April 10, 1951 I. LUBBOCK 2,548,485

COMBUSTION CHAMBER LINING

Filed Jan. 8, 1947

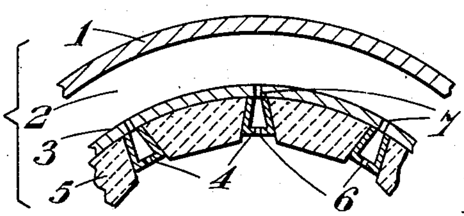



Fig. 1.

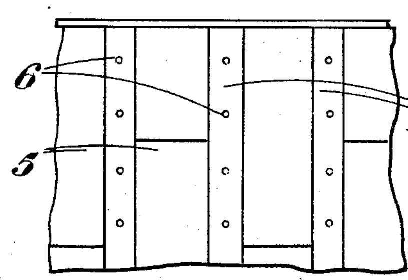
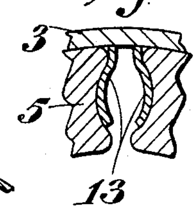



Fig. 2.

Fig. 4.



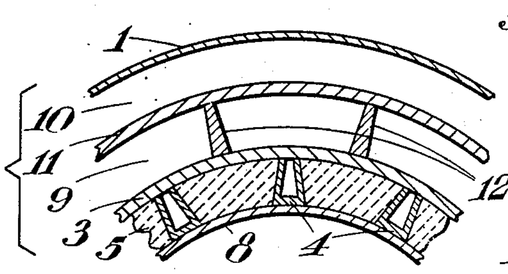




Fig. 3.

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Patented Apr. 10, 1951

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# UNITED STATES PATENT OFFICE

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## COMBUSTION CHAMBER LINING

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Application January 8, 1947, Serial No. 720,896
In Great Britain January 9, 1946

12 Claims. (Cl. 263—44)

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This invention concerns improvements in relation to the lining of combustion chambers, such for example as are used for gas turbines where a very high rate of heat release has to be maintained in a comparatively small volume under high pressure conditions.

This invention is applicable to various known forms of combustion chambers for the purpose of protecting the walls of the combustion chamber and adjoining parts from being subjected to excessive temperatures.

In order to appreciate the problem involved we may consider as a typical example the case of a cylindrical combustion chamber where the air under pressure from a compressor is introduced around a fuel nozzle with various means in the form, for example, of shields, swirling devices, holes or slots, in order to give various forms of turbulence and mixing arrangements with the burning fuel. Under such conditions it is usually arranged to feed only part of the air to the flame in the initial stages so as to get what is known as a primary zone of combustion, or flame zone, while the remainder of the air which is usually of the order of 4 or 5 times the amount necessary for complete burning is admitted progressively into the products of combustion resulting from the primary burning zone.

The temperature ruling in the primary zone where the ratio of air to fuel is not far removed from that required stoichiometrically is usually of the order of 1400° C. or more even though the final products of combustion which pass to the turbine are ultimately reduced to approximately 600° C. to 1000° C. according to the temperature which the turbine wheel can withstand.

It is usual, moreover, to have an inner shroud or complete cylindrical vessel extending at least as far as the primary zone and usually beyond that so that the wall of this inner vessel is swept by the air coming from the compressor and hence cooled to some temperature intermediate between that of the combustion zone proper and the surrounding air.

Even with this air cooling arrangement it has been found that very few metals or alloys will continue to function without distortion or fracture under prolonged conditions of operation particularly around the primary zone of combustion where the temperatures are as high as stated previously and where the inner cylinder may have to operate steadily at temperatures up to and over 900° C. It is also found that even the outer cylinder which when made of metal has to withstand the final diluted products of combustion at temperatures of 600° C. and more is likewise affected after considerable periods of operation by troubles due to creep stresses and failures associated with them.

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As applied to such combustion chambers the present invention may be employed for the lining of the flame zones and if necessary the subsequent lower temperature zones of the main combustion vessel.

It is of course very well known that one can line a combustion chamber made of metal with refractory material to withstand high temperature but the special problem may arise, as it does, in the case of a gas turbine, in that the gases leaving the combustion chamber pass on, e. g. to a turbine wheel running at high speed, and that one must ensure that there is not any possibility whatsoever of pieces of refractory breaking off and getting carried on, e. g. to the turbine blades, where they would cause great damage.

According to the invention, a combustion chamber lining comprises strips of refractory material located in recesses bounded by a wall of the combustion chamber and ribs which extend therefrom so as to key the strips in the recesses. Preferably the ribs project inwardly and convergingly, e. g. radially with respect to the curvature of the wall. This wall and the ribs may be made of metal and may be welded or otherwise attached together.

The ribs may be disposed at comparatively small intervals apart so that the refractory lining will be made in long narrow strips which may be inserted into the recesses by sliding them in from one end, the strips being of trapezoidal cross-section so that they are retained in the recesses bounded by the converging opposing sides of adjacent ribs.

The refractory strips may extend inwards beyond the projection ends of the ribs. By thus making pieces of refractory thicker than the extent of protrusion of the retaining radial ribs a measure of protection for the edge of the ribs, from the flame, is provided.

In the case of a cylindical wall the ribs and strips of refractory material may lie in the longitudinal direction so that the strips are formed as straight pieces. In the case of a wall of hemispherical shape, e. g. the head of a combustion chamber, segment shaped strips will be employed and these may be readily slid into the recesses from the large end of the hemisphere towards the top central portion thereof.

In one embodiment of the invention, each rib has substantially parallel sides.

In another embodiment of the invention, the ribs, in cross-section, widen towards their projection ends. Thus a better locking effect is produced due to the greater convergence of the sides of the recesses produced by the ribs being thicker at the inner edge than where they meet the wall of the combustion chamber.

The ribs are hollow so that a cooling fluid may circulate within them. Such hollow ribs may be formed by bending from strip metal thus producing a hollow wedge with the wider section on the edge nearest the combustion chamber centre line.

The cooling medium circulating within the hollow ribs may be liquid or gas e. g. air, and in the latter case the projection ends of the hollow ribs may have ports for the outlet of cooling fluid into the combustion space. The walls of the combustion chamber may have holes communicating with the interior of the hollow ribs so that the cooling fluid is supplied from a cooling space surrounding the external surface of the combustion chamber wall.

It will be appreciated that the lining according to the invention may be applied to any shape of combustion chamber which may be of the cylindrical or annular type.

In a further embodiment of the invention, as an extra safeguard against pieces of the refractory material being broken away and carried along with the flame products where they may cause damage, as to the blades of a turbine, the inner surface of the refractory lining is wholly or partly covered by a high temperature resisting metal lining, e. g. of molybdenum or its alloys. Such inner lining or shroud or grating of high temperature resisting metal is not required to carry any substantial load, its purpose being merely to prevent broken pieces of refractory material from being carried away in the flame products.

The particular nature of the refractory is immaterial so long as it is capable of withstanding satisfactorily for prolonged periods the temperatures involved. For very high temperatures a refractory having a zirconia base is suitable or a carborundum type of refractory where high conductivity is necessary.

The outer surface of the inner wall of the combustion chamber may be provided with cooling ribs or fins, secured by welding or otherwise, and a radiation shield may be provided between the inner wall and an outer wall or jacket, the space between the inner wall and the outer wall of the jacket being used for the passage of a cooling medium.

In a further embodiment of the invention, each rib is composed of two pieces of curved cross-section arranged to have their respective concave faces opposite each other, the sides of the refractory strips being concave so as to be held firmly in place while providing very considerable shelter for the ribs from direct radiation from the flame.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a cross-section of a portion of a cylindrical combustion chamber according to the embodiment of the invention in which the ribs are hollow and wedge-shaped.

Figure 2 is an underside plan view of Figure 1.

Figure 3 is a cross-section of an embodiment incorporating a plurality of cooling zones, and

Figure 4 is a cross-section of a detail showing a curved form of rib.

Referring to Figures 1 and 2 of the drawings, a cylindrical jacket 1 surrounds an annular space 2, for the passage of air or liquid cooling medium, bounded on its inner side by a combustion chamber wall 3. A number of equally spaced hollow wedge-shaped ribs 4, welded or otherwise attached to the wall 3, hold in place refractory segmental strips 5.

Each hollow rib has air holes 6 at suitable intervals along its projection end. Air holes 7 in the wall 3 allow air to pass into the combustion space from the cooling space 2 via the hollow ribs 4.

In Figure 3, the ribs 4 are of hollow wedge-shaped form, but there are no air holes either in the ribs or in the wall 3. A high temperature resisting cylindrical metal lining 8 abuts the inner surfaces of the refractory strips 5. The space between the wall 3 and the jacket 1 is divided into two concentric annular portions 9 and 10 by means of a cylindrical radiation shield 11. The space 9 is provided with a number of cooling fins 12 arranged radially at suitable intervals and secured to the wall 3 by welding or otherwise. The cooling zones thus comprise respectively the space 9, the space 10, and the interiors of the hollow ribs 4.

In Figure 4, the rib is composed of two pieces 13 of curved cross-section arranged to have their concave faces opposite each other.

What I claim is:

1. A combustion chamber having a chamber wall and a liner comprising a plurality of hollow ribs extending inwardly from said wall, each rib having a pair of side walls, one on either side of an intervening hollow space, the outer surfaces of said side walls diverging gradually from said wall and the adjacent outer surfaces of adjacent ribs converging toward each other away from said wall to define recesses bounded by said wall and said surfaces of the ribs; and strips of refractory material located in said recesses and shaped to be retainingly keyed within the respective recesses throughout a substantial thickness of said strips.

2. A combustion chamber and liner according to claim 1 wherein the said combustion chamber wall is curved cylindrically and the said hollow ribs extend radially to said wall curvature and extend substantially lengthwise with respect to the cylinder.

3. A combustion chamber and liner according to claim 1 wherein the side walls of the hollow ribs are curved throughout a major part of the thickness of the strips to present to the refractory strips convex surfaces that are opposite to each other.

4. A combustion chamber and liner according to claim 1 having a high temperature resisting metal lining covering to a substantial extent the inner, exposed surfaces of the refractory lining strips.

5. A combustion chamber comprising an outer chamber wall; an inner chamber wall spaced therefrom to provide a space for the passage of cooling fluid; cooling fins on the outer surface of the inner wall; and a liner comprising a plurality of hollow ribs extending inwardly from said inner wall, the adjacent outer surfaces of adjacent ribs converging toward each other away from said inner wall to define recesses bounded by said surfaces of the ribs and by said inner wall; and a plurality of strips of refractory mate-

rial extending substantially parallel to the axis of said chamber located in said recesses and shaped to be retainingly keyed therein by the said surfaces of the ribs.

6. In combination with the combustion chamber and liner according to claim 5, a radiation shield between said inner and outer chamber walls.

7. A combustion chamber having a combustion chamber wall and a liner comprising a plurality of ribs projecting inwardly and convergingly from said chamber wall, said ribs being hollow and the combustion chamber wall having holes extending therethrough communicating with the interiors of the hollow ribs; and a plurality of strips of refractory material retainingly keyed in the recesses formed between said ribs.

8. A combustion chamber and liner as claimed in claim 7 in which the chamber wall is curved concavely inwards and the ribs are radial to the curvature of the wall.

9. A combustion chamber and liner as claimed in claim 7 in which the chamber wall and the ribs are of metal and are welded together.

10. A combustion chamber and liner as claimed in claim 7 in which the refractory strips extend inwardly beyond the ends of the ribs.



11. A combustion chamber and liner as claimed in claim 7 in which the ribs have cross sections that widen from the chamber wall towards their projecting ends.

12. A combustion chamber having an inner combustion chamber wall surrounding the flame zone, lined as claimed in claim 7, and having an outer wall spaced from said inner wall to provide an intervening space for the passage of a cooling fluid.

ISAAC LUBBOCK.


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