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COMBUSTION PRODUCTS GENERATOR WITH DIVERSE
COMBUSTION AND DILUENT AIR PATHS
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Fig. 1

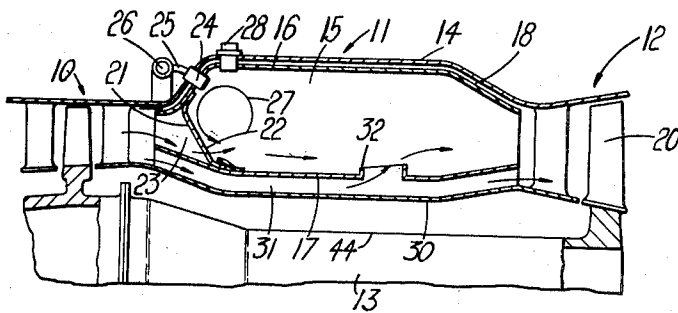
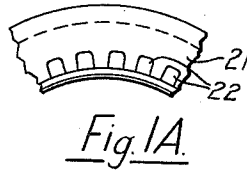
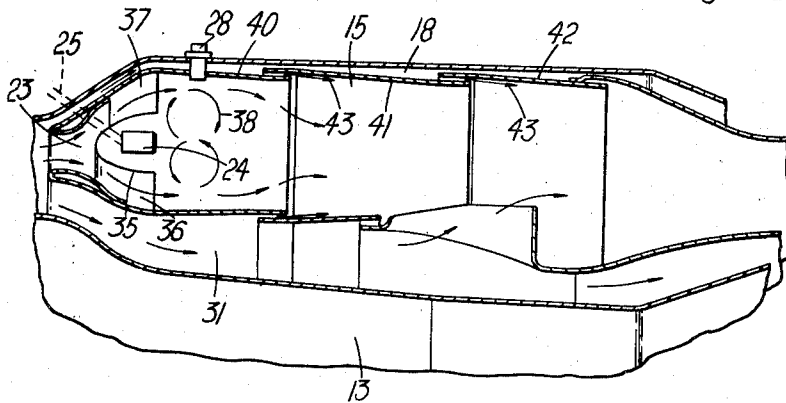


Fig. 2



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1

3,132,484

COMBUSTION PRODUCTS GENERATOR WITH DIVERSE COMBUSTION AND DILUENT AIR PATHS

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1 Claim. (Cl. 60—39.65)

This invention concerns a combustion chamber, e.g. for use in a gas turbine engine.

High pressure gas turbine engine combustion chambers have previously been proposed whose flame tubes have been supplied with "primary" air and with "dilution" air, such combustion chambers normally also being supplied with "secondary" air. The primary air is introduced into the flame tubes upstream of the combustion zones therein and provides at least the greater part of the air required to support combustion. The secondary air, when used, is introduced into the flame tubes downstream of the combustion zones to assist the combustion gases to undergo reversals of direction and to complete the combustion. The dilution air is introduced into the flame tubes downstream of the secondary air so as to mix with the combustion gases and reduce their temperature to a value acceptable to the turbine of the engine.

The dilution air has been supplied to each flame tube from a dilution air duct arranged about the flame tube. The pressure in the dilution air duct has, however, necessarily been higher than that in the flame tube so as to ensure that the dilution air enters the latter. Accordingly there has been a very high compressive buckling load across the outer wall of the flame tube and for this reason high pressure gas turbine engine combustion chambers have normally been made in tubo-annular form. That is to say, such combustion chambers have comprised an annular casing containing a number of tubular flame tubes, each said flame tube having a small diameter so as to give the required stiffness to withstand the high buckling loads.

It is desirable to employ an annular flame tube instead of the said tubular flame tubes, but the difficulty in adopting such an annular flame tube has previously been the problem as to how to avoid the said compressive buckling load across its outer wall.

According therefore to the present invention, there is provided an annular combustion chamber comprising an annular flame tube, a primary air duct arranged to supply primary air to a combustion zone within the flame tube, fuel supply means for supplying fuel to the said combustion zone, and an annular dilution air duct arranged concentrically within and immediately adjacent to said annular flame tube, said dilution air duct having means for supplying dilution air to the flame tube downstream of the said combustion zone therein.

Preferably the combustion chamber has an annular casing within which the annular flame tube is concentrically mounted, a cooling air duct being provided between the said casing and the flame tube, the arrangement being such that no secondary or dilution air is supplied from the cooling air duct to the flame tube. Means are preferably provided for admitting cooling air from said cooling air duct and onto at least part of the internal surface of the outer wall of the annular flame tube. Thus the outer wall of the annular flame tube may comprise a plurality of axially consecutive sections, the downstream portion of each of which is mounted within and spaced from the upstream portion of the adjacent section.

Preferably the fuel supply means are arranged to cause no obstruction of the dilution air duct. Thus the fuel

2

supply means may comprise fuel injection nozzles and fuel supply piping for supplying fuel to said nozzles, said piping and/or said nozzles being arranged to cross the cooling air duct. The combustion chamber is also preferably provided with fuel ignition means which cross the cooling air duct and which therefore do not obstruct the dilution air duct.

The fuel supply means and the primary air duct may be so arranged that the whole mass of the combustion gases undergoes a single reversal of direction. Alternatively, the fuel supply means may comprise fuel injection means arranged centrally of said primary air duct so that primary air is supplied to opposite sides of the fuel injection means, whereby the combustion gases are divided into two portions each of which undergoes single reversal of direction.

The invention also comprises a gas turbine engine provided with an annular combustion chamber as set forth above, the dilution air duct preferably being arranged to effect cooling of the root portions of the turbine blades of the engine.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

FIGURE 1 is a section through part of an annular combustion chamber according to the present invention,

FIGURE 1A is a partial rear view of the combustion stabilizing member forming part of the chamber of FIGURE 1; and

FIGURE 2 is a section through part of a modified embodiment of an annular combustion chamber according to the present invention.

Referring first to FIGURE 1, a gas turbine engine comprises in flow series a compressor 10, an annular combustion chamber 11, and a turbine 12, the turbine 12 driving the compressor 10 through a shaft 13.

The combustion chamber 11 is provided with an outer annular casing 14 within which is concentrically mounted an annular flame tube 15 having outer and inner walls 16, 17 respectively. The outer wall 16 is spaced from the casing 14 to provide an annular cooling air duct 18 whose upstream end receives a supply of cooling air from the compressor 10. The supply of cooling air passing through the cooling air duct 18 prevents overheating of the casing 14, the downstream end of the cooling air duct 18 being arranged to direct the air which has passed therethrough onto the tips of the turbine blades 20 so as to cool the latter.

The upstream end of the flame tube 15 communicates, by way of an annular partition 21 having apertures 22 therein, with an annular primary air duct 23 which is supplied with primary air from the compressor 10. The annular partition is in fact a frusto-conical member converging in the downstream direction of the combustion chamber from the outer wall to the inner wall and acts as a combustion stabilizing means.

The unapertured parts of the partition 21 provide sheltered areas within the flame tube 15, these sheltered areas forming part of a combustion zone into which fuel is injected through fuel injection nozzles 24. The nozzles 24 extend across the cooling air duct 18 and are supplied with fuel through pipes 25 communicating with a fuel manifold 26. The primary air is supplied to one side only of the nozzles 24, whereby, as indicated by the arrow 27 the whole mass of combustion gases undergoes a single reversal of direction.

An ignitor plug 28 is provided to effect ignition of the fuel, the ignitor plug being mounted in the casing 14 and crossing the cooling air duct 18 so as to extend into the flame tube 15.

The combustion chamber 11 has an inner annular wall 30 which is spaced from and concentrically mounted inwardly of the inner wall 17 of the flame tube 15. The

walls 17, 30 define between themselves a dilution air duct 31 whose upstream end is provided with dilution air from the compressor 10.

The wall 17 of the flame tube has apertures 32 therein through which dilution air from the duct 31 may enter the flame tube 15 downstream of the combustion zone therein. The combustion gases which leave the downstream end of the flame tube 15 and which are directed onto the middle portions of the turbine blades 20 have therefore had their temperature reduced to a value acceptable to the blades 20.

The downstream end of the dilution air duct 31 is arranged to direct the air flowing therethrough onto the root portions of the blades 20 to cool the latter.

It will be noted from FIGURE 1 that the combustion chamber shown therein employs no secondary air.

The combustion chamber shown in FIGURE 2 is generally similar to that of FIGURE 1, corresponding parts thereof being given the same reference numerals.

In the FIGURE 2 construction, however, the primary air duct is bifurcated by a channel section annular wall 35 into branches 36, 37, the fuel injection nozzles 24 being mounted within the channel section wall 35. Accordingly the primary air is supplied to opposite sides of the nozzles 24, whereby, as indicated by the arrows 38, the combustion gases are divided into two portions each of which undergoes a single reversal of direction.

In the FIGURE 2 construction, moreover, the annular flame tube 15 is made up of axially consecutive annular sections 40, 41, 42, the downstream portions of the sections 40, 41 being mounted within and spaced from the upstream portions of the sections 41, 42 respectively. Cooling air from the duct 18 may therefore flow onto the internal surface of the outer walls of the sections 41, 42 as indicated by the arrows 43.

In each of the constructions shown in the drawings, although the flame tube 15 is fully annular its walls are not subjected to large compressive buckling loads at high pressures. This is because the dilution air duct 31, instead of being arranged externally of the flame tube 15, as in the prior art, is arranged internally thereof. In consequence, the difference in the pressures prevailing in the flame tube 15 and dilution air duct 31 causes the inner wall 17 of the flame tube to be maintained in tension.

At the same time, the air passing through the cooling air duct 18 is employed for cooling purposes only and since it is not employed as secondary or dilution air it does not require to be at a pressure such that it will penetrate into the combustion gas stream in the flame tube 15. Accordingly, the arrangement may be such that there is only a small difference in the pressures prevailing in the cooling air duct 18 and the flame tube 15, whereby the wall 16 of the flame tube 15 is subjected to very little compressive buckling load. Internal wall cooling may be provided by forming the flame tube 15 of axially consecutive sections as shown in FIGURE 2.

The temperature distribution along the turbine blades of a gas turbine engine is important, since it affects the stressing of the blade. Desirably, the root portion of the blade should be at a fairly low temperature whilst the hottest part of the blade should be about a third of the way along the blade from its root. It will be appreciated that this temperature distribution is achieved by the construction shown in the drawings, the position of the dilution air duct 31 being such as to enable part of the air flowing therethrough to be used to cool the root portions of the turbine blades.

Since the igniter plug 28, nozzles 24, and pipes 25 are arranged to cross the cooling air duct 18 they do not obstruct flow through the dilution air duct 31. This is an important feature because we have found that obstructions in the dilution air duct 31 have a disturbing

effect on the flow of dilution air therethrough and this results in irregular temperatures transversely of the flame tube at the downstream end thereof. Such irregular temperatures can, in extreme cases, give rise to "hot spots" which shorten the life of the turbine.

As will be seen from FIGURE 1, the shaft 13 has a reduced diameter portion 44 adjacent the combustion chamber 11 so as to make way for the latter. In contrast to prior proposals for gas turbine engine combustion chambers, however, this reduction in diameter is not at all substantial. This is an advantageous arrangement since the ability to keep the shaft 13 at substantially its maximum diameter substantially throughout its length permits the number of bearings for the shaft 13 to be kept to the minimum.

It will be appreciated that the present invention, in contrast to providing the annular dilution air duct externally of the flame tube, provides a flame tube having a smaller radial width for a given flow area and therefore a smaller length if the combustion chamber is designed for a constant length/width ratio.

The fact that the combustion chamber shown in the drawings extends radially outwardly of the compressor 10 of the engine is unimportant in those cases in which the engine is provided with a turbine or with a reheat pipe of large diameter. It is also unimportant in supersonic engines where the air intake may have a larger diameter than that of the compressor.

We claim:

An annular combustion chamber comprising an annular casing, an annular flame tube having concentric radially outer and inner walls, the outer wall being mounted concentrically radially inwardly of and spaced from the annular casing to form a cooling air duct therewith, said flame tube having a combustion zone therein, an annular duct wall mounted concentrically radially inwardly of and spaced from said inner wall to form a dilution air duct therewith immediately adjacent to said annular flame tube, passages leading from said dilution air duct to the interior of the flame tube downstream only of said combustion zone, an air supply duct supplying air to each of said cooling air duct, flame tube and dilution air duct, fuel supply means for supplying fuel to said combustion zone, a combustion stabilizing member extending across the flame tube upstream of said combustion zone, said member being frusto-conical and converging in the downstream direction of the combustion chamber from said outer wall to said inner wall, and said member defining circumferentially spaced passages adjacent said inner wall sized to control the whole quantity of primary air from said air supply duct which enters the flame tube and to direct it axially of the flame tube after the velocity of said air has increased during its approach to said passages along the converging upstream side of said member, said member intermediate said passages providing a sheltered zone immediately downstream thereof in which air entering the flame tube via said passages undergoes a single reversal and is mixed with said fuel, said passages being the only passages leading into the flame tube for all the air required for combustion in the flame tube.

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