(19) Europäisches Patentamt
European Patent Office
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(11) EP 3 543 610 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.09.2019 Bulletin 2019/39

(51) Int Cl.:
F23R 3/10 *(2006.01)*

(21) Application number: **18425016.5**

(22) Date of filing: **23.03.2018**

(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:
KH MA MD TN

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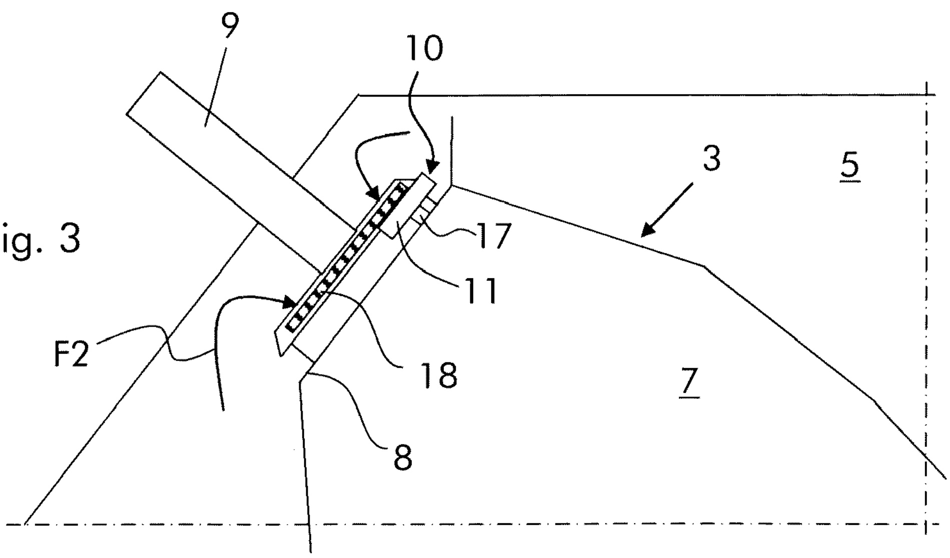
(54) **GAS TURBINE AND METHOD FOR RETROFITTING SAME**

(57) A gas turbine (1) has a compressor (2), a plenum (5) connected to the compressor (2), a combustion chamber (3) with a combustor (7) having a front plate (8) and burners (9) connected to the front plate (8). The front plate (8) and the burners (9) are at least partially housed in the plenum (5). The gas turbine comprises a damper (10) connected to the front plate (8) and housed in the plenum (5). The damper (10) has a chamber (11) tailored to the space available between adjacent burners: (9). The disclosure also refers to a method for retrofitting gas turbines.

Fig. 3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a gas turbine and a method for retrofitting same.

BACKGROUND

[0002] Gas turbines are known to comprise a compressor, a combustion chamber fed with: compressed air supplied from the compressor and with a fuel, in which combustion chamber the fuel is combusted generating a high pressure and high temperature hot gas, and a turbine where the hot gas is expanded to gather mechanical work.

[0003] In particular, the compressor is connected to a plenum and the combustion chamber has a combustor with a front plate provided with burners. The front plate and the burners are housed in the plenum, such that the compressed air is supplied into the plenum and from the plenum it enters the burners where it is mixed with the fuel and thus passes into the combustor where combustion occurs.:

[0004] The combustion process can cause pulsations that, when occurs, should be controlled and damped to prevent mechanical failure of the components of the combustion chamber.

[0005] A kind of damper often used in gas turbine applications is the so called: Helmholtz damper; Helmholtz dampers have a chamber: connected via a neck to the environment where pulsations to be damped are generated, such as the combustor of the combustion chamber.

[0006] The frequency at which the pulsations are damped depends on the volume of the chamber and the length of the neck (actually the effective length that is longer than the geometrical length), such that to damp pulsations in the relevant frequency range (e.g. between 50-500 Hz) given proportions between the chamber volume and the neck length are required.

[0007] In addition, the efficiency of the Helmholtz damper depends on the volume of the chamber, such that the larger the volume, the higher the damping effect.

[0008] Other kinds of dampers are known, such as half wave or quarter wave dampers; these dampers have similar constrains as the Helmholtz dampers with respect to geometrical proportions and volume. In the following description reference to Helmholtz dampers is made.

[0009] In order to optimize the damping effect, the dampers should be provided at an area of the combustor close to the zone where the flame is anchored during operation, because it is there that the pulsations are generated.

[0010] Nevertheless, because of the constrains imposed by the required geometrical proportions of the damper, the volume of the chamber, and the very few space available in the area of the combustor, it could be difficult or even impossible to provide dampers with the required features and at the required position.

SUMMARY

[0011] An aspect of the invention includes providing a gas turbine with a damper that is able to efficiently, damp pulsations in the required frequency range and at the same time that is provided at the required position of the combustor close to the area where the flame is anchored.

[0012] Another aspect of the invention includes providing a method for retrofitting gas turbines.

[0013] These and further aspects are attained by providing a gas turbine and a method in accordance with the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Further characteristics and advantages will be more apparent from the description of a preferred but non-exclusive embodiment of the gas turbine and method, illustrated by way of non-limiting example in the accompanying drawings, in which:

- Figure 1 schematically shows a gas turbine;
- Figure 2 shows a portion of a combustion chamber of a gas turbine without dampers;
- Figure 3 shows a portion of a combustion chamber of a gas turbine with dampers;
- Figures 4 through 7 show different examples of a front plate with burners and dampers;
- Figures 8 through 10 show enlarged portions of the front plate and the area around it in different embodiments;
- Figures 11 through 12 show different examples of dampers;
- Figure 13 shows a damper connected to a front plate.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0015] With reference to the figures, these show a gas turbine 1 having a compressor 2, a combustion chamber 3 and a turbine 4. The gas turbine further has a plenum 5 connected to the compressor 2; in the plenum 5 there is housed a front end of the combustion chamber 3. The combustion chamber 3 comprises a combustor 7 with a front plate 8 and burners 9 connected to the front plate 8. The burners 9 are connected to a fuel supply system (not shown) for fuel feeding.

[0016] The gas turbine 1 comprises one or preferably more than one dampers 10 connected to the front plate 8 and housed in the plenum 5. This way the dampers are connected to an area of the combustion chamber close to the area where the flame is anchored, the combustion process takes place and pulsations can generate. Damping in this area prevents the pulsations from propagating through the combustor and possibly damaging it.

[0017] In a preferred embodiment the combustion chamber 3 is an annular combustion chamber and the burners 9 are provided over the entire circumference of the combustion chamber. Preferably the circumferential distance between the burners is constant, but it could also vary in particular applications. Preferably all the burners lay on one circumference (figures 4 through 6, 11, 12), but embodiments with burners laying on different circumferences, such as concentric circumferences, are also possible (figure 7).

[0018] The dampers 10 have a chamber 11 tailored to the space available between adjacent burners 9. This feature allows an optimized use of the available space, such that the volume of the chambers 11 and therefore the damping efficiency can be optimized, e.g. maximized.

[0019] Preferably tailoring to the space available between adjacent dampers 10 is done in the plane of the front plate 8, as shown for example in figures 4 through 7.

[0020] Tailoring includes shaping the chamber 11 in the plane of the front plate 8 (figures 4 through 7) for the chamber shape to adapt to the available space between the burners 9.

[0021] Preferably, in order to further optimize the use of the available space, the chamber 11 is further tailored to an outer perimeter 13 of the front plate 8.

[0022] Tailoring includes shaping the chamber 11 in the plane of the front plane 8 (figures 4 through 7) for the chamber shape to adapt to the available space delimited by the outer perimeter 13.

[0023] For example, a substantially triangular space can be defined between adjacent burners 9 and the outer perimeter 13 of the front plate 8, and the chamber 11 preferably has a substantially triangular shape and is housed in this space (figure 4) .

[0024] In addition or alternatively, the front plate 8 can be annular in shape and the chamber 11 can be further tailored to an inner perimeter 15 of the front plate 8.

[0025] Tailoring includes shaping the chamber 11 in the plane of the front plane 8 (figures 5 through 7) for the chamber shape to adapt to the available space delimited by the inner perimeter 15.

[0026] For example, a substantially triangular space can be defined between adjacent burners 9 and the inner perimeter 15 of the front plate 8, and the chamber 11 has a substantially triangular shape and is housed in this space (figure 5).

[0027] In a further example, the chamber 11 can extend between the outer perimeter 13 and the inner perimeter 15 of the annular front plate 8. In this case the use of the available space is further optimized (figure 6).

[0028] In addition, in order to even further optimize the use of the available space, the chamber 11 can be tailored to a wall 16 delimiting the plenum 5 (figures 9, 10).

[0029] The damper 10 is preferably a Helmholtz damper and comprises the chamber 11 and a neck 17 that is connected between the chamber 11 and the front plate 8. Other kinds of dampers as described above (half wave or quarter wave or others) are anyhow possible.

[0030] In a preferred and advantageous embodiment, the damper 10 does not substantially affect the air flow through the burners 9, thus neither the total flow through all the burners 9, nor the flow through each burner 9 is substantially affected. For example this feature can promote retrofitting of existing gas turbines; this feature can also be useful in new gas turbines, e.g. for leaving open the possibility of upgrading or to allow the use of existing data on air flow through the dampers and/or formations of the air/fuel mixture and/or combustion during design.

[0031] With reference to figures 2 and 3, during operation a first air flow F1 passes through the burner 9 when no dampers 10 are provided connected to the front plate 8, and a second air flow F2 passes through the burner 9 when the dampers 10 (one or more dampers) are connected to the front plate 8.

[0032] The chamber 11 has a given size S in a direction facing away from the front plate 8. Advantageously, the given size S is limited so that the second air flow F2 is substantially the same as the first air flow F1.

[0033] The fact that the limited size S is limited does not imply that it is less than or equal to the distance between the openings 18 for air entrance into the burners 9 and the front plate 8; the given size S can be less than or equal to or even greater than the distance between the openings 18 for air entrance into the burners 9 and the front plate 8, provided that the air flow into the burners 9 is not substantially counteracted.

[0034] In addition, in a particularly advantageous embodiment the mass flow distribution through the burners and for each burner is not substantially affected, i.e. it is not substantially changed in case the damper is provided or not.

[0035] In this connection, the gas turbine can be provided with guides 20 that influence the air flow F2, such that the distribution of the air flow F2 is substantially the same as the distribution of the air flow F1. The guides 20 can be defined by the shape of the chamber 11 (figures 9, 12) and/or neck 17; alternatively or in addition, the guides can also be defined by baffles or steering components provided within the plenum 5 (figures 10, 11) e. g. connected to the chamber 11 and/or to the neck 17 and/or not connected either to the chamber 11 or to the neck 17 but as separate elements.

[0036] The operation of the gas turbine is apparent from that described and illustrated and is substantially the following.

[0037] The compressor 2 compresses air and supplies it into the plenum 5. From the plenum 5 the air flow F2 of compressed air enters into the burners 9 via the openings 18, it is mixed with fuel and the mixture is fed into the combustor 7. In the combustor 7 the mixture is burned generating the hot gas that is expanded in the turbine 4.

[0038] Pulsations that are generated into the combustor 7 are damper by the dampers 10. Damping is effective because thanks to the optimization of the use of the available space, the damper can be designed in order to match the frequency range to be damped and the damping efficiency with the requirements.

[0039] The invention also refers to a method for retrofitting a gas turbine.

[0040] In particular, the method comprises providing at least a damper 10 connected to the front plate 8 and housed in the plenum 5, the damper 10 having a shape tailored to the space available between adjacent burners 9.

[0041] In a preferred embodiment of the method, the damper 10 has a given size S facing away from the front plate 8, and the method comprises limiting the given size S so that the provision of the damper 10 does not affect, e.g. does not substantially causes a reduction of air flow through the burners 10.

[0042] Figure 13 shows an arrangement of a damper 10 (as described before or also of different type) that is connected to the front plate 8.

[0043] This arrangement is useful (but not mandatory) when the damper 10 has to be connected close to the position where the flame is anchored, e.g. the connection can be done to the front plate 8 or elsewhere.

[0044] Figure 13 shows the Helmholtz damper having the chamber 11 and the neck 17 connected to the front plate 8; this figure also shows the burner 9 and a flame 21 generated by the fuel supplied via the burner 9; the flame can either be a premixed flame or a diffusion flame.

[0045] The damper 10 has its terminal portion 23 inserted in an opening 25 of the front plate 8. In particular between the opening 25 and the terminal portion 23 a gap 26 (e.g. annular gap) is defined. The terminal portion 23 of the damper 10 facing the front plate 8 is flared.

[0046] The gap 26 and the flared terminal portion 23 are advantageous because they provide an efficient way to cool the terminal portion 23. In fact, the gap 26 allows air flow through it; such an air flow cools the terminal part 23 of the damper 10.

[0047] In addition, since the gap 26 constitutes a restricting nozzle for the air- flow (e.g. because of the flared terminal portion 23) the air flow accelerates when passing through the gap 26, further improving the cooling efficiency.

[0048] In addition, notwithstanding the cooling, the operation of the damper 10 and thus its damping efficiency is not affected. In fact the flared terminal portion 23 defines a diverging nozzle that injects the air flow away from the neck 17, e.g. over a conical path. The vortices 28 at the neck 17 (these vortices damp the vibrations) are thus not affected and damping efficiency is consequently not affected.

[0049] For example, when the damper 10 is at a position close to the flame 21, this arrangement advantageously allows to cool the neck 17 preventing its damage without affecting its damping efficiency.

[0050] Naturally the features described may be independently provided from one another. For example, the features of each of the attached claims can be applied independently of the features of the other claims.

[0051] In practice the materials used and the dimensions can be chosen at will according to requirements and to the state of the art.

REFERENCE NUMBERS

[0052]

1 gas turbine
2 compressor
3 combustion chamber
4 turbine
5 plenum
7 combustor
8 front plate
9 burners
10 damper
11 chamber
13 outer perimeter
15 inner perimeter
16 wall of the plenum
17 neck
18 openings
20 guide
21 flame
23 terminal portion
25 opening
26 gap
28 vortices
F1 first air flow
F2 second air flow
S size of the damper

Claims

1. A gas turbine (1) having a compressor (2), a plenum (5) connected to the compressor (2), a combustion chamber (3) with a combustor (7) having a front plate (8) and burners (9) connected to the front plate (8), the front plate (8) and the burners (9) being at least partially housed in the plenum (5), **characterised by** comprising at least a damper (10) connected to the front plate (8) and housed in the plenum (5), the damper (10) having a chamber (11) tailored to the space available between adjacent burners (9).

2. The gas turbine (1) according to claim 1, **characterized in that** the chamber (11) of the damper (10) is further tailored to an outer perimeter (13) of the front plate (8).

3. The gas turbine (1) according to claim 2, **characterized in that** a substantially triangular space is defined between adjacent burners (9) and the outer perimeter (13) of the front plate (8), the chamber (11) having a substantially triangular shape and being housed in this space.

4. The gas turbine (1) according to any one of claims

1 through 3, **characterized in that** the front plate (8) is annular in shape and the chamber (11) is further tailored to an inner perimeter (15) of the front plate (8).

5. The gas turbine (1) according to claim 4, **characterized in that** a substantially triangular space is defined between adjacent burners (9) and the inner perimeter (15) of the front plate (8), the chamber (11) having a substantially triangular shape and being housed in this space.

6. The gas turbine (1) according to claim 2 and 4, **characterized in that** the chamber (11) extends between the outer perimeter (13) and the inner perimeter (15) of the annular front plate (8).

7. The gas turbine (1) according to any one of the previous claims, **characterized in that** the chamber (11) is tailored to a wall delimiting the plenum (5).

8. The gas turbine (1) according to any one of the previous claims, **characterized in that** the damper (10) is a Helmholtz damper and comprises the chamber (11) and a neck (17), the neck (17) being connected ' between the chamber (11) and the front plate (8).

9. The gas turbine (1) according to any one of the previous claims, **characterized in that** during operation a first air flow (F1) passes through the burners (9) when no damper (10) is provided connected to the front plate (8), and
a second air flow (F2) passes through the burners (9) when the damper (10) is provided connected to the front plate (8),
wherein
the chamber (11) has a given size (S) in a direction facing away from the front plate (8), and
the given size (S) is limited so that the second air flow (F2) is substantially the same as the first air flow (F1).

10. The gas turbine (1) according to any one of the previous claims, **characterized in that** during operation a first air flow (F1) passes through the burners (9) when no damper (10) is provided connected to the front plate (8), and
a second air flow (F2) passes through the burners (9) when the damper (10) is provided connected to the front plate (8),
characterized by being provided with at least a guide that influences the second air flow (F2), such that the distribution of the second air flow (F2) is substantially the same as the distribution of the first air flow (F1).

11. The gas turbine (1) according to claim 10, **characterized in that** the at least a guide is defined by the shape of the chamber (11) and/or neck (17), and/or the at least a guide is defined by at least a baffle or steering component provided within the plenum (5).

12. The gas turbine (1) according to any one of the previous claims, **characterized in that**
the damper (10) has a terminal portion (23) facing the front plate (8),
the front plate (8) has an opening (25),
the terminal portion (23) is flared,
the terminal portion (23) is inserted into the opening (25),
a gap (26) is defined between the terminal portion (23) and the opening (25),
the gap (26) defines a diverging nozzle for injecting the air flow away from the damper (10).

13. The gas turbine (1) according to claim 12, **characterized in that** the gap (26) defines a restricting nozzle that accelerates the air flow passing through it.

14. Method for retrofitting a gas turbine (1) having a combustion chamber (3) with a front plate (8), a plenum (5) facing the front plate (8), burners (9) housed in the plenum (5) and connected to the front plate (8), the method being **characterised by** providing at least a damper (10) connected to the front plate (8) and housed in the plenum (5), the damper (10) having a shape tailored to the space available between adjacent burners (9).

15. The method according to claim 14, wherein
the damper (10) has a given size (S) facing away from the front plate (8),
the method being **characterized by** limiting the given size (S) of the damper (10) so that the provision of the damper (10) does not affect the air flow through the burners (9).

Fig. 1

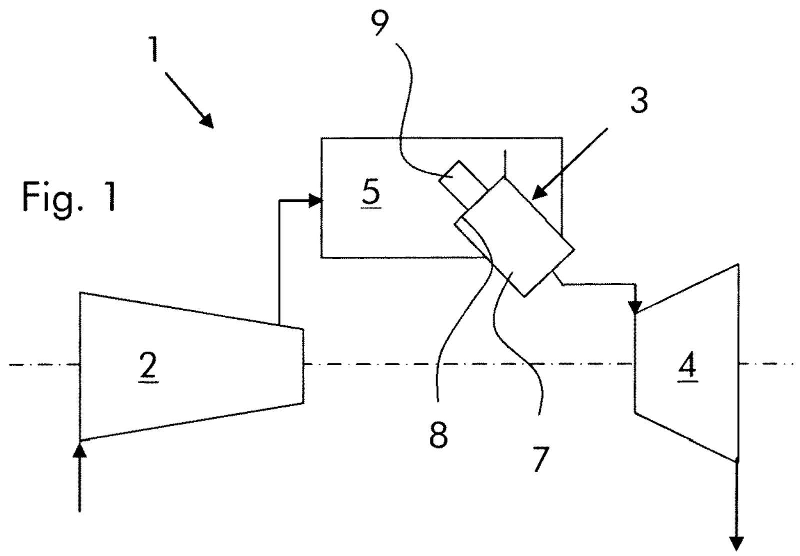


Fig. 2

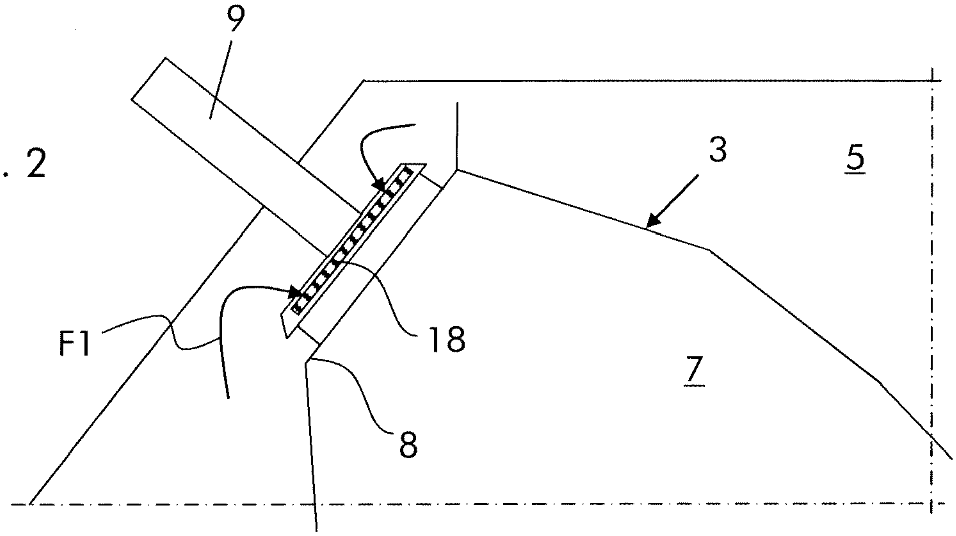


Fig. 3

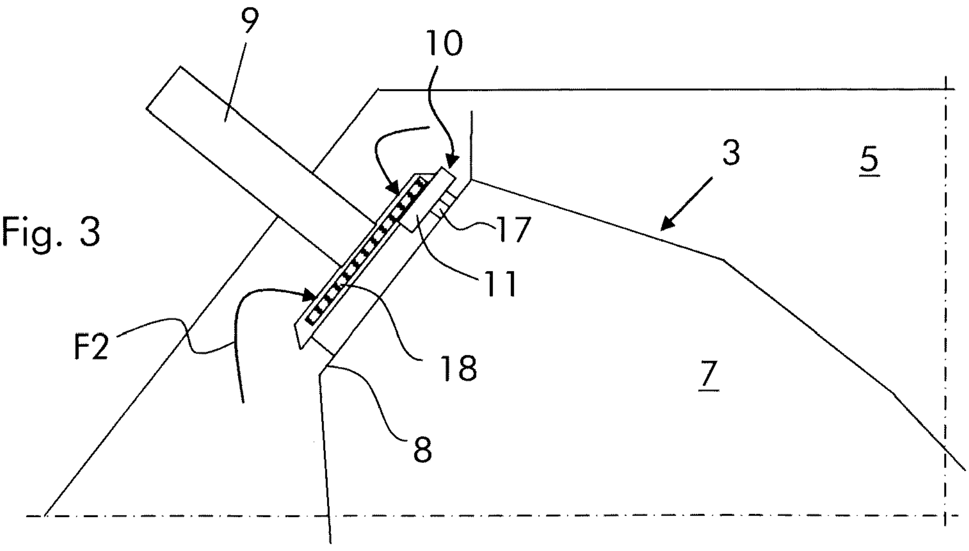


Fig. 4

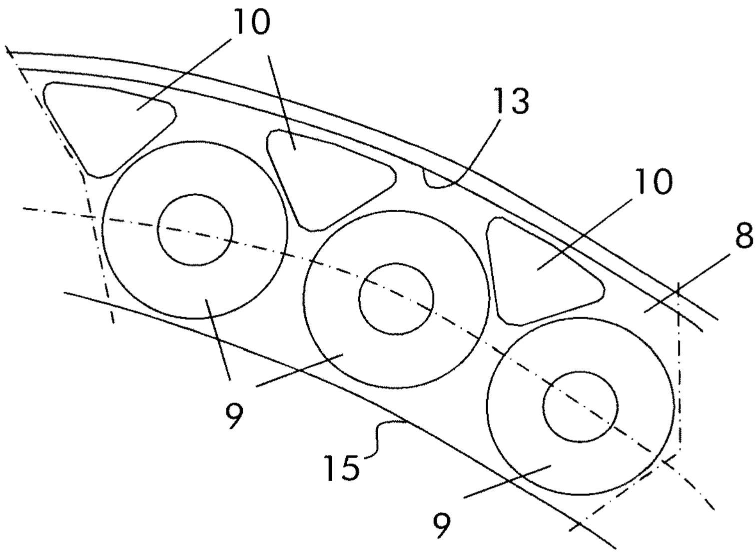


Fig. 5

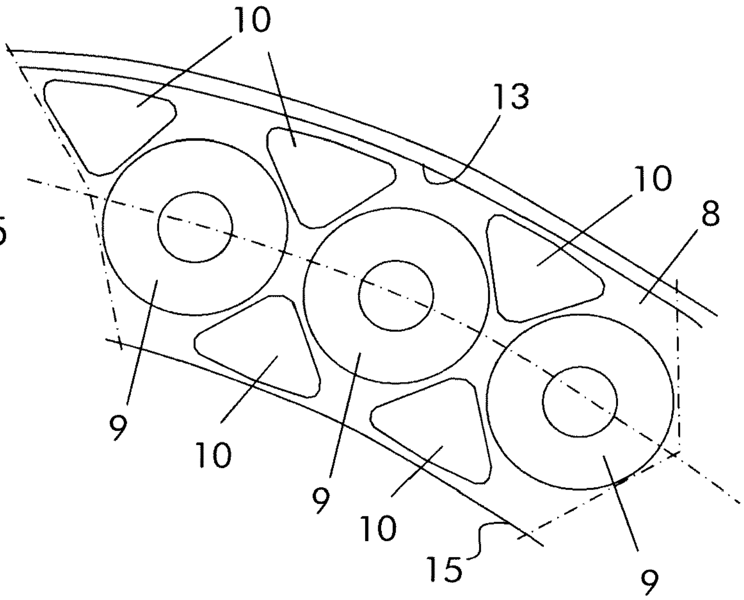
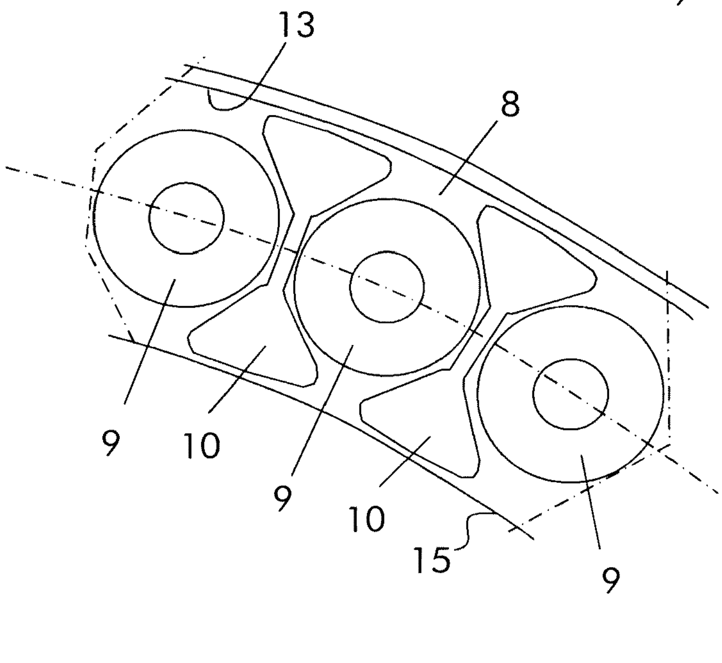


Fig. 6



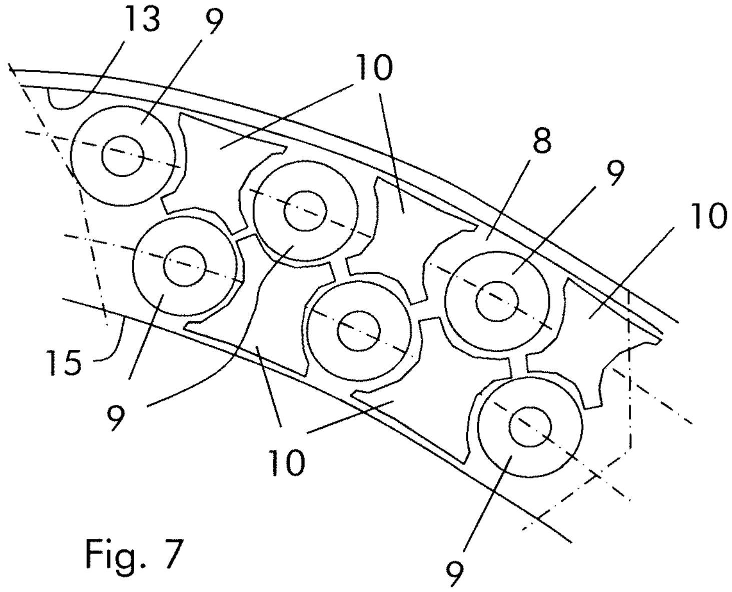


Fig. 7

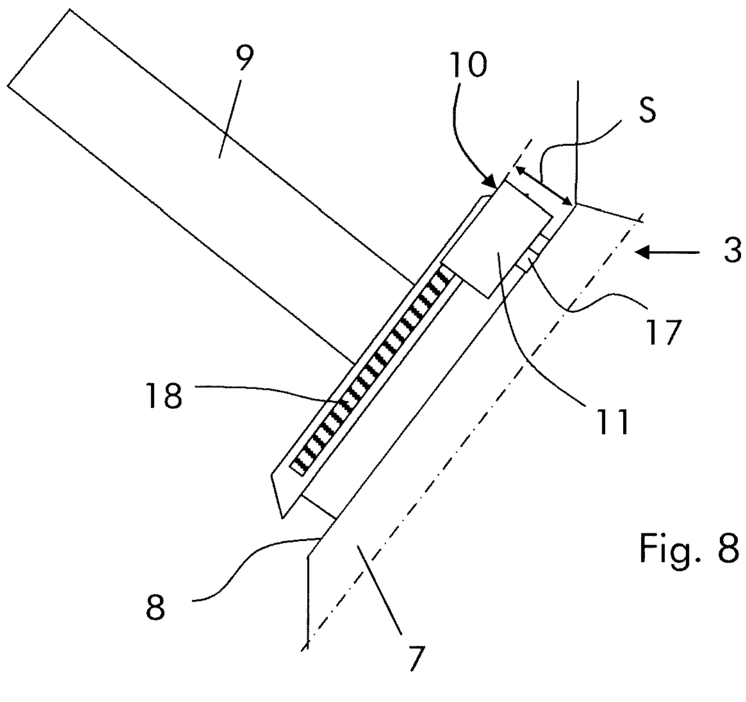


Fig. 8

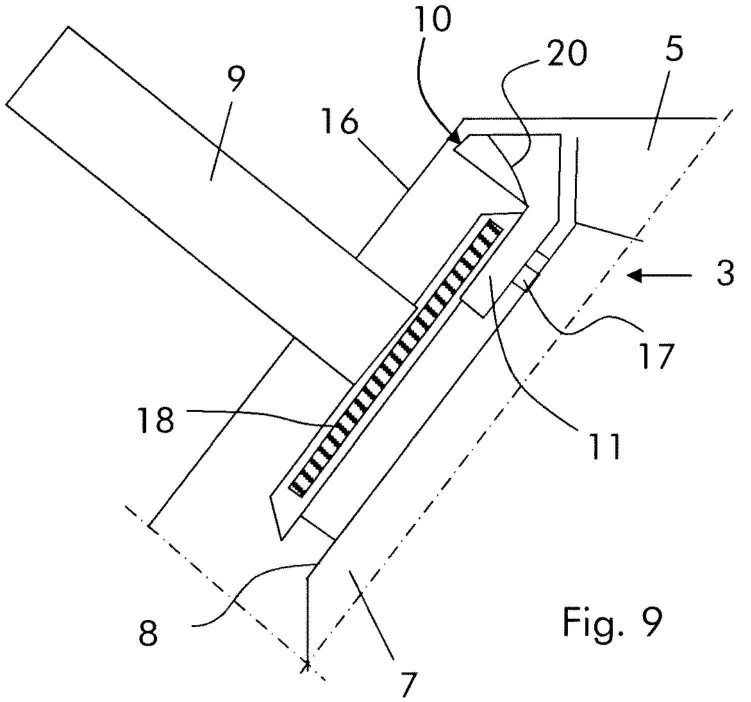
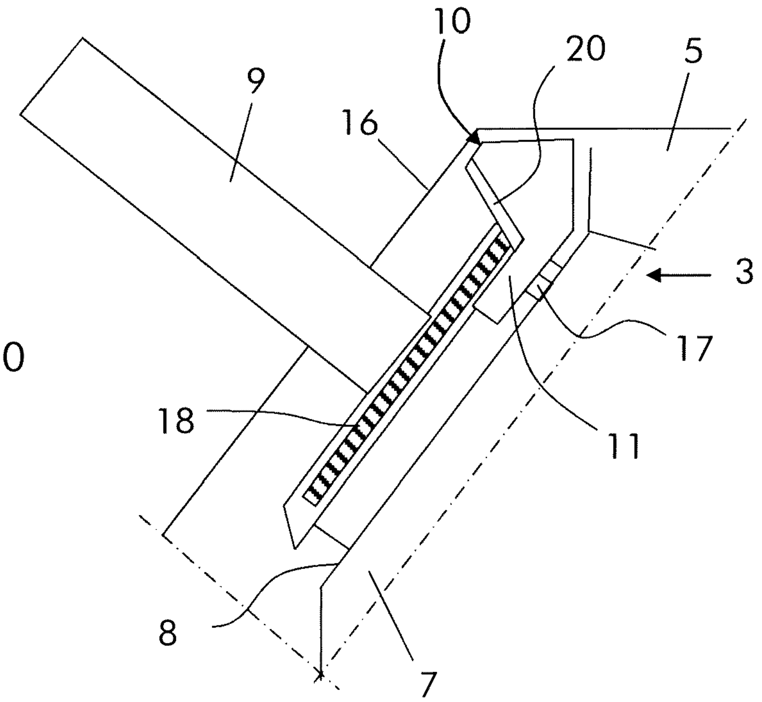


Fig. 9

Fig. 10



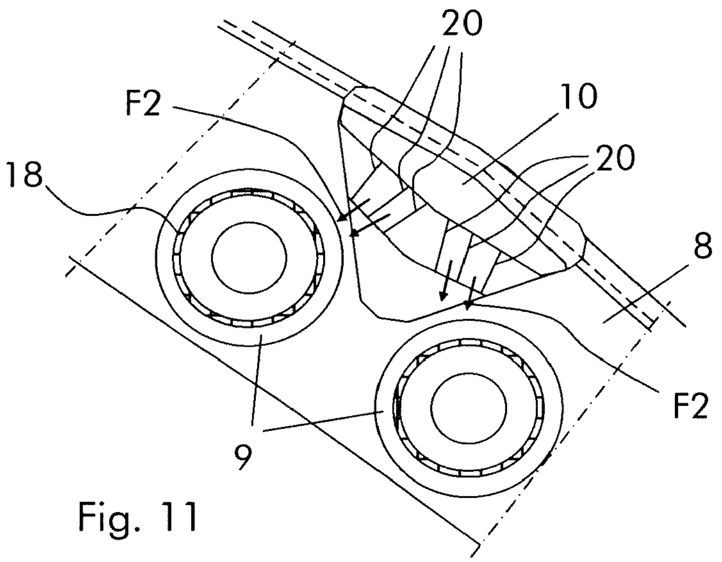


Fig. 11

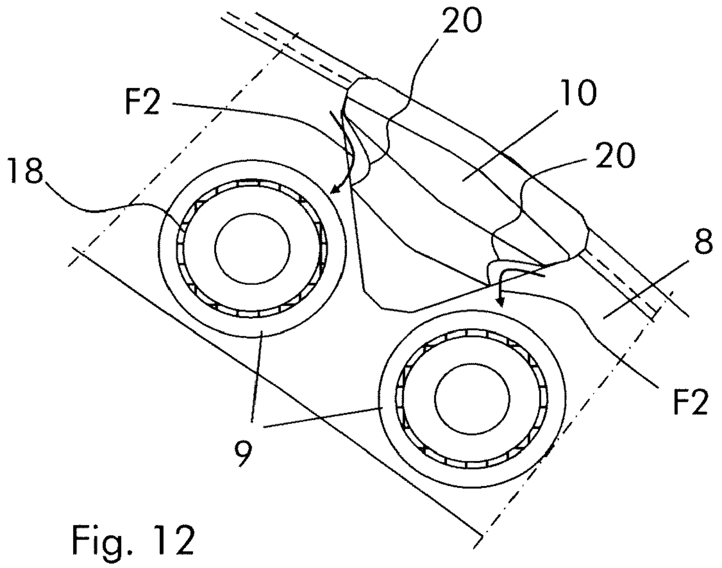


Fig. 12

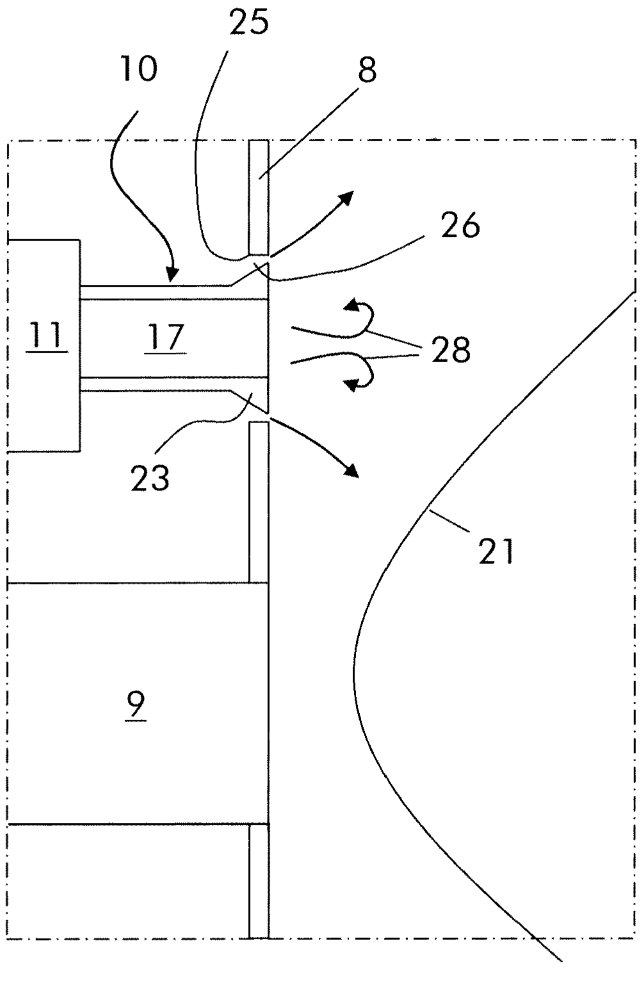


Fig. 13

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EUROPEAN SEARCH REPORT

Application Number
EP 18 42 5016

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	DE 10 2015 218677 A1 (SIEMENS AG [DE]) 30 March 2017 (2017-03-30) * page 3, paragraph 25 - page 4, paragraph 32 * * figures 1-5 *	1-7,9, 10,14,15	INV. F23R3/10
X	US 2017/082287 A1 (BECK CHRISTIAN [DE] ET AL) 23 March 2017 (2017-03-23) * page 2, paragraph 26 - page 3, paragraph 36 * * figures 1-5 *	1-7,9, 10,14,15	
X	US 2013/062425 A1 (BELSOM KEITH C [US] ET AL) 14 March 2013 (2013-03-14) * page 2, paragraph 22 - page 4, paragraph 33 * * figures 1-9 *	1,2,4,6, 7,14	

TECHNICAL FIELDS SEARCHED (IPC)

F23R

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 October 2018	Rudolf, Andreas

CATEGORY OF CITED DOCUMENTS

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