

Feb. 12, 1963

S. B. WILLIAMS ET AL  
GAS TURBINE COMBUSTION CHAMBER

3,077,076

Filed Jan. 20, 1960

2 Sheets-Sheet 1

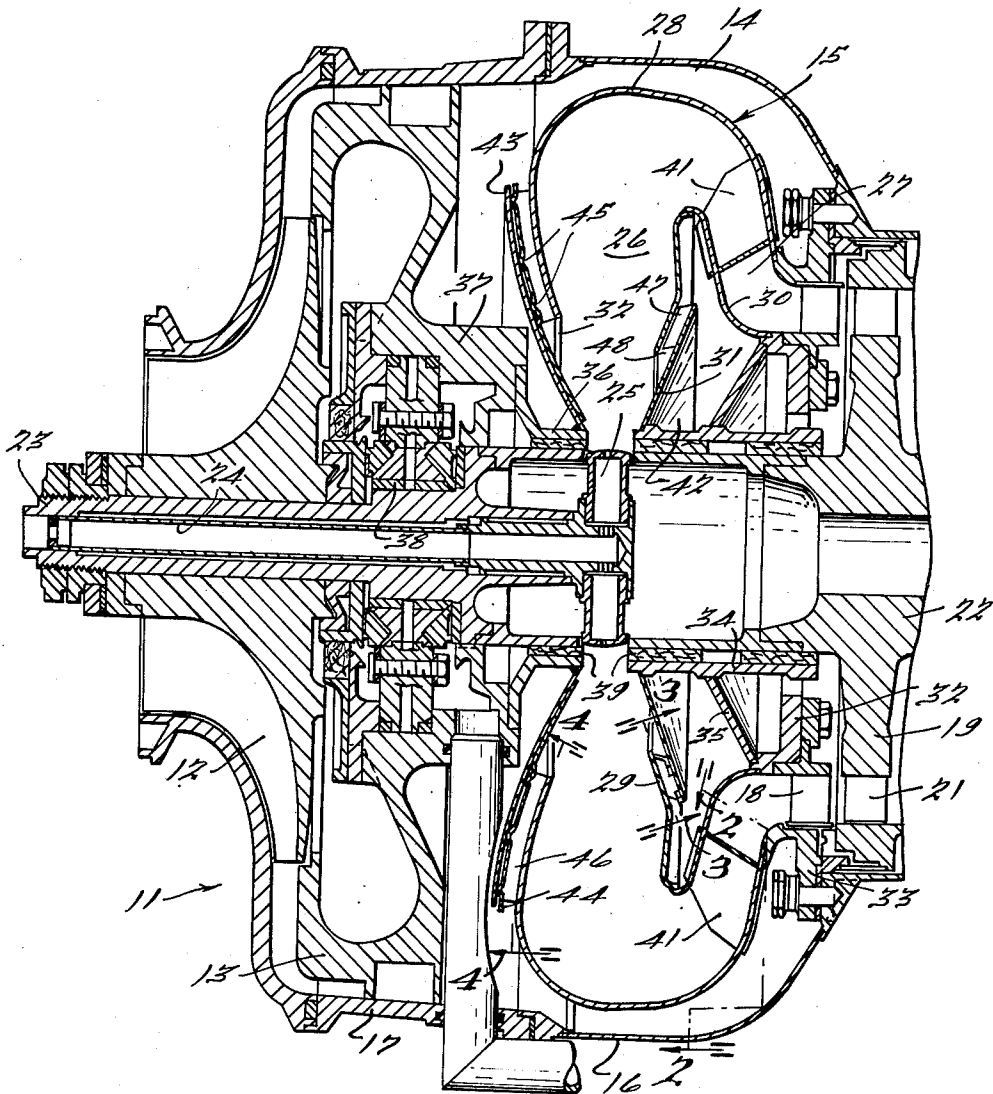


FIG. 1.

INVENTORS.  
Sam B. Williams  
Jack J. Benson.

BY

Harmon, Dickel & Perci  
ATTORNEYS.

Feb. 12, 1963

S. B. WILLIAMS ETAL

3,077,076

GAS TURBINE COMBUSTION CHAMBER

Filed Jan. 20, 1960

2 Sheets-Sheet 2

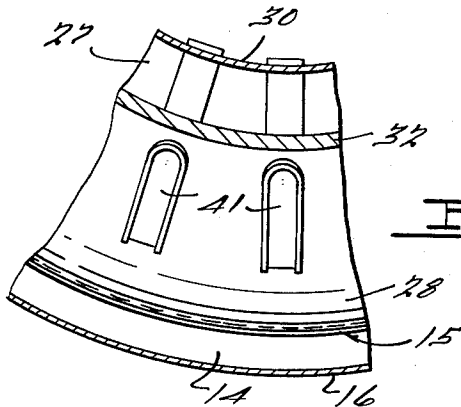


FIG. 2.

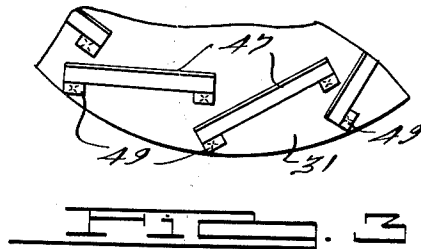


FIG. 3.

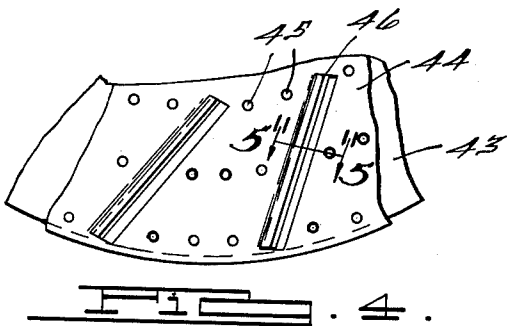


FIG. 4.

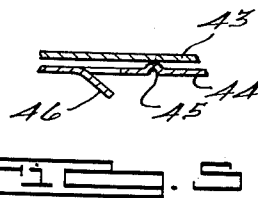


FIG. 5.

INVENTORS.  
Sam B. Williams.  
Jack J. Benson.  
BY  
Harness, Dickey & Poirer  
ATTORNEYS.

1

3,077,076

## GAS TURBINE COMBUSTION CHAMBER

Sam B. Williams and Jack J. Benson, Birmingham, Mich.,  
assignors to Williams Research Corporation, Birmingham,  
Mich., a corporation of Michigan

Filed Jan. 20, 1960, Ser. No. 3,692

2 Claims. (Cl. 60—39.36)

This invention relates to gas turbine combustion chambers, and more particularly to the construction of combustion chambers of the annular type having a centrifugal type of fuel feeding system.

It is an object of the invention to provide a novel and improved combustion chamber for gas turbines which has improved fuel consumption characteristics, decreases the presence of exhaust odors and increases fuel burning efficiency.

It is another object to provide an improved gas turbine of this nature serving to minimize the effect of temperature changes during operation which might cause unevenness in burning or in temperature distribution in different parts of the chamber.

It is also an object to provide an improved gas turbine combustion chamber of the above character which is of simple, inexpensive and compact construction and requires little maintenance during operation.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings.

FIGURE 1 is a side elevational view in cross-section showing the novel combustion chamber incorporated in a gas turbine;

FIGURE 2 is a fragmentary cross-sectional view taken along the line 2—2 of FIGURE 1 and showing the radially extending air ports which pass through the exit end of the chamber;

FIGURE 3 is a fragmentary cross-sectional view taken along the line 3—3 of FIGURE 1 and showing the positioning of the vanes in the annular opening at the outlet side of the chamber; and

FIGURE 4 is a fragmentary cross-sectional view taken along the line 4—4 of FIGURE 1 and showing the formation of the inclined vanes adjacent the back of the combustion chamber; and

FIGURE 5 is a fragmentary cross-sectional view taken along the line 5—5 of FIGURE 4 and showing the vane inclination.

In general terms, the invention comprises an annular combustion chamber coaxial with the compressor shaft of a gas turbine which may be supplied with fuel through slinger ports which eject the fuel outwardly by centrifugal force into the chamber. The combustion chamber has a main portion which extends radially outwardly and an annular outlet portion which extends radially inwardly from one side of the main portion, the outlet portion leading to the nozzle vanes. Radially extending ports are arranged in circumferentially spaced relation and pass through the outlet portion so that compressed air may be delivered to the annular space at the forward end of the combustion chamber radially inwardly of the outlet portion as well as directly into the combustion chamber adjacent the outlet portion for secondary combustion purposes.

The combustion chamber is formed of a plurality of annular plates of a curved or dished shape, the plate forming the back of the combustion chamber having a central clearance opening into which primary combustion air may flow adjacent the fuel slinger ports. The gas turbine casing adjacent the back of the combustion chamber is in spaced parallel relation therewith, and a

2

plurality of guide vanes are disposed in this space and serve to provide a swirling effect to the air flowing toward the central combustion chamber opening, this swirl being preferably in the direction of shaft rotation.

The forward portion of the combustion chamber is formed of first and second annular plates the adjacent portions of which are in spaced overlapping relation so as to form an annular channel of inclined cross-sectional shape through which compressed air delivered by the radial ports may flow. A set of vanes are disposed in this space between the overlapping plates of the forward combustion chamber portion, these vanes likewise being inclined so as to impart a whirling motion to the inlet air. Both sets of vanes are preferably supported and shaped in such a manner as to prevent the possibility of warping or damage due to extreme changes in temperature during operation. The annular passages in which the vanes are located are also of such size as to minimize their sensitivity to any plate warpage which might occur due to such temperature changes, so that the air delivery and temperature distribution in the combustion chamber will be maintained substantially constant.

Referring more particularly to the drawings, a gas turbine generally indicated at 11 is shown in FIGURE 1, this gas turbine being provided with a radial compressor 12 at one end thereof leading to a diffuser 13. The diffuser outlet leads axially to a compressed air chamber 14 in which is disposed a combustion chamber generally indicated at 15. The combustion chamber is enclosed by a housing 16 which is secured to and extends from diffuser housing 17. The combustion chamber leads to a set of nozzle vanes 18 which in turn lead the combustion gases to a first stage turbine wheel 19 having blades 21. This wheel is fixed to a shaft 22 which extends centrally through the annular combustion chamber and is connected to compressor 12. The central portion of shaft 22 extending from its outer end 23 has an axial fuel passage 24 through which fuel is adapted to flow toward a plurality of radially extending fuel nozzles 25.

Combustion chamber 15 comprises a main portion 26 extending radially outwardly from fuel slinger ports 25 and an outlet portion 27 which leads radially inwardly from the outer end of the main portion on one side of the combustion chamber, as seen in FIGURE 1. The combustion chamber is fabricated of a plurality of annular plates, plate 28 forming the outer surface of the chamber while plates 29, 30 and 31 form the inner surface of the chamber adjacent the forward end thereof. A central opening 32 is provided on the rear portion of plate 28, this opening connecting chamber 26 with high pressure inlet chamber 14. The cross-sectional shape of plate 28 is outwardly convex, the convexity being relatively slight on the rear and forward portions of the combustion chamber and somewhat greater around the central portion. The cross-sectional shape of inner plates 29 and 30, which are joined along their adjacent edges, presents a sharper convexity toward the combustion chamber at the mid-portion of the two plates (that is, adjacent their juncture). Plates 28 and 30 together form outlet passage 27, the outer edges of these plates being joined to annular members 32 and 33 between which nozzle vanes 18 are disposed. A sleeve 34 is secured to member 32 by means of a frustoconical annular plate member 35 which also acts to separate spaces at different pressures as will be later seen. Another sleeve member 36 spaced axially from sleeve 34 so as to provide clearance for fuel nozzles 25 is secured to housing portion 37 which carries bearing means 38 for the compressor end of shaft 22. Sleeves 34 and 36 support seals 39 engageable with shaft 22.

The outer portion of plate 31 and the inner portion of plate 29 are in substantial overlapping relation for rea-

sons later described, the space between the plates being substantially uniform and of sufficient size to prevent significant alteration of the slot width should warpage of the plates occur due to temperature changes. The plates adjacent the overlapping portions are so formed as to create an annular channel the cross-sectional shape of which is inclined inwardly toward the turbine axis, that is, toward the fuel nozzle outlets as seen in FIGURE 1.

The outlet section 27 of combustion chamber 15 is provided with a plurality of radially extending ports 41 which are of U-shaped cross-section as seen in FIGURE 2. These ports are in circumferentially spaced relation and lead from chamber 14 to both the inner chamber 42 adjacent the forward wall of the combustion chamber and the combustion chamber itself, the latter connection being approximately at the start of outlet portion 27. This port construction in itself is shown and described in copending application Serial No. 626,274, filed November 13, 1956, and assigned to the assignee of the present application.

A shield 43 of annular shape is disposed rearwardly of the rear portion of combustion chamber 15 in spaced parallel relation with the rear portion of plate 28. The inner edge of plate 43 is secured to sleeve 34 and the plate is slightly concave toward the combustion chamber, the outer edge of the plate being disposed at an intermediate position within chamber 14. A thin doubler plate 44 is secured to plate 43 by means of a plurality of dimples 45 formed in the doubler plate and attached to plate 43 so as to create a slight space between plates 43 and 44 for insulative purposes.

A plurality of vanes 46 are pressed or stamped out of doubler plate 44 as best seen in FIGURES 1 and 4. Vanes 46, like doubler plate 44, are relatively thin, and the vanes have a curved slope in a direction such that the compressed air passing inwardly toward opening 32 as indicated by the arrows in FIGURE 1 will be given a swirling motion, the inner ends of vanes 46 being closely adjacent the outer portion of opening 32. Preferably, this motion is in the direction of rotation of the shaft 23, and when this swirling air enters opening 32 it will mix intimately with the fuel being sprayed from nozzle 25. Vanes 46 are also shown (FIGURE 5) as being inclined in an axial direction so that should their outer edges engage closely adjacent plate 28 due to increases in temperature, the vanes will be able to deflect without damage. It should be observed that vanes 46 could be mounted in other ways than that shown, it being understood that the illustrated arrangement will prevent any problem of vane warpage from arising due to changes in temperature of the parts. The fact that vanes 46 are on cooler doubler plate 44 rather than attached to plate 28 of the combustion chamber will mean that the vanes will be less subject to extreme temperature changes and subsequent strain or deformation. Preferably, the exit angle of the vanes 46 should be about 15° to 35° inclined from a tangent for optimum swirling and mixing effects.

A set of vanes 47 are also provided in the annular space 48 between the overlapping portions of combustion chamber plates 29 and 31. These vanes are illustrated as comprising separate strips of metal secured by welding tabs 49 at opposite ends of each vane to plate 31. As before, the vanes may be mounted in other ways within the space 48, it being noted that the illustrated arrangement mounts the vanes on cooler plate 31 rather than plate 29. As with vanes 46, vanes 47 are curved and inclined in approximately the same fashion and in the same direction of rotation so that air entering space 48 will be imparted with a swirling motion, enhancing the mixing with fuel sprayed from nozzles 25. The outer edges of vanes 47 are closely adjacent the inner portion of plate 29, and the vanes are inclined so that any expansion which causes their outer edges to contact plate 29 will not result in any plate warpage or distortion.

It should be noted that, as seen in FIGURE 1, the air flow through ports 41 will continue through chamber 42 and will enter annular chamber 48 where the swirling motion will be imparted. As noted above, the width of opening 48 should be sufficient to prevent any substantial change in its cross-sectional area during operation of the gas turbine. As an example, a combustion chamber was constructed in which the outer diameter of plate 31 was 4¼" and the inner diameter of plate 29 was 3½", thus resulting in approximately ¾" overlap. In this case, a width of ⅜" was provided for slot 48 with satisfactory results.

The solidity of vanes 46 and 47, that is the ratio of their length to the pitch between blades, was found to give good results at a figure of about 2 or 2.5.

In operation, compressed air delivered from compressor 12 and diffuser 13 will enter chamber 14 and will flow in the direction of the arrows around combustion chamber 15. As the compressed air enters the space between doubler plate 44 and combustion chamber plate 28, a whirling or spinning motion will be imparted to it by blades 46, so that when this air enters opening 32 it will mix intimately and efficiently with fuel sprayed from nozzles 25. Similarly, air entering chamber 42 at the forward end of the combustion chamber through radial ports 41 will flow into annular slot 48, a spinning or whirling motion being imparted to this air by vanes 47. This air likewise will mix well with the fuel emitted from the nozzle. As a result of this construction, it has been found that substantially enhanced fuel consumption characteristics have been attained and that exhaust odors have been greatly reduced. Sensitivity of the gas turbine to changes in temperature, this sensitivity having been at least partially caused by non-uniform changes in air flow into the combustion chamber, has been minimized by this improved construction, and generally improved burning properties have resulted.

While it will be apparent that the preferred embodiment of the invention disclosed is well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. In combination, a gas turbine having a rotatable shaft, an annular combustion chamber surrounding said shaft and having an inwardly facing opening for receiving outwardly moving fuel, a rear surface on said combustion chamber, a shield in spaced parallel relation with said rear surface, said rear surface and shield being inclined inwardly toward the central portion of said combustion chamber, a plurality of vanes mounted on said shield in circumferentially spaced relation, said vanes being slightly spaced from said rear surface and inclined to impart a swirling motion to air moving inwardly within said space, said vanes extending from said shield at an acute angle whereupon contact of said rear combustion chamber surface with said vanes will result in yielding of said vanes and a reduction in said acute angle, and an air inlet opening at the inner portion of said rear combustion chamber surface.

2. The combination according to claim 1, further provided with an annular opening at the forward side of said combustion chamber, and a second set of vanes in said annular opening inclined so as to impart a spiral motion to the air passing therealong.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

|           |           |               |
|-----------|-----------|---------------|
| 2,495,311 | Beaver    | Jan. 24, 1950 |
| 2,856,755 | Szykowski | Oct. 21, 1958 |

##### FOREIGN PATENTS

|         |               |               |
|---------|---------------|---------------|
| 585,343 | Great Britain | Jan. 15, 1943 |
|---------|---------------|---------------|