April 14, 1959 W. H. GOSS 2,881,588

INJECTOR AND METHOD FOR FUEL INJECTION

Filed April 27, 1948 2 Sheets-Sheet 1

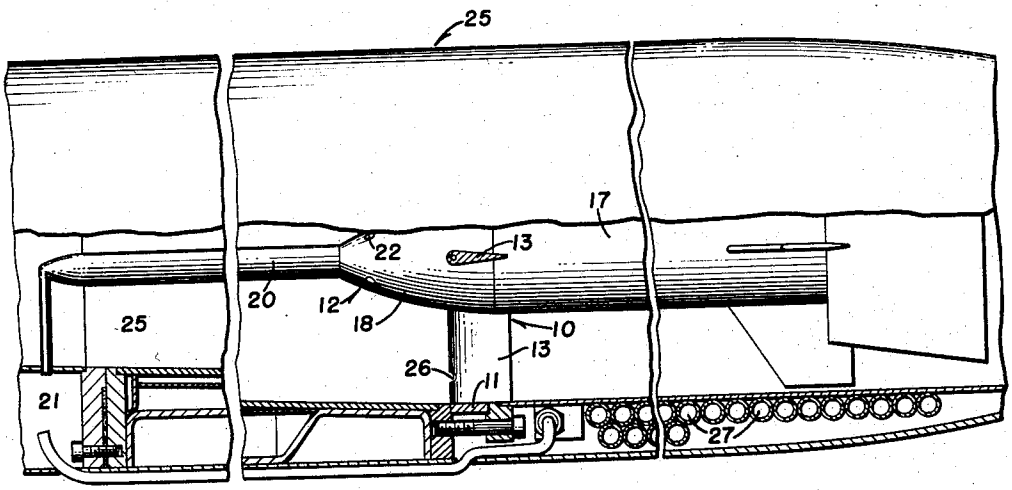


FIG. 1

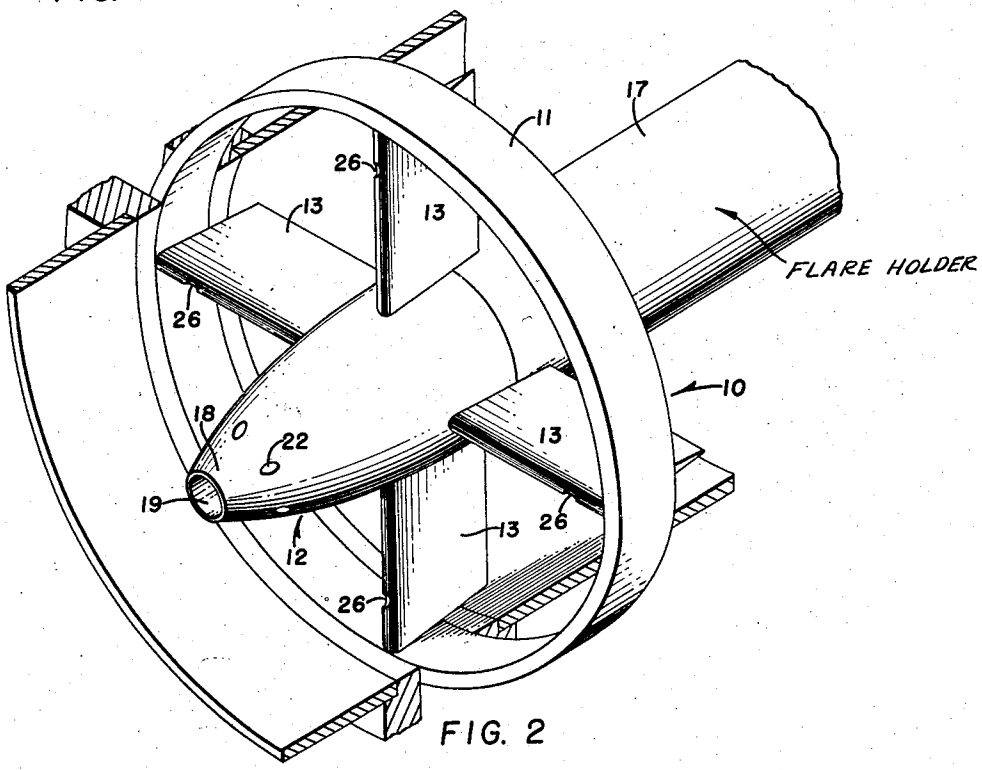


FIG. 2

INVENTOR.
WILBUR H. GOSS
BY D. O'Brien

ATTORNEY

April 14, 1959 W. H. GOSS 2,881,588

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Filed April 27, 1948 2 Sheets-Sheet 2

FIG. 3

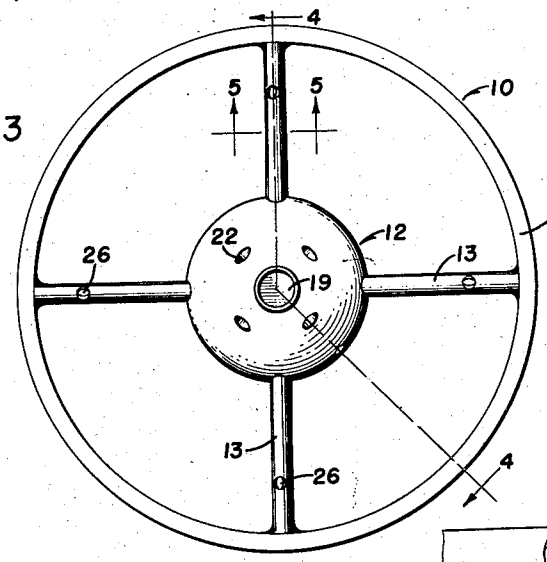
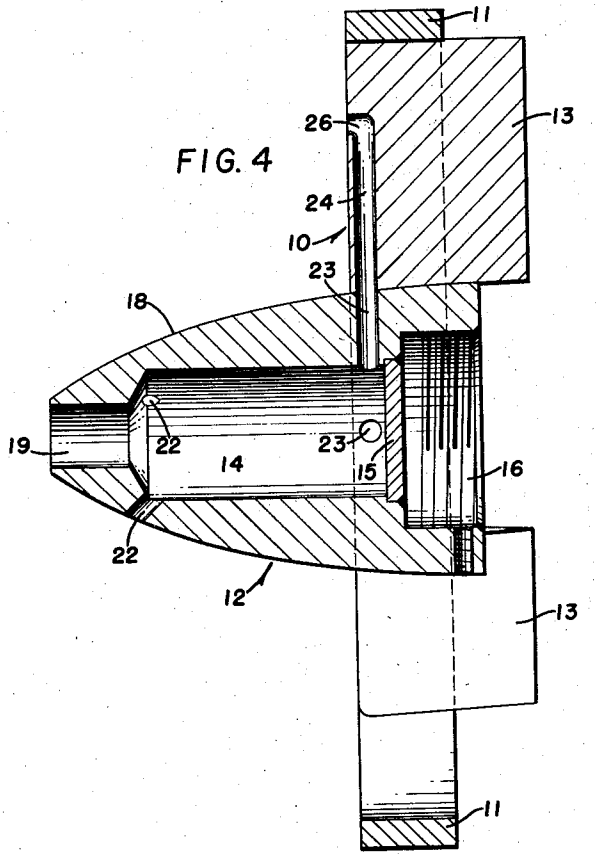


FIG. 4



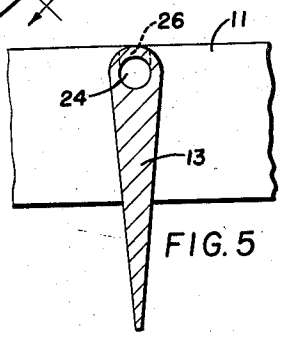


FIG. 5

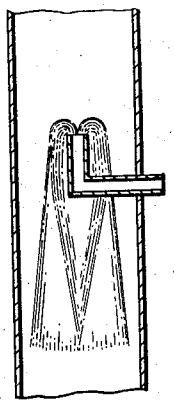


FIG. 7

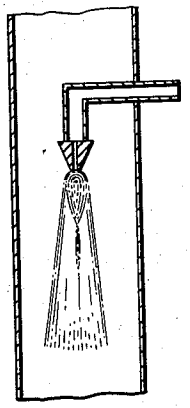


FIG. 6

INVENTOR.
WILBUR H. GOSS
BY G. D. O'Brien

ATTORNEY

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INJECTOR AND METHOD FOR FUEL INJECTION

Wilbur H. Goss, Silver Spring, Md., assignor to the United States of America as represented by the Secretary of the Navy

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3 Claims. (Cl. 60—39.74)

The present invention relates generally to the art of guided missiles of the ram-jet type, and more particularly to an improved injector and method for fuel injection.

In down-stream and trans-stream fuel injection systems for ram-jets in use up to the time of the present invention, the maintenance of the desired rate of fuel injection is made difficult by variations in the back pressure against which the fuel is injected. Moreover, fuel injection lateral to the air stream or parallel thereto is subject to wide variations in static pressures. This is particularly disadvantageous, for example, when the burning efficiency in the combustion chamber of the missile momentarily decreases, immediately lowering the static pressure and thus introducing a transient pressure disturbance in the fuel system.

Another disadvantage for down-stream and trans-stream fuel injection systems is their requirement for high pressure atomizing nozzles which often clog with dirt and become inoperative.

One of the principal objects of the present invention, therefore, is to provide a fuel injector and method of fuel injection wherein, by utilizing the differential velocity between an air stream passing through the missile and a stream of fuel injected against said stream, substantially complete fuel atomization will be effected, so that optimum fuel burning in the combustion chamber will take place and maximum thrust by the missile therefore produced.

Another object of the invention resides in the provision, in a fuel injection method and apparatus for ram-jet missiles, of simple orifices having relatively large exit areas opening against the air stream, with the result that the need for high pressure atomizing nozzles will be obviated and that clogging by dirt or other foreign matter will be eliminated.

And a further object of the invention is to provide a fuel injector and injection method for the purpose set forth wherein maximum area distribution of fuel (penetration of fuel lateral to the air stream) will be effected.

Other objects of the invention will appear from a reading of the following description.

In the drawings:

Fig. 1 is a side elevation, partly in section and partly broken away, showing a fuel injector according to the present invention as it would appear installed in a missile;

Fig. 2 is a perspective view of the injector, a portion of the missile being shown fragmentarily;

Fig. 3 is a front elevation of the injector;

Fig. 4 is an axial section on the line 4—4 of Fig. 3;

Fig. 5 is a detail section on the line 5—5 of Fig. 3;

Fig. 6 is a diagrammatic view showning the pattern of fuel discharged from a nozzle of the type in use up to the time of the present invention; and

Fig. 7 is a diagrammatic view showing the improved pattern of fuel discharge in a ram-jet missile equipped according to the present invention.

Considered briefly, the fuel injection method, according to the present invention contemplates introducing fuel into a ram-jet missile, through simple, relatively large orifices, against, rather than across or along, the stream of air passing through the missile to mix therewith to form a substantially completely atomized combustible mixture. The apparatus consists of an injector which is placed in the ram jet missile near the mid portion thereof and with the windshield employed disposed toward the forward end of the missile. Fuel under pressure is led from an annular tank in the missile to a fuel chamber formed in the windshield and led to orifices in radially disposed struts for discharge from the leading edges thereof. The combustible mixture produced by the admixture of the fuel and air is ignited by a burning flare carried on and forming a part of the igniter.

Referring to the drawings in detail, the injector of the invention is indicated generally by the numeral **10**. The injector **10** includes a ring **11**, a windshield **12** and faired struts **13** connecting the windshield and ring. The ring, windshield and struts are interconnected by welding so as to provide a rigid, unitary structure, and said ring is clamped in place for mounting the injector in the combustion chamber of a ram jet missile. More specifically, the ring **11** is clamped between the adjacent ends of the inner body sections of the missile by cooperating flanges and tie bolts, as best seen in Fig. 1. The struts **13** are shown as being four in number but it should be understood that a greater or smaller number may be used, as desired.

As best seen in Fig. 4, the windshield **12** is formed with a chamber **14** which is closed at its rear end by a wall **15**, welded in place in an annular groove. The wall of the windshield is provided, rearwardly of the wall **15**, with an enlarged, internally threaded socket **16** to receive the threaded neck of a flare holder **17** (see Fig. 2). Flare holder **17** houses a suitable flare for igniting the air-fuel mixture.

The windshield is formed with a tapered nose **18** hav- a relatively large, axially located fuel inlet **19**, which communicates with the chamber **14**. As seen in Fig. 1, a fuel inlet pipe **20** is fitted in the inlet **19** of the nose **18** and supplies fuel to the chamber **14** from a tank **21**. Obliquely disposed orifices **22** are formed in the tapered nose **18**, near its forward end, said orifices being arranged in an annularly spaced series, and communicating with the chamber **14**. Four of the orifices are shown but it should be understood that a greater or smaller number may be provided, as needed.

Openings **23** are formed in the side wall of the windshield **12** near the wall **15** and register with bores **24** in the struts **13** near and parallel to their leading edges. The bores **24** extend radially throughout substantially three-fourths of the lengths of the struts and terminate at their outer ends in forwardly (upstream) presented discharge orifices **26** which communicate with the interior of the projectile.

In operation, fuel is supplied to the chamber **14** through the pipe **20** from the tank **21**. A pressure system, which includes a helical compressed gas storage tank **27**, insures optimum fuel flow from the tank **21**. The pressure system forms no part of the present invention. Fuel is discharged against the airstream flowing through the duct of the missile **25**, through the orifices **22** and **26**, and is mixed with air in said stream to provide a combustible mixture for ignition by the flare holder **17**.

Reference is now had to Figs. 6 and 7. Fig. 6 discloses diagrammatically a fuel injection system as arranged prior to the present invention. Fuel is injected downstream by an injection nozzle, in a cone of relatively small diameter, with the result that sufficient fuel atomization and vaporization will not take place without

the use of high pressure atomizing nozzles. Moreover, transient pressure disturbances in the fuel system are introduced, by momentary decreases in combustion efficiency in the combustion chamber, which lower the static pressure.

By injecting fuel against the stagnation pressure in the duct of the missile, as shown diagrammatically in Fig. 7, variations in back pressure are considerably minimized, since the total (stagnation) pressure, in the case of air flow in ram-jet projectiles, remains nearly constant even though there may be wide variations in static pressures. Attention is called to the fact that area distribution of fuel (penetration of fuel lateral to the air stream) at any point downstream of the injector is broader with the arrangement shown in Fig. 7 than with that shown in Fig. 6, and the need for high pressure injection nozzles, with their need for frequent cleaning, is obviated. Moreover, the need for apparatus required to generate the pressures necessary for the operation of high pressure atomizing nozzles, which apparatus is cumbersome and space consuming, will be dispensed with.

While there has been shown and described what is at present considered to be a preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the true scope thereof, and it is, accordingly, intended in the appended claims to cover all such changes and modifications as fall within the true scope of the invention and without the proper scope of the prior art.

What is claimed is:

1. In a guided missile of the ram-jet type having an air stream flowing therethrough when in flight; in combination, a fuel injector having a chambered windshield and at least one apertured strut, means for conducting fuel to the windshield for discharge therefrom and from the strut in a direction contra to said air stream flow, and

means for mounting the windshield, the leading edge of said strut confronting said air stream flow whereby fuel discharging from said windshield and strut contra to said air stream flow will entirely mix with said air stream to produce a uniform combustible mixture.

2. A fuel injector for a ram-jet aerial missile having air flow therethrough when in flight, comprising a frame having a flare holder, a windshield connected to said flare holder, a supporting ring, struts connecting said windshield and flare holder to said ring, said windshield and said struts having fuel discharge jets for injecting liquid fuel in a direction contra to said air flow in said missile, and means for conducting fuel to said jets for discharge therefrom into and against said air flow through said missile.

3. A fuel injector for a ram-jet aerial missile having an air stream flowing therethrough when in flight, comprising, a body having a frame comprising a ring, a hollow windshield, hollow struts connecting said ring with said windshield and having fuel discharge jets disposed toward the air stream inlet end of said missile, and a manifold for leading fuel to said struts and windshield, whereby said fuel is injected into said air stream in a direction contra to the direction of flow of said air stream.

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