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COMBUSTION APPARATUS FOR USE WITH TURBINES

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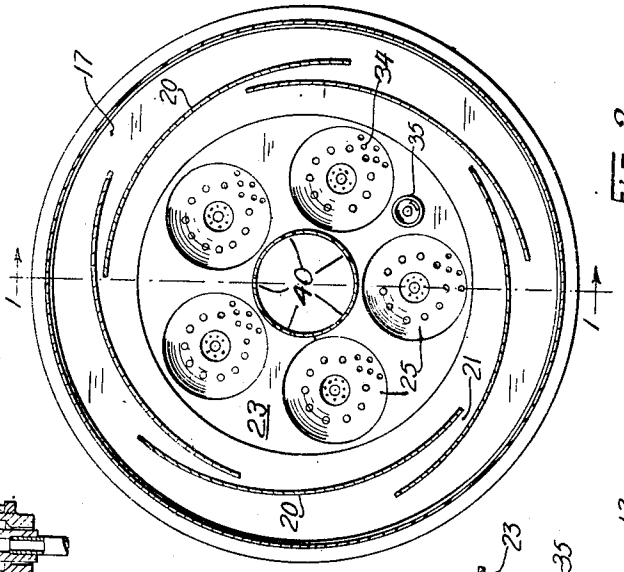

Fig. 2.

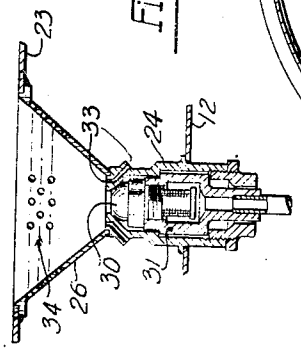

Fig. 3

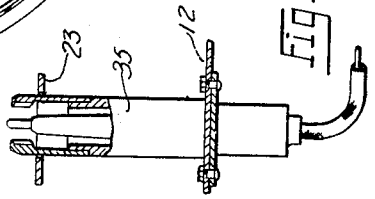

Fig. 4.

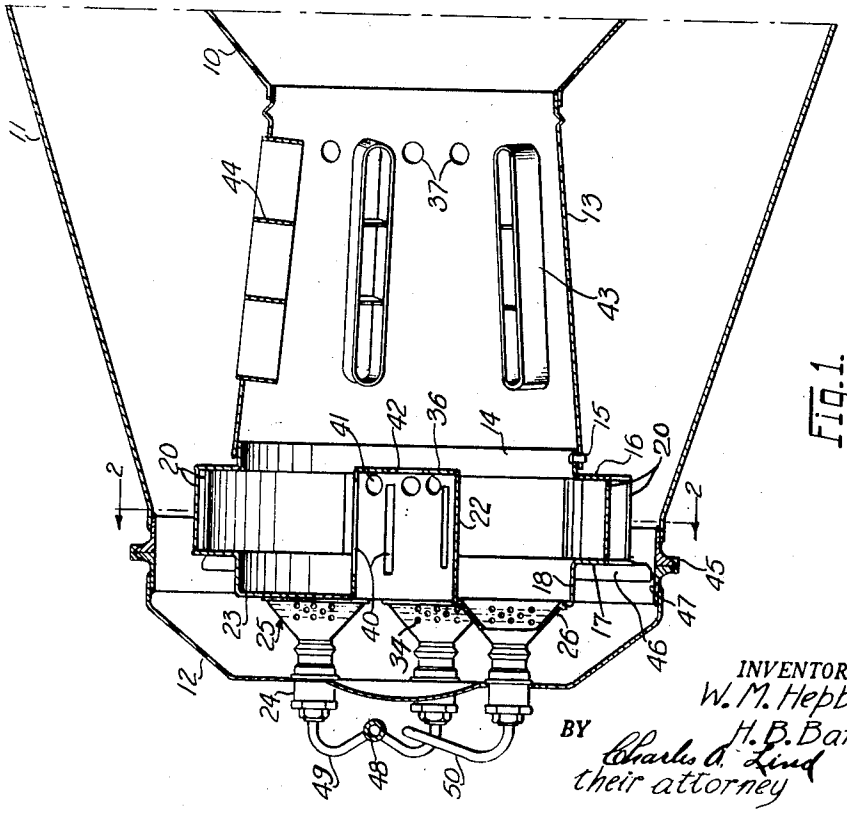

Fig. 1.

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COMBUSTION APPARATUS FOR USE WITH TURBINES

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5 Claims. (Cl. 60—44)

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This invention relates to combustion apparatus for generating an expansive gas for the purpose of actuating a turbine and has for its general object to provide a combustion unit which shall have special utility in environments, as in aircraft, where factors such as compactness, simplicity of operation, and wide operating range are important considerations bearing on its utility. For a consideration of what we believe to be novel and our invention, attention is directed to the following specification and the claims appended thereto.

In the accompanying drawing forming part of this specification—

Fig. 1 is an axial section of the improved apparatus on a plane through line 1—1 of Fig. 2.

Fig. 2 is a transverse cross section on line 2—2 of Fig. 1.

Fig. 3 is an enlarged axial section of one of the burners of which the improved apparatus is comprised.

Fig. 4 is an enlarged fragmentary view showing the manner of mounting a spark plug for igniting the fuel.

In the accompanying drawing, reference numeral 10 may be considered as indicating the gas intake end of a gas turbine, not shown, and 11 as indicating a relatively large size air duct or casing to which air for combustion and dilution purposes is supplied by an air compressor, not shown, the casing having an end wall 12. This particular arrangement of parts may be said to illustrate one environment where the present invention has special utility.

The improved combustion apparatus comprises an annular combustion zone or chamber wherein the fuel is burned in a special way and also a dilution zone wherein the hot products from the combustion zone are diluted with air to cool said products to a safe temperature for turbine operation. The dilution zone is a cylindrical tunnel formed by an annular wall or conduit 13 which is interposed between the intake end 10 of the gas turbine and the discharge end 14 of the preceding combustion chamber. The tunnel 13 will ordinarily be connected to the said end 14 by a slip joint which includes a radial pin 15 which extends into a notch in the rim of the tunnel to hold the latter from turning.

The structure which defines the annular combustion chamber comprises a central annular wall or shell 22 which at its outer end is in open communication with the air duct 11 adjacent the end wall 12 thereof. The inner end of the shell is closed by a wall 36 having a central air outlet aperture 42. The side wall of the shell has a

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series of slot type air outlet ports 40 and also has a ring of ordinary round outlet ports 41. As will more fully appear hereinafter, this particular pattern of air outlet ports in the side of the shell 22 helps to promote complete combustion of the fuel introduced into the space about the shell by a circular row of burners 25 mounted on the end wall 23 of the combustion chamber. As is best shown in Fig. 2, the several slot-type air outlet ports 40 are in planes which extend between the projected axes of adjacent burners.

The outer boundary wall of the combustion chamber comprises two axially spaced cylindrical portions 14 and 18 of the same diameter, these two portions being separated by a radially enlarged portion which forms a channel between said portions 14 and 18 for a purpose presently appearing. The side walls of said channel are indicated at 16 and 17 and they are held in fixed spaced relation by a plurality of curved air vanes 20 arranged in spaced overlapping relation to form a plurality of tangential air inlets 21 to said channel whereby the air from said inlets will initially rotate in said channel before entering the combustion zone proper. It will be understood that the supply of air to said inlets comes from the surrounding air casing 11.

Each of the burners 25 comprises a conical dome 26 which covers an individual firing opening in the front end wall 23 of the combustion chamber. To the small end of each dome there is welded a tubular extension 24 which projects through and is welded to the end wall 12 of the air casing 11. The primary purpose of the extension 24 is to serve as a housing for an atomizing nozzle 30 for spraying liquid fuel into the dome. The nozzle will ordinarily be carried by a chambered fitting 31 to which liquid fuel is supplied under elevated pressure (say, 350 lbs. per square inch) by a supply pipe, the fitting with nozzle attached being so mounted as to permit removal from the extension 24 to permit cleaning of the nozzle.

Each dome 26 is multi-apertured for the admission of air from the air casing 11 for the purpose of aerating the fuel from the fuel nozzle to a sufficient degree to insure that the fuel will begin to burn within the confines of the dome before entering the annular combustion space into which all of the burners discharge. A first set of air inlet ports for this purpose is indicated at 33 as a circular row at the small end of the dome. The air from these particular ports 33 tends to break up the initial spray pattern from the fuel nozzle. A second set of air inlet ports 34 extends around

the dome as a relatively wide band so that the air flows into the dome through these ports as through a sieve. The fuel is ignited in any preferred way as by a spark plug **35** which projects into the main combustion zone through the end wall **23** thereof, the plug being of a length to permit it to be supported by the end wall **12** of the air casing so that it may be readily removed for replacement purposes. To simplify the ignition problem, one of the burners is first ignited, after which the fuel may be turned on to the other burners. The burner which is to serve as a pilot has a fuel supply line **50** independent of the other burners. The other burners may have their fuel lines **49** in connection with a common fuel supply manifold **48**.

As previously stated, the air from the elongate air ports **40** in the central annular wall **22** of the combustion chamber tends to flow radially across the annular combustion zone in planes which extend between the projected axes of adjacent burners **25**. The oncoming streams of fuel from adjacent burners **25** may, therefore, be said to be separated from each other by a radially moving layer of air which, of course, tends to accelerate combustion of the next adjacent fuel. On the other hand the air which enters said combustion zone through the tangential air inlets **21** in the outer wall of said zone tends to form as it were, a ring of air about all of the fuel streams from the several burners and, of course, this air tends to accelerate combustion of the next adjacent fuel. Moreover, because this ring of air is rotating, it tends to impart rotation to the entire fluid contents of said zone. The jets of air from the elongate ports **40** and from the round ports **41** tend to oppose this rotation to some extent but on the other hand this opposition results in greater turbulence in the rotating mass of fluid with consequent more complete intermixing of the air and fuel than would otherwise be the case. The overall result is rapid combustion of the fuel in a space which is relatively short in relation to its diameter.

Because the product gas as produced in the annular combustion chamber is at too high a temperature for safe turbine operation, diluting air is added to the product gas as it flows through the tunnel formed by the conduit **13**. To this end a circumferential row of air inlet holes **37** is provided in the wall of the conduit adjacent its discharge end. However, the air from this source and, it may be added, also from the air port **42** in the end wall **36** of the central cylindrical shell **22** of the combustion chamber is only a relatively small portion of the total amount of dilution air required. The major portion of the dilution air comes from a plurality of circumferentially spaced flat air ducts or nozzles **43** which project a relatively short distance radially into the conduit, each duct being so arranged that its major transverse axis extends lengthwise of the conduit. Rigidity may be imparted to each duct by axially extending spacer elements **44** between the side walls thereof. The air ducts **43** are made flat axially of the tunnel **13** so that they may serve as longitudinally extending baffles for impeding the free rotation of the product gas coming from the annnular combustion zone to such extent as to insure sufficient turbulence in and rapid aeration of the core of the gas to produce rapid combustion of any residual fuel in said core. It will therefore be understood that although the zone defined by the tunnel **13** is primarily a dilution zone it also serves as a secondary combustion zone for residual fuel. This breaking up of the free rotation of the advancing gas also helps to equalize the temperature thereof throughout its cross sectional area. By reference to the drawing it will be seen that the air nozzle **43** extends a relatively short distance into the tunnel **13** in relation to its diameter. There is nothing critical about this distance except that if the nozzles extend too far into the tunnel the leading end of the nozzle is likely to be damaged by overheating by the oncoming product gas.

The end wall **12** of the casing **11** and the casing itself are interconnected by a split joint **47** the parts of which are held together in any preferred way by a clamping ring **45**. The split joint permits the combustion unit to be readily withdrawn from its setting within the air duct **11**. Radial spacing fingers **46** may be provided between the combustion unit at its annular wall **18** and the air duct **11** at its split joint **47** to assist in centering the combustion unit in said duct.

From the foregoing description it should now be clear that the present invention provides a combustion apparatus which is well adapted for its intended purpose.

What is claimed as new is:

1. In combustion apparatus, the combination of means comprising concentric walls forming an annular combustion zone which is closed at one end and open at its other end for the escape of product gas therefrom, means for introducing fuel into said zone through the closed end thereof, means for introducing air into said zone on a tangent to produce a whirling body of air therein, means for introducing air radially into said zone through the inner of said walls, the outer of said walls having a circumferentially extending channel wherein the air entering said zone on a tangent initially rotates, and a conduit forming a tunnel from the outer wall of said zone for receiving the product gas therefrom.

2. In combustion apparatus, the combination of means comprising concentric walls forming an annular combustion zone which is closed at one end and open at its other end for the escape of product gas therefrom, a circular row of burners for introducing fuel into said zone through the closed end thereof, means comprising the inner of said walls for introducing air radially into said zone in planes extending between adjacent burners so that fuel streams advancing from adjacent burners will tend to be separated from each other by the radially moving jets of air, means for producing a rotating body of air in said zone, the outer of said walls having a circumferentially extending channel wherein the air entering said zone on a tangent initially rotates, and a conduit forming a tunnel from the discharge end of said combustion zone to receive the product gas therefrom.

3. In combustion apparatus, the combination of means comprising coaxial annular walls and an end wall forming an annular combustion zone which is closed at one end by said end wall and open at its other end for the escape of product gas therefrom, the said end wall having a series of firing openings, burner means for introducing fuel into said zone through the said firing openings, means for introducing air into said zone on a tangent to produce a whirling body of air therein, the outer of said annular walls having a circumferentially extending channel wherein the air entering said zone on a tangent initially rotates, means comprising the inner of said annular walls for introducing air into said zone, and a conduit

forming a tunnel extending from the discharge end of said zone to receive the product gas therefrom.

4. In combustion apparatus, the combination of means comprising coaxial annular walls and an end wall forming an annular combustion zone which is closed at one end by said end wall and open at its other end for the escape of product gas therefrom, the said end wall having a series of firing openings, burner means for introducing fuel into said zone through said firing openings, means for introducing air into said zone on a tangent to produce a whirling body of air therein, the outer of said annular walls having a circumferentially extending channel wherein the air entering the said zone on a tangent initially rotates, a conduit forming a tunnel extending from the discharge end of said zone to receive the product gas therefrom, a series of baffles extending into said tunnel in a direction tending to retard rotation of the advancing product gas, and said baffles being radially apertured to serve as nozzles for introducing air into said tunnel.

5. In combustion apparatus, the combination of means comprising coaxial annular walls and an end wall forming an annular combustion zone which is closed at one end and open at its other end for the discharge of product gas therefrom, a

series of burner means mounted on said end wall to fire into said zone through firing openings in said end wall, the burner means comprising a dome forming a cover for each of said firing openings and a spray nozzle for spraying liquid fuel into said dome from the small end thereof, the walls of said dome being multi-apertured for the admission of air into the space encompassed by said dome, and means comprising the outer of said annular walls for introducing air into said zone on a tangent to produce a whirling body of air therein.

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