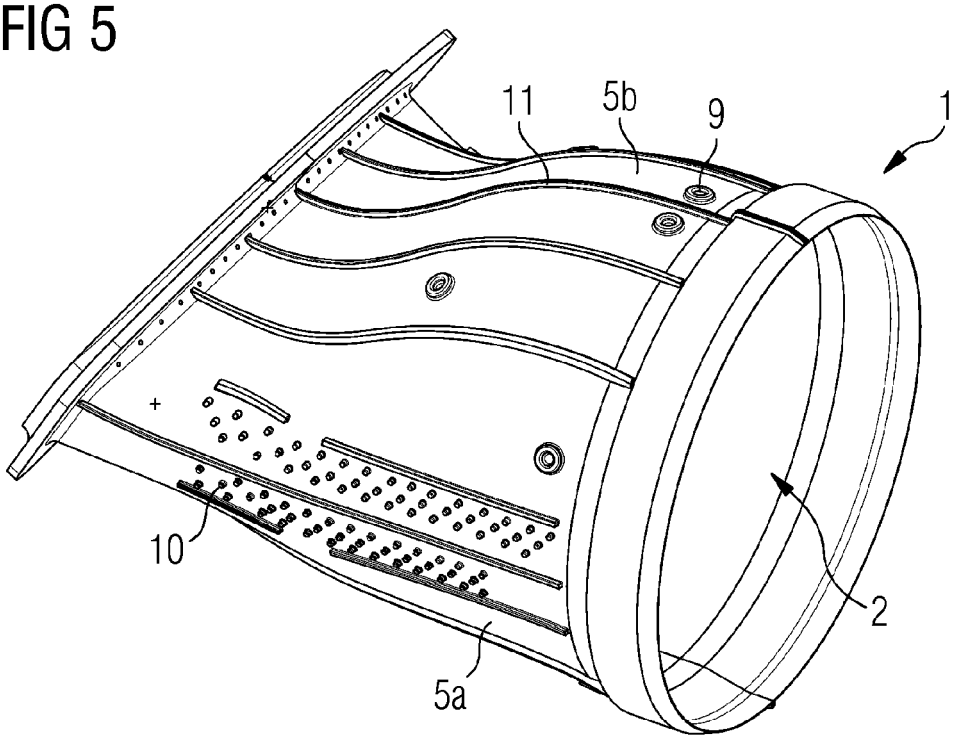
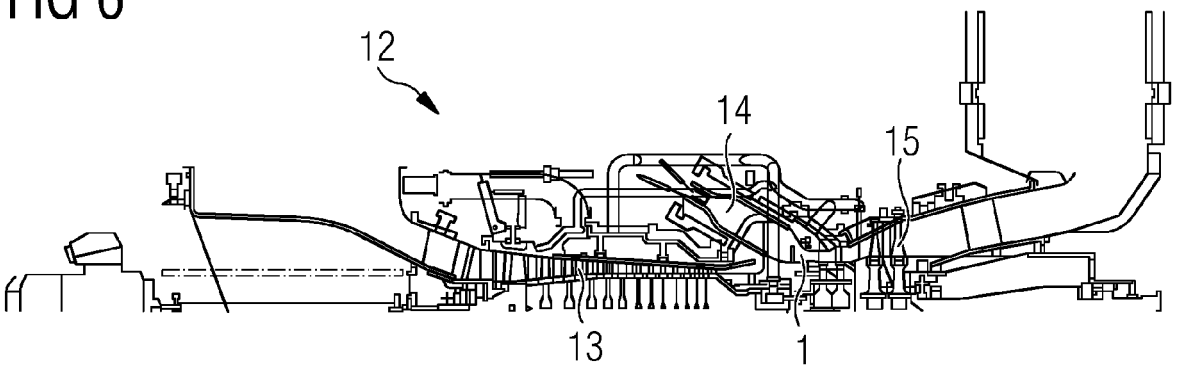


FIG 6



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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 7781

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 Y	EP 2 657 453 A2 (GEN ELECTRIC [US]) 30 October 2013 (2013-10-30) * page 2, column 2, line 24 - line 27 * * page 3, column 3 - paragraph 16 * * page 5, column 7, line 14 - line 42 * * page 5, column 8; claims 1, 8 * * page 7; figure 1 * * page 9; figure 3 * -----	1,7,8 2-6,9,10	INV. F01D9/02 F02C7/18
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Y	US 3 844 116 A (MATTO L) 29 October 1974 (1974-10-29) * column 1, lines 4-6 * * column 5; claim 1 * * figure 2 * -----	2,3,5,6, 9	
Y A	EP 2 206 886 A2 (GEN ELECTRIC [US]) 14 July 2010 (2010-07-14) * page 5, column 7 - column 8; claims 1-6,8, 11-12 * * page 10; figure 4 * -----	4,10 2,3,6,9	TECHNICAL FIELDS SEARCHED (IPC) F01D F02C
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 July 2014	Mihé, Julian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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