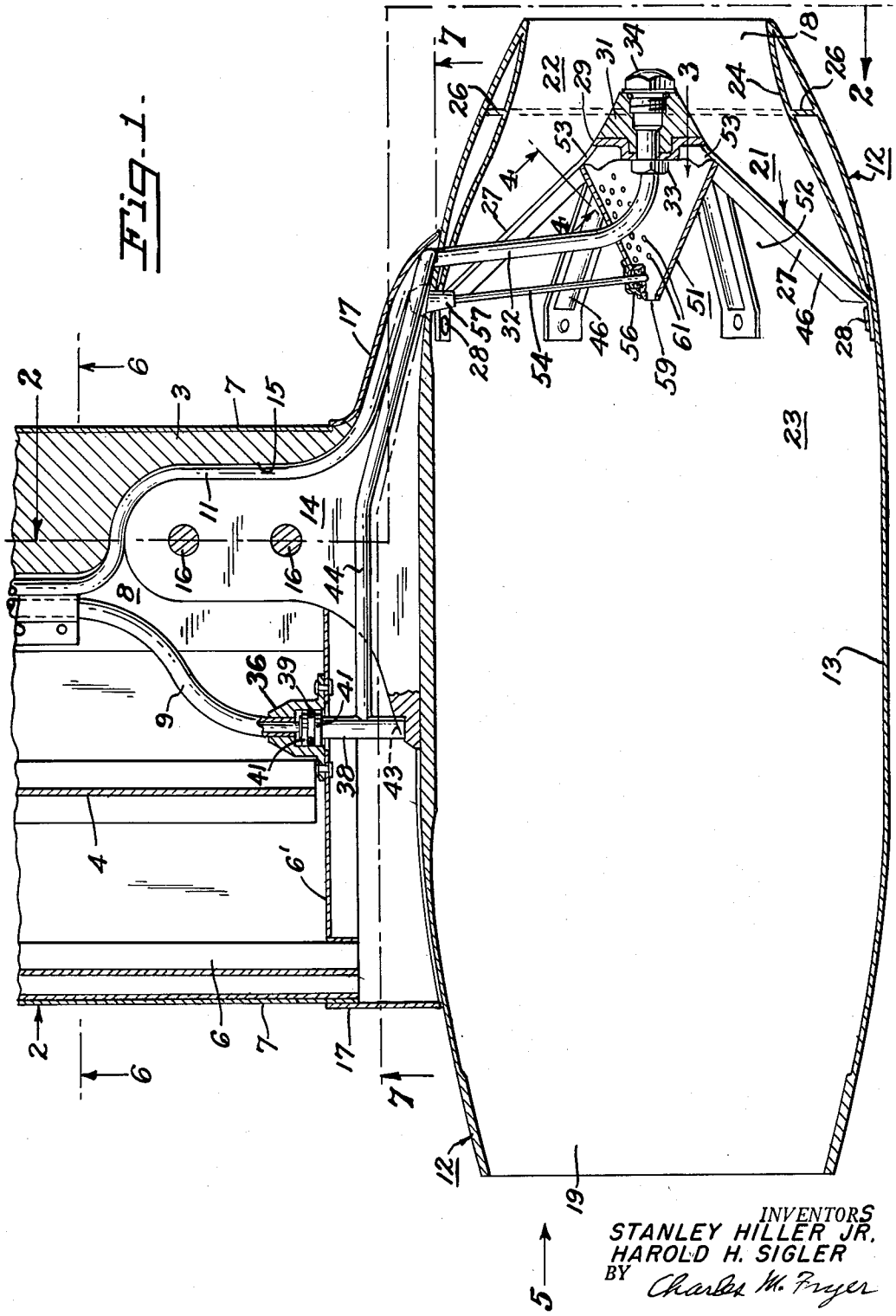
April 3, 1956 S. HILLER, JR., ET AL 2,740,482

ROTOR BLADE MOUNTED JET ENGINE

Filed Nov. 20, 1951 3 Sheets-Sheet 1

Fig. 1.



INVENTORS
STANLEY HILLER JR.
HAROLD H. SIGLER
BY Charles M. Fryer

ATTORNEY

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Fig. 2.

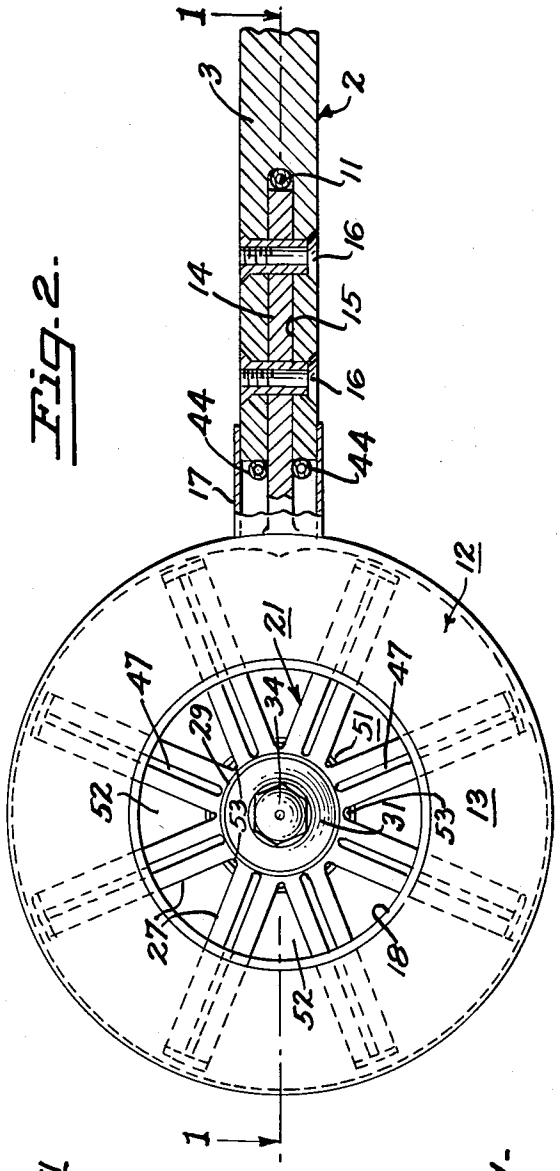


Fig. 3.

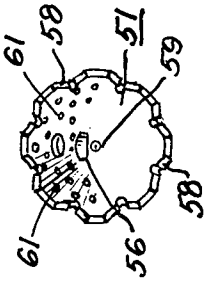
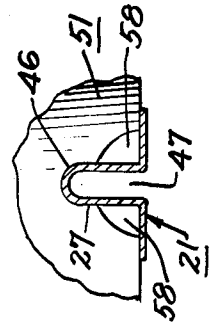


Fig. 4.



INVENTORS
STANLEY HILLER JR.
HAROLD H. SIGLER
BY Charles M. Pryer

ATTORNEY

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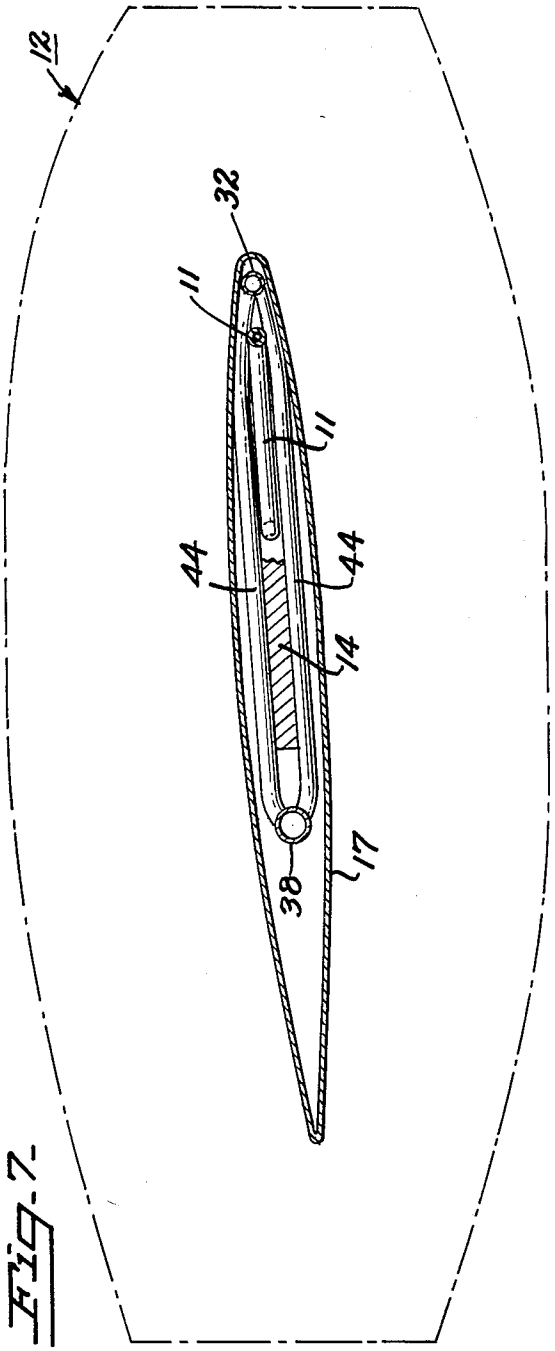


Fig. 7.

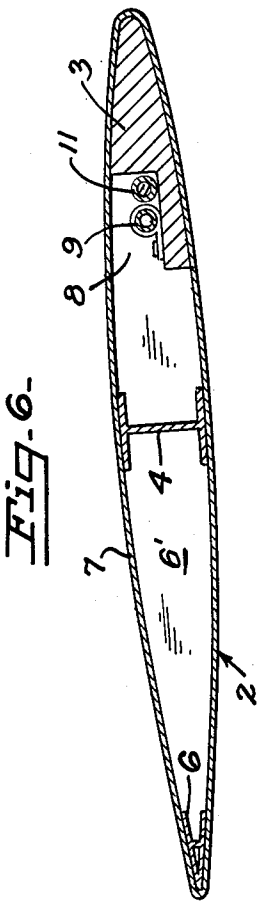


Fig. 6.

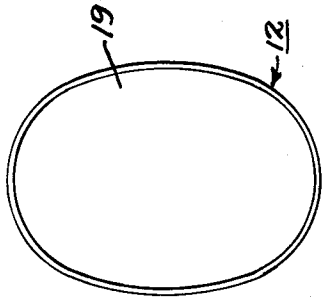


Fig. 5.

INVENTORS
STANLEY HILLER JR.
HAROLD H. SIGLER
BY
Charles M. Fryer
ATTORNEY

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2,740,482
ROTOR BLADE MOUNTED JET ENGINE

Stanley Hiller, Jr., Atherton, and Harold H. Sigler, San Carlos, Calif., assignors to Hiller Helicopters, Palo Alto, Calif., a corporation of California

Application November 20, 1951, Serial No. 257,353
9 Claims. (Cl. 170—135.4)

This invention relates to a jet engine, and more particularly to a ram jet engine which is advantageously employed on the tip of a helicopter blade or wing, as the power unit for driving the blade.

In starting a ram jet engine by the usual spark ignition means while the blade is being rotated, or when the blade is in auto-rotation and it is desired to restart the engine, ignition problems are generally encountered. This is so because the speed of the engine through the air creates a high velocity of the air through the engine, which impedes proper mixture of the fuel and the air.

Summarizing the invention, one of the important features thereof is the provision of an enclosure at the rear of the usual grid or flame holder in a ram jet engine, to provide a trap for pocketing, or in other words throttling, a portion of the air-fuel mixture flowing through the grid, sufficiently to effect a relatively static mass capable of being readily ignited by ignition means. The ignition means extends into this enclosure to ignite the air-fuel mixture pocketed thereby; and the relation of the enclosure with respect to the rest of the engine is such that the ignited pocketed mixture flows into the main mass of the air-fuel mixture in the engine to effect ready ignition of the same.

The grid of the engine is so constructed as to enable ready cooling thereof by the fuel spray ejected from the usual nozzle provided in the engine; and the fuel supply to the nozzle from the blade of the helicopter on which the engine has found particular applicability, is such that it is in heat transferring relationship with respect to the mounting means for the engine on the tip of a helicopter blade, to effect cooling of such mounting means.

From the preceding, it is seen that the invention has as its objects, among others, the provision of an improved ram jet engine which is of simple and economical construction, and which is provided with means for effecting ready ignition of the engine, particularly at higher speeds but which is also useful at all operating speeds of the engine when ignition is desired, together with improved means for cooling the mounting means of the engine, and also the grid. Other objects of the invention will become apparent from a perusal of the following detailed description.

The drawings illustrate the engine of this invention mounted on the tip of a helicopter blade where such engine, as previously related, has been employed advantageously in overcoming ignition problems generally encountered in starting the engine, and also in restarting the same after the blade has been in auto-rotation. It is to be understood, however, that the engine can be employed as a power unit for other devices.

Referring to the drawings:

Fig. 1 is a horizontal sectional view of the engine mounted on the tip of a helicopter blade; only the tip portion of such blade being shown. The plane of the section is indicated by line 1—1 in Fig. 2.

Fig. 2 is a front sectional elevation taken in planes indicated by the line 2—2 in Fig. 1.

Fig. 3 is a front view of an air fuel pocketing enclosure embodied in the engine, looking in the direction of arrow 3 in Fig. 1.

Fig. 4 is a fragmentary section taken in a plane indicated by line 4—4 in Fig. 1.

Fig. 5 is an end elevation of the rear of the engine looking in the direction of arrow 5 in Fig. 1.

Fig. 6 is a vertical section of the blade taken in a plane indicated by line 6—6 in Fig. 1.

Fig. 7 is a vertical section taken in planes indicated by line 7—7 in Fig. 1; a portion of the structure being broken away to disclose more clearly the construction and the engine unit being shown in phantom lines to illustrate its relationship with respect to the tip end of the blade.

The blade 2 of the helicopter can be of any suitable construction. That illustrated, includes metal spar member 3 which is shaped to form the leading edge of the blade, longitudinal medial I-beam 4, and trailing edge spar 6; the usual chordwise extending end stiffening members 6' being also provided. A suitable skin 7, preferably of metal, but which may be of any other suitable material, forms the air-foil surface of the blade. Spar 3 is recessed at 8; the recess extending longitudinally of the spar. A metal fuel conduit 9 extends along such recess from adjacent the root end (not shown) of the blade. Also extending along such recess 8 is an ignition cable 11. Fuel is supplied under suitable pressure, by any suitable pump, for example as illustrated in assignee's co-pending application by Stanley Hiller, Jr. and Harold H. Sigler, Serial No. 233,418, filed June 25, 1951, for "Rotary Wing Aircraft System"; and ignition current is supplied to cable 11 by any suitable means under the control of the pilot, such as also shown in said co-pending application.

Means is provided for fixedly mounting ram jet engine unit 12 on the tip end of the blade. For this purpose, the inner side of shell 13 of engine 12 has fixedly secured thereto, preferably by welding, a metal bracket 14 of heat resistant metal, such as heat resistant steel. Bracket 14 seats within a recess 15 formed in the tip end of spar 3; and the bracket 14 is fixedly secured to the spar by telescopic anchor bolts 16. It will be noted that the tip end of ignition cable 11 is conveniently positioned between the spar and the front edge of bracket 14, while fuel conduit 9 extends around the rear edge of bracket 14. A shroud 17 is located around the space between shell 13 and the tip end of the blade to provide fairing.

Shell 13 is in the usual form of a barrel or tube of highly heat resistant metal. It provides the chamber of the engine which has the usual front or upstream air inlet opening 18, rear or downstream discharge or nozzle opening 19 for the exhaust gases, and grid or flame holder 21 between such openings but adjacent inlet opening 18. In this type of ram jet engine, grid 21 performs the usual function of dividing the engine into front diffuser section 22 and rear combustion section 23. Diffuser section 22 is provided with the usual contoured wall surface 24 which is shaped in the customary manner to slow down the velocity and build up pressure of the air entering inlet opening 18 as the engine moves forwardly through the air stream; a stiffening ring 26 being provided between wall 24 and the wall of shell 13.

The shell is made relatively thin in order to provide as light a weight as possible; and to strengthen the same, the portion thereof secured to bracket 14 is made slightly thicker; the shell wall tapering gradually to a lesser thickness toward the opposite side of the shell, as is indicated in Fig. 2. Inlet end 18 of the shell is circular but the shell flattens out toward the discharge opening 19 thereof which is of a flattened oval shape, as indicated in Fig. 5, to resist flattening of the shell which might otherwise tend to occur due to the high centrifugal loads to which the shell is subjected as the blade rotates at operating speeds.

Grid 21 comprises the usual radially extending and equi-spaced legs or spokes 27 of highly heat resistant metal, the rear ends of which are secured to the shell by suitable means, such as rivets 28. At their front ends, spokes 27 are secured by any suitable means, such as

welding, to a centrally recessed metal nozzle mounting plate 29 upon which is seated a metal, preferably aluminum, nozzle seat 31 into which is screwed the discharge end of metal conduit portion 32 of the fuel line. A retaining nut 33 serves to secure both seat 31 on plate 29 and conduit portion 32 in seat 31. Conventional hollow cone spray nozzle 34 is screwed into seat 31; and fuel is ejected from the nozzle at an extremely high pressure caused by centrifugal force resulting from the rotating blade.

The fuel supply from fuel conduit 9 to fuel conduit portion 32 is so arranged as to effect cooling of bracket 14. Such arrangement will now be described. The discharge end of fuel conduit 9 leading from the blade is connected, preferably by welding, to a metal bushing 36, preferably of aluminum, secured by riveting to the outer wing stiffening member 6'. A conduit portion 38 is provided with a telescopic sealed sliding fit in bushing 36 adjacent one end thereof; such end being sealed by means of a conventional O-ring 39 between collars 41 on conduit portion 38. At its opposite end, conduit portion 38 has a floating mount on bracket 14. Such opposite end of conduit portion 38 is closed and seats freely in a recess 43 formed in bracket 14.

Connected in parallel with conduit portion 38 is a pair of metal conduit portions 44 to provide a divided flow of fuel from conduit portion 38 into conduit portions 44. The upper conduit portion 44 extends along the top side of bracket 14 and engages the same so as to be in heat transferring relationship therewith; and lower conduit portion 44 extends in the same relationship along the bottom side of bracket 14. At the ends opposite their connection with conduit portion 38, conduit portions 44 are connected to conduit portion 32 outside of shell 13; conduit portion 32 extending through the shell.

From the preceding, it is seen that conduit portions 32, 44 and 38 form one unitary part of the fuel line to nozzle 34, which is supported by the shell. This part can be quickly attached to conduit 9 leading from the blade by virtue of the telescopic connection provided for conduit portion 38 in bushing 36. The floating mounting of conduit portion 38 provides for flexibility to enable ready alinement of the parts to be connected. At the same time, when the engine is operating, the relatively cool fuel flowing in the parallel conduit portions 44 will effect heat transfer with the bracket 14 to cool the same.

Grid 21 may be of any conventional construction employed in common forms of ram jet engines; and the spokes or legs 27 thereof may extend radially at a right angle to the axis of the engine along which the spray nozzle 34 is mounted, or at any other suitable angle. However, in the preferred construction illustrated, spokes 27 are inclined in a rearward and upward direction; so that the spokes and nozzle 34 define the shape of a cone, the apex of which is at the nozzle. Although, insofar as the pocketing of the air-fuel mixture at the rear of the grid by the pocketing means to be subsequently described, is concerned, spokes 27 may be flat, it is preferred for strengthening purposes that they each be shaped to form a strengthening rib. For this purpose, each spoke is bent in the shape of a U to provide a longitudinally extending rib 46. The formation of such rib 46 results in a longitudinally extending channel 47 along the front face of each spoke. Such channels enhance cooling of the spokes because the fuel spray is blown into the channels by the inrushing air as the engine moves through the air, to provide cooling prior to vaporization of the fuel.

A highly heat resistant metal enclosure 51 is mounted at the rear of grid 21 along the axis of the engine to pocket or throttle temporarily some of the air-fuel mixture that flows through the grid. The enclosure thus forms a trap to provide a relatively static mixture which can be readily ignited, and in turn ignite the main mass

of the air-fuel mixture in combustion section 23 of the engine. Pocketing enclosure 51 may be of any suitable construction as long as it is open adjacent the rear of the grid so as to collect some of the air-fuel mixture which flows through spaces 52 between spokes 27.

In the preferred embodiment of the invention illustrated, enclosure 51 is funnel or conically shaped with its open ended base secured to the inner ends of the spokes 27 by any suitable means, such as welding. With reference to Figs. 1 and 2, it will be noted that the width of the open ended base of the enclosure, is such as to provide open spaces 53 about nozzle mounting plate 29 and between spokes 27. Thus, a relatively small portion of the air-fuel mixture flows through spaces 53 as the engine moves through the air, and is throttled or in other words pocketed in enclosure 51 to provide the relatively static mass which can be readily ignited.

An ignition rod 54 extends into enclosure 51 adjacent the apex thereof, being supported adjacent its ignition end on suitable insulation pad 56 mounted on enclosure 51. Ignition rod 54 extends transversely with respect to the axis of the engine and substantially radially with respect to the axis of rotation of the blade, to preclude possible bending of the rod which might otherwise occur due to the great centrifugal force effects. At its inner end, rod 54 is connected within insulating button 57 to ignition cable 11; the insulating button 57 being supported on the wall of engine shell 13. Thus, the pocketed air-fuel mixture can be readily ignited by ignition rod 54 when this is desired. The conical shape of enclosure 51 has been found advantageous in facilitating ignition. This is so because apex of the cone heats up to a great extent, and thereby remains hot enough to ignite the fuel should there be any periodic stoppage of the fuel.

Enclosure 51 is also arranged to provide for ready egress of the expanding ignited pocketed air-fuel mixture therein, into the main air-fuel mixture mass in combustion section 23 of the engine. For this purpose, the rim of the enclosure 51 adjacent its base is provided with recesses 58 about spokes 27. This permits the ignited combustion gases to escape from enclosure 51 and travel along the rear faces of the spokes into combustion section 23 and ignite the remaining mixture in the combustion section. To preclude possible collection of liquid fuel in the apex of enclosure 51, which might otherwise result in fouling of the tip of ignition rod 54 adjacent such apex, a vent or bleed hole 59 is formed in the apex to permit escape of any liquid fuel. However, because the shape of enclosure 51 is such that it is wider at its front or upstream end than at its rear or downstream end, the rear of the enclosure effects the pocketing of the air-fuel mixture for ignition purposes. The inboard side of enclosure 51 is formed with a plurality of relatively small vent or bleed apertures 61 to provide ventilation between the inboard side of enclosure 51 and combustion section 23 of the engine.

The principle of the enclosure for pocketing a portion of the air-fuel mixture in back of the flame holder or grid to insure ready ignition has been found under operations pursuant to this invention to be quite important; particularly in successful ram jet propulsion for a helicopter blade where special problems are encountered in starting the engine, and in restarting the same after the blades have undergone auto-rotation. Although the invention may assume varying forms within the scope of the appended claims, the particular embodiment of the invention described and illustrated, is preferred, and has been found extremely satisfactory in actual flight conditions.

We claim:

1. A ram jet engine comprising a chamber having a front inlet opening, a rear discharge opening, a flame holder grid comprising a plurality of spokes between said openings connected to a substantially central hub

structure, a fuel nozzle supported by said hub structure at the front thereof positioned to spray fuel in an upstream direction, an enclosure adjacent the rear of and supported by said grid providing a trap for pocketing an air-fuel mixture, the enclosure being open adjacent said spokes and the width of such opening being such that fuel and air inlet spaces are provided about said nozzle between said spokes, said enclosure being provided with recesses adjacent said spokes to allow fluid to escape from said enclosure along the rear faces of said spokes, and an ignition member extending into said enclosure.

2. The combination with a blade of a helicopter, of a ram jet engine mounted on the tip of said blade by a metal bracket secured to said blade, said engine having a fuel nozzle, and fuel supply means connected to said nozzle leading from said blade, said fuel supply means including a bushing member mounted on said blade, a first conduit portion mounted on said engine and having a telescopic sealed fit in said bushing member adjacent one end thereof and a floating mounting on said engine adjacent the other end, and a metal conduit portion on said engine connected to said first conduit portion in heat transferring engagement with a side of said bracket.

3. The combination with a blade of a helicopter, of a ram jet engine mounted on the tip of said blade, and fuel supply means connected to said engine and leading from said blade, said fuel supply means including a bushing member mounted on said blade, a conduit portion on said engine having a telescopic sealed fit in said bushing member adjacent one end thereof and a floating mounting on said engine adjacent the other end, and another conduit portion on said engine connected to said first mentioned conduit portion.

4. A ram jet engine comprising a chamber having a front inlet opening upstream, a rear discharge opening downstream, a flame holder grid between said openings comprising a plurality of spaced apart members, an enclosure behind said grid open at its upstream end adjacent said members to receive an air-fuel mixture adapted to flow through an opening between such members, said enclosure being wider at its upstream end than at its downstream end; to provide a trap for pocketing said air-fuel mixture, fuel supply means in front of said grid, and ignition means extending into said enclosure for igniting said pocketed air-fuel mixture, said enclosure having an open portion for egress of the ignited pocketed air-fuel mixture into said chamber.

5. A ram jet engine comprising a chamber having a front inlet opening upstream, a rear discharge opening downstream, a flame holder grid between said openings comprising a plurality of spaced apart members, an enclosure behind said grid open at its upstream end adjacent said members to receive an air-fuel mixture adapted to flow through an opening between such members, said enclosure being wider at its upstream end than at its downstream end to provide a trap for pocketing said air-fuel mixture, fuel supply means in front of said grid, and ignition means extending into said enclosure for igniting said pocketed air-fuel mixture, said enclosure having an open portion for egress of the ignited pocketed air-fuel mixture into said chamber.

6. A ram jet engine comprising a chamber having a front inlet opening upstream, a rear discharge opening downstream, a flame holder grid between said openings comprising a plurality of spaced apart spoke members connected to a substantially central hub structure, an enclosure supported by said grid behind said hub structure and open at its upstream end adjacent said spoke members, said open end of said enclosure extending beyond said hub structure to receive an air-fuel mixture adapted to flow through an opening between such spoke members, said enclosure being wider at its upstream end than at its downstream end, to provide a trap for pocketing said air-fuel mixture, a fuel supply nozzle supported by said hub structure in front of said grid with its discharge opening directed upstream, and ignition means extending into said enclosure for igniting said pocketed air-fuel mixture.

7. A ram jet engine comprising a chamber having a front inlet opening upstream, a rear discharge opening downstream, a flame holder grid between said openings comprising a plurality of spaced apart spoke members connected to a substantially central hub structure, an enclosure supported by said grid behind said hub structure and open at its upstream end adjacent said spoke members, said open end of said enclosure extending beyond said hub structure to receive an air-fuel mixture adapted to flow through an opening between such spoke members, said enclosure being wider at its upstream end than at its downstream end to provide a trap for pocketing said air-fuel mixture, a fuel supply nozzle supported by said hub structure in front of said grid with its discharge opening directed upstream, and ignition means extending into said enclosure for igniting said pocketed air-fuel mixture, said enclosure having an open portion for egress of the ignited pocketed air-fuel mixture into said chamber.

8. A ram jet engine comprising a chamber having a front inlet opening upstream, a rear discharge opening downstream, a flame holder grid comprising a plurality of spokes between said openings connected to a substantially central hub structure, a fuel nozzle supported by said hub structure at the front thereof positioned to spray fuel in an upstream direction, an enclosure adjacent the rear of said grid behind said hub structure and open at its upstream end adjacent said spokes, said enclosure being wider at its open upstream end than at its downstream end to provide a trap for pocketing an air-fuel mixture, the width of the open upstream end of said enclosure being such as to extend beyond said hub structure to receive such air-fuel mixture adapted to flow through spaces between spokes, and said enclosure having an open portion for egress of the ignited pocketed air-fuel mixture into said chamber, and ignition means in said enclosure.

9. A ram jet engine comprising a chamber having a front inlet opening upstream, a rear discharge opening downstream, a flame holder grid comprising a plurality of spokes between said openings connected to a substantially central hub structure, a fuel nozzle supported by said hub structure at the front thereof positioned to spray fuel in an upstream direction, an enclosure adjacent the rear of said grid behind said hub structure and open at its upstream end adjacent said spokes, said enclosure being wider at its open upstream end than at its downstream end to provide a trap for pocketing an air-fuel mixture, the width of the open upstream end of said enclosure being such as to extend beyond said hub structure to receive such air-fuel mixture adapted to flow through spaces between spokes, and the rear downstream end of said enclosure being provided with a fluid escape opening of lesser diameter than its front upstream opening, and ignition means in said enclosure.

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