Aug. 23, 1955 F. T. HOLMES ET AL 2,715,813

FUEL INJECTOR AND FLAME HOLDER

Filed April 14, 1952 3 Sheets-Sheet 1

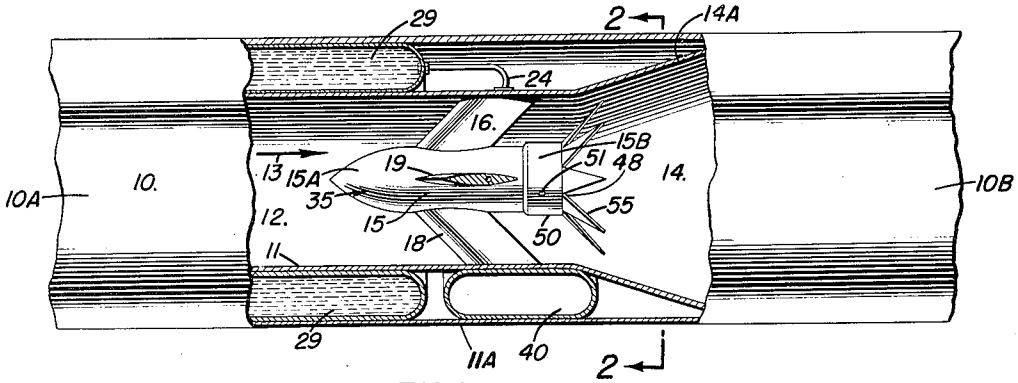


FIG. 1

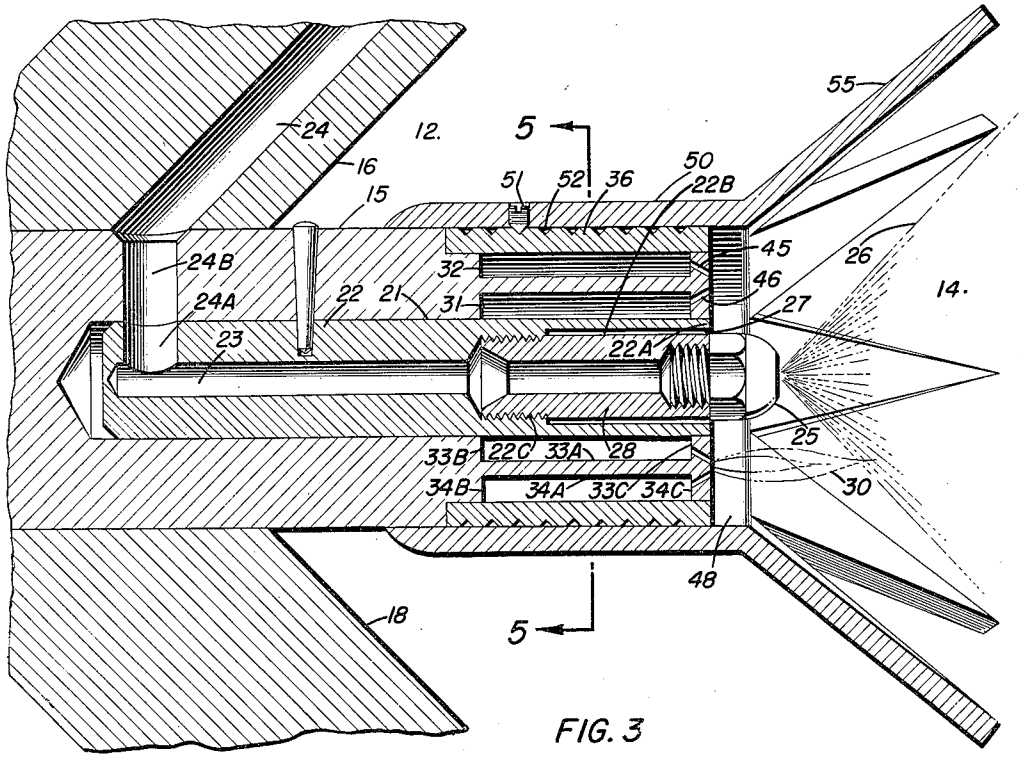


FIG. 3

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FUEL INJECTOR AND FLAME HOLDER

Filed April 14, 1952 3 Sheets-Sheet 2

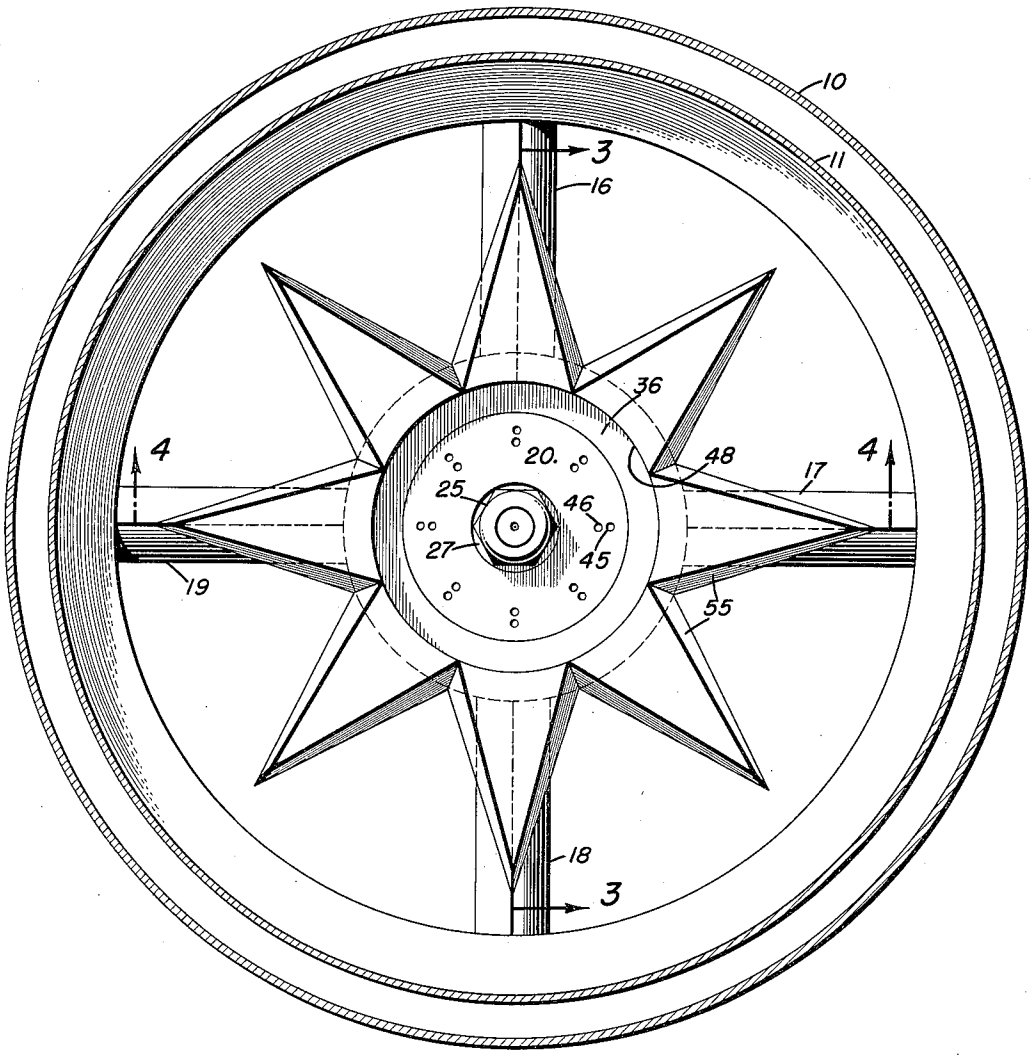


FIG. 2

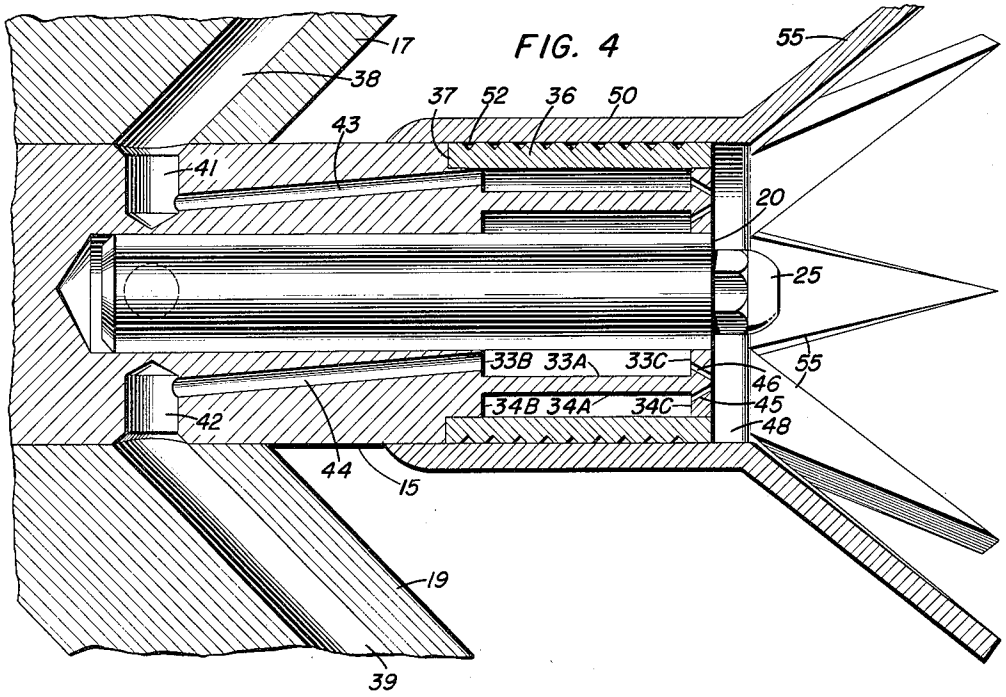
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FIG. 4



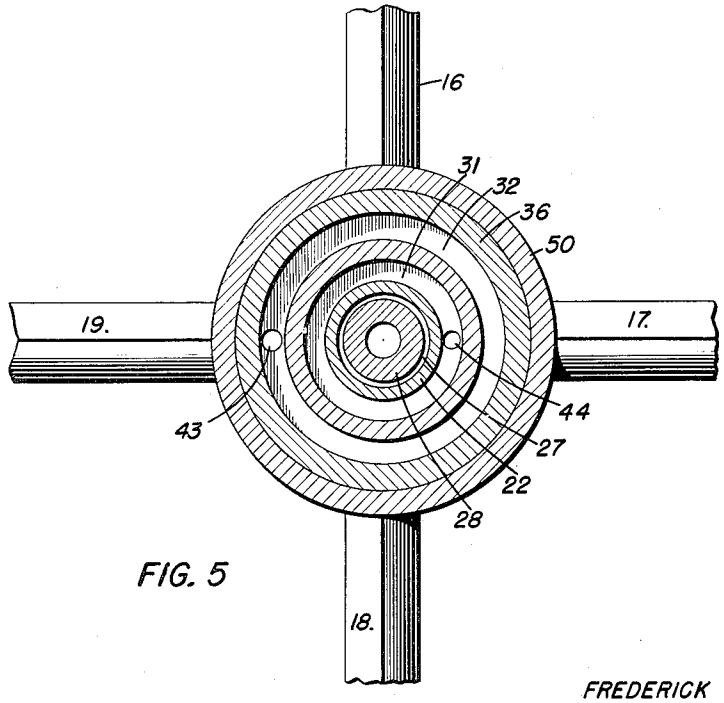


FIG. 5

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FUEL INJECTOR AND FLAME HOLDER

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11 Claims. (Cl. 60—35.6)

This invention relates generally to aerial missiles. More particularly, the invention relates to burner assemblies for controlling the combustion of air fuel mixtures in ramjet engines.

In the operation of ramjet engines, such as used with certain types of aerial missiles, it has been found desirable to have a constant application of driving energy or thrust in order that optimum range and accuracy can be obtained. It is, therefore, desirable that the driving energy be brought about by a smoothly-burning, constantly-ignited air fuel mixture which produces a substantially constant or at least a smoothly varying application of driving energy or thrust.

One of the major disadvantages heretofore found in the operation of ramjet engines has been a condition of improper burning commonly known as "rough burning." Burning of this type is unsteady, irregular and variable. This type of undesirable burning results in bursts or rapidly varying applications of energy so that improper as well as inadequate thrust forces occur.

It is believed that the rough burning referred to, strangely enough, results from a smooth flow of the fuel mixture. When such rough burning occurs, the flame is not uniformly propagated and large quantities of uncombusted fuel mixture accumulate and then burn with explosive violence. This violent burning may result not only in an uneven application of driving or thrust force, but also, in some instances, it may damage the aerial missile itself.

Experimental investigations have indicated that smooth burning can best be obtained by providing turbulent flow of the air-fuel mixture at the point where ignition occurs. This type of flow gives a thorough mixing of the air and fuel, and thus effects rapid propagation of the flame.

Accordingly, it is one of the objects of this invention to provide a highly efficient burner assembly for use in a ramjet engine.

Another feature of the invention is to provide an improved device for directing a flame into a combustible fuel mixture in a ramjet engine.

Still another object of the invention is to provide an igniter arrangement for constant ignition of fuel mixtures in ramjet engines.

To provide an injector arrangement for maintaining a fuel mixture flow adjacent an igniter arrangement, is also another object of the invention.

A further object of the invention is to provide an igniter arrangement, including a shield, for maintaining low turbulence flow of the air fuel mixture adjacent an igniter flame.

Other objects and many of the attendant advantages of this invention will be appreciated readily as the same becomes understood by reference to the following detailed description when considered in connection with the accompanying drawing, and in which:

Fig. 1 is a fragmentary view partially in elevation of a ramjet engine, embodying the improved burner assembly;

Fig. 2 is an enlarged cross-section on the line 2—2 of Fig. 1;

Fig. 3 is an axial-section on the line 3—3 of Fig. 2;

Fig. 4 is an axial-section on the line 4—4 of Fig. 2; and

Fig. 5 is a cross-section on the line 5—5 of Fig. 3.

In the design of ramjet engines and the like, it is necessary to determine the best relative positions of the pilot flames for the fuel used, the main fuel nozzle arrangement, and the fuel distributing vanes in order to create burning conditions which avoid the formation of large volumes of unburned fuel mixtures. Unburned fuel has a tendency to burn backward explosively when ignited, and this results in uneven burning and possible damage or destruction of portions of ramjet engines.

In order to overcome these disadvantages and also to effect smooth burning in the combustor of a ramjet engine, igniting or pilot flames have been provided which burn at a constant rate. These igniting or pilot flames are placed in a comparatively quiet area, but in close proximity to the intermingling fuel and air. Structurally, the smooth burning is accomplished by the use of a novel flame holder, which is preferably in the form of a flared baffle arrangement. This baffle arrangement includes baffle wings or rake fingers, which cause the air and fuel streams to mingle or uniformly mix, and, in addition, provide surfaces for directing the igniting flames into the fuel mixture.

The preferred embodiment of the invention is best illustrated in the drawing of Fig. 1, which shows a ramjet engine, generally designated by reference numeral **10**. This ramjet engine is usually a part of an aerial missile, and it has its body in the form of an elongated tubular duct which is open at both ends **10A** and **10B**. In the forward portion of the ramjet engine, there is located a diffuser usually of the frusto-conical type. This diffuser, which is commonly referred to as a ram channel, such as **12**, delivers air in a substantially constant stream, as indicated by arrow **13**, into a combustion chamber or combustor **14**.

This combustor **14** is located in the tailpipe section **14A** of the ramjet engine. In the forward portion of the tailpipe section **14A**, the air and burner fuel are mixed together and are then ignited and burned, and in the aft portion of the tailpipe section, there is provided a nozzle arrangement (not shown) through which the generated or liberated gases escape at a higher velocity than the entering air stream to give the necessary thrust or driving energy for moving the aerial missile along its trajectory.

The combustion of the air fuel mixture is controlled by a burner arrangement or assembly **35** which is located in the ram channel **12** adjacent the upstream or forward end of the combustor **14** in tailpipe section **14A**.

This burner assembly **35** includes a substantially cylindrical body **15** which is anchored to the wall **11** of the ramjet engine by means of four strut members **16**, **17**, **18** and **19**. The forward or upstream end **15A** of the body **15** is of ogival contour. The rearward or downstream end **15B** of body **15** is constructed with a substantially flat burner face **20**, as shown best in Fig. 4. This burner face **20** is located at the forward or upstream end of the combustion chamber or tailpipe section **14**.

As shown in Fig. 3, body **15** is provided with an axial bore **21** for the reception of a fuel injector **22**. This fuel injector **22** is used for distributing fuel into the combustion chamber **14**. Injector **22** fits snugly into bore **21**. This injector **22** is provided with an axial fuel passageway or conduit **23**. The conduit **23** communicates

with another passageway, such as a pipe **24**, located in the strut member **16** through inlet passages **24A** and **24B** in the injector **22** and body **15**, respectively, for supplying liquid fuel to the burner, such as kerosene or heptane, from a tank **29** located between inner wall **11** and outer wall **11A** of the ramjet engine **10**. This is best illustrated in Figs. 1 and 3. The outer or downstream end **22A** of the injector **22** terminates substantially flush with the burner face **20**. Injector **22** is counter-bored in end portion **22A** to form a bore **22B** so as to provide an air jacket **27** between a nozzle **25** and the burner face **20**. The surface of bore **22B** is internally threaded, as shown at **22C**. Nozzle **25** is connected to the injector **22** by means of a nipple **28** which is screwed into the internally threaded portion **22C** of bore **22B**. This is necessary so that nozzle **25** will be in communication with fuel conduit **23**. Various lengths of nipples may be utilized for adjusting the position of the nozzle **25** with respect to the burner face **20** for different types or amounts of fuel or for various burner conditions.

The burner fuel, such as kerosene or heptane, from tank **29** is delivered through passageways **24**, **24A**, **24B**, and **23** to nozzle **25**. This nozzle **25**, in turn, injects the fuel into combustion chamber **14** usually in a conical spray, although other types of sprays can be utilized. The injected fuel is ignited by a number of pilot flames **30** arranged in a spaced annular series about the injector **22**.

These pilot flames **30** are preferably of the self-sustaining type, that is, the flames **30** are fed by a mixture composed of a plurality of constituents. This mixture, when once ignited, will continue to burn, that is, it is self-sustaining. For example, such mixtures as (1) acetylene and oxygen, (2) hydrogen and air, and (3) chlorine and certain hydrocarbons, where one constitutent is the pilot fuel and the other a supporting medium, have been found to be highly satisfactory.

In order to have effective ignition flames, a plurality of manifolds, such as **31** and **32**, are formed in the body **15** adjacent the burner face **20**, as shown in Figs. 3 and 4. These manifolds or cavities **31** and **32** are preferably formed by machining annular cavities or chambers in the body **15**. These cavities are shown as concentrically arranged, with the innermost cavity **31** being formed adjacent the central or axial bore **21** for injector **22**, while manifold cavity **32** is adjacent the exterior portion of the body **15**.

More specifically, the inner manifold cavity **31** is in the form of an annular groove, with wall surfaces **33A**, **33B**, and **33C** of fuel injector **22** and the exterior surface of the fuel injector **22**. The outer manifold cavity **32** is formed by an annular groove in body **15**, the outer wall of which is constituted by a sleeve **36** and wall surfaces **34A**, **34B**, and **34C** of fuel injector **22**. Sleeve **36** is applied over a cut-away portion **37** of body **15**, and is secured in any desired manner, such as welding, so as to become substantially integral therewith.

Preferably, various constituents, such as a pilot fuel and a supporting medium, as pointed out above, are introduced into the manifold cavities **31** and **32**, respectively, as just described through passageways or pipes **38** and **39**, as best shown in Fig. 4, in struts **17** and **19**. These passageways are connected to sources, such as **40**, which contain either the pilot fuel or the supporting medium. Passageways or pipes **38** and **39** are connected to suitable entrances **41** and **42** in the side of the body **15**. Between entrances **41** and **42** and manifold cavities **31** and **32** there are located suitable passageways **43** and **44**, such as bores within the body **15**. For simplicity, only two manifolds **31** and **32** are shown but obviously a larger number may be employed if it is desired to use more than two pilot fuel constituents.

Referring again to Fig. 3, a plurality of jet forming passageways **45** and **46**, hereinafter to be called orifices, are provided between each of the manifolds **31** and **32**, and the burner face **20** so that the constituents within the manifold cavities **31** and **32** can flow through orifices **45** and **46** to the burner face **20**.

For properly utilizing the various constituents for sustaining a flame, the orifices **45** and **46** are arranged in groups, herein shown as pairs, in which the orifices extending from the several manifolds **31** and **32** reach the burner face **20** in an arrangement so that the constituents flowing from the several manifolds **31** and **32** are commingled into a single stream. In the paired orifices shown, each pair of orifices **45** and **46** are inclined so that they converge at the burner face **20**, and the streams of constituents flowing through the separate manifolds **31** and **32** impinge to provide a single jet.

In order to maintain an optimum burning condition in the vicinity of the pilot flames **30**, a shield **48** is provided around the burner face and extending axially past the face **20** to provide a zone of comparative quiet where the pilot flames **30** will be substantially undisturbed by the flow of air through the ram channel or diffuser **12** or by the burner fuel flow from the injector **22**. The shield **48** is preferably constructed so as to have an annular tubular body portion **50** surrounding the body **15**, and extending past the burner face **20** thereof so that the shield **48**, aids in controlling the flow of air to the burner face **20**. A different length of shield **48** may be desired for different operating conditions. The tubular body portion **50** is shown in telescoping relation to the exterior surface of the body **15**, and is secured thereto by suitable means such as set screws **51** which may engage spaced sockets **52** in the lateral surface of the burner body **15**.

To assure a thorough mixing of burner fuel and air adjacent the forward or upstream region of the combustion chamber **14**, the shield **48** is further provided with rake fingers **55**, formed on the end of the tubular body portion **50**. These rake fingers **55** produce a turbulent flow of the air being delivered through the ram channel **12**, and, consequently, a rapid intermixing or commingling of the main burner fuel spray **26** and the air delivered by the ram channel **12**. The rake fingers **55** are in the form of segments of a conical shell. These fingers **55** also serve as flame holders in that they provide sheltered surfaces behind which the ignition flames **30** can linger, so that the flame is much more readily communicated to or propagated into the fuel mixture adjacent the forward end of the combustion chamber **14**. The maintenance of the constant igniter flames **30** adjacent the commingling surface of the air and fuel, and the utilization of the rake fingers **55** to carry the flame into proximity with the air fuel mixture, produces substantially constant combustion and therefore substantially constant delivery of propulsion energy to the ramjet device **10**.

To produce optimum shielding of the pilot flames **30** and to facilitate the communication of flame behind the flame holding rake fingers **55**, it is sometimes desirable to provide groups of the orifices **45** and **46**, corresponding in number to the number of rake fingers **55**, and to center each of the groups of orifices on the center line of its corresponding rake finger **55**.

Recapitulating, an aerial missile including a ramjet engine **10** and a launching carriage means such as rockets (not shown) or the like, is launched from a launching platform. After the launching carriage means has substantially spent its power the ramjet engine then furnishes the necessary thrust to move the aerial missile along its trajectory.

The entering air stream flows through the ram channel or diffuser **12**, where velocity energy is converted to pressure energy, and it is then mixed with the burner fuel injected therein by nozzle **25**. The airstream and the injected burner fuel are mixed together by means of the rake fingers **55**. The air-fuel mixture is then ignited by flames **30** and burned in the combustion chamber **14**. The products of combustion generated, i. e., the liberated gases, are then expanded through an exit nozzle arrangement located in the furthermost portion of the tailpipe section **14A** at a

velocity considerably higher than the velocity of the entering air stream to furnish the thrust forces required to propel the aerial missile along its trajectory.

Obviously, many modifications and variations of the present invention are possible in view of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In an aerial missile having a body in the form of an elongated tubular duct, a diffuser and a combustor in said duct, and a burner assembly mounted at the entrance of said combustor, said burner assembly, comprising, a body having a burner face, at least two manifolds in said body, a pilot fuel in one of said manifolds and a supporting medium in the other, paired orifices extending between said manifolds and said face to provide a plurality of pilot burners due to the commingling of said pilot fuel and supporting medium, said body having a passage for delivery of burner fuel to said combustor.

2. In an aerial missile having a ramjet engine with a ram channel for supplying air to a combustion chamber; in combination with a burner assembly mounted at the exit of said ram channel, said burner assembly, comprising, a body having a burner face at its downstream end, means for distributing burner fuel into said combustion chamber, and pilot flame means for maintaining a plurality of pilot flames around said distribution means and at said burner face, said pilot flame means being constituted by a plurality of manifolds located in the body of the burner assembly, at least one of said manifolds containing a pilot fuel and another a supporting medium, and a plurality of orifices between each of said manifolds and said burner face, said orifices being arranged in a plurality of groups, each group including an orifice from each manifold.

3. In an aerial missile having a ramjet engine with a ram channel for supplying air to a combustion chamber; in combination with a burner assembly mounted at the exit of said ram channel, said burner assembly, comprising, a body having a burner face at its downstream end, means for distributing burner fuel into said combustion chamber, pilot flame means for maintaining a plurality of pilot flames around said distribution means and at said burner face, said pilot flame means being constituted by a plurality of concentric and annular manifolds located in the body of said burner assembly, at least one of said manifolds containing a pilot fuel and another a supporting medium, a plurality of orifices between each of said manifolds and said burner face, said orifices being arranged in a plurality of groups, each group including an orifice from each manifold, and a plurality of rake fingers secured to said body and extending in an outwardly flaring relation to said burner face.

4. A burner arrangement, comprising, a body having a central passageway extending from one end thereof along a portion of its axis, manifolds arranged concentrically and annularly about said passageway and having paired orifices in the walls thereof adjacent that end of said body having the opening therein, at least one of said manifolds arranged to contain a pilot fuel and another a supporting medium, a separate passageway connected to each of said manifolds and to said central passageway, a fuel injection nozzle detachably mounted in the open end of said central passageway and a shield slidably mounted on said body for shielding said orifices.

5. The arrangement set forth in claim 4, wherein said shield comprises a frusto-conical skirt divided into a plurality of fingers which are aligned with said orifices.

6. In an aerial missile of the ramjet type having a ram channel delivering an air stream to a combustion chamber, a burner assembly mounted in said ram channel in the flow path of the air stream, the downstream end of said assembly constituting a burner face, said assembly having a plurality of concentric manifolds therein, passageways connected to said manifolds for delivering a pilot fuel to at least one of said manifolds and a supporting medium to another, said assembly having a plurality of paired orifices extending from said burner face to the respective manifolds, said orifices converging toward each other to provide impinging jets of said pilot fuel and supporting medium for forming pilot flames, a main fuel passageway in said burner assembly, nozzle means supplied therefrom for producing a burner fuel spray to be ignited by said pilot flames, and shielding means surrounding said burner face.

7. In an aerial missile of the ramjet type having a ram channel delivering an air stream to a combustion chamber, a burner assembly, comprising, pilot flame means mounted in said ram channel in the flow path of the air stream, the downstream end of the said pilot flame means constituting a burner face, said pilot flame means having a pair of concentric, annular manifolds therein, means connected to said manifolds for delivering at least a pilot fuel to one of said manifolds and a supporting medium to another, said pilot flame means having a plurality of paired orifices extending from said burner face to the respective manifolds, said orifices converging toward each other to provide impinging jets of said pilot fuel and said supporting medium to form a ring of pilot flame when ignited, and shielding means surrounding said burner face and including a plurality of diverging rake fingers.

8. In an aerial missile of the ramjet type having a ram channel delivering air into a combustion chamber, a burner assembly, comprising, a body having a burner face defining the forward end of said combustion chamber, means defining manifolds in said body at least one of said manifolds arranged to contain a pilot fuel and another a supporting medium, there being a plurality of paired orifices extending between said manifolds and said burner face to provide a plurality of pilot flames, means for delivering a burner fuel stream adjacent said burner face, and shielding means adjacent said pilot flames.

9. A burner assembly comprising, a body having a burner face, said body having a plurality of concentric manifolds therein, at least one of said manifolds arranged to contain a pilot fuel and another a supporting medium, there being a plurality of orifices in each of said manifolds, said orifices being arranged in proximity to provide a plurality of commingling jets of said pilot fuel and supporting medium, nozzle means directing a fuel spray adjacent said pilot flames, and shielding means surrounding said body.

10. In an aerial missile of the ramjet type having a ram channel and a combustion chamber, a burner assembly located in said ram channel at the forward end of said combustion chamber, said assembly, comprising, a body secured substantially axially in said ram channel, said body having an axial passageway therein, means for supplying burner fuel through said passageway into said combustion chamber, a plurality of manifolds in said body, passageways for supplying a pilot fuel to at least one of said manifolds and a supporting medium to another, there being a plurality of outlet orifices in each of said manifolds, the orifices being arranged in a plurality of groups, each group including an orifice from each manifold, the orifices of a group being arranged so that said pilot fuel and supporting medium from the several manifolds are intermingled to sustain pilot flames, a shield about said pilot flames, and a plurality of outwardly flaring rake fingers extending from said shield in annular arrangement about said body.

11. In combination, with a ramjet type of aerial missile having a ram channel supplying a stream of air to a combustion chamber, a burner assembly, comprising, a substantially cylindrical body secured axially in said ram channel adjacent the upstream end of said combustion chamber, the downstream end of said body constituting a burner face, said body having an axial passage terminating at said burner face, means for delivering burner fuel

through said axial passage, nozzle means connected to said axial passage in proximity to said burner face for delivering said burner fuel from said axial passage into said combustion chamber, a pair of manifolds around said axial passage, one of said manifolds containing a pilot fuel and the other a supporting medium, there being a plurality of pairs of pilot flame orifices in said burner face connected to said manifolds to provide streams of said pilot fuel and supporting medium therefor, shielding means around said body extending axially beyond said burner face to provide a shielded area adjacent said pilot orifices, and a plurality of rake fingers formed on said

shield and extending in divergent frusto-conical relation to said burner face.

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