

May 20, 1958

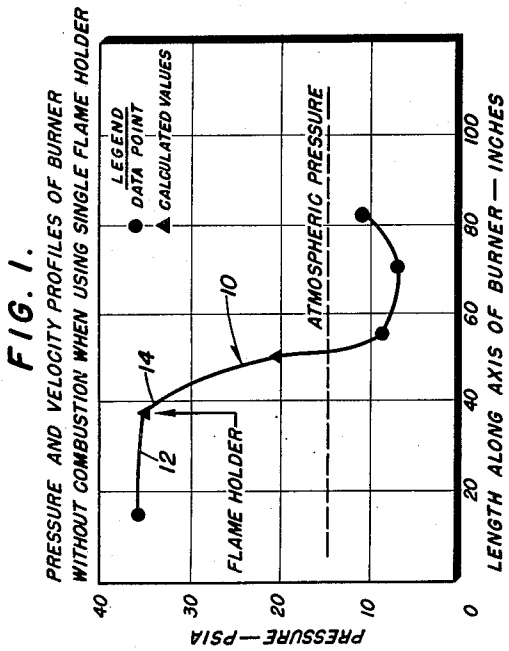
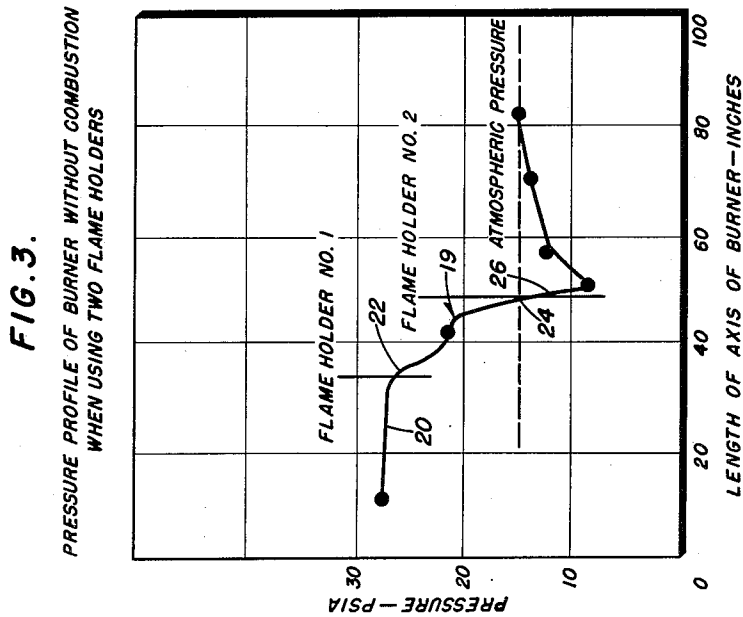
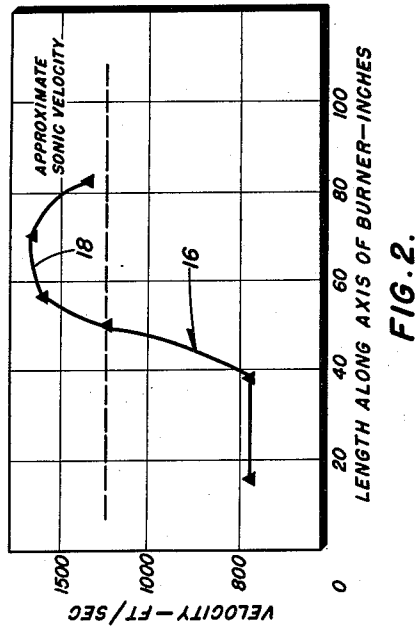
J. P. LONGWELL

2,835,109

IGNITER FOR RAM-JET

Filed July 17, 1952

3 Sheets-Sheet 1



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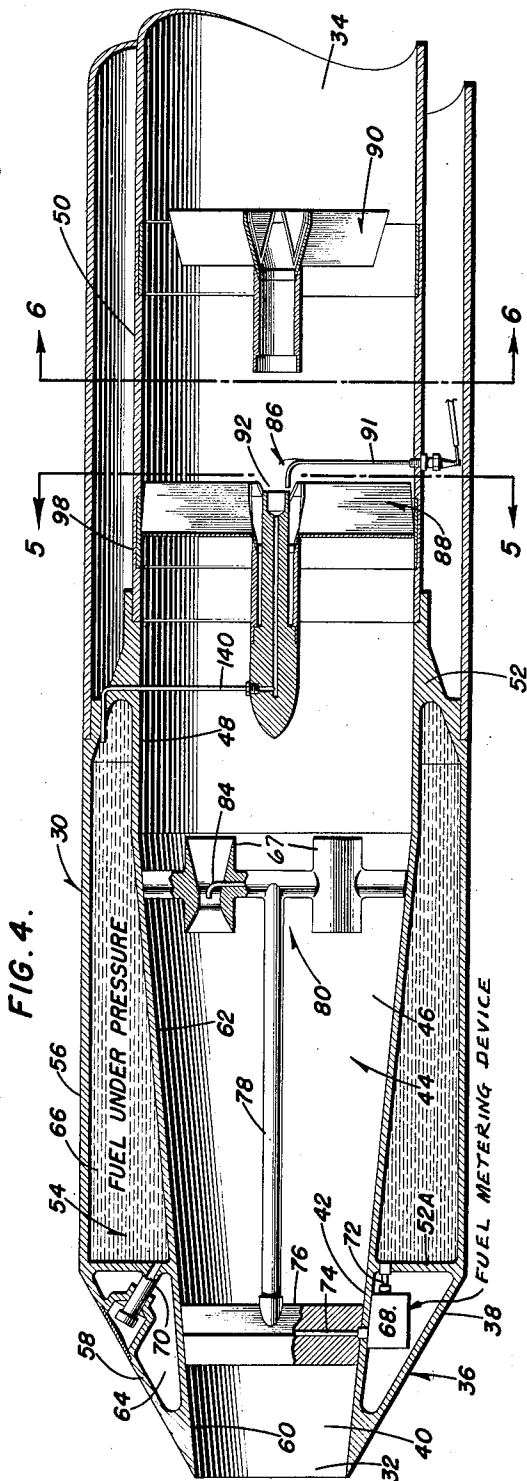
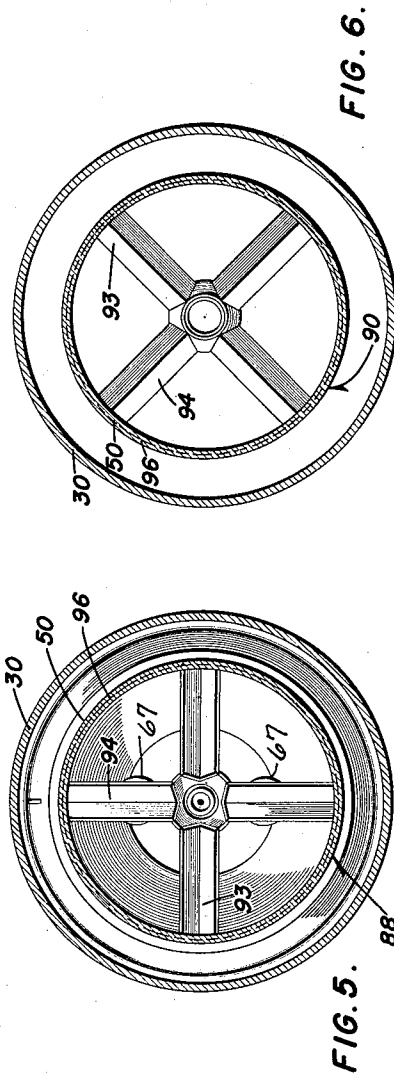
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3 Sheets-Sheet 2



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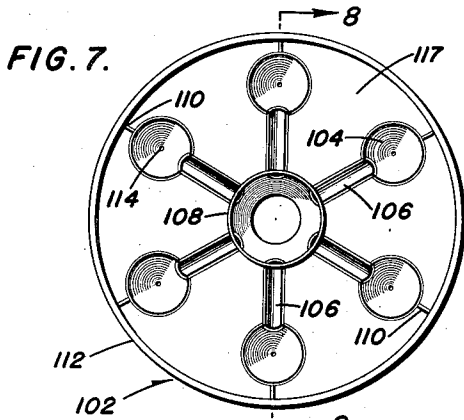
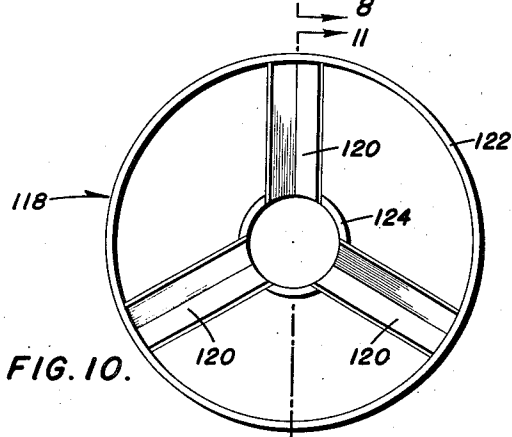
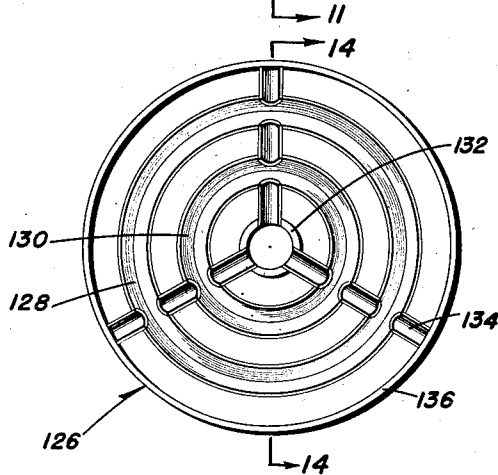
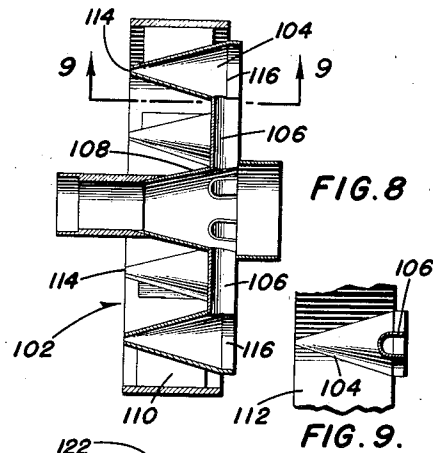
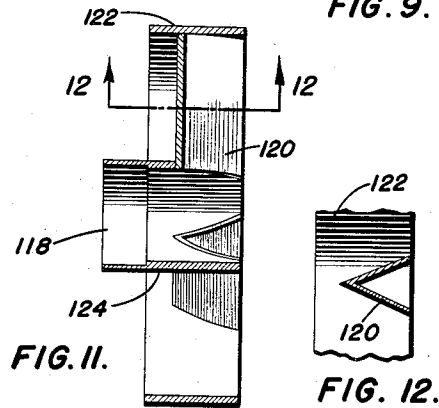
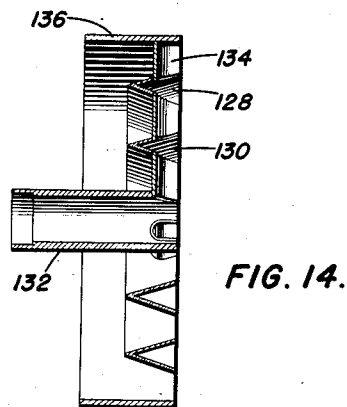
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3 Sheets-Sheet 3



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2,835,109

IGNITER FOR RAM-JET

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10 Claims. (Cl. 60—39.72)

This invention relates generally to aerial missiles, and in particular it pertains to an igniter arrangement for use in supersonic ram-jet engines.

In the launching and starting of a supersonic ram-jet engine, the original ignition of the fuel mixture in the combustor must generally take place while the air is flowing through the combustor at a high rate. In order to ignite the fuel mixture, baffles are placed in a single flame holder in the combustor to create a low velocity zone where the ignition flame will not blow out. It has been observed, however, that these baffles act as a nozzle, and that very low pressures occur downstream from the baffles. Ignition under these conditions, therefore, is extremely difficult. In addition, large pilot flames are necessary to reliably ignite a fuel mixture at high flight velocities.

Accordingly, one of the principal objects of this invention is to provide an igniter arrangement in which ignition is easily obtained at extremely high air rates with a small source of ignition.

Another principal object of the invention is to provide an igniter arrangement which aids materially in the initiation and continuation of combustion of the fuel mixture during the flight of the missile.

To provide an ignition system for a ram-jet combustor which utilizes a plurality of axially and laterally displaced pilot baffles for aiding in combustion of the fuel mixture, is also one of the features of the present invention.

And another object of the invention is to provide an igniter arrangement which is economical to manufacture, reliable and efficient in operation, and easy to install.

Other objects and many of the attendant advantages of this invention will be more fully appreciated as the same becomes understood from the following description and claims, and by reference to the accompanying drawings.

Briefly, the invention provides an igniter arrangement for the initiation of combustion of the fuel mixture. The igniter arrangement consists essentially of two flame holders arranged in series in a combustor and each having a set of baffles. These flame holders, for best operating performance, are arranged from five (5) to twenty-four (24) inches apart. The primary source of ignition is in the upstream flame holder. The flame that is generated in the upstream flame holder is of sufficient intensity to pass through the low pressure region further downstream from the downstream flame holder, and successful ignition is, therefore, obtained. By means of this igniter arrangement, ignition is easily obtained at high air rates with a small source of ignition, such as a spark.

In the drawings:

Fig. 1 illustrates a pressure curve for a burner without combustion when using a single flame holder;

Fig. 2 illustrates the velocity curve for a burner without combustion when using a single flame holder;

Fig. 3 illustrates a pressure curve for a burner without combustion when using two flame holders;

Fig. 4 is a fragmentary view of a ram-jet engine, incorporating one embodiment of the invention;

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Fig. 5 is a cross-section on line 5—5 of Fig. 4;

Fig. 6 is a cross-section on the line 6—6 of Fig. 4;

Fig. 7 is an end view of a modified embodiment of the invention;

Fig. 8 is a cross-section on the line 8—8 of Fig. 7;

Fig. 9 is a detail section on the line 9—9 of Fig. 8;

Fig. 10 is an end view of another modification of the invention;

Fig. 11 is a sectional view on the line 11—11 of Fig. 10;

Fig. 12 is a detail section on the line 12—12 of Fig. 11;

Fig. 13 is an end view of still another modified embodiment of the invention; and

Fig. 14 is a section on the line 14—14 of Fig. 13.

In order to solve the problem presented, namely that of initiating and continuing combustion of a fuel mixture in the combustor of a ram-jet engine, numerous pressure and ignition studies have been made which amply demonstrate that igniting a fuel mixture in a combustor containing a single flame holder is extremely difficult at high air rates.

Actual measurements of pressures without combustion of the fuel mixture in the combustor have been made using a V-gutter type of flame holder. This data has been plotted in Fig. 1, which shows a typical curve 10 of absolute pressure as a function of distance along the combustor. This study, which was made at an air flow of eleven (11) pounds per second in a 6 inch diameter combustor, shows that the pressure is well above atmospheric, as indicated by 12, upstream from a flame holder normally located at a distance along the axis of the combustor corresponding to point 14. Immediately downstream from the flame holder, the pressure drops below atmospheric and continues in this condition for some distance along the tailpipe of the combustor.

Referring now to Fig. 2, there is shown a velocity curve 16 corresponding to the pressure curve 10 in Fig. 1. This curve 16 shows the velocity conditions existing in the combustor. A careful study of the curve reveals that the velocity downstream from the flame holder is above sonic, as indicated by 18. From this, therefore, it can be concluded that the flame holder apparently acts as a supersonic nozzle.

The instant invention has been provided in order to make it possible to initiate ignition in a zone of higher pressure. This is accomplished by providing a combustor having at least two flame holders in series with the point of ignition in the central cavity of the upstream flame holder.

A typical curve 19 of pressure as a function of distance along the axis of the combustor for such an arrangement is shown in Fig. 3. It can be seen that the pressure is above atmospheric in the region of 20 between the two flame holders normally located in the general regions 22 and 24 along the combustor, and that it drops below atmospheric, as indicated by 26, downstream from the downstream flame holder. A spark placed in the center of the upstream flame holder gives reliable ignition at an air rate of 11 pounds per second while with a single flame holder, such as mentioned for Figs. 1 and 2, ignition cannot be obtained at this air rate even with large heat inputs from a pilot flame. With this type of combustor, that is, one having two flame holders arranged in series, the spark is not needed once combustion has been established.

Reference is now made to the drawings for a more detailed description of the invention. In Fig. 4, there is shown the elongated tubular body of a ram-jet engine or motor, indicated generally by 30. The ram-jet engine is usually a part of an aerial missile or the like; however, it is not limited to this particular application. Body 30 is usually formed of a heavy gauge sheet metal, and is open at both ends, as at 32 and 34.

The forward end 32 of body 30 is partially enclosed

by a nose assembly section 36, which includes a nose or ogive 38 of plastic or metal. Section 36 can be formed integral with tubular body 30 as shown, or can be separately attached by annular flanges.

Ogive section 36 is formed with a central passage 40, and also has its rear end 42 communicating with a frusto-conical diffuser section 44, which, likewise, has a frusto-conical passage 46 formed therein for the diffusion of the incoming air stream. Diffuser section 44 has its downstream end 48 attached to a tailpipe section 50 and the tubular body 30 by means of an annular flange 52. The forward portion of tailpipe section 50 is used as a mixing zone for the air and fuel, while the rear portion includes a combustion chamber for burning of the fuel mixture. At the aft portion of tailpipe section 50, there is located an exit nozzle for expansion of the gases liberated during the burning of the fuel mixture.

A partition wall 52A divides an annular cavity 54 between walls 56, 58, 60, and 62 into two sections 64 and 66. Section 64 is used to house a fuel metering device 68 while in section 66 there is stored a liquid fuel, such as kerosene or the like, for the ram-jet engine. Liquid is placed in chamber section 66 through a passageway 70, and it is placed under pressure by conventional means.

The fuel passes from fuel chamber 66 to metering device 68 through a passageway 72, where it is metered. The metered fuel then flows through a passageway 74 located in a support strut 76 and passageway 78 to a fuel injection nozzle arrangement 80, located usually near the exit 48 of the diffuser section 44. The fuel is then injected into the air stream passing from diffuser section 44 by means of injection nozzles 84 contained in the nozzle arrangement 80. In addition, a suitable mounted venturi is provided for each nozzle 84. The nozzles 84 are arranged to inject the fuel at the throats of the venturi 67 in a direction contra to the airstreams which are flowing through the venturis. These venturis are provided in order that a more uniform distribution is obtained of the fuel and air which will improve the combustion efficiency of the system. The fuel mixture is ignited further downstream by means of an igniter arrangement 86.

This igniter arrangement 86, to which this invention is particularly directed, consists of a series of at least two flame holders, that is, an upstream flame holder 88 and a downstream flame holder 90, which are separated from each other by a distance ranging from five (5) to twenty-four (24) inches, depending upon the characteristics of the ram-jet combustor, nozzle injection arrangement, and other factors.

It is the purpose of these flame holders 88 and 90, as previously pointed out, to assist in the original initiation and continuation of combustion of the fuel mixture at high air rates, with a small source of ignition, such as spark igniter 91. This spark igniter 91, is located in small cavity 92.

These flame holders can be of various types, as shown by the embodiments in Figs. 5 through 14. Figs. 5 and 6, for instance, show one embodiment of the flame holders 88 and 90, of Fig. 1, in which the baffles 93 and 94 are arranged in the form of a cross. These baffles 93 and 94 extend from an annular flange ring 96, which is removably attached at 98 in tailpipe section 50. These baffles can be of any general shape, but they are preferably formed of channel or V-shaped gutter members, as shown. The baffles of the flame holders 90 are usually not in alignment with the baffles of the flame holder 88. This is necessary in order to prevent melting of the baffles. It is desirable, however, that there be some contact of the flame from the upstream baffles with the downstream baffles. The baffles can be out of alignment from 0° to 45°; however, it is preferable to have them out of alignment from 5° to 10°.

Another embodiment of a flame holder is shown at 102 in Figs. 7, 8, and 9. Flame holder 102 is often

referred to as of the cone-shaped type. It consists of a series of baffles arranged in the form of cones 104 and radial or V-shaped gutters 106, which radiate from a central support member 108. Cones 104 are further supported by members 110 which are attached to an annular flange 112. The upstream ends of cones 104 have small central openings 114, while the downstream ends 116 are completely open. The air-fuel mixture flows between the cones 104 and gutters 106.

Still another embodiment of flame holder is illustrated at 118 in Figs. 10, 11, and 12. Flame holder 118 is referred to as the V-gutter type or Y type. It is constructed quite similar to the flame holders 88 and 90, in that it consists of three legs or V-shaped gutter members 120 mounted between an annular flange 122 and a central member 124.

In Figs. 13 and 14, there is shown still another embodiment of flame holder 126, known as the annular type. It consists of a number U or V-shaped annular baffles 128 and 130 mounted about a central member 132 and supported by U or V-shaped gutters 134. These gutters 134 are, in turn, supported at their ends by central member 132 and annular flange 136.

In operation, an aerial missile having a ram-jet engine with the igniter arrangement, mounted in the combustor, and a launching carriage, is launched by said carriage from a platform or the like (all of which are not shown in the drawings). At a certain point along the trajectory, the launching carriage will have spent its power and will separate from the aerial missile. The ram-jet engine will then furnish the source of power for the missile.

Unmetered fuel from fuel chamber section 66 passes through passageway 72 to metering device 68, and thence through passageways 74 and 78 to fuel injection nozzles 84 by which it is injected into the air stream flowing from diffuser section 44.

The fuel mixture is then swept past the upstream flame holder 88, where it is ignited by the remote controlled spark igniter 91, which gives a spark in a small cavity 92 located in upstream flame holder 88.

Liquid fuel, such as kerosene, from fuel chamber section 66 may in some engines be fed to cavity 92 through a passageway 140 to aid the spark igniter 91 in starting and maintaining combustion of the fuel mixture.

After ignition of the fuel mixture, the flame generated at the upstream flame holder 88 is of sufficient intensity to pass through the low pressure zone downstream from the flame holder 90. Successful ignition of the fuel mixture is, therefore, obtained. As previously indicated, the other embodiments of the flame holders shown in Figs. 7 through 14 can be utilized in lieu of the flame holders shown in Figs. 4, 5, and 6.

The gases generated by the burning of the fuel mixture in the combustor are then expanded through the exit nozzle in the rear portion of tailpipe section 50 at a greater velocity than the entering stream of air, and are thus utilized to power the missile on its course.

In a general manner, while there has been disclosed what are deemed to be practical and efficient embodiments of the invention, it should be well understood that the invention is not to be limited thereto, as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle and spirit of the present invention as comprehended within the scope of the appended claims.

What is claimed is:

1. In combination, an aerial missile having a body in the form of an elongated tubular duct, a diffuser in said duct, a pressurized fuel source having a fuel chamber in said body, nozzle means connected with said fuel chamber and communicating with said duct, a venturi for said nozzle means and igniter means in said duct, said igniter means including at least an upstream flame holder and a downstream flame holder, with a source of ignition in said upstream flame holder, said nozzle means being

spaced upstream from said igniter means and arranged to inject fuel into an airstream passing through said venturi at the throat thereof in a direction contra to the flow of said airstream therethrough.

2. An arrangement as set forth in claim 1, wherein said flame holders include baffle members arranged in the form of a cross.

3. An arrangement as set forth in claim 1, wherein said flame holders include conical-shaped baffle members located at the end portions of radial gutters.

4. An arrangement as set forth in claim 1, wherein said flame holders include baffle members arranged in the form of a Y.

5. An arrangement as set forth in claim 1, wherein said flame holders include annular-shaped baffle members.

6. An arrangement as set forth in claim 1, wherein said flame holders are separated by a distance ranging from 5" to 24" such that a flame generated at the upstream baffle is of sufficient intensity to pass through the low pressure zone downstream from the downstream baffle, whereby successful ignition is obtained.

7. In combination, a projectile having a body in the form of an elongated tubular duct, a frusto-conical diffuser in said duct, a pressurized fuel source having a fuel chamber in said body, nozzle means associated with said fuel chamber and communicating with said duct, a venturi for said nozzle means and an igniter means including at least an upstream flame holder assembly and a downstream flame holder assembly for aiding in the initiation

and sustaining of combustion of the fuel mixture, with a source of ignition located in said upstream flame holder assembly, said igniter means being spaced downstream from said nozzle means, said nozzle means being arranged to inject fuel into an airstream passing through said venturi at the throat thereof in a direction contra to the flow of said airstream therethrough.

8. An arrangement as set forth in claim 7, wherein said flame holders include baffle members arranged in the form of a cross.

9. An arrangement as set forth in claim 7, wherein said flame holders include conical-shaped baffle members located at end portions of radial gutters.

10. An arrangement as set forth in claim 7, wherein said flame holders include baffle members arranged in the form of a Y.

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