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

(11) EP 3 029 376 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.06.2016 Bulletin 2016/23

(51) Int Cl.:
F23R 3/00 *(2006.01)*

(21) Application number: **14195660.7**

(22) Date of filing: **01.12.2014**

(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

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(54) Helmholtz damper and gas turbine with such a helmholtz damper

(57) A Helmholtz damper (24), especially for damping pulsations in a combustor of a gas turbine, comprises a damper volume (25, which can be connected to a damped space (19) by means of a neck tube (26), and further comprises a piston (27), which is moveable within said damper volume (25) and divides said damper volume (25) into a variable first part (V1) on one side of said piston (27), which variable first part (V1) is connected to said neck tube (26), and a correspondingly variable second part (V2) on the other side of said piston (27).

The control mechanism is substantially simplified in a more compact design by said piston (27) being driven by a pressure drop (Δp) between said first and second part (V1, V2) of said damper volume (25).

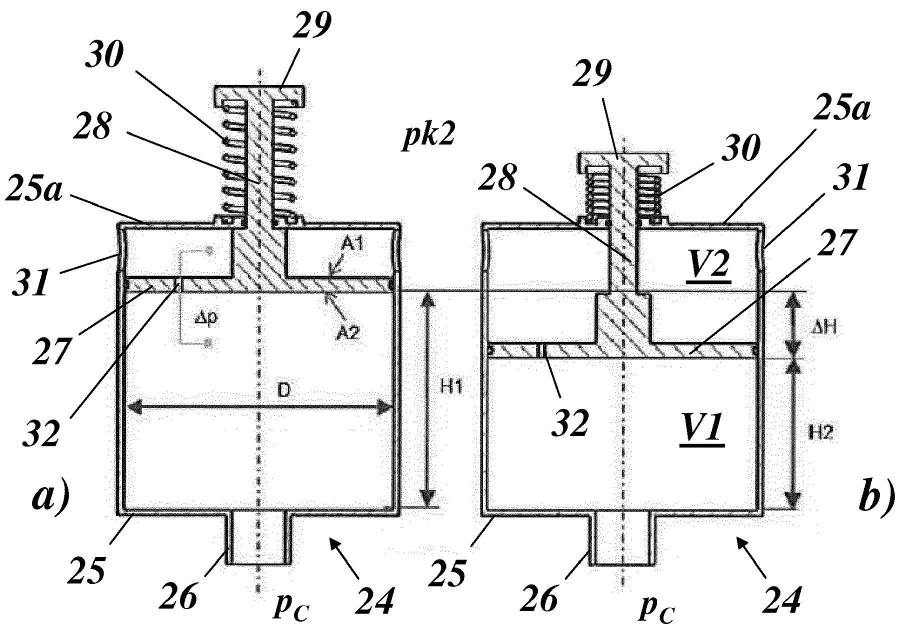

Fig.4

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to the field of combustion technology. It refers to a Helmholtz damper according to the preamble of claim 1.

[0002] It further refers to a gas turbine with such a Helmholtz damper.

PRIOR ART

[0003] Fig. 1 shows in a perspective view an exemplary stationary or industrial gas turbine of the GT13 E2 type. The gas turbine 10 comprises in a casing 13 a rotor 12, which rotates around a machine axis and defines within the casing 13 an annular hot gas channel extending in axial direction through the machine. A compressor 14 with several stages of running blades compresses air, which enters the machine through an air inlet 11. The compressed air with a compressor outlet pressure pk2 fills a plenum and enters a combustor 15, where it is mixed with a fuel supplied by a plurality of burners 16. In this case, the burners 16 are configured as so-called AEV (or Advanced Environmental Vortex) burners, which are described for example in document WO 2009/109454.

[0004] Fig. 2 shows the main parameters of a generic Helmholtz damper configuration. The Helmholtz damper 20 of Fig. 2 comprises a damper volume 21 with a volume V, which is in fluidic connection with a damped space (combustor) 19 via a neck tube 22 of length L_N and inner diameter D_N; u denotes the bias mean flow. The resonance frequency f of this damper can be approximately calculated by the formula:

$$f \approx \frac{c}{2\pi}\sqrt{\frac{A_N}{V(L_N + dL_N)}}$$

with the speed of sound c, and the area AN and length L_N of neck tube 22.

[0005] This means, that

$$f \sim \sqrt{\frac{1}{V}}\,.$$

[0006] When Helmholtz damper 20 is attached to the combustor 15 of gas turbine 10 of Fig. 1, it is surrounded by the plenum of the gas turbine, which is filled with compressed air of compressor outlet pressure pk2. Cooling air is introduced into damper volume 21 through an orifice 23, which experiences a pressure drop Δp due to the difference between the (higher) compressor outlet pressure pk2 and the (lower) pressure within the combustion chamber of the combustor.

[0007] Further, it is known that the frequency of the pulsations within the combustor depends on the operation mode of the gas turbine. Especially, there is a change in pulsation frequency f_P, when the gas turbine changes from part load operation to base load operation, and vice versa. For a gas turbine of the type shown in Fig. 1 there can be a change of up to 20% of pulsation frequency f_P between part load and base load, with the pulsation frequency increasing with growing load.

[0008] To maintain the maximum damping properties of Helmholtz dampers used with such gas turbine, the resonance frequency of the dampers should stay tuned to the pulsation frequency even if the load conditions of the gas turbine change. According to the formula given above, the damper volume V should be changed in accordance with a change in the load conditions.

[0009] In the prior art, there are solutions described on closed loop volume adjustments in Helmholtz dampers by moving pistons. This, however, is not a solution for an actual engine due to high costs of control device (loop), stepping motor, and manufacturing tolerance of piston.

[0010] Another existing solution is to simply place more dampers that are tuned to different frequencies.

[0011] Some of the known solutions are cited below:

[0012] Document EP 2 397 761 A1 discloses a Helmholtz damper and a method for regulating the resonance frequency of a Helmholtz damper. In particular, it refers to Helmholtz dampers to be connected to lean premixed, low emission combustion systems of gas turbines, whereby said Helmholtz damper comprises an enclosure from which a neck extends, and a pipe is inserted into and fits the neck.

[0013] Especially, an actuator is connected to the pipe to adjust its portion inserted into the neck.

[0014] Document EP 2 397 760 A1 discloses a damper arrangement that has a first Helmholtz damper connected in series to a second Helmholtz damper. The resonance frequency of the first Helmholtz damper and the resonance frequency of the second Helmholtz damper are shifted from one another in an amount producing a synergic damping effect.

[0015] Document DE 100 26 121 A1 describes an apparatus for damping acoustic vibrations in a combustor as well as a corresponding combustor arrangement with the apparatus. The apparatus comprises a Helmholtz resonator that can be connected via a connecting channel with a combustor. The Helmholtz resonator contains a hollow body the volume of which can be changed by adding or draining a fluid via a supply line, or is located adjacent to such a hollow body in such a way that the resonance volume of the Helmholtz resonator is changed when the volume of the hollow body is changed. This apparatus makes it possible to adjust the resonance frequency of a Helmholtz resonator arranged inside a pressure container in accordance with the respective current operating point of the combustor to be damped, without having to pass movable components through the pressure container.

[0016] Document US 8,661,822 B2 discloses a system with a turbine engine, comprising: a compressor; a turbine; a combustor disposed downstream from the compressor and upstream from the turbine; a fluid injection system configured to inject one or more fluids into the combustor; a variable geometry resonator coupled to the fluid injection system; and a controller configured to tune the variable geometry resonator in response to feedback.

[0017] However, the problem with all these solutions is that they increase costs on the one hand and often are not possible at all to apply due to limited space to put dampers inside an engine.

SUMMARY OF THE INVENTION

[0018] It is an object of the present invention to provide a Helmholtz damper, which is simple in construction, requires minimum space and has a self-adjusting capability.

[0019] It is another object of the invention to provide a Helmholtz damper with a design that allows an adjustment of the damper volume in a way that is applicable to the combustor environment inside an engine and fulfils requirements of robustness and costs.

[0020] It is a further object of the invention to provide a gas turbine with such a Helmholtz damper.

[0021] These and other objects are obtained by a Helmholtz damper according to Claim 1 and a gas turbine according to Claim 8.

[0022] The Helmholtz damper according to the invention, which is especially suitable for damping pulsations in a combustor of a gas turbine, comprises a damper volume, which can be connected to a damped space by means of a neck tube, and further comprises a piston, which is moveable within said damper volume and divides said damper volume into a variable first part on one side of said piston, which variable first part is connected to said neck tube, and a correspondingly variable second part on the other side of said piston. It is characterized in that said piston is driven by a pressure drop between said first and second part of said damper volume.

[0023] An embodiment of the Helmholtz damper according to the invention is characterized in that the piston is held in an idle position, where the first part of said damper volume is a maximum, by means of a spring, and that said pressure drop drives said piston against the force of said spring.

[0024] Specifically, said spring is arranged within said first part of said damper volume.

[0025] Alternatively, said spring may be arranged outside of said damper volume and acts on said piston via a piston rod, which extends from said piston to the outside of said damper volume.

[0026] Specifically, said spring is a helical spring.

[0027] Another embodiment of the Helmholtz damper according to the invention is characterized in that said second part of said damper volume is in fluidic connection with the outside of said damper volume.

[0028] Specifically, said damper volume is enclosed by a housing, and said fluidic connection is established by at least one opening in said housing.

[0029] The gas turbine according to the invention comprises a compressor, at least one combustor and a turbine, whereby said at least one combustor is enclosed by a combustor casing, the outside of which is exposed to the compressor outlet pressure of said compressor, whereby at least one Helmholtz damper is provided at and connected to one combustor in order to damp pulsations within said combustor. It is characterized in that said at least one Helmholtz damper is a Helmholtz damper according to the invention, and that a pressure drop between said compressor outlet pressure and the pressure within said combustor is used to drive said piston of said at least one Helmholtz damper.

[0030] An embodiment of the gas turbine according to the invention is characterized in that said at least one Helmholtz damper is attached to the combustor casing by adaptation means.

[0031] Specifically, said at least one Helmholtz damper is connected to said combustor through a hole in said combustor casing, and said adaptation means comprises an insert, which fits into said hole and receives a neck tube of said at least one Helmholtz damper such that said neck tube passes through said insert to open out into said combustor.

[0032] More specifically, a neck tube adapter is provided to seal said neck tube against said insert.

[0033] Especially, said neck tube is releasably connected to the damper volume of said at least one Helmholtz damper.

[0034] Another embodiment of the gas turbine according to the invention is characterized in that said combustor is of an annular configuration, and that a plurality of Helmholtz dampers are circumferentially arranged around said combustor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] The present invention is now to be explained more closely by means of different embodiments and with reference to the attached drawings.

Fig. 1 shows in a perspective view a stationary gas turbine of the GT13 E2 type, which is suitable for being used with Helmholtz dampers according to the invention;

Fig. 2 shows the main parameters of a basic Helmholtz damper configuration;

Fig. 3 shows an example of the absolute pressure drop Δp as a function of relative gas turbine load for an exemplary gas turbine;

Fig. 4 shows an embodiment of the Helmholtz damper according to the invention with the piston (a) in a starting position and (b) in an active position driven by a certain pressure drop Δp;

Fig. 5 shows a Helmholtz damper according to another embodiment of the invention attached and coupled to the combustor of a gas turbine of the type shown in Fig. 1; and

Fig. 6 shows (a) in detail the Helmholtz damper of Fig. 5 and (b) in even more detail the piston of said damper;

Fig. 7 shows a Helmholtz damper according to a further embodiment of the invention attached and coupled to a can combustor.

DETAILED DESCRIPTION OF DIFFERENT EMBODIMENTS OF THE INVENTION

[0036] As has been said before, the pulsation frequency in gas turbine combustors usually increases with relative load. A damper that is optimized for part load operation consequently does not exhibit its maximum damping performance at base load and vice versa.

[0037] The idea of this invention is to make use of the relative pressure drop Δp between compressor plenum and combustion chamber that also increases with relative load RL_{GT}. Fig. 3 shows the results of measurements of the absolute pressure drop Δp as a function of relative gas turbine load for an exemplary gas turbine.

[0038] The invention seeks to explore this fact in such a way that the volume V of the damper is reduced so that its resonance frequency is continuously adjusted in order to provide highest damping at the required frequency. This is possible due to the fact that the outside of the damper volume is exposed the compressor outlet pressure pk2, whereas the pressure inside the damper is very close to that of the combustion chamber.

[0039] Fig. 4 shows an embodiment of the Helmholtz damper according to the invention. In Fig. 4(a) shows the damper in a starting position with its damper volume being a maximum. Fig. 4(b) shows the damper in an active position, wherein the damper volume has been automatically reduced due to an increased pressure drop Δp between inside and outside of the damper.

[0040] The Helmholtz damper 24 according to Fig. 4 comprises damper volume 25, which is enclosed by a housing 25a. The damper volume 25 is divided by means of a piston 27 which is moveable within said damper volume 25, into a variable first part V1 on one side of the piston 27, and a correspondingly variable second part V2 on the other side of said piston 27. The variable first part V1 is connected to a neck tube 26 of said Helmholtz damper 24. The variable second part V2 is connected to the outside of Helmholtz damper 24 by means of openings 31 provided in housing 25a. In this way, combustor pressure p_C acts through neck tube 26 on one side of piston 27 with area A2, while compressor outlet pressure pk2 acts through openings 31 on the other side of piston 27 with area A1, such that a pressure drop $\Delta p = pk2 - p_C$ exists across piston 27. An orifice 32 may be provided through piston 27 to allow the access of some cooling air.

[0041] When Helmholtz damper 24 is in its starting position (Fig. 4(a)), the volume is defined by diameter D or area A1 and height H1. When piston 27 has been moved a distance ΔH due to an associated pressure drop Δp (Fig. 4(b)), the damper volume (V1) has been decreased to A2 x H2. The driving force of pressure drop Δp on piston 27 is balanced by the spring force of a helical spring 30, which is in this case arranged outside the damper volume and is compressed, when piston 27 leaves its starting position. The spring 30 is arranged between the top of housing 25a and a bearing plate 29 at the end of a piston rod 28, which extends from piston 27 to the outside of damper volume 25 and serves to couple the balancing spring force to piston 27.

[0042] A more compact design of a Helmholtz damper according to the invention, which is more suitable for being applied to a gas turbine combustor 33, is shown in Fig. 5 and 6.

[0043] Helmholtz damper 38 of Fig. 5 and 6 is attached to combustor casing 34 at a place, where the hot gas 39 is guided to combustor outlet 35. Helmholtz damper 38 comprises a damper volume 40 enclosed by a housing 40a, and divided by a piston 44. Housing 40a is on its upper side in fluidic connection with the environment (plenum pressure pk2) by means of a wide opening 46. At its lower side, it is closed by a bowl-like base element 41. A separate neck tube 43, which extends from the combustion chamber into the interior of damper volume 40, connects the damper volume with the combustor. Neck tube 43 is fixed in a neck tube adapter 42, which is held between base element 41 and an insert 37 that is used to mount the damper arrangement in a hole 36 in the combustor casing 34. The neck tube 43 may be of any cross-sectional shape.

[0044] Piston 44, which has an orifice 47 for cooling purposes, is designed as a free piston. A balancing helical spring 45 is arranged within the damper volume 40. This configuration with a free piston and an internal balancing spring is on one hand very compact, requiring only minimal space, and on the other hand is protected against impacts from outside.

[0045] The embodiment of Fig.7 schematically illustrates a Helmholtz damper 48 attached to a can combustor 49. Arrow 39 represents the hot gas flow. The damper 48 is circumferentially arranged around the can combustor 49, forming an annular damper volume 40, surrounding the combustion chamber or hot gas path respectively. At least one neck tube 43 of any cross-sectional design connects the space 19, to be damped, with the variable first part V1 of the damper volume 40. At least one opening 46 connects the variable second volume V2 with an environment outside of the Helmholtz damper 48. The variable first part V1 of the damper volume 40 and the variable second part V2 of the damper volume 40 are separated by the piston 44. The piston 44 is arranged and designed to perform a movement parallel to the axis of the combustor 49, thereby interacting with the balancing spring 45 of the helical type, arranged within the damper volume 40 along the lateral surface area of the damper housing 40a.

LIST OF REFERENCE NUMERALS

[0046]

10	gas turbine (e.g. of type GT13 E2)
11	air inlet
12	rotor
13	casing
14	compressor
15,33,49	combustor
16	AEV burner
17	turbine
18	exhaust gas outlet
19	damped space
20,24,38,48	Helmholtz damper (HHD)
21,25,40	damper volume
22,26,43	neck tube
23,32,47	orifice
25a,40a	housing
27,44	piston
28	piston rod
29	bearing plate
30,45	spring (helical)
31,46	opening
34	combustor casing
35	combustor outlet
36	hole
37	insert
39	hot gas
41	base element
42	neck tube adapter
A1,A2	area
H1,H2	height
ΔH	height difference
Δp	pressure drop
p_C	combustor pressure
pk2	compressor outlet pressure
RL_{GT}	relative GT load

Claims

1. Helmholtz damper (24, 38), especially for damping pulsations in a combustor (33) of a gas turbine, comprising a damper volume (25, 40), which can be connected to a damped space (19) by means of a neck tube (26, 43), and further comprising a piston (27, 44), which is moveable within said damper volume (25, 40) and divides said damper volume (25, 40) into a variable first part (V1) on one side of said piston (27, 44), which variable first part (V1) is connected to said neck tube (26, 43), and a correspondingly variable second part (V2) on the other side of said piston (27, 44), **characterized in that** said piston (27, 44) is driven by a pressure drop (Δp) between said first and second part (V1, V2) of said damper volume (25, 40).

2. Helmholtz damper as claimed in Claim 1, **characterized in that** the piston (27, 44) is held in an idle position, where the first part (V1) of said damper volume (25, 40) is a maximum, by means of a spring (30, 45), and that said pressure drop (Δp) drives said piston (27, 44) against the force of said spring (30, 45).

3. Helmholtz damper as claimed in Claim 2, **characterized in that** said spring (45) is arranged within said first part (V1) of said damper volume (40).

4. Helmholtz damper as claimed in Claim 2, **characterized in that** said spring (30) is arranged outside of said damper volume (25) and acts on said piston (27) via a piston rod (28), which extends from said piston (27) to the outside of said damper volume (25).

5. Helmholtz damper as claimed in Claim 2, **characterized in that** said spring (30, 45) is a helical spring.

6. Helmholtz damper as claimed in Claim 1, **characterized in that** said second part (V2) of said damper volume (25, 40) is in fluidic connection with the outside of said damper volume (25, 40).

7. Helmholtz damper as claimed in Claim 6, **characterized in that** said damper volume (25, 40) is enclosed by a housing (25a, 40a), and that said fluidic connection is established by at least one opening (31, 46) in said housing (25a, 40a).

8. Gas turbine (10) comprising a compressor (14), at least one combustor (33) and a turbine (17), whereby said at least one combustor (33) is enclosed by a combustor casing (34), the outside of which is exposed to the compressor outlet pressure (pk2) of said compressor (14), whereby at least one Helmholtz damper (24, 38) is provided at and connected to one combustor (33) in order to damp pulsations within said combustor (33), **characterized in that** said at least one Helmholtz damper (24, 38) is a Helmholtz damper (24, 38) as claimed in one of the Claims 1 to 7, and that a pressure drop between said compressor outlet pressure (pk2) and the pressure within said combustor (33) is used to drive said piston (27, 44) of said at least one Helmholtz damper (24, 38).

9. Gas turbine as claimed in Claim 8, **characterized in that** said at least one Helmholtz damper (38) is attached to said combustor casing (34) by adaptation means (37, 41, 42).

10. Gas turbine as claimed in Claim 9, **characterized in that** said at least one Helmholtz damper (38) is connected to said combustor (33) through a hole (36) in said combustor casing (34), and that said adaptation means (37, 41, 42) comprises an insert (37), which fits into said hole (36) and receives a neck tube (43) of said at least one Helmholtz damper (38) such that said neck tube (43) passes through said insert (37) to open out into said combustor (33).

11. Gas turbine as claimed in Claim 10, **characterized in that** a neck tube adapter (42) is provided to seal said neck tube (43) against said insert (37).

12. Gas turbine as claimed in Claim 10, **characterized in that** said neck tube (43) is releasably connected to the damper volume (40) of said at least one Helmholtz damper (38).

13. Gas turbine as claimed in Claim 8, **characterized in that** said combustor (33) is of an annular configuration, and that a plurality of Helmholtz dampers (38) are circumferentially arranged around said combustor (33).

14. Gas turbine as claimed in Claim 8, **characterized in that** said at least one combustor is of the can type, and that the Helmholtz damper (48) is circumferentially arranged around the can combustor (49).

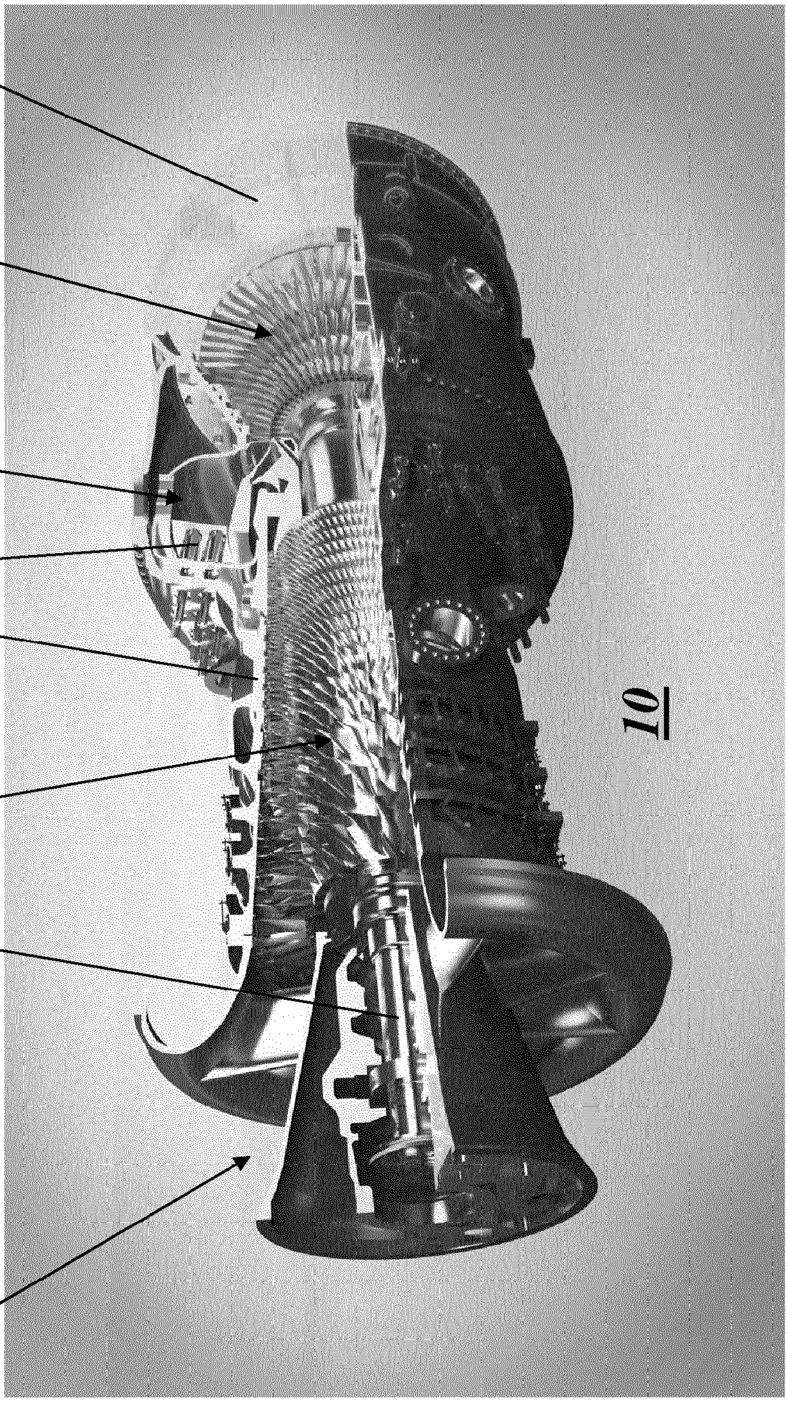
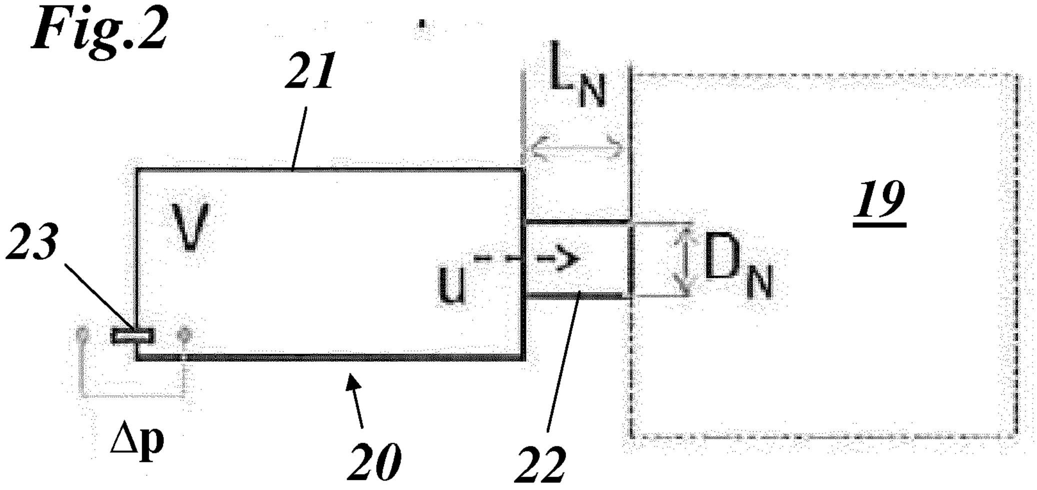


Fig.1

Fig.2


21
L$_N$
19
V
23
U
D$_N$
Δp
20
22

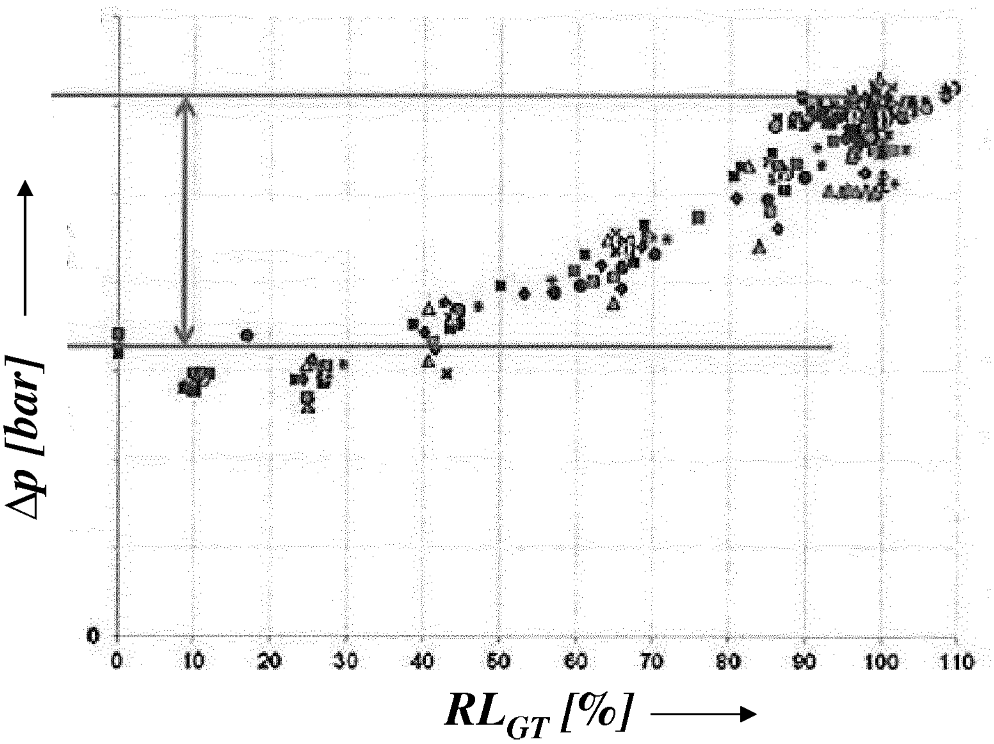

Δp [bar]
0
0 10 20 30 40 50 60 70 80 90 100 110
RL$_{GT}$ [%]

Fig.3

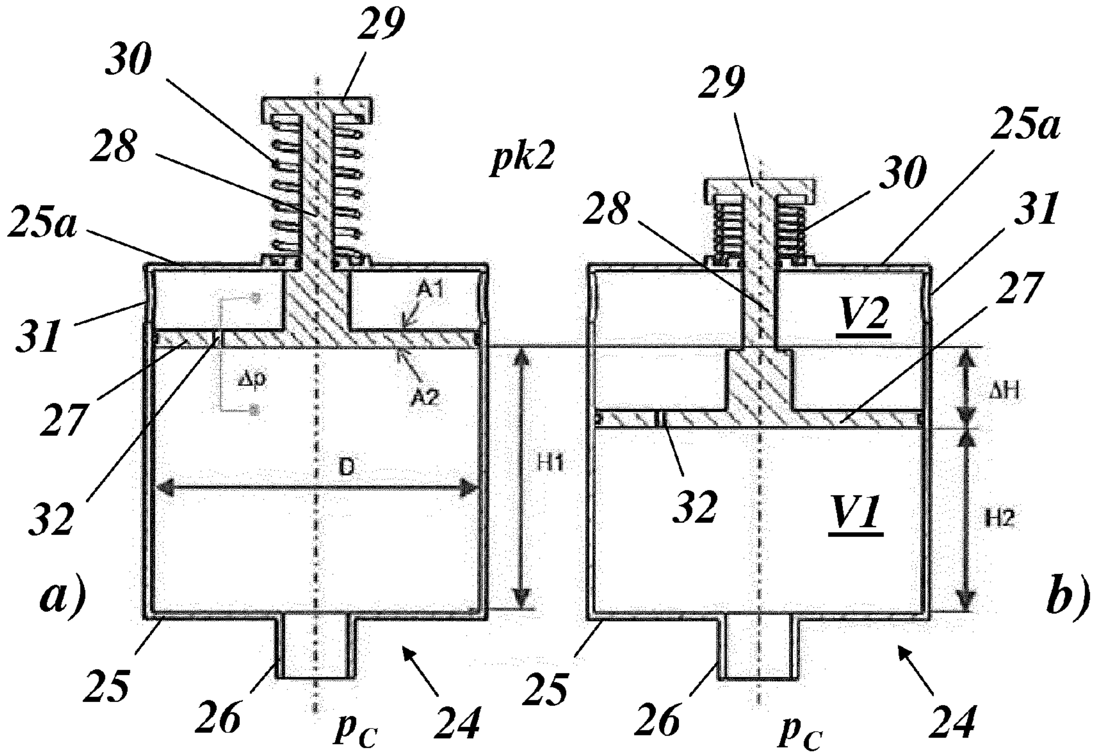

29
30
28
pk2
25a
31
A1
A2
Δp
27
32
D
H1
a)
25
26
p_C
24
29
25a
30
28
31
V2
27
ΔH
32
V1
H2
b)
25
26
p_C
24

Fig.4

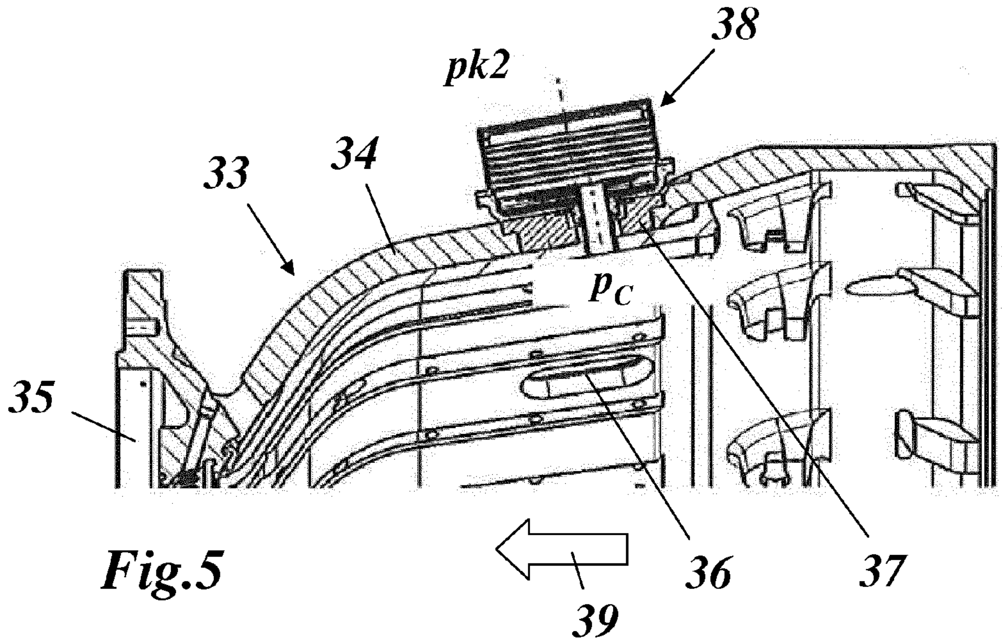
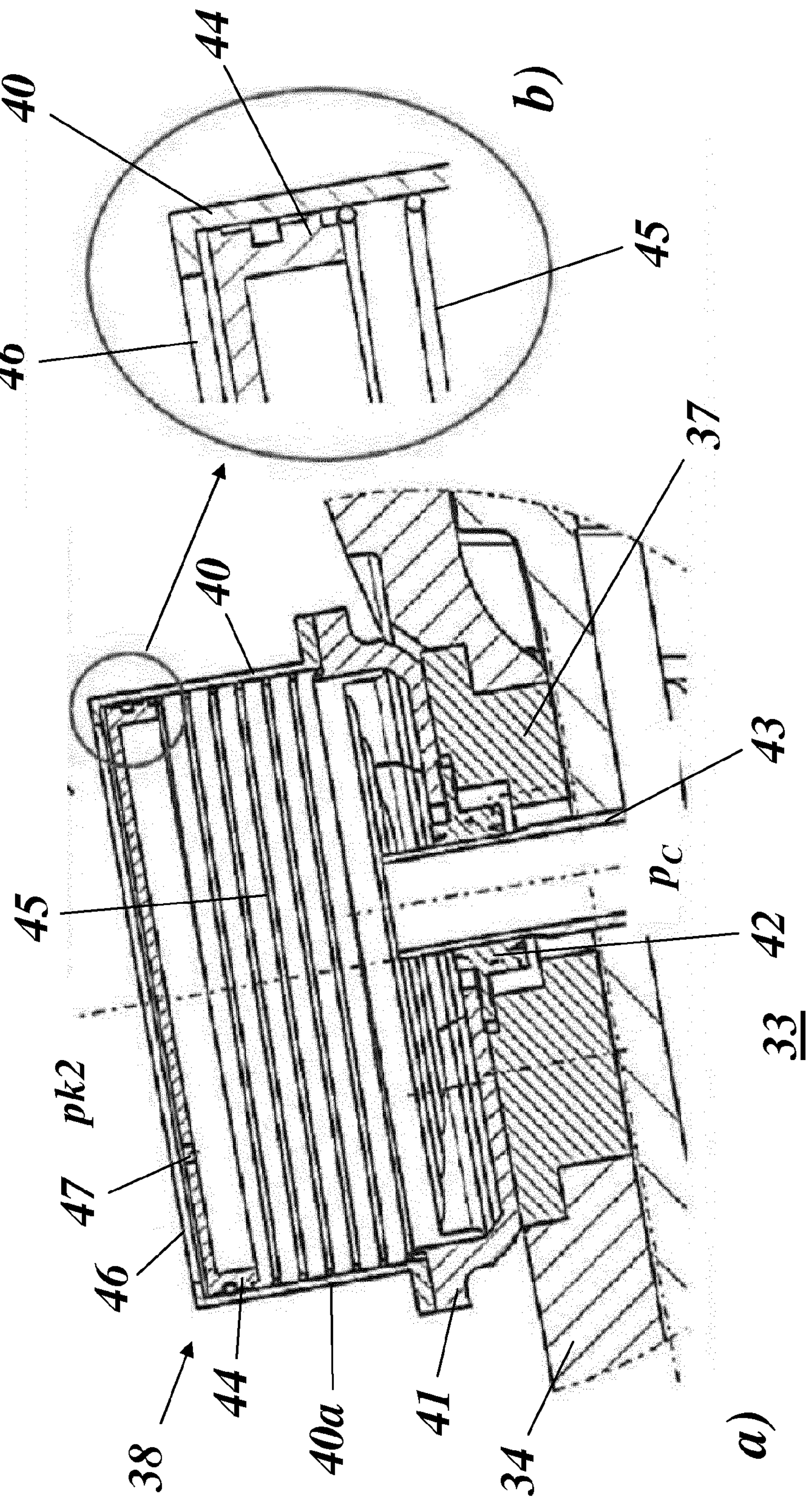

38
pk2
33
34
p_C
35
36
37
39

Fig.5

Fig.6



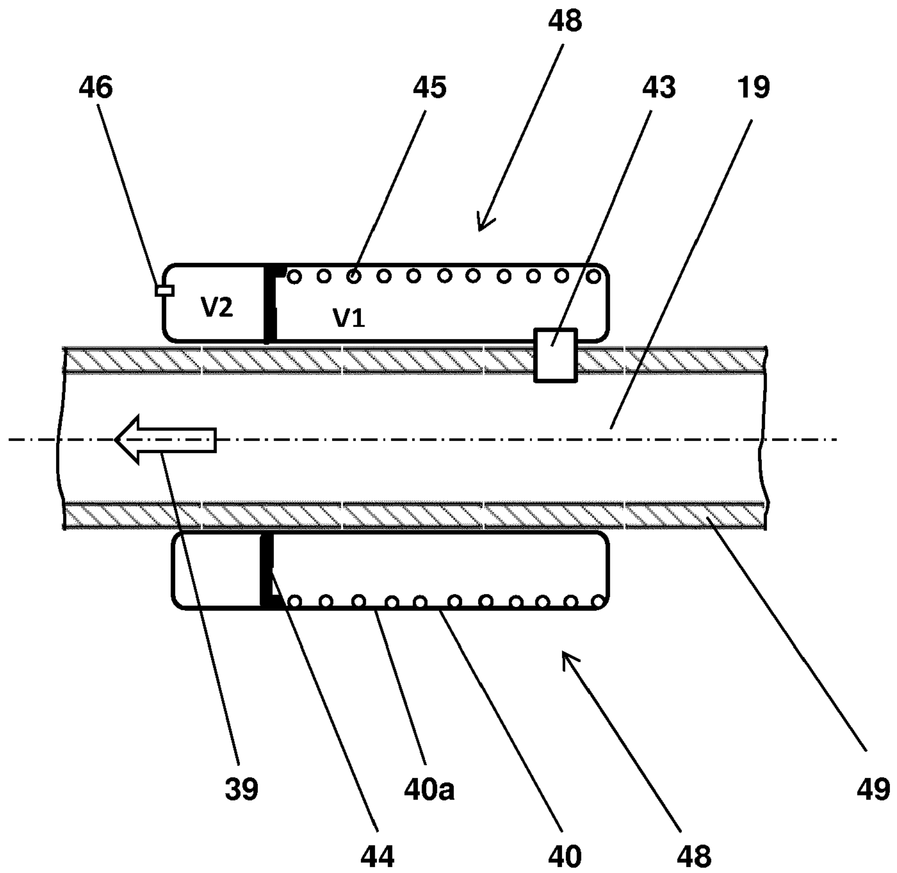


Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 14 19 5660

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A,D	EP 2 397 761 A1 (ALSTOM TECHNOLOGY LTD [CH]) 21 December 2011 (2011-12-21) * the whole document * -----	1-14	
A,D	EP 2 397 760 A1 (ALSTOM TECHNOLOGY LTD [CH]) 21 December 2011 (2011-12-21) * the whole document * -----	1-14	
A,D	DE 100 26 121 A1 (ALSTOM POWER NV [NL]) 29 November 2001 (2001-11-29) * the whole document * -----	1-14	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

3

Place of search	Date of completion of the search	Examiner
Munich	12 May 2015	Christen, Jérôme

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 19 5660

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

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