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PRESSURE TYPE BURNER AND METHOD OF BURNING FUEL

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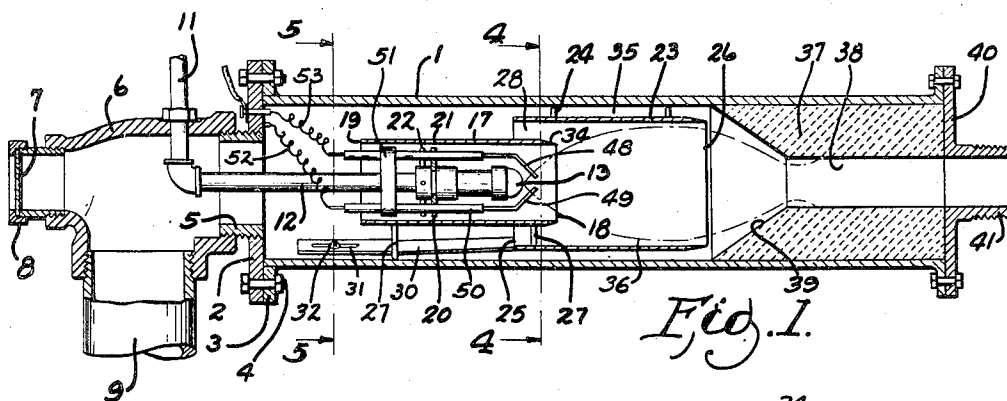


Fig. 1.

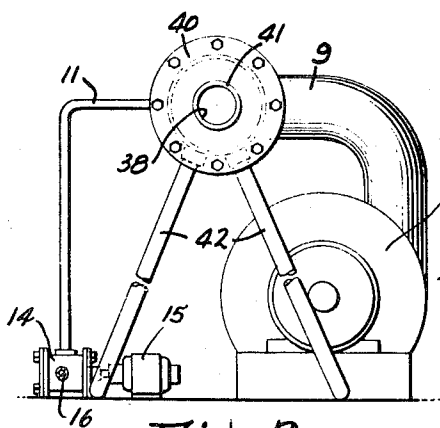


Fig. 2.

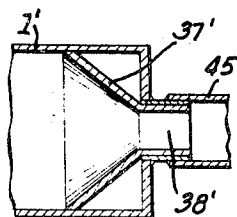


Fig. 3.

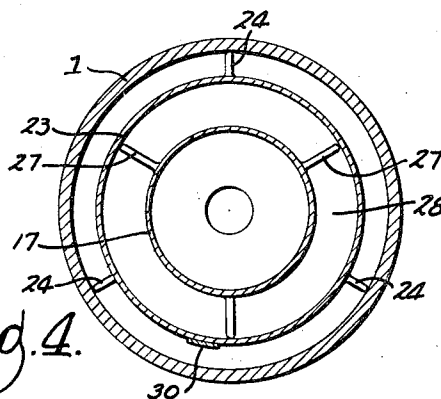


Fig. 4.

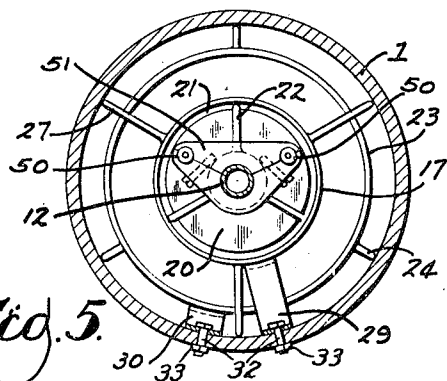


Fig. 5.

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PRESSURE-TYPE BURNER AND METHOD
OF BURNING FUEL

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9 Claims. (Cl. 158-4)

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This invention relates to improvements in a pressure-type burner and method of burning fuel.

It is a primary object of the invention to provide an oil burner capable of delivering flame and products of combustion through the elongated fire tube of a boiler of high rating, the construction of the burner being such as to use effectively the heat of a relatively slight preliminary combustion of the fuel to support continued combustion during an abrupt and complete admixture of fuel and air with a flame propagation rate which will exceed even the high velocities of delivery of products of combustion through a fire tube, the burning fuel and most of the requisite air being delivered under pressure separately to the immediate vicinity where mixing is to occur and being abruptly discharged through the mixing orifice as soon as the flame propagation rate approximates the velocity of travel through the orifice and before sufficient expansion has occurred to increase unnecessarily the pressure required to effect discharge through such orifice. I have found that the proportions and dimensions of the apparatus are somewhat critical if substantially complete combustion is to be achieved and carbon deposits or the pulling off of the flame are to be avoided.

More specifically, it is my purpose to provide a particular arrangement and proportioning of burner parts which include a fuel nozzle in predetermined relation to a restricted orifice through which the products of combustion must pass, the nozzle being surrounded by air passages of predetermined capacity and predetermined relation to the nozzle and to the orifice.

Further objects of the invention are to provide a burner in which air pressures ranging upwards from .2 of a pound per square inch may be used effectively to achieve increased velocity of flow with such turbulence as to assure adequate mixing for accelerating combustion, the entire system preferably being hermetically sealed from the source of air and fuel pressure to the point of flue gas delivery, and the whole arrangement being such as to enable the use of much higher air pressures than are conventionally employed.

The present application is a continuation in part of my application entitled "Pressure system oil burner," Serial No. 543,878, filed July 7, 1944, and now abandoned. This is also a companion to my application entitled "High rating fire tube boilers and methods of boiler operation," Serial No. 619,671, filed October 1, 1945.

In the annexed drawings:

Fig. 1 is a view in horizontal section showing one embodiment of my burner.

Fig. 2 is a view in end elevation of the burner shown in Fig. 1 when mounted for use as a torch.

Fig. 3 is a fragmentary detail view similar to Fig. 1 showing a modified interior construction.

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Fig. 4 is an enlarged detail view taken in cross-section on line 4-4 of Fig. 1.

Fig. 5 is an enlarged detail view taken in cross-section on line 5-5 of Fig. 1.

The modification or form of the invention shown in Fig. 1 comprises a wall forming a burner tube 1 hermetically attached at one end to a radial wall 2. The attachment of the burner tube 1 to the wall 2 may be effected and maintained in different ways, as by a radial flange 3 integral with the end of the tube 1, and detachable bolts 4 securing the flange 3 to the wall 2.

A nipple 5 is hermetically secured to and opens through the wall 2 coaxially with the tube 1. A T-fitting 6 has detachable threaded leak-proof connection with the nipple 5 and is thereby supported close to the wall plate 2 and to the end of the tube 1. A transparent window 7 of glass or other suitable transparent material is hermetically attached to the outer end of the T-fitting 6 by a frame 8, and constitutes means through which the interior of the burner tube 1, the parts contained therein, and the flame of ignition therein may be visually observed. Into one side of the T-fitting 6 an air inlet tube 9 opens for conducting air under pressure into the burner tube 1 through said fitting. Air is impelled and caused to flow through the tube 1 by an appropriate pressure fan 10 connected with the tube 9, as shown generally in Fig. 2, or by a compressor or other air impeller, as desired. The tube 9 may be flexible and of any length, so that the pressure fan or other air impeller may be located at any desired distance from the burner. Air pressure should be at least $2/10$ lb. per square inch.

A fuel supply pipe 11 extends through the wall of the fitting 6 and is connected by an angular extension 12 with a fuel nozzle 13 located coaxially within the burner tube 1 intermediate of and spaced substantial distances from its ends. Oil or other fuel, such as gas, is forced through pipe 11-12 by pressure and through nozzle 13 from a pump 14 operated by an electric motor 15, or otherwise; the particular form of nozzle and size of pipe depending on the fuel used. Fuel is delivered to and received by the pump 14 through a pipe 16 leading from a source of supply. For liquid fuel, any suitable type of pressure atomizing nozzle may be used.

The nozzle 13 is mounted coaxially within an inner sleeve 17 closer to the open effluent end 18 than to the opposite open air inlet end 19 of said sleeve. A disc 20 is attached to and supported by the oil supply pipe extension 12 within the sleeve 17 between the nozzle 13 and the open air inlet end 19 of said sleeve. The peripheral edge of said disc 20 is separated from the sleeve 17 by an intervening annular space 21 constituting a passage for the air through said sleeve to the

nozzle 13. This disc functions to slow down and reduce the velocity of the air flow or current through the inner sleeve 17 for the purpose of stabilizing ignition, and, in conjunction with the sleeve 17, develops an enveloping flow of air around the nozzle and around the flame, which enveloping flow of air prevents overheating of the flame with and also prevents overheating of the effluent end of said sleeve 17. The fuel supply pipe extension 12 and the sleeve 17 are held in coaxial relationship by spacers 22 connected with said extension 12 and extending radially therefrom into engagement with the inner periphery of said sleeve 17.

An intermediate sleeve 23 is supported coaxially within the burner tube 1 by radial spacers 24 attached to and projecting from said sleeve 23 to engagement with the inner periphery of said tube 1. The effluent end portion 18 of the inner sleeve 17 extends concentrically into the inlet end 25 of the intermediate sleeve 23 terminating relatively a considerable distance from the effluent end 26 of said intermediate sleeve 23. Radial spacers 27 attached to and projecting from the effluent end portion 18 of the inner sleeve 17 and engaging the inner periphery of the intermediate sleeve 23, hold said sleeves in coaxial relationship, providing an annular air passage 28 between said sleeves. This annular air passage 28 develops another enveloping flow of air, which air envelope is maintained surrounding the flame to the end of the intermediate sleeve 23, preventing overheating of said sleeve 23 and preventing the flame from contacting therewith.

Brackets 29 and 30 are welded or otherwise attached to the inner and intermediate sleeves 17 and 23, respectively, and are provided with slots 31 for anchor clamping bolts 32. The bolts 32 extend through the respective slots 31 and through holes tapped through the wall of the burner tube 1. Nuts 33 screwed on the bolts 32 are adjustable to clamp and secure the brackets 29 and 30 in rigid relationship with each other, thereby holding the sleeves 17 and 23 rigidly in selected relative adjustments in the burner tube 1. It is evident that, when the appropriate clamping device 32-33 is loosened, the corresponding sleeve 17 or 23 may be moved longitudinally to a selected or needed adjusted position relative to the other and to the nozzle 13, after which said clamping device 32-33 may be tightened to hold its connected sleeve rigidly in its new adjustment. The peripheral walls of the effluent end portions of the sleeves 17 and 23 are preferably beveled or inclined, as indicated at 34 (Fig. 1). This permits the impelled currents or flow of air through the annular passages 28 and 35 to converge axially and contact with the outer portions of the flame of combustion which is indicated diagrammatically by oval outline 36 in Fig. 1. The annular passage 35 develops another enveloping flow of air, which envelope is maintained around the flame until the flame has entered the restricted passage, as further indicated by outline 36.

The sleeves 17 and 23 thus function and are instrumental in maintaining an enveloping flow of air around the flame from the point of ignition until after the flame has entered the restricted passage. This flowing air envelope, besides protecting the burner parts from overheating, prevents carbon deposits in the burner by preventing direct contact of the flame with the burner surfaces; and the general coaxial direc-

tion of air and flame flow in the burner develops a smooth flowing flame free of eddy currents, which currents cause carbon deposits.

A heat resisting reducer device 37 is secured within the burner tube 1 beyond the effluent end 26 of the intermediate sleeve 23. The reducer device 37 has a restricted passage 38 there-through coaxial with the burner tube 1 and in axial alignment with the sleeves 23 and 17 and with the nozzle 13. The inner end of the reducer device 37 is formed with a funnel wall 39 which is shown flaring from the end of the restricted passage 38 to intersection with the surface of the tube 1. The angle of inclination of the wall 39 is preferably 35° to 40° from the longitudinal axis of the burner tube 1 and of the reducer device 37. The reducer device either may be composed of or lined with refractory or other heat resisting material as desired. However, if the burner is submerged, this reducer device may be of common cast iron or steel because the heat is transferred so rapidly. The reducer device may also be made of high heat resistant alloy regardless of immersion, as shown at 37' in Fig. 3, the funnel 37' being welded into the burner tube 1' near the end thereof and the end wall of the burner tube 1' having a sleeve to which the fire tube 45 is welded.

Regardless of the material of which it is constructed, this funnel-shaped reducer device causes symmetrical reduction of the cross-sectional area of the air and burning gas shown at 36. Forcing the gases into the orifice or passage 38 abruptly increases the velocity of flow, breaks up the stratification theretofore desired, and, at this early stage of development of the combustion flame, it creates great turbulence, thereby effecting thorough mixture of the air impelled from the passages 28 and 35 into the flame and in contact with the fuel. This accelerates completion of combustion and effects more complete combustion in less space, thus increasing efficiency and requiring less materials for boiler and burner construction. The ratio of the cross-sectional area of the burner tube 1 to the cross-sectional area of the restricted passage 38 is preferably 10-15 to 1. The fire tube passage may be continuously straight throughout or continuously curved, or may be straight for a distance and then curved or coiled, or of other form as desired.

Additional figures giving desired proportions of the parts will now be furnished for oil burners embodying the invention and the reasons therefor will be stated.

The internal cross-sectional area of the burner tube 1 can handle the requisite air if it has an approximate size amounting to six or seven square inches per gallon of oil burned per hour (similar dimensions would apply to like B. t. u. value of gas). As above noted, it is important that the cross-section of the throat 38 be within a range of approximately $\frac{1}{16}$ to approximately $\frac{1}{15}$ of the cross-sectional area of the burner tube 1. The length of the throat passage 38 should preferably be at least one to one and one-half times its diameter. It may be greatly elongated but preferably should not be shorter.

In the device illustrated, the disk 20 has a clearance ranging from $\frac{1}{16}$ inch to $\frac{1}{8}$ inch between its periphery and the inner surface of the inner sleeve 17. If the clearance is too great the air velocity will be such as to tend to pull off the flame. If the clearance is too small, the resulting deficiency of air will cause a carbon deposit inside the sleeve 17.

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The nozzle tip 13 should be set inside the effluent margin 18 of sleeve 17 for a distance equal approximately to $\frac{1}{2}$ of the I. D. of sleeve 17. If this distance is too short, the flame tends to pull off; if too long, carbon is deposited inside the sleeve.

The distance from the nozzle tip 13 to the inlet of constrictor 37 should be approximately $1\frac{1}{2}$ to $1\frac{3}{4}$ times the diameter of the tube 1. This distance allows just enough development of the flame to permit it to take the required high velocity of flow through the requisite throat 38. The amount of combustion achieved before the flame enters the throat 38 should be carefully controlled. If the distance between the nozzle and the constricting orifice is appreciably increased over that shown, the increased combustion and resulting expansion will greatly increase the air pressure required to force the gases through the orifice. With about twice as much clearance, twice the pressure and consequently twice the power has been required.

Likewise the distance between the tapered end of the intermediate sleeve 23 and the cone-shaped face 39 of the restrictor 37 or 37' should be carefully determined. I have found that such distance, along a line projected axially directly from the terminal margin of sleeve 23 to the point where such projected line contacts the conical surface 39, the distance should be equal to $1\frac{1}{2}$ to 2 times the clearance between sleeve 23 and burner tube 1 as measured radially. That is, the air flow around sleeve 23 should not be throttled around this point but the sleeve should be as close to the conical surface as is reasonably possible without throttling air flow outside of the sleeve. If the air flow outside of the sleeve were throttled, there would not be adequate flow to provide the requisite envelope around the flame at the point where the flame enters the conical restricting surface 39. On the other hand, if the sleeve is spaced too far from the conical restricting surface, the surrounding air mixes prematurely with the flame, prematurely breaking up the air envelope. In either case, the constrictor 37 or 37' will be heated excessively.

The preferred distribution of air flow through the burner is as follows:

The air flow around disk 20 through the inner tube 17 is preferably from 1% to 3% of the total air flow. The air flow between the inner sleeve 17 and the intermediate sleeve 23 preferably ranges from 64% to 72% of the total air flow. The air flow between the intermediate sleeve 23 and the burner tube 1 is preferably 26% to 34% of total air flow. It will be observed that the fuel supplied through nozzle 13 is initially mixed with relatively slow moving primary air in quantities just sufficient to support combustion. The burning mixture is then enveloped in a relatively large volume of air moved in an annular stream at substantially the same rate of flow through the intermediate sleeve 23. Undue agitation of the burning over-rich mixture is avoided, the air and burning fuel being deliberately stratified at this point.

As the flame expands it is enveloped in another annular stream of air moving at like speed outside of sleeve 23 which shields the tapering surface 39 from the full heat of the flame and so smoothly envelops the burning gases that there still is no complete mixture until the burning gases and the annular strata of air encounter the tapering surface 39 at the entrance to the restricted passage 38. At this point sudden ac-

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celeration and resulting turbulence are such that a very thorough mixing is effected abruptly and completed almost immediately. Flame propagation thenceforth is extremely rapid. Rapid as is the flame propagation, the movement of the gases is almost equally rapid due to the specified dimension of orifice 38, the major part of the combustion of the mixture being preferably completed after the flame enters into the restricted passage 38 or 38'. Preferably only 1% or 2% of the fuel supplied through the nozzle has been burned up to the time when the ignited mixture enters passage 38 or 38'. The completion of combustion is effected in what is estimated to be $\frac{1}{50}$ or less of the space and time customarily required. Any excess combustion occurring before the gases enter the passage 38 will greatly increase the power required by increasing the back pressure.

Specific dimensions of an acceptable oil burner embodying the invention are as follows:

The diameter of the disk 20 as used in this particular burner was $3\frac{3}{8}$ inches. The inside diameter of the sleeve 17 was $3\frac{5}{8}$ inches and its external diameter $3\frac{3}{4}$ inches. The nozzle 13 was set back $1\frac{1}{2}$ inches from the effluent end of the sleeve 17 and was $12\frac{1}{2}$ inches from the entrance to the restricted passage 38.

The internal diameter of the intermediate sleeve 23 was $6\frac{3}{4}$ inches and its external diameter 7 inches. The axial dimension between the effluent end 34 of the intermediate tube 23 and the tapering surface 39 was 1 inch. The internal diameter of the burner tube 1 was 8 inches. The internal diameter of the passage 38 was $2\frac{3}{8}$ inches and its length $3\frac{1}{2}$ inches. Using the relative proportions previously given, it is easily possible to provide correct proportions, dimensions and locations of corresponding parts for any desired fuel capacity.

For directing and controlling the flame or gases emanating from the restricted passageway 38, a wall plate 40 equipped with a nipple 41 opening from the passageway 38, may be attached to the end of the burner tube 1. The nipple 41 may form a passage into a hermetically connected fire tube or other heat conduit. When used as a torch, the entire burner may be equipped with and mounted on supporting legs 42, thus adding to portability and versatility of use.

The burners can be operated by manual control with familiar swab ignition; or by electric spark ignition, and by complete automatic controls now in common use; or by partial manual and partial automatic means. For electrical ignition electrodes 48 and 49, shown in Fig. 1, extend from insulators 50 mounted in a holder 51 secured to the oil pipe extension 12 within the sleeve 17. The electrodes 48 and 49 are supplied with current by conductors 52 and 53.

From the foregoing, it should be apparent that my invention attains all of its intended objects and purposes with a high degree of efficiency and economy, and that only minor changes are required to adapt the invention to varied uses. I contemplate such other changes and modifications as may be required or needed from time to time.

I claim:

1. In a burner of the character described, the combination with a generally cylindrical combustion chamber with a restricted outlet orifice at one end and a fuel nozzle remote from the orifice and directed toward the orifice, means for delivering fuel under pressure through said nozzle

zle and means for delivering into said chamber under substantial pressure air adequate for complete combustion of such fuel, of annular means for guiding axially about such nozzle a primary increment of such air said means having sufficient capacity to support stable combustion but inadequate to support complete combustion of fuel issuing from said nozzle, an igniter adjacent the nozzle in the path of the fuel and said primary air, sleeve means for guiding axially beyond the nozzle a major portion of the total air in a plurality of annular strata about the ignited fuel and primary air during continued advance of all of such air and the ignited fuel, the fuel and all of such air being abruptly discharged through said restricted orifice prior to substantial combustion and expansion of said fuel, whereby turbulently to complete at said orifice for the first time the mixture of the stratified air with the burning fuel and constrict the air and fuel before major expansion occurs.

2. A burner of the character described which comprises, in combination, a burner tube, an atomizing nozzle therein, ignition means adjacent the nozzle, a set of sleeves in said tube of progressively increasing cross-section about the nozzle and having delivery ends successively advanced with respect to the nozzle, means for delivering air under pressure into said tube behind the nozzle for flow about the nozzle and said sleeves, means for restricting the amount of air passing immediately about the nozzle to that required to support stable combustion, the total volume of air delivered being appropriate for complete combustion and the air delivered across the successive delivery ends of such sleeves progressively approaching such volume, said air being maintained stratified and substantially unmixed with the burning fuel until all of such air has passed the delivery ends of the last of said sleeves, means at the end of said tube providing a discharge orifice of a size between $\frac{1}{10}$ and $\frac{1}{15}$ of the cross-section of said tube, and flame directing means leading to said orifice and disposed immediately adjacent the delivery end of the largest of said sleeves for abruptly constricting and guiding the flow of air and burning fuel to said orifice, whereby the resulting abrupt acceleration of the velocity of fuel and air prior to appreciable expansion produces suddenly a complete mixture of the air and fuel for rapid completion of combustion.

3. A pressure system liquid fuel burner comprising a burner tube provided with a pressure air supply connection at one end and with a restricted outlet passage having a funnel-shaped inner end within said tube at its other end, intermediate and inner sleeves supported within said tube in substantial axial alignment with said outlet passage and cooperating to provide annular passages for impelled air, a nozzle mounted in said inner sleeve for jetting toward said outlet passage fuel delivered to the nozzle under pressure, and devices connecting said respective sleeves with said tube for holding said sleeves, the intermediate sleeve projecting materially beyond said inner sleeve and into close proximity to said funnel-shaped inner end of the outlet passage, whereby burning fuel leaving the intermediate sleeve is confined and accelerated and turbulently mixed with air immediately upon being enveloped by air delivered annularly thereto about said intermediate sleeve, the distance between the funnel-shaped inner end of the outlet passage and the adjacent end of the intermediate sleeve be-

ing equal to approximately one and one-half to two times the radial distance between such intermediate sleeve and said tube.

4. A pressure system liquid fuel burner comprising a burner tube having an inlet at one end and a restricted outlet at the other end, means for discharging liquid fuel in an atomized spray toward said outlet, means for supplying air under pressure to said inlet, means for directing a portion of said air into said atomized spray in a volume to cause partial combustion thereof, and means forming a plurality of annular passages through which additional air passes about the burning fuel in a direction generally toward said outlet and in enveloping relation to said atomized spray, said outlet having a cross-sectional area one-tenth to one-fifteenth that of said tube and the last of said annular passages for additional air terminating in immediate proximity to said outlet whereby the burning gases are confined and accelerated immediately after the envelopment in such additional air for abrupt mixture therewith as the fuel and air enter said outlet.

5. A pressure system fuel burner comprising a burner tube having at its end an outlet passage not exceeding in cross-sectional area approximately ten per cent of the cross-sectional area of the tube and provided with a funnel-shaped influent end, the length of the passage being at least equal to its diameter, means for delivering air at a pressure of at least two tenths of a pound per square inch into said tube at a point remote from said passage, a fuel nozzle disposed centrally within the tube and spaced from said outlet passage for a distance at least approximately equal to $1\frac{1}{2}$ times the diameter of the tube; means for supplying fuel under pressure to said nozzle; an inner sleeve substantially centered within the tube about the nozzle, the nozzle being located near the effluent end of the sleeve; means within said inner sleeve restricting air flow about the nozzle to substantially the amount required to support stable combustion; means for igniting fuel from said nozzle within said inner sleeve; and an intermediate sleeve materially larger than said inner sleeve and offset toward said outlet passage, said inner and intermediate sleeves lapping and said intermediate sleeve terminating close to the funnel-shaped influent end of said outlet passage at an axial distance therefrom approximately one and one-half to two times the radial clearance between said intermediate sleeve and the burner tube; the air flow toward said outlet passage through the burner tube being so divided that approximately one to three per cent of total air flow passes through the inner tube about the nozzle and from sixty-four to seventy-two per cent of total flow passes between the inner sleeve and the intermediate sleeve and approximately twenty-six to thirty-four per cent of total flow passes externally of the intermediate sleeve and between it and the tube, whereby fuel mixed with primary air in the inner tube burns just sufficiently to develop a rate of flame propagation adequate to withstand sudden acceleration at the outlet passage and is successively enveloped by stratified annular increments of added air cumulatively sufficient to support complete combustion but substantially unmixed with the fuel prior to entering said outlet passage, said funnel-shaped influent end and the constriction of said outlet passage abruptly accelerating the flow of fuel and air at said passage immediately following the envelopment of the fuel in the last in-

crement of air thereby producing turbulence and sudden complete admixture and burning.

6. A burner of the character described comprising a burner tube provided with a restricted outlet passage of a cross-sectional area approximately one-tenth to one-fifteenth of that of said tube and having a funnel-shaped opening, an intermediate sleeve within said tube and co-operating with said tube to provide an annular passage for impelled air circumferentially about said sleeve, said intermediate sleeve terminating close to the funnel-shaped opening of the outlet passage, an inner sleeve of less diameter than said intermediate sleeve remote from said outlet passage and extending into the influent end of said intermediate sleeve and cooperating therewith to form an annular passage for impelled air between said sleeves, a fuel nozzle in said inner sleeve adjacent to the end thereof that is within said intermediate sleeve, means for supplying fuel thereto under pressure, means for igniting the fuel near said nozzle, and means for supplying air under a pressure in excess of the approximate value of two-tenths of a pound per square inch to said burner tube for passage through said annular passages.

7. The burner set forth in claim 2 in which the distance between the nozzle and the means providing the discharge orifice is approximately $1\frac{1}{2}$ to $1\frac{3}{4}$ times as great as the diameter of the burner tube.

8. A burner of the character described comprising a burner tube provided with means forming a restricted outlet passage of a cross-sectional area approximately one-tenth to one-fifteenth of that of said tube and having a funnel-shaped inner end within said tube, an intermediate sleeve within said tube and having relatively much greater cross-sectional area than the cross-sectional area of said passage and cooperating with said tube to provide an annular passage for impelled air circumferentially about said sleeve, said intermediate sleeve terminating close to the funnel-shaped inner end of the outlet passage, an inner sleeve of less diameter than said intermediate sleeve remote from said outlet passage and extending into the influent end of said intermediate sleeve and cooperating therewith to form an annular passage for impelled air between said sleeves, means for supplying liquid fuel for combustion through said inner sleeve adjacent to the end thereof that is within said intermediate sleeve, and means for supplying air under a pressure in excess of the approximate value of two-tenths of a pound per square

inch to said burner tube for passage through said annular passages.

9. A method of burning fuel which consists in advancing fuel through a confined space, supplying under pressure the air required for complete combustion of such fuel and advancing such air through the same space substantially completely about the fuel while separating a major portion of such air from the fuel in a stratified surrounding relation and mixing with the fuel only sufficient of such air to support stable combustion, igniting the fuel and continuing its forward movement through said space, surrounding said forward moving stream by forwardly moving the major portion of said stratified air longitudinally, exposing a forwardly moving portion of said latter air to said ignited fuel during said forward movement, and immediately and abruptly withdrawing the burning fuel and the remainder of such air through a relatively small restricted cross-section of such space prior to combustion of more than a few per cent of such fuel at a rate closely approaching the rate of flame propagation, whereby the resulting turbulence produces a completed mixture of the formerly stratified air with the burning fuel for completing the combustion of such fuel in short space and short time notwithstanding its accelerated velocity.

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