

[54] COMBUSTION LINER

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60/39.74

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[58] Field of Search **60/39.71, 39.74 R;**
239/402.5, 403, 414

[56] References Cited

UNITED STATES PATENTS

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Primary Examiner—William L. Freeh

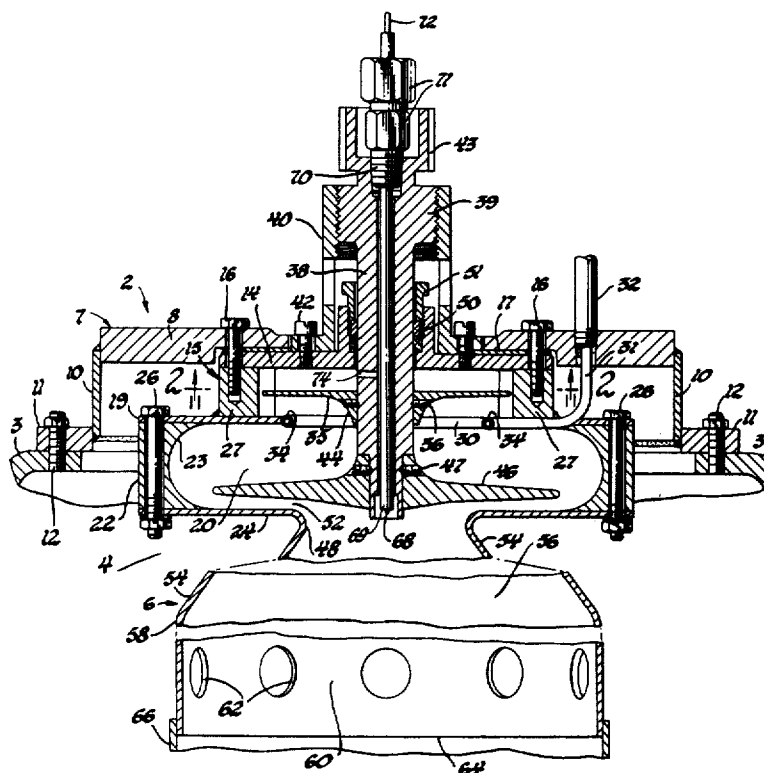
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[57] ABSTRACT

A combustion liner, for a gas turbine or similar use, provides for introduction of fuel and primary air and premixing of the fuel with the air before entry into the reaction zone of the combustion liner. Air is swirled radially inwardly past a fuel spray ring at the upstream end of the liner and then into a premix chamber of greater diameter than the swirler. The premix chamber has a downstream wall at the center of which is a throat through which the fuel-air mixture enters a divergent reaction zone. An axially movable support which enters through the upstream end bears two disks. One disk throttles flow of air through the swirler and the other varies the area of the annular outlet from the premix chamber between the disk and the downstream wall.

4 Claims, 2 Drawing Figures



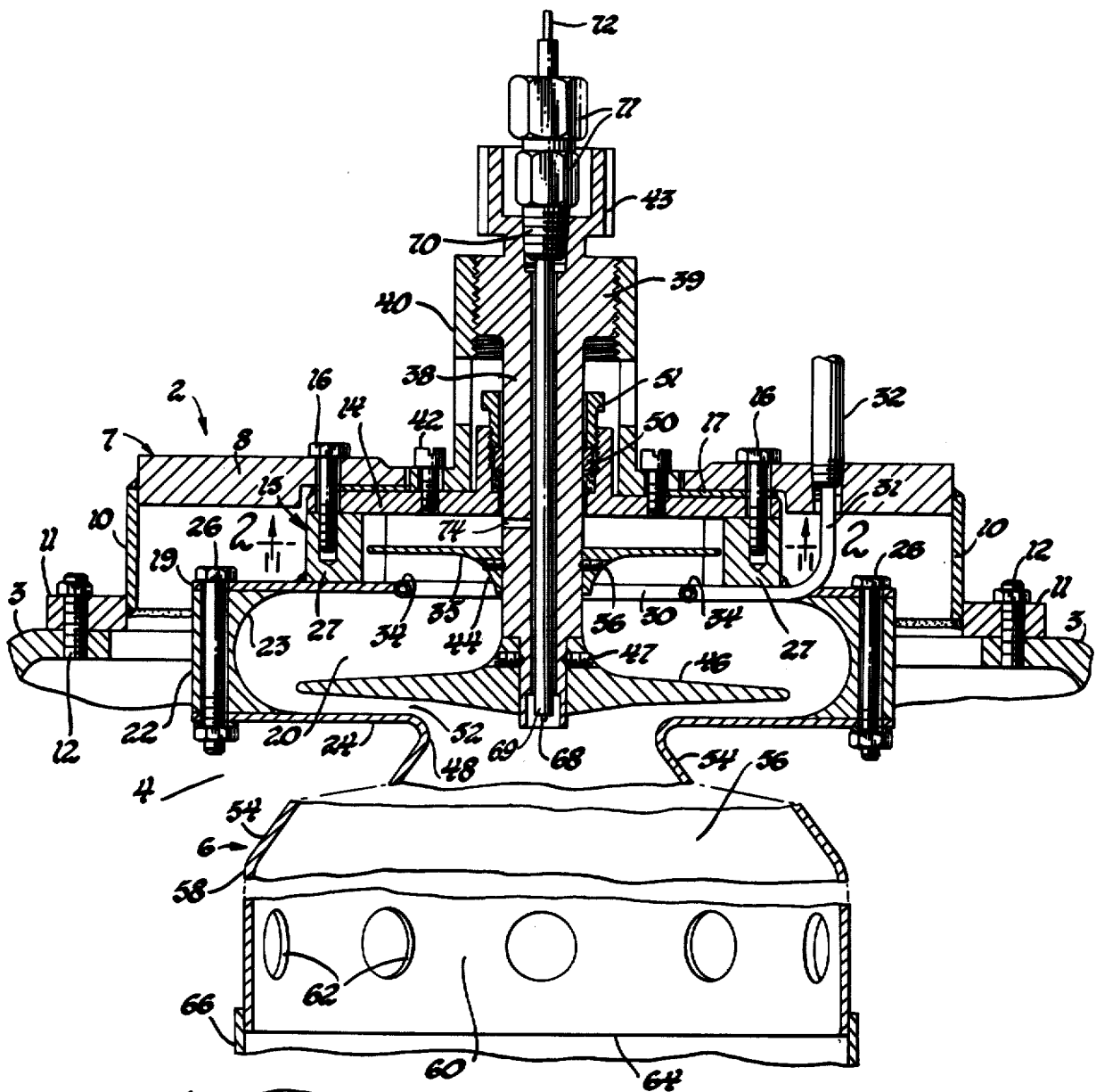


Fig. 1

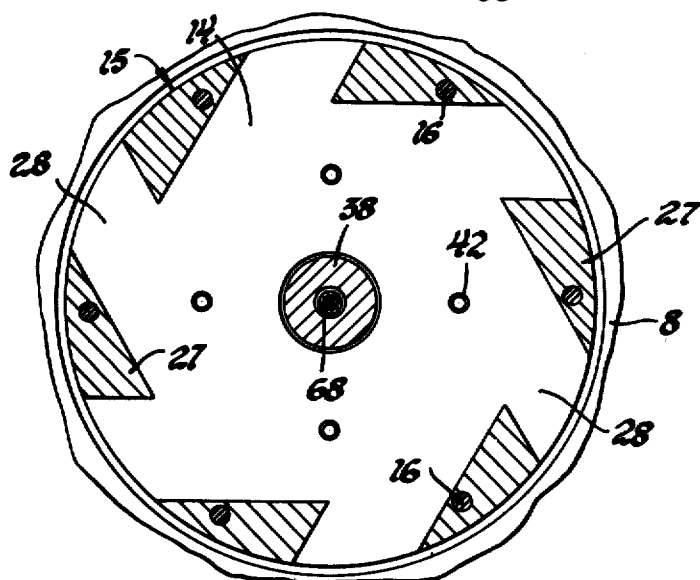


Fig. 2

COMBUSTION LINER

My invention is directed to combustion apparatus, particularly to combustion apparatus such as is used at relatively high pressures and with high energy rate heat release as, for example, in a gas turbine engine.

It is intended particularly for gas turbines in which the power demand varies widely and where there are restrictions on the discharge of incompletely consumed fuel and oxygen-nitrogen reaction products.

Minimization of undesired exhaust products can be furthered by careful control of the ratio of fuel to air in the primary combustion or reaction zone and by thorough premixing of the fuel and air, with vaporization of the liquid fuel, prior to entry of the fuel-air mixture into the reaction zone.

My invention is directed to improvements in the arrangements for supply of primary air and fuel to a combustion liner so as to maintain a constant or controlled ratio of fuel to air in the reaction zone and provide for adequate mixing of fuel and air, preferably with vaporization of the fuel.

In a combustion apparatus according to my invention the primary air is introduced through an inward flow swirler, flows past fuel injection means, and then flows outwardly in a premix chamber coaxial with the swirler. The mixture flows over a reciprocable disk and then between the disk and the downstream wall of the premixing chamber to a throat through which it enters a diverging reaction zone. The disk is reciprocable to vary the area for flow between the disk and the downstream wall of the premixing chamber so as to maintain high velocity of flow and prevent striking back of the flame into the premixing chamber. Another disk, which reciprocates with the one controlling flow from the premixing chamber, varies the area of the air entrance swirler along with the area for flow out, thus maintaining the velocity of the entering air and its swirl component at a high value even at slow rates of flow. This promotes proper mixing of the fuel and air.

The vortex flow from the throat tends to cause recirculation in the reaction chamber which promotes complete combustion.

In the preferred environment of the invention, the air supplied to the combustion apparatus has been heated by regeneration or by compression to a high pressure so that it is sufficiently hot to evaporate the fuel within the premixing chamber.

The overall result is a combustion apparatus which can function over a wide range of fuel and air flows with relatively constant fuel-air ratio and which has relatively clean combustion over such a wide range.

The principal objects of my invention are to provide a clean combustion apparatus suitable for use in gas turbine engines; to provide improved fuel vaporization and mixing arrangements; to provide a variable flow combustion liner of simple and durable construction; and to provide improved means for controlling flow of air into a combustion liner.

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

FIG. 1 is an axial sectional view of a combustion liner installation in a gas turbine engine, the engine being shown fragmentarily.

FIG. 2 is a cross-sectional view on the plane indicated by the line 2—2 in FIG. 1.

FIG. 1 illustrates a combustion liner and associated primary air and fuel introduction means. The installation may be in an engine of known type such as those described in Collman et al. U.S. Pat. No. 3,267,674, Aug. 23, 1966, and Bell U.S. Pat. No. 3,680,983, Aug. 1, 1972. In view of such prior art, it is unnecessary to describe further the environment of the combustion liner.

Referring to FIG. 1, an engine 2 includes a wall or housing 3 enclosing a chamber 4 through which hot compressed air, as from the compressor and regenerator of an engine of the type described in the patents mentioned above, flows into a combustion liner 6. The combustion liner is suspended from a combustion cover 7 comprising an annular plate 8, a side wall 10, and a flange 11. The flange is fixed to the housing 3 by a ring of studs and nuts 12. The combustion liner 6 includes an annular upstream end wall 14 and a swirler ring 15.

The end wall 14 and swirler ring 15 are brazed into a unitary structure and are held against the plate 8 by a ring of cap screws 16. A gasket 17 is disposed between the elements 14 and 8. Swirler ring 15 is brazed to an annular plate 19 which provides the upstream wall of a premix prevaporization chamber 20. This chamber is also defined by an outer wall 22 having a concave inner surface as indicated at 23 and by a radial downstream wall 24. Elements 19, 22, and 24 are held together by a ring of bolts 26.

The structure of the swirler ring is also illustrated in FIG. 2. It comprises six blocks 27 which define between them six air entrances or chutes 28 which are inclined to the radial direction so that air flows radially inwardly through the chutes 28 and swirls in the interior of the swirler between plates 35 and 19. This is the primary combustion air or reaction air for the combustion apparatus.

Fuel is introduced into the air from a fuel spray ring 30 supplied through a pipe 31 connected to an external fuel supply line 32. Any suitable means for controlling the rate of flow or pressure of fuel supplied through line 32 may be employed, and is not described here. Fuel is discharged from the ring 30 through circumferentially spaced orifices 34 disposed entirely around the ring 30.

Air introduced through the swirler 15 flows across the jets of fuel from the orifices 34 and carries the fuel with it around the inner margin of plate 19 and fuel ring 30 into the premixing chamber 20. The quantity of air is varied by a throttling arrangement for the swirler including a disk 35 reciprocably mounted for movement longitudinally of the swirler 15; that is, axially of the combustion apparatus. Disk 35 is fixed by set screws 36 to a support or actuating rod 38 movable axially of the combustion apparatus. Support 38 has an enlarged threaded portion 39 which is received in internal threads in a hollow boss 40. This boss has an outwardly extending flange which is fixed to the swirler upstream end wall 14 by cap screws 42.

The actuating rod 38 is rotated by any suitable means indicated as a gear 43 integral with the rod which may be driven by a suitable gear or rack (not illustrated) actuated by any desired control member. Rotation of the support 38 moves it in or out of the combustion liner so that the disk 35 varies the width of the air entrance

through the swirler on the downstream side of disk 35. Disk 35 includes a hub 44 which aids in smooth deflection of the radially inward flow from the swirler to the radially outward flow through the premixing chamber 20.

A second disk 46, which acts to guide the flow from the premixing chamber and to throttle the outlet from the premixing chamber, is fixed by set screws 47 on the reduced downstream end of support 38. Thus, the two disks 35 and 46 are reciprocated simultaneously by rotation of the support 38. As the area for entrance of air to the premixing chamber decreases, the area of the outlet correspondingly decreases. The position of the disk 35 on the support may be adjusted to trim the area relation of the two passages controlled by the disks.

A conventional seal or gland 50 is provided between the support 38 and end wall 14. This gland may be tightened by a nut 51.

In operation, the air introduced through the swirler swirls inwardly past the spray ring 34 and then outwardly between plate 19 and disk 46, being turned inwardly by the outer wall surface 23 and then swirling inwardly toward the axis between disk 46 and wall 24 to the throat 48 which defines the outlet from the premixing chamber into the reaction zone for all of the fuel and combustion air. During this circulation through the prechamber to the throat, the hot air normally vaporizes the fuel. Of course, upon starting a cold engine, vaporization is temporarily delayed, but the fuel is dispersed into the air.

The premix-prevaporized fuel-air flows with considerable velocity through the gap 52 between disk 46 and wall 24 and through the throat 48 into the diverging wall section 54 which bounds the upstream end of the reaction chamber 56. In the preferred structure, the throat is about 2½ inches in diameter and is about 36% of the diameter of the premix chamber 20. The wall 54 diverges at approximately a 36° angle to a diameter of about 6½ inches in the illustrated embodiment, at which point it continues in a cylindrical wall 58 downstream for a sufficient distance for completion of the reaction. Downstream of the reaction zone there is a dilution zone 60 to which dilution air to reduce the temperature of the combustion products is admitted through a ring of dilution air holes 62. The downstream end of the liner at 64 is slidably piloted within the upstream end of a duct or turbine nozzle box 66 through which the combustion products are carried to the turbine or other user.

By virtue of the adjustable structure according to the invention, the area of swirler 15 is varied so as to keep the velocity high enough to maintain adequate swirl at relatively low rates of air flow and the area at the annular orifice or gap 52 between disk 46 and wall 24 is kept small enough to hold the velocity of flow there above the velocity of propagation of the flame so that the flame does not strike back into the premix chamber 20. Reaction takes place in reaction chamber 56 in which the swirling air will recirculate and mix thoroughly to complete combustion before entry of the dilution air through holes 62.

Flame is established by a spark igniter 68 having an electrode extending through the support 38 within an insulating sleeve 69. The igniter may be threaded at 70 into the outer end of the support and may include a suitable connector 71 for attachment of a high tension

lead 72. The spark gap is from the lower end of electrode 68 to the surrounding tip of support 38.

There is provision for cooling the igniter. Some air entering through the swirler ring 15 flows over the upper surface of disk 35, through a radial port 74 in the support 38, and then into the reaction chamber 56 along the outer surface of sleeve 69. This cooling air is free of fuel.

It may be noted that the physical structure shown is that of an experimental or test combustor. The bolted parts may readily be disassembled and replaced to vary dimensions for test purposes. A more unitary structure would normally be used in series production. However, the basic structural organization and principles of operation would remain the same.

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.

I claim:

1. A combustion liner adapted for high energy combustion and with provisions for maintaining a desired equivalence ratio in the reaction zone, the liner having a closed upstream end and having a substantially circular cross-section, and comprising a radial-inflow primary air inlet swirler closely adjacent to the upstream end with flow through circumferentially distributed slots extending axially of the liner; a premixing chamber juxtaposed to and coaxial with the swirler and having a diameter greater than that of the swirler, the premixing chamber having a generally radial annular downstream wall converging to a throat; means defining a reaction zone connected to the premixing chamber through the throat; a first flow controlling disk reciprocable axially of the liner to close variably the air swirler slots to vary primary air flow; fuel spray means disposed at the upstream end of the premixing chamber; and a second flow controlling disk reciprocable toward and from the said downstream wall to vary flow area from the premixing chamber into the said throat.

2. A combustion liner adapted for high energy combustion and with provisions for maintaining a desired equivalence ratio in the reaction zone, the liner having a closed upstream end and having a substantially circular cross-section, and comprising a radial-inflow primary air inlet swirler closely adjacent to the upstream end with flow through circumferentially distributed slots extending axially of the liner; a premixing chamber juxtaposed to and coaxial with the swirler and having a diameter greater than that of the swirler, the premixing chamber having a generally radial annular downstream wall converging to a throat; means defining a reaction zone connected to the premixing chamber through the throat; a first flow controlling disk reciprocable to close variably the air swirler slots to vary primary air flow; a fuel spray ring disposed at the upstream end of the premixing chamber; and a second flow controlling disk reciprocable concurrently with the first flow controlling disk toward and from the said downstream wall to vary flow area from the premixing chamber to the said throat.

3. A combustion liner adapted for high energy combustion and with provisions for maintaining a desired equivalence ratio in the reaction zone, the liner having a closed upstream end and having a substantially circular cross-section, and comprising a radial-inflow pri-

5

mary air inlet swirler closely adjacent to the upstream end with flow through circumferentially distributed slots extending axially of the liner; a premixing chamber juxtaposed to and coaxial with the swirler and having a diameter greater than that of the swirler, the premixing chamber having a generally radial annular downstream wall converging to a throat; means defining a reaction zone connected to the premixing chamber through the throat; a support movable axially of the liner; a first flow controlling disk mounted on the support reciprocable to close variably the air swirler slots to vary primary air flow; fuel spray means disposed at the upstream end of the premixing chamber; and a second flow controlling disk mounted on the support for reciprocation toward and from the said downstream wall to vary flow area from the premixing chamber to the said throat.

4. A combustion liner adapted for high energy combustion and with provisions for maintaining a desired equivalence ratio in the reaction zone, the liner having a closed upstream end and having a substantially circu-

6

lar cross-section, and comprising a radial-inflow primary air inlet swirler closely adjacent to the upstream end with flow through circumferentially distributed slots extending axially of the liner; a premixing chamber juxtaposed to and coaxial with the swirler and having a diameter greater than that of the swirler, the premixing chamber having a generally radial annular downstream wall converging to a throat; wall means defining a diverging reaction zone connected to the premixing chamber through the throat; a support movable axially of the liner extending through the upstream end of the liner; a first flow controlling disk mounted on the support reciprocable to close variably the air swirler slots to vary primary air flow; a fuel spray ring disposed at the upstream end of the premixing chamber; a second flow controlling disk mounted on the support for reciprocation toward and from the said downstream wall to vary flow area from the premixing chamber into the said throat; and an igniter mounted downstream of the second flow controlling disk on the support.

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