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LIQUID FUEL ATOMIZER LOCATED UPSTREAM
OF A FLAME STABILIZING BAFFLE
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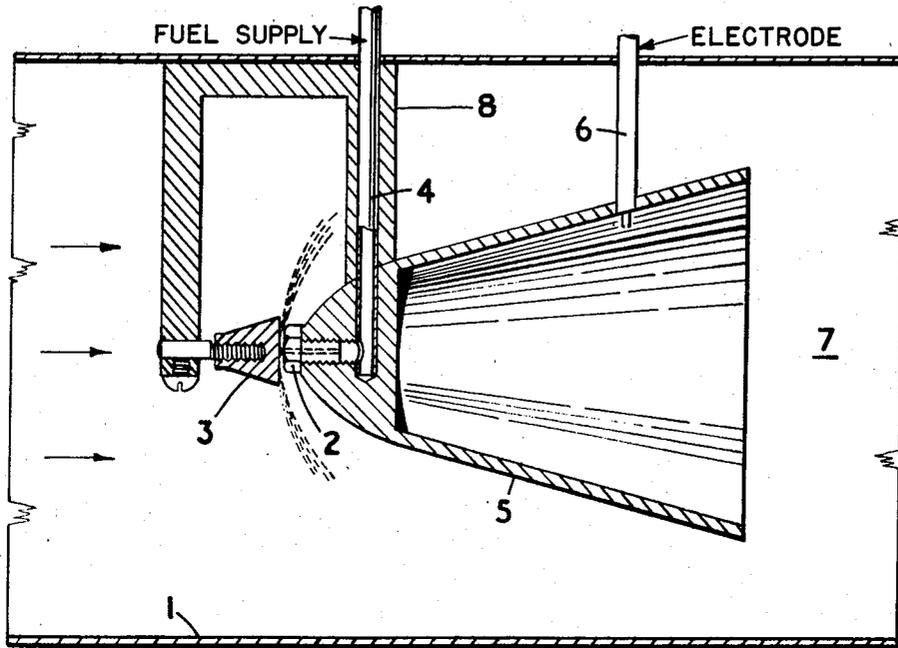


FIG. 1

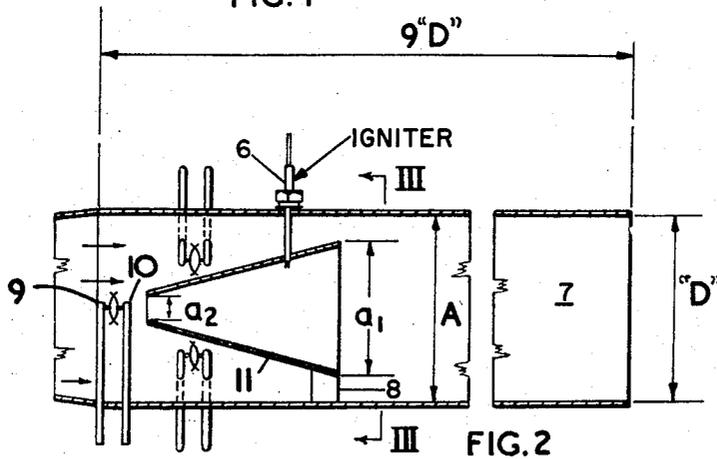


FIG. 2

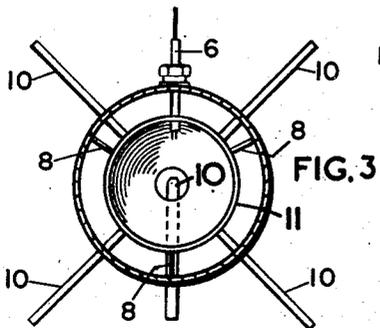


FIG. 3

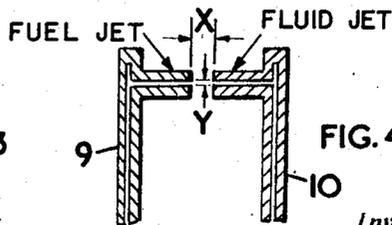


FIG. 4

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LIQUID FUEL ATOMIZER LOCATED UP- STREAM OF A FLAME STABILIZING BAFFLE

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This invention relates to an improved combustion apparatus for burning liquid fuel and provides a method and apparatus whereby a high degree of atomisation of the fuel is obtained which is essential for high combustion efficiencies. In a modified form the apparatus provides means whereby combustion may be stabilised over a wide range of air-fuel mixtures and velocities of a main air supply. The novel apparatus is particularly useful in its application to ram-jet combustion systems.

Accordingly, the present invention provides a combustion apparatus comprising ductings in which combustion has to be started and supported thereafter in an air flow of flame extinguishing velocity, a combustion stabilising baffle means adjacent which a combustion stabilizing zone is formed in which the velocity is sufficiently low for a stable flame to burn once started notwithstanding a flame extinguishing mean overall velocity of flow past said zone and one or more fuel atomisers in said ducting at least one of which is located relative to combustion stabilising means so that a portion of the fuel air mixture will pass to the combustion stabilising zone for the stable flame, the or each fuel atomiser consisting of a liquid fuel supply jet or jets for directing a stream(s) of fuel under pressure against a resisting medium spaced away from the jet(s) at a distance sufficiently small in relation to ambient conditions that the stream of fuel remains compact and continues so until it strikes the medium where it spreads substantially radially at high speed in a film or sheet from the area of impact into the main air stream.

The function of the baffle is to create in the stream of air-fuel mixture a turbulent zone in which the mixture has a low velocity (axially of the duct) so that it may be easily ignited to provide a pilot flame. This pilot flame initiates combustion and promotes great stability of combustion serving to heat the remaining portion of the mixture by conduction and causing the continuous (and self propagating) combustion of this remaining portion of the fuel-air mixture.

The resisting medium may be a solid surface placed a short distance away from the fuel jet to form an anvil which the jet of fuel strikes against and then spreads outwards at high speed.

The resisting medium may also be a jet of liquid which will support combustion or a jet of gas.

These fluids issue from a secondary jet opposed to the fuel supply jet. In the former case the liquid is desirably a second jet of fuel. In

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the latter case it may be a suitable gas or jet of air or other suitable mixtures of gases not necessarily combustible.

In the particular application of the novel combustion apparatus according to the present invention, i. e. a ram-jet system as will be herein-after described and comprising atomisers having secondary jets it is essential that a jet of gas or mixture of gases is used as the resisting medium.

The jet acting as the resisting medium and the fuel supply jet are arranged so that the fuel and fluid streams strike one another and thus create initially a substantially flat sheet of combustible fluid mixture spreading away from the impact point. The main air supply is most conveniently furnished by arranging the atomisers in a duct whereby this air and the combustible atomised mixture are thoroughly mixed before combustion. The atomised fuel is best distributed if the main air stream is supplied to the combustion zone by the duct and if the axis of the fuel jet lies parallel to the axis of the duct and the plane of the anvil which the jet strikes lies transversely of the duct. Also with the opposed jet atomiser the best results are obtained if the axes of both fuel supply jet(s) and secondary jet(s) are in line and parallel to the axis of the duct whereby the atomised fuel mixture is thoroughly dispersed across the main air stream flowing through the duct.

The atomisers are so located relative to the baffle that a portion of the fuel-air mixture will be sucked into the turbulent zone at the downstream end of the baffle. In general it has been found the atomisers should not be further downstream than the downstream end of the baffle. In particular circumstances however the turbulent zone is formed slightly downstream of the baffle and the atomisers may then be placed downstream of the baffle but upstream of the commencement of the turbulent zone.

The baffle dimensions must not be so large in relation to the duct as to cause big pressure losses in the duct or the efficiency of the system will be reduced. The pressure loss may be expressed in the following general terms. At air velocities at Mach number 0.2 upstream of the baffle the ratio of air pressures downstream and upstream of the baffle should be of the order of 0.96.

A convenient form of baffle is a hollow cone located centrally in the duct with its vertex upstream. The blockage ratio of such a baffle, that is the ratio of the maximum cross-sectional area of the baffle to the area of the duct should be about 45% and the ratio upstream area a_1 to the

downstream area a_2 that is cone area ratio should be about 25:1. The baffle may be arranged to carry one or more fuel supply jets at the vertex while the anvil or secondary jet is carried on a separate streamlined support. In another arrangement of the combustion apparatus the baffle may comprise a hollow truncated cone with its vertex pointing upstream, and with one atomiser located with its jet axis in line or its jet axes parallel with the cone axis and upstream thereof. Several more atomisers may be distributed around the exterior of the cone and upstream of its downstream end. The atomiser upstream of the cone serves as a pilot atomiser as a proportion of the fuel-air mixture passing downstream therefrom flows directly into the turbulent zone caused by the conical baffle via the hole at its vertex and round the downstream edge of the cone while the atomiser disposed around the cone furnishes the main fuel supply. Part of the main fuel-air mixture also passes over the downstream edge of the cone into the pilot flame region and the remainder is heated by conduction from the pilot flame and burns further downstream.

The most convenient means for igniting the fuel-air mixture is to install an insulated electrode in the apparatus such that it projects into the pilot flame or turbulent zone. When an electrical current is applied a spark will pass to the baffle and start the combustion. When the baffle is a hollow cone the electrode is best located such that the spark passes to the interior of the cone. Ignition may also be initiated by a thermite charge itself ignited by an electrically heated wire.

One particular mode of employment of the combustion apparatus according to the invention will not be described, viz: its application to a ram-jet combustion system as illustrated in the appended drawings in which:

Figure 1 is a sectional side view of a single ram-jet combustion system having a single atomizer,

Figure 2 is a sectional view to a smaller scale of a ram-jet combustion system having a plurality of atomisers and

Figure 3 is a cross section at III—III of Figure 2 showing the disposition of the atomisers.

Figure 4 is an enlarged view of an opposed jet atomiser, such as is shown in Figures 2 and 3.

In Figure 1, 1 is a cylindrical duct for conveying the main air supply and which on the downstream side of the atomisation zone constitutes a combustion chamber and tail pipe generally indicated at 7. In the atomisation zone the system is constituted by an atomiser having a fuel supply jet 2 fed through a fuel supply pipe 4 and an anvil 3 carried by a faired or streamlined support 8. A baffle member 5 in the form of a hollow truncated circular cone closed at its smaller end is also carried by the support 8 and is located centrally in the duct, vertex upstream. The downstream end of the cone is approximately two thirds the diameter of the duct and the vertex angle of the cone about 30°. The baffle carries at the upstream end a fuel supply jet 2 with its axis parallel to the duct axis. Immediately upstream is the co-operating anvil member 3 placed centrally in the duct with its surface lying transversely of the duct so that fuel striking it will spread radially outward and be dispersed over the whole cross section of the duct into the main air-stream. The angle at which the main air supply flowing over the anvil 3

strikes the fuel flowing radially from the flat surface of the anvil is preferably 90°

The system functions as follows. The baffle creates a turbulent zone in the mixtures within and immediately downstream of the baffle in which zone the mixture has a low velocity axially of the duct. This portion is ignited by a spark passing from electrode 6 to baffle 5 and combustion then becomes self-propagating, a portion of mixture being constantly drawn into the turbulent zone where it ignites and acts as a pilot flame and also heats the other portion of the mixture passing down the duct.

In Figure 2 each of the atomisers consists of a fuel supply jet 9 and a secondary jet 10 axially opposed thereto, both jets having their axes parallel to the duct axis. Five atomisers are provided and the baffle is in the form of a hollow truncated cone 11 of similar dimensions as that in Figure 1. It is located centrally in the duct vertex upstream and is carried on streamlined supports. One atomiser is located upstream of and with its jets axially in line with the cone. The remaining four are, as shown also in Figure 3, disposed symmetrically about the baffle intermediate its upstream and downstream limits. Ignition is carried out as in the apparatus of Figure 1. In this modified system fuel-air mixture from the single atomiser upstream of the cone is carried into the cone via the entry hole and ignited there together with a portion of the main charge furnished by the other four atomisers which is sucked in by eddies at the downstream end of the cone. The mixture within the cone is ignited and combustion proceeds as in the apparatus of Figure 1.

Figure 4 shows the general arrangement of an opposed jet atomiser. Dimensions "X" and "Y" are critical and the following dimensions should be consistent with strength. The shape should be such that as low a resistance as possible is presented to the main air-stream.

A combustion system constructed substantially in accordance with Figures 2, 3 and 4 incorporating a diffusion zone and having the following dimensions:

Duct diameter at A	_____ inches	6
Cone baffle taper	_____ degrees	30
Cone upstream diameter	_____ in	0.75
Cone downstream diameter	_____ in	4.00
Jet dimension "X"	_____ in	0.15
Jets dimensions "Y"	_____ mm	2

has given the following results using petrol issuing from an upstream jet as the fuel and an air blast issuing from the downstream secondary jet as the resisting medium to break up and disperse the fuel.

(1) A rich mixture flame extinction limit of air-fuel ratio 10:1 at main air velocities up to 250 ft. per sec.

(2) A weak mixture flame extinction limit of an air-fuel ratio 150:1 at main air velocities up to 400 ft. per sec.

(3) Combustion efficiencies of 90 to 100% at chemically correct mixture strengths for complete combustion up to velocities of 250 ft. per sec. using a combustion chamber tail pipe of length 4'6".

The following additional data is applicable to result (1), similar data being obtainable for the other two results:

Fuel flow=2000 lb/hr.

Main air supply=5.7 lb/sec.

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Air blast pressure for secondary jet=30 lb/in.² above chamber pressure.

Cone pressure loss at Mach number 0.2 upstream of the cone=0.96.

The above results illustrate the advantages obtained by the new system in a particular application, viz: combustion stability over a wide range of main air velocities and mixture strengths coupled with a high combustion efficiency. Furthermore, in the special application to a ram-jet combustion system these advantages are maintained over a wide range of air densities and fuel flows as the atomisation of the fuel is not dependent on these factors but on the excess pressure of the auxiliary air supply or the fuel supply above the combustion chamber pressure.

We claim:

1. Combustion apparatus for burning liquid fuel in a fast-moving gas stream including a duct for carrying said stream, a fuel atomizing system in the duct, said system comprising at least one liquid fuel injector directed along the duct and means to provide a resisting medium facing and close to said injector so that fuel issuing from the injector is caused to spread out across and mix with the stream, flame stabilizing baffle means in the duct adjacent to, downstream of and aligned with the atomizing system, said baffle means defining a stabilized combustion zone, and an igniter within said zone.

2. Combustion apparatus for burning liquid fuel in a fast-moving gas stream including a duct for carrying said stream, a fuel atomizer co-axially located within said duct, said atomizer consisting of a liquid fuel injector directed axially of the duct and an anvil facing and close to said injector, upon which said fuel impinges to spread out across and mix with the stream, a flame stabilizing baffle co-axially located in the duct adjacent to but downstream of the atomizer, said baffle defining a stabilized combustion zone, and an igniter within said zone.

3. Combustion apparatus for burning liquid fuel in a fast-moving gas stream including a duct for carrying said stream, a fuel atomizer co-axially located within said duct, said atomizer consisting of a liquid fuel injector directed axially of the duct and an anvil having a surface extending transversely of the duct and facing and close to said injector, upon which surface said fuel impinges to spread out across and mix with the stream, a flame stabilizing baffle defining a frusto-conical interior cavity, said baffle being co-axially located in the duct adjacent to but downstream of the atomizer, said cavity of the baffle defining a stabilized combustion zone, and an igniter within said zone.

4. Combustion apparatus for burning fuel in a fast-moving gas stream including a duct for carrying said stream, a plurality of fuel atomizers symmetrically disposed in the duct, each said atomizer consisting of a liquid fuel injector directed along the duct and means to provide a resisting medium facing and close to each injector, so that fuel issuing from each injector is caused to spread out across and mix with the stream, flame stabilizing baffle means in the duct

symmetrically disposed with respect to the atomizers adjacent to but downstream of the atomizers, said baffle means defining a stabilized combustion zone, and an igniter within said zone.

5. Combustion apparatus for burning liquid fuel in a fast-moving gas stream including a duct for carrying said stream, a fuel atomizing system symmetrically disposed in the duct, said system comprising at least one liquid fuel injector directed along the duct and a further fluid injector facing and close to and aligned with said fuel injector, whereby said fuel and fluid impinge upon each other to spread out across and mix with the stream; flame stabilizing baffle means in the duct aligned with, adjacent to and downstream of the atomizing system, said baffle means defining a stabilized combustion zone, and an igniter within said zone.

6. Combustion apparatus for burning liquid fuel in a fast-moving gas stream including a duct for carrying said stream, a fuel atomizer co-axially located within said duct, said atomizer consisting of a liquid fuel injector directed along the duct and a further fluid injector facing and close to and aligned with said fuel injector whereby said fuel and fluid impinge upon each other to spread out across and mix with the stream, a flame stabilizing baffle co-axially located in the duct downstream of but adjacent to the atomizer, said baffle defining a stabilized combustion zone, and an igniter within said zone.

7. Combustion apparatus for burning liquid fuel in a fast-moving gas stream including a duct for carrying said stream, a frusto-conical tubular member coaxially located within the duct, said member being divergent in the downstream direction, a fuel atomizer located at the upstream end of said member, a plurality of further fuel atomizers symmetrically spaced around the outside of said tubular member, each said atomizer consisting of a liquid fuel injector directed along the duct and means to provide a resisting medium facing and close to said injector, so that the fuel is caused to spread out across and mix with the stream, and an igniter within said tubular member towards the downstream end thereof.

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