United States Patent [19]

Johnson

[11] **3,724,207**

[45] **Apr. 3, 1973**

[54] **COMBUSTION APPARATUS**

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[22] Filed: **Aug. 5, 1971**

[21] Appl. No.: **169,307**

[52] **U.S. Cl.** ....**60/39.74 R,** 239/424

[51] **Int. Cl.** **F02c 3/24**

[58] **Field of Search** ....60/39.74 R; 239/424

[56] **References Cited**

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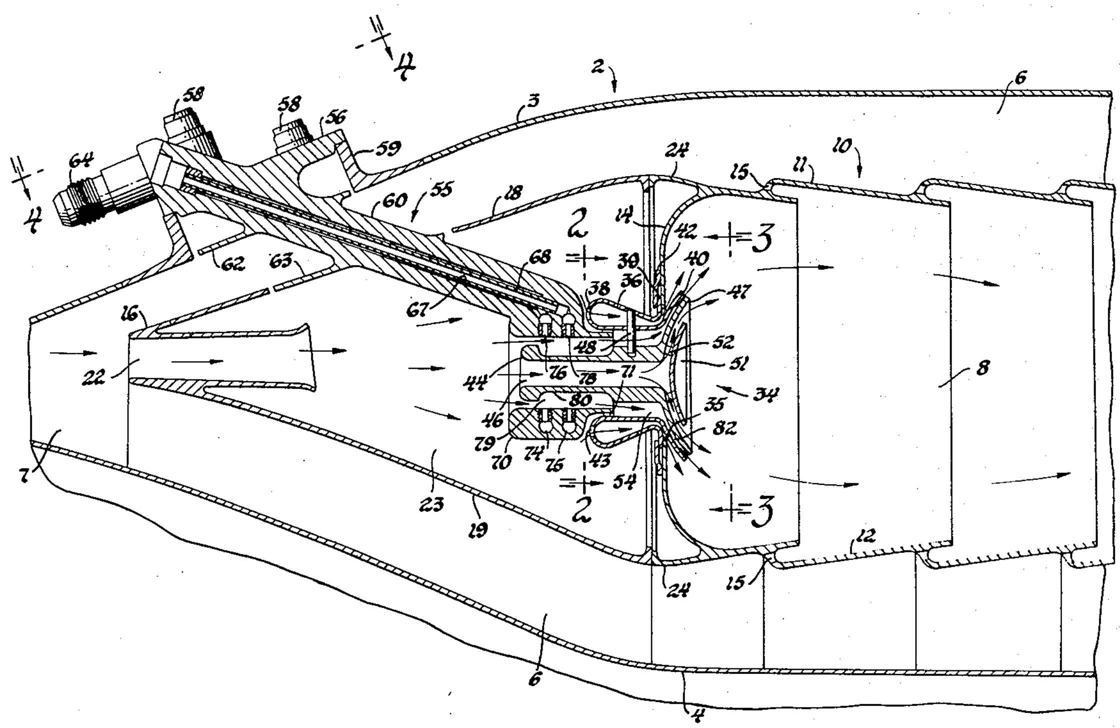
Attorney—Paul Fitzpatrick et al.

[57] **ABSTRACT**

A combustion apparatus having outer and inner casing walls and an annular combustion liner mounted between them. The combustion liner is supported at its upstream end by brackets extending from the front wall of the liner having a radial slip fit connection with struts connecting the outer and inner casings. An annular diffuser fitting against the front end of the combustion liner and extending from and between the struts supplies air to the front wall of the combustion liner. Fuel is introduced through combined fuel and air inlet structures spaced around the front wall of the liner, these having an outer air entrance, an intermediate mixed fuel and air entrance, and an inner air entrance all flaring at the inner side of the combustion liner front wall to direct the entering air and fuel generally radially from these entrances.

2 Claims, 6 Drawing Figures



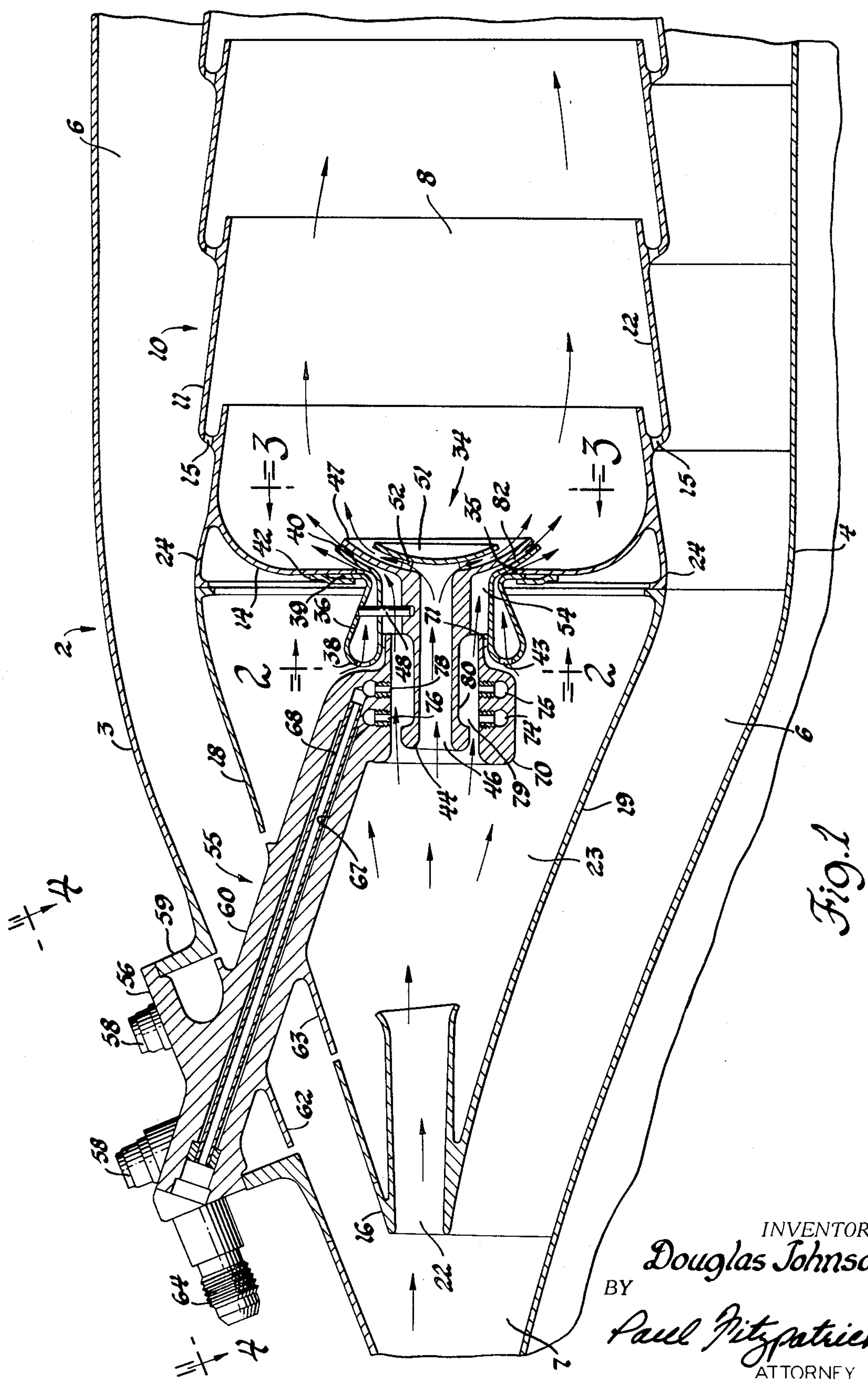


Fig.1

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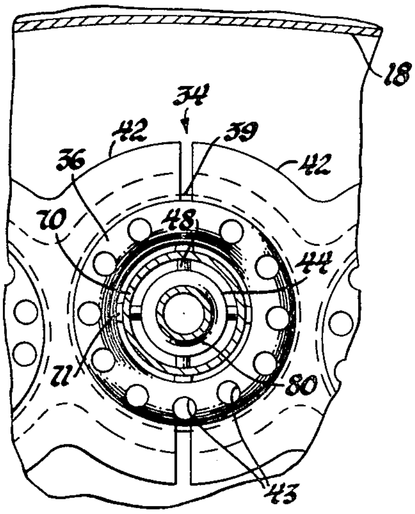

Fig.2

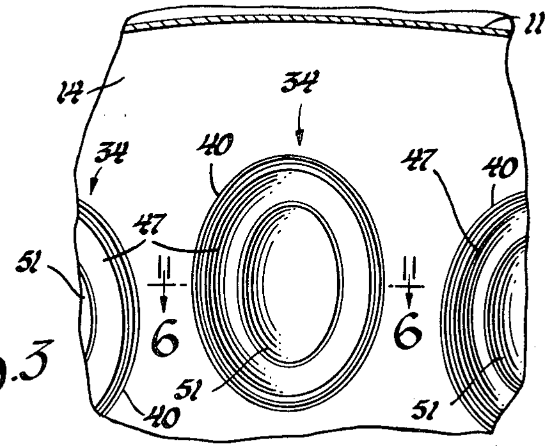

Fig.3

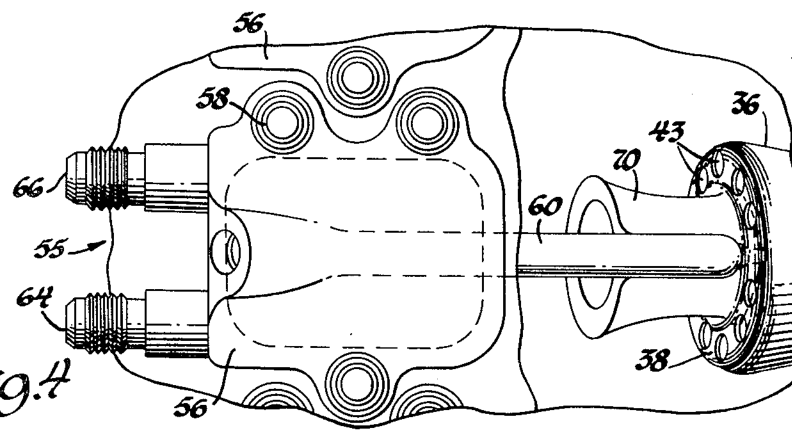

Fig.4

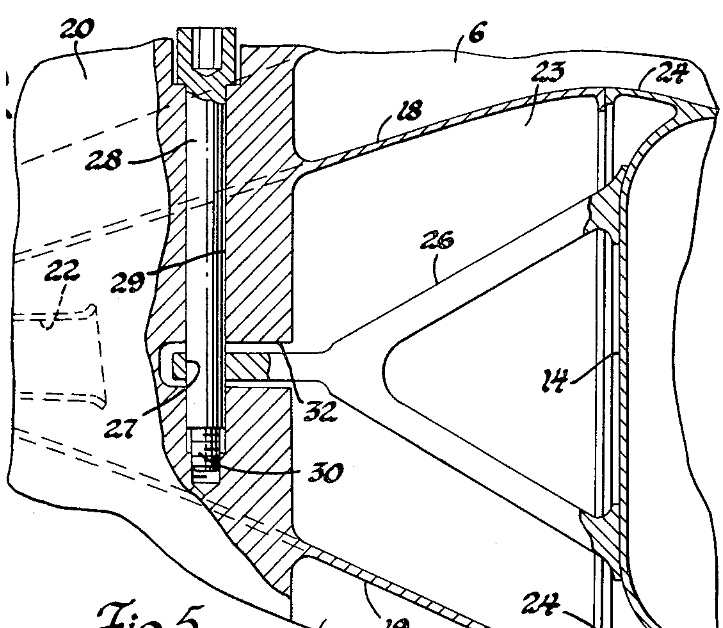

Fig.5

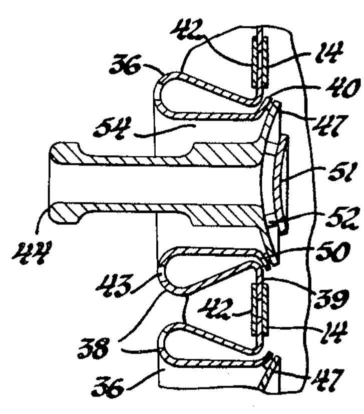

Fig.6

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COMBUSTION APPARATUS

The invention herein described was made in connection with work under a contract with the Department of Defense.

My invention relates to combustion apparatus and, particularly, combustion apparatus of the type employed in aircraft gas turbine engines. In these, there are particular requirements of light weight, compactness, efficient combustion, and minimization of smoky combustion and other combustion phenomena which may produce undesirable combustion products.

My invention is concerned with improved arrangements for the admission of fuel in intimate association with air for clean combustion and also with improved structural arrangements of the elements of a combustion chamber.

Combustion chambers for gas turbines generally fall into three types: The can type in which a combustion liner is disposed within an outer case, generally in more or less concentric relation to it, the can-annular type in which a number of more or less cylindrical combustion liners are disposed in generally parallel relation within an annular air space, and the full annular type in which an annular combustion liner is disposed within an annular air space. The last-named tends to be the lightest and most compact. However, the attainment of optimum supply and circulation of fuel and air in an annular combustion space is generally more difficult than in one of circular cross section.

My invention is directed to provision of combustion apparatus better suited to the requirements of practice than those now known and, more particularly, to provide improved structural relations of the parts of a combustion apparatus and superior arrangements for admission of fuel and air in intimate mixture for complete combustion within a compact flame zone.

The nature of my invention and its advantages will be clear to those skilled in the art from the succeeding detailed description of the preferred embodiment of the invention and the accompanying drawings thereof.

FIG. 1 is a sectional view of the forward portion of an annular gas turbine combustion apparatus taken on a plane containing the axis of the apparatus.

FIG. 2 is a fragmentary view of the front end of the combustion liner, with parts in section, taken on the plane indicated by the line 2—2 in FIG. 1.

FIG. 3 is a fragmentary view looking forward toward the front wall of the combustion liner, taken on the plane indicated by the line 3—3 in FIG. 1.

FIG. 4 is a plan view of a portion of the exterior of the combustion apparatus with parts cut away, as indicated by the line 4—4 in FIG. 1.

FIG. 5 is a partial sectional view taken on a plane containing the axis of the combustion apparatus and angularly displaced from the section of FIG. 1.

FIG. 6 is a fragmentary view illustrating a modification, taken on the plane illustrated by the line 6—6 in FIG. 3.

Referring first to FIG. 1, the combustion apparatus comprises a case 2 including an outer casing 3 and an inner casing 4 defining between them a space 6 for compressed air delivered from a source such as the compressor of a gas turbine engine through a diverging annular inlet 7. Combustion takes place within a space 8 inside a combustion liner 10 defined by an outer wall 11, an inner wall 12, and an annular front wall 14. The walls 11 and 12 are typically of a segmented structure with successive segments defining inlets 15 for film cooling air to flow along the hot side of the liner to protect it from the flame. This film, cooling air may form part of the air for combustion and may also form part of the air for dilution of the combustion products. The specific wall structure is immaterial to the invention. Various arrangements of segmented liners for film cooling of the liner are shown for example in U.S. patents to Seippel U.S. Pat. No. 2,268,464, Dec. 30, 1941; Way U.S. Pat. No. 2,448,561, Sept. 7, 1948; Christensen U.S. Pat. No. 2,537,033, Jan. 9, 1951; and DeZubay et al. U.S. Pat. No. 2,573,694, Nov. 6, 1951. All but the first named of these show full annular combustion apparatus.

The outer and inner liner walls together with the front wall form an annular basket-like rigid structure, the front end of which is supported from the combustion apparatus outer case. The downstream or outlet end of the combustion liner (not shown) is suitably supported from the casing 2, ordinarily by being coupled to a turbine nozzle fixedly mounted with respect to the combustion apparatus. All or a major part of the air for complete combustion of the fuel is admitted to the combustion liner through the front wall 14. This air is supplied through a flow divider or splitter 16 having diverging outer and inner walls 18 and 19. This structure is cast integral with or welded to a plural number, such as six, of struts 20 (FIG. 5) which extend from the outer casing 3 to the inner casing 4 upstream of wall 14. The splitter is thus positively supported in the combustion apparatus case 2. Combustion air inlets 22 are defined in the leading edge of the splitter 16. These deliver a portion of the air supplied by the engine compressor into a space 23 bounded by walls 14, 18, and 19. The remainder of the compressed air flows through the annular space between casing 3 and wall 18 and continues over the outer surface of the liner and a space between walls 19 and 4, continuing over the inner surface of the liner. This air provides the film cooling and dilution air for the combustion apparatus, as is well known.

The rear flanged edges of splitter walls 18 and 19 abut the flanges 24 extending forwardly from liner walls 11 and 12 and terminating approximately at the plane of forward wall 14. The forward end of the combustion liner is supported from the combustion case by a Y-shaped bracket 26 welded or otherwise fixed to the forward wall 14 at the location of each strut 20. The forward end of each bracket 26 has a radial bore 27 to receive a radial pin 28 extending through a suitable bore 29 in the strut 20, which may be secured by threads 30 at its inner end. The strut is notched as indicated at 32 to provide clearance for relative radial expansion of the liner with respect to the struts and combustion case, which are normally much cooler in operation of the engine. Thus pins 28 locate the front end of the combustion liner 10 both axially and radially while allowing radial expansion. Differential expansion between the air splitter 16 and the combustion liner is permitted by the freedom for radial sliding movement between the mating edges of these two parts.

The front wall 14 of the liner has a considerable number of closely circumferentially spaced inlet arrangements 34 for combustion air and fuel. These combustion air and fuel arrangements are a feature of the invention, since they make provision for very thorough mixing of fuel and air and for introduction of a fuel-air mixture between radiating flows of air.

Referring to FIGS. 1 and 2, circular or approximately circular holes **35** are evenly distributed circumferentially around the front wall **14**, preferably at the mean radius of the wall. Hollow bosses **36** which serve as air inlets and distributors are mounted one at each of the holes **35**. The boss **36** is a tubular member folded inside itself to provide a double-walled structure beginning at an annular leading edge **38** and terminating at a preferably circular forward flange **39** and a preferably elliptical rear flange **40**. The flange **39** is held against the forward face of wall **14** with some freedom for motion radially or circumferentially of the combustion apparatus by two adjacent clips **42** the shape of which is readily apparent from FIG. 2, the margins of which overlie the flange **39** of the air distributor. Clips **42** may be spot-welded in place.

The distributor has a ring of air holes **43** in its leading edge so that air may flow from the space **23** between the walls of the air distributor and be discharged generally radially outward with some downstream component, as indicated by the arrow between flange **40** and the inner surface of wall **14**. A tubular member **44** mounted concentrically within the boss **36** defines an air duct **46** for flow of air into the combustion liner. Tubular member **44** has a mushroom head **47** flaring from it rather close to the flange **40**. In the form illustrated in FIG. 1, member **44** is supported within the boss **36** by circumferentially spaced radial pins **48** which may be inserted and then secured by brazing or otherwise in one of the members. In the modification illustrated in FIG. 6, the member **44** is supported from the member **36** by small projections **50** spaced around the upstream side of head **47** which may be welded to the flange **40**. In either case the air duct **46** is centered in boss **36**. The compressed air entering through the duct **46** is caused to flow outwardly by a baffle **51** overlying the outlet of the duct, this baffle being spaced from the flange head **47** by projections **52** on one of these members welded or brazed to the other.

The annular conduit **54** between the outer surface of member **44** and the inner surface of boss **36** provides a third entrance into the upstream end of the combustion chamber between those just described; that is, that between the wall **14** and flange **40** and that between flange **47** and baffle **51**. This entrance provides for the admission of fuel with still more combustion air.

The means for introduction of fuel comprises a fuel nozzle **55** of special type having a bolting flange **56** secured by cap screws **58** or the like to an annular seat **59** extending from the outer casing **3**. The nozzle has a stem **60** which extends through the casing **3** and wall **18** and has flanges **62** and **63** to close the openings through these structures for the entrance to the fuel nozzle into the space **23**. As illustrated, the nozzle **55** is of a duplex type having fuel inlets for small and large fuel flows, respectively. Inlets **64** and **66** communicate with passages defined by a bore **67** through the stem and a tube **68** mounted within the bore **67**, these being isolated from each other and having separate discharges. The fuel nozzle includes a tubular nose **70** at the inner end of stem **60** which is mounted around the tubular member **44** and piloted within the inner surface of the boss **36** as shown. Nose **70** is spaced from boss **66** by spacing ridges **71** integral with the end of the nose **70**. With the fuel nozzle bolted in place, the air and fuel entrance parts **36** and **44** are located by it with respect to their position on the front wall **14** of the combustion liner, the flanges **39** being free to slide to some extent under clips **42**.

The fuel passages **67** and **68** discharge into annular manifolds **74** and **75**, respectively, which are cast in the nose portion **70** of the fuel nozzle **55**. These manifolds discharge through small orifices or jets **76** and **78**, respectively. Preferably, there are four such orifices distributed equally around the axis of the nose communicating with each manifold. The result is that, when fuel is supplied through either or both of the passages **67** or **68**, it is discharged through the ring of jets or nozzles **76** or **78** into the air flowing through the annular conduits **79** and **54** between the nose **70** and boss **36** and the tubular member **44**.

A circumferential recess **80** on the tubular member provides an enlargement and then a contraction of the conduit **79**, creating increased turbulence in the air so flowing and furthering the atomization and uniform mixing of the fuel spray with the air and small fuel droplet size. Some additional air flows between the spacing bosses **71** and the total mixture of atomized fuel and air is discharged through a flaring outlet **82** between the rear flange **40** and the head **47**. The fuel thus generally follows the path of the arrows and is discharged in a radiating sheet which is somewhat conical with additional air for combustion discharged on both the upstream and downstream sides of the sheet through the hollow boss **36** on the upstream side and between head **47** and baffle **51** on the downstream side of the fuel. The result is an intimate mixture of fuel and air providing for complete combustion in relatively short space and providing a mixture of combustion products and nitrogen which is diluted by the air entering through the film air inlets **15** and through dilution holes (not shown) as is customary.

To recapitulate, it will be seen that the forward end of the combustion liner is very effectively and simply mounted by the brackets **26** to the combustion case with an arrangement which provides freedom for expansion of the hotter and cooler parts of the combustion apparatus. The arrangement for admission of air and fuel is movably mounted in the front of the combustion liner and located by the fuel nozzles **56** which are mounted on the combustion outer case **3**. The general arrangement for admission of fuel and air at the front end of the combustion liner is of a simple, trouble-free, and practical nature and is readily installed and removed. It provides an intimate mixture of rapidly-flowing radiating air sheets with a fuel-bearing sheet sandwiched between two sheets of air only.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

I claim:

1. Combustion apparatus comprising, in combination, means defining a combustion space and having an upstream wall, the said wall defining at least one open-

ing for admittance of fuel and air; a double-walled boss mounted on the said wall projecting through the opening with the inner wall of the boss flaring downstream of the opening to define a flange, the boss having air entrances at its upstream end to admit air for flow between the walls of the boss and discharge over the upstream side of the flange; a tubular air duct mounted within and spaced from the boss, the air duct having a flaring head overlying and spaced downstream from the said flange; a baffle mounted on the air duct overlying and spaced downstream from the head to direct the air emerging from the duct generally radially of the duct; the said boss and duct defining between them an annular conduit for fuel and air terminating in a flaring discharge port between the said flange and the said head; and means for introducing fuel into the air flowing through the said conduit; flow of air through the boss, the said annular conduit, and the said air duct resulting from a pressure drop across the wall in operation of the combustion apparatus.

2. Combustion apparatus comprising, in combination, means defining a combustion space and having an upstream wall, the said wall defining at least one opening for admittance of fuel and air; a double-walled boss

mounted on the said wall projecting upstream from the opening with both walls of the boss flaring downstream of the opening to define flanges; means mounting the outer flange on the upstream wall; the boss having air entrances at its upstream end to admit air for flow between the walls of the boss and discharge over the upstream side of the inner wall flange; a tubular air duct mounted within and spaced from the boss, the air duct having a flaring head overlying and spaced downstream from the said flange; a baffle mounted on the air duct overlying and spaced downstream from the head to direct the air emerging from the duct generally radially of the duct; the said boss and duct defining between them an annular conduit for fuel and air terminating in a flaring discharge port between the said flange and the said head; means for introducing fuel into the air flowing through the said conduit; means for inducing turbulence in the air flowing through the said conduit to promote atomization and mixture of the fuel with the air; flow of air through the boss, the said annular conduit and the said air duct resulting from a pressure drop across the wall in operation of the combustion apparatus.

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