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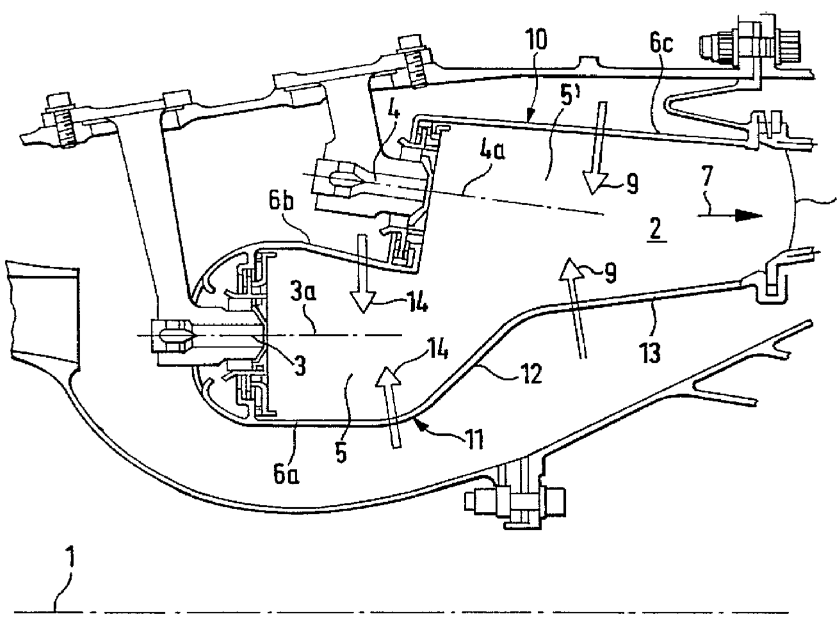
(54) **CHAMBRE DE COMBUSTION A ANNEAU DOUBLE ET ETAGEMENT AXIAL POUR UNE TURBINE A GAZ**

(54) **AXIALLY STEPPED DOUBLE-RING COMBUSTION CHAMBER FOR A GAS TURBINE**




(57) L'invention concerne une chambre de combustion annulaire à étagement axial, destinée notamment à une turbine à gaz d'aéronef. Cette chambre de combustion comporte une chambre de combustion principale (5') indépendante, ainsi qu'une chambre de combustion pilote (5) également indépendante. Grâce à une conception appropriée des parois de limitation internes (6a, 6b) de la chambre de combustion pilote (5), les gaz de combustion de cette dernière pénètrent pratiquement dans le sens radial dans la zone principale de combustion (5'). Ce type de conception permet d'obtenir un mélange air/combustible optimal dans cette zone principale de

(57) The invention concerns an axially stepped annular combustion chamber, in particular for an aircraft gas turbine, the combustion chamber essentially comprising an independent main combustion chamber (5') and an independent pilot combustion chamber (5). Appropriate design of the inner boundary walls (6a, 6b) of the pilot combustion chamber (5) ensures that the combustion gases thereof enter the main combustion zone (5') substantially in the radial direction. As a result, optimum mixing of the fuel and air is thus ensured in this main combustion zone or main combustion chamber (5'), exhaust gas emissions are minimized and the

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combustion ou dans la chambre de combustion principale (5'), une réduction des émissions de gaz d'échappement et une répartition optimale de la température à la sortie (8) de la chambre de combustion. La paroi de limitation interne (6a) peut ainsi présenter une partie de déviation (12), ou bien la partie extérieure de la paroi (6b) peut être inclinée par rapport à l'axe longitudinal (3a) de la chambre de combustion pilote, de sorte que la section de la zone de la chambre de combustion pilote (5) diminue dans le sens d'écoulement.

temperature distribution at the combustion chamber outlet (8) is optimum. The inner boundary wall (6a) can comprise a deflection section (12) or the outer wall section (6b) can be inclined towards the pilot burner longitudinal axis (3a), such that the cross-section of the pilot burner zone (5) decreases in the direction of flow.

Abstract

An axially stepped annular combustion chamber, especially of an aircraft gas turbine, has an essentially independent main combustion chamber 5′ as well as an independent pilot burner chamber 5. An appropriate design of internal limiting walls 6a, 6b of pilot burner chamber 5 ensures that the combustion gases enter the main burner zone 5′ essentially in the radial direction. This ensures optimum mixing of the fuel with air in this main combustion zone and/or main combustion chamber 5′, thus minimizing exhaust emissions and ensuring optimum temperature distribution at combustion chamber outlet 8. Internal limiting wall 6a can have a deflecting section 12 or outer wall section 6b can run at an angle to pilot burner lengthwise axis 3a, so that the cross section of pilot burner zone 5 is reduced in the flow direction.

Axially Stepped Annular Combustion Chamber of a Gas Turbine

The invention relates to an axially stepped annular combustion chamber of a gas turbine with a central axis, with a plurality of pilot burners located between annular wall sections, as well as with main burners that terminate in the combustion chamber downstream from and radially outside said pilot burners, with a main burner zone abutting said main burners, with an outer and an inner combustion chamber wall, each annular in shape, each of said walls extending up to the combustion chamber outlet, with the inner combustion chamber wall having a wall section that runs essentially parallel to the pilot burner axis in the area of the pilot burner zone.

Regarding known prior art, reference is made for example to WO 93/25851 or DE-OS 28 38 258, but especially to GB-A-2 010 408, showing an axially stepped annular combustion chamber in which the combustion gases of the pilot burner zone are conducted by an appropriate design, especially of the inner combustion chamber wall, into the main burner zone.

The goal of the present invention is to improve an axially stepped annular combustion chamber of the above type, especially in regard to the mixing of the pilot burner gases with the main burner gases and thus to the exhaust emissions and/or the temperature distribution in the vicinity of the combustion chamber outlet.

To achieve this goal, provision is made such that the inner combustion chamber wall, adjoining the inner wall section that forms the pilot burner zone and essentially also runs parallel to the central axis, has a deflecting section that is convex-concave in shape, runs toward the main burner zone (i.e. as viewed from inside the combustion chamber) as viewed looking downstream, said deflecting section, viewed in the radial direction relative to the central axis, extending approximately at the level of the outer pilot burner wall section and said deflecting section being abutted by a wall section that leads to the combustion chamber outlet and runs essentially parallel to the central axis.

An additional measure consists in that the outer wall section of the pilot

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burner zone that faces the main burner runs at an angle to the lengthwise axis of the associated pilot burner, so that the cross section of the pilot burner zone decreases in the flow direction. Advantageous improvements and embodiments are the subjects of additional subclaims.

The invention will now be described in greater detail with reference to two preferred embodiments, with Figures 1 and 2 each showing a partial lengthwise section through an annular combustion chamber according to the invention and Figure 3 showing two possible partial cross sections through an annular combustion chamber according to the invention.

Reference number 1 indicates the central axis of a basically known annular combustion chamber 2, especially an aircraft gas turbine. A plurality of pilot burners 3 as well as several main burners 4 are located in annular combustion chamber 2, distributed around its circumference. Main burners 4 as usual are arranged externally in the radial direction and, in one preferred embodiment, can have their lengthwise axes or main burner axes 4a inclined to lengthwise axes 3a of pilot burners 3, in other words, inclined relative to so-called pilot burner axes 3a. The main burners 4 located in the radial direction outside pilot burners 3 thus terminate in combustion chambers 2 downstream from pilot burners 3. A so-called pilot burner zone 5 adjoins pilot burners 3 while a so-called main burner zone 5' is formed directly downstream of main burners 4.

The entire combustion chamber 2, in other words the unit composed of pilot burner zone 5 and main burner zone 5', is delimited by an external annular combustion chamber wall 10 and is delimited from central axis 1 by an internal combustion chamber wall 11. Wall 11 consists of individual so-called wall sections, namely of an inner wall section 6a associated with pilot burner zone 5 and, in the embodiment shown in Figure 1, of an adjoining so-called deflecting section 12, and in both embodiments, of a wall section 13 that leads to combustion chamber outlet 8 (outlet 8 can also be referred to as combustion chamber end 8). Pilot burner zone 5 is delimited externally in the radial direction by an outer wall section 6b that extends up to main burner 4. Outer wall section 6b is adjoined by main burner or burners 4, with each main burner 4 or each main burner axis 4a being arranged at an angle to pilot burner axis 3a of each pilot burner 3, as is clearly evident. Downstream, far outside the combustion chamber, the two lengthwise axes 3a, 4a of burners 3, 4 would intersect, while lengthwise axis 3a is aligned essentially parallel to central axis 1. However, this arrangement only relates to the embodiments shown here; of course, it would also be possible to arrange the individual lengthwise axes 3a, 4a of pilot burners 3 and/or main burners 4 differently (parallel to one another, for example). In addition, pilot burners 3 and main burners 4 do not necessarily have to be in a common lengthwise section plane as shown here, but pilot burner 3 and main burner 4 can also be arranged staggered with respect to one another in the circumferential direction. Moreover, the flow direction of the combustion gases in combustion chamber 2 is also indicated by arrow 7.

In addition, a further outermost wall section 6c of outer annular combustion chamber wall 10 is provided between main burner 4 and combustion chamber outlet 8.

The primary point of importance here is the pattern of internal combustion chamber wall 11. This wall, in the embodiment shown in Figure 1, has a deflecting section 12 that runs toward main burner zone 5', abutting wall section 6a that forms pilot burner zone 5. This deflecting section 12 is aligned at least partially in the radial direction (this is defined as being perpendicular to central axis 1), i.e. deflecting section 12 intersects central axis 1 in the embodiment shown here at an angle of approximately 45° for example. This means that the combustion gases from pilot burners

3, guided by this deflecting section 12, enter main burner zone 5' essentially in the radial direction. This shape of internal combustion chamber wall 11 can also be described specifically by saying that this combustion chamber wall 11 is concave-convex in shape in the area of deflecting section 12 as well as relative to combustion chamber 2, in other words as viewed from the interior of the combustion chamber, looking downstream (namely in flow direction 7). This means that, starting at wall section 6a, a concave curvature is initially provided in deflecting section 12, which is abutted by a wall section 13 with a convex curvature that leads to combustion chamber outlet 8. This design ensures optimum mixing of the fuel that enters main burner zone 5' through main burner 4 with air in main burner zone 5'. As a result, the exhaust emissions are minimized and the temperature distribution at combustion chamber outlet 8 can be matched with that from a non-stepped combustion chamber.

An additional measure for achieving a better mixture of the pilot burner gases with the main burner gases is shown in Figure 2, where for the sake of simplicity the deflecting section according to the invention, designated by reference number 12 in Figure 1, is not shown.

In Figure 2, outer wall section 6b of pilot burner zone 5, facing main burner 4, is inclined relative to lengthwise axis 3a of associated pilot burner 3 in such fashion that the cross section D of pilot burner zone 5 is decreased in the flow direction in other words from pilot burner 3 in the direction of arrow 7 toward the center of combustion chamber 2. This means that main burner 4 is immersed in or penetrates pilot burner zone 5, so to speak, as is especially apparent from Figure 2 in the form of a so-called penetration depth $\Delta$.

This reduction in the cross section of pilot burner zone 5 and/or this penetration of main burner 4 into pilot burner zone 5 firstly produces an especially good mixing of the main burner gases with the gases of pilot burner 3, since the latter undergo an advantageous change in their flow field. The pilot burner gases are vorticized to a greater degree by outer wall section 6b and are additionally accelerated by the reduction in cross section. Improved mixing at the center of combustion chamber 2 with the gas flows emitted from main burner 4 therefore results.

In addition, the axially stepped annular combustion chambers 2 according to the invention described here can also be referred to basically as an assembly of two independent non-stepped annular burners. This means that both main burner zone 5′ and pilot burner zone 5 each exhibit the design features of non-stepped annular combustion chambers and therefore are optimized for the upper load range (for main burner zone 5′) and for the lower load range (for pilot burner zone 5) of the gas turbine. As can be seen, main burner zone 5′ located outward is designed in the same way as a conventional non-stepped annular combustion chamber,... with main burner axis 4a essentially pointing in the direction of the combustion chamber axis or coinciding therewith. In addition, streams of mixed air 9 are added and mixed in main burner zone 5′ and in annular combustion chamber 2 on both sides, in other words, from inside and from outside - this is only shown in Figure 1 - as is usual in conventional annular combustion chambers. In addition, in this (conventional) annular combustion chamber 2, a coupled pilot burner zone 5′ is also provided, i.e. a sort of separate pilot burner chamber that is located radially inward as well as upstream from main burner zone 5′. In order to be able to conduct the combustion gases from this pilot burner chamber or pilot burner zone 5 optimally into main burner zone 5′ and thus permit optimum mixing of fuel and air in said zone 5′, an effort can be made to ensure that the combustion gases from the pilot burner chambers enter main burner zone 5′ and/or the corresponding main burner chambers essentially in the radial

This radial direction determination takes place in Figure 1 as a result of the so-called deflecting section 12 of inner annular combustion chamber wall 11, while in Figure 2 the pilot burner gases undergo increased vorticization as a result of the change in the flow field and are accelerated toward the main burner gases.

Advantageously, especially with the design of annular combustion chamber 2 that is shown and described in Figure 2, an extremely compact form is also achieved, i.e. the diameter of an annular combustion chamber of this type and/or its so-called structural height can be minimized as a result. This leads to favorable conditions when the value of the penetration depth $\Delta$ relative to the cross section D* of pilot burner zone 5 in the area of pilot burners 3 lies in the range from 0.1 to 0.3, in other words, $0.1 \leq \Delta/D^* \leq 0.3$. The compact design is further promoted by the staggered arrangement, shown in Figure 3 as well, of pilot burners 3 as well as main burners 4. Then there is, so to speak, a pilot burner 3 between each two main burners 4.

Figure 2 also shows that inside wall section 6a of pilot burner zone 5 can run at an angle in its end area relative to pilot burner lengthwise axis 3a, so that outer wall section 6b as well as inner wall section 6a run together, so to speak, in the end areas of said sections. Once again, this causes a desired reduction in the cross section of pilot burner zone 5, with this slope of the inner combustion chamber wall 11 being able to continue with essentially the same orientation up to combustion chamber end 8, and thus, with the same orientation, limiting the entire annular combustion chamber 2 on the inside. The outer combustion chamber wall 10 that delimits annular combustion chamber 2 in the area between main burner 4 and combustion chamber end 8 can be shaped In accordance with the most favorable design. Here again it is recommended to use a pattern for wall section 6c that converges toward lengthwise axis 4a initially in the area that directly abuts main burner 4, while in the vicinity of combustion chamber end area 8 there must be a sufficient cross section for the gases that are escaping, and thus a pattern may be required that diverges relative to central axis 1.

Outer wall section 6b of pilot burner zone 5, in both Figure 1 and Figure 2, also extends in the same manner as the entire annular combustion chamber 2, namely essentially annularly, but this does not mean that the reduction in cross section of pilot burner zone 5 over essentially the entire annular combustion chamber 2 must be performed to the same degree all the way around, although this is quite possible. Instead, quasi-shell-shaped depressions can be provided only in the vicinity of main burner 4, in outer wall section 6b which otherwise runs essentially parallel to pilot burner lengthwise axis 3. This latter design is shown schematically in the lower half of Figure 3, while the first design mentioned is shown in the upper half of Figure 3, which shows schematically view X from Figure 2. While the reduction in cross section of pilot burner zone 5 is performed by shell-shaped depressions, the reduction in cross section of pilot burner zone 5 is provided primarily in the planes formed by lengthwise axes 4a of main burners 4 as well as central axis 1 of annular combustion chamber 2.

Especially in the embodiment shown in Figure 1, wall section 13 of inner combustion chamber wall 11 that abuts deflecting section 12 downstream and leads to combustion chamber outlet 8 is once again aligned essentially parallel to main burner axis 4a and/or essentially in the direction of central axis 1. This wall section 13 is therefore essentially once again a part of main burner zone 5′ and/or the corresponding main combustion chamber. The pilot burner zone 5 on the other hand, looking in flow direction 7, terminates in the vicinity of deflecting section 12. In this pilot burner zone 5, a short distance upstream from deflecting section 12, mixed air streams 14 can be supplied both internally and externally a short distance upstream from main burner 4 through openings, not shown in greater detail, in combustion chamber wall 11.

Of course, the precise dimensions as well as the angles that individual wall sections 6a, 6b, 12, and 13 form with one another can be designed to be completely different from the embodiment shown without the content of the patent claims being exceeded. Similarly, additional variations from the embodiment shown are possible. Thus, a wide variety of fuel atomization concepts can be used for pilot burners 3 as well as for main burners 4, and similarly the openings and/or holes for mixed air streams 9 and 14 can be located differently. In addition, these mixed air streams 9, 4 can be supplied twisted or not twisted, without this having enormous consequences as regards the significant advantages of the present invention, namely optimal mixing especially in main burner zone 5'.

Rewritten Claim 1

1. Axially stepped annular combustion chamber of a gas turbine with a central axis (1), with a plurality of pilot burners (3) located between annular wall sections (6a, 6b) as well as with main burners (4) terminating downstream and radially outside these pilot burners in combustion chamber (2), said main burners (4) abutting a main burner zone (5'), with outer (10) and inner (11) combustion chamber walls, both annular in shape, said walls each extending up to combustion chamber outlet (8), with inner combustion chamber wall (11) in the area of pilot burner zone (5) having a wall section (6a) running essentially parallel to pilot burner axis (3a), characterized in that inner combustion chamber wall (11), abutting inner wall section (6a) that forms pilot burner zone (5) and essentially also runs parallel to central axis (1), having a deflecting section (12) that is convex-concave in shape and runs toward main burner zone (5'), relative to combustion chamber (2) when viewed looking downstream, said deflection section, when viewed in the radial direction relative to central axis (1), exiting approximately at the level of outer pilot burner wall section (6b) and abutting a wall section (13) that leads to combustion chamber outlet (8), and running essentially parallel to central axis (1).

2. Annular combustion chamber according to Claim 1, characterized in that the combustion gases of pilot burners (3), guided by deflecting section (12), enter main combustion zone (5') essentially in the radial direction.

3. Annular combustion chamber according to Claim 1 or 2, characterized in that outer wall section (6b) of pilot burner zone (5) that faces main burners (4) runs at an angle relative to lengthwise axis (3a) of associated pilot burner (3), so that the cross section (D) of pilot burner zone (5) is reduced in flow direction (7).

4. Annular combustion chamber according to one of the foregoing claims, characterized in that inner wall section (6a) of pilot burner

zone (5) located opposite main burner (4) is likewise located at an angle in its end area relative to lengthwise axis (3a) of associated pilot burner (3), so that the cross section (D) of pilot burner zone (5) is reduced in flow direction (7) because of convergent end wall sections (6a, 6b).

5. Annular combustion chamber according to Claim 3 or 4, characterized in that the size of the penetration depth (Δ) of main burner (4) in pilot burner zone (5), which is associated with the reduction in cross section of pilot burner zone (5), relative to the cross section (D*) of pilot burner zone (5) in the area of pilot burner (3) lies in the range from 0.1 to 0.3.

6. Annular combustion chamber according to one of Claims 3 to 5, characterized in that the reduction in cross section of pilot burner zone (5) takes place primarily in the planes formed by the lengthwise axes (4a) of main burners (4) as well as a central axis (1) of annular combustion chamber (2).

7. Annular combustion chamber according to one of Claims 3 to 5, characterized in that the reduction in cross section of pilot burner zone (5) is essentially provided all the way around annular combustion chamber (2).

8. Annular combustion chamber according to one of the foregoing claims, characterized in that main burners (4) and pilot burners (3) are arranged staggered with respect to one another in the circumferential direction.

9. Annular combustion chamber according to one of the foregoing claims, characterized in that the downstream end of pilot burner zone (5) is defined by mixed air streams (14) supplied through openings in combustion chamber wall (11, 6b).

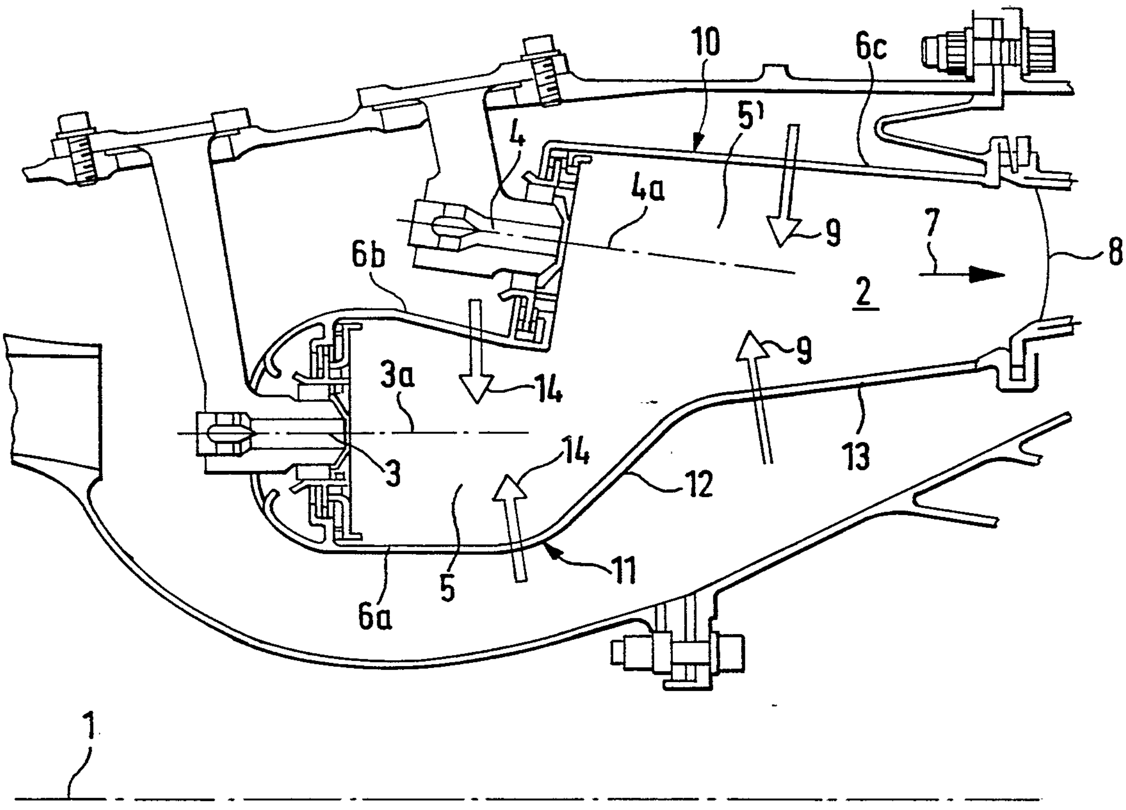



FIG.1

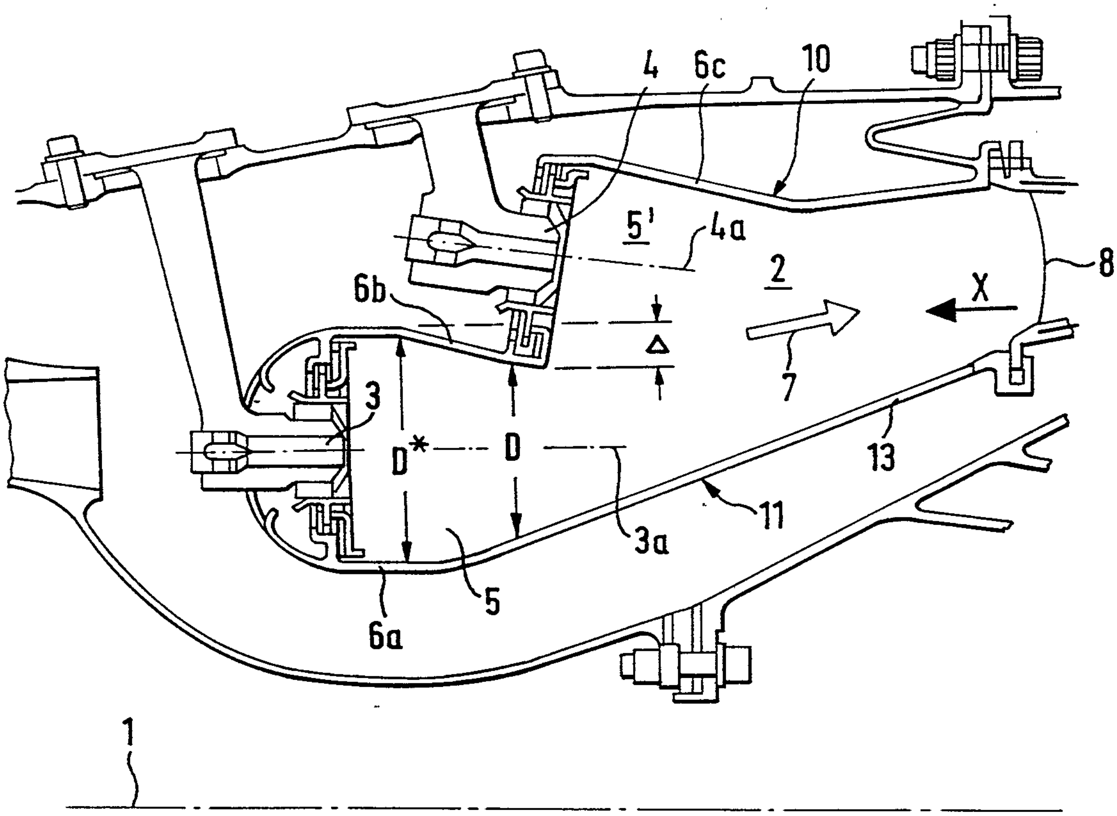



FIG. 2

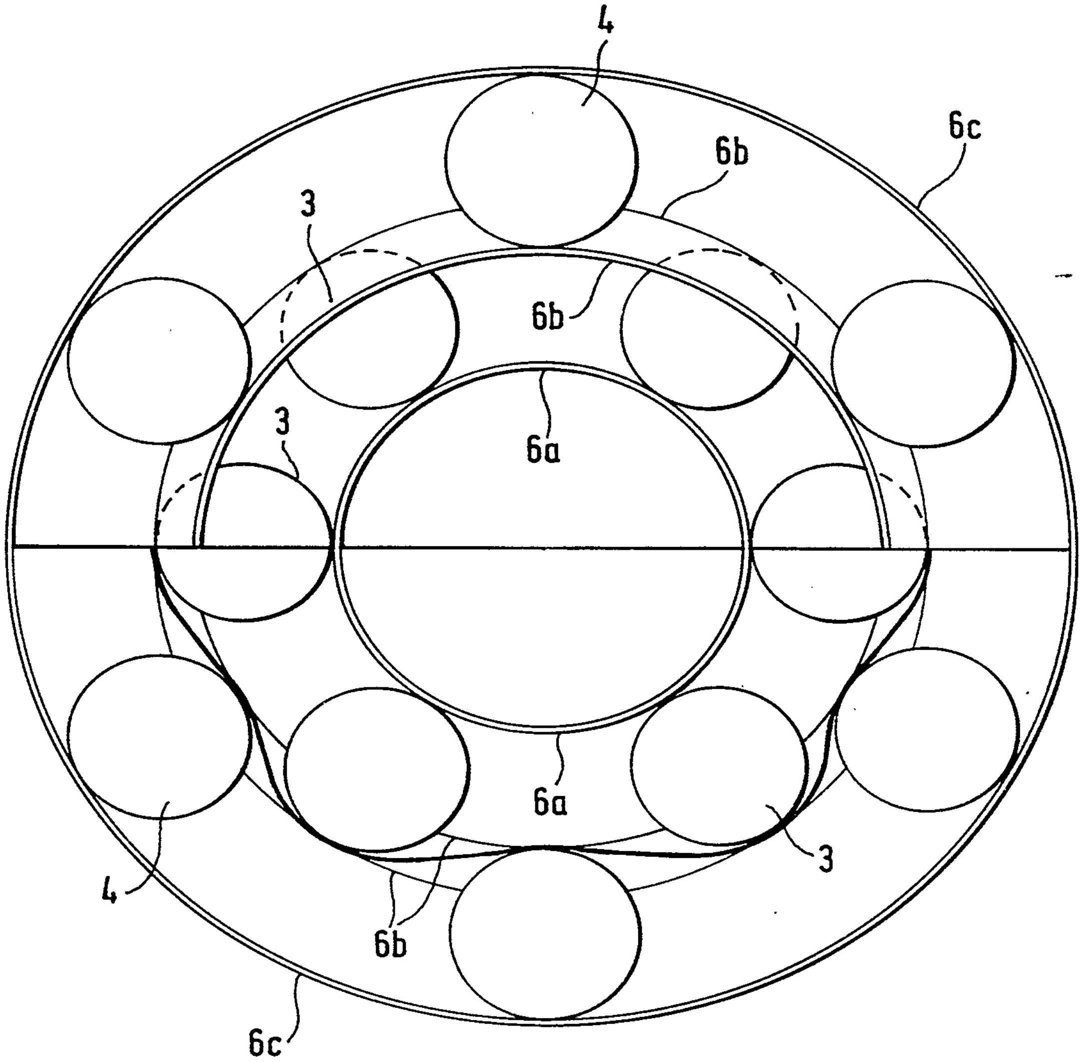
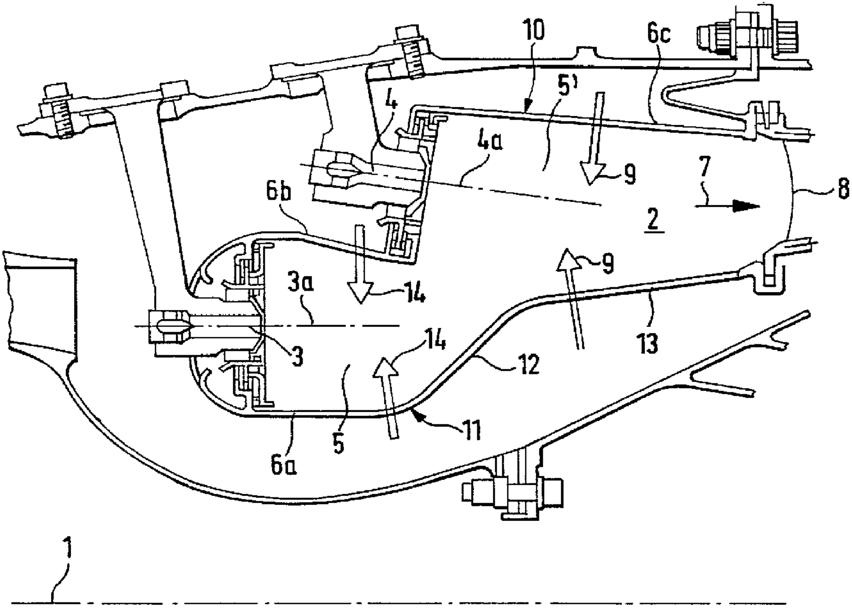



FIG.3



10
6c
5'
4
4a
9
7
8
6b
2
9
3a
14
14
3
12
13
11
5
6a
1