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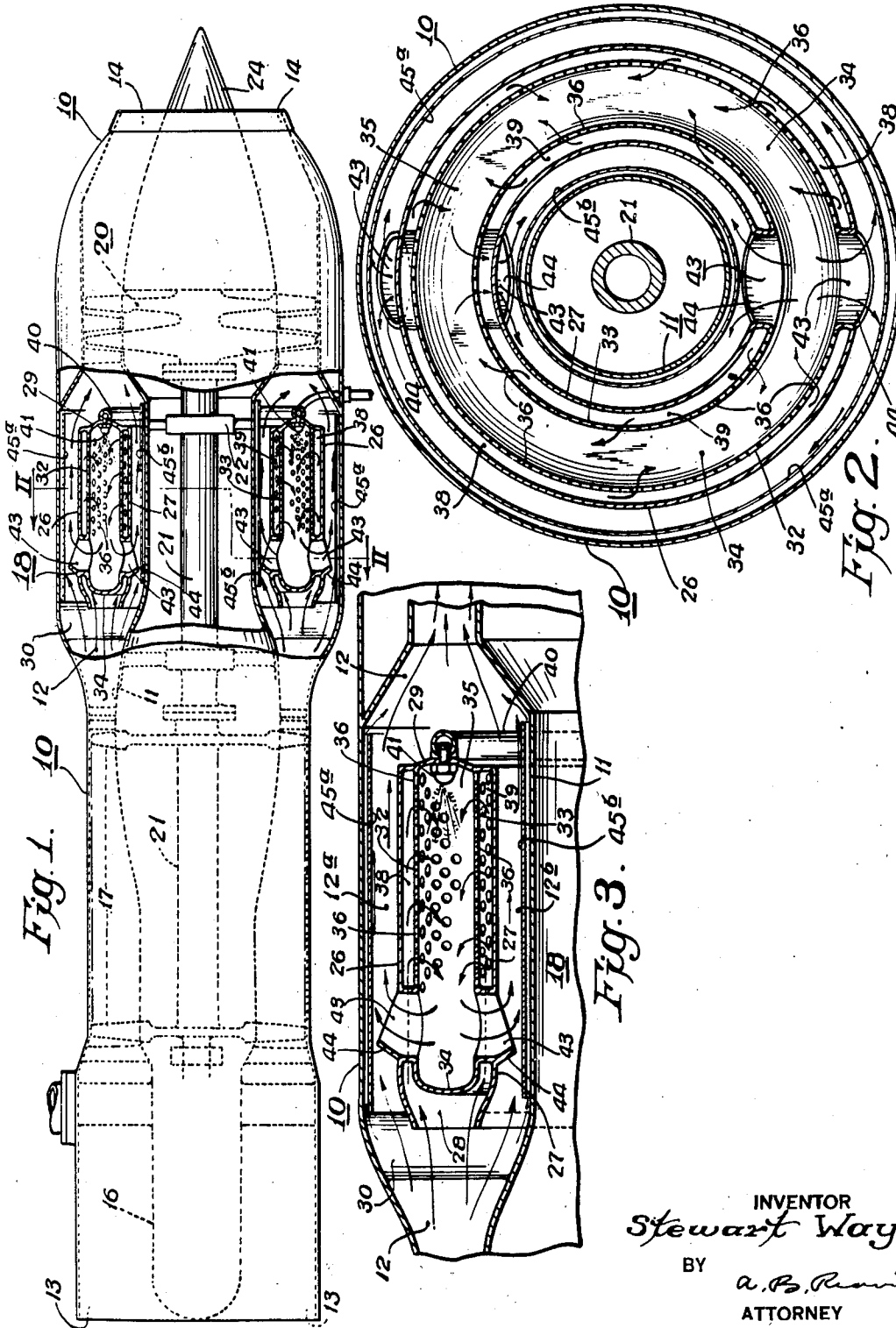
S. WAY

2,498,728

COMBUSTION APPARATUS

Filed May 7, 1948

2 Sheets-Sheet 1



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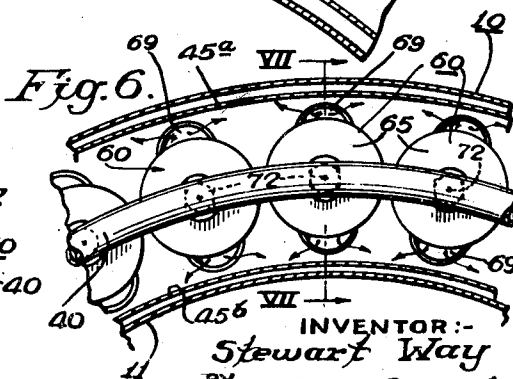
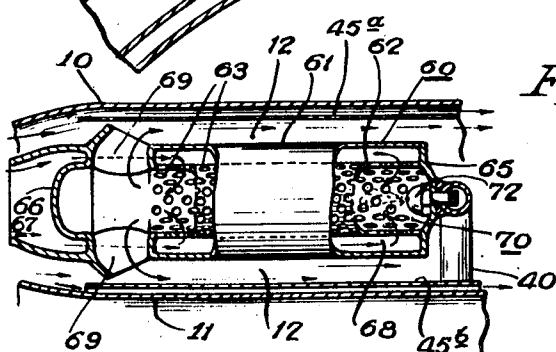
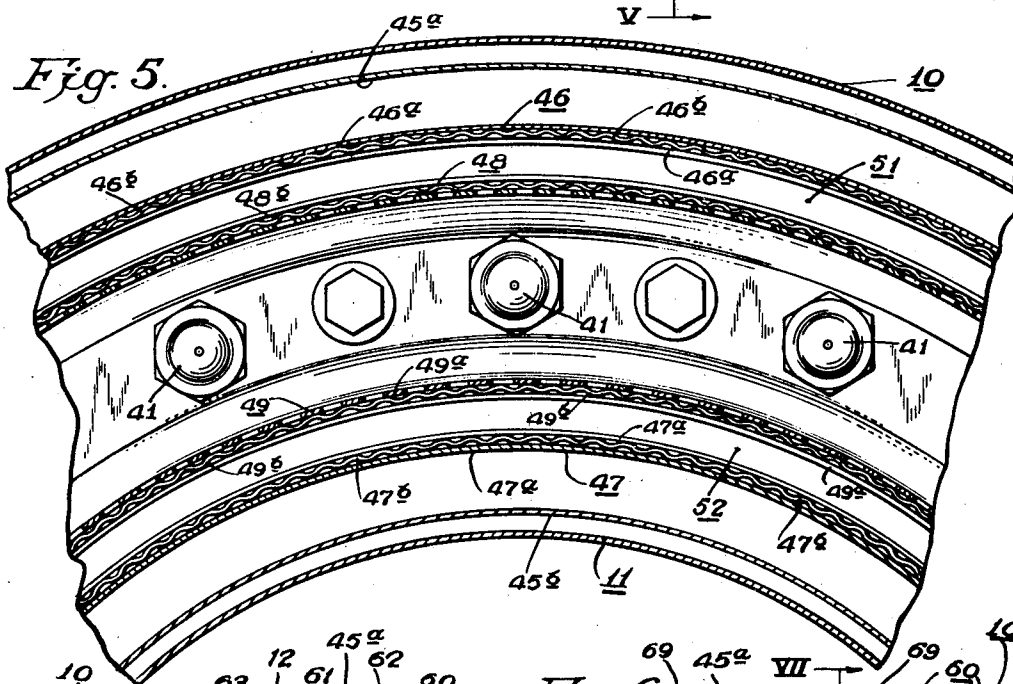
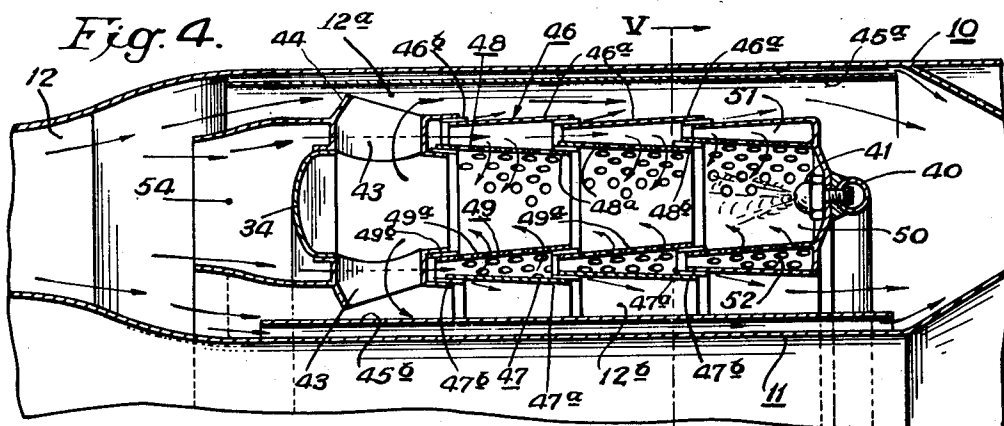
S. WAY

2,498,728

COMBUSTION APPARATUS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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COMBUSTION APPARATUS

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6 Claims. (Cl. 60—44)

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This invention relates to combustion apparatus, and more particularly to fuel combustion apparatus for a gas turbine power plant.

In order to insure efficient operation of a gas turbine engine of the class comprising a turbine-driven compressor operative to deliver air under pressure to fuel combustion apparatus, it is important to maintain constant and uniform flow not only of the so-called primary air for the support of combustion, but also of the relatively larger volume of secondary air required to effect cooling and protection of the elements and casing structure exposed to the heat of combustion. The state of the primary air has an important bearing in determining the performance of the combustion apparatus with respect to stability or wide range of ignitable mixtures, and compactness of burning. The flame propagation velocity, as well as the range of ignitable mixtures, for a combustible gas mixture such as air and hydrocarbon vapors, is extended and increased by increasing the temperature of the gases ahead of the reaction zone. The same beneficial effects are realized by preheating the incoming air when fuel is injected into a burner. It has formerly been proposed to realize the advantages of preheated air in a gas turbine combustion chamber by directing the flow of substantially all the air in a direction counter to the main flow, along the outside of an interior burner tube or liner, for example. Such an arrangement produces a double reversal in direction of flow of a large volume of air, however, and thus may tend to cause costly and undesirable reductions in pressure.

One object of the invention is to provide an improved combustion apparatus having a construction that will effect a doubling back of the primary air only, while permitting relatively straight flow of the secondary or cooling air, thereby rendering feasible the preheating of air supporting combustion without the cost of excessive pressure drops.

Another object of the present invention is the provision of improved combustion apparatus adapted to effect flow of secondary air substantially straight through the power plant, and to conduct only the primary air through a tortuous flow path, the primary air being preheated by contact with the burner shell and the shell separating it from the secondary air, while both shells are correspondingly cooled.

A further object of the invention is the provision of improved combustion apparatus in which the flow path for mixing secondary air with hot

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gases or products of combustion is much longer than is the case in conventional types of combustion chambers.

These and other objects are effected by the invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is an elevational diagrammatic view, partly in section, of a gas turbine power plant equipped with combustion apparatus constructed in accordance with one form of the invention;

Fig. 2 is an enlarged-detail sectional view taken substantially along the line II—II of Fig. 1;

Fig. 3 is a fragmentary sectional view in enlarged detail, of a portion of the combustion apparatus shown in Fig. 1;

Fig. 4 is a fragmentary sectional view of a portion of a combustion apparatus embodying features of the invention in a different form;

Fig. 5 is a fragmentary sectional view, in enlarged detail, taken substantially along the line V—V of Fig. 4;

Fig. 6 is a fragmentary sectional view, in an axial direction, of a combustion apparatus of the cell type embodying features of the invention; and

Fig. 7 is a fragmentary sectional view taken substantially along the line VII—VII of Fig. 6.

Referring to Fig. 1 of the drawings, the gas turbine power plant diagrammatically illustrated therein comprises a substantially cylindrical outer casing structure 10, which is adapted to be mounted in or on the fuselage of an aircraft, and compactly houses operating elements which are constructed and arranged in line in order to present minimum frontal area and drag during operation of the aircraft. Supported within the casing structure 10 is a sectional inner casing structure 11 which together with the outer casing structure forms an annular passageway 12, providing a flow communication that extends longitudinally through the engine from a forwardly directed air intake opening 13 to a rearwardly disposed nozzle 14. Mounted within the casing structure 10—11 along the axis thereof are a fairing section 16, which may contain auxiliary control apparatus (not shown), a multiple stage axial-flow compressor 17, fuel combustion apparatus generally indicated at 18, and a turbine 20. The rotor of the turbine 20 is operatively connected to the rotor of the compressor 17 through the medium of a common shaft 21, which is suitably journaled within the inner casing structure 11 interiorly of the com-

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bustion apparatus 18, on bearings including a bearing 22. The nozzle 14 constitutes the exhaust outlet for the turbine 20, and is preferably annular in form as defined by the terminal edge of the casing structure 10 and a centrally disposed cone or core member 24.

According to the well known principle of operation of such a power plant, it will be understood that air entering the intake opening 13 is compressed by the compressor 17 and supplied by way of annular passageway 12 to the combustion apparatus 18 to support combustion of fuel therein, as hereinafter more fully explained. The resultant hot motive fluid under pressure discharged from the combustion apparatus 18 is then expanded through the turbine 20 and is finally discharged by way of the nozzle 14, usually in the form of a jet establishing a propulsive thrust.

The combustion apparatus 18 is annular in form and is contained within an enlarged portion of the annular passageway 12 defined between the outer and inner casing sections 10 and 11. As best shown in Fig. 3 of the drawings, the combustion apparatus 18 comprises outer and inner annular walls or shells 26 and 27, which are concentrically spaced apart to form an annular forwardly directed inlet opening 28, the rearwardly-disposed portions of the shells being joined and closed by an annular wall 29. Suitable struts such as the struts 30 may be provided to support the shells 26 and 27 concentrically within the passageway 12 for dividing the passageway into outer and inner annular passageways 12a and 12b. Mounted between the outer and inner shells 26 and 27 is a foraminous burner or basket structure comprising outer and inner annular liners or walls 32 and 33, the rearward ends of which are welded or otherwise secured to the wall 29 and the forward ends of which are joined by a rounded wall 34. An annular combustion chamber 35 is thus formed by the liner walls 32 and 33, which are provided with a plurality of apertures 36 through which the combustion chamber communicates with annular overlapping entryways 38 and 39, which in turn communicate through the inlet 28 with the passage 12.

An annular fuel manifold 40 is suitably supported in the casing structure adjacent the wall 29 of the combustion apparatus, and is adapted to supply fuel in an atomized form to the combustion chamber 35 through the medium of a plurality of nozzles 41.

Extending radially through openings in the associated walls 32 and 26, and the walls 33 and 27, respectively, are a plurality of outlet stacks or communications 43, through which products of combustion can be discharged from the combustion chamber 35 to the respective passageways 12a and 12b. The outlet communications 43 are preferably disposed near to or adjacent the forward wall 34. Suitable guide louvres 44 may be provided on the respective shells 26 and 27 to facilitate direction of the products of combustion into the passageways 12a and 12b in the direction of flow. Although only two stacks or communications 43 are indicated in Fig. 2 of the drawings, it will be understood that the number may be increased in actual practice to provide adequate capacity.

In order to prevent the outer and inner casing structures 10 and 11 from subjection to excessive heat in the regions of flow of combustion products through the communications 43, a pair of outer and inner annular baffles or walls 45a and 45b are preferably mounted in parallel alignment

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within the respective passageways 12a and 12b. These baffles are sufficiently spaced from the outer and inner casing structures 10 and 11 to allow streams of cooling or secondary air to flow through the annular spaces thus formed between the respective baffles and casing structures.

When the compressor 17 is operated to supply compressed air through the passageway 12, during combustion of fuel supplied to the combustion chamber 35, most of the air under pressure, constituting the secondary air, is allowed to flow in substantially uninterrupted paths through the passageways 12a and 12b and thence through the remaining portion of passageway 12 to the turbine 20. About twenty-five per cent of the volume of air under pressure, more or less, constitutes the primary air stream, however, which enters the inlet 28 and passes through the outer and inner entryways 38 and 39 and through apertures 36 to the combustion chamber 35 for supporting combustion of fuel therein. In passing through the entryways 38 and 39, this primary air is preheated by virtue of its contact with the liner walls 32 and 33, which are in turn somewhat cooled and thus maintained at a safe temperature. Admission of the preheated primary air under ram pressure, with minimum pulsation, into the combustion chamber 35 is accompanied by vigorous counterflow of the primary air and the fuel spray issued from the nozzles 41. Flowing forwardly through the combustion chamber 35 toward the wall 34, the hot gases and products of combustion are discharged radially through the communications 43 into the rearwardly flowing streams of secondary air passing through the passageways 12a and 12b toward the turbine. With the communications 43 disposed near the forward end of the combustion apparatus, a relatively long mixing path for the secondary air and combustion gases is insured, so that by the time the resultant motive fluid enters the turbine blading it has been rendered uniform in velocity and temperature.

If additional wall cooling appears desirable, a stepped or telescoped construction of the burner shells and of the apertured liners may be substituted for the construction just described. Referring to Fig. 4, such a construction embodying the invention in a different form may comprise outer and inner shells 46 and 47 and outer and inner liners or walls 48 and 49 which are associated in substantially the same manner already described in connection with Fig. 3, to form an annular combustion chamber 50 interposed between entryways 51 and 52. The outer shell 46 may comprise a plurality of annular sections 46a, the adjacent ends of which are suitably formed to enable partial telescoping in association with annular risers 46b, which may be corrugated as shown in Fig. 5 and are interposed between the adjacent telescoped ends of the sections 46a to provide openings allowing restricted communication between the respective entryways 51 and 52 and the passageways 12a and 12b. The inner shell 47 may likewise be made up of annular sections having telescoped ends separated by annular risers 47b.

Similarly, the liners 48 and 49 may comprise, respectively, a plurality of apertured sections 48a, the adjacent ends of which are telescoped and separated by annular risers 48b, and concentrically arranged apertured sections 49a and risers 49b. Since the amount of primary air admitted to the combustion chamber 50 will be partially discharged past the respective risers 46b, 47b, 48b

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and 49b, the quantity of air admitted to the combustor structure should correspondingly be increased by providing an annular inlet 54 of relatively greater flow area than that of the inlet 28 shown in Fig. 8. Operation of the combustion apparatus shown in Fig. 4 will readily be understood from the explanation hereinbefore presented.

The features of construction as taught by the invention may also be embodied in a combustion apparatus of the multiple cell or individual combustion chamber type, such as that illustrated in fragmentary form in Fig. 6 and 7 of the drawings. Referring to Fig. 7, one of a plurality of cells 60 for such a combustion apparatus is illustrated as comprising an outer cylindrical shell 61 suitably supported axially within the annular passageway 12 and spaced from the respective outer and inner casing structures 10 and 11. Contained within the cylindrical shell 61 is a smaller tubular combustor or basket structure 62 in which are formed a plurality of apertures 63. The rear ends of the burner tube 62 and shell 61 are joined and closed by a disc or wall 65, and the forward end of the burner tube is similarly closed by a wall 66, which is disposed centrally within an annular entryway 67 communicating with the annular space 68 surrounding the burner tube 62. Radially disposed outlet tubes or communications 69 are provided for connecting the combustion chamber 70, formed within the burner tube 62, with the passageway 12 of the power plant. Extending through the end wall 65 is a fuel nozzle 72 through which fuel may be injected in a forward direction into the combustion chamber 70.

It will be understood that operation of each of the plurality of combustion cells 60 will be similar to the functioning of the single annular type of combustion apparatus already described. Thus compressed air initially supplied to the passageway 12 will be divided into secondary air, which flows freely past the cells 60 toward the turbine, and primary air which enters each of the entryways 67 of the cells 60 for support of combustion within the combustion chambers 70 thereof. Hot products of combustion are discharged simultaneously from all the combustion chambers into and merged with the secondary air flowing through the passageway 12, thereby insuring thorough mixing and uniform velocity and pressure distribution in the motive fluid supplied to the turbine.

While the invention has been shown in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. Combustion apparatus comprising hollow casing structure having an air inlet and a fluid discharge outlet, shell structure open at one end to said air inlet for receiving primary air and closed at the opposite end, said shell structure being spaced within said casing structure to form a substantially unrestricted passage through which secondary air can flow from said inlet to said outlet, foraminous liner structure mounted in spaced relation within said shell structure and forming a primary air preheating entryway and a counterflow combustion chamber for processing primary air entering said shell structure from said inlet, fuel supply means associated with said chamber, and discharge communications for directing resultant hot gases from said combustion chamber into the path of secondary air flowing

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through said passage toward said discharge outlet.

2. In a combustion apparatus, casing structure including exterior and interior sections forming a space having an air inlet and a discharge outlet, combustor structure having outer and inner shells mounted in said space for providing outer and inner passageways communicating with said inlet and outlet, said combustion structure further including a concentric pair of apertured interior walls mounted coaxially between said outer and inner shells to form outer and inner entryways overlapping a combustion chamber, said entryways being open to said air inlet and closed at the ends adjacent said outlet, annular walls closing the opposite ends of said combustion chamber, nozzles mounted in said casing structure for injecting fuel into one end of said combustion chamber, and a plurality of communications adapted to discharge hot gases from the other end of said combustion chamber into said outer and inner passageways.

3. In a fuel combustion apparatus, casing structure including exterior and interior cylindrical sections forming an annular space having an air inlet and a discharge outlet, combustor structure having outer and inner cylindrical shells mounted in said space for providing outer and inner annular passageways communicating with said inlet and outlet, said combustor structure further including a concentric pair of apertured interior walls mounted coaxially between said outer and inner shells to form outer and inner annular entryways overlapping an annular combustion chamber, said entryways being open to said air inlet and closed at the opposite ends, annular walls closing the opposite ends of said combustion chamber, nozzles mounted in said casing structure for injecting fuel into the downstream end of said combustion chamber in a direction opposite to that of flow of primary air from said inlet through said entryways, and a plurality of conduits for discharging heated primary air and combustion products from the opposite end of said combustion chamber into the streams of secondary air flowing into said outer and inner passageways, whereby such primary air is reversed and preheated during flow through said combustion structure while secondary air traverses relatively unrestricted paths through said outer and inner passageways.

4. Fuel combustion apparatus as specified in claim 3, wherein annular baffles are disposed in spaced relation with regard to the respective exterior and interior sections of the casing structure, for maintaining flow of layers of cool secondary air in protective contact with said casing sections in the regions subject to heat of fluid issuing from said combustion chamber.

5. Fuel combustion apparatus for a power plant of the type including a compressor and a turbine having a common drive shaft, a cylindrical interior casing for containing said shaft and a cylindrical exterior casing surrounding said interior casing for providing an annular space extending from said compressor to said turbine, said combustion apparatus comprising inner and outer cylindrical shells mounted coaxially of and spaced away from said interior and exterior casings to provide annular inner and outer main passages, an annular combustor structure having apertured side walls and terminal closure walls forming an annular combustion chamber, said side walls being spaced between said inner and outer shells

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to provide inner and outer annular entryways adapted to direct fluid discharged by said compressor into said combustion chamber, means for injecting fuel into said combustion chamber, and a plurality of communications disposed radially in said combustor structure for guiding hot gases from said combustion chamber into the upstream ends of said main passages.

6. In a fuel combustion apparatus, casing structure including exterior and interior cylindrical sections forming an annular space having an air inlet and a discharge outlet, combustor structure having outer and inner cylindrical shells mounted in said space for providing outer and inner annular passageways adapted to conduct secondary cooling air from said inlet substantially straight

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through said casing structure to said outlet, a combustor basket structure mounted within said outer and inner shells, means for injecting fuel into said basket structure, said shells and basket structure being adapted to divert primary air drawn from said inlet through a counterflow path for absorbing heat from said shells and facilitating combustion of fuel within said basket structure, and a plurality of radially disposed communications for merging resultant hot gases from said basket structure into the streams of secondary air flowing through said outer and inner passageways.

STEWART WAY.

No references cited.