Jan. 12, 1954 F. H. CORNELIUS 2,665,748

FUEL BURNER

Filed May 27, 1949 2 Sheets-Sheet 1

Fig. 4.

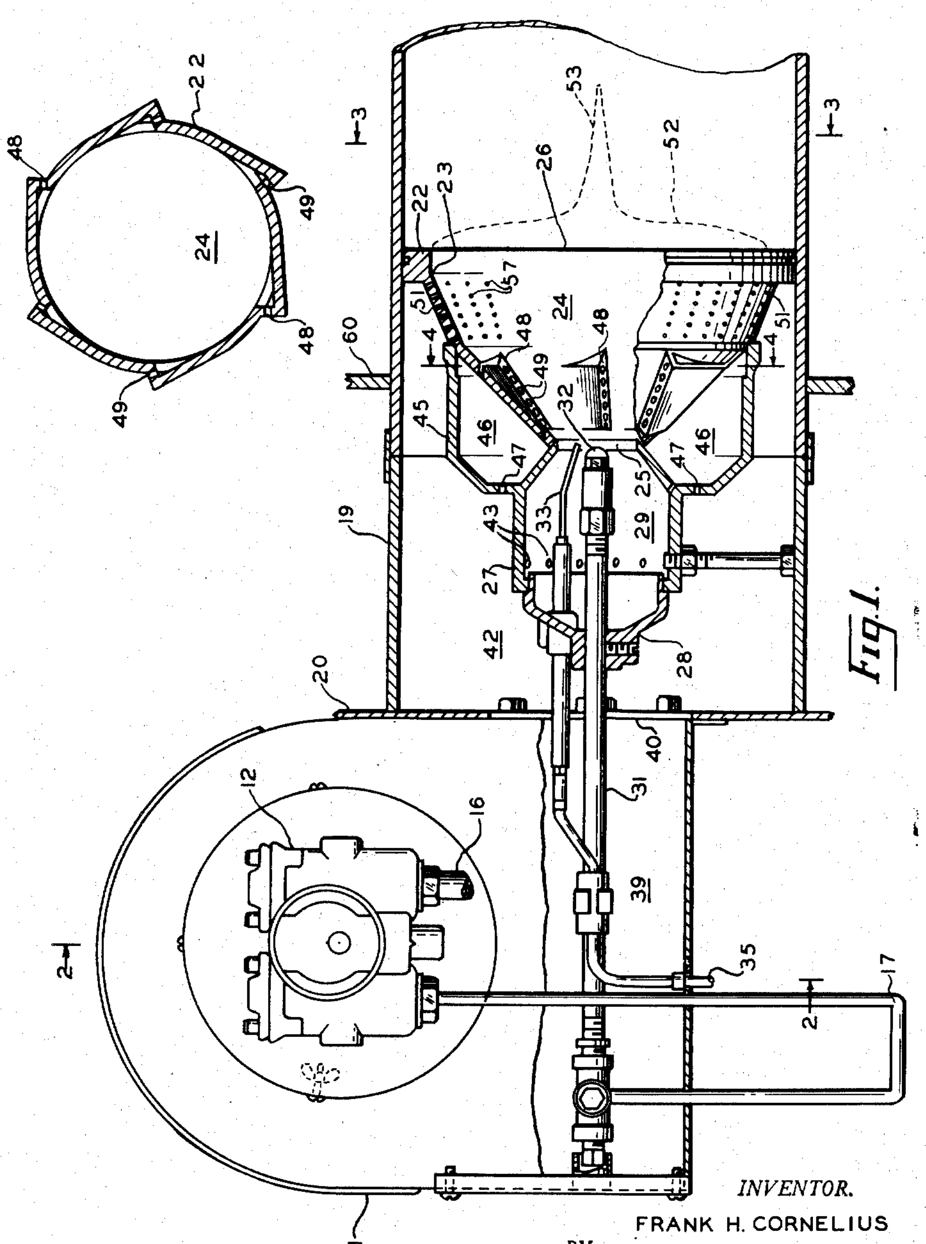


Fig. 1.

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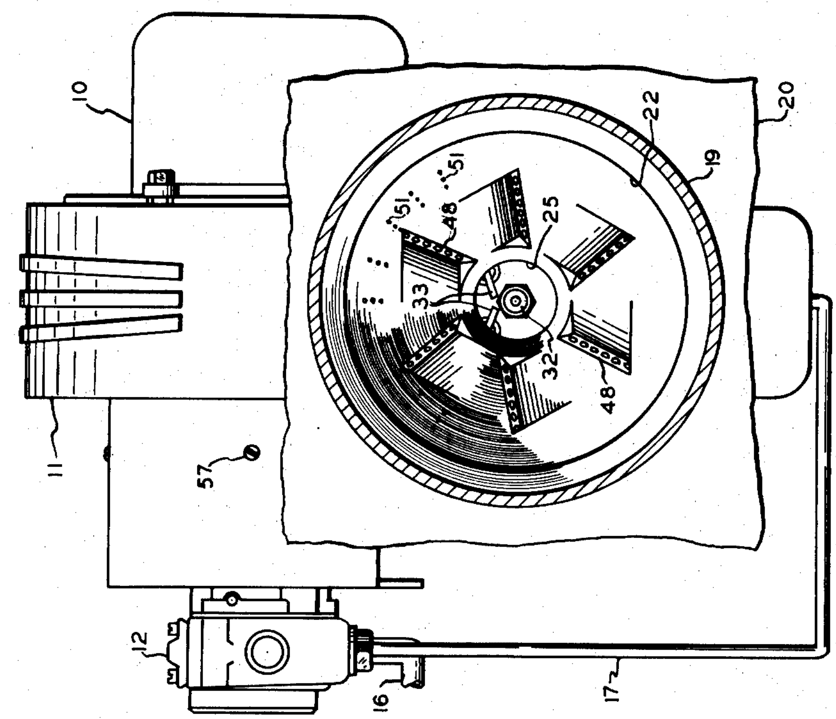


Fig. 3.

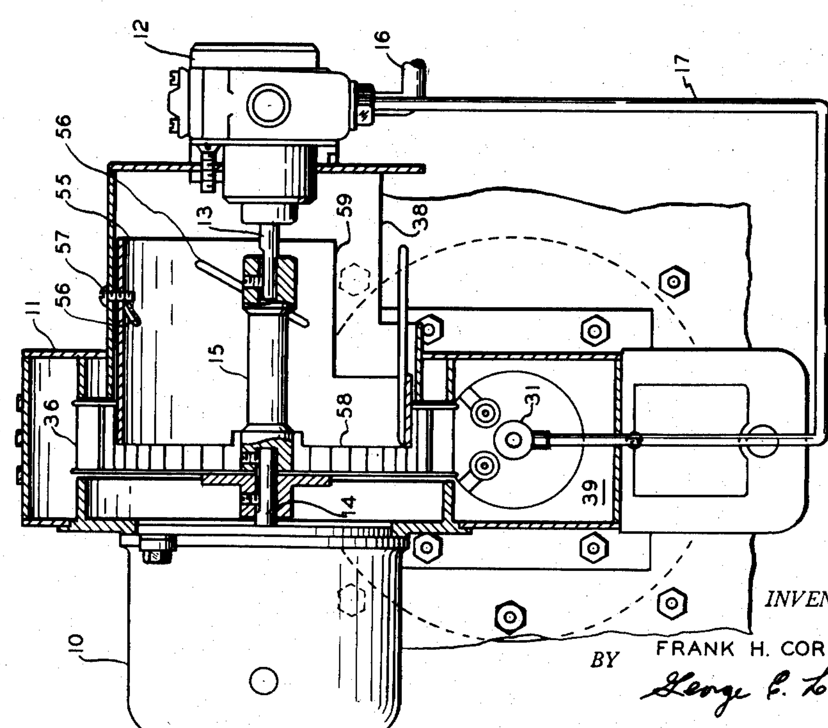


Fig. 2.

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## FUEL BURNER

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Application May 27, 1949, Serial No. 95,789

5 Claims. (Cl. 158—76)

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The present invention relates to an improved method of and apparatus for burning fuel, particularly liquid fuel, such as oil, under pressure.

Oil burners which burn oil under pressure and which are of the type commonly called "gun type" or "gun burners" derive their name from the relatively long air blast tube which has the appearance of a gun barrel. Such a burner includes a pump connected to an atomizing nozzle centrally disposed at the inlet end of the tube for discharging a stream of atomized oil. A fan supplies a relatively large volume of air to the inlet end of the tube. An igniter is usually mounted near the nozzle for igniting the fuel oil and the velocity of the air stream blows the fuel oil through the tube. Some burning takes place in the tube, but most of the burning takes place after the stream of air and fuel oil pass from the tube into a combustion chamber. These gun type oil burners are relatively inefficient and are quite noisy. One cause of this noise is the pulsating pressure produced in the tube and the combustion chamber. Many of these burners include curved or angularly disposed vanes or other means at the outlet end of the tube to provide a whirling action in the stream and thereby mix the air with the fuel oil. This turbulence is another source of noise. Insofar as is known, all types of these pressure type oil burners are quite noisy, and the main difference between various pressure burners, insofar as the apparent noise is concerned, is in the manner in which the furnace is insulated so as to deaden the noise.

Another difficulty encountered in operating pressure type oil burners arises from a tendency to deposit soot on any relatively cold surface against which the partially burned gases impinge or across which the gases flow. A very slight variation of the burner controls from the optimum settings will result in a large amount of soot.

Accordingly, it is an object of the present invention to provide an improved apparatus for burning fuel that will effect better mixing of the fuel and air and thereby burn the fuel with greater efficiency, that will effect complete combustion of the fuel in a relatively short combustion zone, that will prevent the deposition of carbon, and that will be quiet.

Another object of the present invention is to effect better mixing of a fuel with a combustion supporting gas, such as air, so as to more quickly and efficiently burn the fuel in a relatively short combustion zone.

Another object of the present invention is to provide an improved pressure-type liquid fuel burner which includes a combustion head, a nozzle for spraying a stream of liquid fuel into the head and means for blowing a relatively smaller amount of air into the head along with the fuel. This improved burner includes air passages arranged to discharge a relatively larger volume of air in the form of relatively high velocity, low pressure jets or streams into and across the path of the burning stream of gasified fuel. The low pressure jets inspire the gaseous fuel to effect improved mixing of the air and fuel and more efficient combustion. Preferably, the combustion head contains passage means arranged to maintain a rotary stream of air about the burning stream of sprayed liquid fuel while the fuel is being converted to a gaseous form to prevent the deposition of carbon on the inner surface of the head. The present improved burner operates very quietly.

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These and other objects and advantages of the present invention will become more apparent from the following description, taken with accompanying drawings, in which:

Figure 1 is a side view, partially in section, of a burner embodying the principles of the present invention;

Figure 2 is a sectional view taken along line 2—2 of Figure 1;

Figure 3 is an end view taken as shown by line 3—3 on Figure 1; and

Figure 4 is a fragmentary sectional view taken along line 4—4 of Figure 1.

The present invention will be described in connection with the burning of fuel oil but its principles may be utilized in the burning of other liquid fuels, and, as will be pointed out, at least some of its principles may be utilized in the burning of gaseous fuels.

Referring to the drawings showing a preferred embodiment of the present invention and illustrating a preferred method of burning liquid fuel, the burner shown in these drawings is intended for burning fuel oil to heat water in a furnace of a hot water heating system. The burner may be used with other types of furnaces and heating systems. The burner includes an electric drive motor 10 mounted on the side of casing 11. A fuel oil pump 12 is mounted on the opposite side of casing 11 and has a shaft 13 connected to shaft 14 of motor 10 through connector 15. Pump 12 is connected through tube 16 to a tank, not shown, or other suitable source of fuel oil and is connected through an outlet tube 17 to the burner for supplying oil under pressure upon energization of motor 10.

On the side of casing 11, there is mounted a tube 19 and between tube 19 and casing 11 there is a shield 20, shown only in part. The shield 20 may be part of a furnace cover. In the tube 19, there is mounted a combustion head 22 of substantially frusto-conical shape and having an interior surface 23 defining an elongated combustion chamber 24 having an inlet 25 and outlet 26 at opposite ends. It is to be noted that combustion zone 24 has a circular periphery or outline when cut by a plane normal to the length of the zone. An annular wall 27 extends supstream from the combustion head 22 and the upstream end of wall 27 is closed by a cap 28. The wall 27 and cap 28 together define a plenum or chamber 29.

In the bottom of casing 11, there is mounted a tube 31 which extends through cap 28 and has on its outlet end an atomizing nozzle 32 centrally arranged in the inlet opening 25 of head 22. The tube 31 is connected through tube 17 to pump 12 so that when the motor 10 is energized, oil is supplied to nozzle 32 under pressure. Nozzle 32 is preferably of the type which discharges a substantially conical stream of atomized fuel oil in the form of finely divided droplets, although a nozzle which discharges a cylindrical stream may be utilized. A pair of electrodes 33 are mounted closely adjacent to nozzle 32 and each is connected through a conductor 35 to a source of electric current for producing a spark between the electrodes for igniting the atomized fuel oil.

On motor shaft 14, there is mounted a fan 36. When fan 36 is rotated by motor 10, air is drawn into casing 11 through an inlet opening 38 and is forced under pressure into the outer chamber 39. The fan 36 supplies the air for burning the fuel oil. The air flows from chamber 39 through opening 40 into a main or fan discharge plenum 42 inside of tube 19. The tube 19 is closed on the downstream side so that no air can flow from plenum 42 past the head 22 between head 22 and tube 19. The pressure in plenum 42 is the pressure developed by the fan 36. In wall 27, there are a plurality of openings 43 and air flows from the main plenum 42 through openings 27 into the primary air plenum 29 and from plenum 29 through inlet opening 25 into the combustion zone 24. Thus, a stream of burning air and fuel oil is blown into and travels longitudinally through the combustion zone.

As the burning stream enters the combustion zone 24 through the inlet 25, the oil is in the form of small droplets. Enough oil is immediately vaporized so that burning is started by the igniter, electrodes 32. This initial burning heats the stream of fuel oil and aids in vaporizing or gasifying the fuel oil. Conversion of the fuel oil to a gas takes times so that as the burning stream of fuel oil and air move through the initial portion of the combustion zone 24, only a small amount of fuel oil is burned and most of the liquid fuel oil is being converted to a gaseous fuel. As the fuel oil moves through this initial portion and is being only partially burned, there is a tendency for the burning stream to deposit carbon on any relatively cold surface which the stream contacts . In addition, there is some tendency for the initially burning stream to heat the combustion head. While the burning stream will tend to heat the head sufficiently to shorten its life, the head wil be relatively colder and the fact that the head is heated will not eliminate the tendency for coke to be deposited on the internal surface of the head.

In order to prevent the deposition of coke and to prevent overheating of the head, a blanketing stream of air is rotated transversely about the burning stream. This blanketing stream of air rotates about the periphery of the burning stream adjacent the inner surface 23 of head 22. The axis of rotation is the longitudinal axis of the combustion zone as well as the longitudinal axis of the stream extending in the direction of movement through the combustion zone. A preferred means of providing such a blanketing stream of air is shown in the drawings. Extending about the inlet end of head 22 and connected to wall 27 is a wall 45. Wall 45, wall 27 and head 22 together constitute wall means defining a scavenging air plenum 46.

Wall 45 contains a plurality of ports 47 communicating with plenums 42 and 46 so that air flows from plenum 42 into plenum 46. The combustion head wall is provided with a plurality of passages 49 arranged in banks 48. Referring more particularly to Figure 4, the passages 49 are similar and only one will be described in detail. Each outlet passage 49 has an inlet and outlet and extends tangentially to the inner surface 23 and to the periphery of combustion zone 24. As shown, each passage 49 extends in a direction normal to the direction of travel of the burning stream through the head. The passages 49 may be inclined forwardly toward the outlet 26 so as to both direct a stream about the periphery of the combustion zone and also forwardly toward the outlet 26. With either arrangement, passage 49 is located in a plane tangent to the circular periphery of the combustion zone and extends in a direction transverse to the direction of travel of the burning stream of fuel oil through the head. A single wide passage may be substituted for each bank of passages. The passages 49 direct a plurality of streams of air about the inner periphery of the head adjacent the inner surface. This rotating blanket of air primarily prevents the deposition of coke on the surface of the head but also reduces heating of the head. This blanket of air is subsequently mixed with the gaseous fuel oil and supports combustion of the fuel oil, but in the initial portion of the combustion zone there is a thin layer of substantially pure air next the surface of the head.

The total amount of air discharged into the combustion zone through inlet 25 and passages 49 is only a small part of the total air required to complete combustion of the fuel. The major portion of the air required for combustion is added to the burning stream of fuel oil after the oil is completely or substantially completely converted to the gaseous state. To complete combustion, a large amount of air must be diffused throughout the gaseous fuel. This mixing or diffusion of gases normally takes a relatively long time and extends over a long distance of flame travel. In accordance with the present invention, the major portion of air necessary to complete combustion is quickly and thoroughly mixed with the fuel oil and combustion is completed while the fuel oil moves forwardly only a short distance. A large number of passages 51 extend through the wall of head 22 between the banks 48 and outlet 26. Each passage 51 is in communication with plenum 42 and the pressure drop across the passages is relatively high so that each passage directs a high velocity, low pressure jet of air transversely across the burning stream of fuel oil. Each jet inspirates gaseous fuel oil, and the air and inspirated fuel oil are thoroughly mixed and immediately burned. When looking at one of these high velocity jets, there is only a very small clear cone of air adjacent the passage; the remainder of the jet is burning. These high velocity jets draw in and mix with the fuel oil so thoroughly that combustion is complete or substantially complete when the stream of burning gases passes outlet 26. Flames do not extend down the tube 19, and the forward or downstream face of the flame will assume the shape indicated by broken line 52. A very small tip of flame 53 may extend down the center of tube 19 from the face of the main flame. As shown, each passage 51 extends toward the middle or central axis of the combustion zone, but the passages may extend in a direction transversely of or across the combustion zone without extending directly toward the axis. The passages 51 may extend in a direction normal to the axis of the combustion zone. Preferably, the passages 51 are parallel to each other.

For purposes of illustration and not limitation, there are 12 passages 43, each having a diameter of $\frac{3}{32}$ of an inch. Thus, the total cross-sectional area of the passages 43 is less than the area of the inlet 25 so that the passages control the flow of air past the nozzle 32. If desirable, the inlet 25 may be in direct communication with the fan plenum 42 or with air from a different source, but the inlet 25 would, under such conditions, have to be more accurately sized. The structure shown is preferred. Twelve passages 47, each having a diameter of $1\frac{3}{64}$ of an inch, are provided in wall 45 for conducting air from plenum 42 into plenum 46. The tangential passages 49 each have a diameter of $1\frac{3}{64}$ of an inch so that their total cross-sectional area is greater than the total cross-sectional area of passages 47. With this arrangement, the blanketing air stream discharged by the passages 49 has a relatively lower velocity than the jets issuing from passages 51 as the pressure drop between the plenum 46 and the combustion zone is less than the pressure drop between plenum 42 and the combustion zone. The blanketing air stream has a relatively high pressure and lower velocity so that this stream does not tend to inspirate gases as do the high velocity lower pressure jets from passages 51. The pressure drop across the passages 51 is relatively high so that the air jets issuing from the passages have a relatively high velocity and low pressure. Each of the passages has a diameter of $\frac{1}{8}$ inch, and 72 passages are arranged in each row. As shown, there are 6 rows of 72 passages. Thus, by far the major portion of air for combustion of the fuel oil is discharged through passages 51, and only a minor portion of the air is discharged through the inlet passage means or the blanketing or scavenging passage means.

The high velocity jets from passages 51 may be used without the scavenging air blanket from passages 49, especially when the fuel is initially in a gaseous state when discharged into the combustion zone. The high velocity jets are especially useful when the blanketing stream is used, as the high velocity jets mix the gasified fuel oil with this blanketing air when the jets inspirate the surrounding gases of the burning stream.

As shown more clearly in Figure 2, a damper 55 is mounted in the casing 11 and includes slots 56 which are inclined. Screws 57 extend through the casing 11 and the slots 56. One end 58 of damper 55 extends inside of the fan 36. When the fan rotates, air is drawn through the damper opening at 59 through the cylindrical damper 55 and forced into the chamber 39. When it is desired to change the amount of air flow, the screws 57 may be loosened and the damper turned about the axis of rotation of the fan 36 to move the damper longitudinally along this axis to increase or decrease the portion of the fan 36 which is blocked by the end 58. Thus, the rate of air flow and the pressure developed in plenum 42 may be readily adjusted.

Suitable controls may be provided for automatically operating the burner and these controls may be of any well-known type. When the motor 10 is energized, air is supplied to plenum 42 and oil is supplied under pressure to nozzle 32. Some air flows into the combustion zone through inlet 25 along with the atomized oil, and this stream of oil and air is ignited by the igniting means including electrodes 33. The burning stream moves through the combustion zone 24 to the outlet 26. As the burning stream of oil and air passes through the initial portion of the combustion zone, a blanketing air stream discharged through the passages 49 rotates about the periphery of the combustion zone and the burning stream primarily to prevent the deposition of carbon on the interior surface of the combustion head 22. As the stream moves through a subsequent portion of the combustion zone 24, a large number of high velocity jets are directed inwardly from the periphery of the stream and across the stream. These high velocity relatively lower pressure jets from passages 51 inspire the gaseous fuel oil, a part of which has been burned, to form a combustible mixture which burns while the burning stream is moving forwardly a relatively short distance. The hot gaseous products of combustion move through tube 19 to the stack and as the gases move through the tube they give up their heat to the water surrounding the tube, and this water may be confined by an outer casing shown in part at 60. Combustion is so complete in the combustion zone that the internal surface of the tube 19 remains bright and clean, and carbon is not deposited on the relatively cold surface of the tube.

In accordance with the present invention, a burning stream of fuel oil and a relatively small amount of air is discharged into the inlet end of a combustion zone and moved through the combustion zone at a relatively low velocity. As the fuel oil is being converted to the gaseous form, a rotating blanket of air is maintained about the periphery of the burning stream to prevent the deposition of coke on the combustion head defining the combustion zone. After the fuel oil has been converted to a gas, high velocity, low pressure streams of air are directed inwardly across the burning stream to complete combustion. These high velocity jets contain a major portion of the air necessary to complete combustion of the fuel oil and the jets inspire the gases of the stream. No air is added subsequently as combustion is complete. The present method of burning fuel is efficient and relatively quiet and does not result in the deposition of carbon on any surfaces which the burning gases contact.

In the foregoing description, air has been referred to as being the combustion-supporting gas, but it is to be undertsood that other oxygen-containing gases such as oxygen-enriched air or relatively pure oxygen may be used. The combustion zone 24 is shown and described as having a substantially frusto-conical shape, but it is to be understood that the combustion zone may be substantially cylindrical.

I claim:

1. Apparatus for burning fuel oil comprising an elongated blast tube, means including a combustion head extending across the tube to prevent the flow of air therebetween past the combustion head which includes a wall defining an internal frusto-conical combustion zone having an inlet opening at the smaller end and an outlet opening at the larger end, wall means in the tube defining with the combustion head and the tube a main plenum on the upstream side of the combustion head, a fan for supplying air to the main plenum, an atomizing nozzle centrally located in the inlet opening for spraying a stream of fuel into the combustion zone, primary wall means defining a primary air plenum at the upstream side of the inlet opening, primary air passages in and extending through the primary wall means and communicating with primary and main plenums whereby air flows from the main plenum through the primary plenum and then through the inlet opening about the nozzle into the combustion zone, and secondary wall means defining a scavenging air plenum about a portion of the combustion head adjacent the inlet, passages in and extending through the secondary wall means in direct communication with the main plenum, a plurality of banks of scavenging air ports arranged about the periphery of the combustion zone, a passage in the combustion head and extending from each port through the combustion head wall and terminating in an inlet port in direct communication with the scavenging plenum, the passages of each bank being tangent to the periphery of the combustion zone.

2. Apparatus for burning fuel oil comprising an elongated blast tube, means including a combustion head extending across the tube to prevent the flow of air therebetween past the combustion head which includes a wall defining an internal frusto-conical combustion zone having an inlet opening at the smaller end and an outlet opening at the larger end, wall means in the tube defining with the combustion head and the tube a main plenum on the upstream side of the combustion head, a fan for supplying air to the main plenum, an atomizing nozzle centrally located in the inlet opening for spraying a stream of fuel into the combustion zone, primary wall means defining a primary air plenum at the upstream side of the inlet opening, primary air passages in and extending through the primary wall means and communicating with primary and main plenums whereby air flows from the main plenum through the primary plenum and then through the inlet opening about the nozzle into the combustion zone, secondary wall means defining a scavenging air plenum about a portion of the combustion head adjacent the inlet, passages in and extending through the secondary wall means in direct communication with the main plenum, a plurality of banks of scavenging air ports arranged about the periphery of the combustion zone, a passage in the combustion head extending from each port through the combustion head wall and terminating in an inlet port in direct communication with the scavenging plenum, the passages of each bank being tangent to the periphery of the combustion zone, and a plurality of passages in and extending through the combustion head wall adjacent the outlet, each having an inlet in direct communication with the main plenum, said last mentioned passages extending in a direction toward the central longitudinal axis of the combustion zone for directing jets of air into and across the burning stream of fuel oil.

3. Apparatus for burning fuel oil comprising an elongated blast tube, means including a combustion head extending across the tube to prevent the flow of air therebetween past the combustion head which includes a wall defining an internal frusto-conical combustion zone having an inlet opening at the smaller end and an outlet opening at the larger end, wall means in the tube defining with the combustion head and the tube a main plenum on the upstream side of the combustion head, a fan for supplying air to the main plenum, an atomizing nozzle centrally located in the inlet opening for spraying a stream of fuel into the combustion zone, primary wall means defining a primary air plenum at the upstream side of the inlet opening, primary air passages in and extending through the primary wall means and communicating with primary and main plenums whereby air flows from the main plenum through the primary plenum and then through the inlet opening about the nozzle into the combustion zone, secondary wall means defining a scavenging air plenum about a portion of the combustion head adjacent the inlet, passages in and extending through the secondary wall means in direct communication with the main plenum, a plurality of banks of scavenging air ports arranged about the periphery of the combustion zone, a passage in the combustion head extending from each port through the combustion head wall and terminating in an inlet port in direct communication with the scavenging plenum, the passages of each bank being tangent to the periphery of the combustion zone, and a plurality of passages in and extending through the combustion head wall adjacent the outlet, each having an inlet in direct communication with the main plenum, said last mentioned passages extending in a direction toward the central longitudinal axis of the combustion zone for directing jets of air into and across the burning stream of fuel oil, the total transverse cross-sectional area of the plurality of passages extending through combustion head wall adjacent the outlet being greater than the total of the transverse cross-sectional area of all of said primary air passages through primary wall means plus the transverse cross-sectional area of all of the passages extending through the secondary wall means.

4. Apparatus for burning fuel oil comprising an elongated blast tube, means including a combustion head extending across the tube to prevent the flow of air therebetween past the combustion head which includes a wall defining an internal frusto-conical combustion zone having an inlet opening at the smaller end and an outlet opening at the larger end, wall means in the tube defining with the combustion head and the tube a main plenum on the upstream side of the combustion head, a fan for supplying air to the main plenum, an atomizing nozzle centrally located in the inlet opening for spraying a stream of fuel into the combustion zone, primary wall means defining a primary air plenum at the upstream side of the inlet opening, primary air passages in and extending through the primary wall means and communicating with primary and main plenums whereby air flows from the main plenum through the primary plenum and then through the inlet opening about the nozzle into the combustion zone, the total transverse cross-sectional area of the primary air passages being less than the open area of the inlet, secondary wall means defining a scavenging air plenum about a portion of the

combustion head adjacent the inlet, passages in and extending through the secondary wall means in direct communication with the main plenum, a plurality of banks of scavenging air ports arranged about the periphery of the combustion zone, a passage in the combustion head extending from each port through the combustion head wall and terminating in an inlet port in direct communication with the scavenging plenum, the passages of each bank being tangent to the periphery of the combustion zone, the total transverse cross-sectional area of the air passages through the secondary wall means being less than the total area of the passages extending through combustion head wall, a plurality of passages extending through the combustion head wall adjacent the outlet, each having an inlet in direct communication with the main plenum, said last mentioned passages extending in a direction toward the central longitudinal axis of the combustion zone for directing jets of air into and across the burning stream of fuel oil, the total transverse cross-sectional area of the plurality of passages extending through combustion head wall adjacent the outlet being greater than the total of the transverse cross-sectional area of all of said primary air passages through primary wall means plus the transverse cross-sectional area of all of the passages extending through the secondary wall means.

5. Apparatus for burning fuel oil comprising an elongated blast tube, means including a combustion head extending across the tube to prevent the flow of air therebetween past the combustion head which includes a wall defining an internal frusto-conical combustion zone having an inlet opening in the head at the smaller end of the combustion zone and an outlet opening in the head at the larger end of the combustion zone, wall means in the tube defining with the combustion head and the tube a main plenum on the upstream side of the combustion head, a fan for supplying air under pressure to the main plenum, an atomizing nozzle centrally located in the inlet opening for spraying a stream of fuel into the combustion zone, primary wall means defining a primary air plenum at the upstream side of the inlet opening, primary air passages in and extending through the primary wall means and communicating with the primary and main plenums whereby air flows from the main plenum through the primary plenum and then through the inlet opening about the nozzle into the combustion zone, the total cross-sectional area of the primary air passages being smaller than the cross-sectional area of the inlet opening about the nozzle, secondary wall means defining a secondary air plenum about a portion of the combustion head adjacent the inlet, passages in and extending through the secondary wall means in direct communication with the main plenum, a plurality of secondary passages in the combustion head extending through the combustion head wall and terminating in an inlet port in direct communication with the secondary plenum and in an outlet port in direct communication with the combustion zone whereby air flows from the main plenum into the secondary plenum and then through the secondary passages into the combustion zone, the total cross-sectional area of the passages through the secondary wall means being less than the total cross-sectional area of the secondary passages through the combustion head wall and a plurality of jet passages in the combustion head wall adjacent the outlet, each of jet passages having an inlet in direct communication with the main plenum and an outlet in direct communication with the combustion zone and extending in a direction to direct the jets of air into and across the combustion zone, the total cross-sectional area of the jet passages being greater than the total cross-sectional area of all the other air passages in the combustion head whereby the major amount of air discharged into the combustion zone is discharged through the jet passages.

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