United States Patent

Sturgess et al.

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[54] AIR BLAST FUEL ATOMIZER

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[52] **U.S. Cl.** ....**239/400,** 239/404, 60/39.74 R

[51] **Int. Cl.** **B05b 7/10**

[58] **Field of Search** 239/400, 405; 60/39.74

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[57] **ABSTRACT**

An air blast fuel atomizer for establishing a highly atomized fuel dispersion at the confluence of two counter-rotating air swirls, wherein a uniform concentration of fuel is disposed on a circumferential shroud and directed to the atomization forces at the lip of the shroud.

16 Claims, 13 Drawing Figures

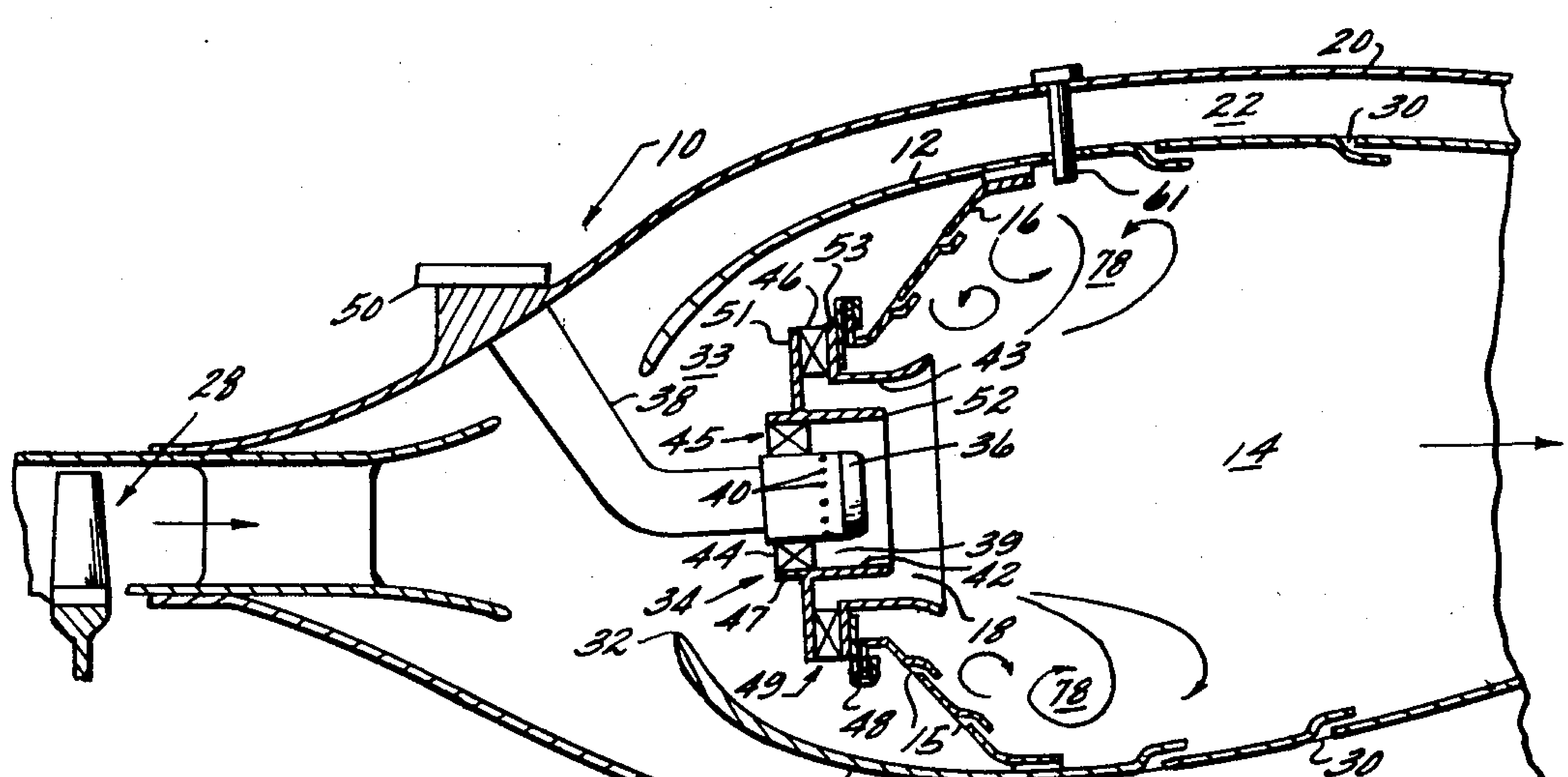

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FIG 1

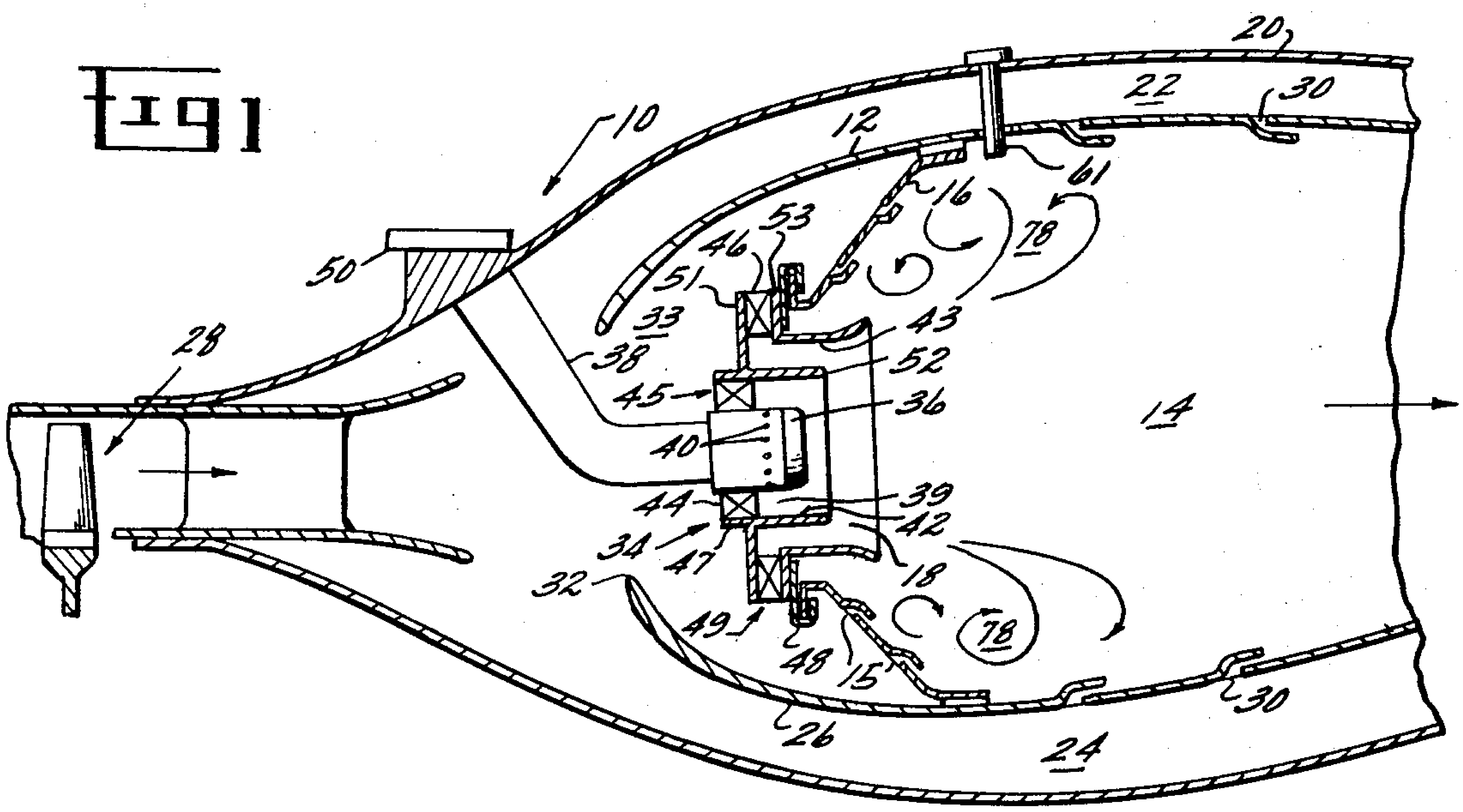

FIG 2

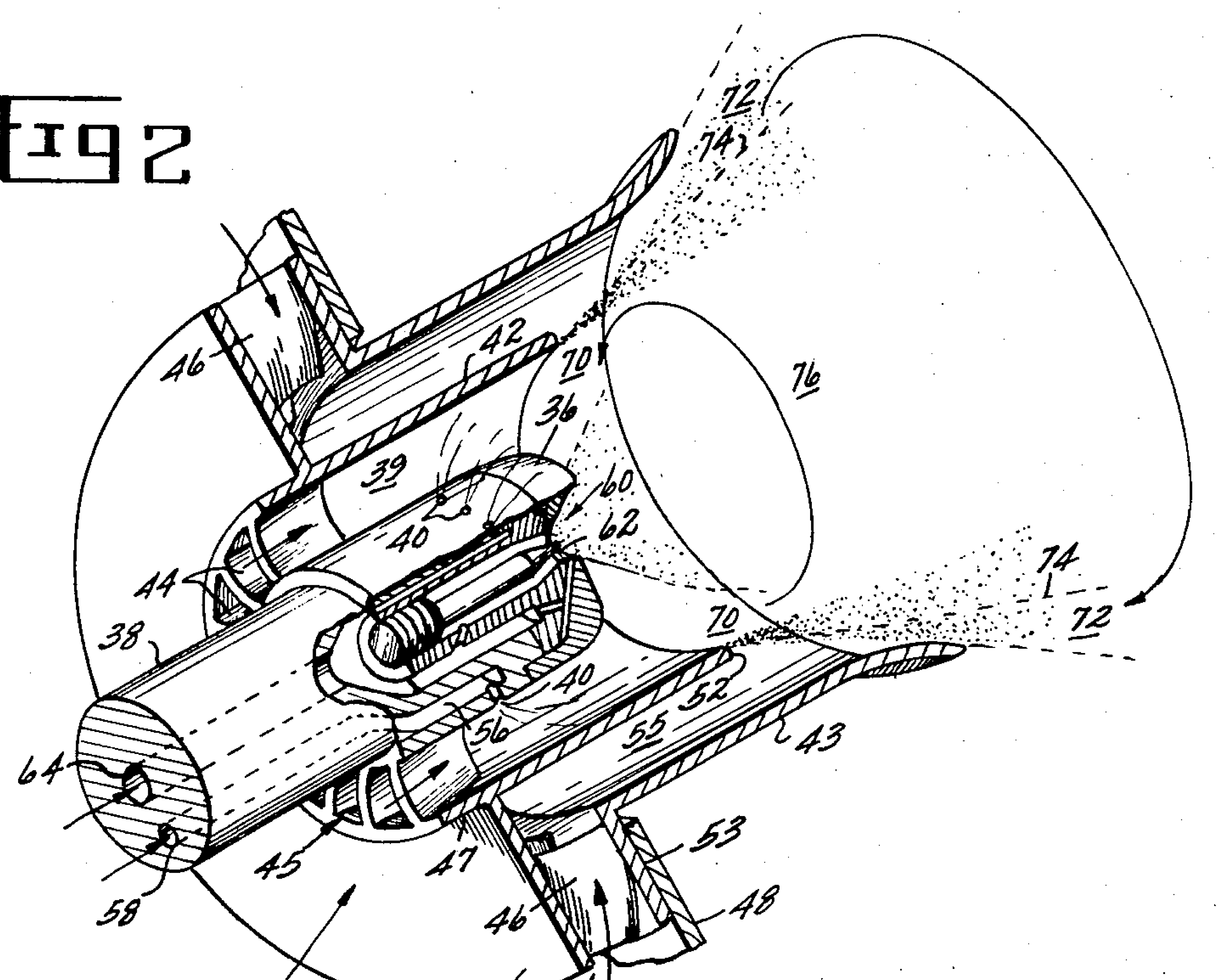

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Fig 3

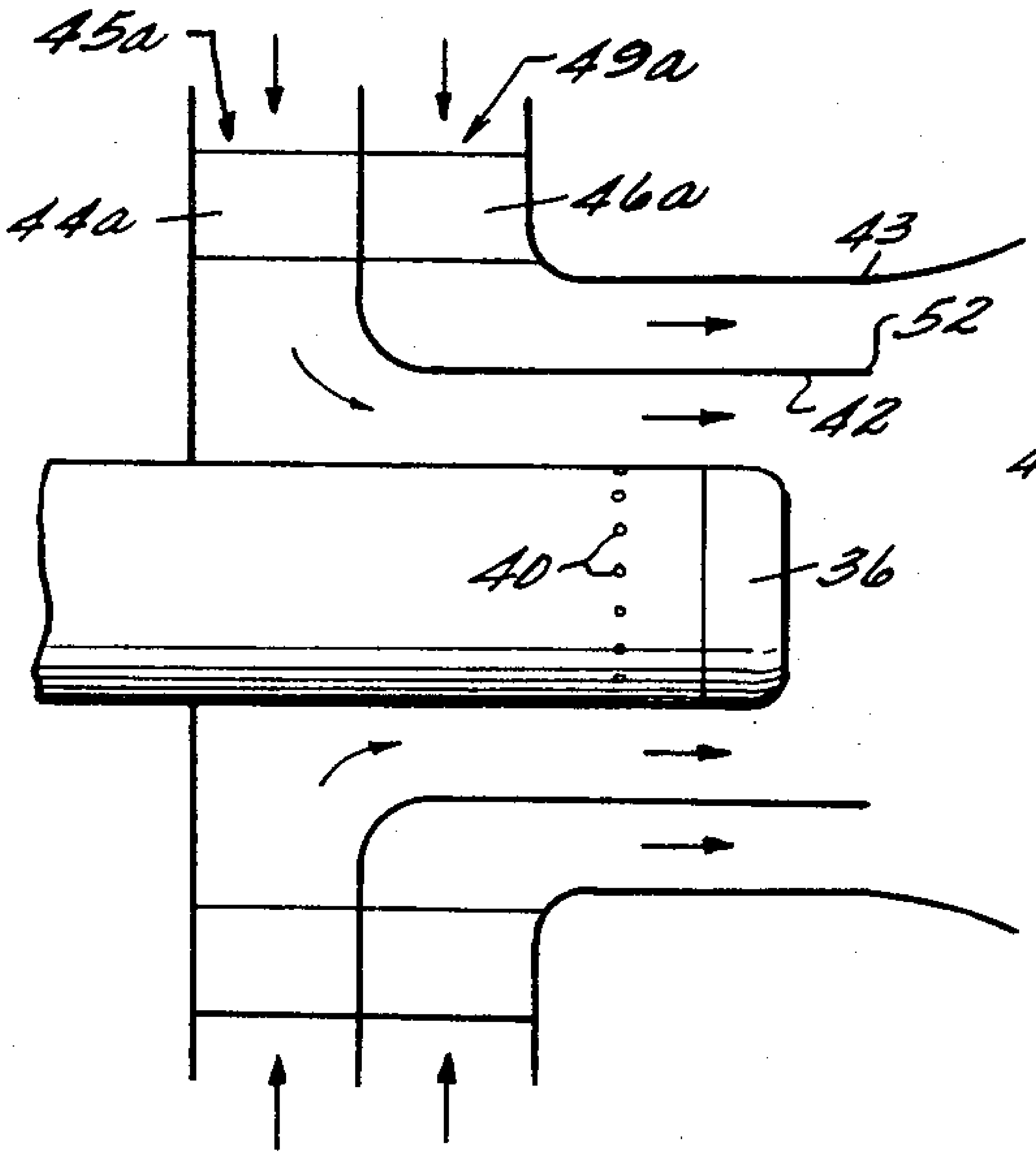

Fig 4

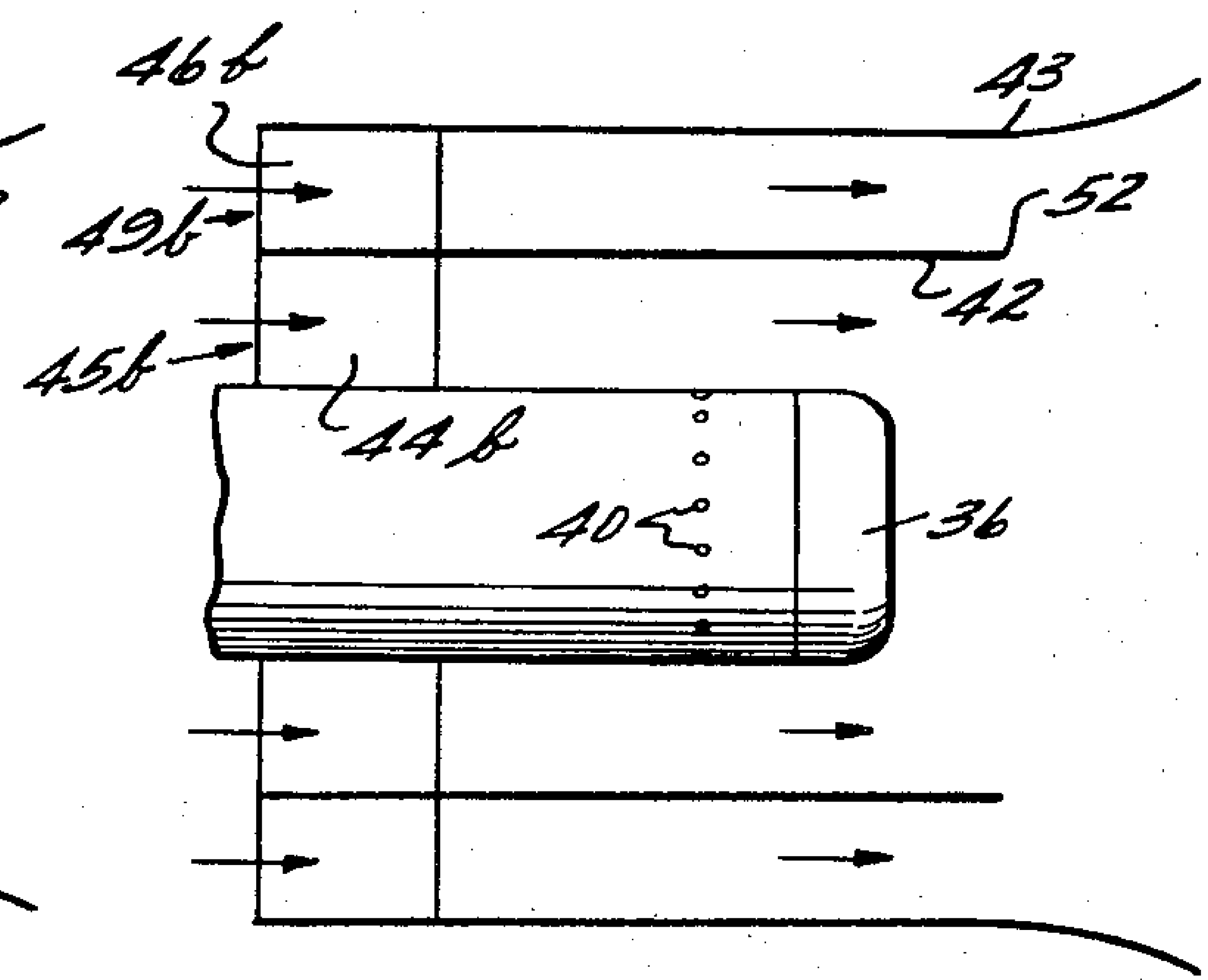

Fig 5

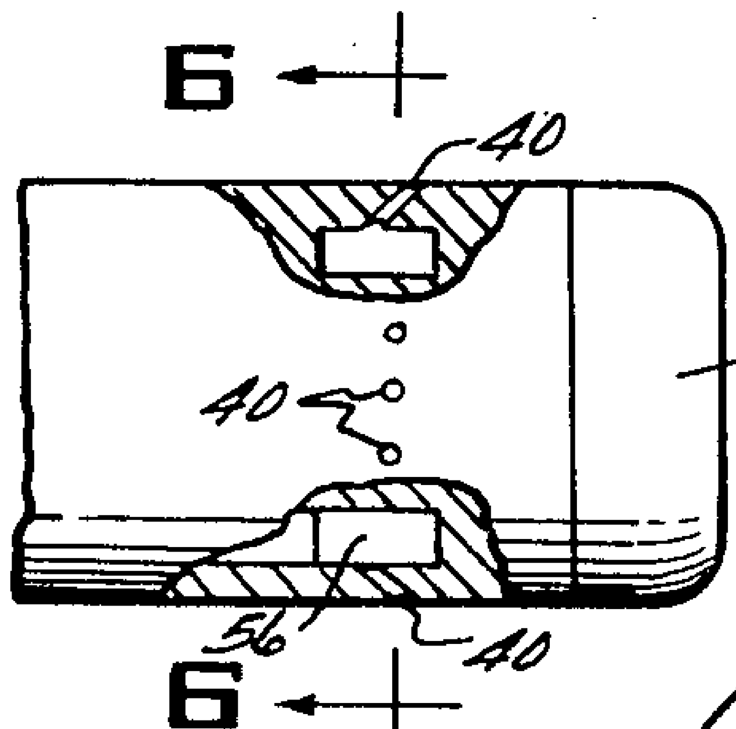

Fig 6

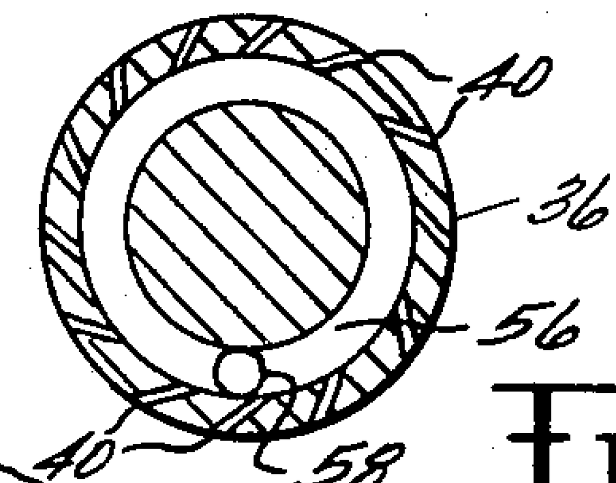

Fig 9

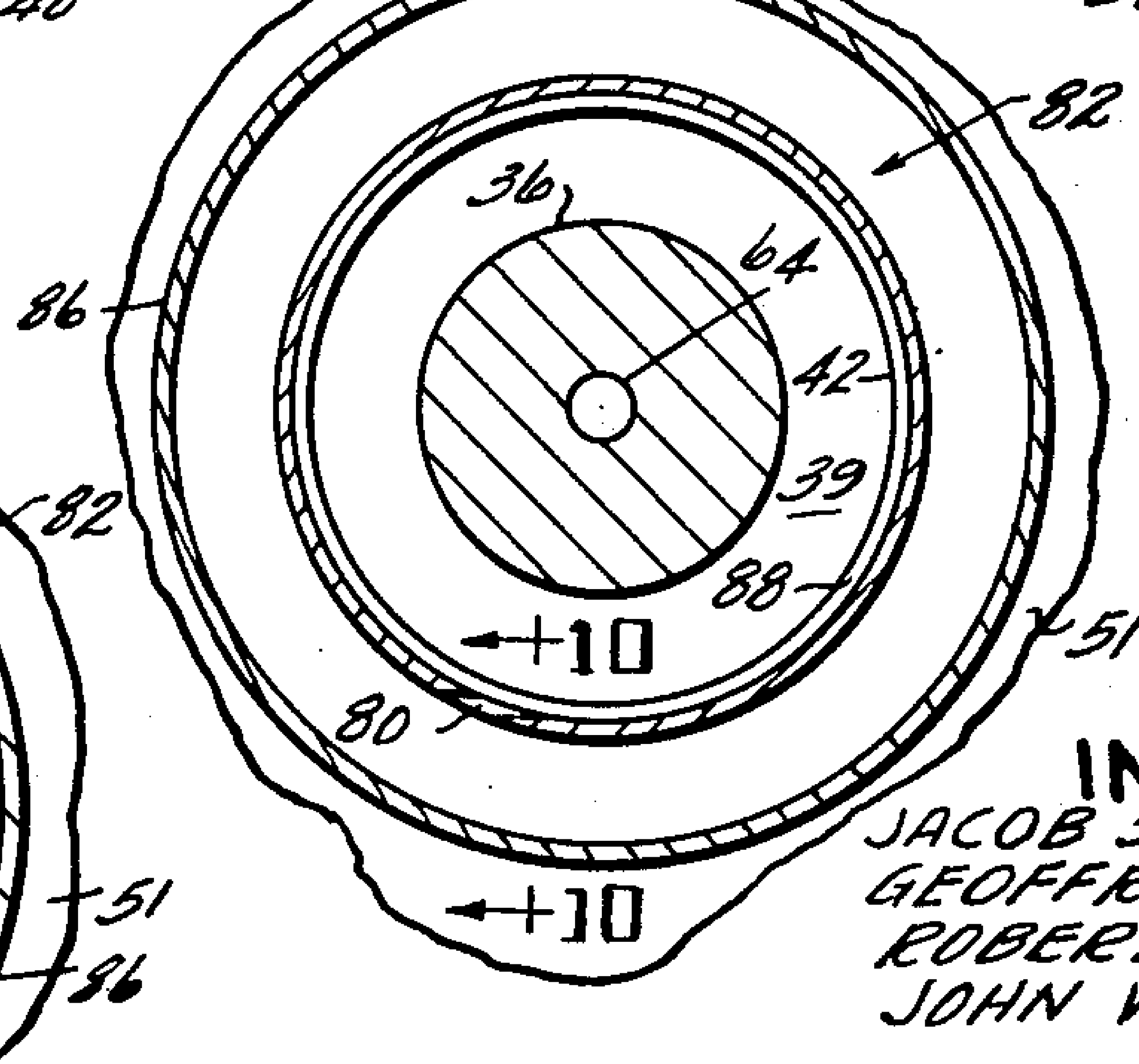

Fig 10

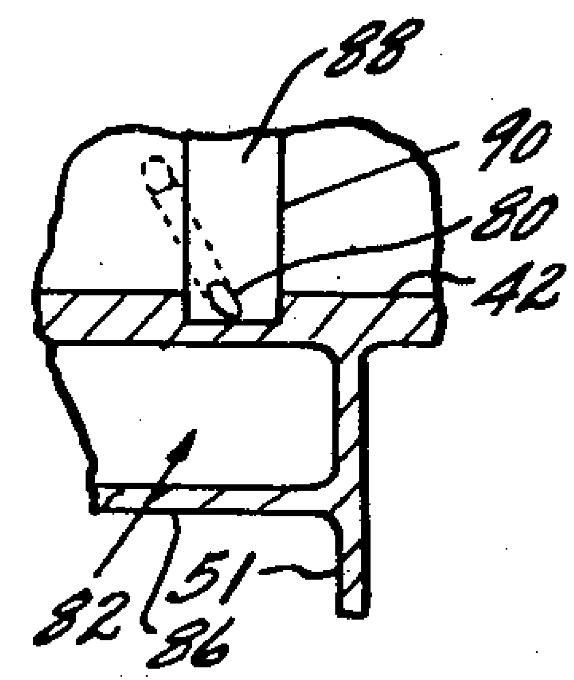

Fig 8

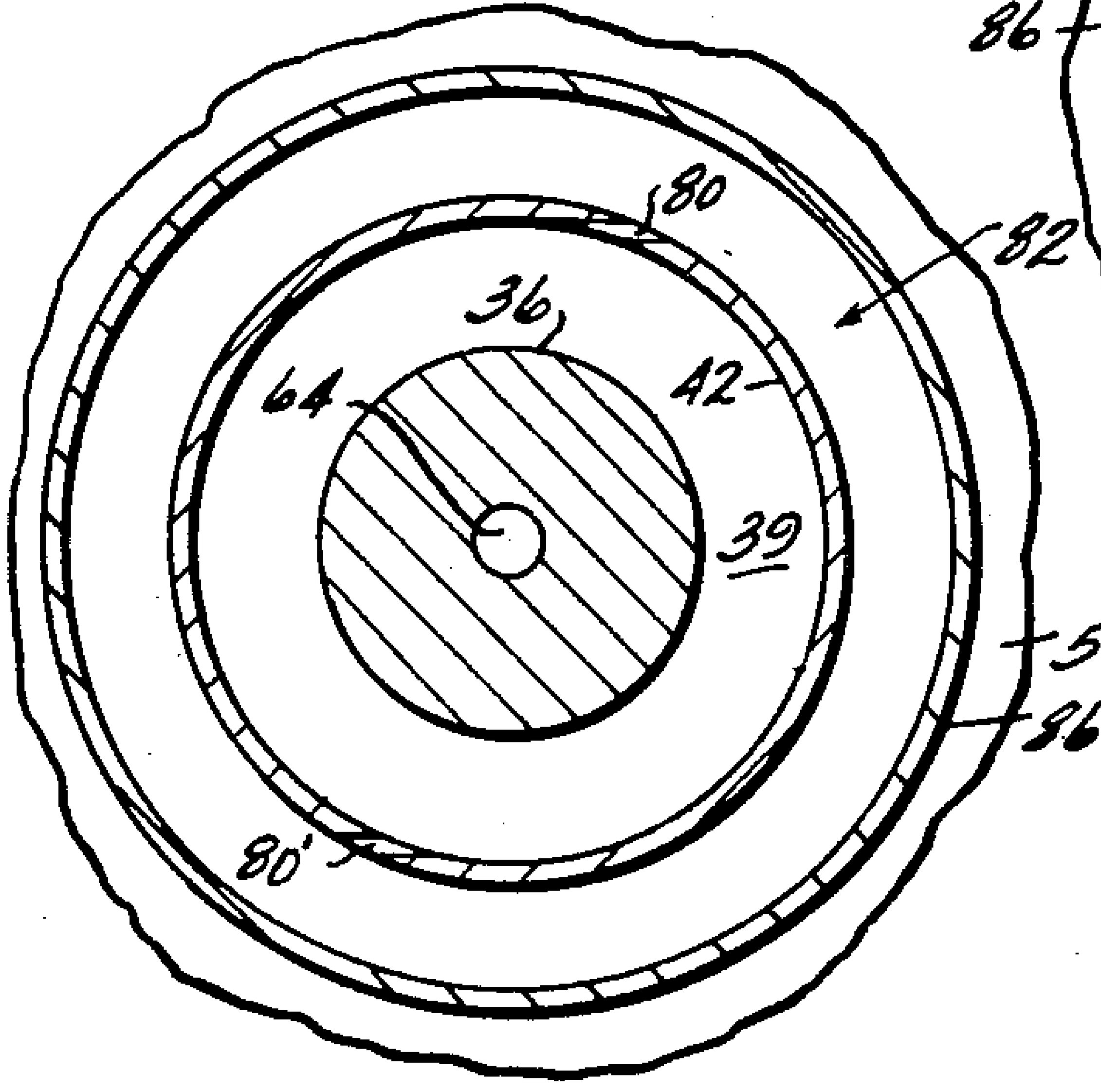

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Fig 7

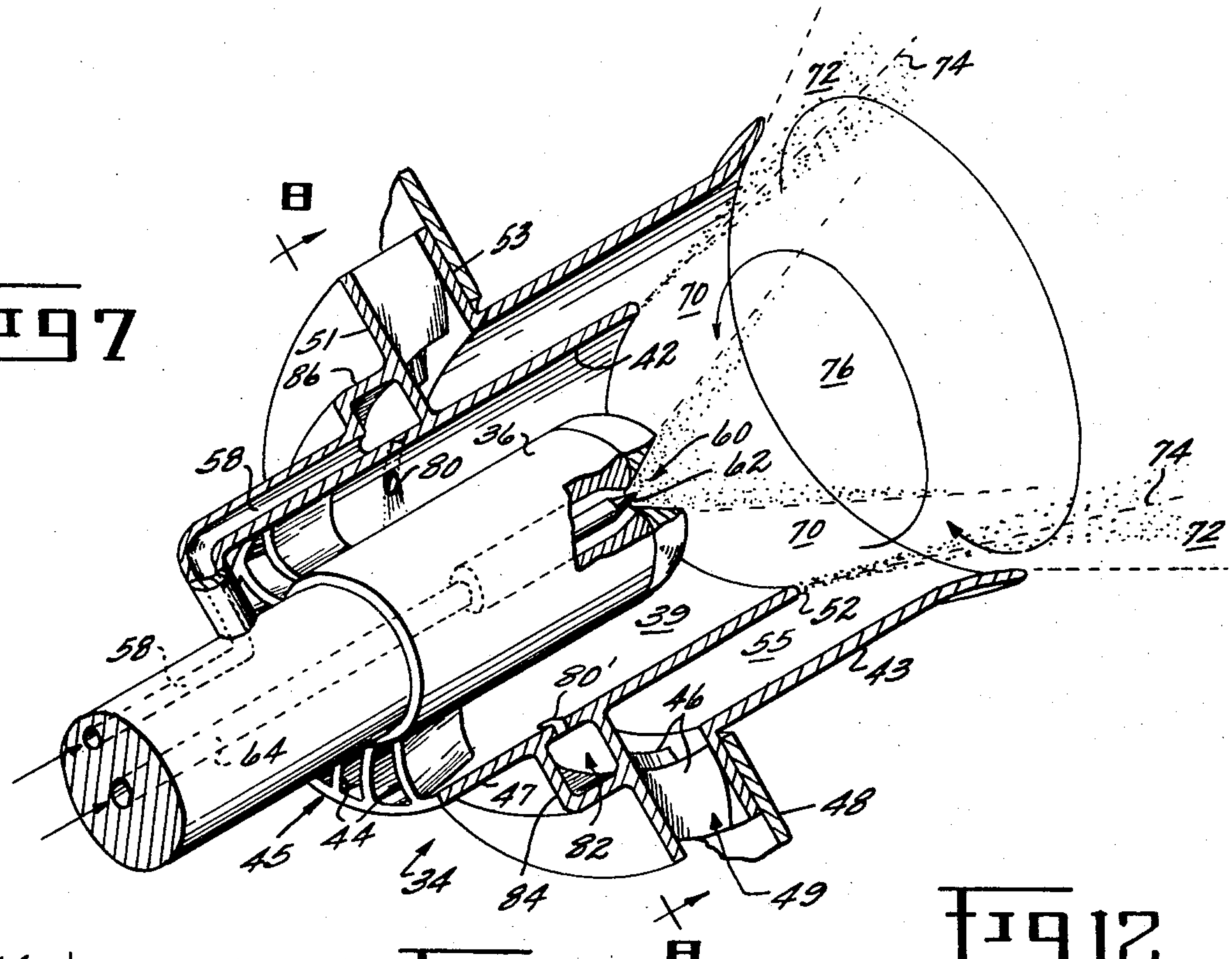


Fig 11

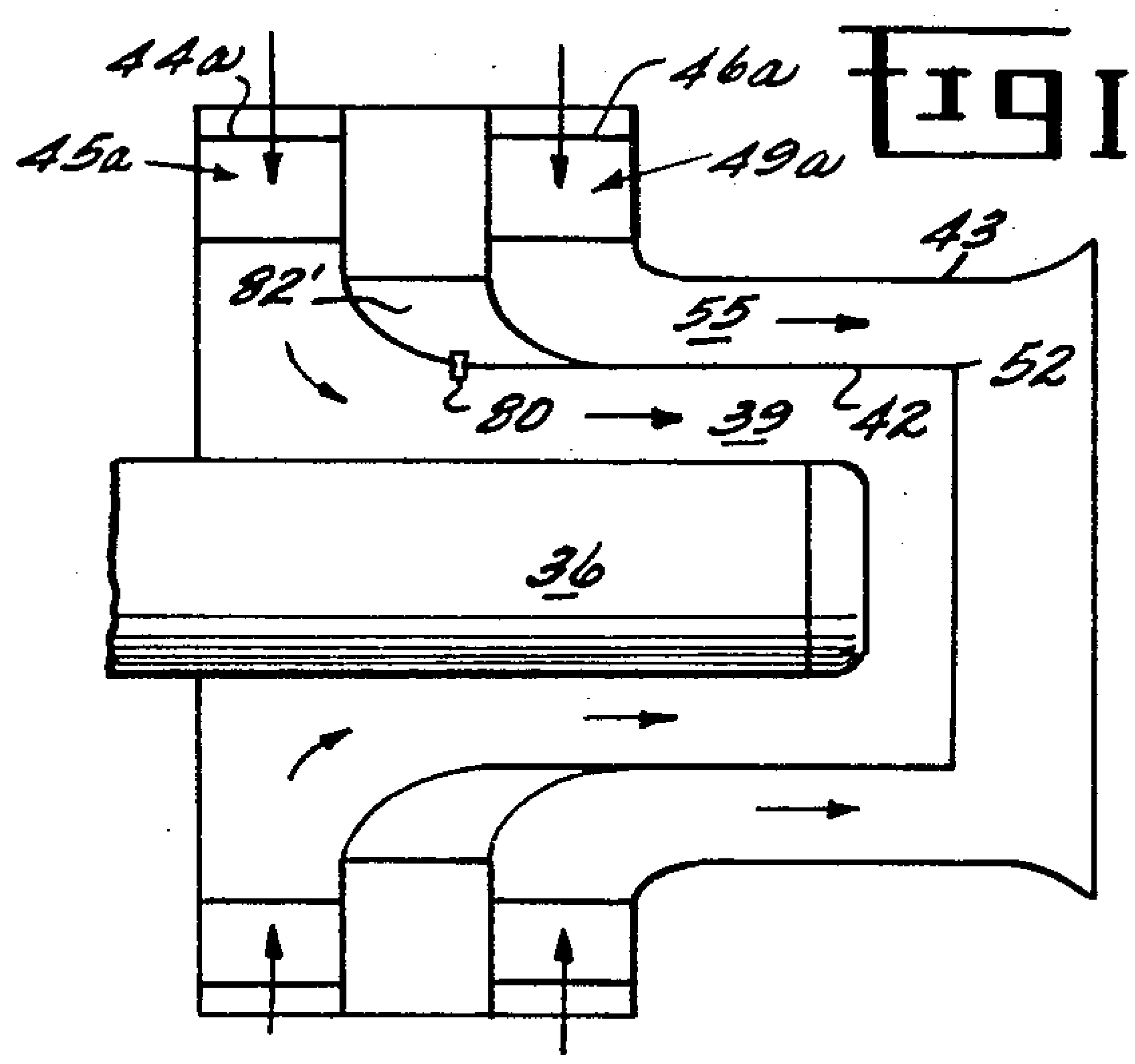


Fig 12

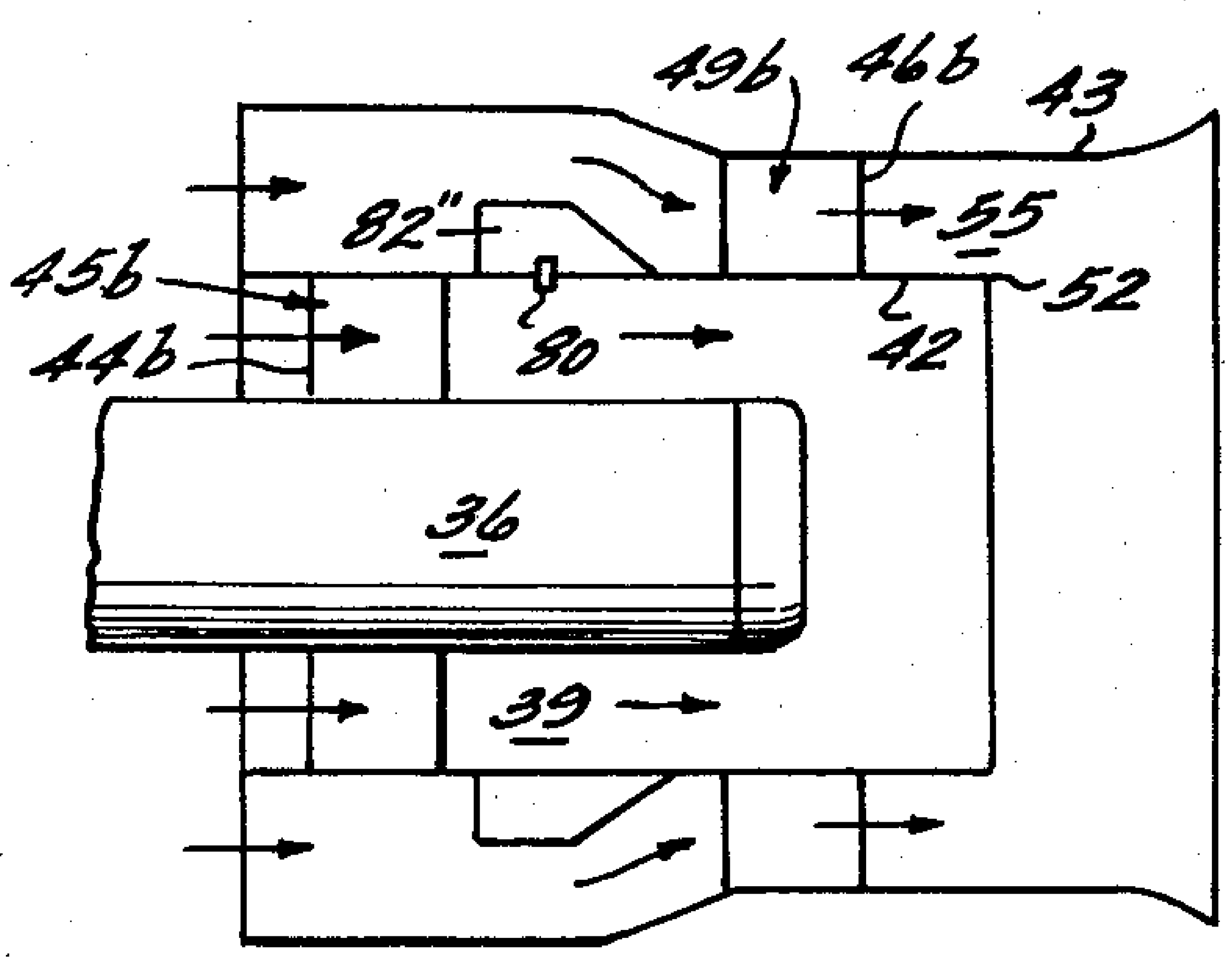
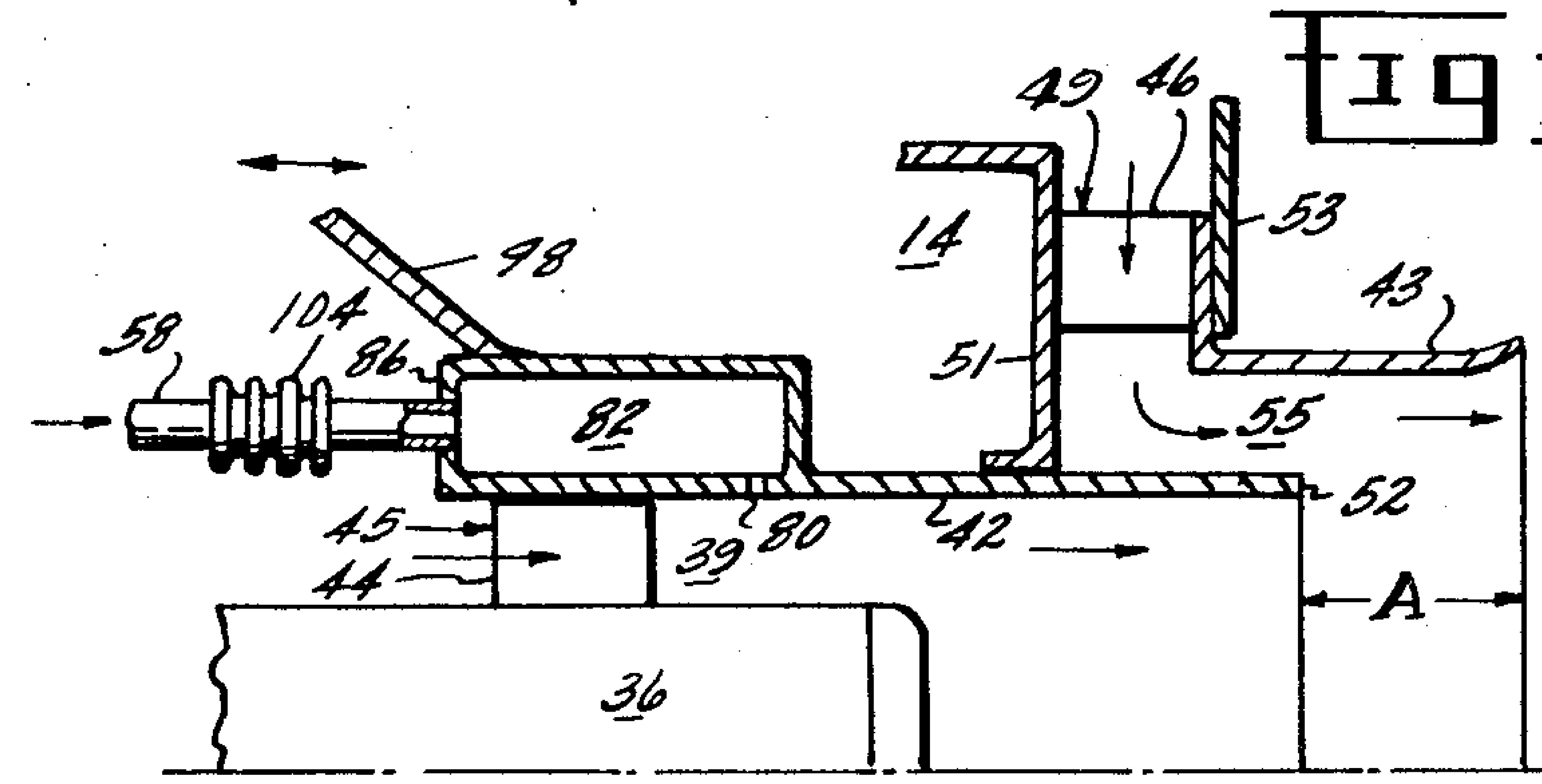


Fig 13



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AIR BLAST FUEL ATOMIZER

BACKGROUND OF THE INVENTION

This invention relates to an air-blast atomizer and, more particularly, to an air-blast liquid fuel atomizer wherein an injector distributes fuel in a manner that enables a concentration of liquid fuel to form on the interior surface of a generally cylindrical shroud. Counter-rotating flows generate aerodynamic forces which establish high shear stresses at the lip of the shroud so as to uniformly disperse and highly atomize fuel directed to the lip.

Fuel injection into a continuous flow combustion chamber as, for example, in a gas turbine engine has posed continuing design problems. Difficulties have been encountered in injecting fuel in a highly dispersed manner so as to achieve complete and efficient combustion of the fuel, and at the same time minimize the occurrence of fuel-rich pockets which upon combustion produce carbon or smoke. Fuel injection difficulties have been further complicated by the recent introduction of gas turbine engines having increased combustor pressure capabilities. Existing fuel sprays atomizer efficiency decreases as combustor pressure is increased, resulting in a more non-uniform dispersion of fuel, together with an increase in the fuel-rich zones within the combustion chamber which cause reduced burner efficiency, excessive exhaust smoke, and a non-uniform heating of the combustor shell, a condition commonly referred to as hot-streaking, which can lead to rapid deterioration of the shell. Also, the recent use of economical heavy hydrocarbon fuels of high viscosity has further reduced the efficiency of existing fuel spray atomizers.

High fuel pressure spray atomizers have been suggested to overcome these adverse effects, but have not proved entirely satisfactory because of present fuel pump pressure limitations. Systems for vaporizing fuel upon injection into the combustor have also proved to be severely limited due to the dependence of the vaporization process on the temperature of the fuel and air entering the combustor.

Recently suggested atomizers employing a system of counter-rotational primary and secondary swirl vanes have proved highly successful in overcoming many of the aforementioned difficulties. In such systems a fuel-air mixture is introduced upstream of the primary swirl vanes and the fuel is subsequently atomized by the high shear stresses developed at the downstream confluence of the counter-rotating air streams. However, this introduction of fuel and its presentation to the air flow upstream of the primary swirl vanes may adversely affect flame stability, and uniform circumferential fuel distribution at the discharge into the chamber.

Therefore, it is a primary object of this invention to provide a fuel injection apparatus that will uniformly disperse fuel in a highly atomized manner for application in high combustor pressure engines.

It is also an object of this invention to provide a fuel injection apparatus whose performance remains substantially unaffected by the introduction of economical heavy hydrocarbon fuels.

It is a further object of this invention to provide a fuel injection apparatus wherein a concentration of fuel becomes highly atomized by the high shear stresses developed at the confluence of the counter-rotating air streams.

It is another object of this invention to provide a fuel injection apparatus whereby flame stability and discharge uniformity is improved by the initial introduction of fuel to air, downstream of the primary swirl vanes.

SUMMARY OF THE INVENTION

The air-blast fuel atomizer of this invention generally includes a cylindrical primary shroud member having a downstream circumferential lip. Fuel injection means are provided to dispose a concentration of liquid fuel which may include a continuous liquid fuel layer, on or near the interior surface of the primary shroud member. A primary air swirler positioned in upstream flow communication with the interior surface of the primary shroud member introduces a primary air swirl into the confines of the primary shroud member thereby imparting both an axial and a tangential velocity component to the concentrated fuel. A secondary air swirler is in upstream flow communication with the primary shroud lip, and introduces an air swirl having a circumferential velocity component opposing that of the primary air swirl. Liquid fuel reaching the lip is atomized by the high shear stresses developed by the counter-rotating aerodynamic forces at the confluence of the primary and secondary air streams. Flow means are provided for introducing an air flow to the primary and secondary air swirlers.

The fuel injection means may be housed in a generally cylindrical hollow centerbody within the primary shroud member and spaced apart therefrom, so as to define a substantially annular air passage therebetween for the primary air swirl. A plurality of circumferentially spaced apart fuel injection ports would pass through the centerbody. The ports may be slanted both tangentially and axially aft to impart initial circumferential and axial velocity components to the fuel. Alternatively, the cylindrical primary shroud member may include at least one fuel injection port through the primary shroud member for establishing a concentration of liquid fuel on the interior surface of the primary shroud. Again the port may be slanted both tangentially and axially aft to impart initial circumferential and axial velocity components to the fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be better understood upon reading the following description of the preferred embodiment in conjunction with the accompanying drawings.

FIG. 1 shows a cross-sectional view of a typical jet engine combustion chamber including the air-blast fuel atomizer of this invention.

FIG. 2 shows a detailed cutaway perspective view of the air-blast fuel atomizer of FIG. 1.

FIG. 3 shows an alternate arrangement for the swirl vanes of the air-blast fuel atomizer of FIGS. 1 and 2.

FIG. 4 shows another arrangement for the swirl vanes of the air-blast fuel atomizer of FIGS. 1 and 2.

FIG. 5 shows a detailed preferred arrangement partly in cross-section for the fuel injection ports of the air-blast fuel atomizer of FIGS. 1 and 2.

FIG. 6 is a cross-section taken on line 6-6 of FIG. 5 of the fuel injection ports of the air-blast fuel atomizer of FIGS. 1 and 2.

FIG. 7 shows a detailed cutaway perspective view of an alternate arrangement for the fuel injection means of the air-blast fuel atomizer of FIGS. 1 and 2.

FIG. 8 shows a cross-section taken on line 8—8 of FIG. 7 of an alternate arrangement for the fuel injection ports of the air-blast fuel atomizer of FIG. 7.

FIG. 9 shows a cross-section taken on line 8—8 of FIG. 7 of another arrangement for the fuel injection ports of the air-blast fuel atomizer of FIG. 7.

FIG. 10 shows a cross-section taken on line 10—10 of FIG. 9.

FIG. 11 shows an alternate arrangement for the swirl vanes of the air-blast fuel atomizer of FIG. 7.

FIG. 12 shows another arrangement for the swirl vanes of the air-blast fuel atomizer of FIG. 7.

FIG. 13 shows a partial cross-section of a variable geometry air-blast fuel atomizer.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly to FIG. 1, a continuous burning combustion apparatus of the type suitable for use in a gas turbine engine has been shown generally at 10 as comprising a hollow body 12 defining a combustion chamber 14 therein. The hollow body 12 includes a domed upstream closure member 16 having a plurality of circumferentially spaced apart openings 18 of which only one is shown in the drawing. The openings 18 receive the air-blast atomizers of this invention, one of which is shown generally at 34. The domed closure member 16 also includes a plurality of air ports 15. The domed upstream closure member 16 and air-blast atomizer 34 define the upstream end of the chamber 14, with the domed member 16 suitably secured to the hollow body 12. As will be understood by those skilled in the art, the combustion chamber 14 may be of the annular type or the cannular type.

An outer shell 20 may be provided to enclose the hollow body 12 and define passages 22 and 24 in cooperation with the hollow body 12 and an upstream extension 26 of the hollow body 12. As will be understood, the passages 22 and 24 are adapted to deliver a flow of pressurized air from a suitable source, such as a compressor 28, into the combustor chamber 14 through suitable apertures or louvers 30 for cooling of the hollow body 12 and dilution of the gaseous products of combustion as is well known in the art.

The upstream extension 26 of the hollow body 12 is adapted to function as a flow splitter to divide the pressurized air delivered from the compressor 28 between passages 22, 24 and an upstream end opening 32 of the extension 26. The opening 32 communicates with a chamber 33 which is defined internally of the extension 26 and the domed member 16.

Referring now to both FIGS. 1 and 2, one embodiment of the air-blast atomizer of this invention has been shown generally at 34 as including a hollow cylindrical centerbody 36 having circumferentially spaced apart fuel injection ports 40 through the sides thereof. Centerbody 36 is integrally formed with hollow stem 38, which is retained in position by connection to the outer shell 20 at fitting 50. Hollow stem 38 includes a suitable fuel delivery means which extends through the outer shell 20, and communicates with a source of pressurized fuel [not shown] so as to provide fuel to the injection ports 40. A generally cylindrical primary shroud member 42 surrounds the centerbody 36, and is radially spaced apart therefrom so as to define a substantially annular air passage 39 therebetween. The primary shroud member 42 includes a downstream circumferential lip 52. A primary air swirler is shown generally at 45 as including a plurality of axial swirl vanes 44 which are circumferentially spaced apart around centerbody 36, and retained in spaced relationship by means of a primary vane shroud 47, which may be attached to or formed integrally with the primary shroud member 42. The primary shroud members 42, 47 coact to establish flow communication from the upstream air swirler 45 to the fuel injection port 40 and to the downstream lip of the primary shroud member designated at 52.

A secondary air swirler is shown generally at 49 as including a plurality of circumferentially spaced radial swirl vanes 46 retained in spaced relationship by circumferential retaining walls 51 and 53 which are axially spaced apart. A generally cylindrical secondary shroud member 43 circumscribes the primary shroud member, and is spaced apart therefrom, to define a substantially annular air passage 55 therebetween, so as to direct flow of the secondary swirl air over the primary lip 52.

Domed closure member 16 plugs into a floating ferrule 48, thereby accommodating both circumferential and radial thermal growth. Floating ferrule 48 may be attached to or formed integrally with either radial wall member 53 or secondary shroud 43. The floating ferrule 48 maintains the concentricity of the primary shroud 42 with respect to the centerbody 36 upon thermal expansion.

The centerbody 36 is shown as comprising an annular fuel manifold 56 which provides fuel to the circumferentially spaced apart fuel injection ports 40. The fuel delivery means within stem 38 are shown as including a fuel conduit 58 in flow connection with annular fuel manifold 56. Centerbody 36 may also include an auxiliary fuel spray atomizer 60 having a spray nozzle 62 serviced by an auxiliary fuel conduit 64. The auxiliary fuel spray atomizer may be utilized for initial ignition or when the situation is such as to demand assisted atomization. However, for most applications it is possible to dispense entirely with such assistance by the auxiliary fuel spray atomizer and use only the fuel injection ports. As will be understood, suitable ignition means 61 such as an electrical spark are provided within the combustion chamber 14 to provide initial ignition of the combustible air fuel mixture discharged by apparatus 34.

In operation, liquid fuel is delivered to annular fuel manifold 56 through fuel conduit 58. Pressurized fuel is sprayed from the fuel manifold through fuel injection ports 40, impinging on the interior surface of the primary shroud member 42 so as to deposit a concentration of fuel thereon. The fuel injection ports 40 may be radial, although it has been preferable preferably to have the fuel injection ports slanting axially aft as shown in the detailed illustration of the centerbody 36 in FIG. 5. Slanting the fuel injection ports axially aft imparts a downstream velocity component to the fuel as it is ejected. It has also been found preferable to align the fuel injection ports 40 in a tangential direction as shown in FIG. 6 to impart a circumferential velocity component to the fuel in the same direction as the circumferential velocity component imparted by the primary air swirler **45**. Therefore the fuel flows from the ports with initial tangential and axial velocity components which act to centrifuge the fuel so as to form a concentration of fuel on the interior surface of the primary shroud **42** and to drive the fuel along the interior surface toward the downstream circumferential lip **52**. The upstream primary axial swirl vanes **44** receive compressor discharge air and impart a circumferential velocity component thereto, such that the aerodynamic forces of the air emanating from the swirl vanes act to further centrifuge the concentration of fuel on the interior surface of the primary shroud member.

The deposited concentration of fuel is centrifugally driven or pushed along the interior surface of the primary shroud member towards the downstream circumferential lip **52**. Depositing and concentrating the fuel over the interior surface of the primary shroud member, by itself, serves to increase the fuel to air contact ratio before atomization, by a factor equal to the area of the interior surface of the primary shroud member divided by the area of the fuel injection ports. Circumferential and axial velocity components are imparted to the concentrated fuel by initially jetting the fuel through the tangentially and axially slanted ports and by the aerodynamic forces of the primary air swirl, which combine to drive the fuel towards the primary shroud lip, imparting substantial kinetic energy to the fuel.

The secondary, circumferentially spaced apart, axial swirl vanes **46** receive compressor discharge air and impart a circumferential velocity component thereto in the opposing direction of the primary swirl air. The primary swirl air discharges from the air blast fuel atomizer in a substantially vortical flow **70** and would be seen from a downstream position as having clockwise circumferential velocity component, while the secondary swirl air also discharges in a substantially vortical flow **72**, and would be seen as having a counter-clockwise circumferential velocity component. A conical area of turbulent air-flow exists on the boundary **74** between the primary and secondary vortices. Fuel delivered to the primary shroud lip **52** is highly atomized by the high aerodynamic shear stresses developed at the confluence of the counter-rotating primary and secondary streams of air. The atomized fuel droplets become highly dispersed by the turbulent air-flow at the boundary area **74** between the primary and secondary vortical flow.

It is believed that the majority of atomized fuel droplets are centrifuged into the secondary vortical flow **72** where they are driven generally outward toward the hollow body **12**. The high differential velocity component between the counter-rotating air swirls permits a high relative velocity component for the fuel droplets without having to accelerate the fuel droplets to such a high absolute velocity. It is further believed that a low pressure area exists between the domed closure member **16** and the secondary vortical flow **72**. This low pressure area causes the highly atomized fuel droplets to recirculate toward the domed closure member as shown by the flow lines of FIG. **1**.

It is also believed that the fuel droplets are ignited by ignition means **61** whereupon the flame subsequently stabilizes in the stagnation zones **78** near the domed closure member. The stagnation zones are enhanced by the recirculation of compressor discharge air entrained through the dome air ports **15**. The core **76** of the primary vortical flow **70** is at a reduced pressure, thereby entraining a portion of the hot products of combustion and causing a recirculation thereof so as to maintain continuous ignition within the combustion chamber **14**.

Auxiliary fuel spray atomizer **60** may be incorporated within centerbody **36** to assist in the situation where there is insufficient aerodynamic energy available for efficient air blast atomization, or in a situation where an auxiliary fuel source would provide improved performance for special requirements. For instance, the auxiliary fuel spray atomizer **60** may provide starting fuel flows at initial ignition by spray atomization at relatively low fuel pressures. Preferably when the auxiliary fuel spray atomizer is not utilized it is continuously purged with an air flow through the spray nozzle **62** in order to prevent blocking of the orifice and buildup of carbon on the face during engine operation.

Although the primary and secondary swirl vanes have been shown in FIGS. **1** and **2** as axial and radial respectively, the actual scope of invention is substantially broader and may include many alternative configurations for the swirl vanes. Referring now to FIG. **3**, there is shown an alternate arrangement for the primary and secondary swirl vanes. The primary and secondary swirlers **45*a*** and **49*a*** are shown as comprising a plurality of circumferentially spaced apart swirl vanes, **44*a*** and **46*a*** respectively, each of which is in a radial configuration. FIG. **4** shows still another suitable arrangement for the primary and secondary swirl vanes of FIGS. **1** and **3**. Primary swirlers **45*b*** and secondary swirlers **49*b*** are shown as including a plurality of circumferentially spaced apart swirl vanes, **44*b*** and **46*b*** respectively, each of which is in an axial configuration.

Referring now to FIG. **7** there is shown an alternate arrangement for the fuel injection means as included in the air-blast fuel atomizer of this invention which is shown generally at **34** where like numerals refer to previously described components. The fuel injection means are shown as including at least one substantially tangential fuel injection port **80** through the primary shroud member **42**. Pressurized fuel may be supplied to the fuel injection port **80** by means of an annular fuel manifold **82** around the primary shroud **42**. Annular fuel manifold **82** is defined by a radially extending circumferential wall **84** and an axially extending circumferential wall **86** cooperating with the exterior surface of primary shroud member **42** and the radially extending circumferential wall **51**. Pressurized fuel is introduced into fuel manifold **82** by means of fuel conduit **58** which is in direct flow connection to an external source of pressurized fuel [not shown].

In operation, liquid fuel is delivered to annular fuel manifold **80** through fuel conduit **58**. Pressurized fuel flows from the fuel manifold **80** through fuel injection port **80** which is preferably formed so as to discharge fuel in a direction substantially tangential to the interior surface of the primary shroud member. The fuel injection port is also preferably slanted axially aft so as to impart a downstream velocity component to the fuel as it is ejected. The fuel flows from the port with initial tangential and axial velocity components which act to centrifuge the fuel so as to form a concentration of fuel on the interior surface of the primary shroud member

42. The concentrated fuel approaches a discrete swirling film travelling downstream along the interior surface of the primary shroud toward the circumferential lip **52**. The upstream primary axial swirl **44** receive compressor discharge air and impart a circumferential velocity component thereto, such that the aerodynamic forces of the air emanating from the swirl vanes act to further centrifuge the concentrated fuel on the interior surface of the primary shroud member. The fuel is centrifugally driven or pushed along the interior surface of the primary shroud member toward the down-stream circumferential lip **52**. The primary swirl air may also induce wave instabilities into the swirling fuel which subsequently enhance the atomization of fuel at the lip **52** of the primary shroud. In order to maximize the enhancing effect of the wave instabilities, the distance from the fuel injection port **80** to the lip **52** of the primary shroud member may be selected as a function of the diameter of the primary shroud. The fuel is subsequently atomized at the primary shroud lip **52** by the high aerodynamic shear stresses developed at the confluence of the counter-rotating primary and secondary streams of air in the same manner as previously described in reference to FIGS. **1** and **2**.

The intended scope of invention for the arrangement of FIG. **7** should not be limited to the single fuel injection port, but may also include a plurality of circumferentially spaced apart fuel injection ports passing tangentially through the primary shroud member. The cross-sectional view of FIG. **8** shows a scheme for a twin port fuel injection system including duel fuel injection ports **80** and **80**^{1}. FIGS. **9** and **10** show an alternate scheme whereby primary shroud member **42** includes a circumferential recessed slot **88** in the interior surface thereof. The swirling fuel spills over the edge **90** of the slot **88** onto the interior surface of the shroud and flows downstream. The slot configuration is not limited to the rectangular cross-section shown, but may be of almost any cross-section, such as a V shape or a curvilinear cross-section, as long as the slot extends circumferentially around the primary shroud and in some way indents the interior surface of the primary shroud.

Although the primary and secondary swirl vanes have been shown in FIG. **7** as axial and radial respectively, again the actual scope of invention is substantially broader and may include many alternative configurations for the swirl vanes. Referring now to FIG. **11**, there is shown an arrangement for the primary and secondary swirl vanes. The primary and secondary swirlers **45**^{a} and **49**^{a} are shown as comprising a plurality of circumferentially spaced apart swirl vanes, **44**^{a} and **46**^{a} respectively, each of which is in a radial configuration. Annular fuel manifolds **82** is disposed between the axial swirl vanes. FIG. **12** shows still another arrangement for the primary and secondary swirl vanes of FIG. **7**. Primary swirlers **45**^{b} and secondary swirlers **49**^{b} are shown as including a plurality of circumferentially spaced apart swirl vanes **44**^{b} and **46**^{b} respectively, each of which is in an axial configuration. Annular manifold **82**^{11} is shown as circumscribing the primary shroud member **42**.

The spray angle of fuel atomized off the lip of the primary shroud member may be critical for effective burning of fuel. FIG. **13** shows a variable geometry configuration for conveniently adjusting the spray angle of the atomized fuel by varying the distance (A) from the lip **52** of the primary shroud **42** to the end of the secondary shroud **43**. The primary shroud **42** is slidably retained with respect to both the radially extending circumferential wall **51** and the primary air swirler **45**. Linkage arm **98** may be fixedly attached to the wall **86**. The other end of linkage arm **98** is not shown, but may be connected through a series of linkages or hydraulic means to an engine fuel control system [not shown]. Conduit **58** includes an expansible and contractible section **104** to allow unrestrained translation of primary shroud **42**.

In operation the spray angle of the atomized fuel may be varied through actuation of linkage arm **98** through the fuel control system. Actuation of linkage arm **98** imparts an axial translation to the primary shroud member **42**. Reduced spray angles may be achieved by translating the lever arm **98** in a forward direction resulting in an increased distance (A) between the lip **52** of the primary shroud **42** and the end of the secondary shroud **43**.

From the foregoing, it will be appreciated that the present invention provides an improved apparatus for efficiently and satisfactorily introducing fuel into a combustion chamber in a positive and controlled manner over a wide range of operating conditions. Initially concentrating fuel on the interior of a primary shroud member serves to greatly increase the fuel to air contact ratio before atomization. Counter-rotating primary and secondary air swirlers impart substantial kinetic energy to the fuel and establish high shear stresses to insure efficient atomization at the confluence of the two air streams.

While the air-blast fuel atomizer has been depicted as satisfying a specific gas turbine application as a fuel injector and atomizer, it should be understood that the concept of this invention has broad applicability as to atomizing all types of liquid fuels as utilized in various combustion processes. As an example, the air-blast fuel atomizer of this invention could be utilized as a fuel injector for a supercharged automotive engine. Accordingly, while preferred embodiments and a preferred application of the present invention have been depicted and described, it will be appreciated by those skilled in the art that many modifications, substitutions, and changes may be made thereto without departing from the invention's fundamental theme.

What is claimed is:

1. An air blast fuel atomizer for atomizing fuel in the combustion chamber of a gas turbine engine comprising:

a generally cylindrical primary shroud member having a downstream circumferential lip;

fuel injection means for establishing a concentration of fuel on the interior surface of said primary shroud member;

a primary air swirler in upstream flow communication with the interior surface of said primary shroud member so as to introduce a primary air swirl into the confines of said primary shroud member, said air swirl imparting both an axial and circumferential velocity component to said concentration of fuel;

a secondary air swirler in upstream flow communication with said lip, so as to introduce an air swirl having a circumferential velocity component opposing that of said primary air swirl such that fuel reaching said lip is atomized by the high shear stresses developed by the counter-rotating aerodynamic forces at the confluence of said primary and secondary air swirls;

flow means for introducing an air flow to said primary and secondary swirlers;

and a generally cylindrical centerbody within said primary shroud member and concentrically spaced apart therefrom so as to define a substantially annular air passage therebetween wherein said centerbody is hollow and said fuel injection means includes at least one fuel injection port through said centerbody, through which fuel may be directed onto the interior surface of said primary shroud to form a concentration of fuel thereon, and also wherein said fuel injection port is tangentially slanted to impart a circumferential velocity component to the fuel in the same general direction as the circumferential component of said primary air swirl.

2. The atomizer of claim 1 wherein said centerbody further includes an auxiliary fuel injection means of the fuel pressure spray atomizer type for providing fuel dispersions at relatively low aerodynamic energies.

3. The atomizer of claim 1 wherein said fuel injection port is slanted axially downstream to impart a downstream velocity component to the fuel.

4. The atomizer of claim 1 wherein the primary air swirler includes a plurality of circumferentially spaced apart, axial swirl vanes, and the secondary air swirler includes a plurality of circumferentially spaced apart, radial swirl vanes.

5. The atomizer of claim 1 wherein the primary air swirler includes a plurality of circumferentially spaced apart, radial swirl vanes, and the secondary air swirler includes a plurality of circumferentially spaced apart, radial swirl vanes.

6. The atomizer of claim 1 wherein the primary air swirler includes a plurality of circumferentially spaced apart, axial vanes, and the secondary air swirler includes a plurality of circumferentially spaced apart axial swirl vanes.

7. An air blast fuel atomizer for atomizing fuel in the combustion chamber of a gas turbine engine comprising:

a generally cylindrical primary shroud member having a downstream circumferential lip;

fuel injection means for establishing a concentration of fuel on the interior surface of said primary shroud member wherein said fuel injection means includes at least one fuel injection port through said primary shroud member so as to accommodate the formation of a concentration of fuel on the interior surface of said primary shroud, together with fuel delivery means for directing fuel to the injection port;

a primary air swirler in upstream flow communication with the interior surface of said primary shroud member so as to introduce a primary air swirl into the confines of said primary shroud member, said air swirl imparting both an axial and circumferential velocity component to said concentration of fuel;

a secondary air swirler in upstream flow communication with said lip, so as to introduce an air swirl having a circumferential velocity component opposing that of said primary air swirl such that fuel reaching said lip is atomized by the high shear stresses developed by the counter-rotating aerodynamic forces at the confluence of said primary and secondary air swirls;

and flow means for introducing an air flow to said primary and secondary air swirlers.

8. The atomizer of claim 7 wherein said fuel injection port is in substantial tangential relation to the interior surface of said primary shroud member so that said concentration of fuel approaches a discrete swirling film of fuel.

9. The atomizer of claim 7 wherein said fuel injection port is slanted axially aft to impart an axial velocity component to the concentrated fuel.

10. The atomizer of claim 7 wherein said fuel delivery means includes a substantially annular manifold circumscribing said primary shroud member and in direct flow communication with a plurality of circumferentially spaced apart fuel injection ports through said primary shroud member, together with conduit means for directing the flow of fuel to said manifold.

11. The atomizer of claim 7 including a recessed circumferential slot in the interior surface of said primary shroud member, said slot being in direct flow connection to said fuel injection slot.

12. The atomizer of claim 7 wherein the primary air swirler includes a plurality of circumferentially spaced apart, axial swirl vanes, and the secondary swirler includes a plurality of circumferentially spaced apart, radial swirl vanes.

13. The atomizer of claim 7 wherein the primary air swirler includes a plurality of circumferentially spaced apart, radial swirl vanes, and the secondary air swirler includes a plurality of circumferentially spaced apart, radial swirl vanes.

14. The atomizer of claim 7 wherein the primary air swirler includes a plurality of circumferentially spaced apart, axial swirl vanes, and the secondary air swirler includes a plurality of circumferentially spaced apart axial swirl vanes.

15. The atomizer of claim 7 including a generally cylindrical centerbody within said primary shroud member and spaced apart therefrom so as to define a substantially annular air passage therebetween, said centerbody further housing an auxiliary fuel injection means of the fuel pressure spray atomizer type for providing fuel dispersions at relatively low aerodynamic energies.

16. The atomizer of claim 1 including a generally cylindrical secondary shroud member circumscribing the primary shroud member and spaced apart therefrom to define a substantially annular air passage therebetween wherein said primary shroud member is slidably retained in respect to said secondary shroud for translation in a generally axial direction thereby permitting adjustment of the spray angle of said atomized fuel.

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