Feb. 10, 1953 I. T. ROSENLUND 2,627,721

COMBUSTION MEANS FOR JET PROPULSION UNITS

Filed Jan. 30, 1947 2 SHEETS—SHEET 1

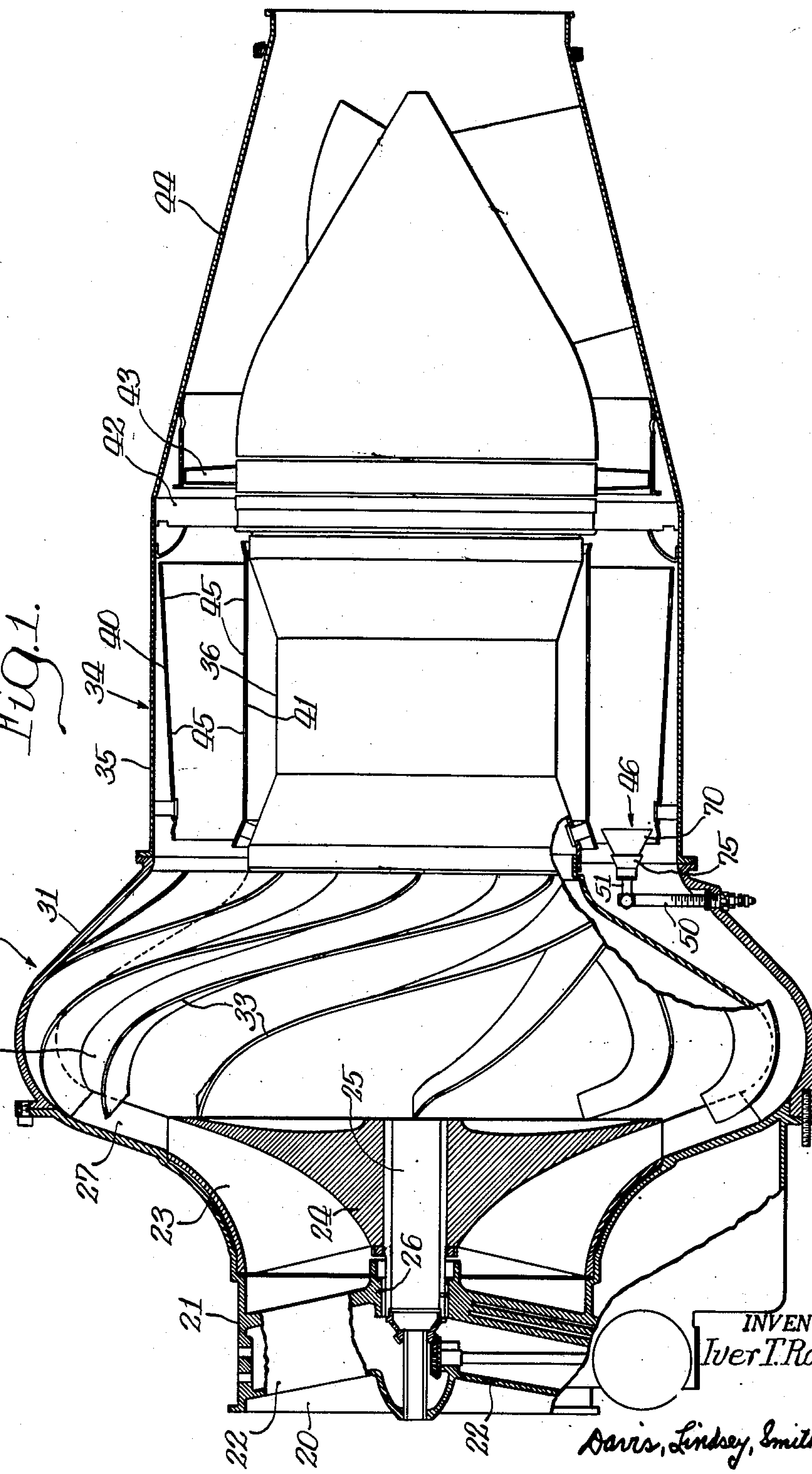

Fig. 1.

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Fig. 2.

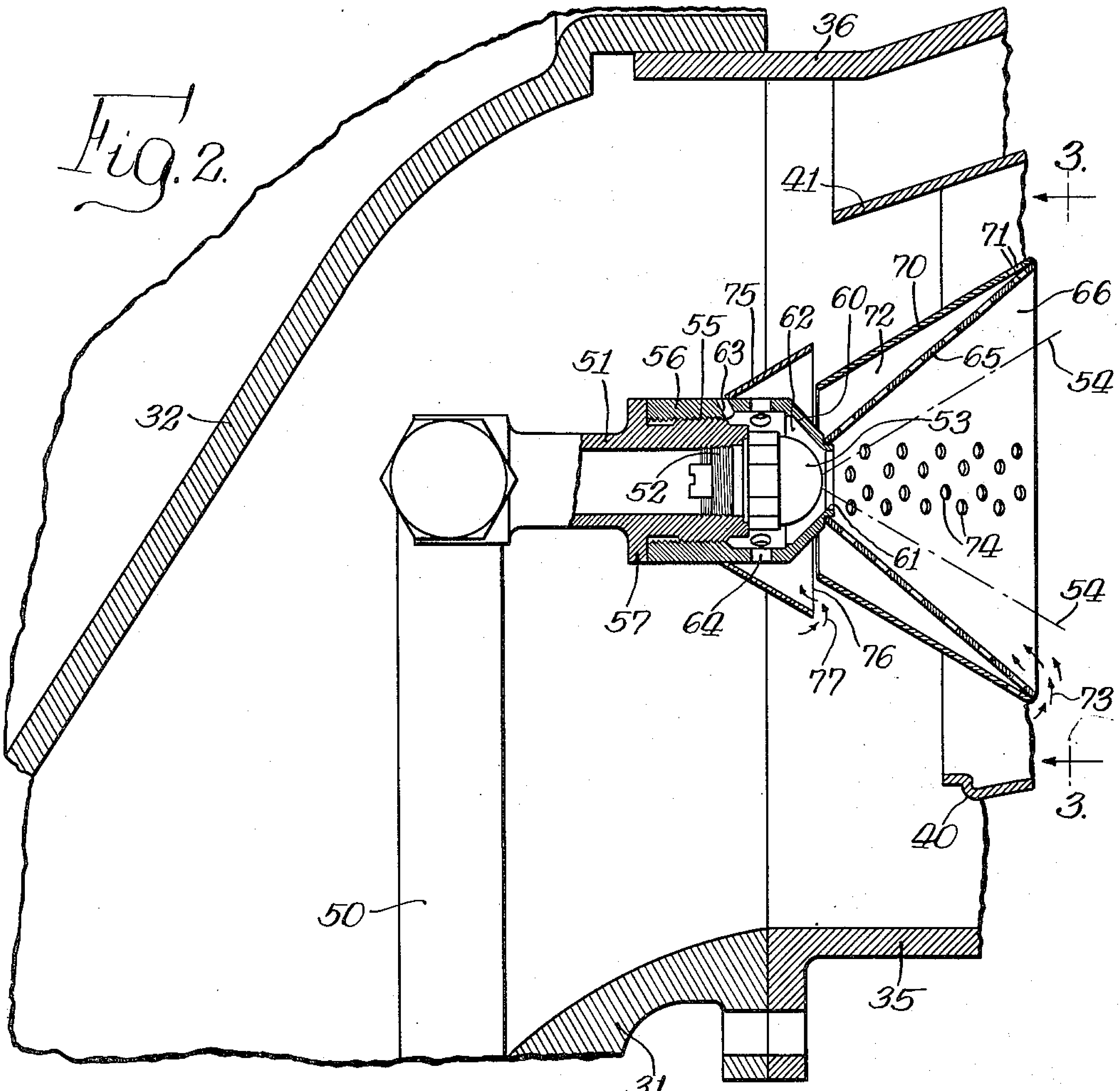
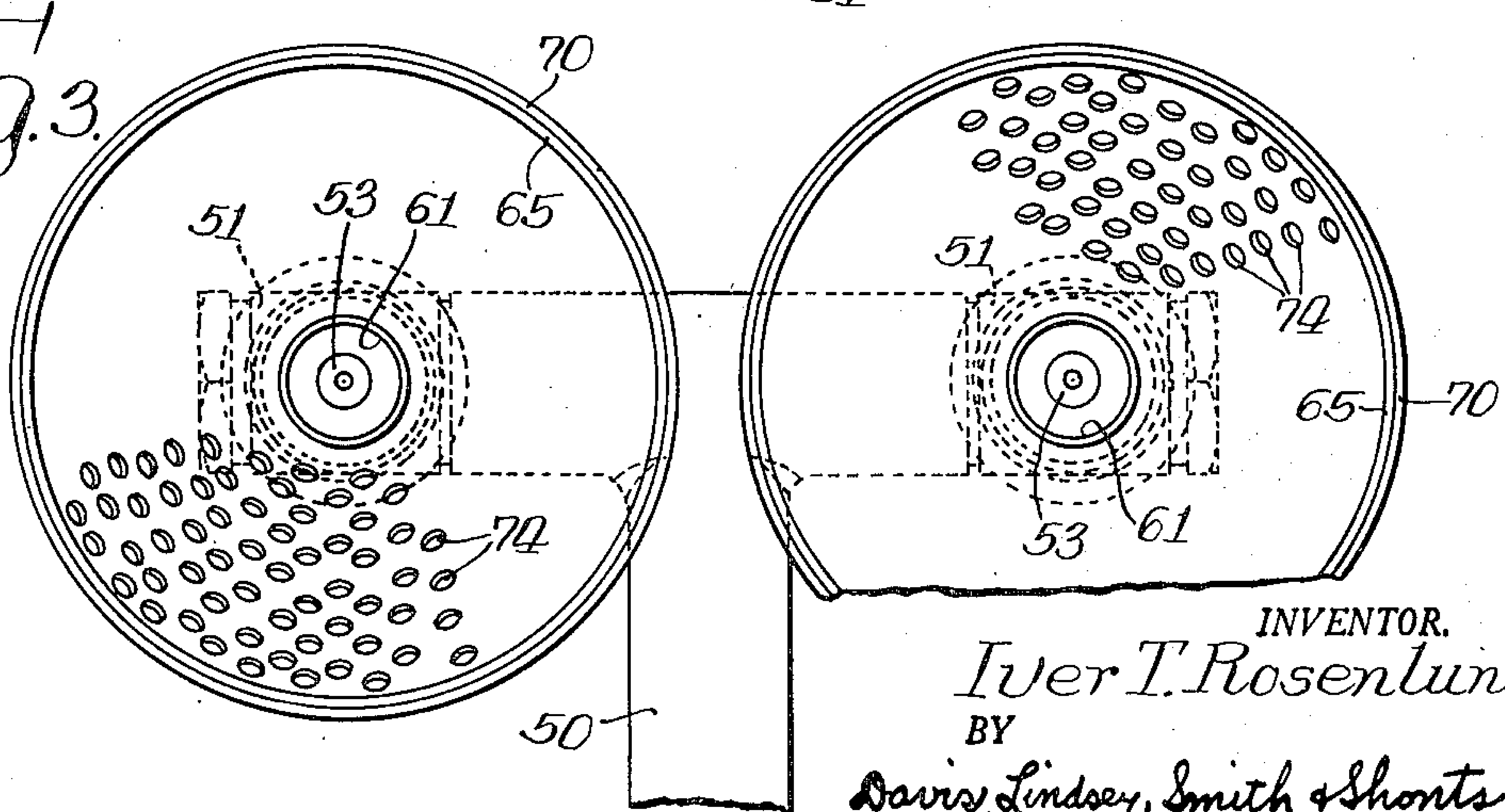


Fig. 3.



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COMBUSTION MEANS FOR JET PROPULSION UNITS

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7 Claims. (Cl. 60—39.72)

The invention relates to combustion means of a character suitable for a jet propulsion unit.

In jet propulsion units, the jet stream is produced by forcing air into a zone where combustion of the fuel takes place, the hot gases emerging from said zone constituting or ultimately producing the jet stream. Because of the high velocity of the air blast entering such zone, it is difficult to maintain combustion therein because of the tendency of the high velocity air to carry the flame away from the point at which the fuel is introduced into the air stream.

The general object of the invention is, therefore, to provide a novel combustion means or burner for a jet propulsion unit, providing an area where a nucleus of flame can be developed and maintained with protection against extinguishment of the flame by the high velocity air blast in the path of which the burner is located.

Another object is to provide a novel burner providing a flame area which receives air from the high velocity air blast wherein the burner is located, but which is protected from the direct velocity of the blast, so that a nucleus of flame may thereby be maintained to insure continued combustion of the fuel.

A further object is to provide a novel burner providing an area through which fuel is sprayed and in which a small portion of the fuel is burned with the flames therein shielded from the surrounding high velocity air blast, so that a nucleus of flame is maintained to insure combustion of the remaining or major portion of the fuel beyond the burner and so that such major portion is preheated in its passage through said area.

Still another object is to provide a novel burner of the general character referred to above, which is so constructed that no carbon will accumulate in the burner to interfere with its operation.

A still further object is to provide novel combustion means comprising a combustion chamber of annular form with a plurality of burners located in the upstream end thereof, a portion of the high velocity air blast passing around said chamber to enter through the sides thereof to supply secondary air for combustion while primary air from said blast enters the upstream end about the burners, with a part of the primary air drawn into each burner to provide the air necessary to support combustion for a nucleus of flame developed within the burner.

It is also an object to provide a novel method of effecting combustion of fuel in a high velocity air blast.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view of a jet propulsion unit having combustion means embodying the features of the invention.

Fig. 2 is an enlarged fragmentary sectional view of a portion of the jet propulsion unit and showing the structure of a burner.

Fig. 3 is a face view of a pair of burners taken substantially on the line 3—3 of Fig. 2.

A jet propulsion unit for which the present invention is adapted may be of any desired form. For purposes of illustration, however, I have shown a jet propulsion unit of the general character shown in copending application Serial No. 649,871, filed February 25, 1946, in which Robert M. Williams and Curtis N. Lawter were co-inventors. Such a unit is illustrated in Fig. 1 of the drawings and comprises generally an intake opening **20** centrally positioned at the front end of the unit and provided by a shell or cover **21**. Within the cover **21** are a plurality of guide vanes **22** for directing the flow of air rearwardly to a single-stage mixed flow compressor formed by blades **23** carried by a rotor or hub **24**. The latter is fixed on a shaft **25** journaled at its front end in a bearing **26** supported by guide vanes **22**. The air entering the intake opening **20** passes between the guide vanes **22** and is directed axially to the blades **23**, from which it is discharged substantially radially into a vaneless diffuser **27**.

From the vaneless diffuser **27** the air is directed rearwardly through a vaned diffuser, indicated generally at **30**, and formed by an outer shell **31** and an inner shell **32**. The shells **31** and **32** are so formed as to direct the air inwardly and rearwardly. The space between the members **31** and **32** is divided by spiral partitions **33** which impart a helical motion to the air. The shells **31** and **32** are so dimensioned as to provide an increased cross-sectional area in the passage therebetween, in spite of the fact that the diameter of such space is reduced, so that the velocity of the air is gradually but materially reduced, as it flows rearwardly through the vaned diffuser **30**. The air emerging from the vaned diffuser, however, still has a high velocity as it enters the combustion portion, indicated generally at **34**, of the unit.

The combustion portion **34** is annular in form and is provided by an outer substantially cylindrical casing **35** and an inner casing **36**. Within the annular space between the casings **35** and **36** is a combustion chamber which is also annular in form and is provided by an outer liner **40** and an inner liner 41. Within the combustion chamber, fuel is burned to provide a power stream of hot gas emerging rearwardly therefrom to pass through stationary turbine guide vanes 42 and then through turbine blades 43. The turbine is mounted on the rear end of the shaft 25 and thus drives the impeller 23 mounted on the forward end of the shaft. The power stream, after passing through the turbine, enters a converging portion 44 of the outer casing, constituting a tail cone.

The invention herein disclosed relates to the combustion of fuel in the combustion chamber provided by the liners 40 and 41. The high velocity air blast emerging from the vaned diffuser 31 may be said to be divided into two portions, one portion passing between the outer liner 40 and the outer casing 35 as well as between the inner liner 41 and the inner casing 36 to provide the secondary air for combustion, such air entering the combustion chamber through apertures 45 provided in the outer and inner liners 40 and 41. The other portion of the air enters the upstream end of the combustion chamber between the outer and inner liners 40 and 41. Mounted in the same end of the combustion chamber is an annular series of burners, indicated in Fig. 1 at 46, for spraying fuel into the combustion chamber. The burners 46 are preferably mounted in pairs, as shown in Fig. 3, with each pair supported by a T-shaped pipe 50 extending radially inward through the outer shell 31 of the vaned diffuser.

With an air blast having as high a velocity as is necessary in a unit of this character, particularly when the unit is operating at loads approaching maximum, there is difficulty in maintaining combustion since the air blast tends to carry the flame downstream faster than the rate of propagation of the flame in the incoming stream of fuel supplied by the burner. In other words, the velocity of the air blast is such that it tends to extinguish the flame. To prevent this from occurring, the burners in the present instance are so constructed that they maintain a nucleus of flame protected from the direct action of the air blast, thus insuring continued combustion of the fuel as it is supplied. Furthermore, the nucleus of flame, which consumes only a small portion of the fuel, is utilized to preheat the major portion of the fuel so as to facilitate combustion thereof.

In the preferred embodiment of the invention shown in the drawings, the T-shaped pipe 50 at the outer end of each arm thereof is provided with a fitting 51 (see Fig. 2) extending forwardly or in a downstream direction toward the combustion chamber. The downstream end of the fitting 51 is internally threaded as at 52 to receive a nozzle 53 for producing a conical spray of fuel. A nozzle of this type is well known in the art and, therefore, need not be described in detail. In the drawings, the spray of fuel is indicated by dash-and-dot lines 54 and in the present instance has an angle of divergence of substantially 60 degrees. The fitting 51 is also provided with external threads 55 to receive a hub 56, the longitudinal position of the hub on the fitting being determined by a flange 57 formed on the fitting. The hube 56, at its front end, is beveled as at 60 and is provided with an opening 61 through which the spray 54 passes. The front end of the hub 56 is hollowed out so as to provide an air passage 62 surrounding the forward end of a nozzle 53. To hold the parts firmly together, the hub may be provided with an aperture 63 to receive a wire (not shown) for preventing the parts from becoming unscrewed. The hub is also provided with a series of radial apertures 64, twelve in the present instance, to admit air to the interior of the hub, such air being drawn forwardly through the opening 61 by jet action of the spray 54.

With an air blast having as high a velocity as is utilized in apparatus of the present character, the fuel, as it is sprayed from the nozzle 53 through the opening 61, if unprotected, would not continue to burn since the direct action of the air blast on the flame would tend to extinguish it. To this end, the cone of fuel is protected from the direct action of the air blast and a nucleus of flame is maintained about the main body of the spray so that continued combustion will be insured. In the preferred form, the means for protecting the spray from the direct action of the air blast comprises an air diffuser 65 of conical form having its smaller end rigidly secured to the hub 56 about the opening 61. The diffuser 65 extends downstream from the opening 61 and is spaced from the fuel spray 54 to provide an annular space 66 of conical form extending about the spray. In the preferred form, the diffuser 65 has an angle of divergence somewhat greater than the conical spray 54 so that the space 66 is of greater radial thickness at its downstream end than at its upstream end, as is apparent in Fig. 2.

The space 66 constitutes an area which is protected from the direct action of the air blast and in which a nucleus of flame is maintained to insure continued combustion of the fuel and to preheat the main portion of the spray as it passes within the space 66. To this end, a conical shield 70 is mounted externally of the diffuser 65. The shield 70 is of substantially the same diameter at its downstream end as the downstream end of the diffuser 65 and is secured thereto as by welding. Holes 71 may be provided at predetermined points in the periphery of the two cones, through which wires may be threaded to insure that the two cones cannot become separated. The cone or shield 70 has its smaller end located in a transverse plane which is slightly upstream from the upstream end of the diffuser 65 and the opening 61 in the hub 56. The shield 70 has a smaller angle of divergence than the cone 65 so that an air space 72 is provided therebetween, the air space 72 being widest at its upstream end and tapering toward its forward end where the two cones are secured together. The shield 70 is subjected exteriorly to the air blast and thus, at its downstream end, produces a low pressure area at the forward or downstream end of the space 66. As a result, air from the air blast will be drawn inwardly, as indicated by the arrows 73, to enter the space 66. Such flow of air, due to turbulence occurring therein, tends to create a mist of fuel within the space 66 which burns to provide the nucleus of flame.

To provide air to support combustion of the mist drawn from the fuel, air is admitted to the space 66, not only at the downstream end of the space as indicated by the arrows 73, but also through the diffuser 65 which, for this purpose, is provided with perforations 74 throughout its area. Air from the air space 72 between the two cones 65 and 70 may be admitted into the space 66 through the perforations 74, the thickness of the metal from which the diffuser 65 is formed tending to direct the flow of air through the perforations 74 toward the spray 54, thus effecting a thorough mixture of the air with the mist in the space 66.

Air is supplied to the air space 72 from the air blast, but such space 72 is protected against the direct velocity of the air. To this end, a conical deflector 75 is mounted on the hub 56 rearwardly of the shield 70 and spreading outwardly beyond the upstream end of the air space 72. Thus, the deflector 75 has its larger end located substantially in the same transverse plane with the upstream end of the shield 70 but the larger end of the deflector 75 is of greater diameter than the adjacent small end of the shield 70 so that an annular opening 76 is provided therebetween. The deflector 75 creates a low pressure area at the opening 76 tending to draw air into the deflector from the air blast, as indicated by the arrows 77. Thus, air from the air blast will be supplied to the air space 72, but at a greatly reduced velocity, so that the air will provide for combustion of the fuel mist within the space 66 without tending to extinguish the flame therein. The air drawn inwardly by the deflector 77 also constitutes the source of air passing inwardly through the radial apertures 64 in the hub, since the deflector 75 engages the hub at a point upstream from the apertures 64.

With the foregoing arrangement of parts, a mist of fuel is created in the space 66 and combustion thereof is maintained by air supplied from three sources, namely: first, from the low pressure area at the downstream end of the diffuser 65, as indicated by the arrows 73; second, from the air space 72 through the perforations 74; and third, from the air passing through the apertures 64 and drawn forwardly through the opening 61 by the jet action of the spray. Such condition and mode of operation apply when the velocity of the air blast is in the lower or middle portion of its range. However, when the unit is operating at loads approaching maximum, the velocity of the air blast may increase to a point where a somewhat different flow of air takes place. Thus, at such high velocities, the blast in passing the deflector 75 may, instead of creating a low pressure area tending to draw air inwardly through the opening 76 between the deflector 75 and shield 70, cause a balancing of pressure at this point so that no air will enter through the opening 76, the entire air for the space 66 being supplied from the low pressure area 73 at the downstream end of the deflector 70. In fact, there may be a complete reversal of air flow through the opening 76. However, in either instance a mist of fuel is created in the space 66 and combustion of such fuel takes place within this space so as to maintain a nucleus of flame extending about the upstream end of the spray. Such nucleus of flame insures complete combustion of the major portion of the fuel passing out in the spray since it forms what may be termed a flame anchor within the high velocity air blast. The cone of flame within the space 66 also functions to preheat the main body of the fuel and thus facilitates subsequent combustion thereof. Such flame further functions to maintain the diffuser 65 in a highly heated condition so that no carbon can form thereon and perforations 74 are therefore maintained clear and free to conduct air to the space 66.

I claim:

1. A burner for use in a high velocity air blast comprising a nozzle for directing a spray of fuel downstream in the blast, an apertured wall, said wall forming an air diffuser extending downstream from said nozzle about said spray and radially spaced therefrom to provide an annular combustion space about the spray, said diffuser being open ended in a downstream direction and an imperforate wall forming a conical shield extending about said diffuser to prevent entrance of air from said blast at a high velocity into said combustion space, the downwstream end of said shield being concentric with and supported from the downstream end of said diffuser, said shield having its downstream end adapted to be positioned in said blast and being open for creating a low pressure area at the downstream end of said space for drawing air through the open end of said diffuser into said space at reduced velocity to vaporize a portion of the spray and effect combustion of said portion.

2. A burner for use in a high velocity air blast comprising a hollow hub, a nozzle mounted in said hub for directing a spray of fuel downstream in the air blast, an air diffuser extending downstream from the hub and providing a combustion space about the spray, a shield extending about said diffuser and producing a low pressure area at the downstream end of said diffuser for drawing air into said space, the upstream end of said shield being open and spaced from the diffuser to admit air thereto, and a deflector carried by said hub for protecting the open end of said shield from direct action by the high velocity blast but spaced from the upstream end of said shield for permitting entrance of air at a reduced velocity.

3. A burner for use in a high velocity air blast comprising a nozzle for directing a conical spray of fuel downstream in said blast, a conical air diffuser extending downstream from said nozzle and flaring outwardly at a greater angle than said spray to provide a conical combustion space about said spray, a conical shield having its downstream end fitting snugly about and secured to the downstream end of said diffuser and its upstream end of larger diameter than the upstream end of said diffuser to provide an air space therebetween, and a conical deflector located upstream from said shield and flaring outwardly beyond the upstream end of said shield to protect said air space from the direct action of said blast.

4. A burner for use in a high velocity air blast comprising a hollow hub having its downstream end open, a nozzle mounted in said hub for directing a conical spray of fuel through the open end of said hub, a conical air diffuser mounted on the open end of said hub and flaring outwardly at a greater angle than said spray to provide a conical combustion space about the spray, a conical shield encircling said diffuser and providing an air space therebetween, and a conical deflector mounted on said hub and flaring outwardly beyond the adjacent end of said shield to protect said air space from the direct action of said air blast but providing communication between said air space and the air blast.

5. A burner for use in a high velocity air blast comprising a hollow hub having its downstream end open, a nozzle mounted in said hub for directing a conical spray of fuel through the open end of said hub, said hub and said nozzle being dimensioned to provide an air passage communicating with said open end, and said hub having a series of radial openings communicating with said air passage, a perforated conical air diffuser extending downstream from said hub and flaring outwardly at a greater angle than

said spray to provide a conical combustion space about the spray, a conical shield encircling said diffuser and providing an air space therebetween, and a conical deflector mounted on said hub upstream from said radial openings and flaring outwardly beyond the adjacent end of said shield to protect said air space from the direct action of the air blast but admitting air at a reduced velocity to said radial openings and said air space.

6. A burner for use in a high velocity air blast, comprising a nozzle for directing a conical spray of fuel downstream in said blast, a hub supporting said nozzle and having a portion radially spaced from said nozzle with the front end thereof tapered inwardly and provided with an opening through which said spray emerges, said portion being provided with a series of radial apertures for supplying air to the space within said portion for discharge through said opening, a perforated diffuser of conical form having its smaller end secured to said hub about said opening and extending downstream therefrom, a conical shield flaring outwardly in a downstream direction and having its downstream end secured to the downstream end of said diffuser and its upstream end extending about the tapered portion of said hub in spaced relation thereto for admitting air to said diffuser, and a conical deflector having its smaller end secured to said hub upstream from said series of apertures and flaring outwardly in a downstream direction in radially spaced relation to the upstream end of said shield.

7. A burner for use in a high velocity air blast, comprising a hub having a tapered front end provided with a central opening, a nozzle

mounted within said hub for discharging a spray of fuel through said opening, a perforated diffuser having its upstream end secured to said hub about said opening and flaring outwardly therefrom in a downstream direction, a shield secured at its downstream end to the downstream end of said diffuser and tapering inwardly therefrom in an upstream direction but at a different angle from said diffuser so that its upstream end is spaced from the tapered end of said hub, and a deflector secured to said hub and tapering outward in a downstream direction in radially spaced relation to the upstream end of said shield.

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