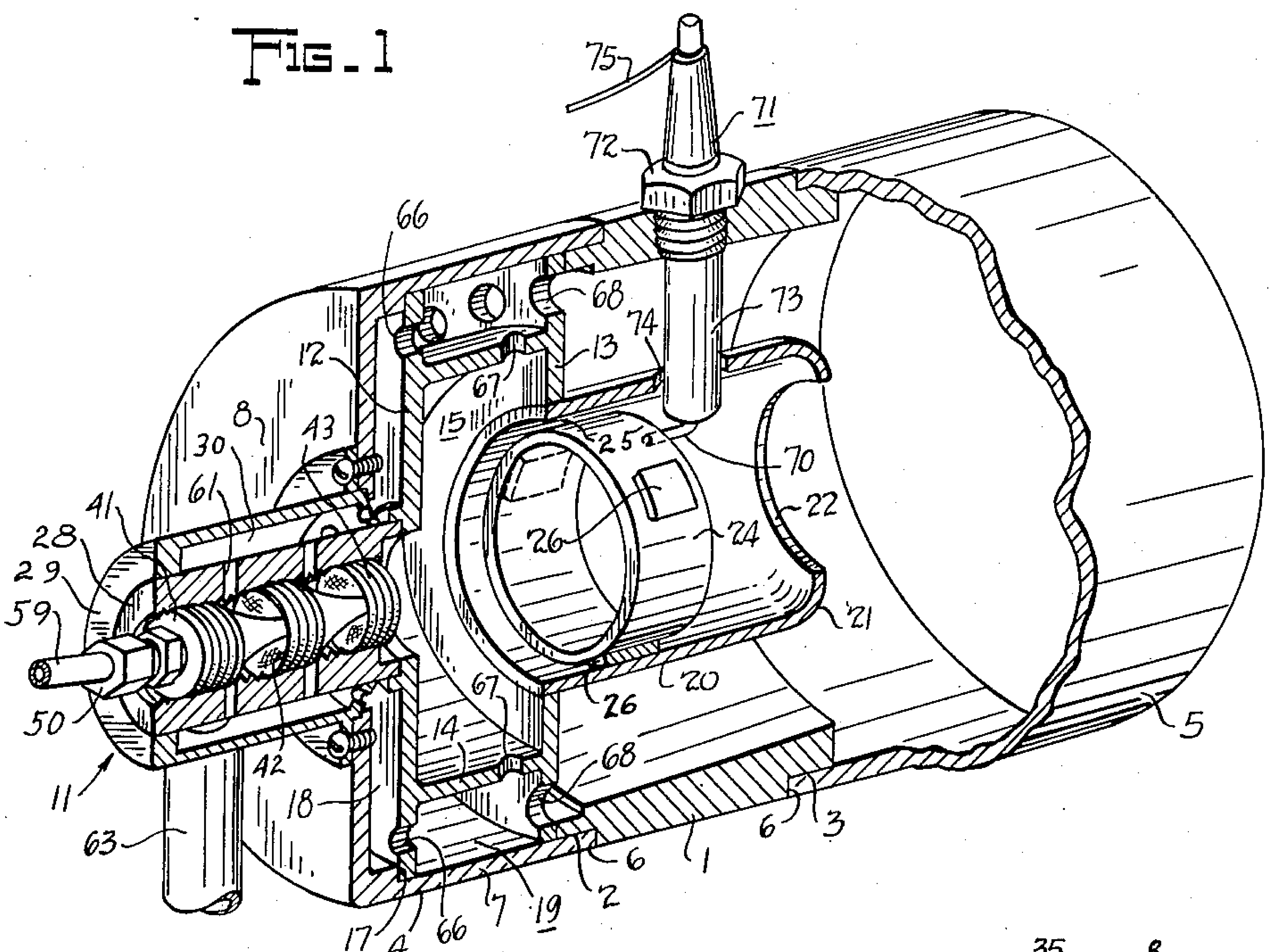
Dec. 25, 1962 R. H. HUNTER ET AL 3,070,317

VARIABLE RATE MULTIPLE FUEL NOZZLE

Original Filed May 21, 1958

FIG. 1



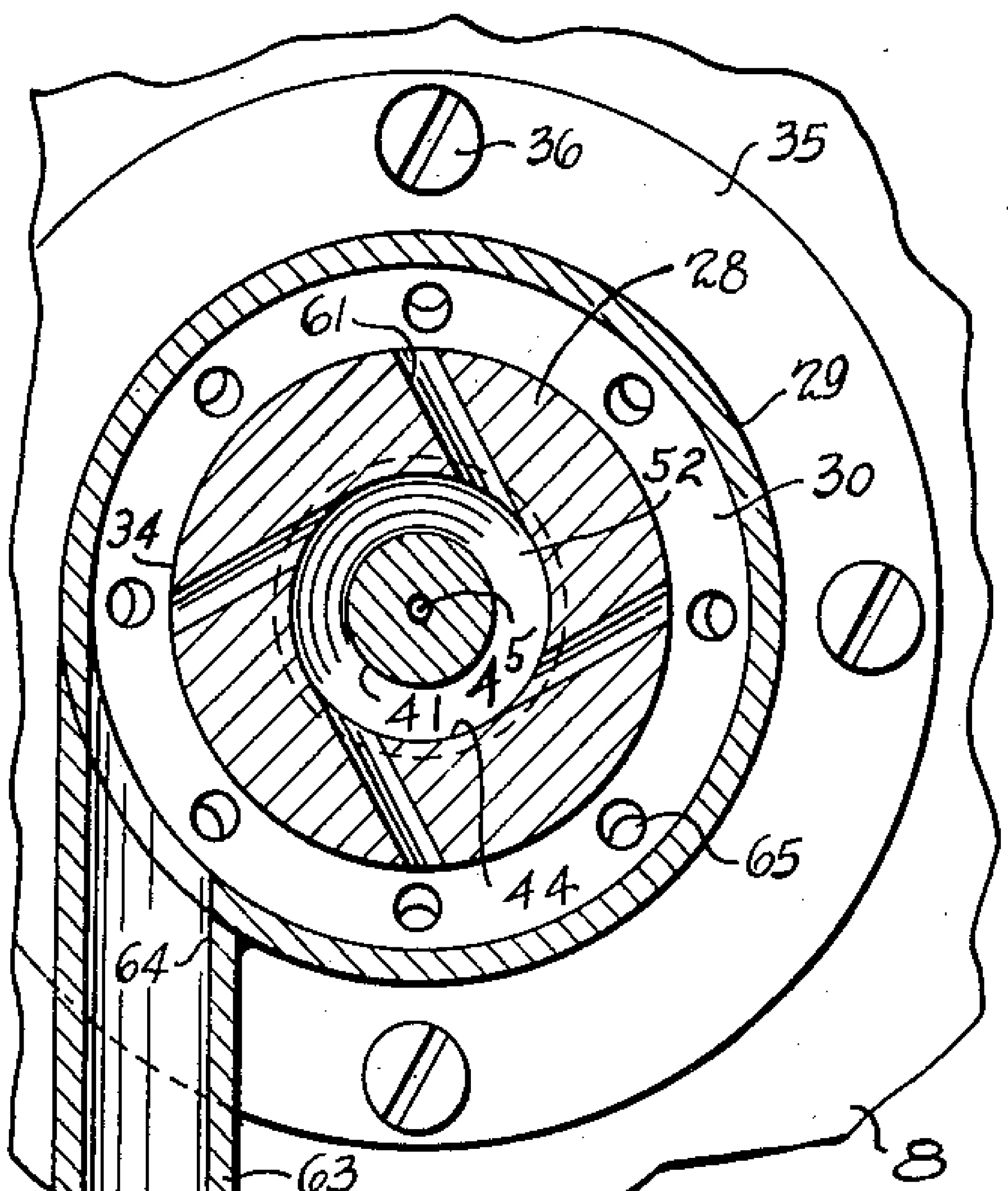


FIG. 3

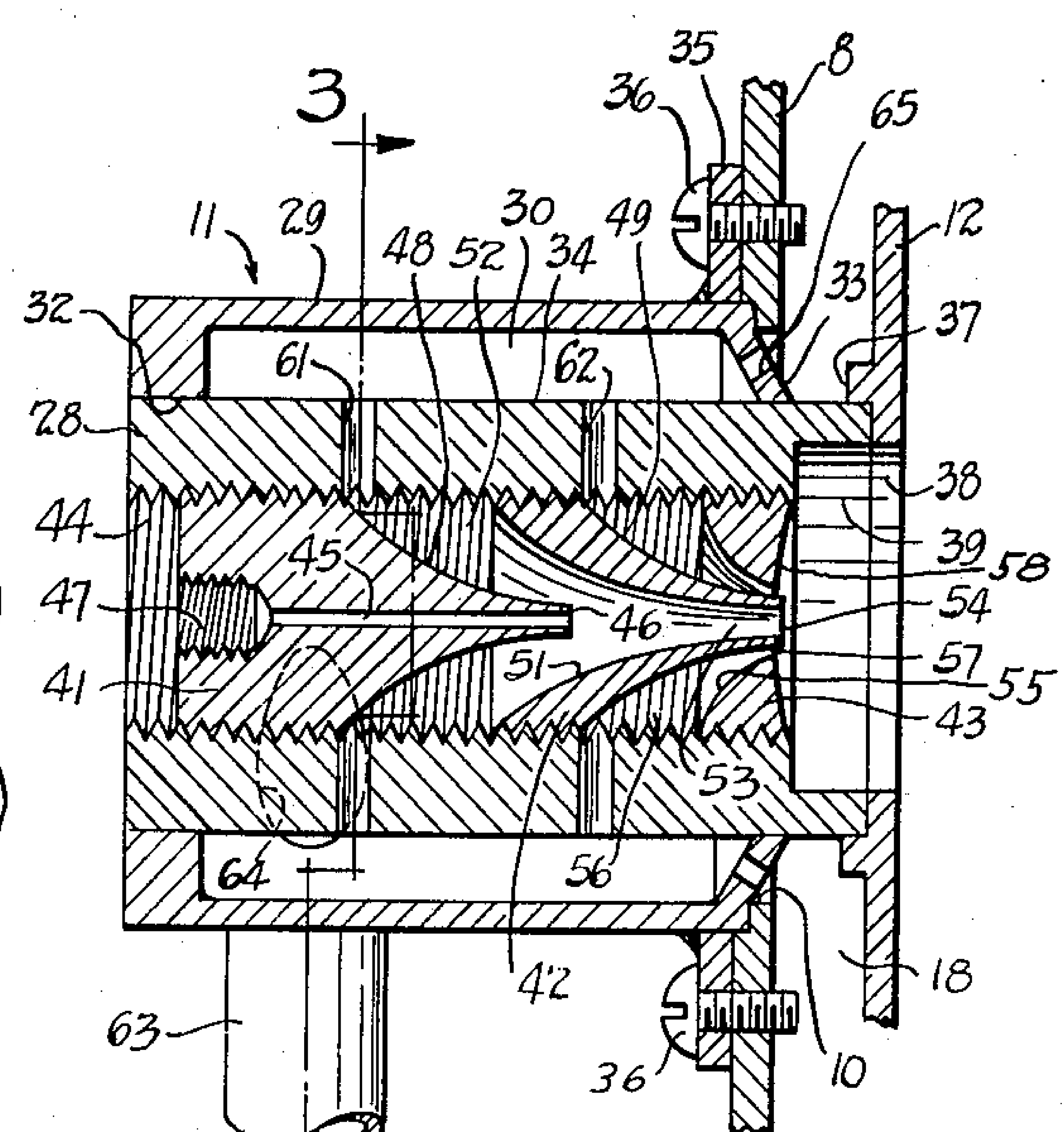


FIG. 2

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United States Patent Office

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VARIABLE RATE MULTIPLE FUEL NOZZLE

Robert H. Hunter, Gates Mills, and Harris W. Smith, Bainbridge, Ohio; said Smith assignor to said Hunter

Original application May 21, 1958, Ser. No. 736,829. Divided and this application Mar. 29, 1961, Ser. No. 99,191

7 Claims. (Cl. 239—402)

This invention relates to nozzles for heating devices, more particularly to atomizing nozzles of the type to which are supplied both combustion supporting air and liquid fuel oil, the air being supplied under pressure to entrain the fuel for discharge from a common orifice in the form of a combustible spray mixture.

Oil burning heaters are frequently required to operate efficiently on oils of different types and viscosities, at different firing rates and under greatly varying climatic conditions. A number of burner designs have evolved as a result of attempts to provide systems capable of being fired at different rates and also capable of burning different oils without adjustment. One such burner is disclosed in copending application Serial No. 515,686, filed June 15, 1955, by Robert H. Hunter, one of the present applicants, and Ralph S. Damon, now United States Patent 2,876,763, dated March 10, 1959, owned by the assignee of the present application.

The principal object of the present invention is to provide a simplified nozzle structure and arrangement for effecting complete and thorough mixing of the air and fuel oil over a wide air pressure range, such nozzle structure being formed with separate internal fuel and air passages adapted to be connected to suitable sources of fuel and air. The fuel and air are combined in stepwise fashion and are projected from the nozzle under pressure in the form of an expanding spray. One portion of primary air is mixed with the fuel within the nozzle and another portion is supplied in the form of a high velocity enveloping sheath paralleling the mixture as the latter leaves the nozzle. The nozzle is designed as an aspirator so that fuel oil can be made to flow into the nozzle as from a float bowl or other constant level source by reason of the decrease in pressure within the nozzle passages resulting from the flow therethrough of the pressurized primary air.

Another object is to provide a nozzle structure of the type referred to in which members formed with tapered surfaces of revolution coaxial to the path of the fuel define a plurality of primary air supply chambers that progressively decrease in diameter and area toward the fuel projection orifice. In a particularized version of the invention a series of aligned circular sectioned plug members are mounted in axially spaced relation within a common bore of a nozzle body cooperatively to define the plural tapered air chambers. The plug members define an axial through passage for the fuel oil, air from each air chamber being added to the stream of fuel oil as it advances through the nozzle. By feeding the air into the chambers with a tangential component the air advances spirally and the mixture ejected from the nozzle orifice forms a rotating spray.

Another object is to provide a nozzle structure for such a heater in which the fuel oil is progressed through a succession of orifices, being surrounded by and entrained in a rotating air mass immediately upon release from each such orifice. According to a refinement and objective related to this concept of a succession of orifices, the primary air is added to the advancing fuel oil in a succession of stages; that is to say, the mixture resulting from the entraining of fuel oil from a first orifice in a first portion of the primary air is advanced through a second

orifice and entrained in a second portion of the primary air. As a still further refinement of this aspect of the invention both the first and second portions of the primary air are made to rotate in the same direction about the axis of the fuel path at the time the mixing takes place.

Other objects and advantages are concerned with certain structural features, combinations and arrangements of parts obtaining simplicity in design with attendant economy in manufacture. The invention is described with reference to a preferred embodiment representing the best known mode of practicing the invention. This embodiment is illustrated in the accompanying drawings forming a part of the specification.

In the drawings:

FIG. 1 is a fragmentary isometric drawing partly in axial section and with parts broken away and removed showing a heating device incorporating the nozzle of the present invention;

FIG. 2 is an enlarged fragmentary longitudinal section through the nozzle assembly of the device of FIG. 1; and

FIG. 3 is a transverse sectional detail taken through the nozzle assembly substantially in the plane represented by the line 3—3 of FIG. 2.

The heating device in which the nozzle of the present invention is incorporated is essentially an oil burner and as such may be used in various conventional and well known ways as stated in copending application for United States patent Serial Number 736,829, filed May 21, 1958, for Variable Rate Multiple Fuel Burner, of which this is a division.

The heater comprises a main tubular shell or casing **1** having reduced diameter end portions **2**, **3** that are respectively received telescopically one within one end of main housing **4** and the other within the rear end of cylindrical extension tube **5** into which the products of combustion are discharged. The ends of the housing **4** and the extension tube **5** abut radial shoulders **6** on the main shell **1**, thereby locating the parts in assembly.

The extension tube **5** may be secured to and open into, for example, the intake manifold of a diesel or other internal combustion engine. Thus the heater may be supported by such manifold to discharge hot gases and products of combustion into the manifold where they will comingle with and heat air moving into the cylinders of the engine. In another arrangement the extension tube **5** may be suitably supported and connected to a heat exchanger through which the hot gases and products of combustion of the heater are caused to flow in a conventional manner. In other arrangements the extension tube **5** suitably lengthened and supported, may be made to discharge the hot gases and products of combustion into the interior of a kiln, retort or other space or device to be heated.

The main housing **4** has a cylindrical wall **7** and, at the rear end of the latter, an end closure wall **8** which is normal to the main axis and is formed with a central opening **10** (FIG. 2) closed by a nozzle structure **11**.

Although it is feasible to ignite the fuel-air spray in an open combustion chamber such as provided by the housing **4**, casing **1** and extension tube **5**, a combustion tube **20**, open at both ends, is supported in coaxial relation to the path or trajectory of the fuel spray and is positioned with its receiving end spaced axially from the nozzle. A pair of axially spaced cross walls or partitions **12**, **13** and a cylindrical inner wall **14** define a cushion chamber **15** across which the fuel-air spray from the nozzle **11** is projected. The outer periphery of the circular partition **12** is locatingly abutted against shoulder **17** in assembly; a narrow air chamber **18** is provided between the walls **8** and **12**; an annular air chamber **19** surrounds the cushion chamber **15**.

The forward or discharge end of the combustion tube 20 is formed with a circular inwardly directed curved radial flange 21 which defines circular discharge opening 22. Within and concentric to the combustion tube and spaced axially from both of its ends is a flame controlling ring or sleeve 24 which has an external diameter less than the internal diameter of the combustion tube 20 in the provision of circumferentially extending clearance space 25. The control sleeve is centered in the combustion tube by a number of spacing blocks 26 distributed about the circumference of the sleeve.

The nozzle structure 11 comprises inner and outer tubular body members 28, 29 and plugs or orifice members 41, 42, 43. The body members are disposed one within the other and are separated by an annular air chamber 30. The ends of the chamber 30 are closed by inwardly directed circular flanges 32, 33 integrally formed on the outer member and closely embracing cylindrical outer surface 34 of the inner member 28 at the ends of the latter. The body members 28, 29 are turned from brass or other suitable metal and the circular joints where the surface 34 of the inner member is embraced by the inner peripheries of the end flanges 32, 33 are sealed as by brazing.

An annular ring 35 surrounds and is brazed to the forward end of the outer member 29 adjacent the end flange 33 and is apertured at circumferentially spaced points to receive attaching screws 36 which are threaded into the end wall 8 of the main housing 4 to secure the nozzle assembly in place over the circular opening 10.

The inner body member 28 is longer than the outer member 29, projecting axially beyond the end flange 33 of the latter, across the narrow air chamber 18, and being received within a shallow axial flange 37 on the partition 12. A circular opening 38 in the partition 12 registers with a counterbore 39 in the end of the inner body member 28, these openings constituting the outlet of the nozzle into the cushion chamber 15.

The plugs or orifice members 41, 42 and 43 are disposed in alignment within the hollow interior of the tubular inner body member 28. These members are each of circular cross section and are suitably held in axially spaced fixed relation coaxial to one another and to the tubular members 28, 29. A convenient structural arrangement comprises external threads all of the same diameter on the circular sectioned members 41, 42, 43 and matching internal threads on the body member 28 throughout the entire length of its axial bore. The orifice plugs thus may be screwed into desired positions in the bore of the body member.

The first orifice member 41 has an axial through passage 45 terminating at the forward end of the member in a discharge orifice 46. At its rear end the member 41 is counterbored and tapped at 47 to receive the threaded fitting on the end of a fuel supply line. Fuel oil, such as kerosene or gasoline, is contained in a suitable remote storage vessel or tank and supplied as by gravity flow to the passage 45 of the orifice member 41 through a suitable flow control system such as a constant level float bowl device (not shown) which has a needle valve actuated by a float to maintain a constant level in the bowl. The bowl of the constant level fuel control device is connected to the passage 45 through a short conduit such that the level in the bowl is substantially the same as or only slightly below the level of the orifice 46.

The plug or orifice members are formed on their confronting ends with coaxial surfaces of revolution which shape the aspirating chambers of the nozzle. Thus the orifice members 41 and 42 are formed with external or outwardly facing concave tapering surfaces of revolution 48, 49 which are concentric to the axis or path of fuel traveling through the nozzle device and approach such path tangentially. An internal or inwardly facing convexly curving tapered surface 51 on the orifice member 42 is disposed in axially spaced relation to the surface 48 of the orifice member 41, providing between the orifice members 41, 42 a first aspirating or air chamber 52 which surrounds and is coaxial to the fuel path and progressively diminishes in cross-sectional area in the direction of fuel flow. The smoothly curving wall 51 of the chamber 52 blends tangentially into the wall of an axial passage portion 53 in the forward part of the orifice member 42. The passage 53 terminates in a discharge orifice 54 spaced axially beyond or forward of the orifice 46.

An internal convexly curved tapered surface 55 is formed on the orifice member 43 and faces rearwardly, confronting the tapered surface 49 of the second orifice member 42 in axially spaced relation, thus providing between the members 42, 43 a second air or aspirating chamber 56 which surrounds and is coaxial to the path of fuel advancing through the nozzle structure. The chamber 56 progressively decreases in diameter and cross sectional area toward an annular axially directed orifice 57 defined by a circular wall opening in the forward end of the orifice member 43 and the smaller diameter circular end of the second orifice member 42 which projects slightly through and is concentric to such wall opening in the third orifice member 43. Front end face 58 of the orifice member 43 may be flat or, as shown, may be slightly dished or concave with the circular opening which defines the annular orifice 57 located at the bottom of the concavity.

A number of oblique passages 61, 62 are drilled or otherwise formed in the nozzle member 28 to place the annular air chamber 30 in communication with each of the tapering air chambers 52, 56 at the rear or large diameter ends of the latter.

Air is supplied to the annular chamber 30 from a suitable source such as a centrifugal blower or fan (not shown) at a pressure of from about 1 to about 30 or more inches of water, the exact pressure depending upon factors such as fuel oil viscosity and the desired rate of fuel consumption. The air pressure is increased to increase the rate or with higher viscosity fuel oil and is decreased to decrease the rate or with lower viscosity fuel oil. The air is conducted from the blower or other supply through suitable conduit means which includes a tubular conduit 63 brazed or otherwise secured to the outer member 29 of the nozzle structure. The conduit 63 is disposed so that air forced into the chamber 30 enters tangentially through opening 64 and flows about the inner nozzle member 28 in a clockwise direction as viewed in FIG. 3. The pressurized air thus introduced into the annular chamber is forced tangentially into the rear or closed ends of the tapering air chambers 52, 56 through the oblique passages 61, 62 so that the air rotates in the tapered chambers in the same direction it rotates in the outer chamber 30, but at a higher velocity resulting from the reduced cross-sectional area. The high velocity air thus traveling through the first air chamber 52 and approaching the fuel path tangentially, generally from left to right as viewed in FIG. 2, has an aspirating effect on the liquid fuel supply system, the reduced pressure which prevails in the chamber 52 and at the discharge orifice 46 results in fuel being drawn or projected into the chamber from such orifice. The projected fuel is comminuted and entrained in the high velocity air advancing helically and as a contracting cone into and through the axial passage 53 of the second orifice member 42 so that the mixture is projected from the orifice 54 as a fine spray into and across the cushion chamber 15.

The high velocity air issuing from the annular orifice 57 picks up and entrains any liquid particles or drops of fuel oil that collect on the forward discharge end of the second or intermediate orifice member or plug 42. By thus traveling the fuel oil through a succession of axially spaced nozzle orifices 46, 54, each surrounded by a helically rotating axially advancing air mass which approaches the fuel path tangentially, complete atomization of the fuel is achieved, the collecting on and dripping from the nozzle of fuel oil being completely eliminated.

Since the external surfaces 48, 49 and the internal surfaces 51, 55 formed on the orifice members or plugs to define the tapered air chambers 52, 56 are all surfaces of revolution concentric to the nozzle axis and the fuel path, the axial spacing of the orifices 46, 54 can be adjusted and also the relative sizes of the chambers 52, 56 by axial adjustment of the relative positions of the members 41, 42 and 43.

The circular opening 10 in the end wall 8 of the main housing is larger than the external diameter of the inner body member 28 of the nozzle structure to allow air to flow into the air chamber 18 from the chamber 30 through a number of ports 65 formed in the flange 33. At circumferentially spaced points located radially outwardly of the annular wall 14 the partition 12 is formed with axial ports 66 which place the chamber 18 in communication with the annular chamber 19 to supply pressurized air to the latter. Radial ports 67 in the wall 14 and axial ports 68 in the wall 13 place the cushion chamber 15 and the interior of the main shell 1 in communication with the annular chamber 19, the ports of each group being circumferentially spaced uniformly about the axis of the device.

The system provides a center rich fuel-air mixture conducive to efficient burning with minimum smoking and deposition of carbon onto the metal parts of the burner. Ignition of the fuel-air spray is suitably effected as by a high frequency electrical spark produced between center electrode 70 of a spark plug assembly 71 and one of the grounded metal parts such as the control sleeve 24 of the combustion tube assembly. In the arrangement shown, the spark plug assembly includes a threaded support sleeve 72 screwed into a tapped radial hole in the casing 1. The spark plug has an internal insulator of porcelain and an outside metal tube or sleeve 73 which extends radially across the annular chamber that surrounds the combustion tube 20 and projects into the interior of the latter through a hole 74, a suitable annular clearance separating the sleeve 73 from the metal of the combustion tube. The electrode 70 extends through the internal porcelain insulator which is inside the metal sleeve 73; at its outer end the electrode is threaded and provided with nuts or other suitable connector means for attachment of a high tension electrical cable 75 by means of which the spark plug is connected to one of the terminals of a suitable source of high frequency electrical current. The other terminal of the current source is grounded to the metal casing of the oil burner device so that, upon energization of the ignition system, the desired spark is produced inside the tube 20.

Thus the present invention provides a nozzle assembly operating on the aspirating principle and capable of atomizing fuel at a variable rate depending upon the pressure at which air is supplied through the tube 63. Since the entire air supply is furnished through this single tube, variation in the pressure of the air so supplied automatically varies the rate of air supply to the several air chambers of the nozzle.

The first air chamber 52 progressively decreases in diameter from the left end (as viewed in FIG. 2) of the internally tapered surface 51 of the second plug or orifice member 42, which is at a point rearward of the orifice 46, to a point forward of the orifice 46 at which the chamber merges into the axial passage 53. Similarly, the reduction in diameter of the second air chamber 56 commences at the left end of the tapered internal surface 55 (also as viewed in FIG. 2) the reduction in diameter continuing forwardly to a minimum diameter at the orifice 57. Thus, the primary air advancing helically to the fuel path through the chambers 52 and 56 is progressively accelerated and approaches the fuel path tangentially, or substantially so. The orifices 46 and 54 constitute primary and secondary fuel projecting orifices through which the fuel passes sequentially. The annular orifice 57 is a tertiary orifice through which air only is projected, the air from the tertiary orifice completely surrounding the fuel-air mixture projected from the secondary orifice 54 as a sheath which picks up and entrains any fuel oil droplets or particles tending to drop out of the spray or from the orifice 54.

In accordance with the patent statutes the principle of the present invention may be utilized in various ways, numerous modifications and alterations being contemplated, substitution of parts and changes in construction being resorted to as desired, it being understood that the embodiment shown in the drawings and described above is given merely for purposes of explanation and illustration without intending to limit the scope of the claims to the specific details disclosed.

What we claim and desire to secure by Letters Patent of the United States is:

1. A nozzle for a liquid fuel burner comprising body means defining first and second coaxial elongated swirl chamber portions each of circular section, each chamber portion having a relatively large diameter entrance end and a relatively small diameter exit end of progressively decreasing diameter tapering toward and terminating in a discharge orifice on the nozzle axis, the first chamber portion extending axially through substantially the entire axial length of the second chamber portion,

and the orifices of the two chamber portions being disposed substantially in a common plane transverse to said axis;

means for conducting pressurized air to and introducing it tangentially and simultaneously into the entrance ends of the two swirl chambers to rotate therein in the same direction about said axis and to accelerate and advance spirally toward and through the respective orifices;

and means comprising a member projecting axially into the first chamber portion for supplying liquid fuel to the tangentially introduced air, said fuel supply member being formed with an internal passage terminating in a fuel orifice located on the nozzle axis intermediate and spaced axially from both ends of the first swirl chamber portion, liquid fuel discharged from the fuel orifice mixing with air accelerating and advancing spirally through the decreasing diameter exit end of the first chamber portion, the mixture being discharged as a spirally rotating stream through the orifice at the exit end of the first chamber portion into a surrounding air sheath also rotating spirally in the same direction simultaneously discharged from the exit orifice at the exit end of the second chamber portion.

2. A nozzle for a liquid fuel burner comprising body means including means defining first and second coaxial air chamber portions each of circular section,

the chamber portions each including a tapered part progressively decreasing in diameter from a relatively large entrance end to a relatively small exit end;

the first chamber portion being axially longer than and extending axially through substantially the entire axial length of the second chamber portion,

the chamber portions having coaxial discharge orifices disposed substantially in a common plane transverse to the nozzle axis at their exit ends,

means defining passages adapted to conduct pressurized air to and to introduce such air tangentially into both chambers at their entrance ends to flow spirally therein and in the same rotational direction about the nozzle axis,

a tubular member projecting axially into the first chamber portion and terminating in an orifice for supplying liquid fuel to air moving toward the orifice of the first chamber portion, the fuel orifice being located intermediate and spaced axially from both ends of the first chamber portion and within the tapered part of the latter, liquid fuel discharged from the fuel orifice mixing with air advancing spirally toward the exit end of the first chamber portion and the mixture discharging from the nozzle through the orifice at the exit end of the first chamber portion into a surrounding spirally advancing air stream discharged simultaneously from the exit orifice at the exit end of the second chamber portion and rotating in the same direction as the surrounded fuel air mixture.

3. A nozzle for a liquid fuel burner comprising a body formed with an internal air chamber including a part of circular section symmetric about the nozzle axis, the body being formed at one end with a circular discharge orifice coaxial to and in communication with the circular section chamber part,

a plurality of plugs each of circular section,

means supporting the plugs in coaxial relation to the chamber and orifice and in axially spaced relation to one another, one of the plugs partitioning the chamber into first and second portions and having a tapered projection extending axially into and through the second chamber portion substantially to the plane of the orifice,

said one plug being formed with a tapered through axial passage terminating in an orifice on the end of the projection and in the center of and substantially coplanar with said discharge orifice;

another of the plugs having a tapered projection extending axially into said through passage and being formed with a fuel passage terminating in a fuel orifice located on the end of said second projection intermediate the axial limits of the through passage in the one plug,

means adapted to conduct liquid fuel to the fuel passage, and passage means adapted to connect air to and to introduce it tangentially into both the first and the second portions of the air chamber.

4. A nozzle for a liquid fuel burner comprising body means formed with an internal air chamber including a part of circular section symmetric about the nozzle axis, the body means having a forward end formed with a circular discharge orifice coaxial to and in communication with the circular section chamber part,

a first plug disposed in said chamber part and having a circular periphery in engagement with the body means, the plug having on its forward side a tapered axial projection extending substantially to the plane of the orifice, said plug constituting a partition dividing the chamber into an annular forward portion surrounding the plug projection adjacent the orifice and a rearward portion separated from the forward portion by the plug,

said forward end of the body means being formed with an internal surface of revolution decreasing in diameter toward the orifice and surrounding the plug projection in spaced relation,

the plug being formed with a through axial passage having an inlet end continuous with the rearward portion of the chamber and an outlet opening centered in the orifice, said plug passage decreasing in cross sectional area progressively between its inlet end and outlet opening, a second plug having a tapered forward portion and an internal fuel passage terminating in an axial fuel orifice at the forward extremity of such forward portion, means mounting the second plug in the body means in coaxial relation to the first plug and to the discharge orifice and with the tapered forward portion projecting axially through the rearward chamber portion and into the plug passage through the inlet end of the latter, and means defining separate passages for supplying fuel and pressurized air to the fuel passage and the air chamber, respectively, the air supplying passage means being adapted to release the supplied air into the forward and rearward chamber portions for spiral flow therein rotating in the same direction in both such chamber portions.

5. A nozzle for a burner of the type adapted to receive air under pressure and liquid fuel at relatively low pressure and to form a combustible mixture of such fuel and air;

said nozzle comprising a body formed with a through chamber of substantially uniform section and a series of plugs carried by the body and disposed within the chamber in axially spaced relation, the plugs delineating and partitioning the chamber into a plurality of chamber portions and being formed with axially aligned passages terminating in orifices, a plurality of the plugs each having a projection extending into the passage of an adjacent plug and each having its passage terminating orifice opening through the extreme end of its projection, said orifices including a substantially coplanar concentric pair located at one end of the nozzle; means including the body formed with air passage means communicating with the several chamber portions, means for conducting air to the air passage means under pressure, the air passage means being disposed and adapted to project pressurized air into the chamber portions in tangential jets for simultaneous advancement spirally and in the same direction through the several chamber portions and for release simultaneously through said coplanar orifices; and

a first one of said plurality of plugs being adapted to receive liquid fuel in its passage and disposed to release fuel so received through its terminating orifice at a point within the axial limits of the passage of another of said plurality of plugs for entrainment in air advancing spirally through such last mentioned passage and toward said coplanar orifices.

6. A nozzle for a liquid fuel burner comprising a body having forward and rearward ends and an elongated internal chamber of circular section, a plurality of plugs supported by the body and disposed in the chamber in axially spaced relation, the plugs defining and partitioning the chamber into front and rear chamber portions;

a first one of the plugs having a first forward tapered projection extending into one of the chamber portions, the projection having a surface symmetric about the longitudinal axis of the chamber, said one plug being formed with a fuel passage terminating in a first orifice on the end of the projection and centered on said axis;

a second one of the plugs having a recessed rear face and a second forward tapered projection extending into another of the chamber portions, the second projection having a surface symmetric about said axis, the second plug having a through passage terminating in a second orifice located on the end of the second projection and centered on said axis;

a third one of the plug having a recessed rear face symmetric about said axis and a through passage terminating in a third orifice centered on said axis;

said first projection extending axially into the recessed rear face of the second plug with the first orifice located intermediate and spaced from the axial limits of such second plug recess, said second projection extending into the recess rear face of the third plug and through substantially the entire axial length of the passage in the latter;

means adapted to conduct liquid fuel to the fuel passage;

means adapted to conduct air to and to introduce it simultaneously and tangentially into the chamber portions to rotate therein spirally and in the same direction; and

said second and third orifices being substantially coplanar for substantially simultaneous discharge of fuel and air through the second orifice and a surrounding sheath of air through the third orifice.

7. In a nozzle for use in a burner of the type having

means for supplying liquid fuel and pressurized air to be projected from the nozzle as a combustible mixture,

body means having a generally cylindrical chamber with front and rear ends,

means at and having a surface defining the rear end of the chamber,

said rear end means being fast to the body means, providing a fuel passage adapted to be connected to the fuel supplying means and providing a primary fuel inlet orifice into the chamber,

said inlet orifice being coaxial to the chamber and continuous with the fuel passage for axial release of fuel supplied thereto,

means at and having a surface defining the front end of the chamber,

said front end means being fast to the body means and providing an outlet passage and orifice axial to the chamber,

and a partition within and dividing the chamber into a first portion at said rear end and a second portion at said front end,

said partition being formed with a through passage coaxial to the chamber and with a secondary orifice terminating its passage,

said secondary orifice being disposed substantially in the plane of the outlet orifice,

said partition being formed on opposite sides with tapered surfaces of revolution concentric to the chamber axis,

the surface on one side of the partition member facing generally inwardly and rearwardly and being disposed in axially spaced relation to said surface at the rear end of the chamber,

the surface on the other side of the parti-

tion member facing generally outwardly and forwardly and being disposed in axially spaced relation to said surface at the front end of the chamber,

said primary fuel inlet orifice being located intermediate and spaced from both ends of said tapered surface on the other end of the partition,

and means providing passages adapted to receive pressurized air from the supplying means and conduct the received air and project it with tangential flow components in the same direction into the first and second chamber portions,

conducted air projected into the chamber portions rotating in the same direction about the chamber axis in the second as in the first chamber portion, accelerating in the through passage before passing the plane of the primary orifice, advancing helically in both chamber portions toward and exiting substantially simultaneously through the primary and secondary orifices, and fuel released from the primary orifice being received in and at the axis of the accelerating air with the air in which it is received being projected into the center of and surrounded by the helically rotating axially advancing air issuing from the outlet orifice in the provision of a center rich fuel-air mixture.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,070,317 December 25, 1962

Robert H. Hunter et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 35, for "connect" read -- conduct --; column 9, line 20, for "axial" read -- coaxial --; column 10, line 7, for "other end" read -- one side --.

Signed and sealed this 6th day of April 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents