United States Patent [19]

Caruel et al.

[11] **3,735,589**

[45] **May 29, 1973**

[54] **WALLS OF COMBUSTION CHAMBERS**

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[22] Filed: **June 1, 1971**

[21] Appl. No.: **148,715**

[30] **Foreign Application Priority Data**

June 2, 1970 France..........7020243

[52] **U.S. Cl.**..........**60/39.65**, 60/39.66
[51] **Int. Cl.**..........**F02g 1/00**
[58] **Field of Search**..........60/39.65, 265, 39.66

[56] **References Cited**

UNITED STATES PATENTS

3,490,230	1/1970	Pillsbury et al.	60/39.65
3,447,318	6/1969	Caruel et al.	60/39.65
2,447,482	8/1948	Arnold	60/39.65
3,046,742	7/1962	Egbert et al.	60/39.65
2,657,531	11/1953	Pierce	60/39.65
2,867,267	1/1959	Nerad et al.	60/39.65

FOREIGN PATENTS OR APPLICATIONS

700,017	11/1953	Great Britain	60/39.65

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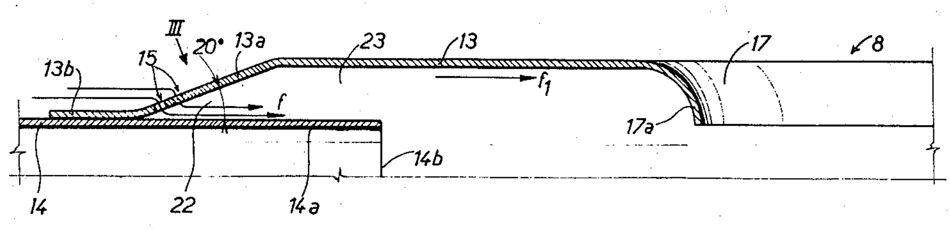
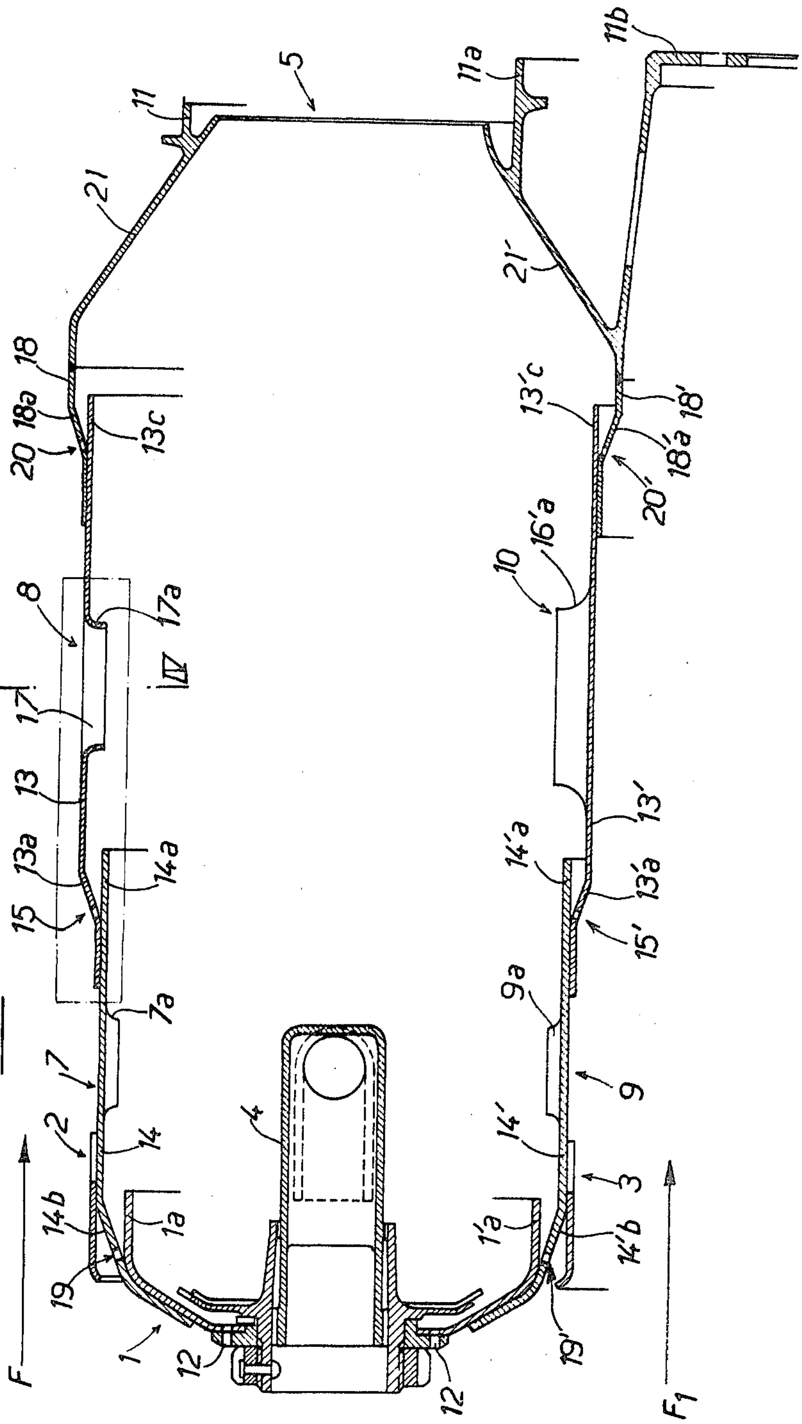
[57] **ABSTRACT**

A combustion chamber mounted in a flow of air at high pressure and the wall of which is provided with dilution holes located in the path of a cooling air film derived from the said flow through holes provided at a substantially truncated junction connecting an upstream wall element with a downstream wall element offset relative to the upstream element towards the outside of the chamber, wherein the upstream wall element is extended rearwardly of this junction by means of a tongue substantially parallel to the rear element, and wherein this junction has an inclination between 15° and 25°, preferably about 20°, the holes are arranged in zig-zag very near the upstream element so as to provide in the downstream direction a divergent portion of unperforated wall of substantial length, and the dilution holes are surrounded by flanges projecting into the combustion chamber.

5 Claims, 5 Drawing Figures




1
1a
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IV
F
F_1

FIG. 1

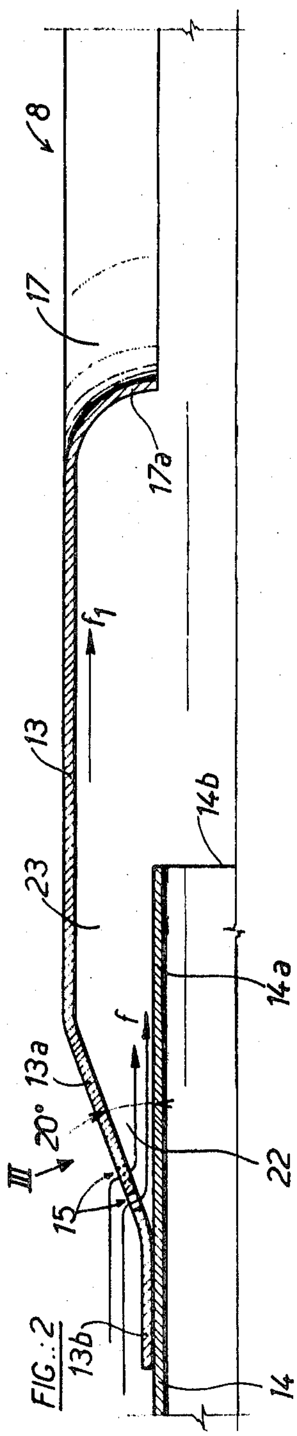

FIG.:2

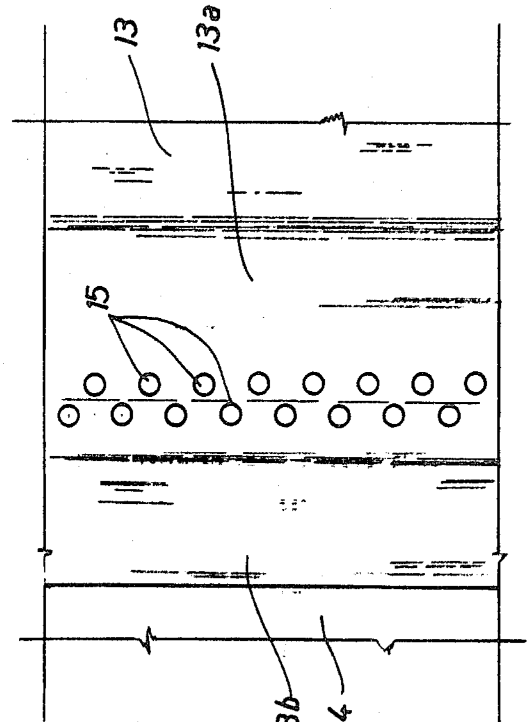

FIG.:3

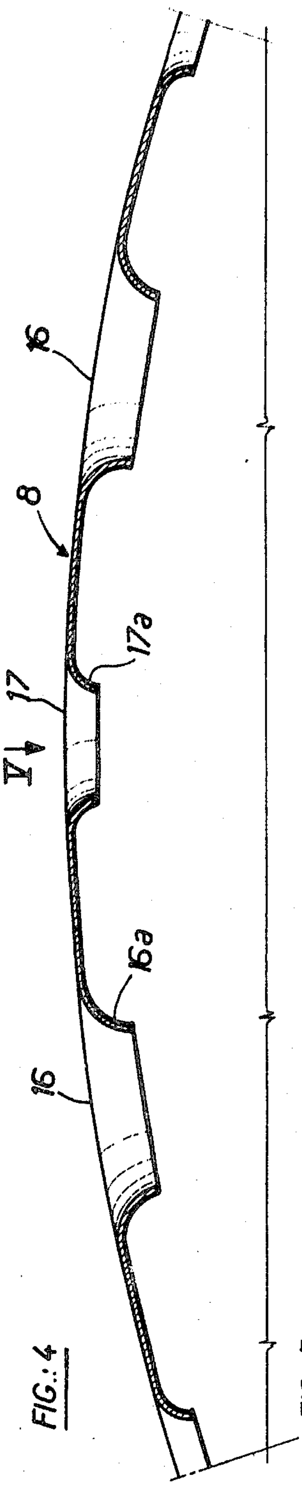

FIG.:4

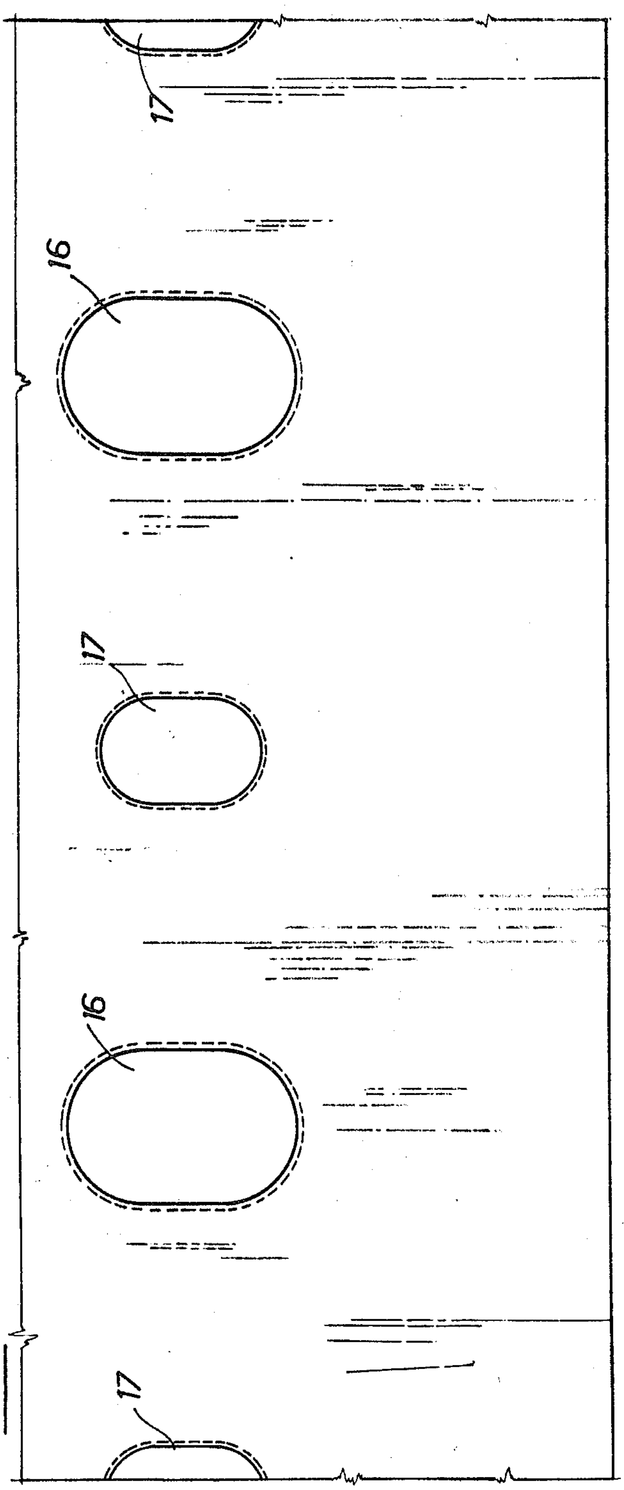

FIG.:5

WALLS OF COMBUSTION CHAMBERS

The invention relates to dilution type combustion chambers having walls cooled by air films, more especially of the type used in jet engines for aircraft. Such a combustion chamber is constructed to ensure combustion of fuel in a flow of air under high pressure. It is mounted within a wall called a flame tube arranged longitudinally in the flow of air. This wall is provided with lateral openings through which dilution air, derived from the high pressure flow, enters transversely into the chamber, and with and arrangement for cooling comprising means for forming an air film on the inner surface of the walls in order to protect them from the direct action of the flame. This method of cooling is known in the art under the name of "film cooling."

It is known to take the cooling air from the high pressure flow by means of holes provided in a truncated connection connecting an upstream part of the wall with a downstream part of the wall, offset relative to the upstream part towards the outside, wherein the upstream wall element is extended rearwards of this connection by a tongue which is substantially parallel to the downstream element. In operation, the air passing through the holes is channelled between the tongue and the downstream wall element to form the film on the inner wall of the downstream element.

However, when this arrangement is located upstream of the dilution holes, at least in the region of the combustion chamber which is subjected to the highest temperatures, the part of the downstream wall element surrounding the dilution holes, especially the parts located downstream thereof, are not efficiently cooled. The applicants have found, according to the invention, that an efficient cooling may be achieved by providing the truncated joint with an angle of inclination between about 15° and 25°, and preferably 20°, by arranging the holes in staggered relation adjacent the upstream wall element so as to leave downstream a divergent non-perforated wall portion of substantial length, and by surrounding the dilution holes with flanges projecting into the combustion chamber.

The flanges of the dilution holes preferably extend into the combustion chamber substantially to the level of the said tongue i.e., the distance of the offset of the downstream wall section from the upstream wall section.

According to one feature of the invention, the dilution holes are not circular but oblong, with their long axes in the longitudinal direction of the combustion chamber, that is to say in the direction of the flow of the air film.

The following description, given by way of example with reference to the accompanying drawings, indicates further features and advantages of the invention and its mode of practice. In the drawings:

FIG. 1 shows a combustion chamber in longitudinal cross-section;

FIG. 2 shows on a larger scale the part of FIG. 1 within the dot-dash lines;

FIG. 3 is a development along the arrow III in FIG. 2;

FIG. 4 is a partial cross-section on an enlarged scale along the line IV—IV in FIG. 1; and

FIG. 5 is a view in the direction of the arrow V in FIG. 4.

The combustion chamber shown is annular; its wall comprises, as known in the art, an annular base 1, an annular outer part 2, and an annular inner part 3. The base 1 carries a plurality of burners 4 in crown arrangement and the rear edges of the outer and inner parts 2 and 3 form an annular outlet orifice 5. The outer part 2 is provided with two rows of openings 7, 8. The inner part 3 has also two rows of openings 9, 10.

Elements, some of which are shown at 11, 11*a* and 11*b* are provided for mounting the combustion chamber in a jet engine, (not shown), between the compressor and the turbine (not shown) of this engine. Air at high pressure compressed by the compressor flows in a flow F at the outside of the ring formed by the combustion chamber and in a flow F_1 inside this ring. A part of this air also enters the combustion chamber through holes such as 7, 8, 9, 10 and 12, surrounding the burners 4 and between them. The operation of such a combustion chamber is well known. Fuel is injected into the burners 4 and lit, by means not shown, so that it burns in the primary air entering through holes such as 7 and 9 and its combustion is furthered and continues in the secondary and dilution air which enters through the openings 8 and 10. Cooling air enters at 12. The hot gases escape at high speed through the opening 5 for driving the turbine, and the combustion chamber is at low pressure relative to the external alr flows F, F_1.

The outer part 2 of the wall of the combustion chamber is made of three metal sleeves, the diameters of which increase from upstream to downstream, and the inner part 3 is made of three sleeves with stepped diameters decreasing from upstream to downstream. Each sleeve has at the beginning a connecting part which is welded to The wall element located immediately upstream slightly in front of the rear edge thereof. FIG. 2 shows on a larger scale the connection of the center sleeve 13 of the outer part 2 with the sleeve 14 located upstream therefrom.

It may be seen on FIG. 2 that the sleeve 13 of generally cylindrical shape is connected upstream by a truncated section 13*a*, with an apex angle of about 20°, to cylindrical portion 13*b* of smaller diameter which is located on the sleeve 14 and fixed thereto by welded joints (not shown). The truncated portion 13*a* is perforated by a crown of holes 15 which, as shown in FIG. 3, are arranged in zig-zag or staggered relation in two rows quite near the cylindrical portion 13*b*, so that the truncated part 13*a* is provided with perforations over the major part of its length.

The sleeve 14 extends towards the rear forming a cylindrical tongue or skirt 14*a*, the rear edge 14*b* of which is located slightly beyond the truncated portion 13*a*.

During operation, outside air from the flow F under high pressure flows in the direction of arrows f through the holes 15, passes through the annular divergent channel 22 between the tongue 14*a* and the unperforated part of the truncated section 13*a*, then through the annular channel formed between the cylindrical walls 13, 14*a* and leaves this channel, forming an air film, indicated diagrammatically by the arrow f_1 which flows along the inner surface of the sleeve 13.

The dilution holes 8 provided in the sleeve 13 are arranged in a ring at a certain distance downstream of the rear edge 14*b* of the tongue 14*a*. As may be seen on FIGS. 4 and 5, the ring of apertures 8 comprises a plurality of large apertures 16, alternating with smaller apertures 17, wherein the apertures are regularly spaced apart. They are not circular but oblong, with their large dimension pointing in the longitudinal direction of the combustion chamber. Each opening **16** or **17** has a flange **16a** or **17a**, bent back towards the interior of the combustion chamber. These flanges **17a** extend substantially to the level of the tongue **14a** and the flanges **16a** extend even further into the chamber. The upper sleeve **14** and the lower sleeve **18** are connected respectively to the base **1** and to the center sleeve **13**, as already described with reference to FIG. **2**. It may be seen from FIG. **1** that the truncated parts **14b** and **18a** are used for these connections, each perforated by a ring of holes in staggered arrangement **19** and **20** respectively, and also showing the tongues **14a** and **13c**. The inner part **3** of the wall is formed by three sleeves **13'**, **14'**, **18'** connected to each other and to the base **1** in a similar manner, wherein the elements playing the same role as in the outer part **1** are marked with the same reference numerals, with the addition of an apostrophe. The ring of dilution holes **10** provided in the sleeve **13'** has holes corresponding to the holes **16** and **17** in FIGS. **4** and **5**, equipped with flanges, such as **16'a**, projecting into the combustion chamber at least to the level of the tongue **14'a**. The openings **7** and **9**, provided respectively in the sleeves **14** and **14'**, are circular and equipped with flanges **7a** and **9a** projecting into the interior of the combustion chamber. The lower sleeves **18** and **18'** are not provided with dilution holes and are respectively welded to annular elements **21** and **21'** defining the outlet orifice **5**.

The part of the combustion chamber of which the construction is most critical is clearly that comprising the sleeves **13** and **13'**. It is this part which is exposed to the most intensive thermal radiation and the dilution air must be introduced into this part in large amounts, transversely of the longitudinal direction of the flame, in order to generate the necessary turbulence, but without inhibiting the flow of hot gases towards the outlet orifice **5** and without impairing the cooling of the walls.

It is found that in operation, due to the combination of the arrangements described above, satisfactory dilution and flow of the hot gases leaving through the outlet **5** are obtained without excessive heating of the walls, and particularly of the wall portions located around the dilution holes, especially downstream thereof, which parts are usually very much overheated in combustion chambers constructed according to the prior art.

This advantageous effect of the invention may be explained in the following manner. As already mentioned above, the combustion chamber is under a considerable vacuum, relative to the external flow of air F, F_1 which permits dilution air to flow in at high velocity through the dilution holes **8** and **10**. However, this strong depression also causes inflow at high speed of cooling air (film cooling) and if very efficient measures are not taken, this high speed of flow would risk the creation of vortices and wakes in the air film flowing on the inner surface of the wall. This is probably the cause of the heating formed in walls of combustion chambers according to the prior art. Referring to FIG. **2**, it can be seen that the air entering along the arrow f meets at the outlet of the holes **15** a sudden widening of the flow cross-section, thereby undergoing a reduction of the pressure and a slowing down. Moreover, the air is split into a multitude of elementary flows which, owing to the zig-zag arrangement of the holes **15**, are very near each other, thereby favoring the formation of a homogenous flow in the divergent channel **22** formed between the tongue **14a** and the unperforated truncated portion **13a**. It has been found that the best apex angle for this truncated portion is about 20° and it is thought that this comparatively small angle favors the slowing down and the diffusion of the air in the divergent part **22**. Moreover, the air enters the holes **15** at a lesser speed than if the truncated part **13a** were more inclined. The air leaving the divergent channel **22** flows through the annular channel **23** with parallel walls, protected against the turbulence occurring in the combustion chamber, and leaves this channel **23** along the arrow F_1, forming a homogenous film without turbulence flowing at low speed over the inner surface of the sleeve **13**. In addition, the air leaving the holes **15** has impinged on the tongue **14a**, which contributes to its cooling.

The good cooling of the part of the sleeve **13** surrounding the holes **16, 17** and downstream thereof may be explained by the co-operation of two elements, namely the flanges **16a, 17a**, the height of which prevents the air film from being swept along by the jets of dilution air entering through the holes, and the homogenous and comparatively slow flow of this air film which makes it possible to pass around the flanges **16a, 17a** and to reform downstream thereof.

The oblong shape of the dilution holes makes it possible to provide the air with the required flow cross-section by reducing the transverse dimensions of the holes. In this manner, the distance between the parts of the cooling air film flowing on either side of the holes is reduced, which facilitates the restoration of the film downstream of the holes. Moreover, the jets of dilution air which enter the combustion chamber present less of a risk to form a barrier in front of the outlet **5**. The alternation of openings such as **16** with smaller openings such as **17** favors the dilution and the restoration of the cooling air film downstream of the openings.

It is obvious that the embodiments described are merely examples and can be modified, particularly by equivalent techniques, without departing thereby from the scope of the invention as defined by the appended claims. More particularly, instead of being annular, the combustion chamber according to the invention may be a flame tube in the form of a bag open at its downstream end and provided with a burner forming part of an assembly of flame tubes arranged around the axis of a jet engine or gas turbine.

The dilution and film cooling device according to the invention may be used only in the part of the combustion chamber exposed to the worse heat effects, whilst the other parts can be cooled by other means.

We claim:

1. A combustion chamber operable in a flow of high pressure air, having an outer wall extending generally longitudinally in the flow of air and comprising an upstream wall section, a downstream wall section offset radially outward of the chamber relative to said upstream section, and an outwardly flaring wall section connecting said upstream and downstream sections and having an inclination angle in the range of about 15° to 25° relative to said upstream section, said outwardly flaring section comprising an upstream portion penetrated by a multiplicity of apertures arranged in staggered relation and an imperforate downstream portion of substantial length; said upstream wall section including an extension projecting substantially parallel to the downstream wall section and extending longitudinally beyond the outwardly flaring wall section to form therewith an unperforated divergent passage of substantial length for cooling air entering through said multiplicity of apertures and flowing as a thin layer along the inner surface of said outer wall; said downstream wall section having flange-rimmed holes therein for inflow of dilution air to the combustion chamber, said flanges projecting interiorly of said chamber.

2. A combustion chamber according to claim 1, wherein the outwardly flaring wall section has an inclination angle of approximately 20°.

3. A combustion chamber according to claim 1, wherein the length of said flanges at least substantially equals the extent of the radial offset of said downstream wall section.

4. A combustion chamber according to claim 1, wherein the dilution holes are oblong, with their long dimension in the longitudinal direction of flow of the air film.

5. A combustion chamber according to claim 1, wherein the dilution holes comprise large holes alternating over the periphery of the wall with smaller holes.

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