

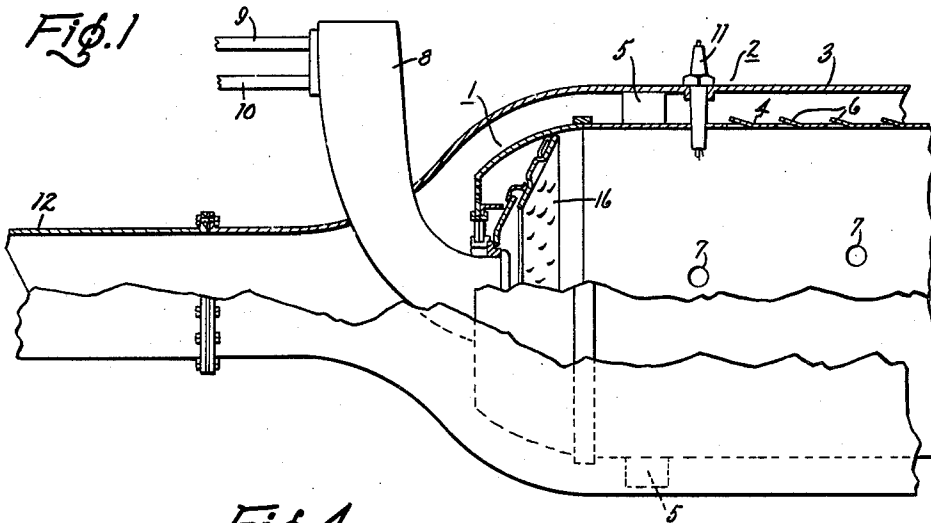
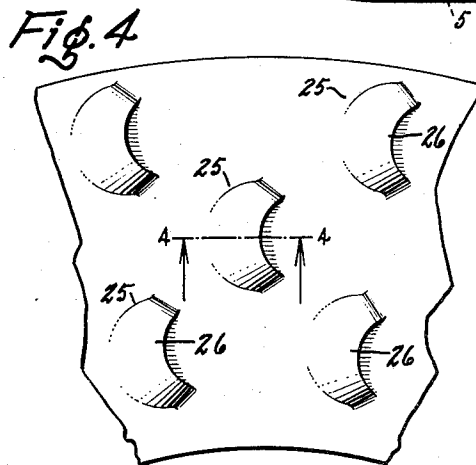
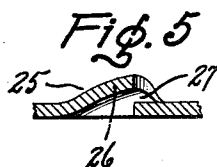
July 1, 1958

R. W. MACAULAY
END CAP FOR COMBUSTOR

2,840,989

Filed Sept. 15, 1955

2 Sheets-Sheet 1



Inventor
Robert W. Macaulay
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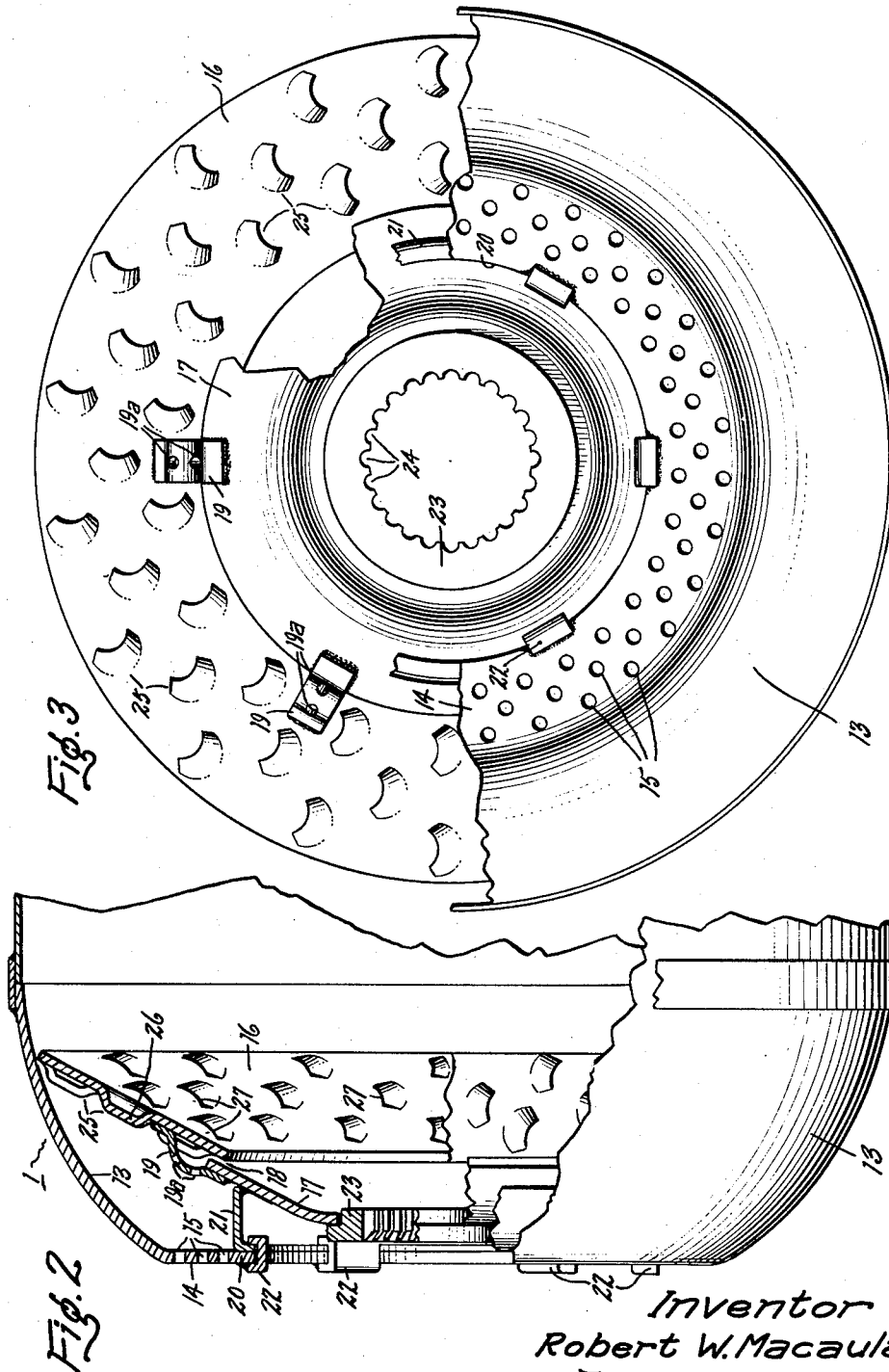
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END CAP FOR COMBUSTOR

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Application September 15, 1955, Serial No. 534,455

7 Claims. (Cl. 60—39.65)

My invention relates to combustors for the production of a hot working fluid such as combustors for gas turbine power plants. More particularly, my invention relates to an end cap structure forming the upstream or closed end of the liner for such combustors.

Present practice is to make gas turbine combustors of as lightly constructed material as possible consistent with strength requirements and ease of providing louvers or other air-admitting ports. The relatively thin metal structural portions of such combustors must be carefully designed for adequate cooling and resistance to high temperatures and to expansion and contraction forces as well as to deliver the proper amount and proportion of combustion air. These problems, though they are present in burning gas and liquid fuels in general, are particularly aggravated when fuels such as Bunker C oil are used which burn with a highly luminous flame and tend toward the formation of excessive deposits of carbon or so-called coke from carbonized fuel which clog nozzles, ports, sparking devices and other combustor parts and foul the combustor walls creating hot spots making necessary frequent cleaning and shortening the combustor life.

An object of this invention is to provide an end cap for combustor liners which is simple in structure, durable, not subject to carbonization, which compensates for thermal stresses and mechanical vibration occurring during operation and stabilizes the combustor flame.

Briefly stated, my end cap comprises a generally hemispherical annular shroud having air ports therethrough and mounted therein two annular frustum-like segments resiliently arranged in overlapping spaced fashion with the outer edge of the outer segment slidably engaging the shroud and the inner segment connected to the inner edge of the shroud and having in turn at its inner edge a ring adapted to receive a fuel nozzle.

The features of my invention which are believed to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description and the drawing in which Fig. 1 shows the relation of my new end cap to various other components of a gas turbine power plant, Fig. 2 is a detailed cross-sectional view of my invention, Fig. 3 is an end view, partially cut away, of the end cap taken from the upstream direction, Fig. 4 is an enlarged view of a section of the outer segment portion, and Fig. 5 is a cross-sectional view of one of the louvers of Fig. 4 taken along the line 4—4.

Referring to Fig. 1, there is shown my end cap structure 1 in general relation to other portions of a gas turbine power system. The combustor 2 in general comprises an outer shell 3 in which is mounted a combustion liner 4, the liner being held in spaced relationship with shell 3 by suitable means such as supports 5 and forming therebetween a plenum chamber for the passage of combustion, cooling and diluting air into liner

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4 through louvers 6, ports 7, or other apertures formed in the wall of liner 4. The downstream end of liner 4, not shown, is open for the exit of hot working gases produced therein and the upstream end is closed by end cap 1 which will be described in detail hereinafter. The spraying of atomized fuel into combustor liner 4 is provided by a suitable nozzle 8 which has fuel inlet means 9 and also air inlet means 10 if air atomization is used. Sparking or other means 11 is provided for the ignition of fuel in the combustor. Shell 3 is extended upstream beyond liner 4 either integrally or by means of an extension 12 to provide for the introduction of air for the operation of the combustor from a compressor or other source not shown.

Combustors such as that described generally above are well-known and are typified for example by the so-called "Nerad type" combustor set forth in U. S. Patent No. 2,601,000. Others will occur to those skilled in the art. While any suitable nozzle can be used in conjunction with my invention, I prefer one of the swirl type shown in copending application Serial No. 518,602, filed June 28, 1955, by Franz J. Neugebauer et al., now Patent No. 2,801,134, issued July 30, 1957, and assigned to the same assignee as the present application.

Referring to Fig. 2, end cap 1 of my invention has a generally hemispherical annular shaped shroud portion 13 with an inner radially directed portion 14, the latter portion defining a plurality of holes or ports 15 therein for the passage of air therethrough. Mounted within shroud 13 as shown are a larger outer segment 16 and a smaller inner segment 17, each being, in general shape, a frustum of a right circular cone with the larger end thereof directed downstream and with the outer part of the inner segment upstream of and overlapping the inner part of the outer segment in spaced fashion to provide a circular air passage 18 therebetween. Segments 16 and 17, which as extended are parallel or approximately parallel, are resiliently connected by any suitable means such as flexible metal connector 19, one end of which is fixed to segment 16 and the other to segment 17. Preferably, connector 19 is bowed or otherwise shaped to provide for relative movement between the segments due to thermal expansion and the like and may have holes 19a for passage of air therethrough, although they are usually so narrow as not effectively to block any air flow even when continuous. Any number of connectors 19 necessary to hold the segments together can be used, although from four to six are normally adequate. The outer edge of outer segment 16 is in freely slidable contact with the inner wall of shroud 13 so that under thermal expansion and contraction and under the resilient action of connector 19 segment 16 will not buckle or become deformed but will merely adjust itself in relation to the shroud. This slidable contact, as well as the connection afforded by resilient connectors 19, also permits the absorption without damage of mechanical vibrations.

Fixed in any suitable manner to the inner edge 20 of shroud 13 is a cylindrical member or ring 21. A plurality of clips 22 bent securely around the mated edges of the shroud and cylinder serve this purpose very well and six have been found to be sufficient for most installations. Preferably, the clips 22 are welded to shroud 13. Also preferably, they are merely friction fitted to ring 21 to compensate for expansion and contraction of the parts. The downstream edge of ring 21 is connected as by welding to inner segment 17. A nozzle receiving ring 23 is fixedly secured to the inner edge of inner segment 17, a nozzle such as 8 being held in the hole in said ring. About the inner periphery of ring 23 are preferably a plurality of indentations or recesses 24

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which serve to provide a passage for air to cool the nozzle during operative periods.

Formed in outer segment 16 as shown are a plurality of louvers 25. These louvers are arranged in staggered fashion and so that air entering them from upstream will form a continuous film of air over the inner wall of segment 16. I have shown louvers 25 preferably as crescent-shaped with the detached or raised portion 26 in the upstream direction. By making the louvers 25 of the distinctive crescent-shape shown, the air passing through the narrow louver slits 27 sweeps over the lifted crescent-shaped portion 26 of the louver and is spread over the hot downstream wall of segment 16 in a fanwise manner. Since the louvers are arranged in staggered relationship over segment 16, the entire downstream wall of that segment is protected by a cooling film of air. I prefer that louvers 25 be directed with their slits lengthwise in a radial direction around segment 16 as shown in the same direction as the swirl produced by the fuel nozzle, although particular circumstances might dictate that they be otherwise oriented. In an actual combustor it was found that when the louvers 25 were arranged with their slits circumferentially arranged the end cap burned out in about 800 hours, whereas with the louvers arranged as shown with their slits directed lengthwise radially the end cap had not burned out under exactly similar operating conditions at 3,000 hours.

By having the louvers oriented as preferred there is created a vortex of air around the inner periphery of the end cap which, being in motion, resists disintegration at least until it is downstream of the end cap portion, thus efficiently cooling the end cap and a portion of the liner downstream.

When nozzles producing a relatively wide angle spray are used, the vortex of air produced as above also counteracts any tendency for fuel particles or the flame to impinge upon the end cap portion or liner immediately downstream thereof and form carbon and hot spots thereon.

In operation, a part of the air proceeding downstream from conduit 12 is metered through end cap shroud ports 15 in substantially laminar or streamline flow. It will be understood that air entrant into the combustor liner must be metered or limited at some point to attain a fuel-air mixture of proper proportions. I prefer to meter the air at shroud ports 15 rather than at louvers 25 so that the latter may have relatively longer, more easily made openings or slits. A portion of this air spreads outwardly passing through louvers 25. As pointed out above, the vortex of air produced by the air passing through these louvers effectively cools the outer segment and the adjacent portion of the liner, overcomes any tendency of wide angle spray nozzles to direct fuel particles or flame in the relatively cool end cap or adjacent liner walls where they would become carbonized creating hot spots and causing early failure of the relatively thin sheet metal structure even though such parts are made of heat resistant metals. The air vortex produced having a direction of rotation the same as that of the spray produced by the vortex nozzle has a stabilizing effect on the flame in that it serves to provide an air stream of relatively slow downstream velocity, thus allowing the fuel-air mixture to burn efficiently counteracts any tendency of the flame to be carried out of the combustor exit as it would in a fast moving air stream. As a result the hot gas exit temperature distribution is improved.

The remainder of the air entering through ports 15 passes through slot 18 between the inner and outer segments. This air sweeps downward over the downstream face of the inner segment cooling it and preventing the flame from contacting it. At the same time, this downward progressing air provides an intimate fuel air mixture, thus preventing the objectionable coking and long flames which occur when the fuel is not properly mixed with air. In the meantime, air enters apertures or recesses 24 in nozzle ring 23 effectively cooling the nozzle

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and preventing excessive heating of the nozzle which would encourage carbonization or coking of the fuel as it passes therethrough.

The advantages to be realized by the use in combustors of my improved end cap are further evidenced by the fact that the end cap has operated for over 3,000 hours without coking or failure under most stringent conditions in a gas turbine burning Bunker C fuel with the wall temperature at 1300° F. and a flame temperature at over 3800° F.

While I have described certain specific embodiments of my invention, I wish it to be understood that I desire to protect in the following claims all changes or modifications thereto which fall within the spirit and scope of those claims.

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

1. A combustor end cap having a generally hemispherical annular shroud portion, the inner part of said shroud having ports for metering air passing there-through, two annular coaxial segments of different diameters mounted within said shroud in partial overlapping, resiliently connected, spaced fashion with the smaller inner segment upstream of the larger outer segment, the outer edge of said outer segment being in slidable contact with said shroud, means to resiliently connect said inner segment and the inner edge of said shroud, and a nozzle receiving ring having apertures for the passage of cooling air around its inner periphery fixed to the inner edge of said inner segment, said outer segment having a plurality of louvers in overlapping rows therein, said louvers having their slits arranged in a generally radial direction.

2. A combustor end cap comprising an annular shroud having a radially directed inner portion containing ports for metering air therethrough, two coaxial annular segments, each a frustum of a cone mounted within said shroud, said segments being of different sizes and arranged in partially overlapping, resiliently connected, spaced fashion with the inner segment upstream of the outer segment and the larger end of each segment downstream, the outer edge of said outer segment being in slidable contact with the inner wall of said shroud, and means to resiliently connect said inner segment to the inner edge of said shroud, and means defined by said outer segment for passing air therethrough and in a generally circumferential direction over the downstream surface of said outer segment.

3. An end cap for a combustor, said end cap having a generally hemispherical shroud portion having ports for the passage of air therethrough, two partially overlapping spaced annular segments, each a frustum of a cone mounted within said shroud with the smaller end of each segment upstream, the outer edge of the outer segment slidably engaging said shroud, said outer segment being resiliently connected to the inner segment, means to connect said inner segment and the inner edge of said shroud, and a nozzle receiving ring fixed to the inner edge of said inner segment, said outer segment having louvers therein arranged to spread air over the downstream surface of said outer segment in a vortex fashion.

4. An end cap for a combustor, said end cap having a generally hemispherical annular shroud portion, the inner part of said shroud having ports for the passage of air, two partially overlapping, spaced and resiliently connected annular conical segments of different sizes forming a circular aperture therebetween, the smaller end of each segment being upstream of the larger end, and the smaller segment upstream of the larger segment, the outer edge of the larger segment being in slidable contact with the inner surface of said shroud, means to movably connect said smaller segment and the inner edge of said shroud, and a nozzle receiving ring fixed to the inner edge of said smaller segment, said larger segment having therein louvers for spreading air over the downstream

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surface of said segment in a fanwise, generally circumferential direction.

5. An end cap for a combustor, said end cap comprising a generally hemispherical annular shroud portion having a radially directed inner portion containing ports for the passage of air, two coaxial and partially overlappingly spaced annular segments, each a frustum of a cone mounted within said shroud, the larger end of each segment being downstream of its smaller end, the outer edge of the outer segment being in slidable contact with the inner wall of said shroud, the outer segment being resiliently connected to the inner segment, a cylindrical shell connecting said inner segment and the inner edge of said shroud, and a nozzle receiving ring fixed to the inner edge of said inner segment, said outer segment having formed therein a plurality of louvers arranged to spread air in a film over the downstream surface of said outer segment in a circumferential direction.

6. An end cap for a combustor, said end cap having a generally hemispherical annular shroud portion having ports for the passage of air therethrough, two partially overlappingly, spaced annular segments of different sizes, each generally in the shape of a frustum of a right circular cone, mounted within said shroud with the smaller end of each segment upstream and said segments in approximately parallel planes, the outer edge of said outer segment slidably engaging said shroud, said outer segment being resiliently connected to said inner segment, means to movably connect said inner segment and the inner edge of said shroud, and a nozzle ring connected to the inner edge of said inner segment, said nozzle ring having

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apertures in the inner periphery thereof for the passing of air, said outer segment having overlappingly spaced louvers therein for the passage of air therethrough and in a circular fashion over the downstream surface of said outer segment.

7. A combustor end cap comprising a generally hemispherical annular shroud portion having an inner radially directed portion containing ports for metering air therethrough, two annular coaxial segments of different diameters, each in the shape of a frustum, mounted within said shroud in partial overlapping, resiliently connected spaced fashion, with the smaller inner segment upstream of the larger outer segment whereby an annular space is provided for the passage of air between said segments inwardly over the downstream surface of the inner segment, the outer edge of said outer segment being in slidable contact with said shroud, means to resiliently connect said inner segment and the inner edge of said shroud, and a nozzle ring having apertures for the passage of cooling air around its inner periphery fixed to the inner edge of said inner segment, said outer segment having a plurality of louvers circumferentially arranged in overlapping rows, said louvers having their slits arranged in a generally radial direction.

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