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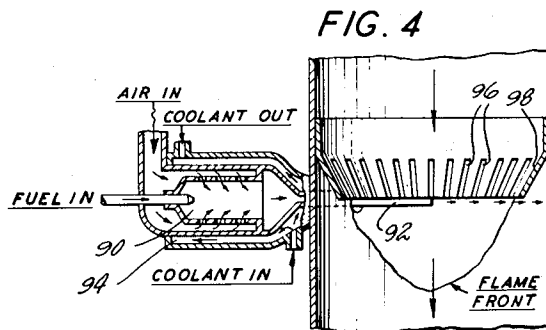
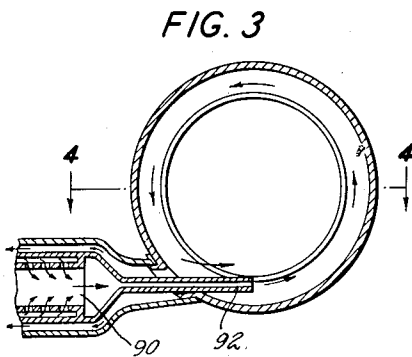
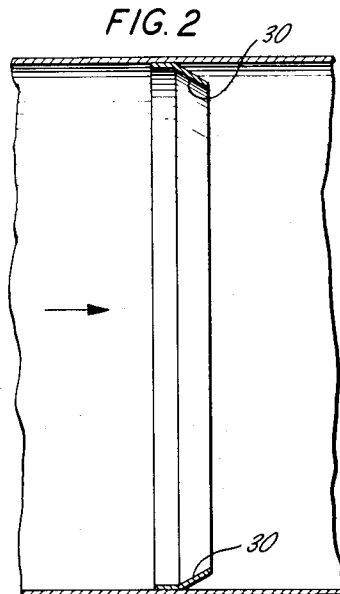
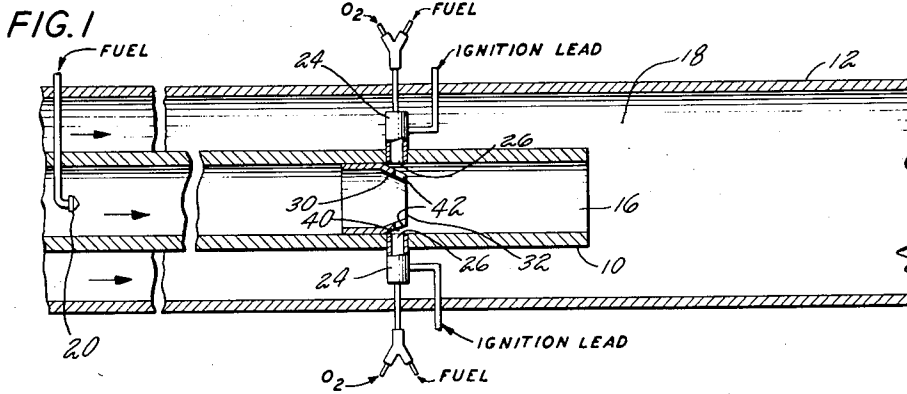
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2,744,384

BURNER CONSTRUCTION FOR HIGH VELOCITY GASES

Original Filed Sept. 28, 1949

2 Sheets-Sheet 1



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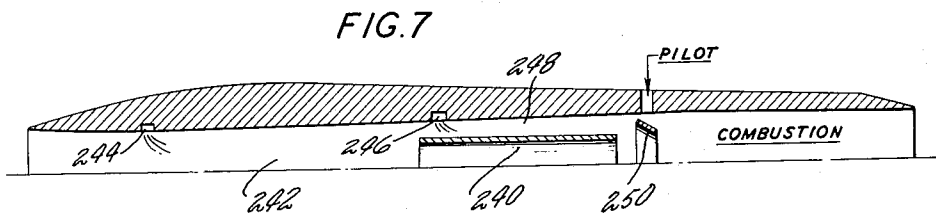
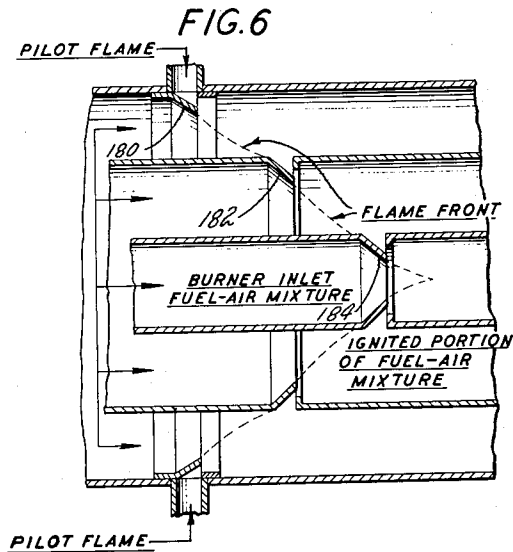
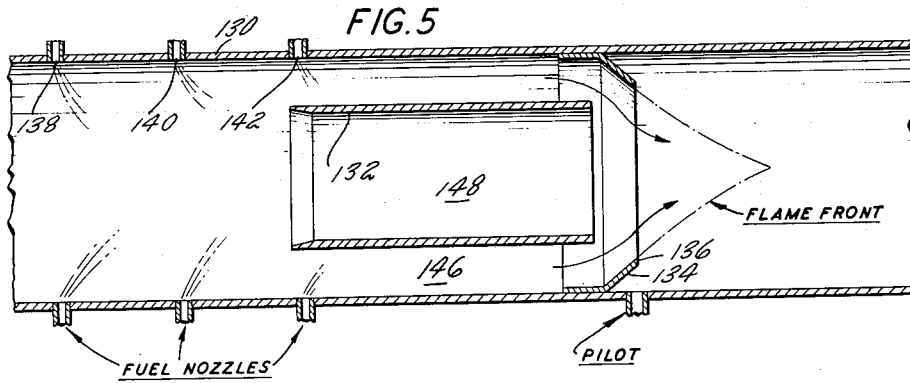
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BURNER CONSTRUCTION FOR HIGH VELOCITY GASES

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2 Sheets-Sheet 2



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BURNER CONSTRUCTION FOR HIGH VELOCITY GASES

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Continuation of application Serial No. 118,296, September 28, 1949. This application August 9, 1952, Serial No. 303,599

2 Claims. (Cl. 60—39.72)

This application is a continuation of patent application Serial No. 118,296, filed September 28, 1949, now abandoned.

This invention relates to burners and the like and particularly to means for improving the combustion of high velocity gas burners while being specifically adaptable to ramjet power plants, main combustion chambers or afterburners for turbojet engines.

In burners adapted to operate normally with relatively high velocity gases flowing therethrough it is necessary to insure proper starting of combustion at low and high gas velocities and to maintain smooth and efficient combustion at high gas velocities over a wide range of fuel-air ratios. Further when burners are utilized in aircraft power plants it is often difficult to obtain smooth and efficient combustion over a wide range of fuel-air ratios at extremely high speeds and altitudes.

It is therefore an object of this invention to provide an improved burner construction which will maintain efficient and smooth combustion under varied velocity, pressure and density conditions of the combustion ingredients.

Another object of this invention is to provide a burner construction wherein flame propagation adjacent the point of ignition of the combustible gases is controlled to greatly increase the effective combustion efficiency at high gas velocities and to provide good starting characteristics at low and high gas velocities.

A still further object of this invention is to provide progressive ignition of flame propagation in a burner whereby blowout is eliminated at high gas velocities.

A still further object of this invention is to provide protected pilot flame igniter means for a gas burner to maintain a low rate of fuel consumption in the pilot burner in relation to the fuel consumption in the main portion of the burner, while also permitting operation with relatively low fuel-air ratios in the burner.

Another object of this invention is to provide a protected ignition stage and flame spreader construction for high velocity combustion gases in a burner to maintain smooth and efficient burning transversely of the main stream of the gases and to eliminate flash back or back-fire upstream of the point of ignition; the entire combustion efficiency of the burner being greatly increased while the resultant drag of the protected igniting mechanism is maintained at a substantially negligible value.

Still another object of this invention is to provide a burner construction for increasing the combustion efficiency of high velocity gases which is readily adaptable to primary combustion in supersonic ramjet power plants and to main combustion chambers and afterburners of turbojets and the like.

Another object of this invention is to provide improved gas burner construction wherein the distance along the axis of flow which is necessary to develop flame propagation and burning completely transversely of the gas stream is greatly diminished; various modifications being indicated herein for burner ducts of large diameters or cross sections.

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These and other objects of this invention will become readily apparent from the following detailed description of the drawings.

In these drawings,

Fig. 1 is a cross-sectional view of a portion of a burner indicating the improved construction according to this invention.

Fig. 2 is a partial cross section of the burner duct in approximate scaled proportion indicating more clearly the relative size of the pilot flame shield as compared with the size of the main duct.

Figs. 3 and 4 are cross-sectional views illustrating protected pilot combustion chambers which direct the pilot flame tangentially to the inner periphery of the burner duct; Fig. 4 being taken along the line 4—4 of Fig. 3 and indicating more clearly the bleed passages in the flamespread shield which bleeds portions of the boundary layer fuel-air mixture therethrough.

Fig. 5 is a cross-sectional view of a burner duct construction which enables operation at extremely high, low, and intermediate gross fuel-air ratios.

Fig. 6 illustrates burner mechanism for rectangular or annular burners of large cross-sectional area whereby complete combustion transversely of the burner duct is accomplished within a relatively short distance along the axis of flow.

Fig. 7 is a partial cross-sectional view of a modified environment for this invention.

In attempting to maintain smooth and efficient combustion in gas burners having high velocity gases flowing therethrough, various methods have been attempted in the past to protect the igniter means and to maintain smooth burning by the insertion of various types of turbulence creating structures which usually result in large drag and friction losses. In the case of afterburners the use of such devices entails unjustifiable power loss due to drag especially when the afterburner is not in operation.

To this end, Fig. 1 represents a burner having a primary combustion duct 10 which is surrounded by a secondary combustion duct 12 thereby forming a primary combustion chamber 16 and a secondary air duct 18. Fuel is injected into the primary combustion chamber 16 at a point upstream thereof by means of a nozzle 20 which atomizes the liquid fuel, if such is used, causing the fuel to intermix with the primary combustion gases as the latter move through the chamber at a relatively high velocity. The gas fuel mixture is preferably ignited by a pilot flame which is directed into the combustion chamber 16 downstream of the point of fuel injection. In order to maintain a vigorous pilot flame under all conditions, fuel and oxygen or air are mixed and ignited in a protected pilot chamber 24 so that efficient combustion is obtained and a strong flame is introduced into the chamber 16 at 26.

At extremely high velocities it has been found that the pilot flame will normally ignite the gas fuel mixture immediately adjacent the walls of the duct 16 and will be forced to travel downstream along the wall so that flame propagation and proper burning is often not developed completely transversely of the duct. Under these conditions extremely poor combustion efficiency is obtained. To provide efficient combustion a frusto-conical shield 30 is located immediately adjacent and upstream of the pilot flame entrance and has its tapered portion terminating in a lip 32 which is located adjacent the pilot flame. The shield 30 thereby forms an annular chamber 40 which causes the pilot flame to spread circumferentially about the inner walls of the duct 16 and produce a conical flame front whose apex is at a point downstream of the pilot flame. The shield 30 is shown enlarged in relation to the duct for illustration purposes, but in actual practice it is much smaller to offer very little resistance to the gas

flow and resembles more closely the proportions shown in Fig. 2.

In order to progressively propagate a firm flame front which will rapidly extend completely across the duct 16, a plurality of perforations may be peripherally spaced around the lip 32 of the shield 30. These perforations are shown in the form of small bleed passages (Fig. 4) which permit a portion of the low velocity boundary layer gas fuel mixture to penetrate into the pilot flame to progressively strengthen flame propagation. In this manner the strength of the pilot flame is sufficiently increased to minimize the pilot fuel and oxidizer flows required to provide satisfactory combustion of the main portion of the gas stream. The perforations may be of helical shape rather than substantially radial and may prove more efficient especially when the pilot flame is introduced tangentially to the wall of the duct.

It should be noted that due to the constriction of the stream at the shield 30 a local high velocity will exist adjacent the lip thereof so that the strengthened pilot flame will not flash back upstream from the shield.

It may be desirable to introduce the pilot flame tangentially to the inner wall 10 of the duct 16 (of Fig. 1) in a manner shown in Figs. 3 and 4 by introducing the pilot flame tangentially into the annular chamber 40.

In referring to the generation of a strong flame front and also to progressive combustion it is to be understood that reference is made to the well-established principle that the combustion process is a branching chain reaction. In other words, the transition between initial local ignition by flame or spark and complete combustion of the fuel-air mixture is one in which a branching chain of intermediate hydrocarbon groupings are created or generated. Some of these intermediates in turn act as chain carriers and initiate the combustion of molecules not affected by the initial flame or spark. The construction of the flamespreader shown operates on this basic principle so as to provide a continuous, minimum supply of intermediates to a diverted portion of the main stream flow favorable to the production of additional intermediates. Also, the range of fuel-air ratios and burner inlet pressures and velocities at which combustion may be efficiently maintained is greatly increased.

In order to produce a vigorous pilot flame it is preferred that efficient combustion be maintained prior to entrance of the flame into the burner duct. Thus as shown in Figs. 3 and 4 air or oxygen and fuel may be mixed and ignited in the chamber 90 and then emitted circumferentially within the main burner duct via the passage 92. As illustrated, coolant fluid or gas may be passed through the duct 94 which surrounds the chamber 90 of the pilot flame mechanism. In the construction shown in Fig. 4 the pilot flame will be fed by a portion of the low velocity boundary layer gas-fuel mixture by a plurality of peripherally spaced bleed slots 96 which are located adjacent the lip of the flamespreader or shield 98. It is again important to note that the bleed slots 96 appear exaggerated in width for clarity of illustration inasmuch as for extreme velocities they may be smaller in width. Also as shown herein, the centerline of the pilot flame passage 92 may coincide with the downstream lip of the shield 98 or it may be located farther outward on the duct radius at the lip section depending upon the flow conditions and the construction of the flamespreader.

Inasmuch as obtaining a wide gross burner air-fuel ratio range of operation is dependent upon the proper local concentration and gradient of fuel-air ratio across the duct, it is desirable under certain flow conditions to maintain a locally rich fuel-air ratio immediately adjacent the lip of the pilot flame shield by utilizing a structure as shown for example in Fig. 5. To this end the main burner duct 130 has mounted therein a secondary coaxial duct 132 which is positioned upstream of the flamespreader shield 134 and has its downstream end terminating adjacent the lip 136 of the shield 134. A plurality

of fuel injection nozzles 138, 140 and 142 are provided upstream of the shield 134, the nozzles 138 and 140 being located upstream of the entrance of secondary duct 132 so that a fuel-gas mixture is supplied throughout the duct 130 in the chambers 146 and 148. The nozzles 142 are located adjacent to the upstream end of the secondary duct 132 so that the fuel issuing therefrom is supplied only to the chamber 146 and a richer fuel-air mixture is provided at the lip 136 of the shield 134 than is present in the center of the gas stream. In this manner the pilot flame is supplied with a high local fuel-air ratio adjacent the lip 136 of the shield 134 so that strong flame propagation is maintained to cause complete burning transversely of the duct 130 within a short distance downstream from the point of ignition. With the construction shown in Fig. 5 it is possible for the burner to operate at low gross fuel-air ratios inasmuch as sufficiently high local fuel-air ratio is supplied at the critical point of ignition of the main gas flow, i. e., at the lip 136 of the shield 134. By properly selecting and/or controlling the fuel nozzles in this type of construction the rich limit as well as the lean limit of fuel-air ratios can be extended since when the main stream is operating in rich regions the relative fuel-air ratio adjacent the lip 136 may be maintained somewhat lower to prevent quenching of the flame thereat. A preferred method of maintaining the fuel-air ratio adjacent the lip 136 relatively leaner than the remainder of the stream and thus extend the gross rich limit of operation for the burner is shown in Fig. 5 where individual fuel nozzles are provided for a plurality of longitudinal passages. Thus in starting a burner of the type shown in Fig. 5 the nozzles 142 may be turned on first to supply the necessary rich mixture at the lip 136 or else all the nozzles 138, 140 and 142 may be turned on simultaneously and their flow increased in gradual increments. Under certain flow conditions bleed passages may be provided in the flamespreader 134 adjacent the lip 136 so that a portion of the rich gas mixture may enter the pilot flame on the downstream side of the shield 134.

In high gas velocity burners having large diameters the ignited portion of the fuel-air mixture may, even with the flamespreader construction as described above, assume the shape shown in Fig. 6 due to the high velocities and the large distance which the flame front must travel to ignite the fuel-air mixture completely transversely of the burner. Under certain conditions where transverse burning is possible the burner length must be unjustifiably excessive in aircraft and missiles. To insure complete cross-sectional burning in rectangular or annular ducts having large cross-sectional areas, one or more partitions are inserted within the main duct; each partition having a passage and a flamespreader shield cooperating therewith. Transversely of the duct each adjacent passage and its cooperating flamespreader shield is successively staggered in a downstream direction so that each successive passage is located sufficiently downstream at a point where the flame front has travelled completely across the next preceding separated passage.

In circular or polygonal burners of extremely large cross section the distance downstream at which complete burning transversely of the duct obtains may also be shortened considerably by supplying a pilot flame circumferentially within the main duct and progressively igniting a series of coaxial passages within the main duct. In the construction shown in Fig. 6, it may be desirable to provide separate live pilot flames for each of the cross-sectional burning stages rather than depending upon a single pilot flame at the outermost wall. The primary flamespreader 180 and the secondary flamespreaders 182, 184 may be of the type shown herein or of the bleed type as shown, for example, in Fig. 4.

Fig. 7, for example, illustrates the use of a circular sleeve 240 located within a ramjet conical diffuser 242 which includes an upstream fuel nozzle 244 providing

fuel for the entire duct and a nozzle 246 providing fuel for the passage 248. The nozzle 246 then may be regulated to maintain the proper fuel-air ratio at the flame-spreader 250 so that proper ignition is obtained from the pilot flame. As previously mentioned, to operate at gross lean fuel-air ratio the fuel injection may be controlled to provide a locally rich fuel-air ratio adjacent the flame-spreader 250 (relative to the remaining stream) so that efficient flame propagation may be maintained. The inverse control of fuel-air ratios is employed where gross rich fuel-air is desired in the main duct. The fuel being emitted from the nozzle 246 may be reduced and in conjunction with the low velocity layer adjacent the wall of the main duct 242 a relatively lean fuel-air ratio is locally obtained at the flamespreaders 250 to prevent quenching and maintain a vigorous flame front.

As a result of this invention it is apparent that an improved gas burner construction has been provided which insures positive and efficient combustion under varied velocity and pressure conditions. Further, the maintenance of strong flame propagation permits overall efficient combustion in burner ducts where the length of the duct is restricted and extreme high or low gross fuel-air ratios are present. Hence, in missiles having ramjet power plants and the like and in turbojet burners and afterburners, the length of burner duct can be reduced for the sake of weight saving while maintaining excellent combustion at extremely high velocities, low pressures and with little drag.

From the various embodiments illustrated and described herein it is readily apparent that numerous modifications and changes of the construction and arrangement of the component parts of this invention may be made without departing from the scope of this novel concept.

What it is desired to obtain by Letters Patent is:

1. In a combustion chamber construction for a ramjet power plant, a duct through which high velocity air flows, a plurality of nozzle means for injecting fuel into said duct to mix with said air, means in the form of a solid frustro-conical shield extending away from the wall of the duct and located downstream of the fuel injecting means, the maximum constriction of the duct caused by the shield occurring downstream of the air flow, said shield accelerating the fuel-air stream at said restriction whereby upon ignition of the stream the velocity of flame propagation is less than the stream velocity so that upstream flame propagation is eliminated, means adjacent the downstream face of said shield for igniting the fuel-air mixture including a pilot flame emitting passageway, means for supplying said passageway with a continuous flame of high intensity comprising a mixing chamber and means for supplying said chamber with a fuel under pressure and a combustion supporting fluid under pressure, electrical means for igniting said last mentioned fuel and combustion supporting fluid in said chamber prior to their being emitted through said passageways, at least one

other duct located within said first mentioned duct, said other duct including passage means in the wall thereof providing communication from the outside to the inside thereof, a flange extending inwardly from the wall of said other duct and located upstream of said passage means to form a flamespreader, said passage means and said flange being located downstream of said shield whereby the flame propagates across the space between the walls of said ducts and is received by said passage means to provide a pilot flame for said other duct.

2. In a combustion chamber construction for a ramjet power plant, a duct through which high velocity air flows, a plurality of nozzle means for injecting fuel into said duct to mix with said air, means in the form of a solid frustro-conical shield extending away from the wall of the duct and located downstream of the fuel injecting means, the maximum constriction of the duct caused by the shield occurring downstream of the air flow, said shield accelerating the fuel-air stream at said restriction whereby upon ignition of the stream the velocity of flame propagation is less than the stream velocity so that upstream flame propagation is eliminated, means adjacent the downstream face of said shield for igniting the fuel-air mixture including a pilot flame emitting passageway, means for supplying said passageway with a continuous flame of high intensity comprising a mixing chamber and means for supplying said chamber with a fuel under pressure and a combustion supporting fluid under pressure, electrical means for igniting said last mentioned fuel and combustion supporting fluid in said chamber prior to their being emitted through said passageways, one other duct coaxially disposed with respect to said first mentioned duct, said other duct including other passage means in the wall thereof providing communication from one side of the wall to the other, a flange extending from the wall of said other duct and located upstream of said other passage means to form a flamespreader, said passage means and said flange being located at spaced points along their common axis relative to said shield whereby the flame propagates across the space between said shield and said flange and communication is provided between said passageway and said passage means.

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