United States Patent

Goldberg et al.

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[45] **Dec. 19, 1972**

[54] **WALL STRUCTURE FOR A GAS TURBINE ENGINE**

[72] Inventors: **Perry Goldberg**, West Hartford; **Irwin Segalman**, Bloomfield, both of Conn.

[73] Assignee: **United Aircraft Corporation**, East Hartford, Conn.

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 812,793, April 2, 1969, abandoned.

[52] **U.S. Cl.** **60/39.65**, 60/39.66, 431/353

[51] **Int. Cl.**.....**F02c 7/18**

[58] **Field of Search** 60/39.65, 39.66; 431/353

[56] **References Cited**

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Primary Examiner—Douglas Hart

Attorney—Charles A. Warren

[57] **ABSTRACT**

A combustion wall or liner construction which utilizes a unique geometry, primarily a plurality of flow channels with predetermined length-to-diameter ratio which are positioned between the walls of the liner, to maintain the liner wall at an acceptable operating temperature. Cooling air flows through the flow channels and control of the frictional pressure losses of this stream provide the control of the wall temperature.

4 Claims, 4 Drawing Figures

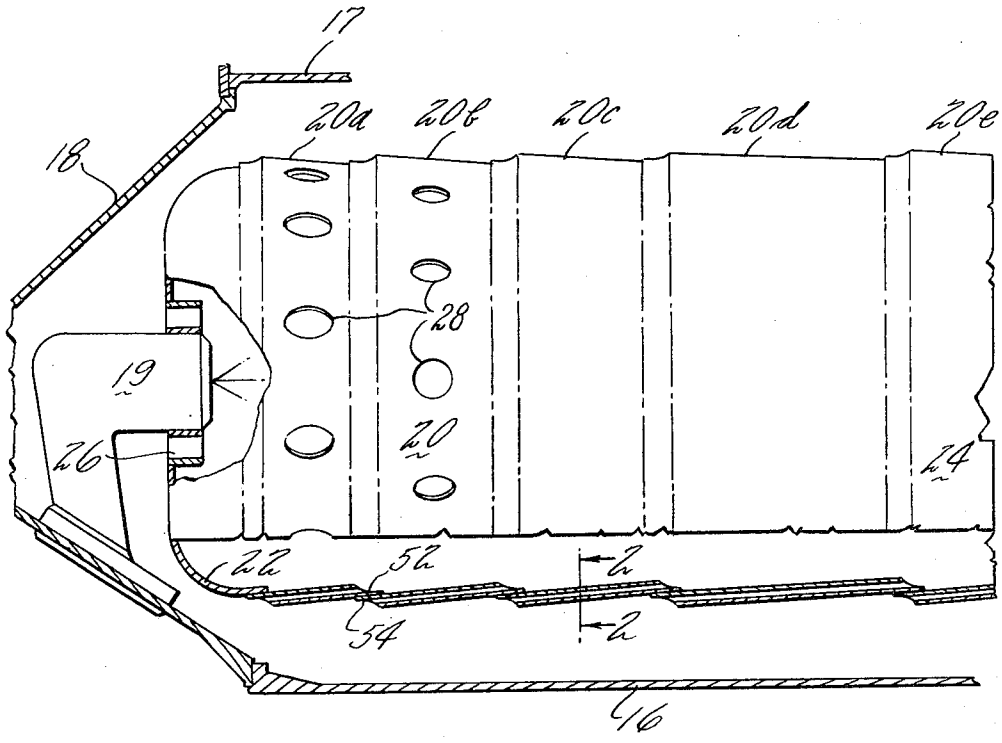


FIG. 1

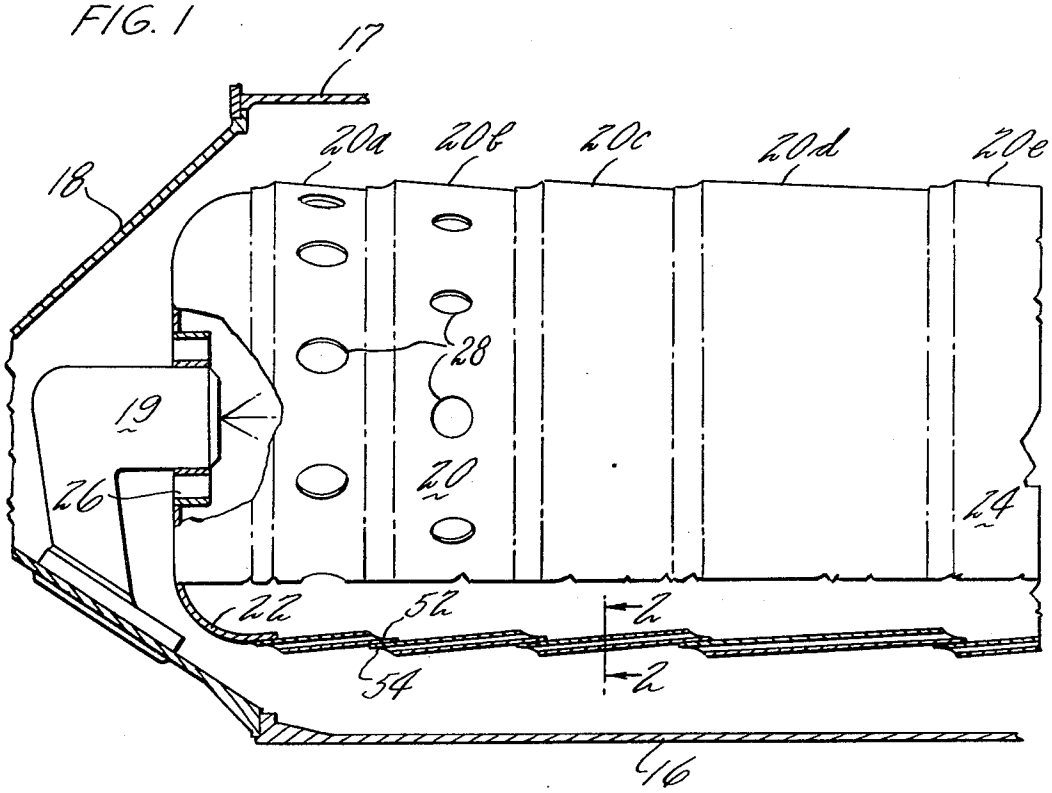


FIG. 2

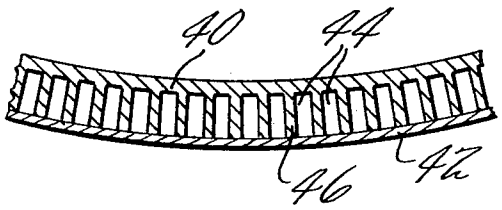
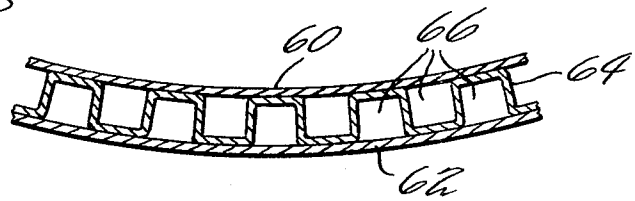


FIG. 3



INVENTORS
PERRY GOLDBERG
IRWIN SEGALMAN

BY ATTORNEY

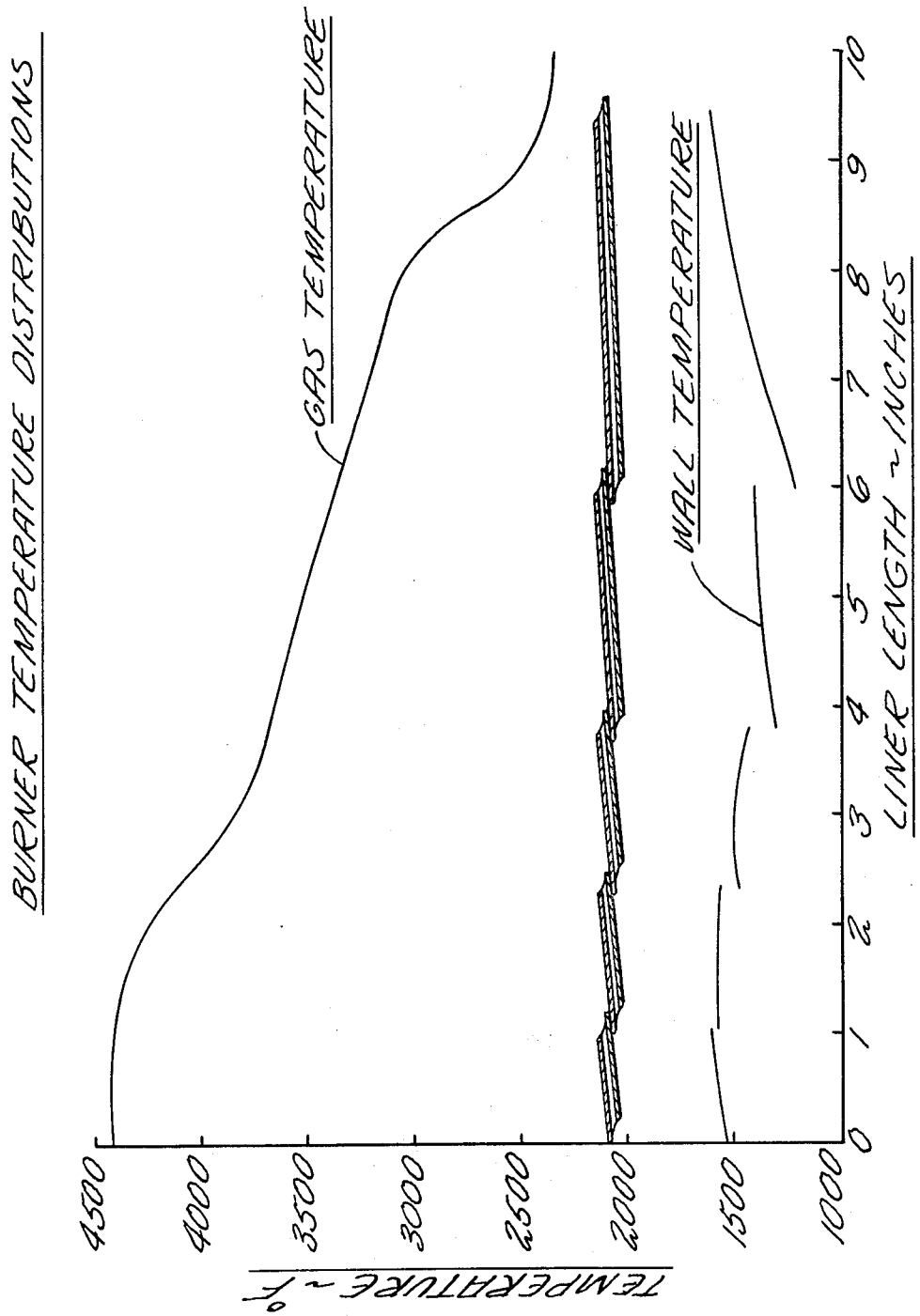

BURNER TEMPERATURE DISTRIBUTIONS
GAS TEMPERATURE
WALL TEMPERATURE
TEMPERATURE ~ °F
4500
4000
3500
3000
2500
2000
1500
1000
0
1
2
3
4
5
6
7
8
9
10
LINER LENGTH ~ INCHES

FIG-4

WALL STRUCTURE FOR A GAS TURBINE ENGINE

This is a continuation-in-part of Ser. No. 812,793, filed Apr. 2, 1969, now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to a heat resistant wall construction, and more particularly to a wall construction which has particular utility in the hot temperature environment of a gas turbine engine.

In most gas turbine applications the combustion chambers, either main burner or afterburner, utilize a cooled combustion chamber liner or wall construction to limit the temperature of the main load carrying structures of the engine such as the inner and outer walls of the burner section of the engine. In the main burner application this liner also serves to control the fuel-air distribution in the primary combustion zone and to permit controlled mixing of unburned air with the combustion products to achieve desired turbine inlet temperature profiles. The cooling for the liner or wall construction, which actually defines a combustion zone within which the combustion or burning occurs, is intended to limit the temperature of the liner wall itself and thereby the temperature of the surrounding main load carrying structural members.

Conventional combustion chamber liners have a number of drawbacks. For example, these constructions require large quantities of cooling air hence reducing the air available for combustion and/or dilution in the main burners. This limits the combustor performance in terms of temperature rise capability and quality of exit temperature profile. It can also result in longer combustion chambers or increased combustor pressure loss to achieve the desired turbine inlet temperature profiles with the reduced dilution air. These obviously result in weight and performance penalties for the gas turbine engine.

SUMMARY OF THE INVENTION

The present invention provides a burner construction which avoids the principal problems encountered by the prior art in a construction in which the cooling air requirements are reduced by approximately 50 percent. Additionally, the construction provides a liner or a wall structure which is substantially free from severe thermal gradients, therefore, improving the life characteristics of the burner.

The description and discussion heretofore has been directed and limited to a construction which has particular utility in the hot environs of a gas turbine engine; however, it should be noted that the present invention has utility in many other environments, e.g., anywhere a double wall structure confining a fluid between the two walls is utilized.

It is a primary objective to provide a wall construction which has particular utility in the combustion section of a gas turbine engine, the construction being such as to maintain the wall and surrounding structural members at an acceptable operating temperature without subjecting these members to adverse thermal gradients.

The burner or combustion chamber includes a liner or wall construction which comprises a pair of radially spaced walls. The radial space is actually a flow passageway which extends over the entire length of a liner wall segment. The flow passageway in turn comprises a plurality of relatively small diameter flow channels, the flow channels being formed by either openings or through the use of a corrugated strip member. The walls separating the individual cooling passages increase the surface area on the coolant side and thereby enhance the ability of this wall construction to maintain itself at an acceptable wall temperature with a given amount of cooling. In the preferred burner embodiment, a plurality of double wall segments are joined to one another to form sets of flow channels extending over the entire length of each of the wall segments, with the length of each segment controlled with respect to the temperature in the adjacent portion of the combustion area. Each of the flow channels has a relatively large length-to-diameter ratio.

The inner wall of the liner actually confines or is the boundary member for the hot combustion gases, and it is this wall in the liner construction which has to be maintained at an acceptance operating temperature. To do this a cooling stream, with a temperature relatively cooler than the combustion gases, is introduced into the flow channels. As a result of the unique geometry of the flow channels, i.e., the large length-to-diameter ratio, the frictional pressure losses of the cooling stream in each of the flow channels can be established and controlled, and thus the operating temperature of the inner wall can be maintained at an acceptable level. Additionally this is achieved with an amount of cooling flow which is approximately 50 percent less than other burner construction. Another feature of the present invention is that since the flow channels extend over the entire length, and since the control of the cooling flow can be accurately controlled, the temperature of the inner wall is maintained at a uniform level. Therefore the adverse thermal gradient and stress loads are substantially eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial cross-sectional view of the burner apparatus, the burner apparatus including a liner wall means utilizing the construction of the present invention.

FIG. 2 is a sectional view taken substantially along line 2—2.

FIG. 3 is a sectional view similar to FIG. 2 showing a modification.

FIG. 4 is a plot showing diagrammatically the relation of burner temperature, liner temperature, and length of wall segments.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention is shown in a burner can or liner for a combustion chamber which is located between the compressor and turbine of a gas turbine power plant and in which fuel is burned in the high pressure gas discharged from the compressor to provide a hot gas under pressure for expansion through the turbine. A power plant to which this type of combustion chamber is applicable is disclosed for example in the Savin U.S. Pat. No. 2,747,367.

As best shown in FIG. 1 the combustion chamber is of a can-annular type only one can being shown. It is understood that any type of combustion chamber may

be employed whether it be a can-annular type or an annular type. The can-annular combustion chamber has an inner cylindrical wall **16** and an outer wall **17** both attached at their upstream ends to a diffuser **18**. Within the diffuser is mounted a fuel nozzle **19** for each burner can **20** or liner. The liner or can includes a dome-shaped head **22** at the inlet end with an opening therein to receive the fuel nozzle. Combustion occurs within this burner can or liner and the products thereof discharge from the open downstream end **24** into the turbine.

High pressure air from the compressor is discharged into and through the diffuser **18** and flows into the combustion chamber. A portion of this air enters the liner or can **20** through a swirler **26** around the fuel nozzle and also through a plurality of combustion holes **28** which are positioned within the liner wall. This liner is made up of a plurality of rings or segments **20***a*, **20***b*, **20***c*, **20***d*, and **20***e* which are attached to one another and through the walls of which cooling air flows for the purpose of maintaining the wall temperature within the desired limits. It is essential that the liner and the surrounding structural members of the engine be maintained within acceptable operating temperature ranges and to this extent the liner **20** has a cooled wall of novel construction.

Referring to FIG. **2** which shows a sectional view through one embodiment of the liner wall, this wall is double thickness and has an inner wall element **40** and radially spaced therefrom, an outer wall element **42**. The inner wall element **40** is directly exposed to the combustion gases within the liner or can and because of the temperature of these gases it becomes necessary to cool the wall to a suitable operating temperature to prevent damage to this wall during operation of the engine. Cooling flow passages **44** are provided between the wall **40** and **42** by circumferentially spaced, longitudinally extending ribs **46** integral with and projecting outwardly from the inner wall and into contact with the outer wall, the spaces between the ribs defining the flow passages.

The burner can segments **20***a*, **20** *b*, **20***c*, **20***d*, and **20** *e* are each of the double thickness described and with the downstream end **52** of each segment attached to and positioned within the upstream end **54** of the next adjacent liner segment. The arrangement of these segments is such that the cooling air enters the upstream end of the passages **44** from outside of the liner, flows through the passages and is discharged into the space inside of the liner in a direction substantially parallel to the liner and directly within the liner. This arrangement is shown in FIG. **1** in which each of the liner sections tapers slightly from the upstream end to the downstream end as shown and the purpose of this is so that the successive liner sections will telescope one with respect with another. As shown, the inner wall element **40** of the first liner section extends over the edge of the dome **22** for the burner can and the downstream end of the outer wall element **42** of this liner section fits within the upstream end of the inner wall element **40** of the next liner section. Also as shown in FIG. **1**, the inner wall element **40** extends forwardly somewhat beyond the passages within the liner so that this wall is exposed to permit welding or other attachment to the underlying end of the outer wall of the adjacent liner segment. Thus, it will be apparent that adjacent liner sections may be suitably attached one to another by welding the overlapping and contacting inner wall of one segment with the outer wall of the adjacent segment.

As shown in FIG. **1**, the liner segments vary in length depending upon the temperature of the combustion gases within the burner can in order that the wall temperature of the liner segments may remain substantially constant and at no time reach a point above that at which the burner can may operate successfully without damage to the material of the liner wall. Thus, the first liner segment is made only 1 inch in length. The second segment is one and three eighths of an inch, the third segment is 1½ and the successive segments are longer since at this time the gas temperature within the burner can is diminishing as shown and less cooling is neccessary to accomplish the desired result of maintaining a workable temperature for the liner wall.

In the modified wall structure of FIG. **3**, the wall of the burner can consists of an inner wall element **60**, an outer parallel wall element **62** radially spaced therefrom, and a corrugated sheet **64** positioned therebetween and bonded to both to hold them in spaced relation and to define a plurality of longitudinally extending circumferentially spaced passages **66**. The effective diameter of these passages for the particular burner can shown, which has a diameter of approximately 6.5 inches was 0.04 inches. These double thickness wall elements are made up in the same manner as shown in FIG. **1** with the outer wall extending beyond the passages at the downstream end and with the inner wall extending beyond the passages at the upstream end to provide overlapping flanges by which successive segments may be secured together. With either construction, FIG. **2** or FIG. **3**, the additional coolant side surface area as a consequence of the dividers between individual coolant channels, significantly enhances the thermal effectiveness of the wall construction and thereby reduces the cooling air requirement.

As described above, each segment may have a small taper from end to end so that when the several segments are secured together, the resulting can will have a substantially constant diameter from end to end.

Referring now to FIG. **4**, this plot represents a burner can that was built and tested and shows the temperature variation within the can and the temperatures at which the successive sections of the liner operated. As shown, by selecting the proper length of burner can segments to produce the desired amount of cooling, it was possible to keep the wall temperature from going above 1,600°F, where the temperature within the burner can was extremely high. The particular wall construction of the burner can used was the arrangement of FIG. **3** above described, and was of such dimension that the effective diameter of each of the cooling passages was 0.04 inch, so that the length-to-diameter ratio for the first section was **25**. It is thus apparent that by selecting the relative lengths of the successive liner segments, the greatest amount of cooling accomplished was in those portions of the liner that were subjected to the greatest heat from the combustion gases within the liner and therefore the liner wall may be kept at appropriate temperatures regardless of the temperature within the liner.

Furthermore, with the successive burner can segments lengthening as the temperature within the can decreases the amount of cooling air needed is materially reduced, thereby minimizing the amount of cooling air required. By making the passages very small, on the order, as above indicated of from 0.02 inch to 0.06 inch in effective diameter, the coolant side heat transfer is significantly enhanced. The smaller the area of the channel, the greater the surface area of the channel that is exposed to the air passing through the channel, and thereby, the greater cooling effect. The ability to cool the structure with a minimum of cooling air is enhanced by significantly increasing the heat transfer coefficients and a significant increase in coolant side surface area. The liner or burner can segments extend circumferentially but obviously the flow passages are longitudinally or axially of the combustion chamber, and the length of each segment determines the length of the flow passages in that segment.

As shown in FIG. 4, the liner segments increase in length toward the downstream end of the liner or burner can and thus the length of segments increases as the operating temperature within the can decreases. The essential feature is to provide only enough cooling of the wall to keep the temperature of the wall from exceeding the safe operating temperature, normally established for the particular alloy used as 1,600°F in the particular arrangement shown. This has been accomplished in the construction shown as evidenced by the chart of FIG. 4.

We claim:

1. A liner for a combustion chamber for use in a gas turbine engine in which combustion occurs in a gas stream moving axially through the combustion chamber, said liner including a plurality of liner segments arranged circumferentially, each segment having spaced inner and outer wall elements and means interconnecting the elements and defining closely spaced longitudinally extending flow passages therebetween, the outer wall of one segment being connected to and overlying the inner wall of the next adjacent downstream segment to cause cooling air to flow into the upstream ends of the passages from the chamber space outside the liner and to enter the space inside the liner at the downstream ends of said passages, successive liner segments increasing in length in a downstream direction as the operating temperature within the liner decreases.

2. An annular combustion chamber for a gas turbine engine in which combustion occurs in a stream of gas moving axially through said chamber, said chamber having inner and outer walls forming an annular space therebetween and a liner spaced from one of the said walls to define between said one wall and the liner a passage for cooling air and on the other side of the liner a combustion space, said liner comprising a plurality of segments extending in a circumferential direction within the chamber and located in side-by-side relation axially of the chamber and secured together, each segment having spaced inner and outer wall elements and spacer means between said elements serving to hold said elements in spaced relation and forming closely spaced parallel passages between said wall elements extending in an axial direction, the inner wall element of one liner segment overlying and secured to the outer wall element of the adjacent upstream element and said successive segments increasing in length toward the downstream end of the combustion chamber for increasing the lengths of the flow passages near the areas of decreasing temperature within the combustion space, each of said passages being relatively small in effective diameter on the order of between 0.02 and 0.06 inches.

3. An annular combustion chamber as in claim 2 in which the length-to-diameter ratio is between about 20 and 85.

4. A combustion chamber as in claim 2 in which the liner is in the form of a burner can with the segments extending peripherally around the can and forming the wall thereof.

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