

[54] COMBUSTOR PRECHAMBER

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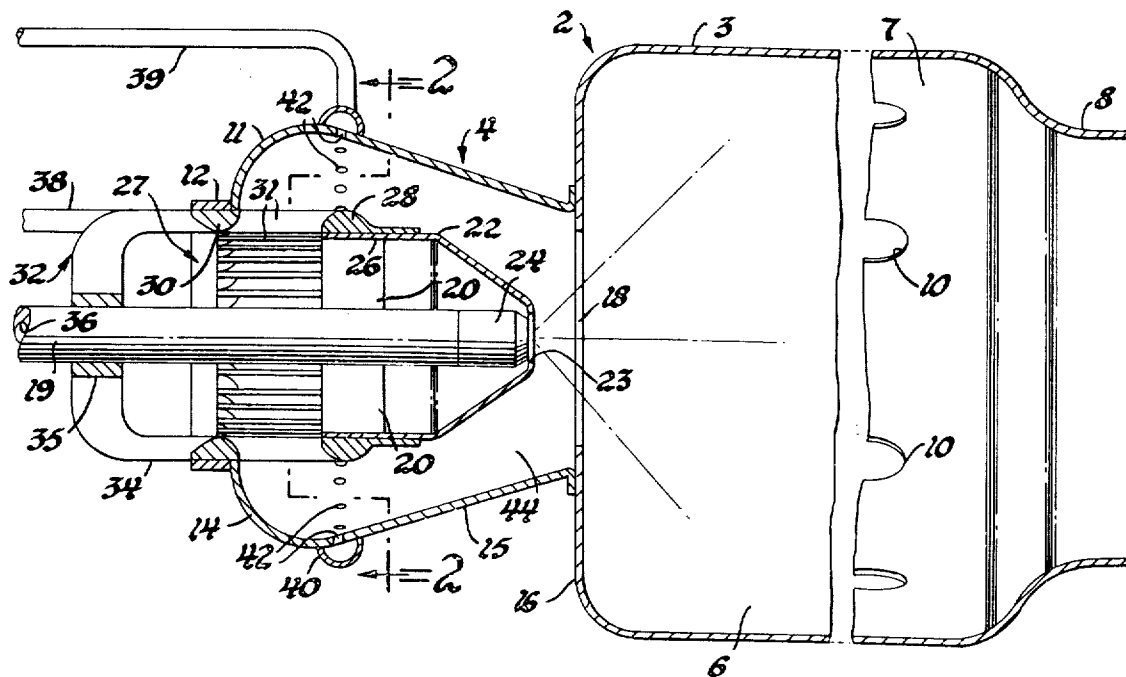
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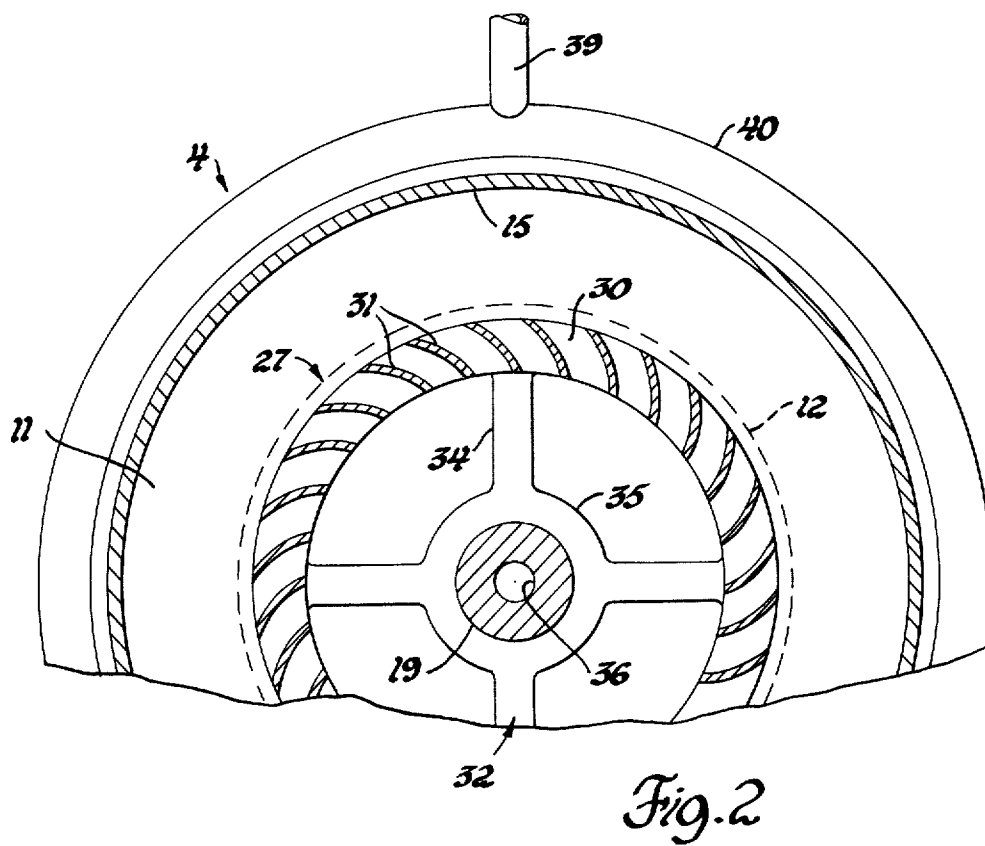
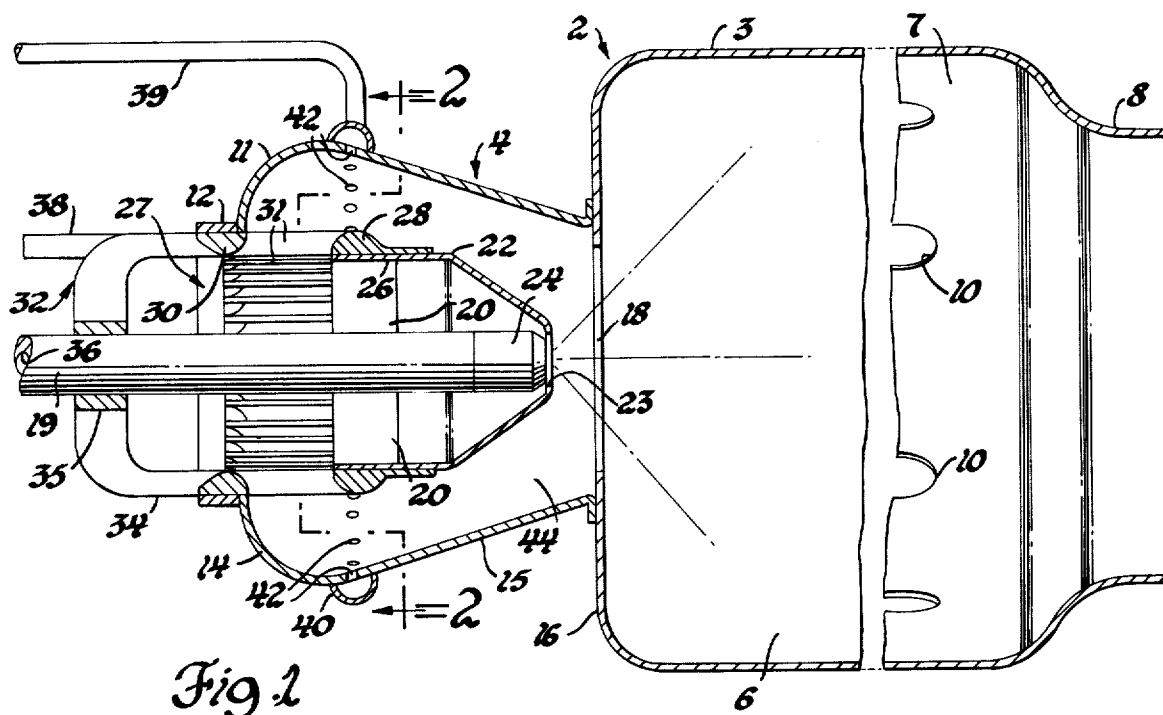
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ABSTRACT

A combustion liner for a gas turbine combustion apparatus has a prechamber for mixing of fuel and combustion air. Air enters the prechamber with a radially outward and tangential flow through a cylindrical swirler. The swirler is movable axially to reduce its axial length and thus the effective area of the swirler to control the primary air flow into the prechamber and on into the reaction zone of the combustion liner. Fuel is scoured off the outer wall of the prechamber and preferably vaporized by the air flowing with swirling movement from the air inlet to the reaction zone.

4 Claims, 2 Drawing Figures





COMBUSTOR PRECHAMBER

My invention is directed to combustion apparatus for liquid fuel, particularly those used at relatively high pressures and rates of flow as compared to ordinary fuel burners supplied with air at substantially atmospheric pressure. Examples of such pressurized combustion apparatuses are found in gas turbine engines. In such engines, it is desirable in many cases to improve combustion so as to minimize the discharge of carbon, unburned hydrocarbons, carbon monoxide, and nitrogen oxides. One helpful technique in reducing emissions is thorough mixing of the fuel with air and evaporation of the liquid fuel prior to its entry into the reaction zone of the apparatus where combustion takes place.

Particularly where the energy rate output of the combustor varies over a considerable range, it may be necessary to control the air flow so as to maintain a desired fuel-air ratio in the reaction zone. This fuel-air ratio is commonly referred to as the equivalence ratio, which is the quotient of the actual fuel-air ratio divided by the stoichiometric fuel-air ratio. Prevaporization of fuel facilitates clean and complete burning with relatively low equivalence ratios which are conducive to low formation of nitrogen oxides.

My invention is directed to a prechamber type of combustor, and particularly to the prechamber itself. To summarize the principles of my invention briefly, air is admitted to an annular prechamber through a swirler which delivers the air outwardly and circumferentially so that the air swirls along and scours the inner surface of the outer wall of the prechamber. This wall converges toward the outlet of the prechamber. At a point near its greatest diameter and downstream of the swirler, fuel is put on the wall to be picked off by the air flow and evaporated as it flows into the combustion chamber. The swirler is of a type having a constant cross section but of variable length so that the area for entrance of primary air may be varied in accordance with operating conditions which determine the required amount of fuel. In this way, the equivalence ratio in the reaction zone of the combustor may be varied as desired.

The principal objects of my invention are to improve combustion of liquid fuels, to provide an improved prechamber for combustion apparatus, and to provide a prechamber having variable air flow but substantially constant flow characteristics as flow is varied. A further object is to provide a prechamber having an annular air entrance with a variable-area radial outflow air swirler disposed in the entrance.

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

FIG. 1 is an axial sectional view, with parts broken away, of a combustion liner including a prechamber embodying the invention.

FIG. 2 is an enlarged cross sectional view of the prechamber taken on the broken surface indicated by the line 2—2 in FIG. 1.

Referring to FIG. 1, a combustion liner 2 may be installed in an engine housing or combustion chamber outer case (not illustrated) to which air is supplied under pressure for combustion of fuel. Air may be supplied in the usual manner by a compressor and may be heated in a regenerator. Such an installation may be

similar to that described in Collman, et al., U.S. Pat. No. 3,267,674, Aug. 23, 1966.

Fuel fed to the combustion chamber is burned in the air thus supplied and the resulting combustion products are directed to a user, such as the turbine of a gas turbine engine. Preferably, and as illustrated, the combustion liner is of circular cross section. A liner wall 3 defines in flow sequence from the upstream end of the liner a prechamber 4, a reaction or combustion zone 6, a dilution zone 7, and an outlet 8 for combustion products. All except the prechamber may be of known structure. The liner is shown broken away, and in practice the length will be greater than illustrated. Air enters the dilution zone 7 for mixing with and cooling of the combustion products through dilution or secondary air ports 10 in wall 3.

The prechamber wall 11 is of a divergent-convergent configuration, beginning at the extreme upstream end with a guiding flange 12 from which extends a flaring wall portion 14, followed by a converging wall portion 15 which terminates at a radial wall portion 16 defining the upstream end of the reaction zone. The entrance to the reaction zone is through a circular opening 18 in the radial wall portion 16. Opening 18 is preferably of slightly smaller diameter than the downstream end of the prechamber to provide an annular baffle.

A support 19, which also serves as a pilot fuel tube, is fixedly connected to the liner wall 3 by suitable structure of the combustion apparatus, not illustrated. It is coaxial with the prechamber. Struts 20, at least three in number, fixed to tube 19 extend outwardly to support a centerbody 22 which defines the inner boundary of an annular flow path through the prechamber. The downstream end of the centerbody converges to an opening 23. A pilot fuel nozzle 24 suitably mounted on the end of tubular support 19 contains suitable spray mechanism of known type to discharge a small quantity of fuel in a conical spray through the opening 18 into the reaction zone 6. This fuel is for maintenance of flame under low power conditions, or for starting the engine.

The forward portion of centerbody 22 constitutes a cylindrical guide 26. Guiding flange 12 and guide 26 provide support for an air swirling cylinder 27. This cylinder comprises a downstream ring 28 slidable on the exterior of guide 26 and an upstream ring 30 slidable on the inner surface of guiding flange 12. An annular row or set of radial outflow swirl vanes 31 extends between the rings 28 and 30. These vanes may be brazed or otherwise fixed to the rings, the mode of construction of the swirler being immaterial to the present invention. As is clear from FIG. 2, these vanes are of such shape as to deliver air radially outwardly and with a considerable circumferential component of motion into the prechamber. The ring 30 may be integral with a spider 32 including arms 34 and a hub 35. Hub 35 is slidably guided on the support 19. As illustrated in FIG. 2, support 19 defines a conduit 36 for carrying fuel to the pilot nozzle 24. Support 19, which is fixed to centerbody 22, may be considered to be part of the centerbody.

The air swirling cylinder 27 is illustrated in the extreme position, to provide maximum opening of the swirler and airflow. It may be moved to the left as illustrated in FIG. 1, with ring 30 sliding in flange 12 and ring 28 sliding on guide 26, whereupon the space between ring 28 and the chamber wall portion 14 lessens

to reduce air flow. Means for reciprocating the swirler is indicated by a rod 38 fixed to the spider 32.

The main fuel supply is conducted to the prechamber by a fuel line 39 which enters a ring manifold 40 of semi-circular cross section brazed or otherwise fixed sealingly to the outer surface of the prechamber wall 11. Fuel supplied to the manifold, ordinarily at a pressure only slightly higher than that of the air in the prechamber, is delivered to the interior surface of the prechamber walls through a ring of small ports 42, which may be directed somewhat tangentially and somewhat downstream relative to the axis of the prechamber.

In operation of the combustion apparatus, the air under pressure surrounding the liner 2 flows through spider 32 and swirl vanes 31 into the prechamber 4, where it picks up the fuel supplied through ports 42. The air swirls downstream with the fuel through the annular flow path 44 defined between wall 15 and centerbody 22. The air, which is heated by compression and ordinarily by regeneration from the engine exhaust, evaporates the fuel and delivers it through the opening 18 into the reaction zone. Combustion may take place as is customary in prechamber combustors, the mixture of air and evaporating fuel burning readily without local hot spots such as would be due to combustion around fuel droplets in a fuel spray. The structure of the combustion and dilution zones of the liner is not explained in detail, since it may be conventional. The hot combustion products from the reaction zone 6 are mixed with additional air delivered from the same source as the combustion air, this dilution air being supplied through ports 10 and mixing as it flows from the liner through outlet 8 to a user. For starting the engine or maintaining the flame, a small amount of fuel may be delivered by the pilot nozzle 24.

With a fixed area for entrance of primary combustion air, the equivalence ratio varies undesirably with changes in the operating level of a combustor which accompany changes in power level of the engine in which it is used. To reduce the amount of primary combustion air, the swirling cylinder 27 may be moved leftward as illustrated in FIG. 1 from the position shown to throttle the air flow as desired.

It will be clear that this provides a means for throttling the air flow without changing the effective direction of flow or disturbing its natural tendency to scour the outer wall of the prechamber. The radially outward swirling flow enhances this scouring tendency, and also tends to centrifuge any unevaporated oil droplets toward the outer wall 14, 15.

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 for a gas turbine combustion apparatus or the like comprising a wall extending from an upstream end to a downstream end of the liner defining, in flow sequence, a prechamber, a reaction zone, a dilution zone, and an outlet for combustion products, the prechamber wall having a substantially circular cross section; means for delivering fuel to the inner surface of the prechamber wall; means defining an annular radial outflow air inlet at the upstream end of the prechamber, the air inlet extending circumferentially and axially of the prechamber upstream of the

fuel delivering means; an air swirling and throttling cylinder disposed across the said air inlet movable axially of the prechamber, the cylinder bearing a set of swirl vanes adapted to direct the air outwardly and circumferentially from the inlet into the prechamber, the area of the set of swirl vanes being variable by axial movement of the cylinder to vary primary air flow into the liner.

2. A combustion liner for a gas turbine combustion apparatus or the like comprising a wall extending from an upstream end to a downstream end of the liner defining, in flow sequence, a prechamber, a reaction zone, a dilution zone, and an outlet for combustion products, the prechamber wall having a substantially circular cross section; means for delivering fuel to the inner surface of the prechamber wall; means defining an annular radial outflow air inlet at the upstream end of the prechamber; a centerbody defining with the prechamber wall an annular flow path leading from the inlet to the reaction zone; the air inlet extending circumferentially and axially of the prechamber upstream of the fuel delivering means and centerbody; an air swirling and throttling cylinder disposed across the said air inlet movable axially of the prechamber, the cylinder bearing a set of swirl vanes adapted to direct the air outwardly and circumferentially from the inlet into the prechamber, the area of the set of swirl vanes being variable by axial movement of the cylinder to vary primary air flow into the liner.

3. A combustion liner for a gas turbine combustion apparatus or the like comprising a wall extending from an upstream end to a downstream end of the liner defining, in flow sequence, a prechamber, a reaction zone, a dilution zone, and an outlet for combustion products, the prechamber wall having a substantially circular cross section; means for delivering fuel to the inner surface of the prechamber wall; means defining an annular radial outflow air inlet at the upstream end of the prechamber; the prechamber wall being divergent at the air inlet and convergent through the downstream portion of the flow path; the air inlet extending circumferentially and axially of the prechamber upstream of the fuel delivering means; an air swirling and throttling cylinder disposed across the said air inlet movable axially of the prechamber, the cylinder bearing a set of swirl vanes adapted to direct the air outwardly and circumferentially from the inlet into the prechamber, the area of the set of swirl vanes being variable by axial movement of the cylinder to vary primary air flow into the liner.

4. A combustion liner for a gas turbine combustion apparatus or the like comprising a wall extending from an upstream end to a downstream end of the liner defining, in flow sequence, a prechamber, a reaction zone, a dilution zone, and an outlet for combustion products, the prechamber wall having a substantially circular cross section; means for delivering fuel to the inner surface of the prechamber wall; means defining an annular radial outflow air inlet at the upstream end of the prechamber; a centerbody defining with the prechamber wall an annular flow path leading from the inlet to the reaction zone, the prechamber wall being divergent at the air inlet and convergent through the downstream portion of the flow path; the air inlet extending circumferentially and axially of the prechamber upstream of the fuel delivering means and centerbody; an air swirling and throttling cylinder movable

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axially of the prechamber guided on the prechamber wall and the centerbody, the cylinder bearing a set of swirl vanes adapted to direct the air outwardly and circumferentially from the inlet into the prechamber, the

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area of the set of swirl vanes being variable by axial movement of the cylinder to vary primary air flow into the liner.

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