

[54] **METHODS FOR PREPARING FUELS AND ALSO FOR THEREAFTER FEEDING THEM INTO FURNACES AND BURNING THEM THEREIN**

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[58] **Field of Search:** 431/9, 182, 183, 431/187; 239/404, 406, 402.5

[56] **References Cited**

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[57] **ABSTRACT**

Methods for preparing fuels comprising continuously discharging from the discharge orifice of an atomizing nozzle at a linear velocity of about 4–200 ft/sec. swirling liquid fuel particles in the form of a spray cone which under surrounding atmospheric conditions is about 50°–100° and the average diameter of the particles is 25–150 microns, and simultaneously through means surrounding the nozzle, spaced therefrom, extending downstream thereof and having a discharge opening spaced from the orifice, continuously feeding a stream of a swirling gaseous medium against the cone at a linear velocity sufficient, and in the range of 100–2000 ft/sec., to reduce the angle of the cone to such a value that the wall defining the opening will not be wetted thereby and to reduce the size of the fuel particles of the spray to such value that all of them emerging from the opening are no greater than 10 microns in diameter, but when the cone is under surrounding atmospheric conditions, the wall defining the opening will become wetted thereby.

9 Claims, 9 Drawing Figures

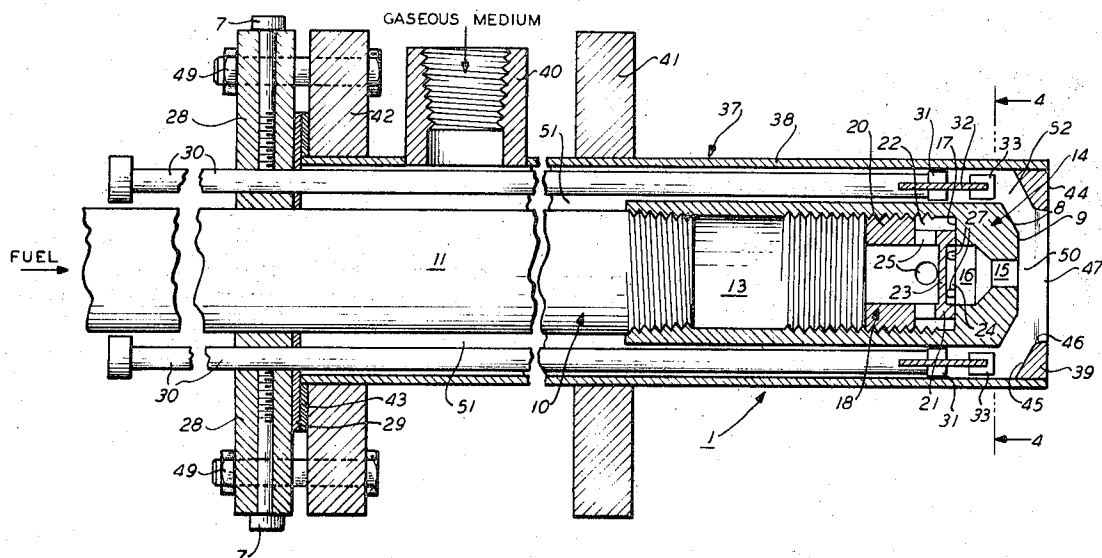


FIG. 1

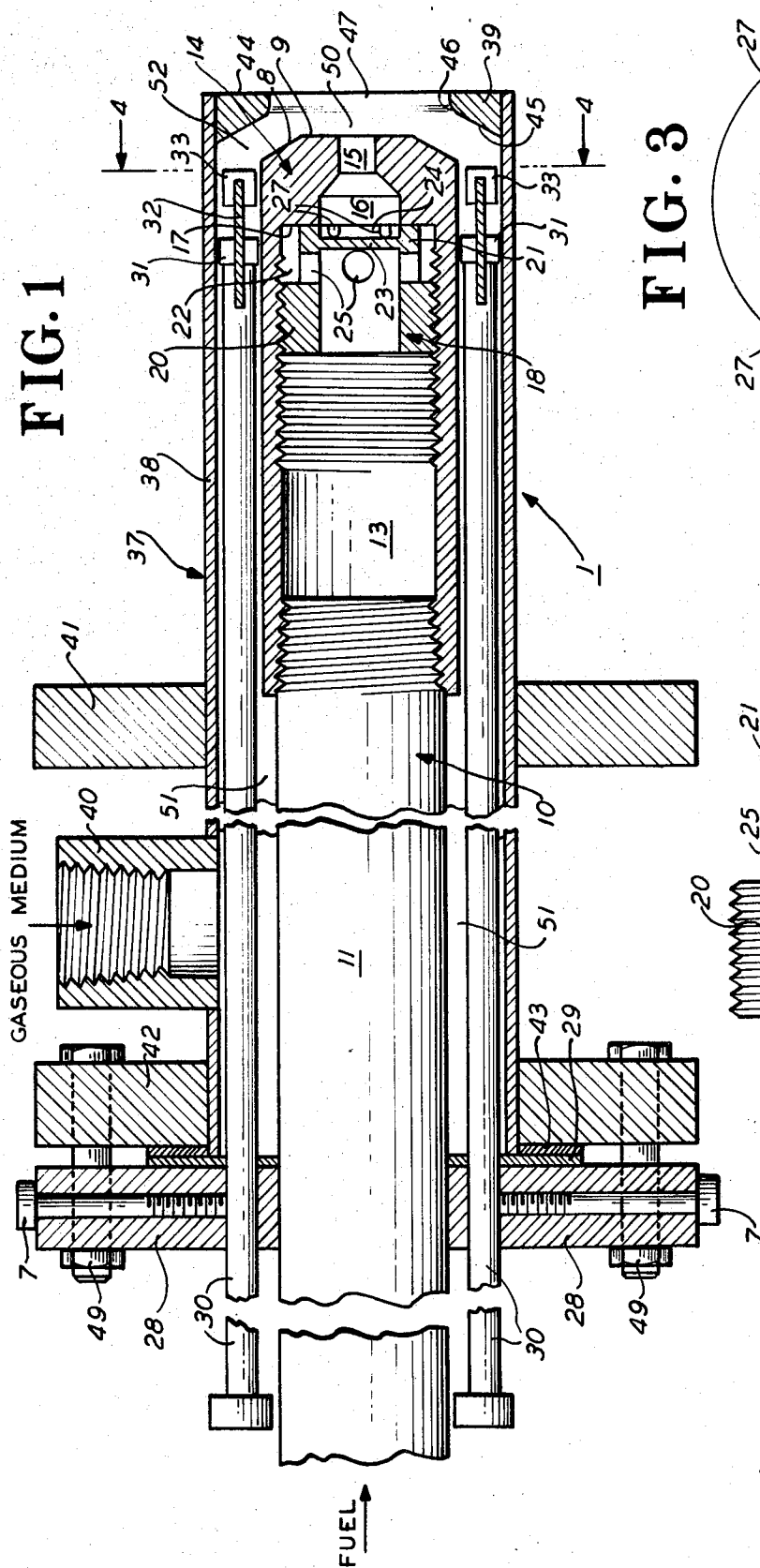


FIG. 3

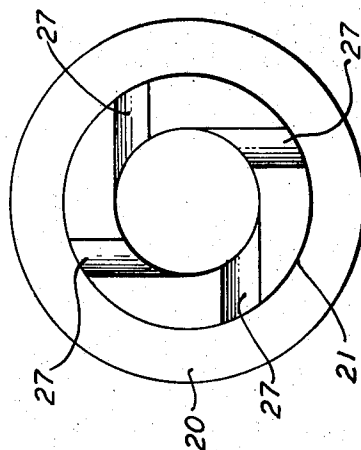
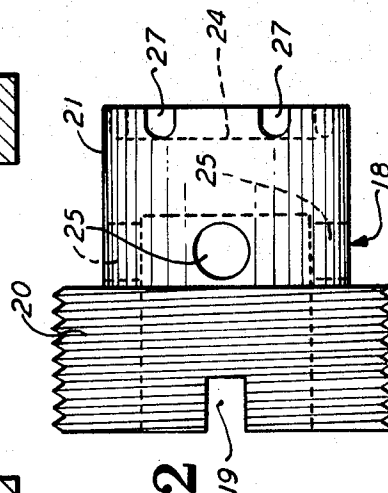


FIG. 2



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FIG. 4

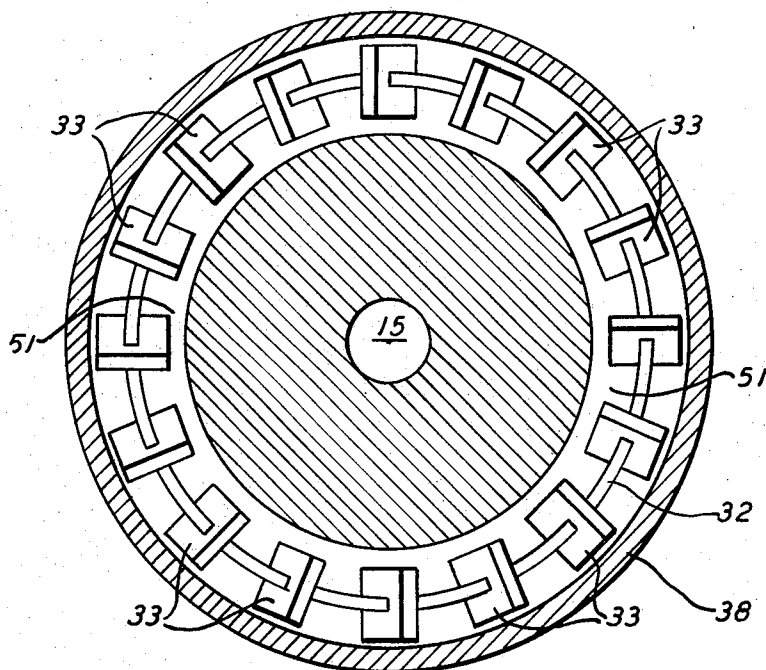
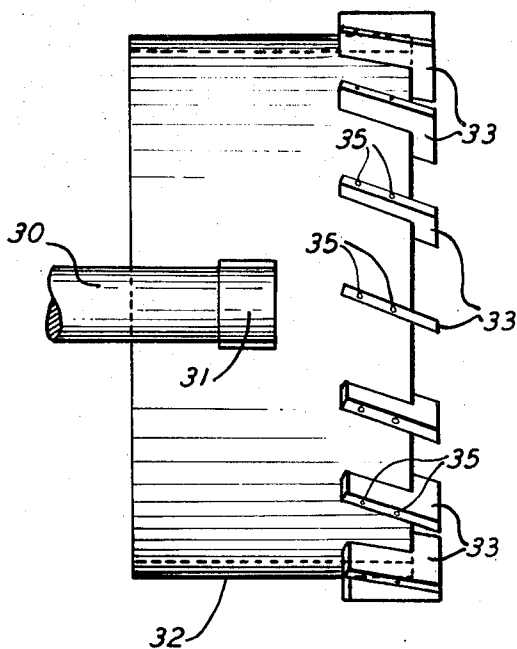
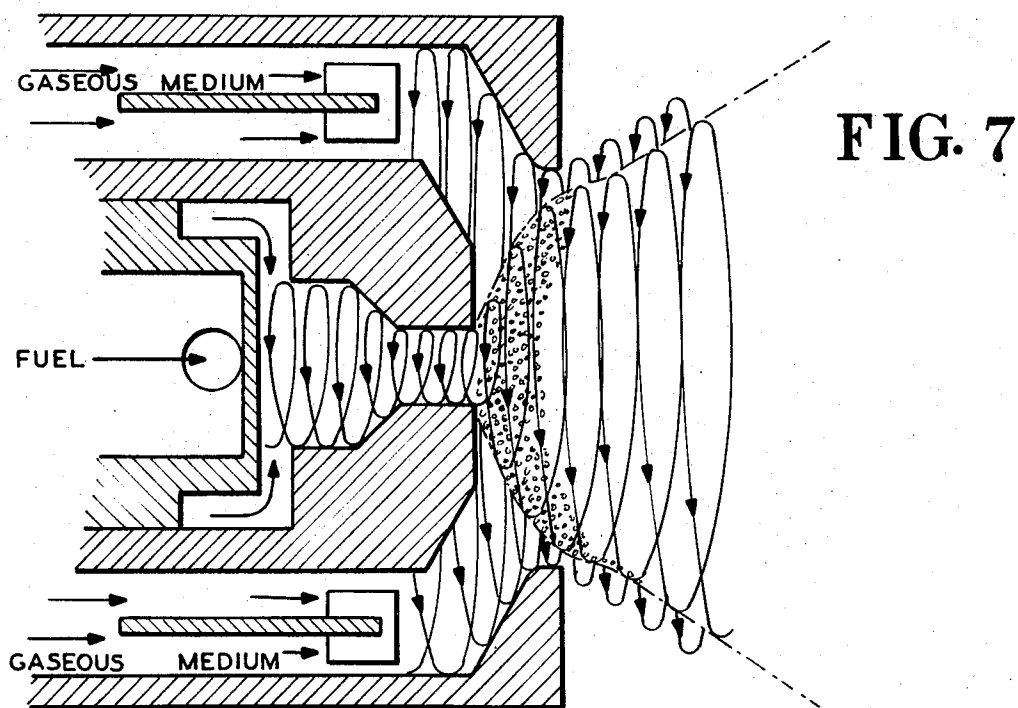
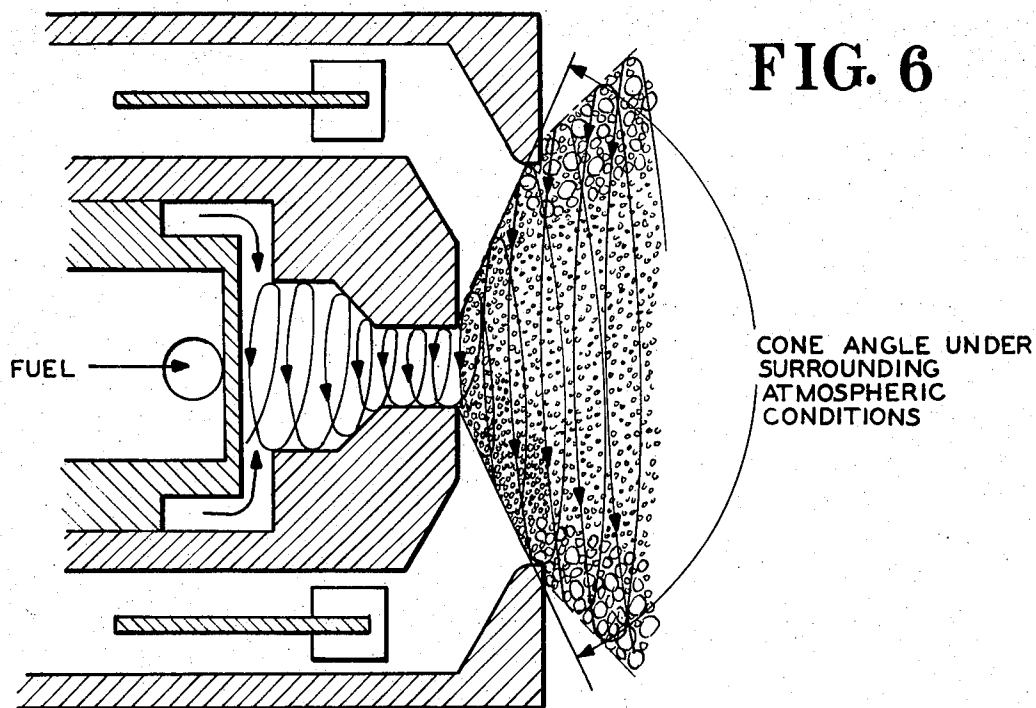


FIG. 5



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FIG. 8

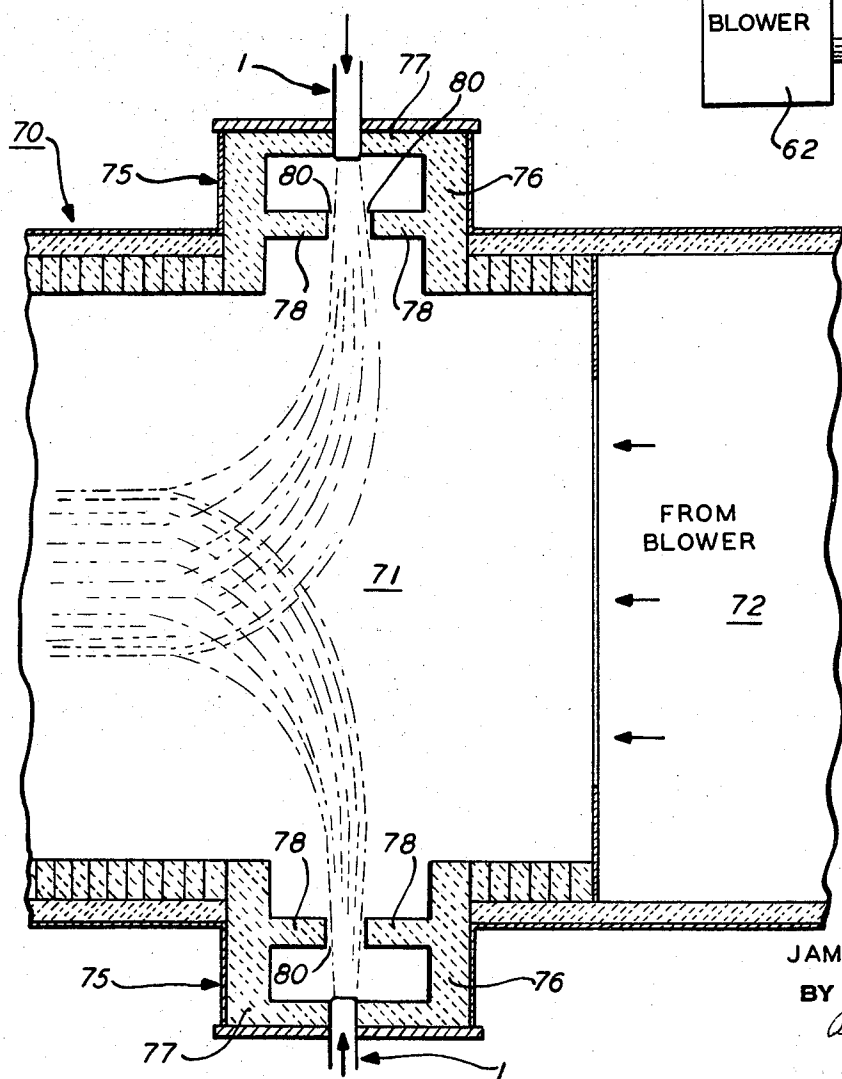
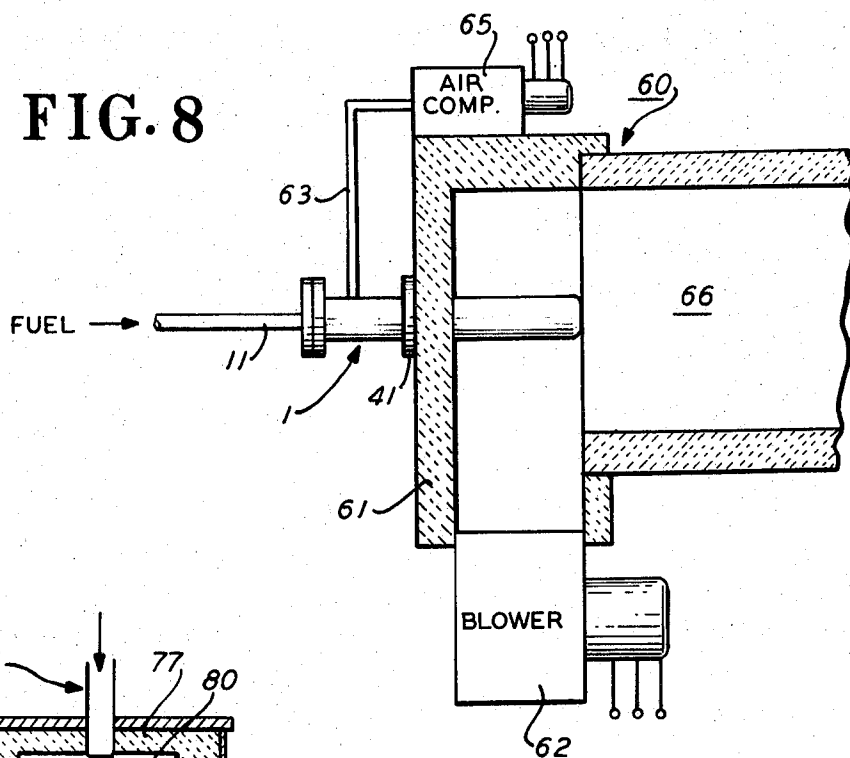


FIG. 9

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METHODS FOR PREPARING FUELS AND ALSO FOR THEREAFTER FEEDING THEM INTO FURNACES AND BURNING THEM THEREIN

BACKGROUND OF THE INVENTION

Prior to this invention various constructions have been proposed for producing and feeding from the orifice of an atomizing nozzle a conical spray of swirling fuel particles and feeding air towards a discharge opening spaced from the orifice.

Among some of them disclosed in the prior art are the U.S. Pat. Nos. 1,439,320 and 1,904,509. In my more than 25 years experience in the art to which this invention pertains so far as I know no one other than I has even described or employed the novel methods of this invention.

SUMMARY OF THE INVENTION

This invention is directed to methods for preparing fuels comprising continuously producing and feeding from the discharge orifice of an atomizing nozzle at an emission linear velocity of about 4-200 ft/sec., swirling liquid fuel particles at a viscosity up to 300 SSU and in the form of a spray cone which when under surrounding atmospheric conditions is about 5°-100° and the average diameter of the particles is 25-150 microns; and simultaneously through means surrounding the nozzle, spaced therefrom, extending downstream thereof and having a discharge opening substantially coaxial with the orifice and spaced from the orifice, continuously feeding towards the opening and against the cone a swirling gaseous medium which is air, steam, gaseous fuel or a mixture of two or more of them at a sufficient linear velocity, which is in the range of 100-2000 ft/sec., to reduce the angle of the cone to such value that the wall defining the opening is not wetted thereby, and to reduce the size of the fuel particles to such value that all of them emerging from the opening are no greater than 10 microns in diameter, but when the cone is under surrounding atmospheric conditions, the wall defining the opening will become wetted thereby.

By practicing the methods of the present invention wetting of the wall of the opening spaced from the nozzle orifice is prevented so that when the burning of the fuel downstream of the opening is effected, it will not cause undesirable carbonaceous build-up in and around the wall defining the opening which now occurs in the present methods of using the commercial internal mixing burners of which I am aware. Still another advantage resulting from practicing the present invention is to provide a spray of swirling fuel particles all of which are no greater than 10 microns in diameter as they emerge from the discharge opening for admission to a furnace wherein they become mixed with the required combustion air thus ensuring substantially complete combustion in the burning of the fuel particles. Thus I have prevented the feeding into the furnace of coarse or "oversize" particles which if fed into the furnace would cause smoke and soot in the burning of such fuel feed in the furnace. In addition by practicing the methods of this invention, substantially complete combustion of the liquid fuel is achieved upon burning of the spray in a furnace to which sufficient combustion air is admitted so that the resultant gases discharged from the furnace stack are substantially free of smoke or soot thereby more than meeting the present day non-

pollutant requirements for stack gases. Also by practicing the methods of this invention the substantially complete combustion of the fuel particles fed into a furnace is achieved when burning thereof is effected in admixture with required combustion air to provide a sharp profile flame which is clear with sharply delineated edges and termini free of smoke or soot. In addition in the practice of this invention into the furnace in which said flame is continuously maintained, gases, finely divided liquids or solids which are pollutants due to their odor or other characteristic, are continuously fed into the furnace wherein they are oxidized, degraded or chemically or otherwise converted by the heat generated by the burning fuel oil into non-pollutant substances.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a view mostly in cross section and illustrating a burner employed in the practice of the present invention.

FIG. 2 is a view in side elevation of a fitting which is part of the mechanical atomizing nozzle shown in FIG. 1.

FIG. 3 is an end view of FIG. 2.

FIG. 4 is a cross sectional view taken on line 4-4 of FIG. 1 in direction of the arrows.

FIG. 5 is a view in side elevation of the gaseous-medium swirler or spinner assembly.

FIG. 6 is a schematic view showing the spray cone of swirling fuel particles emerging from the orifice and then wetting the wall of the opening defining the discharge orifice or opening of the burner shown in FIG. 1 when the cone is under surrounding atmospheric conditions.

FIG. 7 is a view similar to FIG. 6 and shows the conical spray of FIG. 6 as modified by the swirling gaseous medium applied thereto, such modification being the reduction of the spray angle of the conical spray to such value that the wall defining the discharge opening is not wetted thereby and the reduction of the size of the fuel particles in the practice of this invention.

FIG. 8 is a schematic sectional view showing the burner in combination with a furnace or rotary kiln used in the practice of one aspect of this invention.

FIG. 9 is a cross sectional view of a furnace having a pair of burners, each including a chamber in combination with the burner shown in FIG. 1 and used in the practice of another aspect of this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The novel burner 1 as shown in FIG. 1 and used for practicing the methods of this invention comprises a first sub-assembly 10 including a rigid steel tube 11 threadedly coupled and completely circumferentially welded at one end thereof to one end of a rigid steel tube or hollow fitting 13 in communication with tube 11 and terminating in a head 14 at the other end thereof. The head 14 terminates in a flat face 9, and has a frusto-conical face 8 inclined inwardly at the downstream end thereof. The head 14 has a central discharge opening or orifice 15 therein extending through the downstream end thereof and in communication with an enlarged axial opening or passageway 16 therein. The passageway 16 is of cylindrical-frusto-conical form, with the downstream end of the frusto-conical portion thereof being in registry with the orifice 15. The upstream end of passageway 16 has a diameter

less than that of the interior of tube 13 to provide of head or flat annular face or shoulder 17.

Threadedly coupled with the tube 13 at the downstream end thereof is a hollow fitting 18, having tool-accommodating short recesses 19 therein, and comprising an outwardly threaded hollow portion 20 threadedly engaging the internally threaded tube 13. Portion 20 is integral with a hollow portion 21 of the same internal diameter as but of substantially lesser outside diameter than portion 20. Portion 21 is disposed downstream of portion 20 and abuts firmly against the shoulder face 17 to make a hermetic seal therebetween and to provide a passageway 22 between tube 13 and portion 21. Located in the portion 21 and disposed between the ends thereof is a closure disc 23 hermetically sealed to portion 21 around the entire periphery of disc 23 to provide a shallow circular recess 24 in registry with the cylindrical upstream end of passage 16 which together form a swirl chamber. A plurality of, and as shown for the purposes of illustration, four radial openings 25 spaced 90° from each other extend through that part of the portion 21 upstream of disc 23 for the passage of fuel in the liquid state out of the fitting 18 and into the passageway 22. The portion 21 downstream of disc 23 has a plurality, and as shown for the purposes of illustration, four like slots 27 therein extending through the downstream face of the fitting 18 which bears against the face 17. Each of the slots 27 is in communication with both the passageway 22 and the recess 24. The slots 27 are disposed tangentially to the outer circular face of portion 21 downstream of disc 23 so that the fuel under pressure passes angularly from the passageway 22 through the slots 27 confined by face 17 into the swirl chamber (24-16) wherein it automatically becomes a swirling mass therein and so passes into, through and out of the opening 15 as a swirling spray of fuel oil particles. The before described head 14 together with fitting 18 and that part of tube 13 to which fitting 18 is secured is a mechanical atomizing nozzle, so known to the art, for discharging therefrom a conical spray of swirling fuel particles. The cross sectional area of the slots 27 and the cross sectional area of the orifice 15 are so chosen in the conventional ways well known to the art that when fuel in the liquid state and having a viscosity up to 300 SSU is passed through the slots 27, swirl chamber (24-16) and orifice 15 at an emission velocity in the range of 4-200 ft/sec., from orifice 15, it discharges from orifice 15 as swirling fuel particles in the form of a spray cone which under surrounding atmospheric conditions has a spray angle of 50° - 100° and preferably about 60° - about 80° and the average size of the particles is in the range of about 25 - 150 microns. A rigid annulus or flange 28 is welded to the tube 11 to lock and hermetically seal flange 28 thereto, and a compressible gasket 29 extends around tube 11 downstream of flange 28 and abuts against the flange 28. The flange 28 has a pair of diametrically disposed openings therethrough. A pair of diametrically disposed cylindrical rods 30 extend through the openings in flange 28 and made slideable hermetic seals thereat by use of appropriate packing (not shown) therebetween. The flange 28 has a pair of radially disposed threaded openings therethrough which make threaded engagement with locking bolts 7. Each of the rods 30 extends along the length of the coupled tubes 11 and 13 and terminates in a short cylindrical space, head 31. The downstream end of each head

has a recess therein accommodating one end of a thin rigid ring 32 locked thereto by welding or other convenient manner and extending downstream thereof. A plurality of vanes 33, each having a slot therein is mounted on the other end of ring 32 by inserting ring 32 into the slots of vanes 33, then adjusting the vanes 33 at any desired angle at which they are fixed by set screws 35. It is preferred that each of the vanes be disposed at about the same angle. The angular disposition of each of the vanes is preferably in the range of about 5° - 45° to the common axis of the ring 32 and tubes 11 and 13. The rods 30 are adjustable longitudinally by pulling or pushing them to dispose the vanes at any desired location along the length of the tubes 11 and 13 and are lockable at desired locations by the locking bolts 7.

A second sub-assembly 37 is in combination with the first sub-assembly as shown in FIG. 1 and comprises a rigid steel tube or hollow cylinder 38 of considerably greater diameter than tubes 11 and 13 and having a partial closure ring 39 welded thereto at the outlet end thereof, an inlet opening therethrough at which an inlet nipple 40 is hermetically sealed and also having a pair of spaced steel flanges 41 and 42 welded thereto with a gasket 43 abutting against flange 42 and flange 41 located downstream of nipple 40. The downstream face 44 of ring 39 is flat and in the same plane as the downstream end-face of tube 38. The inner face of the ring 39 consists of a face 45 inclined inwardly towards the downstream end thereof, curves slightly at 46 and then terminates in a shallow circular face which defines the discharge or outlet opening 47 thereof.

The first sub-assembly 10 is inserted into the second sub-assembly 37 to provide the combination shown in FIG. 1 wherein the outer surface of centering heads 31 are close to the opposing surfaces of tubes 13 and 38 and the flanges 28 and 42 are secured together by locking nut and bolts 49 extending through coaxial openings therethrough to lock and maintain the first sub-assembly 10 in position with respect to sub-assembly 37. In this combination, the sub-assemblies are so constructed and arranged and disposed relative to one another that the face 9 is spaced from the upstream extremity of the wall defining the opening 47 to provide a space or passageway 50 therebetween and inner wall of the tube 38 is substantially coaxial with and spaced from the outer wall of tubes 11 and 13 thereby defining an elongated passageway 51 and the faces 8 and 45 are opposite and substantially parallel to each other to define a downstream-inclined passageway 52 which is in communication with the passageway 51 and the space or passage 50 in communication with opening 47.

The vanes act to impart a resultant spinning or swirling motion about the longitudinal axis of tube 38 to the gaseous medium passing thereby in the course of travel of the gaseous medium through passage 51 and into the passageway 52 and the spinning or swirling angle of that medium is determined by the angularity of the vanes 33 at a particular location in the combination. The spinning or swirling angle can be adjusted by changing the angularity of the vanes and/or varying the distance of the vanes from the passageway 52. By controlling the spinning or swirling angle of the gaseous medium as it strikes the outer surface of the cone of swirling fuel oil spray the configuration or angle of the spray of the swirling particles after passing beyond opening 47 may be varied from a relatively long, nar-

row spray to a relatively short, wide spray. While the burner is in operation, the rods 30 may be moved back and forth to locate the vanes 33 at any desired location and then locked in desired location by screws 7, thus requiring no shut-down when a change in the angle of the spray from opening 47 is desired.

The orifice 15 is coaxial with and spaced from the opening 47, with the diameter of opening 47 being greater than the diameter of the orifice 15. The diameters of orifice 15 and opening 47 are so proportioned and the distance between the orifice 15 and opening 47 is such that when the spray cone is discharged from the orifice 15 under surrounding atmospheric conditions the fuel particles of the cone from orifice 15 would be intercepted by the wall defining the opening 47 to become wetted thereby, but when a swirling gaseous medium passes into the opening 52 at such linear velocity that it strikes the cone at a sufficient velocity, which is at least 100 ft./sec. and no greater than 2000 ft./sec., it will bend the outer surface of the cone in the space between orifice 15 and opening 47 to reduce its angle to such value that none of the fuel particles are intercepted by the wall of opening 47 and also reduces the fuel particles to such size that all of them have a diameter no greater than 10 microns, and also so confine the spray that the swirling gaseous medium completely surrounds the spray in the course of its passage from orifice 15, into and out of opening 47 and at least slightly therebeyond. In general the greater than viscosity of the fuel emerging from the orifice 15, the greater is the linear velocity of the swirling gaseous medium required for optimum conditions. In all instances a linear velocity of the swirling gaseous medium even of only 1000 ft./sec., striking the cone will effectuate the above results no matter what the viscosity of the fuel up to 300 SSU as it emerges from orifice 15. However for economical reasons the linear velocity of the gaseous medium striking the cone need not be even as high as 1000 ft./sec. but may be as low as about 300 ft./sec. when light oils, such as kerosene, Diesel oils and the like having a viscosity of about 35 SSU are used.

The diameters of the orifice 15 and opening 47 and the ratio of the diameter one to the other as well as the distance between the orifice and opening will vary, depending mainly upon the quantity of the liquid fuel emerging from the orifice 15 and the velocity of the gaseous medium striking the spray cone. The quantity of the fuel discharged from the orifice 15 is dependent upon its diameter which may be in the range of 1/64 to 1 inch but for most purposes is in the range of about 1/64 to about 1/2 inch and the ratio of the diameter of orifice 15 to the diameter of opening 47 is in the range of about 1 to 15 to 1 to 5, and the distance between orifice 15 and opening 47 is in the range of about .1 to .5 and preferably .2 to .4 the diameter of the opening 47.

One of the aspects of this invention may be practiced in the firing of a furnace, such as a kiln or the like. For this purpose the burner 1 is coupled with a furnace 60 as shown in FIG. 8. The burner 1 extends through a central opening in the hood 61 which has an enlarged opening accommodating the wind-box of a high volume blower 62 for continuously supplying and feeding into the furnace combustion air at normal or elevated temperature and in required amount. By "air" as employed herein, I mean either normal air or air whose oxygen content has been partially depleted, such as the exhaust by-product air from gas turbine engines or the like.

A source of fuel supply which may or may not include a heater therefor depending upon the viscosity at 25°C. of the fuel to be used is operatively connected to a fuel pump (not shown) whose discharge end is operatively connected to tube 11 for conducting the fuel to the mechanical atomizing nozzle. The fuel pump may be one of any of the conventional types on the market and includes a control for changing the fuel pressure whereby the operator may at will change the rate of fuel feed into the through the head 14. One end of a pipe 63 is connected to the threaded end of the nipple 40 and its other end is connected to the discharge outlet of a conventional electrically driven air compressor 65. The air compressor 65 having a rating of 2 pounds per square inch or any other value up to 30 pounds per square inch is generally used. A gas pilot or other igniter not shown is carried by the hood to provide a flame near and downstream of the burner 1 for initial ignition of the fuel discharging from opening 47.

Instead of the compressor 65, an equivalent device for feeding gaseous fuel through pipe 63 may be used. When steam is used, it is supplied to pipe 63 by any appropriate means.

A method of this invention for preparing fuels by the use of the apparatus as shown in FIG. 1 together with FIG. 8 is as follows: A fuel in the liquid condition and at a viscosity up to 300 SSU is continuously fed under such pressure by the fuel pump (not shown) into and through the tubes 11 and 13 and passes through openings 25, passages 22 and 27, and swirl chamber (24-16) wherein it automatically is caused to swirl and discharge from the orifice 15 at an emission linear velocity in the range of about 4-200 ft./sec., as swirling fuel particles at a viscosity up to 300 SSU and in the form of a spray cone which when under surrounding atmospheric conditions has a spray angle in the range of about 50°-100° and the average diameter of the particles is in the range of about 25-100 microns and simultaneously a gaseous medium, which is air, steam, gaseous fuel or a mixture of two or more of them, is continuously fed under such pressure (by the air compressor 65 where air alone is used or by other appropriate means when such other gaseous medium is used) into and through pipe 63, nipple 40 and thence through the space 51 wherein it strikes the vanes 33 to impart a swirling motion thereto after which the swirling gaseous medium passes into the passage 52 and towards opening 47 and in the course of which the swirling gaseous medium strikes the cone at a linear velocity in the range of 100-2000 and preferably 100-1000 ft./sec. to reduce the angle of the cone to such value that the wall defining the opening 47 is not wetted thereby and to reduce the size of the fuel particles to such value that all of them emerging from the orifice 47 are no greater than 10 microns in diameter, but when the cone is under surrounding atmospheric conditions the wall will become wetted by the fuel particles. In the practice of this invention the gaseous medium is continuously fed at said linear velocity against the wall of the spray cone in what may be termed a collar of the gaseous medium at said linear velocity towards the axis of the cone. In the course of the continuous feeding the gaseous medium through passage 52 and before striking the cone, the gaseous medium in the form of a collar as before set forth acts upon and moves into or towards the cone such random fuel particles outside of the cone, which

otherwise would deposit and cause wetting of the wall defining opening 47 in the course of operation.

Thus by using the above method a continuous mixture of the liquid fuel and gaseous medium flows through the opening 47 without wetting the wall defining that opening and is continuously fed therefrom in the form of a whirling stream into the main combustion zone 66 of the furnace 60 into which there is continuously admitted sufficient combustion air by operation of the blower 62 and the pilot or igniter (not shown) is operated to initially ignite the whirling stream in the course of its passage from the opening 47 towards the main combustion zone and this flame is thereafter continuously maintained.

Another aspect of this invention may be practiced in the firing of a furnace with a burner 1 as shown in FIG. 1 in combination with a chamber as shown in FIG. 9.

The apparatus shown in FIG. 9 comprises a furnace 70 having a main combustion zone 71 in communication with an enlarged space 72 for the admission of combustion air into the zone 71 and in this embodiment along the axis thereof. Mounted in the wall of the furnace are a pair of refractory chambers 75.

Each of the chambers consist of a refractory cylinder 76 having a refractor closure 77 with a central opening therethrough, and a refractory disc 78 in the cylinder 76 and sealed thereto. The disc 78 is spaced from disc 77 and has a central opening 80. The discharge end of the burner 1 extends into opening 77 and is sealed thereto and preferably terminates flush with or slightly upstream of the inner face of closure 77. The discharge opening 47 of burner 1 is substantially coaxial with the opening 80. In one of its preferred forms the diameter of the opening 80 is about one to two times the sum of the diameter of the opening 47 and the distance between the elements 77 and 78, the diameter of chamber is at least twice the diameter of opening 80 but for most purposes is in the range of two to six times the diameter of opening 80 and the distance between the discs 77 and 78 is in the range of 1 - 7 inches and preferably in the range of 2 - 5 inches.

Whether one, two or more of said combinations of burner and chamber are used, each combination is mounted in an opening in the furnace downstream of the travel of the combustion air from the space 72. As shown in FIG. 9 there are two of such combinations mounted in diametrically disposed openings in the furnace wall. If desired, two oppositely disposed rows of two or more of such combinations spaced from each other may likewise be coupled with the furnace. The chambers of the two combinations as shown in FIG. 9 are in substantial alignment. However, in a still other aspect and for certain purposes the preferred form is to dispose them substantially opposite each other but with the longitudinal axis of one being inclined in one direction at an angle of about 1° - 10° and preferably about 1° - 5° to the transverse axis of the furnace and the other inclined in the opposite direction at an angle of about 1° - 10° and preferably 1° - 5° to that axis. By so disposing the combinations, more even heat distributions are obtained.

Another method of this invention wherein the use of the apparatus shown in FIG. 1 together with FIG. 9 is as follows: The method heretofore described by the use of the burner 1 is used except that steam is not used as the gaseous medium and the linear velocity of air and/or gaseous fuel striking the cone is in the range of 100

- 1000 ft/sec., and instead of feeding the stream of fuel and gaseous medium directly into the main combustion zone, it is fed through chamber 75 and thence into the main combustion zone. In the practice of this other method, the mix of the swirling fuel particles and air and/or gaseous fuel is continuously discharged from the opening 47 in the form of a stream into chamber 75 thence through opening 80 and thence downstream thereof into the furnace. An igniter pilot or the like not shown and disposed in the chamber is ignited to initially ignite the stream thereby to provide a stream of flame passing through the chamber and opening 80 into the furnace. The cross section of the burning stream as it passes through the opening 80 is such that more than 98 percent of the fuel particles therein pass through the opening 80 and that ejector action is provided by the passage of the burning stream therethrough to lower the static pressure in the chamber to such value that fresh air is drawn back or upstream substantially continuously into the chamber through the narrow space between the wall defining opening 80 and the burning stream passing therethrough whereby the fuel particles which were entrapped in the chamber are maintained in a burning condition to substantially continuously maintain a collar of flaming fuel around the burning stream as it passes through the chamber thereby to prevent cooling and deposition of the entrapped fuel particles and to aid in gasifying the fuel particles in the stream and also to aid in the prevention of flame out.

With the construction shown in FIG. 9 both of the combinations are used in accordance with this method to provide two like-streams of flame, each travelling towards the axis of the furnace. The burning of these streams is maintained and substantially complete combustion is effected continuously feeding into the furnace the required amount of air or other gaseous medium containing free oxygen in a direction along the longitudinal axis of the furnace.

In one of its aspects the combustion air fed to the furnace through the opening 72 is either normal air or partially oxygen-depleted air exhaust or by-products from gas turbine engines or the like which are at elevated temperatures of 500°F or above in order to take advantage of the heat therein. The quantity of air supplied to the furnace through space 72 is dependent upon the percent of oxygen therein, the less the percent of oxygen therein, the greater the quantity thereof is supplied for effectuating the substantially complete combustion effectuated.

In a further preferential aspect of the methods of this invention is to limit the air fed by the compressor 65 into the space 51 to a value such that the rate of feed is no greater than 10 percent and preferably no greater than 5 percent of the rate of air feed from the blower into either the furnace 60 or 70.

A still further preferential aspect of the methods of this invention is to also feed pollutant compositions in the gaseous, liquid or finely divided solid state through the space 72 or through some other opening in the furnace 70 and towards the burning fuel therein wherein they are acted upon by the heat from the burning fuel and/or become mixed with the components thereof to burn or be subjected to other chemical action, such as interaction, oxidation, destruction, degradation or such other chemical or other action that the resultant hot gases emanating from the stack (not shown) of the furnace are free of soot or smoke and of the pollutants.

Those compositions subjected to such action are generally characterized as being noxious or have a disagreeable and unpleasant odor and are exhaust or other by-products of certain processes and are generally in admixture with air and heretofore have been discharged into the atmosphere.

Thus I have provided a number of different specific processes or methods which are employed for the production of heat and/or also conserving and using the heat present in the exhaust air by-products, which are partially-oxygen-depleted, and are at temperatures above 500°F from gas turbines or the like and/or also for converting pollutants, normally air borne, into non-pollutant compositions.

In addition by employing the methods herefore described, wetting of the otherwise wettable wall of the opening 47 is prevented so that when the burning of the fuel downstream of opening 47 is effected, it will not cause undesirable carbonaceous build-up in and around the wall defining opening 47 which now occurs in the present methods of using the commercial internal mixing burners of which I am aware. Still another advantage resulting from practicing the present invention is to provide a spray of swirling fuel particles all of which are no greater than 10 microns in diameter as they emerge from the discharge opening for admission to a furnace wherein they become mixed with the required combustion air thus aiding in ensuring substantially complete combustion in the burning of the fuel particles. Thus I have prevented the feeding into the furnace of coarse or "oversize" particles which if fed into the furnace would cause smoke and soot in the burning of such fuel feed in the furnace. In addition by practicing the methods of this invention, substantially complete combustion of the liquid fuel is achieved upon burning of the spray in a furnace to which sufficient combustion air is admitted so that the resultant gases discharged from the furnace stack are substantially free of smoke or soot thereby more than meeting the present day non-pollutant requirements for stack gases. Also by practicing the methods of this invention the substantially complete combustion of the fuel particles fed into a furnace is achieved when burning thereof is effected in admixture with required combustion air to provide a sharp profile flame which is clear with sharply delineated edges and termini free of smoke or soot. In addition in the practice of this invention into the furnace in which said flame is continuously maintained, gases, finely divided liquids or solids which are pollutants due to their odor or other characteristic, are continuously fed into the furnace wherein they are oxidized, degraded or chemically or otherwise converted by the heat generated by the burning fuel oil into non-pollutant substances.

By the term "air" as employed in the present description and claims, unless otherwise defined, I mean air of normal or sub-normal free oxygen content.

Also in practicing the methods of this invention as before described, should it be desired to change the angle of the spray discharging from opening 47 and that of the flame which is the spray in burning condition, the desired change is readily and easily effected while the operation of the burner is continuously maintained by merely loosening set screws 7, then pushing or pulling the rods 30 to move the vanes 33 to such different location in space 51 that the spinning or swirling intensity of the gaseous medium striking the spray cone from ori-

fice 15 is such that the spray discharging from opening 47 and when in burning condition being a flame is of the desired angle. Then the screws are turned down to again lock the rods and the vanes carried thereby in their new location without any shut-down of the burner operation.

Since certain changes in carrying out the above process which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all the generic and specific features of the invention herein described, and all statements of the scope of the invention, which as a matter of language might be said to fall therebetween.

I claim:

1. A method for preparing and burning fuel comprising:

continuously producing and feeding towards the combustion zone of a furnace from the discharge orifice of an atomizing nozzle at an emission linear velocity of about 4-200 ft/sec., swirling liquid fuel particles at a viscosity up to 300 SSU and in the form of a spray cone which when under surrounding atmospheric conditions is about 50° - 100° and the average diameter of the particles is 25 - 150 microns;

and simultaneously through means surrounding the nozzle, spaced therefrom, extending downstream thereof and having a discharge opening substantially coaxial with the orifice and spaced downstream from the orifice, with the opening being in communication with the zone, continuously feeding towards the opening and against the cone swirling air at a sufficient linear velocity, which is in the range of 100-2000 ft/sec., to reduce the angle of the cone to such value that the wall defining the opening is not wetted thereby, and to reduce the size of the fuel particles to such value that all of them emerging from the opening are no greater than 10 microns in diameter but when the cone is under surrounding atmospheric conditions, the wall will become wetted thereby;

all of said air is converted to the swirling condition upstream of the discharge terminus of the orifice and then in that condition is fed towards the opening and cone;

said simultaneous feeding of the fuel and air also effecting feeding of the resultant spray of said reduced angle and reduced particle size towards the combustion zone of the furnace;

igniting the resultant spray; and

feeding other air into the combustion zone of the furnace to effect substantially complete combustion of the fuel particles fed therein;

the rate of feeding the first mentioned air is no greater than 10 percent of the rate of feeding the said other air.

2. A method according to claim 1, and simultaneously changing the angle of the resultant discharge from the opening.

3. A method according to claim 1, the linear velocity of the gaseous medium being in the range of about 100 - 1000 ft./sec. and under surrounding atmospheric conditions the angle of the spray cone is in the range of about 60° - 80°.

4. In a method for burning fuel by the use of apparatus including a furnace having a combustion zone, first means including a conduit in communication with an atomizing nozzle including a swirl chamber and a discharge orifice in communication with the chamber and second means surrounding the first means and spaced therefrom, the second means extending downstream beyond the first means and having a discharge opening substantially coaxial with and of greater diameter than that of the orifice, said opening being in communication with said combustion zone, third means in the space between the first and second means, all of the third means located entirely upstream of the discharge terminus of the orifice for imparting swirling to air when fed through the space, the diameters of the orifice and opening being so proportioned and the opening being so spaced downstream from the orifice that when fuel under pressure is continuously fed in the liquid state at a viscosity up to 300 SSU through the first means it emerges from the orifice when under surrounding atmospheric conditions in the form of about a 50° - 100° spray cone of swirling fuel particles whose average diameter is 25 - 150 microns and at an emission linear velocity of 4-200 ft/sec. from the orifice, but when air under pressure is continuously fed through the space and towards the opening the third means imparts swirling motion thereto after which the swirling air strikes the conical spray at a linear velocity of 100 - 2000 ft/sec. to reduce the angle of the spray to a value sufficient to prevent the spray from wetting the wall defining the opening and to reduce the size of the particles to a value such that all of the particles are no greater than 10 microns as they emerge from the opening but when the spray cone is under surrounding atmospheric conditions, it will wet the wall; the steps comprising continuously feeding through the first means fuel in the liquid state at a viscosity up to 300 SSU at such pressure that when under surrounding atmospheric conditions it emerges from the orifice in the form of about a 50° - 100° spray cone of swirling fuel particles having average particle size of 25 - 150 microns and emission linear velocity of 4-200 ft/sec. from the orifice, simultaneously feeding air through the space and towards the opening to provide swirling air which strikes the spray cone at a sufficient linear velocity, in the range of about 100-2000 ft/sec., to reduce the angle of the spray to such value that the wall defining the opening is not wetted thereby and to reduce the size of the fuel particles to such value that all of them emerging from the opening have a diameter no greater than 10 microns, but when the cone is under surrounding atmospheric conditions, the wall will become wetted thereby;

all of said air is converted to the swirling condition upstream of the discharge terminus of the orifice and then in that condition is fed towards the opening and cone;

5 said simultaneous feeding of the fuel and air also effecting feeding of the resultant spray of said reduced angle and reduced particle size towards the combustion zone of the furnace;

10 igniting the resultant spray; and

15 feeding other air into the combustion zone of the furnace to effect substantially complete combustion of the fuel particles fed therein;

the rate of feeding the first mentioned air is no greater than 10 percent of the rate of feeding the said other air.

5. A method according to claim 4, and simultaneously varying the angle of the spray discharging from the opening by moving the third means to a different location with respect to the opening.

20 6. In a method according to claim 5, and the step of simultaneously varying the angle of the spray discharging from the first mentioned opening, by changing the location of the third means with respect to the first mentioned opening.

25 7. In the method of burning fuel according to claim 4, the apparatus further including a chamber including a body member having a closure with an inlet opening associated with the discharge end of the second means and a member coupled with the body member, and spaced from the closure, the second mentioned member having a discharge opening therein substantially coaxial with the inlet opening and the first mentioned discharge opening, and the step of continuously feeding through the inlet opening and the second mentioned chamber and through the second mentioned discharge opening the resultant spray discharging from the first mentioned discharge opening.

30 8. In a method according to claim 7, the openings in the closure and the second mentioned member being so dimensioned and spaced from each other that when the resultant spray is in the burning condition in the course of its passage through the second mentioned chamber to reduce the static pressure therein so that air and fuel downstream of the second mentioned member travels upstream continuously into the second mentioned chamber to aid in maintaining a collar of flame therein and around said burning spray in the course of its passage through the second mentioned chamber.

35 9. In a method according to claim 9, the rate of feeding the first mentioned air is no greater than 5 percent of the rate of feeding the said other air.

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