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Cross et al.

[11] **3,880,575**

[45] **Apr. 29, 1975**

[54] **CERAMIC COMBUSTION LINER**

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[73] Assignee: **General Motors Corporation,** Detroit, Mich.

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[52] **U.S. Cl.** **431/353;** 60/39.65; 431/352

[51] **Int. Cl.** **F23m 5/04**

[58] **Field of Search**.................... 431/352, 353, 158; 60/39.65

[56] **References Cited**

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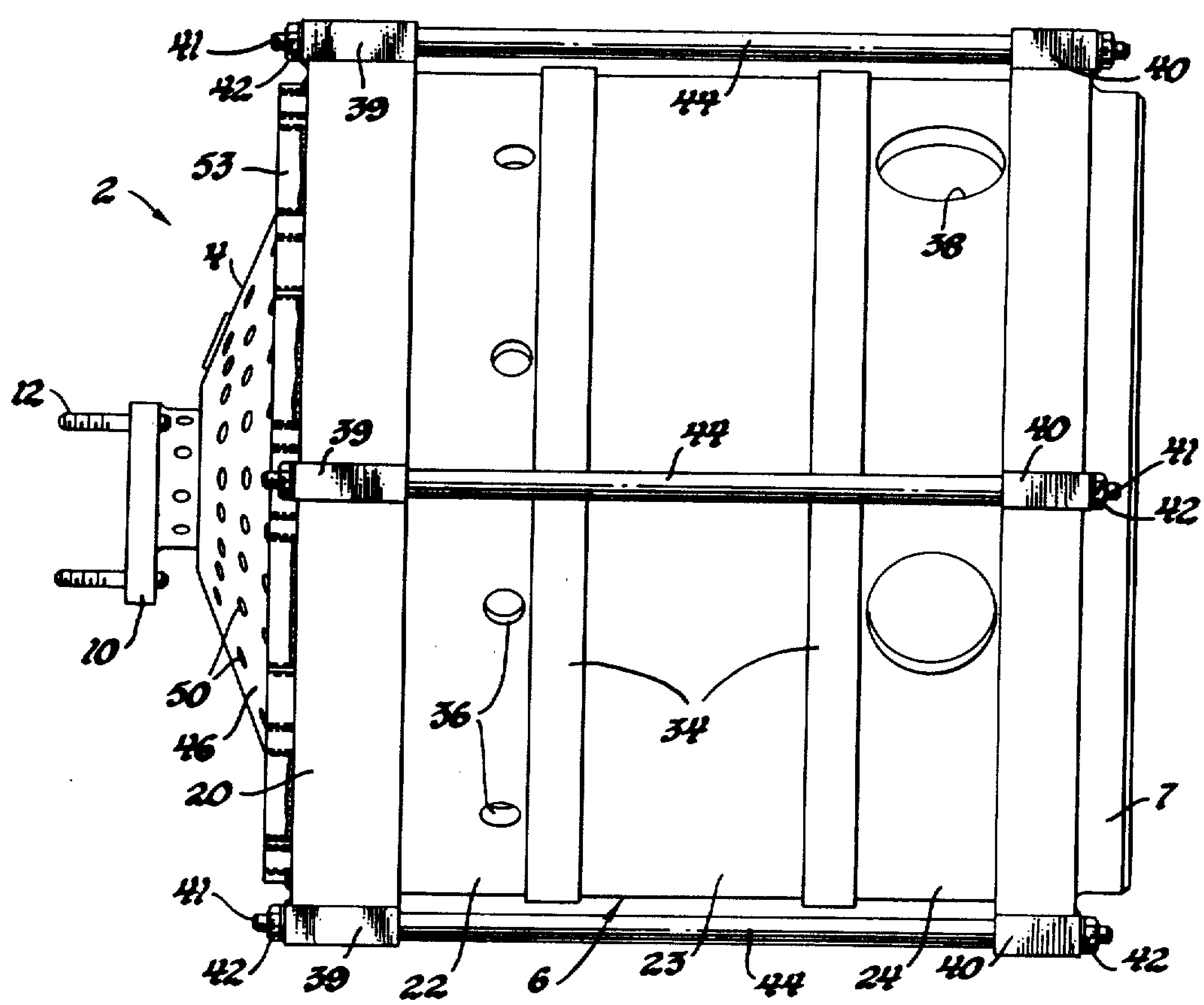
[57] **ABSTRACT**

A liner for a gas turbine combustion apparatus has a ceramic side wall made up of a number of axially-aligned rings. These are retained between a metal dome and a metal outlet fitting which are connected together by tie rods and maintained at proper axial spacing by sleeves disposed around the tie rods. A T-section metal ring is disposed between each adjacent pair of liner wall segments to align the segments with each other. A resilient compressive connection is disposed between the upstream ring and the dome. These arrangements accommodate differential thermal expansion of the metal and ceramic parts of the liner.

2 Claims, 3 Drawing Figures



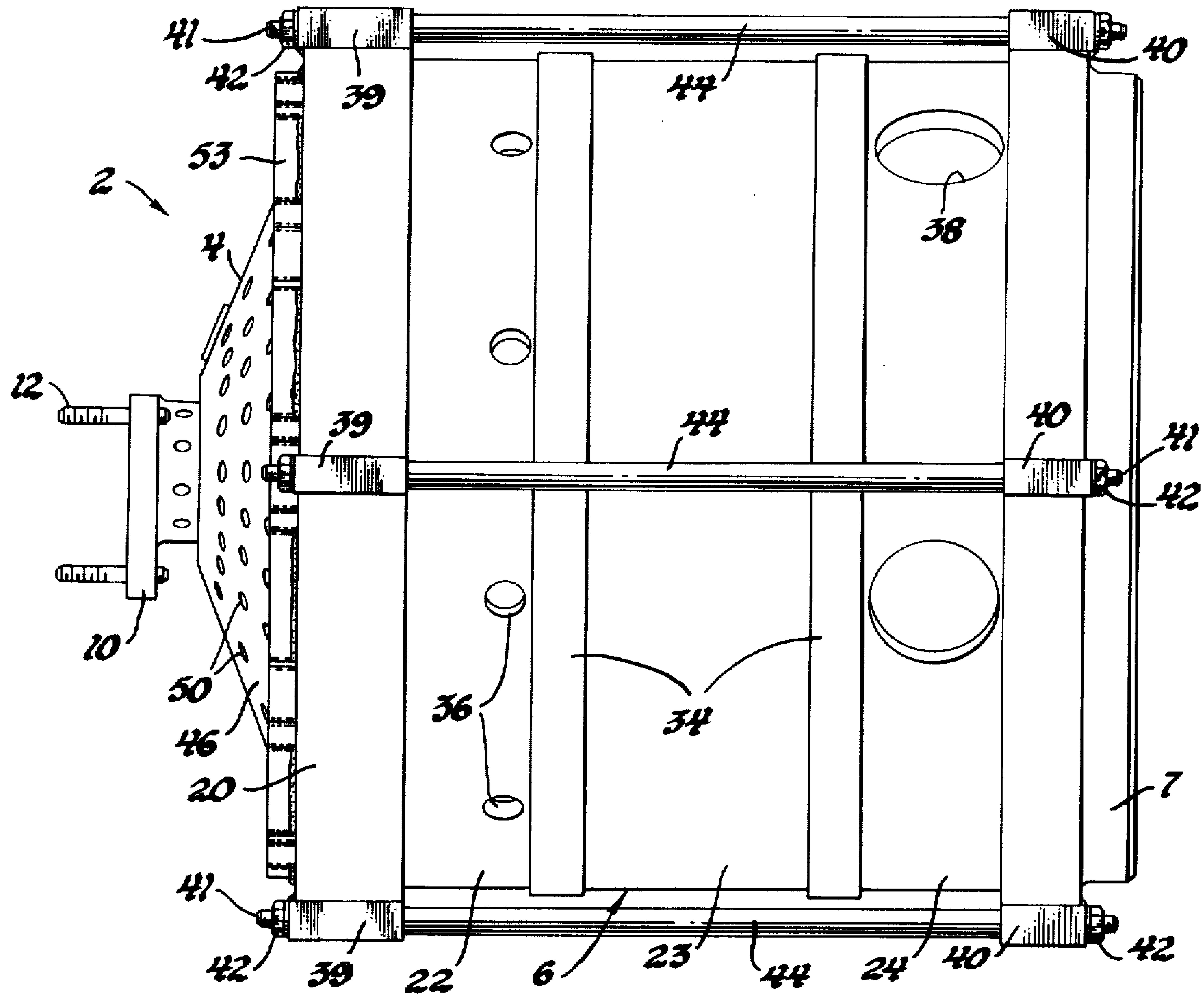

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Fig.1

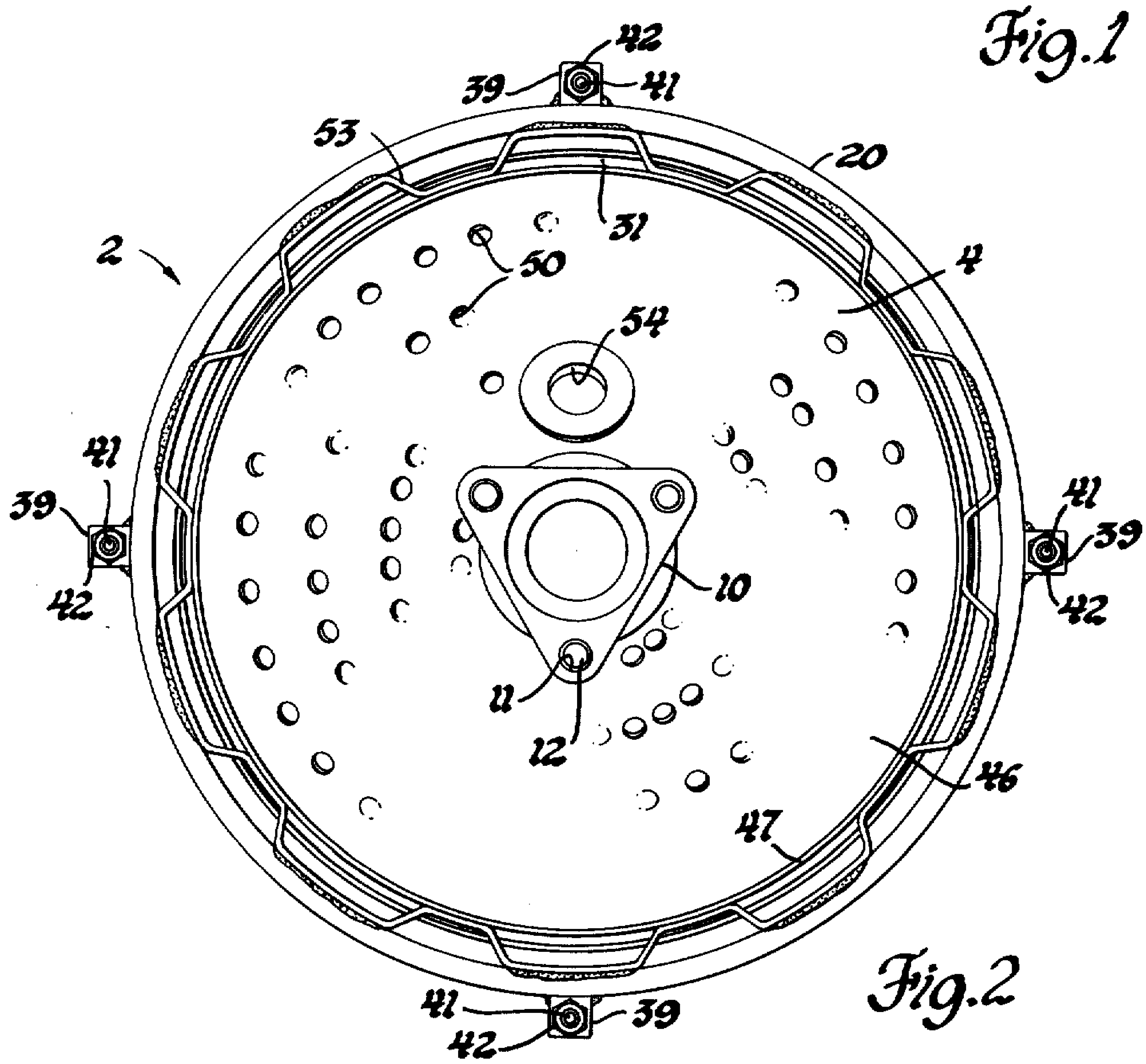
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Fig.2

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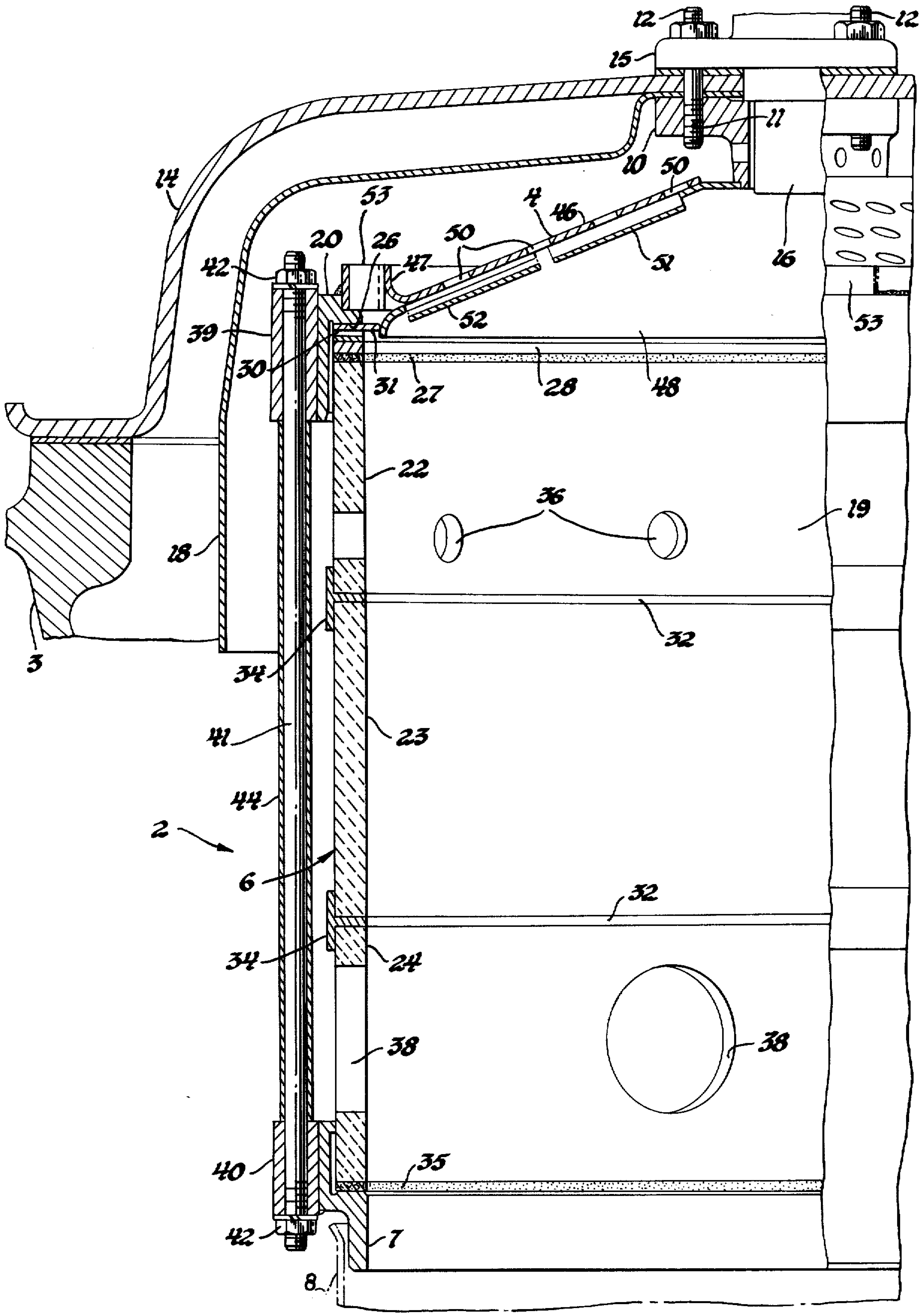

Fig 3

CERAMIC COMBUSTION LINER

This invention is directed to combustion apparatus such as is used in a gas turbine engine, and particularly to combustion liner structure for such apparatus.

By way of background, most gas turbine combustion apparatuses include a liner within which combustion takes place. Such liners ordinarily are of circular or annular cross-section, with an upstream end called a dome and an outlet at the downstream end for combustion products. Fuel is sprayed at the upstream end and air enters through the upstream end and through the side wall of the liner to effect combustion and to dilute the combustion products to a suitable temperature.

Although walls of many combustion apparatuses have been made of various ceramic materials, gas turbine combustion liners in practice, so far as we are aware, have been made of high temperature resisting metal alloys. Such metal alloy structures have good hot strength and a relatively high degree of durability. However, such combustion liners are very expensive; therefore, if ceramics can be substituted for the metal to provide a satisfactory liner, considerable savings may result.

While various known ceramics are highly resistant to heat and may be formed into cylinders and other shapes by known techniques, such materials are relatively weak and brittle. Also, the ceramics have relatively low thermal expansion, which presents a problem when it becomes necessary to mount them with metal components in an engine combustion apparatus.

This invention is directed to a structure which facilitates the employment of ceramic elements for the major portion of a combustion liner so as to retain the cost and temperature resisting advantages of the ceramic while avoiding stresses on the ceramic material which would be likely to cause cracking or breaking.

Briefly stated, the combustion liner is made up of a metal dome or upstream end cap which may be similar to previously known structues, a number of aligned ceramic rings defining the side wall of the combustion liner, an outlet fitting engaging the farthest downstream ring, means between the rings to align them, and an interconnection between the dome and the outlet fitting providing a confining cage or support for the liner wall sections. These structures embody an arrangement to accommodate the relatively greater expansion of the metal parts than the ceramic.

The principal objects of the invention are to provide a combustion liner of largely ceramic composition which is adpated to withstand the shocks, both mechanical and thermal, which are encountered in service, to provide an economical and durable combustion liner largely of ceramic composition, and to provide a simple arrangement for supporting a ceramic combustion liner in a gas turbine engine or other combustion apparatus.

The nature of the invention and its advantages will be more clearly apparent to those skilled in the art from the succeeding detailed description of the preferred embodiment of the invention and the accompanying drawings thereof.

FIG. 1 is a side elevation view of a combustion liner, shown with its axis horizontal.

FIG. 2 is an end elevation view of the same.

FIG. 3 is a longitudinal sectional view of the liner as installed with its axis vertical in a gas turbine engine combustion apparatus.

FIG. 3 is a partial view of the liner as installed in a gas turbine engine of known type which may be similar to those described in United States patents as follows: Collman et al. U.S. Pat. No. 3,077,074, Feb. 12, 1963; Collman et al. U.S. Pat. No. 3,267,674, Aug. 23, 1966; and Bell U.S. Pat. No. 3,490,746, Jan. 20, 1970. The combustion liner **2** may be mounted in a suitable space within the engine, a portion of the frame or housing of the engine being designated at **3.** The combustion liner includes a metal dome or upstream end cap **4** and a side wall **6** which preferably is of circular cross section, as illustrated. The downstream end of the combustion liner is defined by a ring-shaped outlet fitting **7** which may telescope into a scroll or transition section **8** which conducts the combustion products from the combustion liner into the turbine of the engine (not illustrated).

The dome **4** includes a central hollow flanged bracket **10.** The flange is of triangular outline and has three threaded holes **11** to receive studs **12** by which the dome is mounted in the engine so as to support the liner. Studs **12** extend through a combustion cover **14** suitably fixed to the frame **3** of the engine. The studs extend through a flange **15** on a fuel spray nozzle **16.** Nuts on the studs thus hold the nozzle against the outer surface of the cover **14** and the flange **10** against the inner surface. A heat shield **18,** which shields the combustion cover **14** from heat radiated within the engine and influences air flow to the dome, is also mounted between the flange **10** and cover **14.** The dome **4** may be of structure previously known providing for admission of a large part of the combustion air through the dome into a combustion space **19** defined within the liner. Passing over details of the dome for the time being, it may be noted that this is a sheet metal structure to the outer margin of which is fixed a mounting ring **20.**

The liner wall **5** illustrated is composed of three annular sections or rings **22, 23,** and **24** in the direction of flow from the dome to the outlet fitting **7.** This segmented wall allows for different expansion of the sections of the liner wall while minimizing stress. In operation, the central section **23** becomes much hotter than the adjoining sections. Since they are separate, they do not stress each other because of differential expansion.

Wall section **22** fits with some slight clearance within the mounting ring **20.** The end of section **22** abuts through intermediate structure against a flange **26** on the mounting ring **20.** The intermediate structure shown includes a slightly yieldable ceramic felt washer or gasket **27** of commercially available material, a rigid washer **28** of heat resistant metal, a wavy resilient washer or annular spring **30** of heat resistant metal alloy, and an air flow controlling or blocking washer **31.** The felt washer **27** may be omitted, since the rigid washer **28** distributes the concentrated force from the wave washer convolutions over the end surface of the liner section **22.**

An aligning ring **32** is disposed between each two adjacent wall sections **22** and **23** or **23** and **24.** These rings, which are of T-shaped cross section, include an outer band **34** which engages the outer surface of the wall rings to align them and a portion which extends between the end faces of adajcent wall rings.

A second yieldable ceramic washer **35** may be disposed between the downstream end of wall section **24** and the outlet fitting **7.**

In the embodiment illustrated, the upstream wall section 22 has a ring of ten primary air entrance holes **36** and the downstream wall section **24** has five equally spaced secondary or dilution air holes **38.** Thus, so far as the air entrances through the side wall is concerned, the liner is similar to a common type of metal-walled liner. Any suitable arrangement of air holes may be used.

The several parts of the liner are maintained in assembled relation by structure including sleeves **39** fixed 90° apart around the circumference of mounting ring **20** and sleeves **40** fixed 90° apart around the outlet fitting **7.** These sleeves may be welded to the parts **20** and **7** respectively. Tie rods **41** extending through the aligned sleeves **39** and **40** mount nuts **42** on the threaded ends of the rods which bear through washers against the outer ends of sleeves **39** and **40.**

The spacing between parts **20** and **7** is controlled by hollow struts **44** which are fitted over the tie rods **41** before the assembly is completed. Thus, by tightening the nuts **42,** the sleeves **39** and **40** are brought to bear against the ends of the struts, definitely establishing the spacing between the flange **26** of mounting ring **20** and the bearing surface of the outlet fitting **7.** This distance should be such as to compress to some extent the washers **27** and **35** (if provided) and the wavy spring **30.** When the apparatus heats up during combustion, the metal parts such as the tie rods and sleeves shown, or other metal supporting structures for the liner, will ordinarily expand somewhat more than the ceramic, notwithstanding their lower temperature. The preloaded spring **30** will then expand resiliently to prevent looseness of the parts which might allow shock or vibration to cause chipping of the ceramic.

The dome **4** illustrated is an adaptation of the dome structure used on a prior all-metal combustion liner. Any suitable dome structure may be used. This one is effectively a double-walled structure with an outer layer **46** terminating in a flange **47** at its outer edge and an inner layer **48** which is fixed by welding or brazing to the bracket **10.** Numerous primary air holes **50** extend through the outer layer **46.** The inner layer **48** is deformed to provide louvers **51** and **52** which swirl the air entering through the holes **50** in opposite directions.

The flange **47** is welded to a zigzag strip **53** which in turn is welded to the mounting ring **20.** The original purpose of the zigzag strip is to admit film cooling air to the interior of the liner. In a ceramic liner structure such as that described here, there is no need, or only a very slight need, for such cooling air. To control the flow of air through the zigzag strip into the interior of the liner, the washer **31** extends across the gap between the ring **20** and the layer **48** of the dome. The amount of air flow can be varied by choice of width of washer **31.** The dome also provides an opening **54** (FIG. 2) for an igniter.

The operation of the combustion chamber is similar to that of other combustion chambers of like overall configuration. Air entering through the holes **50** and **36** provides for combustion of fuel sprayed through the nozzle **16.** The resulting combustion products are diluted by additional air entering through openings **38** and the resulting mixture is discharged through the outlet fitting **7** and into the turbine through suitable structure. It will be seen that the liner structure described provides for accurate alignment and support of the ceramic parts without concentrated loads or freedom for vibration and rattling of the parts. It thus is adapted to promote long life of the ceramic notwithstanding its lack of strength and its brittleness. The mounting structure is simple and may readily be taken apart for replacement of any part which deteriorates in service.

The nature of the ceramic is a matter of choice. So far it appears that a silicon carbide ceramic is best adapted to meet the requirements of practice. The metal parts need have no unusual property except sufficient strength at high temperature and resistance to oxidation or corrosion to have sufficient life in service. The tie rods **41** and struts **44** are out of direct contact with the hot ceramic parts which are the hottest parts of the liner.

By segmenting the ceramic, it is possible to minimize thermal stresses due to uneven heating of the ceramic because of the differences in temperature at various zones of the combustion liner.

For information, it may be pointed out that the liner described is intended to operate at temperatures up to 1057°F. for inlet air and up to 1763°F. for outlet air temperature to the turbine. It operates at about five atmospheres with an air flow of about 4½ lbs. per second and a fuel flow of about 190 lbs. per hour at full capacity.

It should be apparent to those skilled in the art from the foregoing that the combustion liner structure described is particularly well adapted to meet the requirements of practice in a small gas turbine engine.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

We claim:

1. A combustion liner for a combustion apparatus comprising, in combination, a dome defining the upstream wall of the liner; a plural number of alinged ceramic wall rings defining the side wall of the liner, one ring being adjacent to the dome; means for aligning the said one ring with the dome; an aligning ring disposed at each junction between adjacent wall rings engaging a radially facing surface of each wall ring to align the wall rings; an outlet fitting abutting the farthest downstream wall ring; and means interconnecting the dome and the outlet fitting including tie rods distributed circumferentially of the liner between the dome and outlet fitting.

2. A combustion liner for a combustion apparatus comprising, in combination, a dome defining the upstream wall of the liner and providing support means for the liner; a plural number of aligned ceramic wall rings defining the side wall of the liner, one ring being adjacent to the dome; means for aligning the said one ring with the dome; an aligning ring disposed between each two adjacent wall rings engaging an end surface and a radially facing surface of each wall ring to align the wall rings and transmit compressive force between the wall rings; an outlet fitting abutting the farthest downstream wall ring; and means independent of the wall rings interconnecting the dome and the outlet fitting including tie rods distributed cirumferentially of the liner between the dome and outlet fitting.

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