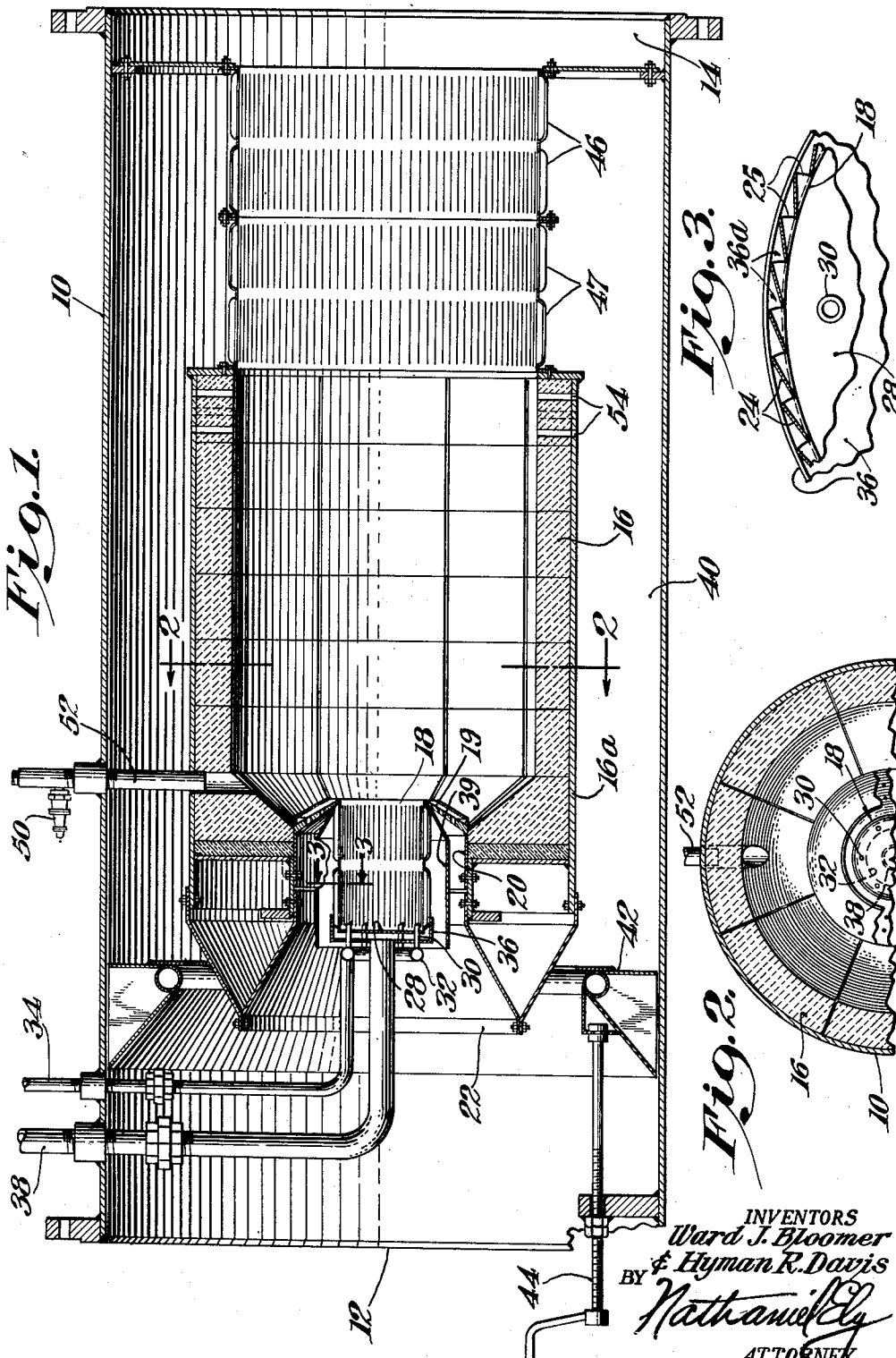


W. J. BLOOMER ET AL

COMBUSTION CHAMBER WITH BAFFLE MEANS TO CONTROL SECONDARY AIR

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COMBUSTION CHAMBER WITH BAFFLE
MEANS TO CONTROL SECONDARY AIR

Ward J. Bloomer, Westfield, N. J., and Hyman R. Davis, Jackson Heights, N. Y., assignors to The Lummus Company, New York, N. Y., a corporation of Delaware

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This invention relates to power plants of the gas turbine type and more particularly to the fuel burner and combustion chamber therefor. It is a continuation-in-part of our copending application Serial No. 98,214, filed June 10, 1949.

It is known that the development of the gas turbine has been dependent to a large extent on the supply of hot products of combustion with such uniformity of temperature as to establish efficient operation and with the particular advantage of minimum maintenance and long time runs. Various types of combustion chambers have been used in which the fuel is supplied under pressure and mixed with air and thereafter diluted to a suitable temperature for operation in the turbine but it has been found that the uniformity of temperature is unsatisfactory. It is to be understood that a gas turbine operates under such conditions that it is particularly sensitive to excessive temperature and where there is a spread of several hundred degrees it is necessary to maintain average operating conditions well below the theoretical maximum.

The particular type of burner and combustion chamber contemplated herein is not only more efficient in combustion than these heretofore available but it also provides a uniformity of temperature of the gas discharge which is unusual for the high heat capacity installations characteristic of gas turbines. Our improved combustion chamber also has the advantage of being adaptable to various fuels which include gas, distillate and the heavy residual fuels which have not successfully been burned in similar combustion chambers. It is also somewhat simpler than our prior construction and is a commercial adaptation of the prior invention.

Further objects and advantages of our invention will appear from the following description of a preferred form of embodiment thereof taken in connection with the attached drawing in which:

Fig. 1 is a substantially central vertical cross section taken through the burner.

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Figs. 2 and 3 are transverse cross sectional views taken substantially on the lines 2—2 and 3—3 of Fig. 1 respectively.

As described in our copending application and as generally known, the power plant accessories of a gas turbine normally include a blower or compressor for the combustion supporting gas, usually air, a burner or mixer for mixing the air and fuel, a combustion chamber and an air diluting device. Our present invention concerns the burner, the combustion chamber and the air dilution device, all of which are conveniently mounted in a casing 10. The combustion supporting gas, hereinafter referred to as air, is supplied under pressure to the casing inlet 12, and the desired products of combustion are discharged at 14. Although this casing is represented as being horizontal, it is independent of gravitational forces and may be at any desired angle to the horizontal.

Within this casing 10 is the combustion chamber or flame tube formed by the refractory lining 16. While this is preferable, it is to be understood that the chamber may be formed solely by the shell 16a which may be made of cobalt-nickel or chrome-nickel alloys.

One end wall of the combustion chamber is adapted to receive the burner or mixer in the form of a tuyere which serves to mix the air and fuel and to discharge the combustible mixtures into the combustion chamber in a unique manner. More specifically the tuyere 18 is annular and preferably a cylindrical member, the side wall of which is provided with blades 24 which may be stamped out of the wall or be formed in any other equivalent manner. These blades, which are tangentially disposed, form converging air paths or slots 25 extending into the tuyere.

The tuyere 18 is provided with apertured face plate 19 extending to windbox 20 which is simply a circular shell which may be provided with a cone shaped baffle 22 to divert some of the air entering the inlet end 12 of the casing into the combustion chamber 16 and some into the sur-

rounding air duct 40. As will be appreciated by reference to the drawing, air entering the casing inlet 12 and passing through the windbox 20 will pass through the air paths 25 between the tuyère blades into the tuyère. The angularity of the blades and the available air pressure is such that a highly compact rotating air column sufficient to create a vortex is thus formed within the tuyère. Continued supply of air of course forces the air as an annular stratum adjacent the tuyère wall into the combustion chamber 16.

Fuel is introduced to this rotating air column in either or both of two ways as desired. Preferably a light fuel such as distillate or gas may be introduced through line 38 and the feed pan 36 as hereinafter described and thence into the air stream as it passes between the blades 24 into the tuyère and the heavier fuels may be introduced from line 34 through the closed end 28 of the tuyère as by the use of one or more nozzles 30. These nozzles, which are in communication with a distributing ring 32 are preferably arranged near the outer wall of the tuyère and may extend about $\frac{1}{4}$ " into the tuyère itself.

The uniform distribution of fuel by the external fuel feed regardless of angularity of the casing with respect to the horizontal is accomplished by engaging the side wall of the feed pan 36 with the outer edges of the tuyère blades whereby a peripheral series of small fuel openings 36a are formed. This establishes a highly effective distribution of the fuel adjacent the outer edge of the tuyère so that as the air flows through the openings 25 between the blades it picks up the fuel exposed in the peripheral slots and carries it into the internal vortical air column. Alternatively the air will pick up the fuel from the end of the nozzles 30 to establish a highly intimate air-fuel dispersion within the tuyère. This is discharged as an annular column adjacent to the tuyère wall and thus into the combustion chamber 16 in which the combustion actually takes place. A skirt 39 surrounding the tuyère 18 may be found desirable to maintain controlled velocities of the air entering the tuyère and thereby preventing possible disentrainment as described and claimed in the copending application of Bloomer, Serial No. 66,445, filed December 21, 1948, now Patent No. 2,560,074.

The amount of air which passes over the tuyère blades when burning gaseous fuels is preferably 10% to 20% in excess of the stoichiometric amount normally required for combustion and when burning liquid fuels 40% to 50% excess air over that stoichiometrically required is most effective and to establish the desired vortical effect in the tuyère, the velocity of the entering air should be in the range of 50 feet per sec. to 150 feet per sec. This requires a pressure drop of from 6 inches to 16 inches water gauge. As a result, the fuel-air mixture is thus discharged as a hollow column with a substantial rotational effect.

Within the combustion chamber we establish a closed pattern type of flame by limiting the diameter of the chamber 16 to approximately $1\frac{1}{2}$ to 3 times the tuyère diameter and providing a length of about 2 to 4 times the diameter of the tuyère, excellent flame of great stability is thus formed due in part to the rotary nature of the flame on an axis coinciding with the axis of the tuyère but also due to the presence of both internal and external eddies which tend to rotate the flame on itself in a plane cutting through the axis.

These eddies result from the linear ejector action of the outgoing annular strata which causes vortices of flame gases on either side of the concentric stream. With no rotation, these are closed annular vortices recycling the inflammable mixture back to the source and igniting and reigniting it. With rotation, further stabilizing is achieved as the flame pattern and the vortices are changed from closed loops by the tangential velocity of the tubular strata issuing from the tuyère and the flow lines of the gas in each eddy forms helical lines on a torus. All this permits very high flame velocities without blow-outs. Indeed the greater the issuing velocity the greater the vortical velocities so that the flame may be regarded as stabilizing itself. Complete combustion is thus accomplished in a relatively short length of the combustion chamber.

In most turbine practice it is necessary to reduce the temperature of the discharge gases to about 1000° F.-2000° F. depending upon the duty and this is accomplished by by-passing a substantial part of the inlet air through the annular passageway 40 between the combustion chamber 16 and the casing 10. A damper 42 may be used to control the amount which passes in this manner, the positioning of such damper being controlled by the shaft 44. This air then passes through the secondary tuyère arrangement shown at 46 and 47.

The secondary tuyère is of the same general construction as the burner tuyère 18 and is especially effective in accomplishing a uniform dilution of the products of combustion. As the secondary air from channel 40 passes into the tangential openings, it is uniformly diffused with the hot products of combustion to establish a uniform temperature of gas discharge. The secondary tuyère must be carefully formed to avoid the formation of a vortex which would form a core however and this may be accomplished by proportioning the air path openings so that there is about only one third the air velocity through the tuyères 46 and 47 that there is through tuyère 18. In addition, some air may enter the combustion chamber through the ports 54 and this air serves to keep the adjacent row of blades cool and helps to prevent warping and distortion of the blades.

It may also be found desirable to reverse the rotational direction of certain of the blades 48, 47 in the secondary tuyère not only with respect to each other but also with respect to the blades in the burner. In a particularly successful operation, the two rows of blades 47 next to the combustion chamber were oppositely pitched with respect to the burner blades, and the next adjacent row of blades in tuyère 46 were in the same direction as the burner blades.

Start up of the burner is readily accomplished by first establishing a circulation of air and then igniting the gas pilot light through ignition port 52 as by spark plug 50. The fuel is next introduced through either line 34 or 38. After the chamber 16 becomes sufficiently heated and stable conditions obtained, the gas into ignition port 52 can be discontinued.

Temperatures at the gas discharge outlet 14 show extremely good distribution with average deviation from the mean of only about 10° F. to 20° F. where the mean was 1350° F. This is strikingly contrasted with other turbine combustion practice in which variations of about several hundred degrees from the mean temperature are often found.

An operating combustion zone of the type described has been found to have the following characteristics:

Summary of operating results

	Gas			
	I	II	III	IV
Heat Liber.....	0.4 MM*	10 MM*	3.3 MM*	11.5 MM*
Oper. Press.....	Atmos.	Atmos.	9.0 p. s. i. g.	40.5 p. s. i. g.
Press. Drop.....	1.4" H ₂ O	10.8" H ₂ O	1.3" H ₂ O	5.0" H ₂ O
Temp. Deviation.....			10° F	20° F
	Diesel Fuel		Bunker "O"	
Heat Liber.....	4 MM*	11 MM*	4.95 MM*	13.3 MM*
Oper. Press.....	13 p. s. i. g.	49 p. s. i. g.	19 p. s. i. g.	41.0 p. s. i. g.
Press. Drop.....	4.7" H ₂ O	7.0" H ₂ O	7.2" H ₂ O	9.8" H ₂ O
Temp. Deviation from Mean.....	10° F	20° F	10° F	20° F

*Million BTU/Hr.

This data shows operation at turn-down ratios of 25 to 1. It also shows high heat liberation of an unusual order which makes the apparatus particularly beneficial for heavy duty industrial gas turbine practice.

We claim:

1. In a combustor of the class described for a gas turbine having an open-ended combustion chamber of substantially circular cross section, an outer housing surrounding said combustion chamber, said outer housing having an inlet for air under pressure, and forming, with said combustion chamber, an air passage, said combustion chamber having air diffuser openings therein in communication with said air passage, and baffle means within said outer housing to control the ratio of air passing through said air passage, the improvement which comprises an air and fuel mixing device adjacent one end of the combustion chamber, said device comprising a first cylindrical tuyère having its side wall formed by a plurality of fixed generally tangentially disposed blades extending substantially throughout the length of the tuyère and forming inwardly directed air inlets therebetween, said first tuyère being open at the end in communication with the combustion chamber and having fuel feeding means within the interior thereof adjacent its opposite end, said fuel feeding means forming an airtight end for the tuyère, means for supplying fuel through said fuel feeding means into said last named end of the first tuyère, means for supplying air from said housing air inlet and directing said air through said first tuyère air inlets between said blades for forming a hollow outwardly moving column adjacent the side wall of said first tuyère and an inwardly moving central core, said column comprising a combustible fuel-air mixture, said combustion chamber having a larger diameter than the outlet of said tuyère but small enough to restrict the lateral component of the fuel-air mixture as it discharges from the first tuyère, said combustion chamber diameter being larger than the tuyère outlet but not more than about three times the diameter of the tuyère outlet, means adjacent the outlet end of the combustion chamber in communication with the air passage to dilute the products of combustion, said diluting means comprising a second cylindrical tuyère having its side wall formed by a series of generally tangentially disposed blades forming inwardly directed air inlets therebetween, and means closing the end of the

annular space formed between the casing and the second tuyère at the discharge end of the second tuyère.

2. A combustor as claimed in claim 1 in which the second tuyère has a plurality of banks of blades, the blades of certain banks being reversed in rotational direction with respect to the blades in the fuel mixing tuyère whereby a destructive vortical effect in the combustion chamber is minimized.

3. A combustor for producing hot gas comprising a casing having an inlet for combustion supporting gas at one end and an outlet for products of combustion at the other end, a first cylindrical tuyère mounted within said casing and spaced from the wall thereof, the side wall of said first tuyère having a plurality of spaced tangentially disposed blades forming air passages therebetween, one end of said first tuyère being closed and the opposite end being open, a primary air windbox within the combustor casing and surrounding the first tuyère whereby the passage of air under pressure into the windbox and through said air passages will form a vortical air column within the first tuyère which moves outward as an annulus adjacent the side wall of the tuyère, fuel feeding means adjacent the closed end of the first tuyère, a fuel conduit extending from said fuel feeding means into the first tuyère, said fuel feeding means being adapted to discharge fuel through the fuel conduit into the vortical air column to become intermixed therewith, a combustion chamber having the shape of a curve of revolution in the path of said discharging vortical air-fuel column with one end in communication with the open end of the tuyère, said combustion chamber being at least 1½ times the diameter of the tuyère opening and having a length at least as great as its diameter, and a second cylindrical tuyère co-extensive with the other end of the combustion chamber, means closing the end of the annular space formed between the casing and the second tuyère at the discharge end of said second tuyère, the side wall of said second tuyère having a plurality of spaced tangentially disposed blades forming secondary air passages therebetween in open communication with the combustor casing whereby secondary air may be directly passed through the secondary air passages to form a rotating air column therein, and uniform blending of secondary air with products of combustion from the first tuyère is accomplished before the gases discharge from the combustor casing outlet.

4. A combustor as claimed in claim 3 in which

the second tuyère has a plurality of banks of blades, the blades of certain banks being reversed in rotational direction with respect to the blades in the fuel mixing tuyère whereby a destructive vortical effect in the combustion chamber is minimized.

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