

United States Patent

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[56]

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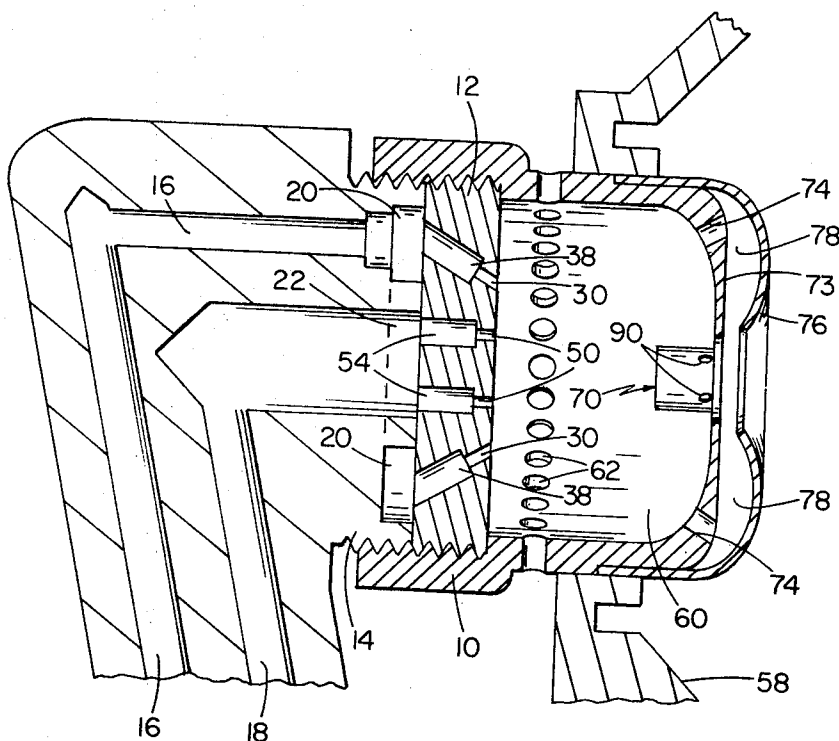
[54] **STREAMING NOZZLE**
7 Claims, 4 Drawing Figs.

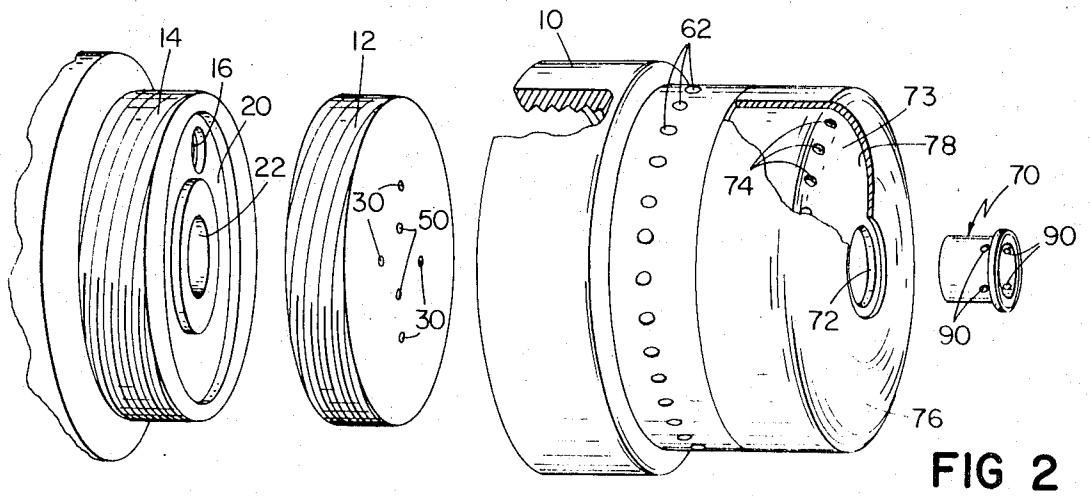
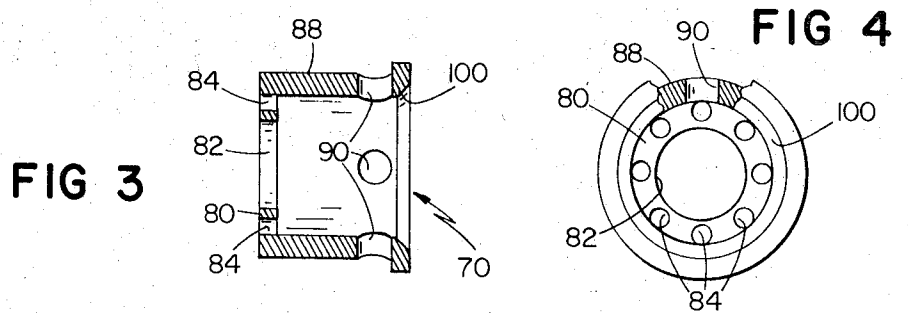
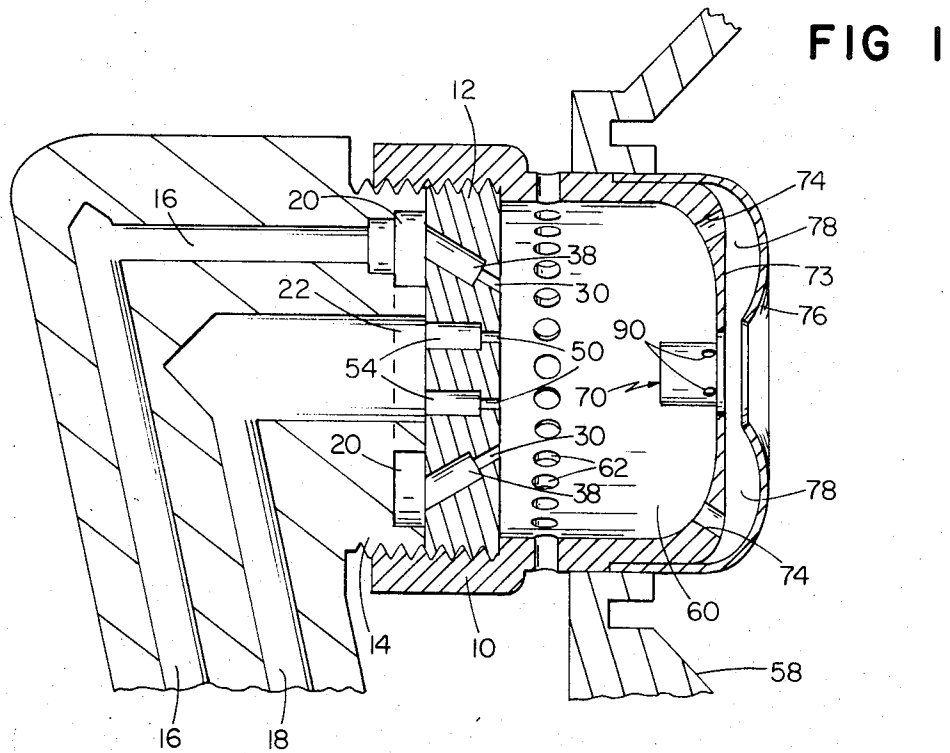
[52] U.S. Cl. **239/102,**
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ABSTRACT: Imploding a stream of compressible fluid under pressure at the outlet of a supersonic nozzle sculpted in boundary layer.





STREAMING NOZZLE

This invention relates to streaming at supersonic speeds using small nozzles of the general character disclosed in the pending applications of Nathaniel Hughes, Ser. No. 718,447, filed Apr. 3, 1968, now Pat. No. 3,531,048 "Supersonic Streaming;" and Ser. No. 734,089, filed Jun. 3, 1968, now U.S. Pat. No. 3,542,291, "Streaming," in which effective nozzle surfaces within essentially cylindrical bores are defined by boundary layer effects.

Objects of the invention are to increase the intensity of the shock process at the outlet of such nozzles and, in preferred embodiments in jet aircraft engines, to increase fuel atomization.

In general, the invention features implosion at the nozzle outlet of a stream of compressible fluid flowing toward the outlet at greater than environmental pressure. In preferred embodiments the imploding stream fully surrounds the outlet, is confined by a shroud that extends toward the nozzle outlet to define a zone tapering toward the nozzle axis, and consists of a mixture of gas and liquid; and the imploding stream and all streams to the nozzle including those through throat plane stabilizer holes, are connected to a common source of liquid-carrying gas under pressure.

Other objects, advantages, and features of the invention will be apparent from the following description of a preferred embodiment thereof, taken together with the drawings, in which:

FIG. 1 is a side view, mostly in section, of a portion of a jet aircraft engine embodying the invention;

FIG. 2 is an exploded isometric view thereof;

FIG. 3 is a sectional view through the longitudinal axis of the nozzle shown as a part of FIGS. 1 and 2; and

FIG. 4 is an end view, partially broken away, of the nozzle of FIG. 3.

Referring to FIGS. 1 and 2, nozzle nut 10 is screwed over fuel metering plate 12 and onto pedestal 14, which communicates with a fuel manifold (not shown) through passages 16 and 18. Passages 16 and 18 respectively feed fuel oil to annular recess 20 and bore 22 concentric therewith in pedestal 14. Four oblique fuel inlet holes 30 each 0.043 inch in diameter) equally spaced circumferentially in plate 12 communicate with recess 20 through enlarged passages 38 (two of which are shown in FIG. 1). Two fuel inlet holes 50 (each 0.02 inch in diameter) communicate through enlarged passages 54 with bore 22.

Forward of plate 12, nut 10 extends into combustion can 58 (a fragment of which is shown in FIG. 1) and defines mixing chamber 60, through the wall of which, outside can 58, extend air inlet holes 62.

Nozzle 70 is welded in countersunk circular opening 72 in front wall 73 of nut 10 centrally of a ring of oblique exit holes 74. Generally annular shroud 76 extends out from nut 10 and bends around in front of holes 74 and then back in toward wall 73 and nozzle 70, defining a zone 78.

Central inlet hole 82 extends through rear wall 80 of nozzle 70 and is concentric with an imaginary circle containing the centers of eight equally spaced smaller inlet holes 84 arranged in pairs, toward opposite ends of diameters of nozzle 70. Cylindrical boundary layer confining wall 88 has, toward its outlet, four radial throat stabilizing holes 90 (which together constitute a throat plane stabilizer), with coplanar axes spaced 90° from one another. The front of the nozzle is open to the interior of can 58, and includes 45° countersink 100.

In operation, JP-4 jet engine fuel is introduced through holes 30 and 50 into relatively large chamber 60 to mix with air entering through holes 62. The angular relationship of holes 30 causes the streams of fuel to hit one another, improving the mixing. At engine start-up the inlet air pressure is, e.g., 0.2 p.s.i.g., air flow is at a rate of 8 lbs./hr., and fuel flow is at a rate of 15 lbs./hr. These figures may increase respectively to 12 p.s.i.g., 200 lbs./hr., and 1,100 lbs./hr. during steady operation, after start-up. Part of the compressible air fuel mixture passes through inlet hole 82 into the nozzle defined by boundary layer confined within wall 88. Fluid mixture also moves

outside wall 88 and through holes 90 to stabilize the plane of the throat of the nozzle sculpted in boundary layer in the manner taught in the said patent applications. Another part of the mixture passes through holes 84 each of which is small enough to promote within its own confining cylindrical wall sufficient boundary layer growth to provide barely supersonic flow. (Flow within boundary layer confining wall 88 in said nozzle helps to speed up the flow through the holes 84 by increasing the pressure drop thereacross.)

The characteristic burst frequencies of the main portion of said nozzle, and of the streams leaving holes 84, produce a superheterodyne effect, with resultant beats which may be measured, for example to monitor functioning.

The rest of the mixture in chamber 60 passes through holes 74 into zone 78 and implodes under compressible fluid pressure into the nozzle outlet zone, increasing the shock effects and work done there, and improving atomization.

The included cone angle of the atomized stream, under flow conditions already set forth, is 70° during start-up and before ignition, and about 140° at initial ignition, the doubling being attributable to the great intensity of heat owing to localization (through efficient atomization and mixing) of the zone of combustion. During steady operation, after start-up, at flow rates above specified, the ignited cone angle may be about 85°.

The preferred embodiment, used in a jet aircraft engine as described, enables the efficient processing of large quantities of fuel even during engine start-up when air inlet pressure and flow rate are low. Smoking is reduced, and ignition is facilitated by wide cone angles.

The diameter of hole 8 or the number of holes 84 can be increased to obtain even wider cone angles. Holes 84 must always, however, be arranged in pairs along diameters of hole 82.

Nozzle parameters are calculated in the manner set forth in said pending applications. In the preferred embodiment, the parameters are:

L*	inch	0.187
L	do	0.282
D _f	do	0.260
D _i	do	0.177
Hole 90 diameter	do	0.062

Each hole 84 has a diameter and length of 0.032 inch. The centerlines of opposing pairs of holes 84 are 0.226 inch apart.

Other embodiments will occur to those skilled in the art and are within the following claims.

I claim:

1. A nozzle device comprising means to provide a supersonic jet through said nozzle, said means including: a boundary layer confining wall with inlet and outlet ends and a throat plane stabilizer therebetween; a portion defining a zone downstream of and in communication with said outlet end; and a conduit connecting said zone to a source of compressible fluid under greater than environmental pressure.

2. The nozzle device of claim 1 in which said zone extends 360° around said outlet end.

3. The nozzle device of claim 1 in which said zone is confined by a shroud of which extends toward said outlet end from downstream thereof to cause the downstream face of said zone to taper in the direction of said outlet end.

4. The nozzle device of claim 1 in which said conduit connects said zone to a chamber adapted to supply a mixture of said gas and liquid under pressure to said zone.

5. The nozzle device of claim 4 in which said chamber is connected to said inlet end.

6. The nozzle device of claim 5 in which said chamber supplies all streams to the nozzle.

7. The nozzle device of claim 6 in which said stabilizer comprises an even plurality of orifices in said wall, said orifices being arranged in coaxial pairs 180° apart.