

[54] COMBUSTION DEVICES

[75] Inventors: William Dean Bryce, Farnham;
Peter George Street, Fleet, both of
England

[73] Assignee: The Secretary of State for Defence in
Her Britannic Majesty's
Government of the United Kingdom
of Great Britain and Northern
Ireland, London, England

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[58] Field of Search..... 60/39.72 R, 261; 431/350

[56] References Cited

UNITED STATES PATENTS

2,771,743	11/1956	Lovesey	60/39.72 R
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Primary Examiner—Meyer Perlin
Assistant Examiner—Larry I. Schwartz
Attorney, Agent, or Firm—Cameron, Kerkam, Sutton,
Stowell & Stowell

[57] ABSTRACT

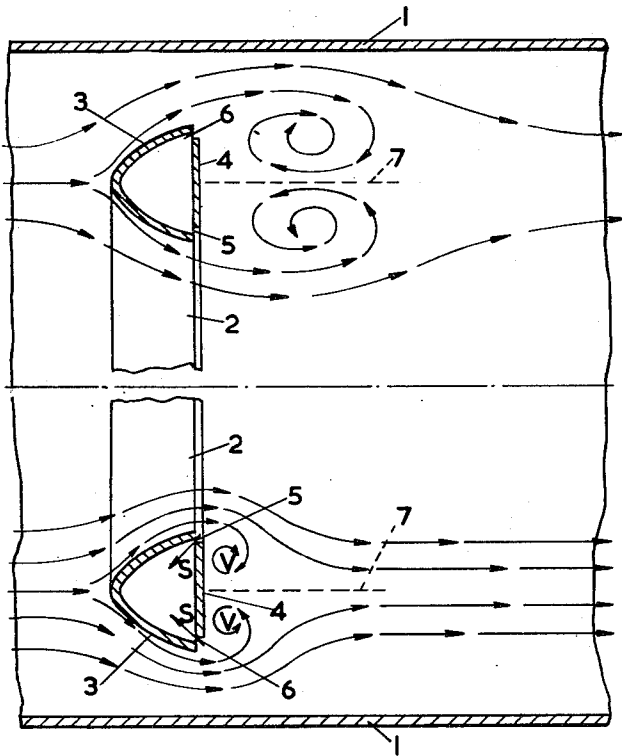
The invention relates to combustion devices wherein a flame stabilisation zone is formed in the wake of a body disposed in a swiftly moving gas stream.

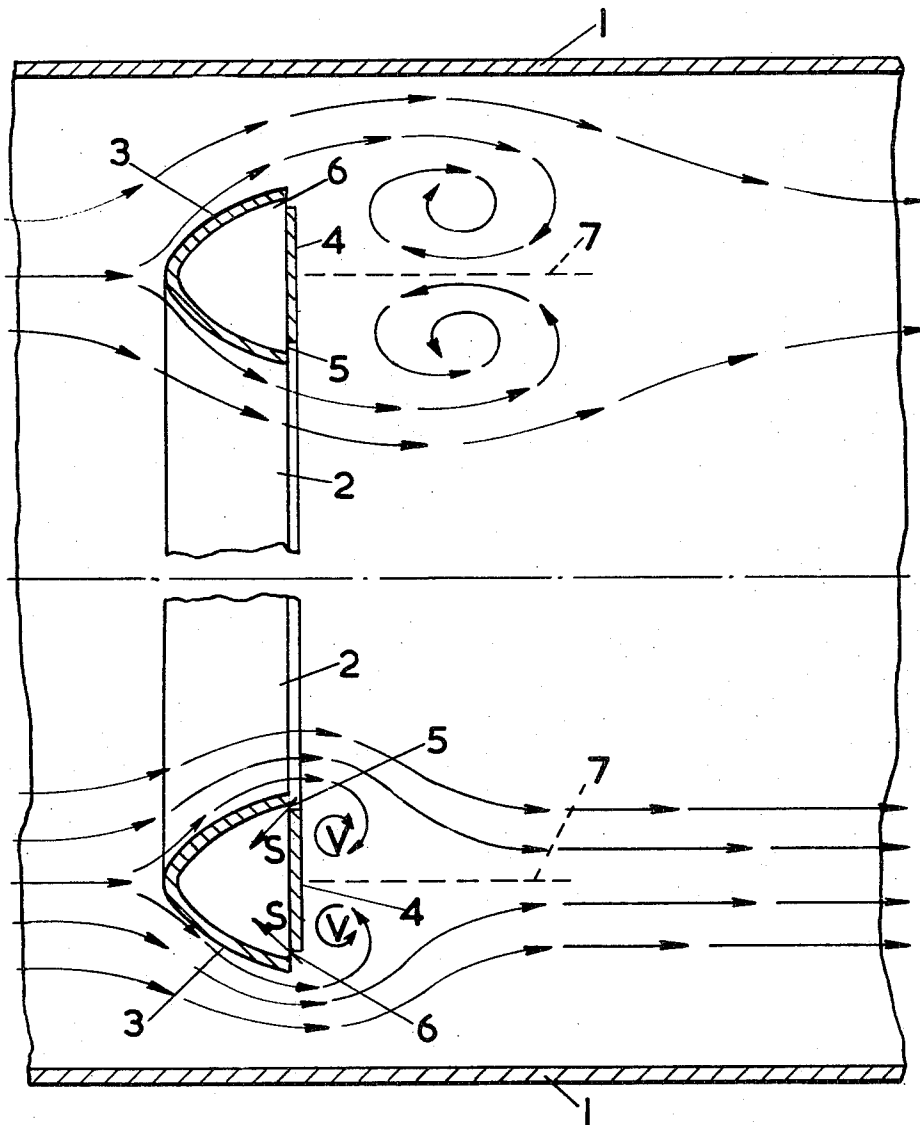
The invention provides a combustion device comprising a bluff-body disposed in a gas stream, the body having an aerodynamically smooth upstream-facing portion terminating downstream through a step change of section in a substantially flat downstream-facing surface extending transversely to the direction of flow of the stream, and means for influencing flow over the body to induce stable vortex formation adjacent said downstream facing surface.

Preferably such means comprise suction means, suction being applied from the interior of the body in each region of the step change of section.

Combustion devices according to the invention may include a flow divider extending downstream of the downstream facing surface to separate vortices originating at the step change of section.

4 Claims, 1 Drawing Figure





COMBUSTION DEVICES

The present invention relates to combustion devices wherein a flame stabilisation zone is formed in the wake of a body disposed in a swiftly moving gas stream.

In aircraft gas turbine jet propulsion engines, extra power can be developed by burning additional fuel in an afterburner. It has long been the practice in such installations to use fixed baffles to produce stable turbulent (or recirculation) zones in their wakes wherein flames will maintain themselves. Such baffles offer undesirable resistance to flow during such time as afterburning is not in operation. One of the more common forms of fixed baffle is a V-shaped gutter having its apex pointing upstream of the flow, the extreme simplicity of the arrangement tending to outweigh adverse considerations. By setting the arms to an included angle of the order of 45°, or slightly less according to flow velocity, a reasonable optimum between resistance and the provision of an adequate recirculation zone can be obtained.

Nevertheless, baffle resistance can be critical in determining the total amount of afterburning which can be employed, and an after-burner system having a lower pressure loss when in the non-operating condition is desirable, provided that the penalties arising out of other considerations are not too severe. The present invention is concerned with means directed towards this end.

Various schemes have already been proposed with this end in view and many of them employ aerodynamic means. One of the more common forms of device comprises a body having a profile which normally gives rise to low drag and from which flow is caused to separate when afterburning is required by discharging air or other gas from the body across the direction of main flow. It has also been proposed, for example in prior Brit. Pat. No. 1,218,122, to utilise a body normally giving rise to high drag with resultant turbulent wake and, when after-burning is not required, to influence the boundary layer of flow over the body so as to reduce the wake. The present invention is on similar lines but wake reduction is achieved in somewhat different manner.

A combustion device according to the invention comprises a member disposed within a gas flow duct so as to produce a flame stabilisation zone in a swiftly moving gas stream and having a bluff-body configuration including a smooth upstream-facing portion with step change of section to a substantially flat downstream-facing surface extending transversely relative to the direction of flow through the duct, and means for influencing flow over the member to induce stable vortex formation adjacent said downstream-facing surface.

In a preferred form of the invention, suction is applied from the interior of the member in the region of the step change of section.

An embodiment of the invention will now be described by way of example with reference to the accompanying diagrammatic sole FIGURE which is an axial section through an afterburner duct including a flame stabiliser.

The afterburner duct shown in the FIGURE comprises a cylindrical casing 1 extending between a turbine outlet and a jet propulsion nozzle (neither of

which is shown), the direction of gas flow being from left to right as indicated by the arrows at the left. An annular tubular member 2 mounted coaxially within the duct has an aerofoil leading-edge surface 3 directed upstream relative to flow through the duct and terminates downstream in a flat surface 4 normal to the streamwise axis of the member, a step change of section occurring between the two surfaces. Annular orifices 5, 6 extend through the peripheral boundary of the member 2 in the region of change of section between the surfaces 3, 4.

Gases passing along the duct will flow around the curved surface 3 of the member 2 as far as the change of section. In the absence of any external influence, flow will separate from the member 2 at the change of section to form turbulent recirculation zones in its wake as shown in the upper part of the drawing. Liquid or gaseous hydrocarbon fuel introduced into the duct and ignited will burn in the recirculation zone where the turbulence will act to maintain a flame pattern.

When afterburning is not required, the fuel supply is discontinued and suction is applied to the interior of the member 2. The suction acts by way of the orifices 5, 6, as indicated by the arrows S in the lower part of the drawing, on flow passing over the member 2 to form vortices V adjacent to the downstream facing surface 4. Where the amount of suction applied is sufficient to maintain rotation of the vortices at a velocity similar to that of the normal flow through the duct, entrainment of the latter will occur causing it to be changed to a streamline stable flow pattern within a very short distance, with consequent drag reduction.

The precise mechanism whereby this effect is achieved is not yet fully understood but it is believed that the initial application of suction causes diversion of flow boundary layer whereby a vortex is initiated, some of the vortex flow in turn being drawn off by the suction until a stage is reached when the main flow suddenly changes direction, somewhat after the manner of a bi-stable fluidic switch. The boundary layer of flow over the curved surface, instead of breaking away as previously is transferred mainly to the vortex flow and the vortex becomes stabilised during such time as suction is maintained, part of the boundary layer being drawn into the orifices 5, 6.

The orifices 5, 6 may be in the form of substantially continuous slots extending around the member 2, or in the form of a series of shorter slots or they may be defined by a row of holes.

In an embodiment of the invention there is provided a flow divider extending along the duct from the downstream-facing surface 4, as indicated in dotted lines at 7 in the drawing, in order to keep the vortices separate and of the same order of magnitude since there may be a possibility of one entraining the other.

What we claim is:

1. A combustion device for installation in a gas flow duct to form therein a flame stabilisation zone, said combustion device comprising a member having a bluff-body configuration including an aerodynamically smooth upstream-facing portion, said portion terminating downstream through a step change of section of the member in a substantially flat downstream facing surface extending transversely relative to the direction of said flow, and suction means establishing low pressure in the interior of the member to influence said gas flow over said member, a stable vortex formation adjacent

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said downstream-facing surface being induced thereby, said member having at least one opening in each region of step change at opposite edge portions of said downstream-facing surface where through suction is applied.

2. A combustion device as claimed in claim 1 including a flow divider extending downstream of said downstream-facing surface whereby vortices originating at said step change of section at opposite edge portions of said downstream-facing surface are separated.

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3. A combustion device as claimed in claim 1, said member having two openings therein, each said opening comprising a slot, said slots extending along opposite edges of said downstream-facing surface where through suction is applied.

4. A combustion device as claimed in claim 1 wherein said member is of annular form, said member occupying a plane normal to the direction of gas flow.

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