Sept. 15, 1953 R. W. ABBOTT 2,651,912

COMBUSTOR AND COOLING MEANS THEREFOR

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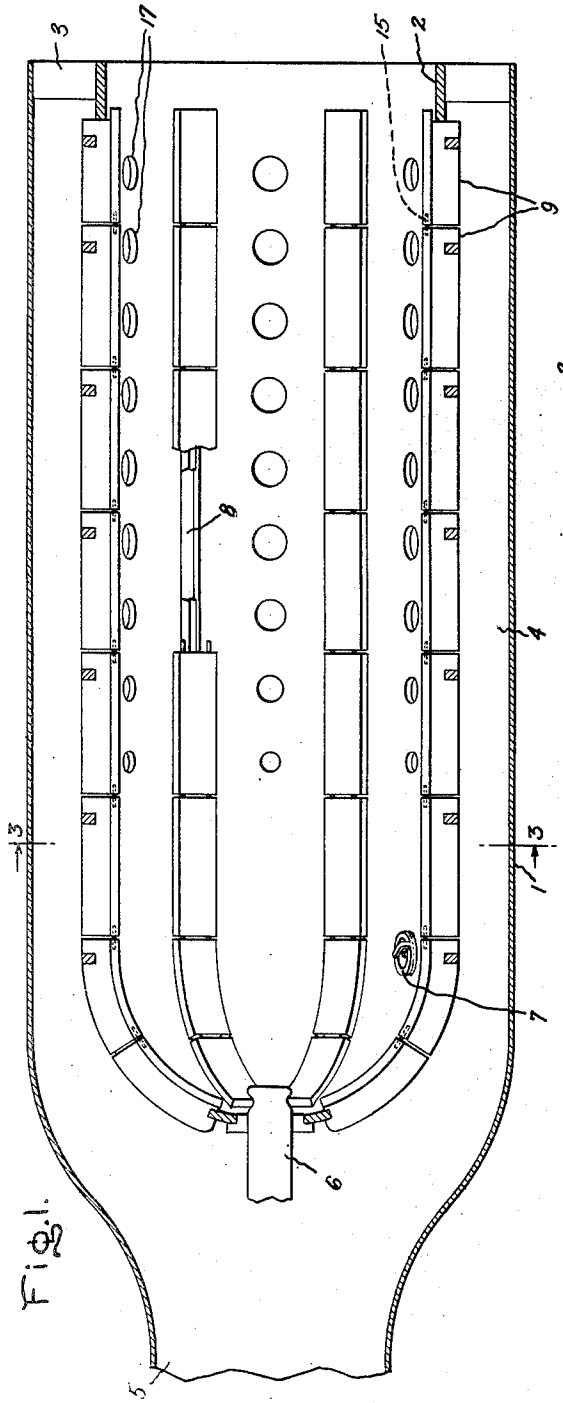


Fig. 1.

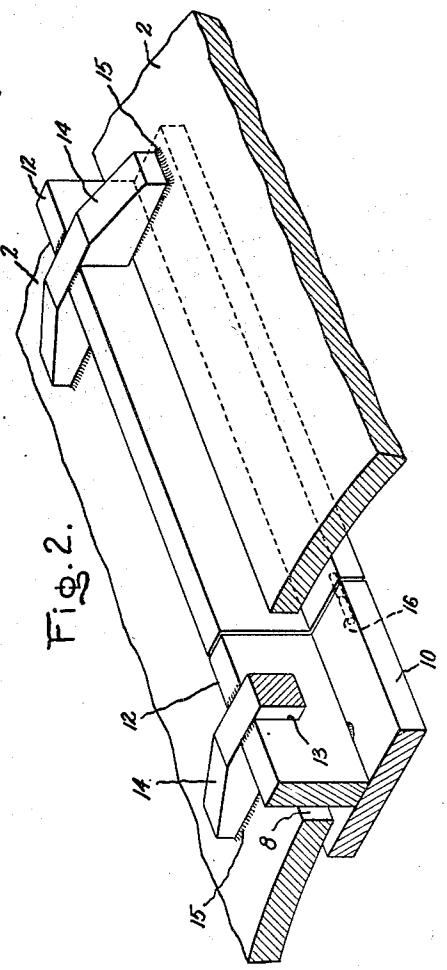


Fig. 2.

Inventor:
Roy W. Abbott,
by Paul A. Frank
His Attorney.

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Fig. 3.

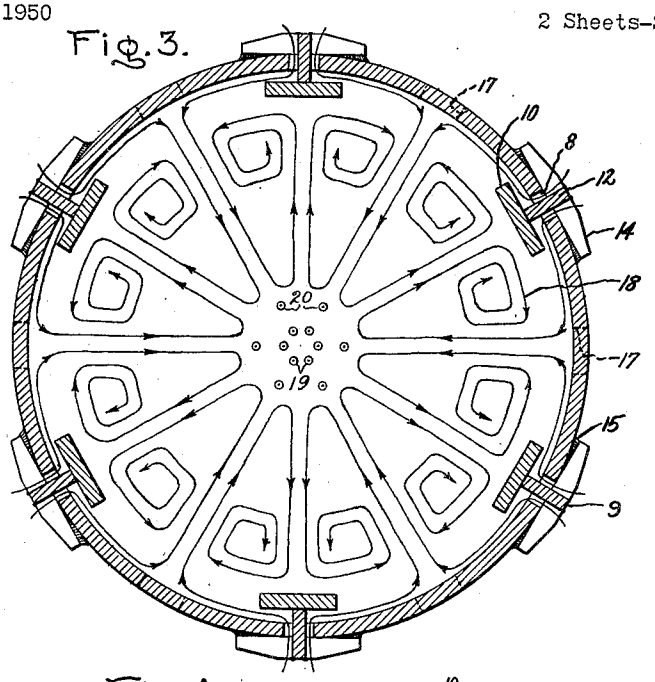
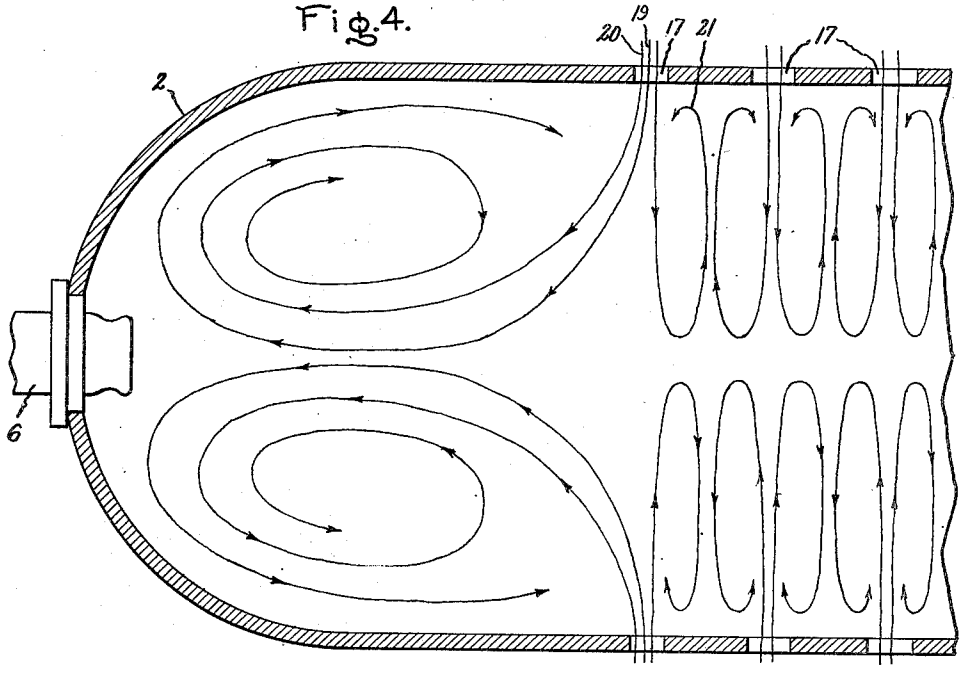


Fig. 4.



Inventor:
Roy W. Abbott,

by Paul A. Frank
His Attorney.

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COMBUSTOR AND COOLING MEANS THEREFOR

Roy W. Abbott, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application October 31, 1950, Serial No. 193,100

3 Claims. (Cl. 60—39.65)

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This invention relates to apparatus for the combustion of fluid fuels. More particularly, it relates to an improved combustion chamber liner having new and novel means for cooling such liner.

An object of this invention is to provide combustion apparatus for fluid fuels which affords improved combustion efficiency.

Another object of the present invention is to provide combustion apparatus which is characterized by improved liner wall cooling.

A further object of the invention is to provide a combustion chamber liner in which hot spots are substantially eliminated.

Another object of this invention is to provide combustion apparatus in which the cooling area per louver is substantially increased.

Another object of the invention is to provide a combustor in which the exit gases are characterized by improved temperature uniformly across the chamber.

A still further object of the present invention is to provide combustion apparatus in which the liner is cooled by substantially circumferentially flowing gas.

Other objects will become apparent from a consideration of the following description and the drawing in which Fig. 1 shows in partial longitudinal cross-section a combustor embodying the present invention; Fig. 2 is a detail perspective view of the louver structure; Fig. 3 is a cross-sectional view of a portion of the liner of Fig. 1 taken in the direction 3—3; and Fig. 4 is a longitudinal cross-sectional view of a portion of the liner.

It has been found that a combustor for fluid fuels which is characterized by improved liner cooling may be very readily provided.

More particularly, it has been found that such a combustion apparatus may be realized by providing a plurality of deflecting louvers so mounted in longitudinally disposed slots in the liner that air introduced into the slots is spread tangentially and circumferentially over the inner surface of the liner.

Heretofore, a number of methods of cooling the inner surfaces of combustor liners have been proposed. One such method introduces the air in a downstream direction through louvers provided by making U-shaped cuts in the liner wall and bending inwardly the tongue so formed. While such a method of film cooling is efficient insofar as the areas actually contacted by the coolant are concerned, the latter has a tendency to rapidly disperse and become entrained in the combustion

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gases. Additionally, the provision of sufficient of such louvers to effectively cool the entire liner wall and eliminate all hot spots has a tendency to physically weaken the liner wall.

By the present invention there is provided a means of effectively cooling the entire surface of a combustor liner by metering air through longitudinally disposed slots and associated louvers so that the coolant is swept tangentially and circumferentially over the inner circumference of the liner.

The present method of liner wall cooling reduces to a minimum the conduction and connection of heat from the high temperature flames to the wall. It offers the further advantage of reusing this cooling air for combustion and dilution to further augment that introduced through the liner holes for this purpose. The improved cooling also makes possible a more uniform exhaust gas temperature and high combustion efficiency.

For a more complete understanding of the present invention, reference is made to the drawing. In Fig. 1 is shown a typical combustor embodying the present improvement. Mounted within the outer combustor shell 1 is liner 2 which is held in spaced relationship with the shell by means of struts such as 3 to form a plenum chamber 4. Air is fed to plenum chamber 4 through the end 5 of the combustor from a source of supply not shown. The only requirement for the air supply in space 4 is that it have substantially no downstream velocity component, such condition being readily attained by adjustment of feed pressures and directions and chamber size which are well known to those skilled in the art. Fuel is introduced into the combustor through a nozzle which introduces a conical spray of fuel into the liner. Preferably, though not necessarily, the nozzle is of the so-called duplex type which delivers a multiple conical spray of fluid. Such a nozzle is described in application Serial No. 622,604, filed October 16, 1945, now Patent 2,590,853, assigned to the same assignee as the present invention. Ignition of the fuel is accomplished by means of spark device 7 mounted in the wall of the combustor.

A plurality of slots 8 is provided in liner 2 extending from a position near the nozzle at the closed end of the liner downstream beyond the dilution portion of the liner. A plurality of T-shaped louvers 9 is mounted in slots 8 in inverse fashion to allow air to be metered through slot 8 and into the liner chamber between the louvers and liner wall, and arranged end-to-end with a slight space between each to provide for ex-

pansion. Louvers 9 may be made in any desired manner which will occur to those skilled in the art. In Fig. 2 is shown a louver structure which has been found very satisfactory in actual use. Horizontal piece 10 is fixed as by welding 11 to upright piece 12. Piece 12 is also notched as at 13 to receive bridge 14 which rests in the notch 13 perpendicular to part 12. The height of bridge 14 and the depth of notch 13 are so adjusted that when the louver is placed in slot 8 as shown in the drawing and the bridge fixed in the notch, the bridge will rest on the outer wall of liner 2 and hold the louver in proper relationship with the slot 8 and liner wall 2. To provide or compensate for differential expansion between the liner wall and the louver or deflecting arrangement, the latter is made in a number of sections 9 which are welded to the liner as shown in Fig. 2 at 15. The other end is fitted to the adjacent louver section for slight longitudinal movement by means of pins 16 which fit loosely into holes drilled in the horizontal portion of the louver. In a chamber about four and one-half inches in diameter, end play between louver sections of about one-sixty-fourth inch is adequate.

The louvers and combustor liner may be constructed of any heat resistant metal. Preferred are stainless steel, calorized or stainless steel clad copper and Inconel, an alloy having 12%–14% Cr, 78%–80% Ni, and 6%–8% Fe.

The space between the upright portion of the louver or deflecting means and the liner wall and the space between the horizontally disposed portion of the louver will vary with the size of the combustor. The width of the space between the edge of slot 8 and the louver upright may vary from 0.014 to 0.03 and preferably about 0.0055 of the inner diameter of the liner. The distance between the liner and the horizontal part of the louver may vary from about 0.003 to 0.01 of the liner diameter and preferably is about 0.0055 of the liner diameter.

The number of slots found most preferable in the present combustor in order to provide the necessary cooling is six. However, from five to seven equidistant slots will produce almost as good results. Less than five slots provides inadequate cooling while more than seven produces too much interference and turbulence between air flow from adjacent slots.

Rows of combustion and dilution air inlet holes 17 are provided between the rows of louvers. It has been found that for most efficient operation, the size of these holes should range from about 0.01 to 0.12 of the inner diameter of the liner. The preferred hole size is 0.11 that of the liner diameter.

In operation, fluid fuel is sprayed through nozzle 6 in a conical spray as shown. At the same time air pumped into plenum chamber 4 enters slots 8 and is metered between the louver and liner wall into the liner chamber. That part of the air introduced through louvers located upstream of holes 17 describes a path similar to that shown by the arrows 18 in Fig. 3. As shown, entrant air sweeps circumferentially over the inner liner surface, being held against the wall by centrifugal force. As the air from two adjacent slots meets, the air streams flow radially inward toward the center of the chamber as shown. At a point near the center of the chamber the streams reverse and flow radially outward toward the low pressure area under the louver from which the particular stream emanated.

Combined with the above air stream flow is

that shown in Fig. 4. Here the air entering air inlet hole 17 nearest the nozzle is shown as flowing radially inward toward the center of the chamber where part of it turns and proceeds toward the nozzle as typified by arrows 19 and 20, sweeping up any unburned fuel particles. The other part of the air stream proceeds downstream and forms a tore as indicated by arrow 21. Air which is entrant through other holes downstream describes paths as shown. A more detailed description of the formation of torous regions within the combustion chamber will be found in application Serial No. 750,015, filed May 23, 1947, now Patent 2,601,000, and assigned to the same assignee as the present application.

The first air inlet hole 17, it will be noted, is located some distance downstream from the nozzle. This distance, about one and one-half times the inner chamber diameter, is maintained in order that such entrant air will not chill the primary combustion area which extends to the first inlet hole 17, but will be preheated before it reaches that region to combine with air from the louvers in the primary combustion zone. Since the primary air obtained from the louvers is also heated by convection and radiation, the temperature of the gases in the primary combustion region is maintained at a higher temperature than in other combustors. This makes possible improved efficiency and stable combustion with a reduced oxygen volumetric concentration as low as 15% instead of the usual 21% found in air.

The primary combustion region or zone is one of gas preheating, high energy mixing and calm burning. That region just downstream of the first air inlet holes is called the secondary combustion zone and is one of more violent mixing and burning. This zone covers roughly the middle third of the combustor where air issuing from the louvers is entrained in that issuing from the air inlet holes as it reaches the holes and produces a violent torous region of burning gases. The last third of the combustor comprises a diluting zone wherein the burned gases are diluted with air from the louvers and holes and reduced to a temperature which will not damage any mechanism such as turbine blades which are to be driven by the gases.

The present method of wall cooling and additional utilization of the cooling air for combustion and diluting makes possible the elimination of hot spots in the liner and chamber and produces a uniform skin temperature. With an average exhaust temperature of 1500° F., the exhaust gas temperature variation across the chamber is not over 150° F. Under the same conditions the liner wall temperature ranges from 850° F. to 950° F.

The pressure drop in the present combustor is about 2.3 per cent. The combustion efficiency ranges from 99 per cent at 19 per cent by volume oxygen concentration in the inlet air to 98 per cent at 15 per cent oxygen concentration.

The present combustor is also characterized by ease of ignition, stability of combustion over wide fuel feed ranges and lack of smoke.

The present apparatus is capable of burning any type of fluid fuel including gaseous fuels, kerosene, the various fuel oils, including Bunker C oil, alcohol, and other similar organic fuels and powdered coal.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combustion apparatus for burning fluid

fuel, a liner of substantially circular cross-section closed at one end and open at the other end for the discharge of hot combustion gases, means for introducing fuel into said liner adjacent the closed end thereof, means for igniting the fuel, means for cooling the inner wall of said liner comprising a plurality of axially disposed slots in said liner extending from the fuel introducing means to nearly its discharge end, each of said slots having associated therewith deflecting means for deflecting air entering the slots circumferentially over the inner surface of the liner, said deflecting means comprising a plurality of T-shaped members mounted in inverse fashion in said slots and in end-to-end spaced relationship to compensate for relative axial expansion between the liner and said deflecting means, the distance between the upright portion of the deflecting means and the edge of the slots being 0.014 to 0.03 that of the liner diameter and the distance between the horizontally disposed portion of the deflecting means and inner surface of the liner being 0.003 to 0.01 that of the liner diameter.

2. In combustion apparatus for burning fluid fuel, a liner of substantially circular cross-section closed at one end and open at the other end for the discharge of hot combustion gases, means for introducing fuel into said liner adjacent the closed end thereof, means for igniting the fuel, means for cooling the inner wall of said liner comprising a plurality of axially disposed slots in said liner extending from the fuel introducing means to nearly its discharge end, each of said slots having associated therewith deflecting means for deflecting air entering the slots circumferentially over the inner surface of the liner, said deflecting means comprising a plurality of T-shaped members mounted in inverse fashion in said slots and in end-to-end spaced relationship to compensate for relative axial expansion between the liner and said deflecting means, the

distance between the upright portion of the deflecting means and the edge of the slots being 0.007 that of the liner diameter and the distance between the horizontally disposed portion of the deflecting means and the inner surface of the liner being about 0.0055 that of the liner diameter.

3. Combustion apparatus for burning fluid fuel comprising a liner of substantially circular cross-section closed at one end and open at the other end for the discharge of hot combustion gases, means for introducing fluid fuel into said liner adjacent the closed end thereof, means for igniting the fuel, means for introducing combustion and cooling air into said liner comprising from five to seven axially disposed equidistant slots in said liner extending from near the fuel introducing means to nearly its discharge end, said slots having associated therewith means for deflecting air entering said slots circumferentially over the inner surface of said liner, said deflecting means comprising T-shaped members mounted in inverse fashion in said slots with the vertical portion extending upward through said slots in spaced relationship with the edges of said slots, the horizontal portion of said member forming a restricted passage with the inner surface of said liner.

ROY W. ABBOTT.

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