

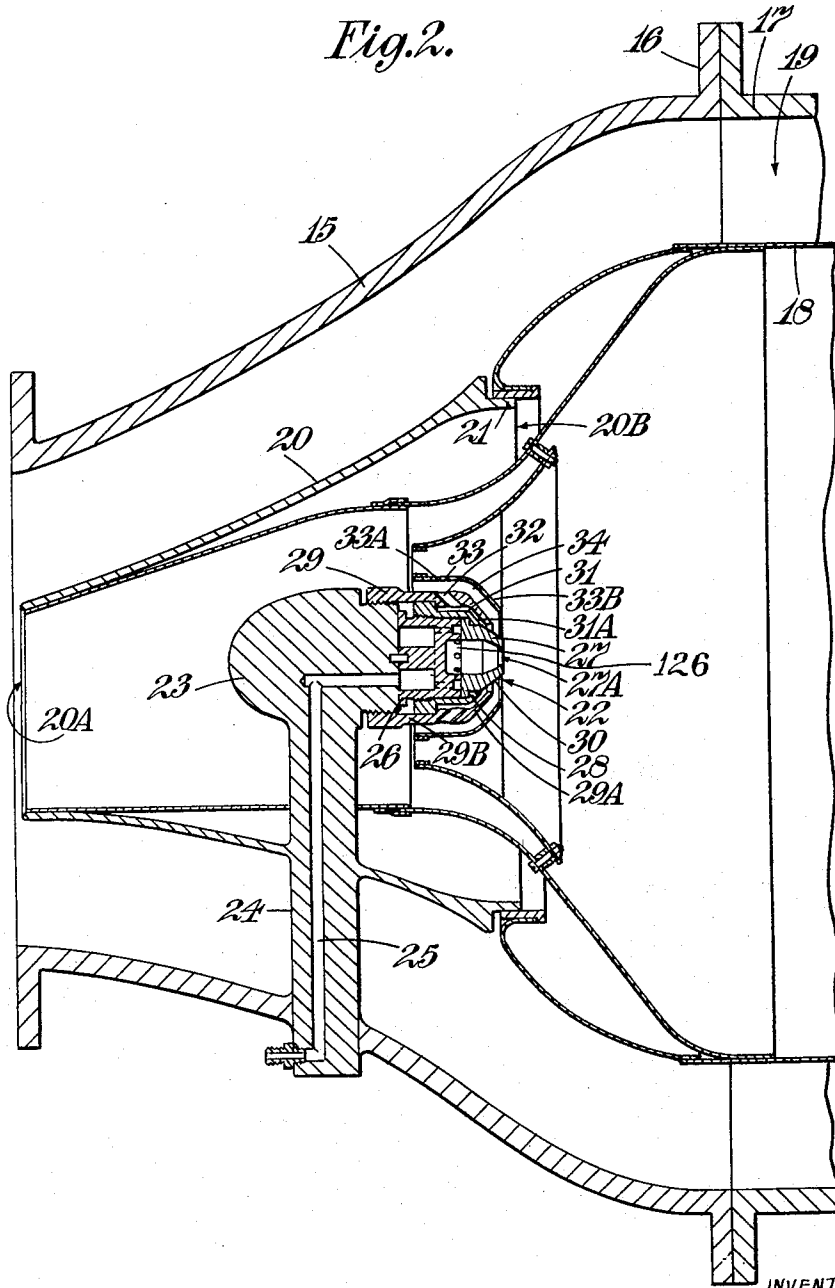
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FUEL INJECTION MEANS FOR GAS-TURBINE ENGINES
AND COMBUSTION EQUIPMENT USED THEREWITH

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1

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FUEL INJECTION MEANS FOR GAS-TURBINE ENGINES AND COMBUSTION EQUIPMENT USED THEREWITH

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1 Claim. (Cl. 158—76)

This invention relates to fuel injection means for gas-turbine engines and combustion equipment used therewith. It is concerned with fuel injection means of the kind which is located in a duct through which air flows into the combustion chamber and by which fuel is introduced into combustion equipment through an atomising orifice in the form of an atomised liquid spray.

Fuel injection means of this kind are extensively used in gas-turbine engines, a fuel supply from an external source being introduced into a swirl chamber, from which it emerges through an atomising orifice co-axial with the chamber.

Difficulties have been experienced with fuel injection means of this kind due to incomplete combustion of the fuel in the combustion equipment tending to cause carbon to be deposited on the face of the injection means in which the atomising orifice is formed; such carbon deposits adversely affect the production of uniformly atomised fuel spray. As a result, after extended periods of running of the engine, combustion efficiency and uniformity of combustion have been found to deteriorate.

The primary object of the present invention is to provide an arrangement of fuel injection means in which such tendency to carbon formation is decreased or obviated.

According to the present invention, fuel injection means of the kind specified comprises an assembly of parts, whereof the nose portion of the assembly has a substantially conical exterior surface at the apex of which the atomising orifice is provided to extend axially of the conical surface, said conical nose portion being surrounded over part of its axial length by a shroud element to define with the said conical surface an annular passage into which cooling air is fed from the duct through which the combustion air flows to the combustion chamber and from which the cooling air issues in a direction towards the axis of the orifice and so as to sweep the conical surface.

In one embodiment of the invention, the atomising orifice is formed in a part of the assembly which constitutes the nose portion of the fuel injection means.

In certain cases the nose portion may be constituted by two separate conical surfaces of differing apical angles, of which the one of greater apical angle has its smaller end of substantially the same diameter as the larger end of the one of smaller apical angle, and which are so arranged that the conical surfaces form a substantially continuous surface, the atomising orifice being formed in or being carried at the apex of the part of lesser apical angle. In such an arrangement, the shroud element may encircle the part of the nose having the larger apical angle and may be given an internal conical form similar to the surface of greater apical angle thus to provide an annular convergent passage from which a cooling air flow issues to sweep over the conical surface of lesser apical angle.

With the arrangement of the invention, the cooling air issuing from the annular passage is directed to pass over the surface of the part formed with or supporting the atomising orifice to cool the latter, and by virtue of its scouring action to prevent the deposition of carbon on the orifice part.

It should be mentioned that in constructions previ-

2

ously adopted the exterior surface of the orifice part has been in a plane substantially normal to the axis of the orifice, and cooling air for the injection device issued therefrom at a substantial angle to the plane of the exterior surface of the orifice part so that it did not flow over this surface, and it is thought that this has contributed to the difficulties outlined above.

In fuel injection means according to the invention the shroud surrounding the nose portion to provide the annular passage is conveniently formed as an element of the injection means, i. e. the shroud element forms part of the assembly of the injection means to be removed and installed therewith. Alternatively the shroud may be constituted by an element of the combustion equipment.

In a preferred embodiment of the invention one shroud element surrounds the nose portion and constitutes an item of the fuel injection means, whilst an additional part of the combustion equipment surrounds the fuel injection means and defines with the external surface of the shroud element a second annular passage from which air issues substantially parallel to the conical surface of the nose portion.

The invention may conveniently be used in combination with the arrangement described in our co-pending application No. 154,965, filed April 10, 1950, in which provision is made in combustion equipment comprising flame tubes for preventing carbon formation on the divergent portion of a flame tube in the region of the fuel injection means.

Two embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings of which:

Figure 1 illustrates diagrammatically a gas turbine engine.

Figure 2 is a sectional view through a combustion chamber of such engine on an enlarged scale showing the fuel injection means, and

Figure 3 shows a modification of the fuel injection means.

The gas turbine engine shown in Figure 1 comprises a compressor 10 delivering compressed air to combustion equipment 11, from which the products of combustion pass through a turbine 12, which drives the compressor 10, and through a jet-pipe 13 with propelling nozzle 14 to atmosphere. The engine is suitable for aircraft jet propulsion.

The combustion equipment 11 comprises a plurality of substantially tubular flame tubes accommodated within substantially tubular air casings.

In Figure 2 one such air casing and flame tube is shown in section, the arrangement comprising an entry expansion chamber portion 15 which is connected with the delivery side of the engine compressor 10, and is of divergent substantially circular cross section. The expansion chamber 15 is connected by a bolted flange joint 16 with a tubular main air casing part or structure 17, which in turn is connected at its outlet end with a nozzle entry assembly of the turbine 12. Internally of the air casing 17 there is accommodated a generally tubular flame tube or flame tube structure 18. The flame tube 18 is spaced from the wall of the air casing 17 to form an annular duct 19 which extends into the expansion chamber 15 and provides a passage for the flow of mixing air into the flame tube. Within the expansion chamber 15 is mounted air entry duct means comprising a divergent entry duct 20, the smaller end 20A of which is directed towards the inlet end of the expansion chamber 15 to provide a forward-facing air inlet, and this entry duct 20 divides the air entering the air casing 17 from the compressor system into a mixing air flow which passes into the annular duct 19 between the flame tube 18 and air casing 17 and into a primary air flow which passes through the divergent entry duct 20 into the interior of the flame tube 18 at its entry end. The divergent entry duct 20 is also formed at its downstream end 20B with a spigot flange 21 which serves to support the flame tube 18 at the outer radius, so that the entry duct 20 is in effect an extension of the flame tube 18 into the expansion chamber 15.

Fuel injection means generally indicated at 22 is sup-

ported within the divergent entry duct 20 to introduce fuel as an atomised spray into the interior of the flame tube 15 in a direction generally downstream of the air flow.

The fuel injection means 22 comprises a main body part 23 which is supported by a number of legs 24 (of which one only is shown in the figure) cast integrally with the divergent entry duct, one or more of the legs being drilled at 25 in known manner for the supply of fuel under pressure from an external source through connection 25. The fuel injection means 22 further includes a swirl chamber part 26 which defines a swirl chamber 126 and an orifice plate 27 with orifice 27A through which the swirl chamber is adapted to inject fuel. The swirl chamber part 26 and orifice plate 27 are secured together axially as an assembly by a first nut member 28, whilst this assembly is secured axially to the body part by a second nut member 29.

In accordance with the main feature of this invention the orifice plate 27 and first nut member 28 are formed with a substantially conical exterior surface 30, which is coaxial with the orifice, so that the nose portion of the fuel injector 22 is of pointed form. Additionally a shroud part 29A is provided surrounding this conical surface, to form an annular passage 31 between the surface 30 and the shroud 29A.

The shroud 29A is constituted as part of the second nut member 29 and has a cylindrical extension part 29B surrounding the swirl chamber part 26 and orifice plate 27. It will be seen that the cylindrical extension 29B and conical shroud portion 29A are of greater diameter than the adjacent surface of the assembly comprising the swirl chamber part 26 and orifice plate 27, so as to provide an annular passage 31 for a flow of cooling air, which passage converges at its outlet end 31A. The cooling air enters the annular passage 31 from the space within the divergent entry duct 20 through passage or aperture means comprising a number of circumferentially distributed holes 32 in the cylindrical extension 29B of the clamping nut member, and issues from the convergent part 31A of the passage to flow along the unshrouded part of the conical surface 30 of the orifice plate towards the atomising orifice.

The clamping nut 29 is surrounded by a part 33 of the flame tube 18, which part 33 has a cylindrical portion 33A and a convergent portion 33B corresponding in shape to the form of the external surface of the nut, thereby to form an annular passage or duct 34 around the fuel injector assembly, through which passage cooling air passes from the interior of the divergent entry duct 20 into the interior of the flame tube 18, the direction of air flow at the outlet from this passage being substantially parallel to the conical surface 30 of the orifice plate 27.

The arrangement provides that the unshrouded portion of the conical surface 30 of the orifice plate 27 and first nut member 28 is swept by the flow of cooling air which does not diverge away from the surface 30, whilst the exterior surface of the clamping nut member 29 is cooled by the flow through the annular passage 34. It will be noted that the apical angle of the portion of the conical surface 30 on the plate 27 is less than that of the portion of the surface 30 on the nut member 28, which arrangement assists in the maintenance of the flow over the unshrouded portion of the surface 30.

In the modification shown in Figure 3 the fuel injection means comprises a body portion 45 with a fuel entry duct 46. The body portion 45 accommodates

a filter element 47, which is loaded by spring 48 and bears on swirl plug 49. An orifice 50 is formed in an orifice part 51 the exterior surface 51A of which is substantially conical. The orifice part 51 is clamped on to the body part by a nut element 52 having a cylindrical portion 53 and a flanged portion 54 which has a conical surface 54A.

A shroud element 55 is screwed on to the nut element 52 at 55A, and is formed with a conical portion 55B, thereby to constitute an annular passage for the flow of cooling air which enters through passages 56. In this manner cooling air flows over the conical surfaces 54A and 51A.

Arrangements in accordance with the invention have been found effective to prevent the formation of carbon on the nose portion of the fuel injection means assembly.

The invention can be applied to fuel injection means of the kind comprising concentric atomising orifices, e. g. to arrangements in which a first (pilot) spray emerges through the atomising orifice used for a main fuel supply.

We claim:

In gas turbine combustion equipment of the kind including an air casing structure, a flame tube structure accommodated in said air casing structure, air entry duct means to said flame tube having a forward-facing air inlet, and fuel injector means mounted in said air entry duct means to introduce fuel into said flame tube in the direction of air flowing into said flame tube through said air entry duct means, the provision of fuel injector means comprising means forming an atomising orifice joined to a swirl chamber part forming a swirl chamber adapted to inject fuel through said orifice, the exterior surface of said orifice forming means bounding said orifice being of substantially conical form, said exterior surface being surrounded over part only of its axial length by a spaced annular shroud element which is both internally and externally conical, whereby there is defined between said internal conical surface and the conical surface surrounding said atomising orifice an annular passage of conical form, there being additionally provided an annular part spaced from and surrounding said shroud element and having an internally conical surface, said annular part and annular shroud defining an annular duct connected to said annular passage by aperture means extended through the wall of said shroud and said annular duct having an air entry adapted to face the inlet of said entry duct means, whereby air is abstracted from said entry duct means to flow in said annular duct in part through said passage means to emerge along said conical surface surrounding the orifice and in part through the annular conical duct formed between the exterior conical surface of the shroud element and the internal conical surface of the annular part.

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