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M. L. NATHAN

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AIR DUCTING ARRANGEMENT FOR COMBUSTION CHAMBERS

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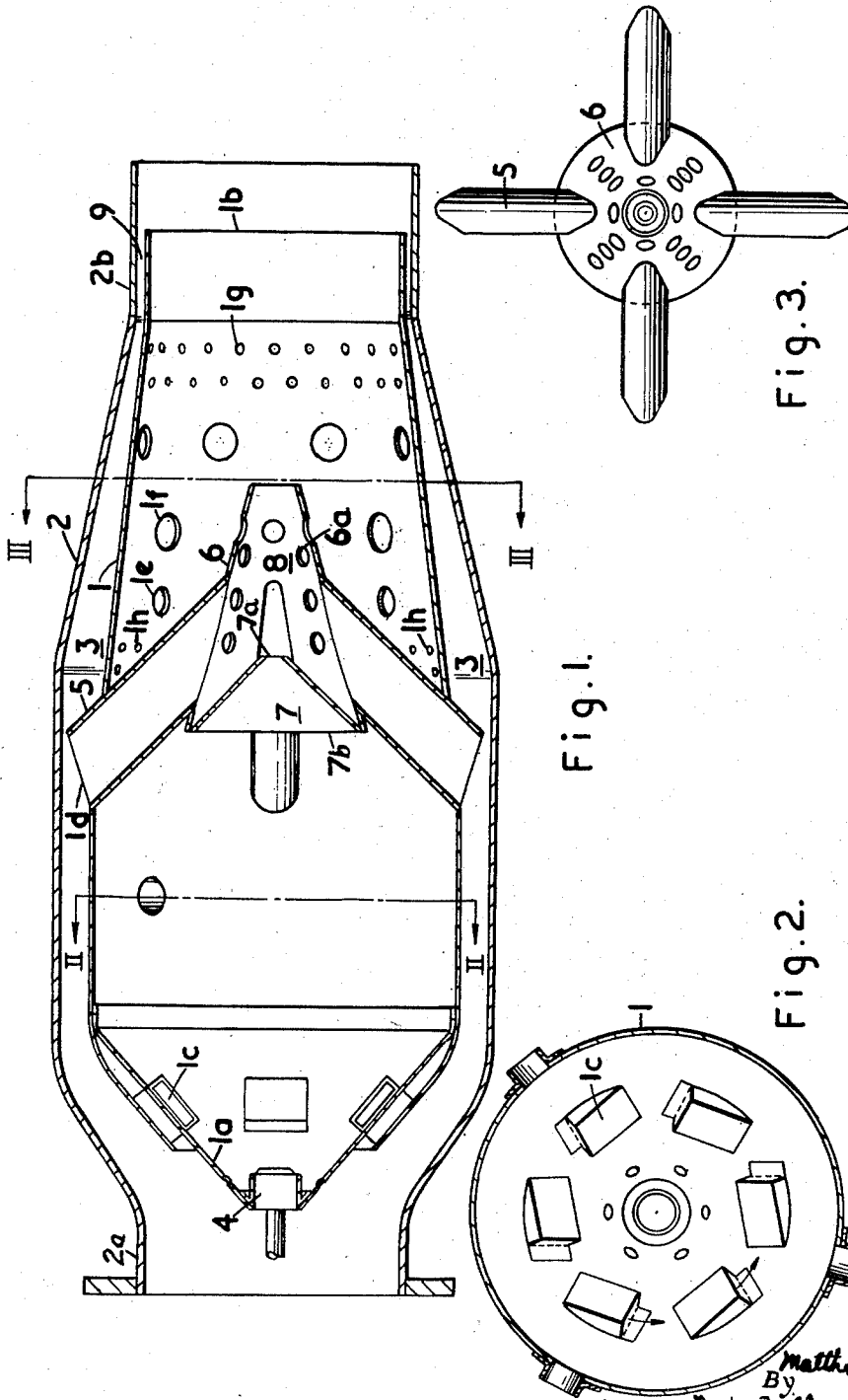


Fig. 1.

Fig. 2.

Fig. 3.

Inventor
Matthew L. Nathan
By
Steven Davis Miller & Mosher
his Attorney

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AIR DUCTING ARRANGEMENT FOR
COMBUSTION CHAMBERS

Matthew L. Nathan, Godalming, England, assignor to Power Jets (Research and Development) Limited, London, England, a British company

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9 Claims. (Cl. 60-44)

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This invention relates to improvements in combustion apparatus intended to be particularly applicable to cases where combustion has to be supported by a fast-moving stream of gaseous fluid (hereinafter considered as being air).

The description "fast-moving" as applied to a combustion supporting air stream is intended herein to indicate that the mean speed of the air stream in its general direction of flow past a combustion initiating zone, calculated from the ratio air volume passing in unit time/cross sectional area of the flow path, is sufficiently high in relation to the speed of flame propagation in the fuel-air mixture concerned to have flame extinguishing properties. For hydrocarbon fuels burning in air the speed of flame propagation is considered as being of the order of one foot per second at an atmospheric temperature; the invention, on the other hand, is especially applicable to combustion apparatus for internal combustion gas turbine and/or jet propulsion power units in which the speed of the air stream in its general direction of flow past a combustion zone, calculated on the basis intended, might be from 10 to 300 feet per second or even more depending on the design. The invention is further of particular interest in relation to installations which, in common with such power units, require stabilised burning to be supported not only by a fast-moving air stream but also with high air/fuel ratios, and in which stable burning is required to be maintained at high rates of fuel injection with a minimum of pressure loss.

The particular use of the invention at present envisaged is as a flame tube suitable for use in a gas turbine aero engine and of the kind having entries at an upstream region for a part of an airstream to constitute primary air, further entries located downstream of the primary air entries for the entry of additional air to constitute secondary and tertiary air, and a downstream outlet for the gases of combustion. Preferably, the primary air is swirled during its admission into the tube and the secondary air may also be swirled. Such a flame tube has been described in our prior British specification No. 583,086.

It has been found that at high altitude it is beneficial to use a rich mixture, i. e., with a relatively smaller quantity of primary air as for example 15% of the total air flow. On the other hand this involves a decreased velocity of the gases through the flame tube, and as in addition the density of the air is decreased relative to the density of the fuel droplets which are injected into the upstream end of the flame tube, it may

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happen that a substantial part of the fuel is no longer carried along with the air flow within the tube, but tends to fall and be deposited on the lowest surface of the flame tube to form a pool of fuel thereon, and this is liable to interfere seriously with the efficiency of the combustion process.

Such a condition is especially liable to occur in the case of a wide flame tube, e. g., having a ratio of length to maximum diameter of less than 3:1, with low primary air admission, e. g., less than 15 per cent of the total air flow.

Moreover while it is generally desirable to lead secondary air to an axial region within the flame tube, the pipes, chutes or other devices which have been used for this purpose are situated within the flame tube and are exposed to the hot gases, and therefore frequently suffer such considerable damage after a relatively short operating period as to be comparatively useless, thereby substantially diminishing the useful life of the apparatus.

The present invention seeks to minimise these disadvantages, and for this purpose provides a flame tube of the kind set forth comprising, arranged coaxially within and located downstream of said primary air entries, a device in the form of two chambers arranged one within the other of which the inner chamber has one or more openings for the passage of gas from the outer chamber into the inner chamber and one or more further openings for the passage of gas from the inner chamber into the flame tube, and a plurality of ducts leading from the periphery of the flame tube into the outer chamber, the latter having one or more openings for the passage of gas from the outer chamber into the flame tube.

Preferably the outer chamber has an open downstream end and the inner chamber has an open downstream end and an open upstream end. The two chambers may both be of circular section, and the upstream end of the annular space between them may be partly or wholly closed. In the preferred form, the upstream ends of both chambers are of the same diameter, while the outer chamber is of frusto-conical form with its narrower end pointing downstream. Preferably also the inner chamber is in the form of a cone, having its apex pointing downstream so that in effect the device presents a frusto-conical chamber having an open downstream end, and having its upstream end closed by a hollow conical element which enters into said chamber. With this arrangement air flows from the periphery of the flame tube through the ducts into the outer

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chamber and thence mainly through the open downstream end of the device to the outlet of the flame tube while a smaller part of this air passes through the inner chamber into the flame tube.

The device above described has two effects. Firstly, it enables secondary air to be delivered from the periphery of the flame tube to an axial region thereof, while at the same time providing a large mass flow of relatively cooler air through the structure so preventing it from becoming too hot.

Secondly, since the presence of the device within the flame tube reduces the available cross sectional area of flow, the mean velocity of the air within the flame tube is increased. This promotes the movement of the fuel droplets along with this air, thus preventing the above-mentioned tendency of forming, in some conditions, a pool of fuel along the lower surface of the flame tube.

The invention is illustrated by way of example in the accompanying drawing in which, Figure 1 is a longitudinal section; Figure 2 is a section on the line II—II of Figure 1; Figure 3 is a section on the line III—III of Figure 1.

In Figure 1 a flame tube 1 having a closed upstream conical end 1a and an open downstream end 1b is disposed within an air casing 2 so as to form an annular space 3 into which air can be led via the entry 2a. At the upstream end 1a of the flame tube 1 is provided an axially disposed burner 4 by means of which a stream of atomised liquid fuel is injected downstream into the flame tube. In the wall of the conical portion 1a are entries in the form of tangentially directed chutes 1c for the entry of primary air thus swirling this air around the axis of the flame tube 1 so as to provide the usual vortex flow with reversed core for flame stabilization. Downstream of the primary air entries 1c are entries 1d for secondary air and 1e, 1f, 1g for tertiary air, the gases of combustion leaving the flame tube 1 through its downstream outlet 1b. A small amount of secondary air also enters through apertures 1h.

The main entries for secondary air comprise a number of wide ducts 5 extending into the space 3 and leading from this space into a frusto-conical chamber 6 within which is co-axially arranged a conical chamber or baffle 7 having an open upstream end and an open downstream end. The upstream end of chamber 6 abuts around the upstream end of chamber 7 and the wall of chamber 6 is perforated with openings 6a.

With this arrangement the major part of the secondary air flows from space 3 through ducts 5 into the space 8 and thence through the open downstream end of chamber 6 towards the outlet 1b of the flame tube 1.

Some of the air in the space 8 flows through aperture 7a into the chamber 7 and out through its upstream end 7b and is thence absorbed in the reverse core of the vortex formed of the chutes 1c.

Downstream of the entries for secondary air are provided three groups of apertures 1e, 1f and 1g whereby further air can pass from the space 3 to within the flame tube 1, all three groups of apertures being preferably distributed symmetrically in a circumferential direction as a circular series around the wall of flame tube 1. The apertures 1e immediately downstream of the chamber 6 are of relatively smaller diameter while the next succeeding group of apertures 1f in the downstream direction are of greater diameter.

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At its downstream outlet 1b, the flame tube 1 is narrowed down to a diameter which is small relative to the diameter of the main body of the tube 1, and it is general practice to narrow down the diameter of the end 2b of the casing in this region so as to form an annular space 9 of very small radial dimensions relative to space 3 and through which space 9 a small proportion of the air stream passes for cooling purposes.

The small dimensions of this annular space 9 give rise however to a stagnant region which does not provide sufficient cooling at the outlet 1b, and in order to avoid this effect the flame tube wall 1 is provided in the immediately upstream vicinity of its outlet 1b, with a series of apertures 1g which are of still smaller diameter than the apertures 1e and are about the same diameter as aperture 1h.

Preferably, matters are arranged so that approximately 10–15 per cent of the air stream enters the primary air entries 1c approximately 20–40% enters the axial region of the flame tube through the entries 1d and the remaining part of the air stream enters the flame tube 1 through the three groups of apertures 1e, 1f and 1g.

I claim:

1. A flame tube of circular section for the combustion of a high velocity air stream, having means defining entries at an upstream region of said tube for the admission of a part of said air stream into said tube to constitute primary air, a hollow body of circular section arranged coaxially within said tube and downstream of said primary air entry defining means, a plurality of ducts for leading air from the periphery of the flame tube to the interior of said body, a baffle of circular section arranged coaxially within said body at an upstream region thereof and with its upstream face arranged to be exposed to a downstream flow of combustion gases, the baffle wall having at least one opening to admit a relatively minor flow of air from the interior of said body to the upstream face of the baffle, and said body having at least one opening at its downstream region to admit a relatively major flow of air from the interior of the body into the flame tube.

2. A flame tube according to claim 1 wherein the baffle is of conical form having its narrower end pointing downstream.

3. A flame tube according to claim 1 wherein the baffle fits within the body in the region of the upstream end of said body.

4. A flame tube according to claim 1 wherein the baffle is of conical form having its narrower end pointing downstream and fits within the body in the region of the upstream end of said body.

5. A flame tube according to claim 1 wherein the body is of conical form having its narrower end open and pointing downstream and the baffle is of conical form having its narrower end pointing downstream, said baffle fitting within the said body in the region of the upstream end of said body.

6. A flame tube according to claim 5 comprising towards the downstream end of the flame tube two circumferentially axially spaced series of openings for the admission of tertiary air, the more downstream series being of small diameter relative to the more upstream series.

7. A flame tube according to claim 6 comprising a circumferential series of openings for secondary air in the wall of the flame tube and in the region of the ducts, the diameter of these openings being small relative to the diameter of the more upstream openings for tertiary air.

8. A flame tube according to claim 5 wherein the outer ends of the ducts project beyond the wall of the flame tube and are inclined at an angle to the axis of the flame tube.

9. A flame tube according to claim 5 wherein the longitudinal wall of the body is perforated in the region of its upstream end to admit a minor flow of air from the interior of said body over said upstream end.

MATTHEW L. NATHAN. 10

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