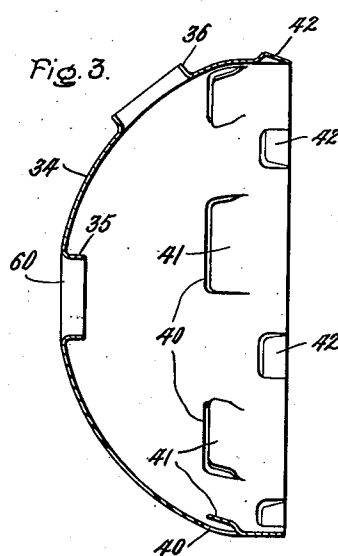
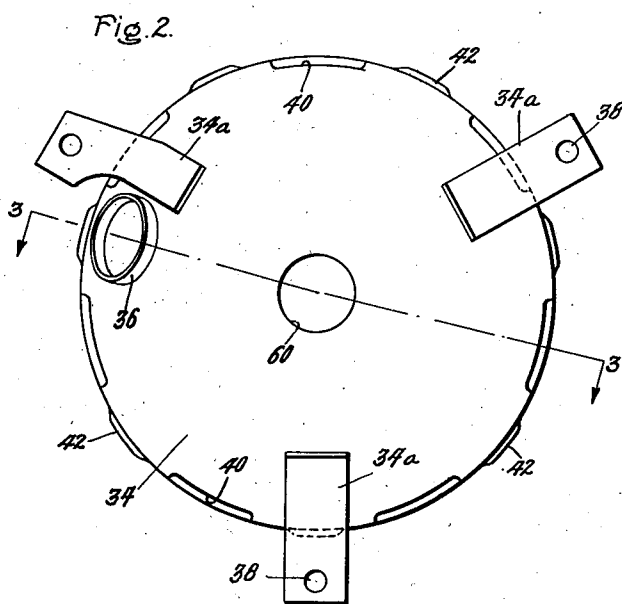
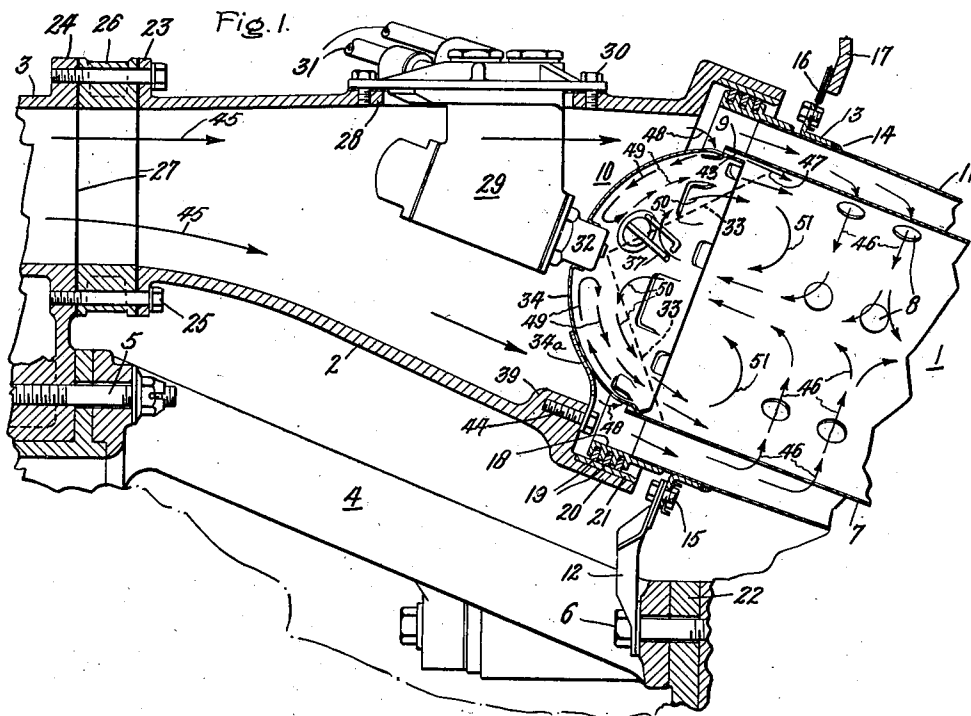


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W. L. BLATZ
HEMISPHERICAL COMBUSTION CHAMBER END DOME HAVING
COOLING AIR DEFLECTING MEANS
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HEMISPHERICAL COMBUSTION CHAMBER
END DOME HAVING COOLING AIR DE-
FLECTING MEANSWalter L. Blatz, Scotia, N. Y., assignor to General
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My invention relates to combustion chambers, such as are employed in thermal powerplants. It is particularly applicable to gas turbine powerplants, for instance those used for the jet propulsion of aircraft.

This invention constitutes an improvement in one component part of the combustion chamber disclosed in application Serial No. 750,015, filed May 23, 1947, in the name of Anthony J. Nerad, and assigned to the same assignee as the present application. Said application is a continuation-in-part of application Serial No. 501,106, filed September 3, 1943, now abandoned. My invention is specifically an improved end dome arrangement for combustion chambers similar to those described in the above defined applications.

An object of the invention is to provide an improved dome structure forming the closed end of a combustion chamber.

A further object is to provide a combustion chamber end dome arrangement which is comparatively free from trouble with detrimental carbon deposits, and which at the same time gives improved operating characteristics and extended range to the combustion chamber arrangement in which it is used.

A further object is to provide a combustion chamber end dome which may be readily removed and serviced, repaired, or replaced.

Further objects and advantages will be apparent from the following description taken in connection with the accompanying drawing, in which Fig. 1 is an assembly view showing in section my improved combustion chamber end dome arrangement; Fig. 2 is an end view in elevation of the dome by itself; and Fig. 3 is a sectional view of the dome taken on the plane 3—3 in Fig. 2.

Referring now to Fig. 1, my invention is disclosed in connection with a combustion chamber indicated generally at 1, which is supplied with combustion air by a transition piece or "air adapter" 2 from a compressor discharge passage defined by walls 3, which may be part of a centrifugal or axial flow compressor (not shown). A suitable framework indicated generally at 4 forms part of the main frame of the powerplant, supporting a turbine casing 22 in spaced relation to compressor housing 3.

The general arrangement and operation of the combustion chamber 1 is more particularly disclosed in the above-mentioned applications of Anthony J. Nerad. An aircraft gas turbine powerplant having a compressor-combustion chamber-turbine-frame assembly similar to that

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partially represented in Fig. 1 is more completely disclosed in an application Serial No. 525,391, filed March 7, 1944, in the name of Dale D. Streid, issued December 9, 1947 as Patent No. 2,432,359. It should be understood that my invention is equally applicable to other gas turbine powerplants, for instance those disclosed in applications Serial No. 506,930, filed October 20, 1943, now Patent No. 2,479,573, and Serial No. 541,565, filed June 22, 1944, both in the name of Alan Howard.

The details of the compressor, turbine, and supporting framework are not necessary to an understanding of the present invention, but it may be noted that the compressor casing 3 is secured by suitable threaded fastenings 5 to the frame 4, which is in turn secured to the turbine support casing 22 by threaded fastenings 6.

The combustion chamber 1 consists of a cylindrical liner 7 open at both ends and having a plurality of rows of circumferentially spaced combustion air inlet openings 8, the nearest row of openings being axially spaced from the open end portion 9 of the liner. The arrangement of the air inlet openings is more fully disclosed in the above-mentioned applications of Anthony J. Nerad. The liner 7 may be supported at its "downstream" end by various types of suitable supports (not shown), while the "upstream" end 9 is supported by the dome 10 in a manner which will appear hereinafter.

Surrounding liner 7 is an outer housing 11, which may be supported by suitable brackets 12 secured to the frame 4 by threaded fastening 6. The housing 11, like liner 7, is circular in cross section, or substantially so, and may be supported by an annular member 13 having a flange welded to the outer housing as indicated at 14, and secured to bracket 12 by a suitable threaded fastening 15. The member 13 may also be secured to a baffle 16 of flexible material, such as leather, and arranged to engage a cooperating baffle member 17 in such a manner as to prevent undesired circulation of air around the outside of the combustor housing 11. This baffle arrangement may be seen in more detail by reference to the above-mentioned application of Dale D. Streid.

It will be apparent that the liner 7 and outer housing 11 define an annular inlet chamber to which air is supplied from compressor housing 3 by the air adapter 2.

A flexible joint and air seal are provided between the end of housing 11 and the adjacent enlarged end of air adapter 2. This sealed joint comprises a piston ring seal member 18 welded

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to the open end of housing 11. The member 18 is provided on its exterior surface with a number of grooves containing piston rings 19 arranged in conventional manner. The inner diameter of the rings is greater than the minimum diameter of the grooves, so that the rings are permitted some radial movement in order to take up an eccentric position relative to member 19.

It will be appreciated by those skilled in the art that liner 7 must be made of very carefully selected metallic alloys able to withstand the high temperatures encountered. The outer housing 11 is not subject to such extreme temperatures and may be made of various suitable alloy steels. The piston ring member 18 may be made of stainless steel and the rings 19 may be of cast iron. Since air adapter 2 is cast of light metal such as aluminum or magnesium alloy, the end portion 20 may be provided with a bushing 21 of harder material to provide a bearing surface for the piston rings 19. Bushing 21 may be shrunk or pressed into the air adapter. It should be noted that the outer housing 11 is rigidly supported in fixed position relative to the turbine casing 22 by the bracket 12 and other suitable means at the downstream end of housing 11 (not shown).

It will be appreciated by those familiar with gas turbine powerplants that housing 11 is during operation heated by radiation from liner 7 to a temperature considerably above that of the frame 4 and compressor housing 3.

The small end of air adapter 2 is provided with a transversely extending flange 23 aligned with an attachment flange 24 on compressor housing 3. The flange 23 is secured to attachment flange 24 by an annular row of threaded fastenings 25 with a cylindrical spacer member 26 inserted therebetween, for a purpose which will appear hereinafter. It will be obvious that suitable gaskets 27 may be employed, if found necessary to prevent air leakage.

It will be seen from the above that air adapter 2 is rigidly fixed to the comparatively cool compressor casing 3, while the heated housing 11 is fixed relative to the turbine casing 22. The above described piston ring seal between housing 11 and air adapter 2 is intended to permit limited axial, radial, and angular displacement between the end of housing 11 and the associated end of air adapter 2. By permitting such displacements, assembly of the powerplant is facilitated and differential thermal expansion during operation is permitted.

Secured by fastenings 30 to a mounting pad 28 on air adapter 2 is a fuel spray nozzle 29. The nozzle shown is of the duplex type, which is more fully disclosed in an application Serial No. 622,604, filed October 16, 1945, in the names of C. D. Fulton and D. C. Ipsen. The specific structure of nozzle 29 is disclosed in an application of G. N. Miles, Serial No. 669,072, filed May 11, 1946, now Patent No. 2,524,820, and assigned to the assignee of the present application. However, it should be understood that the specific type and structure of the fuel nozzle used is not essential to an understanding of the present invention. It is sufficient to note that fluid fuel is supplied to the nozzle by conduits 31 and discharged from nozzle tip 32 in the form of a substantially conical spray pattern indicated by the dotted lines 33.

The end dome to which my invention specifically relates is shown in assembled relation in Fig. 1 and by itself, to an enlarged scale, in

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Figs. 2 and 3. This end dome comprises a thin wall 34, preferably formed from suitable temperature-resisting sheet metal, and shaped substantially in the form of a hemisphere. Adjacent the "pole" of the hemisphere is a central opening 60 for receiving the discharge end or tip 32 of the fuel nozzle. The wall around this opening may be provided with an axially extending flange 35 dimensioned to slidably engage and snugly fit the nozzle tip 32. A second flanged opening 36 is provided to receive the electrode end of a suitable spark-plug 37, shown in assembled relation in Fig. 1. It will be understood that the bushing of the spark-plug may be threadedly received in an opening (not shown) in the wall of the air adapter 2.

Circumferentially spaced around the dome, and welded thereto, are radially extending support arms 34a. The tips of these arms are provided with openings 38, so that the arms can be secured to mounting bosses 39 in the air adapter (see Fig. 1) by suitable fastening means such as cap screws 44.

Radially spaced from the central opening 60 is a circumferential row of air inlet openings 40. It will be readily apparent from Fig. 3 that these openings are formed by making U-shaped cuts in the dome and deflecting the tongues 41 so formed inwardly.

Around the rim or "equator" of the hemispherical dome is a row of circumferentially spaced "dimples" 42 formed by striking the material of the dome outwardly in a manner which will be obvious from Fig. 3. The dimpled outer circumference of the dome is so dimensioned as to form a free sliding fit with the interior surface of liner end portion 9, as may be readily seen from Fig. 1. The portions of the circumference of the dome between the dimples 42 define with the liner end portion 9 a plurality of circumferentially spaced arcuate slots 43.

The method of assembly of my improved combustion chamber dome is as follows. The fuel nozzle 29 is assembled to the air adapter 2 through the opening defined by mounting pad 28. The dome 10 is then assembled with the central flange 35 slipping over the nozzle tip 32, and the arms 34a are secured to bosses 39 by the threaded fastenings 44. Then, assuming that the liner 7 and housing 11, compressor housing 3, framework 4, and turbine casing 22 have been previously assembled, the air adapter is moved transversely into position in the space between the piston ring assembly 18, 19, and the compressor discharge casing 3. The axial length of the spacer 26 is so selected that sufficient space is provided to permit ready insertion of the air adapter in this manner (when spacer 26 is removed). Once the end portion 20 of the air adapter is slid over the piston rings 19 it will be obvious that air adapter 2 can be moved axially with respect to the combustion chamber 1, the dimpled circumference of dome 10 sliding into the open end 9 of liner 7, until sufficient clearance is provided at the other end of the air adapter to insert spacer 26 transversely into the position shown in Fig. 1.

To remove the air adapter for inspection and servicing of the fuel nozzle and the end dome, the above procedure is followed in reverse; that is, screws 25 and spacer 26 are removed, and the air adapter 20 is moved axially with respect to the combustion chamber 1 until end portion 20 disengages from the piston rings 19, the circumference of dome 10 meanwhile being withdrawn

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from end portion 9 of liner 7. The air adapter assembly can then be removed in a transverse direction. In some cases it may facilitate assembly and disassembly to rotate air adapter 2 (after removing spacer 26) about an axis parallel to the axis of the combustion chamber, such rotation causing the end flange 23 to move radially outward so as to easily clear the attachment pad 24 on compressor casing 3.

It will be observed that the brackets 12, as well as the air baffle 16, are secured to the outer housing 11 by means which are independent of the piston ring sealed slip-joint 18, 19, 20. Thus the air adapter 2, complete with fuel nozzle 29 and dome 10 can be inserted and removed from the powerplant simply by removing the spacer 26, and without disturbing other parts of the combustion chamber and associated parts. This considerably facilitates maintenance of the powerplant because of the frequency with which the air adapter must be removed for servicing the nozzle and dome and for cleaning, repairing or replacing the liner 7.

Besides lending ease of assembly and disassembly, the piston ring sealed slip-joint 18, 19, 20 has the additional advantage of providing the flexibility needed for permitting differential thermal expansion and compensation for misalignment.

Referring now to Fig. 1, the operation of the apparatus is as follows. Air from the compressor discharge casing 3 flows in the direction of the arrows 45 into the annular space defined between liner 7 and housing 11. From this space it flows through the combustion air inlet openings 8 in the manner indicated by the arrows 46, as more specifically described in the above-mentioned applications of Anthony J. Nerad. Some air also flows along the inner surface of liner 7 through the arcuate slots 43 formed between dimples 42. This flow is in the direction of the arrow 47 in Fig. 1 and forms a thin sheet of pure comparatively cool air so as to "insulate" the inner surface of liner 7 from contact with hot products of combustion containing unburned fuel particles. If such particles were permitted to contact the comparatively cool surface of liner 7, they would be deposited in the form of unburned carbon. Thus, it will be seen that the air flow 47 serves both to cool liner 7 and to insulate it from contact with unburned carbon particles which might otherwise be deposited thereon.

Air also flows as represented by arrows 48 through the slots 40 formed by the inwardly struck tongues 41. Slots 40 form nozzles which direct a comparatively thin sheet of cooling and insulating air inwardly toward the nozzle tip 32 in the direction of arrows 49. This cooling and insulating air flows over the exposed end surfaces of nozzle tip 32, thereby also keeping them free from carbon deposits. It will be apparent from the arrows in Fig. 1 that this cooling and insulating air after passing over nozzle tip 32 flows reversely in the same direction as the combustion air flow represented by arrows 50. The combined flow of primary combustion air 50 and cooling and insulating air 49 then flows axially through liner 7, some of it recirculating in the manner indicated by arrows 51 to form the toroidal flow path or "tore" more specifically described in the above-mentioned applications of Anthony J. Nerad. The portion of the combined air flow 49, 50 which does not recirculate in the manner of arrows 51 flows axially down the liner 7 passing between the circumferentially spaced radial jets 46 of inflowing combustion air.

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It has been found by much testing and actual operating experience, that combustion chambers of the type desired in the above-mentioned Nerad applications embodying my improved dome with the construction described herein have a number of important advantages. The dome and nozzle tip are kept within safe temperature limits and free of carbon deposits. Also, the flame in the combustion chamber appears to be more stable over a wide range of difficult operating conditions. While it is not definitely known, I believe this to be due to the fact that the reversely flowing cooling and insulating air 49 forms what might be considered an "elastic boundary" for the combustion tore 50, 51. It is believed that as the operating conditions vary, the thickness of the insulating layer 49 changes somewhat with a corresponding change in the volume occupied by the combustion tore 50, 51. This appears to have a beneficial effect on the combustion process.

It will be understood by those skilled in this art that the liner 7 and the end dome 10 are most subject to deterioration during the operation of the powerplant and therefore require most frequent inspection, servicing, and replacement. It will be seen that my invention provides a simple end dome which is easy and cheap to fabricate and can be readily serviced when in need of cleaning, repair or replacement. The convenience of disassembling the arrangement facilitates frequent inspection and servicing and thus lengthens the time interval between major powerplant overhauls.

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

1. An end dome for a combustion chamber of the type having an open-ended liner comprising a wall defining a substantially hemispherical surface having a central opening arranged to receive fuel injecting means adjacent the pole of the dome and having a circumferential row of openings, deflector means including a wall portion spaced from said wall in cooperative relation with each of said openings to form a plurality of nozzles facing said central opening for directing a comparatively thin sheet of cooling and insulating air over the inner surface of the dome inwardly toward said central opening.

2. In a combustion chamber for a thermal powerplant the combination of a first wall defining an open ended liner of substantially circular cross section, an outer housing surrounding said liner, a dome adapted to form a closed end wall of the liner, and means supporting the dome from said housing, the dome comprising a wall defining a substantially hemispherical surface with a central opening located adjacent the pole of the dome, fuel injecting means supported in said housing and having a discharge end cooperatively associated with said central opening, said dome also having openings therethrough radially spaced from said central opening and arranged to direct a comparatively thin sheet of cooling and insulating air over the inner surface of the dome inwardly toward the central opening, the outer circumference of said dome having circumferentially spaced projections arranged to engage the inner surface of the adjacent end of said liner so as to define therewith circumferentially spaced arcuate slots arranged to direct a thin sheet of cooling and insulating air axially along the inner surface of said liner toward the open end thereof.

3. An end dome for an open-ended combustion

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chamber liner comprising a wall defining a substantially hemispherical inner surface and having a central portion defining an opening adapted to receive the discharge end of fuel injecting means, said wall also defining a plurality of openings radially spaced from the central opening, deflector means including a wall portion spaced from said wall in cooperative relation with each of said openings to form a plurality of nozzles facing said central opening for directing a comparatively thin sheet of air over the inner surface of the dome radially inwardly toward said central opening.

4. An end dome for an open-ended combustion chamber liner comprising a wall defining a substantially hemispherical inner surface and having a central portion defining an opening adapted to receive the discharge end of fuel injecting means, said wall also defining a plurality of openings radially spaced from the central opening and arranged to direct a comparatively thin sheet of air over the inner surface of the dome radially inwardly toward said central opening, and a plurality of projections spaced around the outer circumference of the dome and arranged to engage the inner surface of the liner to define therewith a plurality of circumferentially spaced arcuate slots.

5. An end dome for a cylindrical combustion chamber liner comprising a thin wall defining a substantially hemispherical surface and having a central opening adapted to receive fuel injection means, the rim portion of said wall forming circumferentially spaced projections adapted to engage the inner surface of the liner, and other portions of the wall intermediate said central opening and said rim portion defining nozzles adapted to direct cooling and insulating air in a thin sheet along the inner surface of the dome radially inwardly toward said central opening.

6. An end dome for a cylindrical combustion

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chamber liner comprising a thin wall defining a substantially hemispherical surface and having a central opening surrounded by an axially extending flange adapted to slidably engage the outer circumferential surface of fuel injection nozzle means, the rim portion of said wall forming circumferentially spaced projections adapted to engage the inner surface of the liner, and other portions of the wall intermediate said central opening and said rim portion defining nozzles adapted to direct cooling and insulating air in a thin sheet along the inner surface of the dome radially inwardly toward said central opening.

WALTER L. BLATZ.

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