

Nov. 6, 1962

E. COLIN-SMITH

3,062,273

METHOD AND APPARATUS FOR ATOMIZING LIQUIDS

Filed May 31, 1957

2 Sheets-Sheet 1

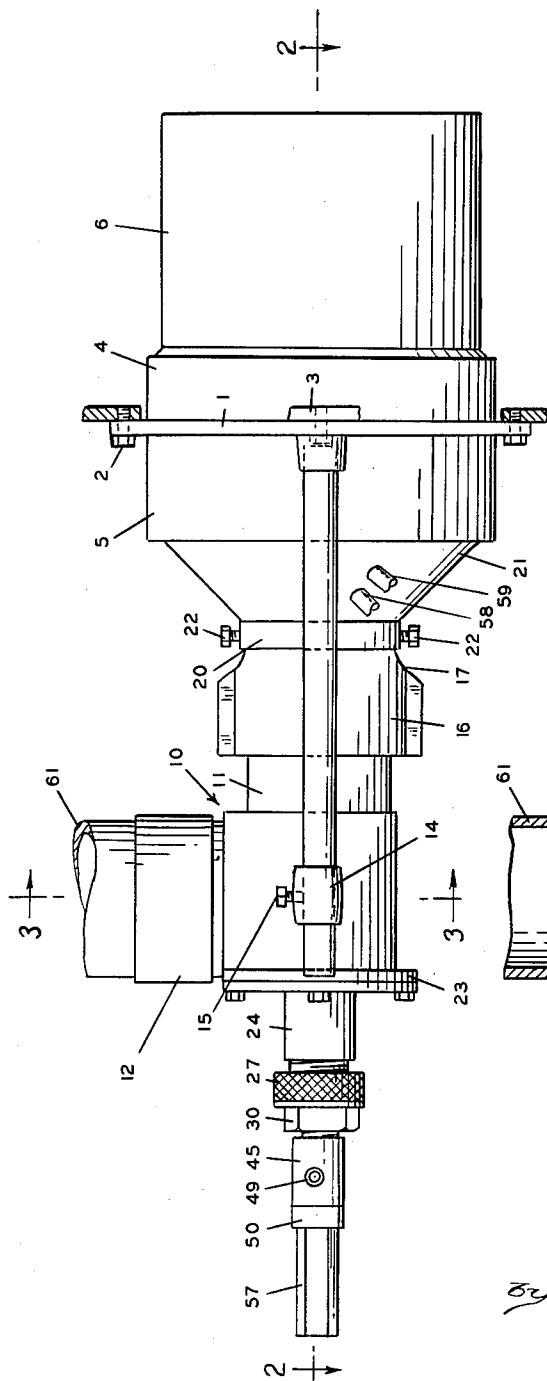


FIG. 1.

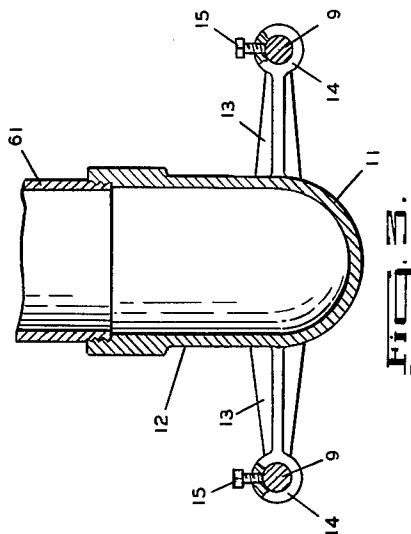


FIG. 3.

INVENTOR

ERIC COLIN-SMITH

Douglas S. Johnson

ATTY.

Nov. 6, 1962

E. COLIN-SMITH

3,062,273

METHOD AND APPARATUS FOR ATOMIZING LIQUIDS

Filed May 31, 1957

2 Sheets-Sheet 2

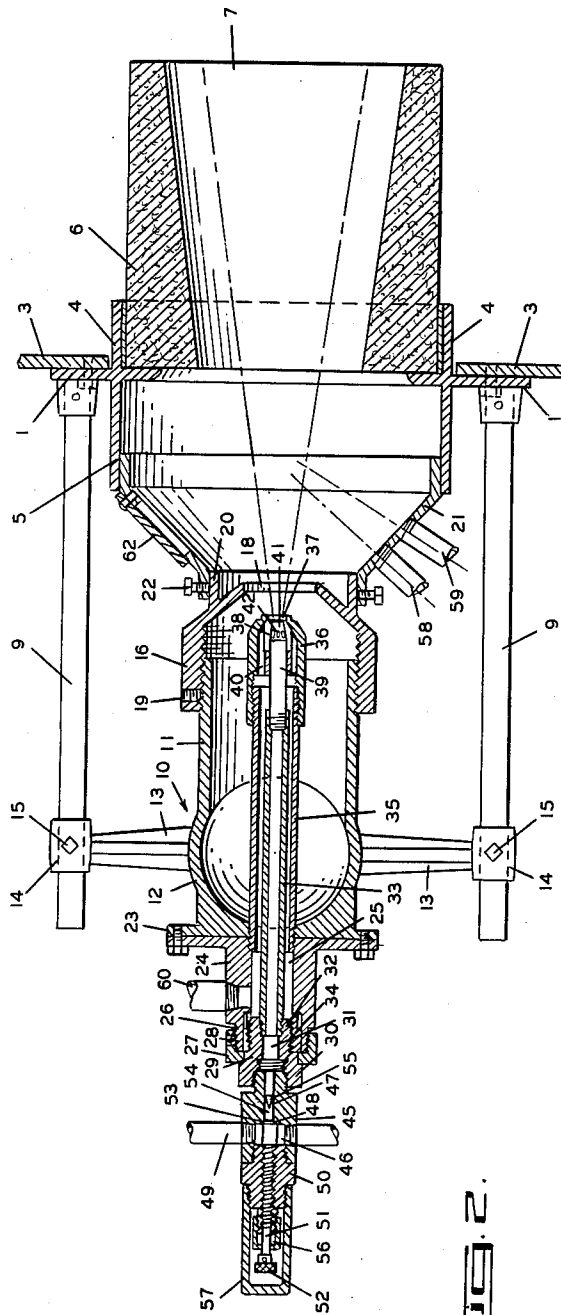
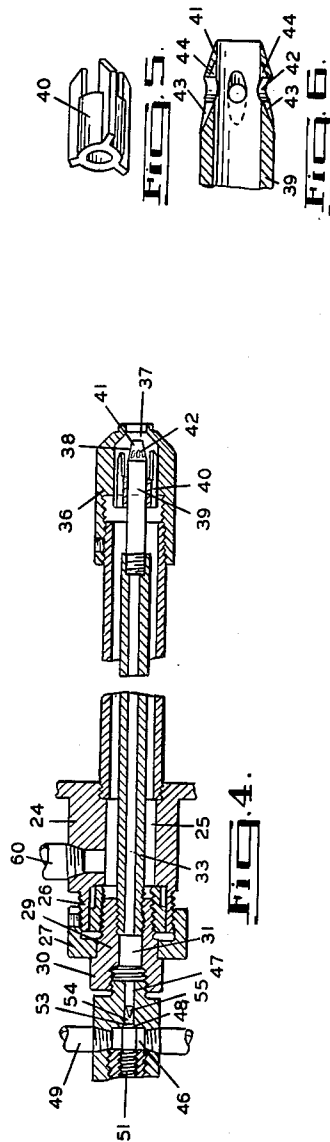


FIG. 2.



INVENTOR

ERIC COLIN-SMITH

Raymond S. Johnson

ATTY.

1

3,062,273 METHOD AND APPARATUS FOR ATOMIZING LIQUIDS

Eric Colin-Smith, Wellesley, Mass., assignor to Combustion Research Corporation, West Newton, Mass.

Filed May 31, 1957, Ser. No. 662,906

Claims priority, application Great Britain June 6, 1956
13 Claims. (Cl. 158—76)

This invention relates to improvements in the atomization of liquids and devices therefor, the invention having particular application in the oil burner field.

The object of the invention is to achieve more complete atomization of liquid than has heretofore been achieved. Specifically with reference to the application of the invention to the oil burner field the object of the invention is to achieve maximum atomization of oil in the oil burner to obtain complete or maximum and stable combustion of the oil, and further to obtain such results with all types and grades of oil. Thus, it is a particular object of the invention to provide an oil burner which will have universal application burning any and all types of oil, including Bunker C oil, with the highest efficiency obtainable for maximum B.t.u. output and maximum economy.

Another object is to provide an oil burner which, by achieving complete combustion, will eliminate the problems presently encountered in oil fired installations resulting from the detrimental effects of the by-products of incomplete combustion.

Still another important object is to enable complete combustion to be achieved irrespective of the particular installation in which, or conditions under which, the burner operates.

Again it is an object to provide an oil burner which will be particularly adapted for automatic operation with all types of oil including Bunker C oil, and further will enable the burner to be operated efficiently over a wide range of fuel consumption rates.

Again an important object is to provide a liquid atomizing device or oil burner capable of achieving the objects of the invention which burner will be of economical construction and which can be readily installed.

According to the invention the liquid or oil is reduced to a highly atomized state and the fine liquid particles completely surrounded with air through the utilization of three stages of atomization. More particularly according to the invention the liquid or oil is subjected to the atomizing action of a relatively high pressure low volume air stream in the first and second stages of its atomization and to a relatively low pressure high volume air stream in the final stage of its atomization whereby the liquid is first broken up into extremely small closely packed particles by the high pressure air, and the finely divided particles are further dispersed and isolated by the low pressure air which supports air envelopes around the particles.

A further feature of the invention resides in providing for the accurate regulating of the atomization at each stage so that it can be adjusted to suit each particular installation to give complete combustion yet to prevent the presence of any excess air.

In the carrying out of the atomization according to the invention a central liquid or oil feed tube terminating in a discharge nozzle is disposed concentrically within an air feed tube terminating in a reduced discharge nozzle surrounding the liquid tube nozzle, the liquid tube having a plurality of orifices leading into the interior thereof adjacent to its discharge nozzle, and the liquid or oil tube and surrounding air tube are disposed concentrically within a second larger air feed tube or casing terminating in a nozzle or nose portion surrounding the aforesaid nozzles.

According to the invention the apparatus is further

2

characterized in that means are provided for axially adjusting the liquid or oil tube into and out of the reduced orifice in the surrounding air tube nozzle, and further means are provided for adjusting the liquid or oil tube and first-mentioned air tube relative to the second air tube for movement of the oil and first air tube in unison towards and from the discharge orifice in the second tube nozzle or casing nose portion.

Still a further feature resides in providing an adjustable mounting for the three stage atomizer or burner so that the entire unit can be quickly and easily adjusted on installation to accommodate each particular burner application.

With reference to the accompanying drawings,

FIGURE 1 is a side elevational view of an oil burner unit embodying the invention;

FIGURE 2 is a plan section on the line 2—2 of FIGURE 1;

FIGURE 3 is a vertical section on the line 3—3 of FIGURE 1;

FIGURE 4 is a broken away plan section on the line 2—2 of FIGURE 1, but showing the parts adjusted from the position of FIGURE 2;

FIGURE 5 is a perspective view of the spider centering the oil tube of the device of FIGURES 1 to 4;

FIGURE 6 is an enlarged mid-vertical sectional view of the discharge nozzle of the oil tube.

Referring particularly to FIGURES 1 and 2, the oil burner unit embodying the invention is supported from a furnace mounting ring or plate 1 secured by bolts or other suitable fasteners 2 in a position concentric with the opening in the wall of a furnace or combustion chamber 3. The ring 1 is formed with a pair of annular flanges 4 and 5, the flange 4 projecting through the opening of the furnace 3 and receiving the inner end of a tuyere block 6, preferably formed of hard firebrick, the tuyere block having an inwardly diverging frusto conical passage 7 therethrough.

Carried by the mounting ring or plate 1 are a pair of spaced parallel tubular guides 9 on which is slidably supported a casing 10 having a horizontal cylindrical portion 11, the axis of which is concentric with the axis of the ring 1 and the frusto conical passage 7 in the tuyere block 6 and having a vertical cylindrical portion 12. The casing 11 is provided at each side with an arm 13 carrying a sleeve 14 slidably receiving one of the guides 9, the sleeve being adapted to be locked in position along the guide by means of a clamp screw 15.

Threaded on the end of the cylindrical casing portion 11 adjacent the mounting ring 1 is a nose cap 16 having a convergent forward end 17, provided with a discharge orifice 18, again in axial alignment with the casing portion 11, ring 1 and tuyere block passage 7. The nose cap 16 is set in adjusted position along the cylinder portion 11 by means of a suitable set screw 19.

Extending forwardly from the convergent end 17 of the nose cap is an annular flange 20 on which is slidably received the smaller end of a frusto conical casting 21, the larger end of which is in snug sliding fit with the inner surface of the flange 5 of the mounting ring 1. The frusto conical casting 21 is locked to the flange 20 of the nose cap by suitable lock screws 22 and is adjusted in the flange 5 for movement towards and from the ring 1 and tuyere block 6 by the sliding adjustment of the casing 10 along the guide 9.

Secured to a flange 23 provided on the end of the casing 10 remote from the nose cap 16 is a cylindrical block or casting 24 having a cylindrical chamber 25 therein in axial alignment with the cylindrical casing portion 11, plate 1 and tuyere block passage 7. The casting 24 is provided with a reduced threaded outer end 26 on which is threaded a collar 27, the collar being

locked in position by a suitable set screw 28. The collar 27 is rotatably received on a reduced circular portion 29 of the cylindrical block 30 having a bore 31 there-through.

The inner end 32 of the block 30 has threaded into the bore 31 thereof an oil tube 33 which extends axially through the casting 24 and casing cylinder 11 into the nose cap 16. A nut 34 threaded on the inner end 32 of the block 30 serves to maintain the collar 27 on the reduced block portion 29 whereby rotation of the collar to thread it on and off the end 26 of the casting 24 axially advances and retracts the oil tube 33.

Threaded into the end of the cylindrical chamber 25 of the casting 24 adjacent the casing 10 is a pressure air tube 35 which concentrically surrounds the oil tube 33. Adjustably threaded on the inner end of the air tube 35 is a nozzle 36 having a reduced central discharge orifice 37 and a convergent frusto conical portion 38 leading to the discharge orifice.

The forward portion 39 of the oil tube 33 is centered in the nozzle 36 by means of a spider 40 shown particularly in FIGURE 5, and as shown particularly in FIGURE 6, the oil tube portion 39 has a convergent tip 41. As seen in FIGURE 6, the tip of the oil tube 41 has a plurality of holes 42 formed in the wall thereof to extend angularly inwardly therethrough at an acute angle to the axis. The outer ends of these holes 42 preferably form fluted recesses 43 in the outer periphery of the tube, and the holes extend inwardly to cut into and form fluted recesses 44 on the inner side of the tube. By this arrangement, air directed inwardly through the holes 42 will flow into the tube portion 41 with the least amount of obstruction.

Threaded into the bore 31 of the block 30 at the end thereof opposite to the oil tube 33 is a valve body 45 having a cylindrical chamber 46 leading to a cylindrical passage 47 through a valve seat 48, the chamber, passage and valve seat all being coaxial with the oil tube 33 and block bore 31. Leading into the chamber 46 is an oil inlet passage 49 and closing the outer end of the chamber is a sleeve nut 50 through which extends a valve spindle 51.

The spindle 51 is threaded in the sleeve nut 50 and is actuated by a wheel 52 for axial displacement on threading in the sleeve nut 50. The intermediate portion of the spindle 51 is formed with a conical portion 53 adapted to move into and out of cooperative relation with the valve seat 48 to open and close the valve. Forwardly of the intermediate portion 53 is a stem portion 54 which operates in the passage 47 of the valve body 45. The valve stem 54 has a V-notch 55 cut therein, the notch having its apex at the surface of the stem near the conical portion 53 which cooperates with the valve seat 48. With this arrangement, a large movement of the wheel 52 is translated into a small increment of oil feed.

The outer end of the spindle 51 extends through the usual packing gland 56 and is preferably enclosed by a cap 57.

Mounted in the frusto conical casting 21 is a suitable pilot 58 and a safety device 59 which may take the form of a sulfide cell, which is arranged to scan the interior of the casting 21 and flange 5 so that it will be protected from the misleading effects of glowing firebrick or other surfaces.

In operation, oil under pressure is supplied through the oil inlet 49 and compressed air comprising the primary air feed is delivered into the chamber 25 through a suitable connection 60. The main source of air, however, is delivered into the casing 10 from a fan or blower, not shown, through a suitable conduit or pipe 61 connected to the vertical portion 12 of the casing. The air which is delivered into the casing portion 12 normally constitutes approximately 95 percent of the total air by volume consumed in the atomizing and combustion, and this air is delivered at a relatively low pressure supplied

at pressures of approximately 2 to 32 ounces within the casing portion 11.

The pressure of the compressed air delivered through the connection 60 into the chamber 25 and through the air tube 35 may vary, but this pressure must be greater than the oil delivery tube 33, so that the air will enter the fluted holes 42 in the tip of the oil tube and act in the first stage of atomization to break up the moving oil stream within the tube while the oil is constrained by the tube to stream flow. As the plurality of small streams of air are projected angularly inwardly into the bore of the oil tube 33 uniformly therearound, they break up the body of the oil stream in the oil tube, thus applying a higher pressure to the oil as it is emitted from the tip 41. This mixed stream of air and oil has a tendency to expand on being released from the constraint of the tube to maintain it in stream flow, and as it expands, it is further broken up by the flow of pressure air through the annular passage defined between the tip of the oil tube 41 and the nozzle 36 of the air tube 35. Thus the air and oil stream both expands and is further broken up as it leaves the tip 41 of the oil tube, and the oil is broken up into extremely fine particles of globules as it moves through the discharge orifice 37 of the nozzle.

As the particles issue from the nozzle discharge orifice 37 they emerge into a relatively low pressure area defined between the nozzle 36 and the nose cap 16 of the casing 10, and a further expansion takes place to assist in breaking up the oil stream into the fine individual particles. The relatively low pressure but high volume of air flow through the casing portion 11, while allowing the rapid expansion of the oil stream, provides sufficient air to ensure that the high velocity oil particles ejected from the nozzle 36 acquire air envelopes to support them as aerosols as they move through the discharge orifice 37 into the flame zone. Thus the low pressure air feed through the casing 10 serves a dual function in first supplying sufficient air to enable the finely divided oil particles to isolate themselves from each other through the acquiring of air envelopes, and secondly, supplying sufficient air to support complete combustion in the fire zone.

It will be appreciated that the compressed air, which is utilized in the first and second stages of atomization which occur respectively within the tip of the oil tube 41, and as the oil is discharged from the oil tube through the nozzle discharge 37, is supplied through the single pressure air tube 35. The relative volume of air used in the first and second stages of atomization is adjusted by moving the tip 41 of the oil tube towards and from the discharge orifice 37 in the nozzle 36 by means of the collar 27.

The control of the atomization in the third stage, which occurs as the low pressure air stream strikes the expanding oil stream as it issues from the nozzle orifices 37 and through the discharge orifice 18 in the nose cap, is regulated in addition to the control of the air supply to the casing 10 by adjusting the relative relation or spacing of the orifices 37 and 18. This adjustment is effected by threading the nose cap 16 on and off the casing cylinder portion 11.

In addition, the entire assembly, supported from the furnace mounting ring 1, can be adjusted towards and from the ring on the guides 9 to control the flame. By virtue of these controls, the required flame can be obtained with the unit irrespective of whether the flame is being subjected to a back pressure or draft from the furnace or combustion chamber, the flame being inspected through the access door 62.

Thus, for example, by withdrawing the oil tube tip 41 from the discharge orifice 37 in the air tube nozzle 36, more compressed air will pass between the outside of the oil tube tip 41 and the air nozzle which will cause the fire to burn with excess air. This, in turn, causes the

flame to shorten in overall length, and the point of ignition to move further from the nozzle 36.

On the other hand, by adjusting the oil tube so that its tip 41 projects into the discharge orifice 37 in the air tube nozzle 36, a greater amount of air will be directed into the oil tube, increasing the volume of oil and its velocity projected from the oil tube, and cutting down the air, causing the fire to ignite and burn closer to the nozzle 36 and extending the length of the fire or flame path and giving a reducing type of fire.

The volume and pressure of the fan or low pressure air passed through the casing 10 and orifice 18 also changes the character of the combustion. In the event that firing is occurring against a heavy back pressure, the nose cap 16 is adjusted to advance the orifice 18 therethrough a further distance ahead of the discharge orifice 37 of the air tube nozzle to allow maximum air pressure and volume to overcome the back pressure in the furnace. At the same time, the frusto conical casting 21 is withdrawn out of the ring 5 to further counteract the back pressure.

In the event that the fire is operating under heavy draft or suction from the furnace, then the adjustments would be reversed. An oil burner such as described has been found to operate satisfactorily on all types of fuel oil, giving essentially complete combustion regardless of the type of oil employed. The burner also lends itself to purging in the event that Bunker C oil is used, as pressure air can readily be emitted into the cylindrical chamber 46 of the valve body 45 in advance of the valve seat 48 to purge the valve and oil tube, and suitable controls can be provided to ensure that the Bunker C oil is not delivered into the valve body until it has been heated to a point where its viscosity is satisfactory for delivery through the oil tube.

While atomization has been described as effected with pressure air, it will be understood that such atomization can be similarly effected by the use of steam, and it is intended that the term "air" include both dry air and air containing water vapour or steam.

It will be also understood that the high degree of atomization in the three stages accomplished by the device described may also be advantageously employed in fields other than the atomization of oil for combustion.

It will be understood that various modifications in the details of the device may be made without departing from the spirit of the invention.

What I claim is:

1. A method of atomizing a liquid comprising first constraining liquid to be atomized to flow in column form, and, simultaneously, providing pressure air and constraining same to surround and impinge upon and enter the liquid while flowing in column form, then expanding the resulting liquid-air mixture into a region at relatively lower pressure and, simultaneously, providing pressure air and constraining same to surround and converge in the direction of flow of, and impinge upon, the first expanded liquid-air mixture, then expanding the resulting liquid-air mixture into a region at relatively lower pressure and, simultaneously, providing pressure air and constraining same to surround and converge in the direction of flow of, and impinge upon, the second expanded liquid-air mixture and then expanding the resulting liquid-air mixture into a region at relatively lower pressure.

2. A method of atomizing a liquid comprising first constraining liquid to be atomized to flow in column form, and, simultaneously, providing pressure air at a pressure greater than the pressure of the liquid and constraining same to flow annularly of and in the direction of liquid flow and directing the pressure air to impinge upon and enter liquid while flowing in column form and then expanding the resulting liquid-air mixture into a region at relatively lower pressure and, simultaneously, providing pressure air at a pressure of the order of the first-mentioned pressure air, and constraining same to flow an-

nularly convergently of, and in the direction of, the flow of the first expanded liquid-air mixture and impinge upon the first expanded liquid-air mixture, then expanding the resulting liquid-air mixture into a region at relatively lower pressure and, simultaneously, providing pressure air at lower pressure and greater volume relative to said first- and second-mentioned pressure air and constraining same to flow annularly convergently of, and in the direction of, the flow of the second expanded liquid-air mixture and impinge upon the second expanded liquid-air mixture and then expanding the resulting liquid-air mixture into a region at relatively lower pressure.

3. A method according to claim 2 wherein the pressure air directed into the liquid constrained to flow in column form is provided in the form of a plurality of streams uniformly circumferentially spaced around the periphery of the liquid flowing in column form, with the streams forming acute angles with the direction of liquid flow and entering the liquid substantially immediately prior to the first expansion of the liquid-air mixture.

4. A method according to claim 3 wherein the pressure air injected into the liquid constrained to flow in column form and the pressure air constrained to flow annularly convergently of and in the direction of flow and impinge upon the first expanded liquid-air mixture emanates from the same source of pressure air, which pressure air is maintained at higher pressure and lesser volume respectively, relative to the source of the pressure air which is constrained to flow annularly convergently in the direction of flow and impinge upon the second expanded liquid-air mixture.

5. A method according to claim 4 wherein the pressure air directed into the liquid, the pressure air impinged upon the first expanded liquid-air mixture and the pressure air impinged upon the second expanded liquid-air mixture is controlled to vary the characteristics of the atomization of the liquid.

6. A method of atomizing liquid fuel for combustion comprising constraining liquid fuel to be atomized to flow in column form and while the liquid fuel is so constrained, simultaneously providing pressure air at a pressure greater than the liquid fuel pressure, and constraining the pressure air to flow annularly of, and in the direction of, the flow of the liquid fuel and injecting the pressure air in the form of a plurality of streams into the liquid fuel at acute angles thereto, then substantially immediately following the injection of the pressure air expanding the resulting liquid fuel and air mixture into a region at relatively lower pressure, and, simultaneously, providing pressure air at a pressure of the order of the pressure of the first-mentioned pressure air and constraining same to flow annularly convergently of and in the direction of the flow of the first expanded liquid fuel and air mixture and impinge upon same, then expanding the resulting liquid fuel and air mixture into a region at relatively lower pressure and, simultaneously, providing pressure air at lower pressure and greater volume relative to the first- and second-mentioned pressure and constraining same to flow annularly convergently of and in the direction of the flow of the second expanded liquid fuel and air mixture and impinge upon same, then expanding the resulting liquid fuel and air mixture into a region at relatively lower pressure, and igniting the resulting liquid fuel and air mixture.

7. A method according to claim 6 wherein the pressure air injected into the liquid fuel constrained to flow in column form and the pressure air constrained to flow annularly convergently in the direction of flow and impinge upon the first expanded liquid fuel and air mixture emanates from the same source of pressure air, which pressure air is maintained at a higher pressure and lesser volume respectively, relative to the source of the pressure air which is constrained to flow annularly convergently in the direction of flow and impinge upon the second expanded liquid fuel and air mixture.

8. A method according to claim 7 wherein the pressure air directed into the liquid fuel, the pressure air impinged upon the first expanded liquid fuel and air mixture and the pressure air impinged upon the second expanded liquid fuel and air mixture is controlled to vary the characteristics of the atomization of the liquid fuel and accordingly vary the characteristics of the combustion of the fuel.

9. In atomizing apparatus, a first conduit adapted to be connected rearwardly to a source of liquid under pressure to be atomized and having an orifice at its forward end, the forward tip portion of the first conduit having a plurality of circumferentially spaced passages there-through communicating with the bore thereof, a second conduit surrounding said first conduit and spaced therefrom to define an annular flow passage therebetween, the second conduit being adapted to be connected rearwardly to a source of pressure air having a pressure greater than the pressure of the liquid adapted to be supplied to the first conduit, and having a nozzle formation at its forward end, the second conduit having an extent in relation to the first conduit to provide communication between the passages in the forward tip portion of the first conduit and the pressure air adapted to be supplied to the second conduit, the nozzle formation having a forwardly convergent annular wall formation defining a central orifice arranged in co-axial relation with the orifice of said first conduit and spaced forwardly thereof, the nozzle formation defining with the tip portion of the first conduit a convergent annular flow passage formation having an extent and configuration arranged to direct pressure air in convergent annular flow and impinge upon a liquid and air mixture adapted to be expanded through the orifice of the first conduit in its passage therefrom to the orifice of said nozzle formation, and a third conduit surrounding said second conduit and spaced therefrom to define an annular flow passage therebetween, the third conduit being adapted to be connected rearwardly to a source of pressure air at relatively lower pressure and greater volume, respectively, than the pressure air adapted to be connected to the second conduit, the third conduit having a nozzle formation at its forward end, the nozzle formation having a forwardly convergent annular wall formation defining a central orifice in coaxial relation with said first- and second-mentioned orifices and spaced forwardly thereof, the nozzle formation of the third conduit defining with the nozzle formation of the second conduit a convergent annular flow passage formation having an extent and configuration arranged to direct the pressure air adapted to be connected to the third conduit in convergent annular flow and impinge upon the resulting liquid and air mixture adapted to be expanded through the orifice of the nozzle formation of the second conduit in its passage therefrom to the orifice of the nozzle formation of the third conduit.

10. Apparatus according to claim 9 wherein the outer wall of the tip portion of the first conduit has a uniform taper convergent uniformly forwardly toward the orifice thereof and said circumferentially spaced passages are provided with axially extending flutings rearwardly of the intersection of the passages with the outer tapered surface

of the tip portion and forwardly of the intersection of the passages with the surface of the bore of the conduit.

11. Apparatus according to claim 9 wherein said first conduit and second conduit comprise straight tubular members with their axes arranged in substantially co-axial relation and means are provided to displace said first conduit axially of said second conduit to vary the thickness of the first annular convergent flow passage and to thereby alter the pressure and volume of the pressure air which is adapted to be injected into the liquid and the pressure air adapted to be impinged upon the liquid-air mixture expanding from the orifice of the first conduit.

12. Apparatus according to claim 9 wherein the second conduit and third conduit have a straight tubular configuration at their forward ends and have their axes arranged in substantially co-axial relation, and means are provided for adjustably mounting the nozzle formation of said third conduit for axial displacement therealong to vary the thickness of the second annular convergent flow passage, and to thereby alter the pressure and volume of the pressure air which is adapted to be impinged upon the liquid-air mixture expanding from the orifice of the nozzle formation of the second conduit.

13. Apparatus according to claim 9 wherein said first, second, and third conduits have a straight tubular configuration with their axes arranged in substantially co-axial relation and in which said second conduit is fixed, and means are provided to displace said first conduit axially of said second conduit to vary the thickness of the convergent annular flow passage therebetween, and means are provided for adjustably mounting the nozzle formation of said third conduit, for axial displacement therealong, independently of the axial displacement of said first conduit, to vary the thickness of the convergent annular flow passage between the nozzle formations of the second and third conduits.

References Cited in the file of this patent

UNITED STATES PATENTS

1,100,141	McConnell	June 16, 1914
1,422,907	Wilkinson	July 18, 1922
1,446,514	Norris	Feb. 27, 1923
1,451,063	Anthony	Apr. 10, 1923
1,481,419	Davies	Jan. 22, 1924
1,746,180	Ainscow	Feb. 4, 1930
1,808,952	Gulick	June 9, 1931
1,844,315	Forney	Feb. 9, 1932
2,157,265	Pothier	May 9, 1939
2,530,269	Smith	Nov. 14, 1950
2,601,540	Marcus et al.	June 24, 1952

FOREIGN PATENTS

860,667	France	Jan. 21, 1941
907,204	France	Mar. 6, 1946
78,396	Holland	July 15, 1955

OTHER REFERENCES

Industrial Furnaces, volume 11, W. Trinks, copyright 1942, John Wiley and Sons, Inc., New York.