Nov. 14, 1950 P. LLOYD ET AL 2,529,506

BURNER FOR LIQUID OR GASEOUS FUELS

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FIG. 1.

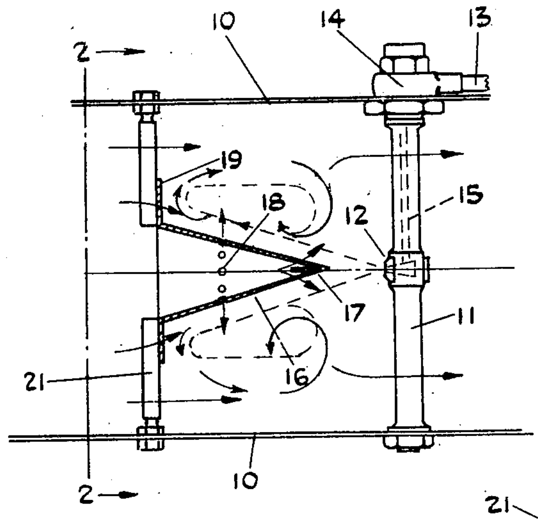

FIG. 2.

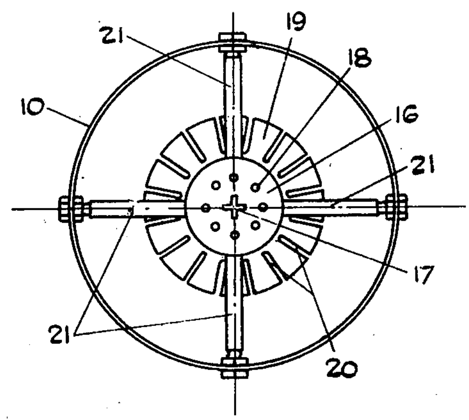

FIG. 4.

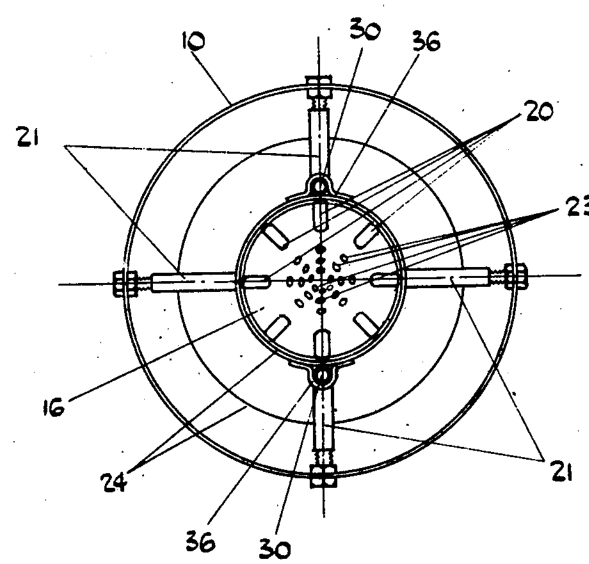

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FIG 3

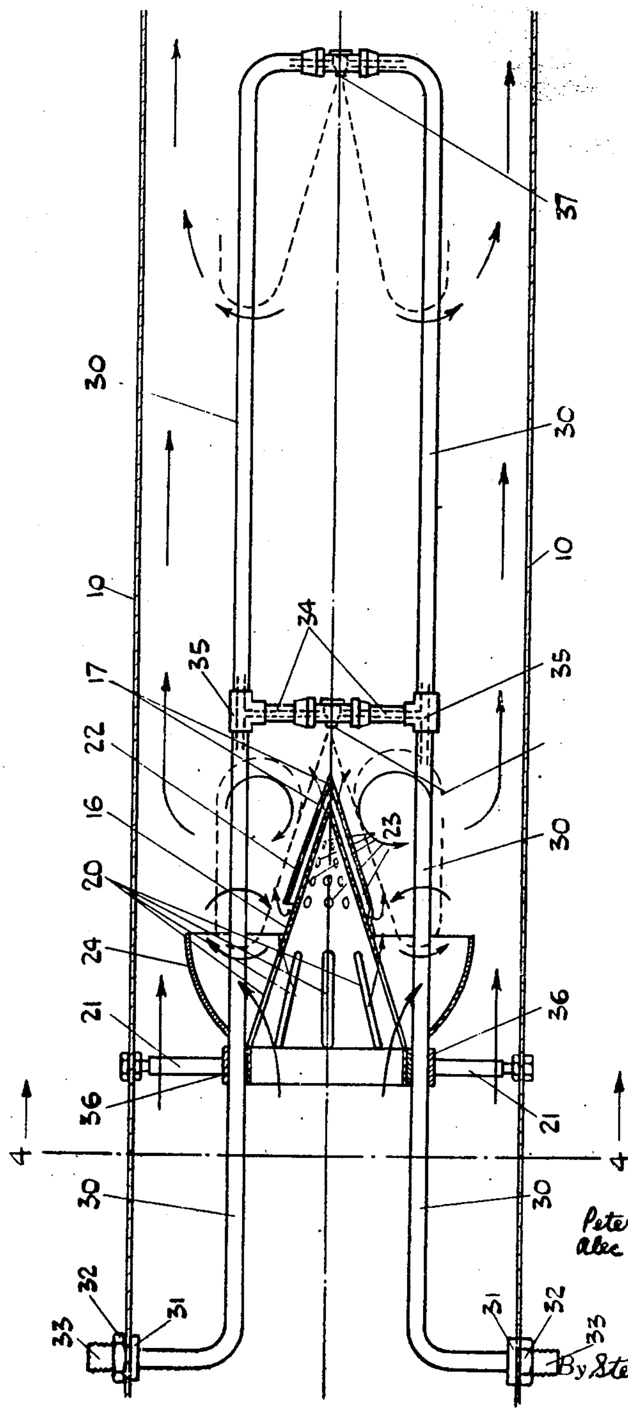

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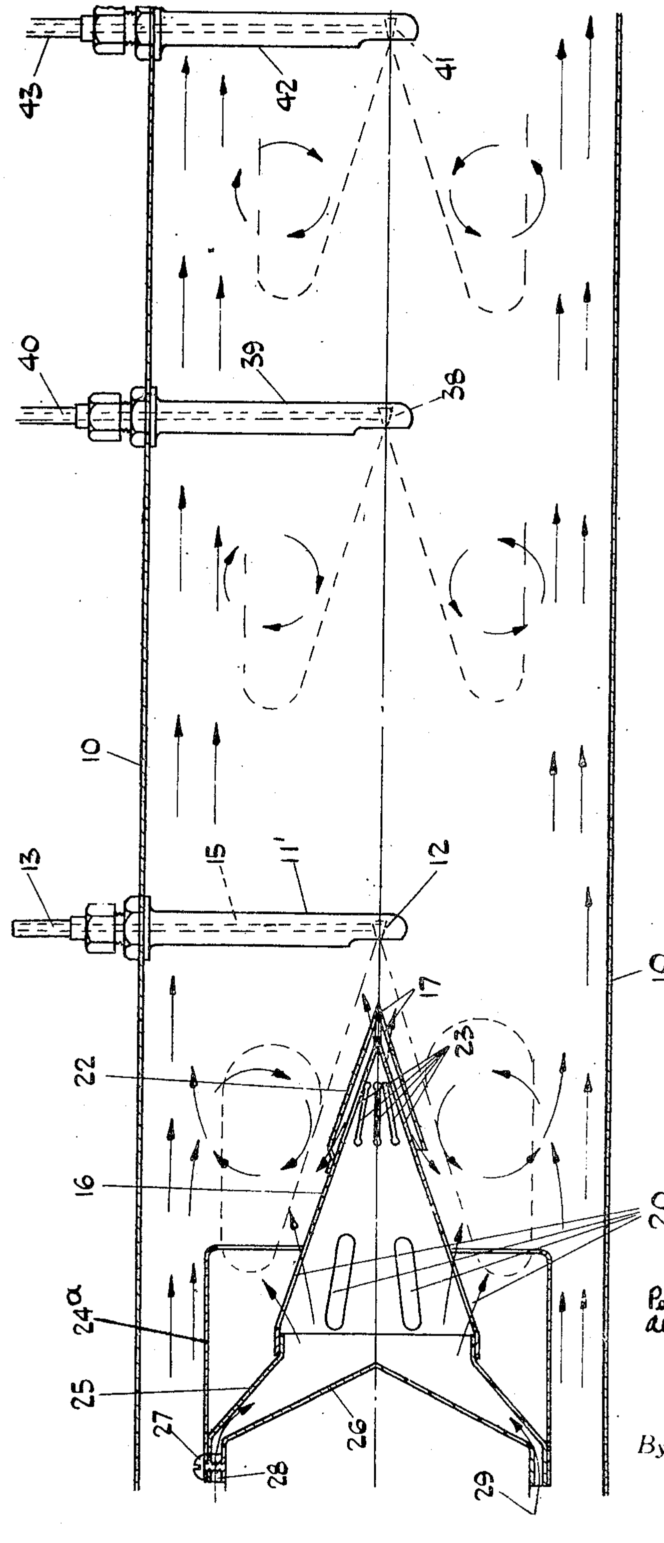
FIG. 5



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2,529,506

BURNER FOR LIQUID OR GASEOUS FUELS

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9 Claims. (Cl. 60—44)

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The invention relates to combustion apparatus for liquid or gaseous fuels of the kind in which a nozzle or atomiser injects a jet or spray of fuel upstream into a current of air. The invention has a special reference to combustion apparatus for gas turbines or/and jet propulsion motors which require stabilised burning in a fast moving air stream and with high air/fuel ratios. The description "fast moving" as applied to a combustion-supporting air current is used herein to indicate that the mean speed of the air current in its general direction of flow past a combustion zone, calculated from the ratio air volume passing in unit time/cross sectional area of the flow path, is high in relation to the speed of flame propagation in the fuel-air mixture concerned. For hydro-carbon fuels burning in air the speed of flame propagation is considered as being of the order of one foot per second at atmospheric temperature; the invention, on the other hand, is especially applicable to combustion apparatus for gas turbine or/and jet propulsion power units in which the speed of the air current in its general direction of flow past a combustion zone, calculated on the basis indicated, might be from 30 to 300 feet per second or even more, depending on the design.

Combustion apparatus for this purpose is also required to maintain stable burning at high rates of fuel injection with a minimum of pressure loss.

The flame from a nozzle or atomiser injecting fuel upstream is intrinsically more stable than that from one injecting fuel across or down stream, on account of its self-piloting action, the burning gases or/and fuel particles being continually carried back by the air stream into or/and past the jet or spray and thereby tending to kindle the fuel issuing from the nozzle or atomiser.

To be fully effective, however, the self-piloting action requires a good supply of oxygen to the base of the flame, because the latter being carried back by the air blast, tends to envelop the jet or spray of fuel and to exclude air therefrom, thereby inhibiting burning although the issuing fuel is heated to ignition temperature. The flame therefore tends to be self-choking unless its base is adequately fed with oxygen.

An object of this invention is to provide means for increasing the intrinsic stability of the flame from a fuel jet or spray directed upstream into a fast moving air stream, and more especially for ensuring adequate oxygen supply to the base of the flame.

Another object is to ensure improved mixing of

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air and fuel in the parts of the flame more remote from the centre of the spray, so as to avoid a concentric stratification of rich and weak mixture.

Yet another object of the invention is to provide means for ensuring stable burning at high rates of fuel injection while at the same time minimising pressure loss.

According to this invention, means are provided, in association with a nozzle or atomiser delivering fuel upstream (against the general direction of air flow), for delivering a part at least of the primary air supply in a stream directed downstream into a radially inner region of the jet or spray issuing from the nozzle or atomiser.

A preferred means for this purpose comprises a hollow baffle of generally conical shape coaxially aligned on the fuel nozzle or atomiser with its apex pointing down stream towards the nozzle or atomiser, said baffle being provided with an opening or openings at or near the apex through which opening(s) a stream or air constituting part of a fast moving air stream is directed into the centre of the jet or spray of fuel issuing from the nozzle or atomiser.

The cone shaped baffle may also be provided with other openings or equivalent means for supplying an additional part of the main air stream to radially inner parts of the fuel being burnt at or near the flow reversal region, i. e. at points more remote from the nozzle or atomiser and for supplying a still further part of the air supply to a radially outer part of the fuel being burnt which is carried back around the fuel nozzle or atomiser. The latter may be of the kind adapted to produce a divergent or conical spray of fuel and the profile of the cone shaped baffle may be such as to conform approximately to the cone angle of the spray.

To ensure thorough mixing of air and fuel throughout the whole of the flame zone and to suppress the concentric stratification of mixture strengths hereinbefore mentioned, the cone shaped baffle or/and an extension of its upstream edge disposed substantially transversely of the general air stream (forming, as it were, the brim of a hat of which the conical baffle part is the crown) is/are provided with a number of radial slots admitting air to the upstream end and radially outer portions of the fuel being burnt, whereby the air feeding these parts is supplied in a number of regularly disposed flattened streams tending to set up a radial stratification of alternate rich and weak mixture layers which will operate to break up the concentric mixture stratification that would otherwise be formed.

The nature of this invention and preferred manners of performing the same will be more fully understood from the following description, having reference to the accompanying drawings, illustrating, by way of example, selected typical embodiments of the invention.

In the drawings,

Fig. 1 shows in central longitudinal cross section part of a flame tube of a combustion apparatus containing a fuel injector and conical baffle means;

Fig. 2 is a view of the same in transverse section taken along the line 2—2 of Fig. 1;

Figs. 3 and 4 are views similar to Figs. 1 and 2 respectively of an alternative embodiment of the invention, the sectional view, Fig. 4, being taken along the line 4—4 of Fig. 3; and

Fig. 5 is a view in central longitudinal cross section (similar to Fig. 1) of a third embodiment of the invention;

Referring to Figs. 1 and 2, a hollow transverse supporting member 11 is secured to the walls 10 of a flame tube and carries a fuel injection nozzle 12 positioned centrally of the flame tube and directing a jet or spray of fuel upstream, the direction of the air flow being indicated by full line arrows and the direction of fuel spray being indicated by dotted lines. Fuel is fed to the nozzle 12 by means of an external pipe 13, banjo union 14 and a passage 15 formed in the interior of the support 11. A conical baffle 16 is aligned coaxially with the fuel nozzle 12 with its apex pointing towards the nozzle and in fairly close proximity thereto. The base of this conical baffle is open to the air stream and its apex is provided with a cruciform opening 17 through which a part of the main air supply is directed into a radially inner part of the fuel spray issuing from the nozzle 12. The baffle 16 is also provided with a ring of openings 18, more remote from the nozzle 12 than the opening 17, and serving to feed an additional part of the main air supply into the flow reversal region of the fuel being burnt where the fuel droplets, which have penetrated that far, have lost their initial momentum and are carried back by the air stream as indicated by the dotted lines. The main body of air flows at high speed through the duct 10 and in the neighborhood of baffle 16, is confined mainly to the radially outer region of the duct 10, thus surrounding the fuel being burnt and causing a flow reversal thereof at the limit of its upstream path. The base of the conical baffle 16 is provided with a flat rim 19 forming an extension thereof which is provided with a number of radial slots 20 through which further air passes over a path radially within the main air stream in the form of flattened streams to feed the radially outer portions of the fuel spray. The presence of the baffle produces turbulence in the air flow which creates a local re-circulation of the jet or spray being burnt, from a radially outer to a radially inner part thereof and towards the burner; this effect is supplemented by that of the arrangement of radial slots 20 which, by inducing a radial stratification of the mixture strength, serves to break up the concentric mixture stratification, with over-rich mixture in the inner part of the flame zone and over-weak mixture in the outer part thereof, which would otherwise tend to form.

The rim 19 of the conical baffle is attached to four supports 21 which are secured to the walls of the flame tube and thereby support the conical baffle.

Referring now to Figs. 3 and 4, the arrangement is similar in many respects to that of Figs. 1 and 2, corresponding elements being designated by the same reference numerals, but the baffle member comprises a small extra conical element 22, placed coaxially over the apex of the cone-shaped member 16, and spaced therefrom, so as to provide a narrow annular space between them, fed with air through openings 23 in member 16. The outer cone 22 is provided with a cruciform opening 17, through which air is fed into the centre of the spray from nozzle 12, as before, and air escaping from the rear of the space between the cones 16 and 22 feeds the reversal region of the flame zone. In this construction, the rim 19 of Figs. 1 and 2 is replaced by a frusto-spherical shield 24, and the radial slots 20 are situated in the basal portion of the cone member 16.

In this construction, two stages of injection are provided, of which the second is furnished by a second nozzle or atomiser 37, situated downstream of and directly behind the first nozzle 12. No baffle means is provided for the second injection stage, the flame thereof being piloted and stabilised by that of the first stage.

Constructionally this arrangement differs from that of Figs. 1 and 2 in that the nozzles or atomisers are rigidly connected to the baffle means and supported from the walls of the flame tube 10 by common support means, consisting of the radial supports 21 and a U-shaped tubular member 30, which, being hollow, serves to feed the fuel to the nozzles 12 and 37, the former being carried by a cross tube 34, secured to the side limbs of the tube 30 by T-pieces 35. The tubular member 30 is secured to the radial supports 21 and to the bases of the cone 16 and shield 24 by a clamping member 36 and the ends of the tubular member 30 pass through the walls of the flame tube 10, being secured thereto by collars 31 and nuts 32, and terminate in threaded portions 33, for attachment to the fuel feed lines (not shown).

In the embodiment of Fig. 5, in which also corresponding elements are designated by the same reference numerals as in the figures already described, the frusto-spherical shield 24 of Figs. 3 and 4 is replaced by a cylindrical shield 24*a*, connected to the cone member 16 by means of a conical element 25, of wider angle than the cone 16 and forming an extension of the base thereof. Elements 24*a* and 25 are secured to a shallow conical member 26 by screws 27 and spacing washers 28, leaving an annular opening between the members 25, 26, through which air is fed into the interior of the cone 16.

Otherwise, the baffle system is similar to that shown in Figs. 3 and 4. The embodiment of Fig. 5, however, has three stages of injection, furnished by three injector tubes, 11, 39, 42, fed by external pipes 13, 40, 43, and having nozzles or atomisers 12, 38, 41, all situated on the axis of the flame tube 10, which is also the axis of the baffle 16, 22, etc. The latter, together with its primary air feeding openings 17, 23, stabilises the first stage flame from nozzle 12, the second and third stage flames from nozzles 38 and 41 being piloted and stabilised by the flames from the nozzle or nozzles preceding them.

All the foregoing embodiments are characterised by upstream injection (in the first stage) against the apex of a conical baffle provided with openings for directing primary air into the centre of the spray or jet of fuel and acting to produce turbulence creating a re-circulation from a radially outer to a radially inner part of the jet or spray, and also by the provision of radial slots for feeding air into the reversal region and radially outer parts of the flame zone in a number of narrow radial streams, for the purposes already described. The second and third embodiments are also characterised by multi-stage injection with baffle means for stabilising the flame of the first stage only, stabilisation of the succeeding flame or flames being brought about by the flame or flames in front. Finally, the second embodiment incorporates the preferred constructional feature of rigid connection and common support of the injector and baffle means, ensuring maintenance of their correct alignment.

What we claim as our invention and desire to secure by Letters Patent is:

1. Combustion apparatus comprising a conduit for the flow of a combustion-supporting air stream therethrough, means for injecting a fuel jet into said conduit directed upstream relative to the general direction of said air stream, and means for leading a first portion of the said air stream through said jet to an inner region thereof located towards the base of the jet, the said jet being located so that the main body of air flows downstream around the jet to cause flow reversal thereof.

2. A combustion apparatus according to claim 1 comprising means for leading a second portion of the air stream through said jet to an inner region thereof located further from the base and nearer the flow reversal region of the jet than the first said portion.

3. A combustion apparatus according to claim 2 further comprising means for delivering by a path radially within the main air stream a third portion of the air stream to an outer part of the jet located towards the flow reversal region of the jet.

4. Combustion apparatus comprising a conduit for the flow of a combustion-supporting air stream therethrough, a burner nozzle for injecting a fuel jet within said conduit directed upstream relative to the general direction of said air stream, and a hollow baffle of generally conical shape having its axis in alignment with

said nozzle and its apex pointing downstream towards said nozzle, the wall of said baffle having perforations for delivering a first portion of the air stream through said jet and into an inner region thereof.

5. A combustion apparatus according to claim 4 wherein the conical baffle is provided with a first opening located in the vicinity of its apex.

6. A combustion apparatus according to claim 5 wherein the conical baffle is provided with a second opening further from its apex than said first opening for delivering a second portion of the air stream through said jet and into an inner region thereof located further from the base of the jet than said first portion.

7. A combustion apparatus according to claim 6 wherein a baffle is provided with a rim extending transversely to the axis, said rim having a number of radial slots through which a third portion of the airstream is delivered to an outer region of the jet.

8. Apparatus according to claim 4, wherein the fuel injector means is adapted to produce a divergent spray conforming substantially to the cone angle of the baffle.

9. A combustion apparatus according to claim 4, wherein a hollow baffle is provided, in the region of its apex, with an outer cone arranged coaxially therewith and spaced therefrom, said outer cone having perforations for leading air from the space between said outer cone and said hollow baffle to an inner region of the jet.

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