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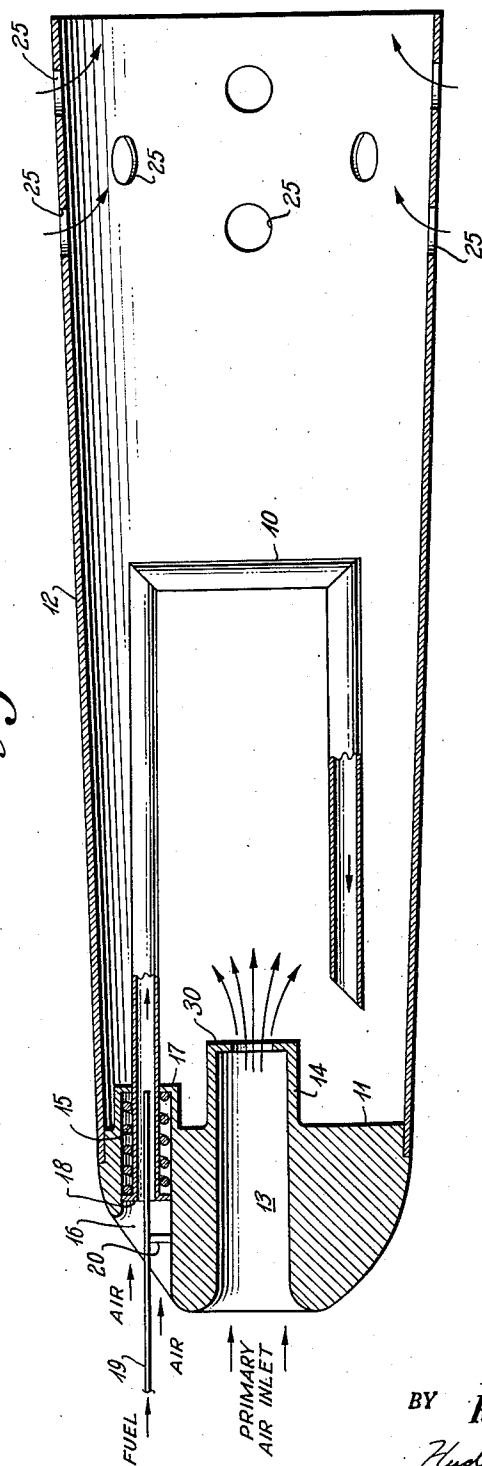
E. H. FROMM ET AL
PREVAPORIZER TYPE COMBUSTION CHAMBER HAVING
LONGITUDINALLY MOVABLE PREVAPORIZER TUBE

2,810,260

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3 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

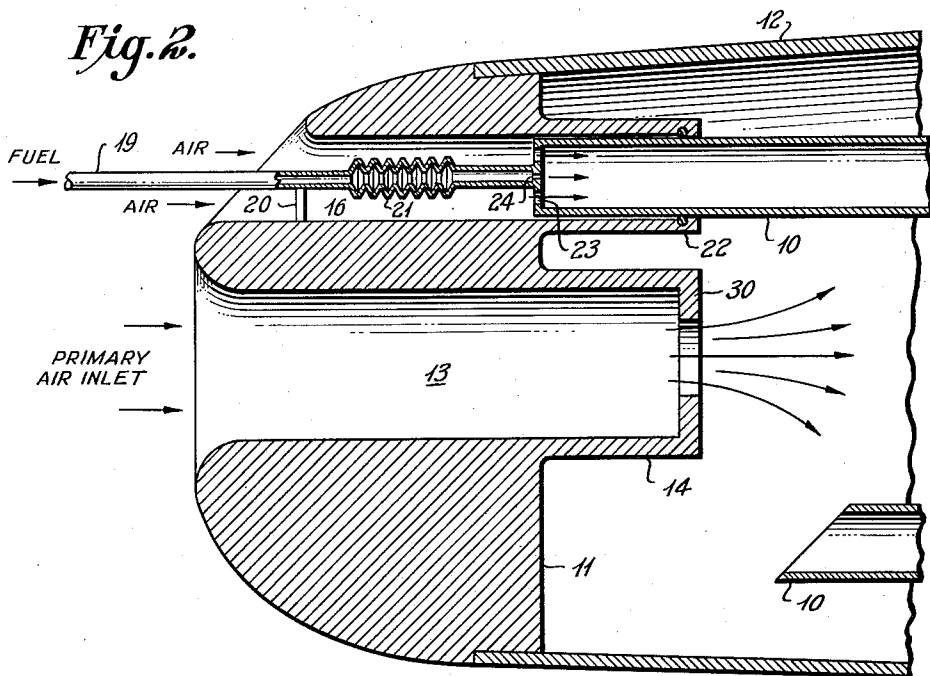
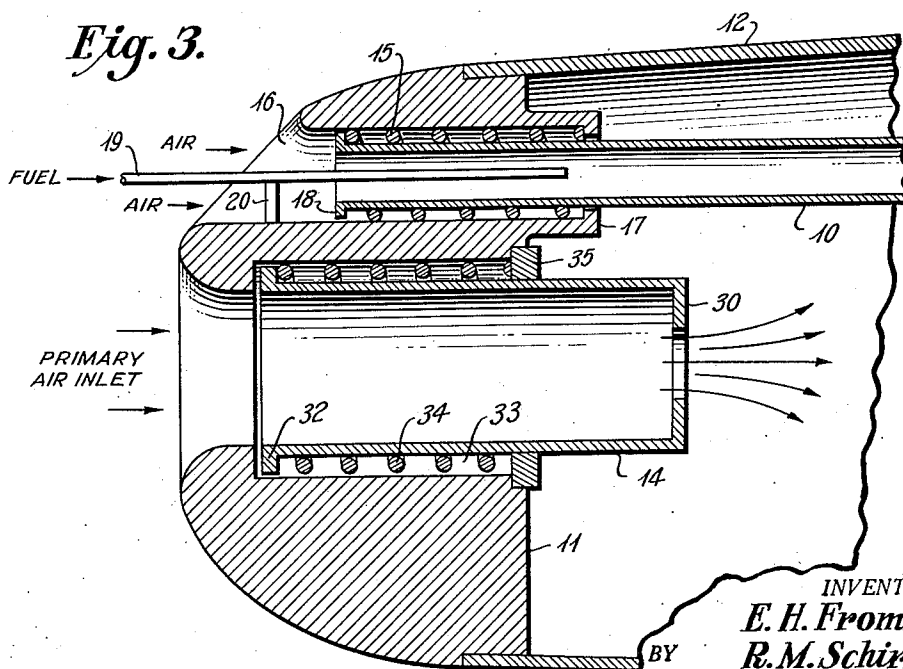


Fig. 3.



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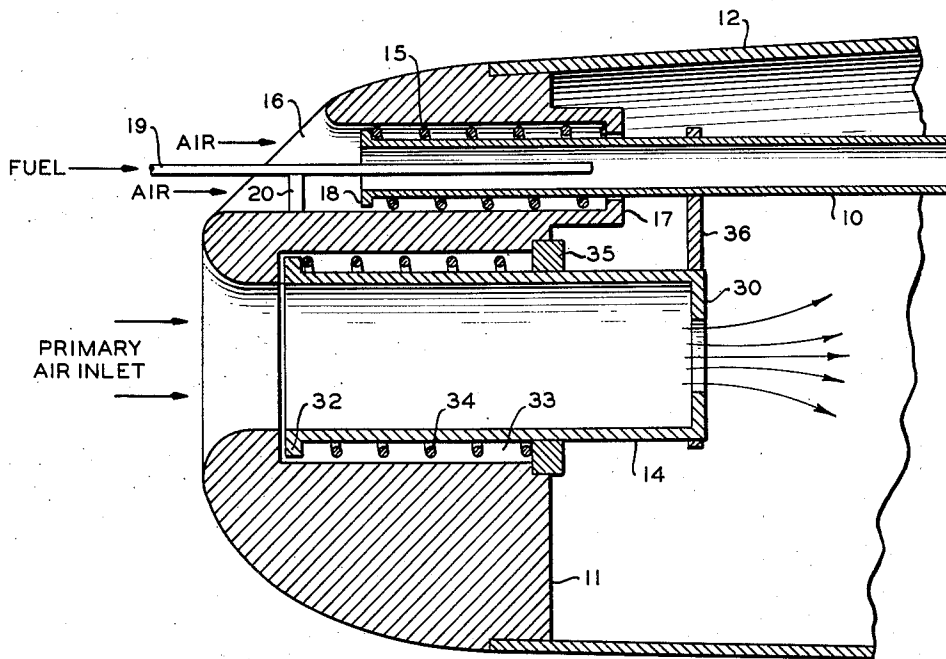


Fig. 4.

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PREVAPORIZER TYPE COMBUSTION CHAMBER HAVING LONGITUDINALLY MOVABLE PRE- VAPORIZER TUBE

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5 Claims. (Cl. 60—39.71)

This invention relates to prevaporizer type combustion chambers. In a further aspect this invention relates to a prevaporizer type combustion chamber in a jet engine. In a further aspect this invention relates to prevaporizer type combustion chambers in which the prevaporizer tube is longitudinally movably attached to the closed end of the combustion chamber. In a further aspect this invention relates to a prevaporizer type combustion chamber in which both the prevaporizer tube and the primary air inlet conduit are longitudinally movably mounted in the closed end of the combustion chamber.

In aircraft propulsion systems comprising an air compressor, fuel burner means at the compressor outlet, a gas turbine driven by the combustion products and air heated thereby, said turbine mechanically driving said compressor, thrust is developed by reaction arising out of the expansion of the stream of gas through a nozzle or jet. One suitable method utilized in such apparatus is to introduce the fuel into the combustion chamber in the form of a vapor through vaporizer tubes mounted in the upstream end of the tube plate or closed end of said flame tube and extending into the flame tube. The tube plate forms a closure in the upstream end of the flame tube so that air from the compressor is directed into the vaporizer tubes, around the flame tube, and through holes in the flame tube into the combustion zones, and through primary air ducts located in the tube plate which direct air into the combustion zones.

The liquid fuel and vaporizing air are introduced into the upstream end of the vaporizer tubes and the fuel is vaporized in these tubes which are exposed to the combustion flame. The downstream ends of the vaporizer tubes change direction through approximately 180° and the fuel and air mixture formed in these tubes is discharged upstream into the stream of air supplied through an orifice located in the downstream end of the primary air duct located in the closed end. The primary air flowing through the vaporizer tubes assists in the vaporization of the fuel by reducing the temperature required for complete vaporization. The air also serves to reduce the deposition of carbon on the walls of the tubes, which results from overheating of the fuel, and aids in the transport of liquid and vaporized fuel through the vaporizing tubes. The air entering through the primary air duct aids in the completion of combustion of the vaporized fuel discharged from the vaporizer tubes.

In engines employing tubular type combustion chambers, a number of vaporizer tubes can be provided in each combustion chamber, these being arranged symmetrically around a single primary air duct. However, it is more usual to provide a separate primary air duct for each vaporizer tube. In engines employing an annular type combustion chamber, the same arrangement of vaporizer tubes and primary air ducts can also be employed. Each vaporizer tube is an independent source of fuel supply and a uniform discharge of vaporized fuel, in accordance with the combustion requirements of the particu-

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lar operating conditions of the engine, must be maintained in order to provide efficient and stable combustion in the combustion chamber. As is evident, various conditions are necessary in order to provide the most efficient combustion in such engines. Regardless of the position of the primary air inlet, it has been found that increased operating efficiency occurs when the outlets of the vaporizer tubes are positioned further downstream as increased amounts of fuel are burned. Another variable found to be important, is the flame holding area in the combustion zone, which is varied in accordance with the inlet air velocity to the combustion chamber. This area may be controlled by regulating the volume of slow moving fuel-air mixture existing between the orifice of the primary air duct and the closed end of the combustion chamber.

Each of the following objects is obtained by at least one of the aspects of this invention.

An object of this invention is to provide an improved prevaporizer type combustion chamber. A further object is to provide apparatus for controlling the location of the vaporizer tubes in the combustion zone of a prevaporizer type combustion chamber in response to at least one of the components being supplied to said combustion zone. A further object of this invention is to provide apparatus for regulating the volume of slow moving fuel-air mixture between the air discharge orifice of the primary air duct and the closed end of the prevaporizer type combustion chamber. A further object of this invention is to provide apparatus so that the most efficient operating conditions will be maintained at all times.

Other objects and advantages will be apparent to one skilled in the art upon reading this disclosure.

Accompanying this disclosure and a part thereof are the accompanying drawings in which:

Figure 1 is a cross section of a flame tube of a combustion chamber of our invention;

Figure 2 is a section of a flame tube of a combustion chamber showing a modification of the apparatus of Figure 1; and

Figure 3 is a cross section of further modification of our invention.

Figure 4 is a cross section of a further modification of our invention.

In its broadest aspect, our invention provides apparatus for automatically controlling the location of the vaporizer tubes in the combustion zone in accordance with a change in an operating variable in order to extend the blowout limits, and therefore to extend the operating range, of the burner configuration. In Figures 1 and 2, apparatus is shown wherein the position of the vaporizer tubes is controlled by the air flow, and the fuel respectively, to the vaporizer tubes. In Figure 3, the primary air duct is also adjustable.

Two problems are involved in providing stable operation where such apparatus is used. The first of these is mixing a sufficient amount of the primary air with the fuel-air mixture flowing from the vaporizer tube to give an approximately stoichiometric mixture. This prevents over-richening in the region of the outlet of the vaporizer tube and possible rich-mixture blow-out, the extent of the mixing being dependent upon the velocity of the primary air and the position of the outlet of the vaporizer tube. Thus, as the velocity increases, at a fixed position of the outlet of the vaporizer tube, less air in the stream mixes with the fuel-air mixture from the vaporizer tube thereby increasing the fuel-air ratio. In this invention, as the velocity of the primary air stream increases due to an increase in fuel flow, the outlet of the vaporizer tube moves downstream, thus permitting participation of the

divergent air stream with the fuel-air mixture. This tends to prevent overly rich mixtures in the region of the outlet of the vaporizer tube.

Another consideration is the volume of slow moving air between the closed end of the flame tube and the downstream end of the primary air duct, which serves as a flame holding zone. As the velocity of primary air increases, it is desirable to increase this volume. In one modification of our invention we provide a movable primary air duct which results in an increased flame holding zone as the velocity increases. In this modification it is also desirable to provide a movable vaporizer tube, the movement of this tube being at least as great, and preferably greater, than the movement of the primary air duct. The most preferable situation is one in which the movement of the primary air duct and the vaporizer tube is such that the spatial relationship of these components increases in an amount equal to that provided by the first modification of our invention. It will be apparent to one skilled in the art that the exact amount of movement in either of these situations is dependent upon the design of the particular combustion chamber.

In the attached drawings we have illustrated specific apparatuses for providing these improved operating conditions. Figure 1 shows a longitudinal section through a flame tube of a jet engine combustion chamber, the location of the vaporizer tube being controlled through a spring-loaded coupling in accordance with the flow of air to the combustion chamber. In this figure, a single J-type vaporizer tube 10 is slidably mounted in the closed end 11 of flame tube 12 adjacent to a primary air duct 13, this primary air duct including primary air tube structure 14, from which a high velocity, divergent stream of air contacts and mixes with the vaporized fuel-air mixture from the outlet of vaporizer tube 10. Vaporizer tube 10 is slidably mounted through a spring-loaded coupling in closed end 11 by a compression type spring 15 located in the annular spacing between the inner surface of cylindrical chamber 16 in the closed end 11 and the outer surface of vaporizer tube 10. The action of spring 15 against retaining structure 17 and annular lip 18 on the inlet end of vaporizer tube 10 is balanced by the impact of the air stream on the surface of lip 18 so that regulation of the extension of vaporizer tube 10 into the combustion zone is proportional to the air flow from the compressor. Fuel is supplied to the vaporizer tube 10 by fuel line 19, this line being rigidly mounted in the inlet end of vaporizer tube 10 by support member 20. At the end of tube 13, there is provided orifice plate 30. The secondary air holes 25 in flame tube 12 are schematically shown.

In Figure 2, the location of the vaporizer tube is determined by the expansion of a bellows in the fuel line in accordance with fuel flow to the vaporizer tube. More specifically, the extension of vaporizer tube 10 into the combustion zone is controlled by the degree of expansion of bellow 21 rigidly attached to the inlet end of vaporizer tube 10 through a section of fuel line 19. Bellows 21 constitutes an integral section of fuel line 19 and is located in cylindrical chamber 16 of the closed end 11 and downstream from the supporting member 20 to provide a stationary location from which bellows 21 can expand and extend vaporizer tube 10 into the combustion zone through slidable contact with guide 22 rigidly attached to the closed end 11. The inlet end of vaporizer tube 10 is attached to the end of fuel line 19 which extends downstream from the bellows, by means of radial spokes 23 which offer low resistance to the flow of air from chamber 16 into vaporizer tube 10. An orifice 24 is located in the end of fuel line 19 so that changes in the fuel flow to the combustion chamber through bellows 21 results in a movement of vaporizer tube 10 into the combustion zone.

Figure 3 of our invention discloses a modification in which an adjustable primary air duct is provided in the closed end of the combustion chamber. In the operation

of this modification this orifice is extended downstream into the combustion zone by an increase in air velocity, thus increasing the volume of low velocity air-fuel mixture existing between the discharge of this orifice and the closed end of the combustion chamber. Conversely this air inlet retracts from the combustion chamber when the flow of primary air is decreased.

The movement of the primary air duct is preferably accomplished by spring-loading. The primary air conduit 14 is provided with an outer lip 32 on the upstream end and an orifice plate 30 on the downstream end and is slidably mounted in the spring retaining chamber 33 in the closed end 11 of flame tube 12. Retaining member 35, rigidly attached to the closed end 11, retains compression spring 34 in the spring retaining space 33. Spring 34 maintains the position of the primary air tube 14 through the action on lip 32 and retaining member 35 in accordance with the impact of the air stream on the surface of plate 30 to regulate the extension of primary air orifice 14 into the combustion zone and, thereby, the volume of the region of slow moving air between the closed end 11 of the combustion chamber and the outlet end of conduit 14.

In Figure 3 the automatic positioning means for vaporizer tube 10 is shown as being similar to the positioning means of Figure 1, but it will be apparent that the vaporizer tube can also be positioned in a manner similar to that shown in Figure 2. It will be obvious that the movement of vaporizer tube 10 could be effected by having a rigid connection 36 between tube 14 and tube 10. This would provide an apparatus for moving these elements further into the combustion chamber while maintaining their spatial relationship constant.

In the embodiments shown herein, flame tube 12 is provided with secondary air holes 25, but primary air holes may also be located near the closed end 11 of combustion chamber 12 if desired. In the interests of simplicity the flame tube is shown with only one primary air conduit 14 and vaporizer tube 10 but, it will be understood, that our invention is also applicable in combustion chambers in which a plurality of vaporizer tubes and primary air tubes are used. Certain additional elements, such as ignition means, are well known in the art and are not shown.

As many possible embodiments may be made of this invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. A combustion chamber comprising a flame tube having an open end and a closed end, at least one primary air inlet tube extending through said closed end and into said flame tube, at least one prevaporizer tube mounted in and communicating through said closed end, spring retaining means attached to said closed end, spring retaining means on the end portion of said prevaporizer tube, a spring between said two spring retaining means, and a fuel supply conduit extending into said prevaporizer tube.

2. A combustion chamber comprising a flame tube having an open end and a closed end, at least one primary air inlet tube extending through said closed end and into said flame tube, at least one longitudinally movably mounted prevaporizer tube mounted in and communicating through said closed end, a fuel inlet conduit connected to and communicating with said prevaporizer tube, a restricted orifice in the downstream end portion of said fuel inlet conduit, and a bellows section in said fuel inlet conduit.

3. A combustion chamber comprising a flame tube having an open end and a closed end, longitudinally movable primary air inlet means extending through said closed end and into said flame tube, at least one vaporizer tube longitudinally movably connected at its upstream end to and communicating through said closed end and extending into

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said flame tube, and means for supplying fuel to said prevaporizer tube.

4. A combustion chamber comprising a flame tube having an open end and a closed end, longitudinally movable primary air inlet means extending through said closed end and into said flame tube, said means comprising a movable air conduit, a spring retaining recess in said closed end, a spring retaining member on the downstream end of said closed end, an orifice at the downstream end of said air conduit, a spring retaining lip on the upstream end of said air conduit, a spring in spring retaining recess, at least one vaporizer tube longitudinally movably connected at its upstream end to said closed end and extending into said flame tube, and means for supplying fuel to said prevaporizer tube.

5. A combustion chamber comprising a flame tube having an open end and a closed end, at least one primary air inlet conduit extending through said closed end and into said flame tube, at least one prevaporizer tube con-

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nected at its upstream end to said closed end and extending into said flame tube, means for supplying fuel to said vaporizing tube, and means associated with said prevaporizer tube and responsive to a change in flow of one of the combustion components for longitudinally moving the tube, said last recited means moving the tube downstream in the combustion chamber in response to an increase in flow of one of the combustion components and upstream in the combustion chamber in response to a decrease in flow of one of the combustion components.

References Cited in the file of this patent

UNITED STATES PATENTS

15	1,647,409	Klein	Nov. 1, 1927
	1,815,317	Klein	July 21, 1931
	2,304,136	Woods	Dec. 8, 1942
	2,522,081	Allen	Sept. 12, 1950
	2,655,787	Brown	Oct. 20, 1953