Nov. 26, 1935. A. MACCHI 2,022,512

COMBUSTION METHOD AND APPARATUS

Filed Dec. 31, 1930

Fig. 1.

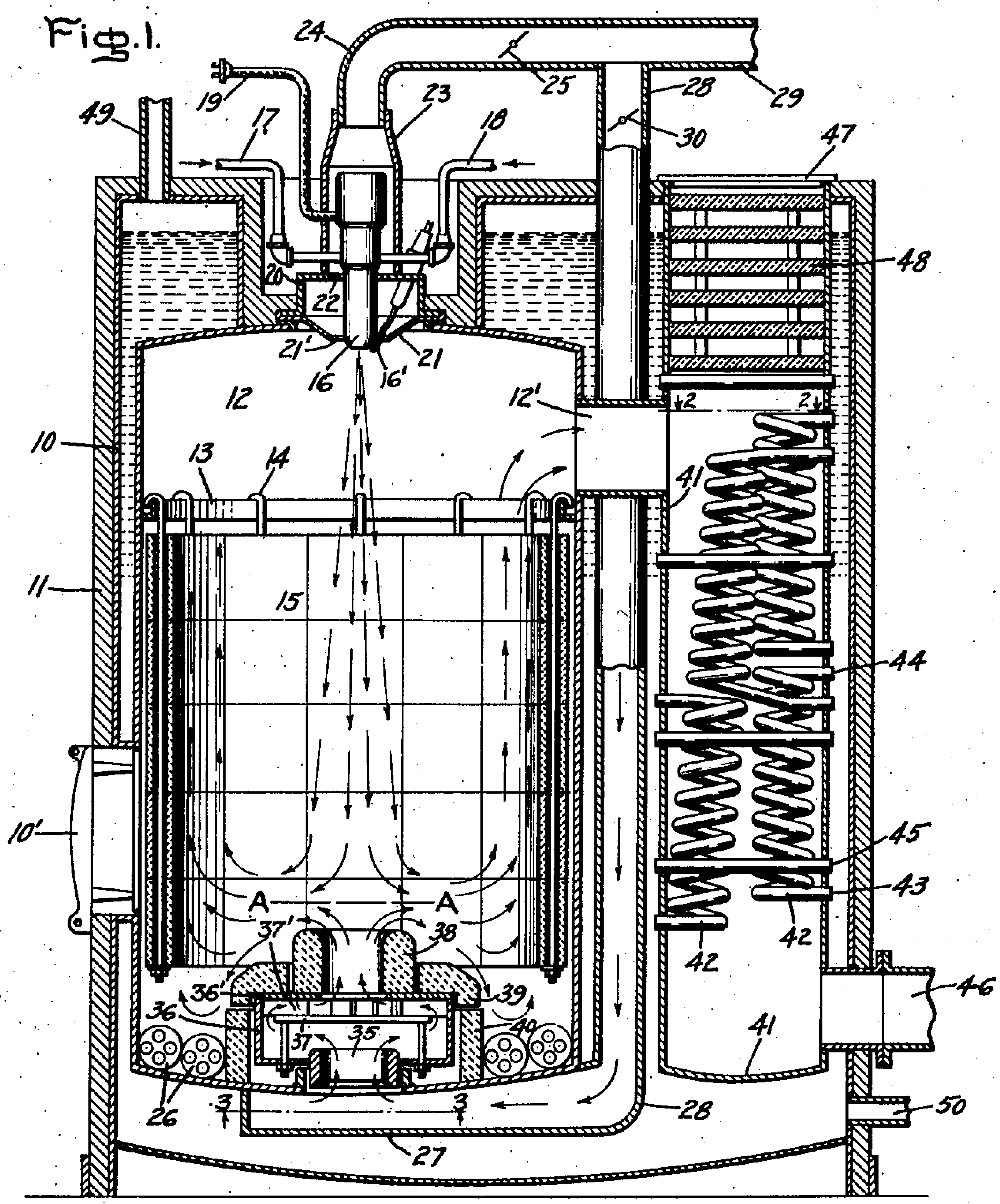


Fig. 2.

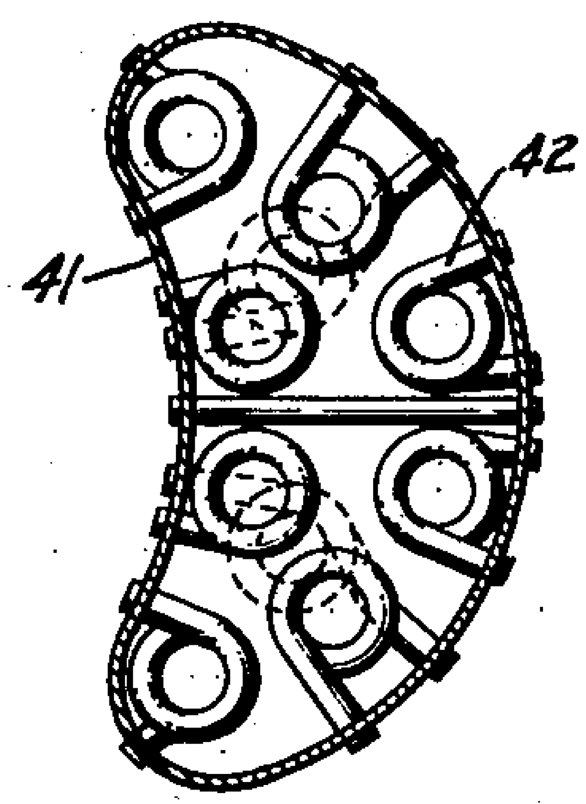


Fig. 3.

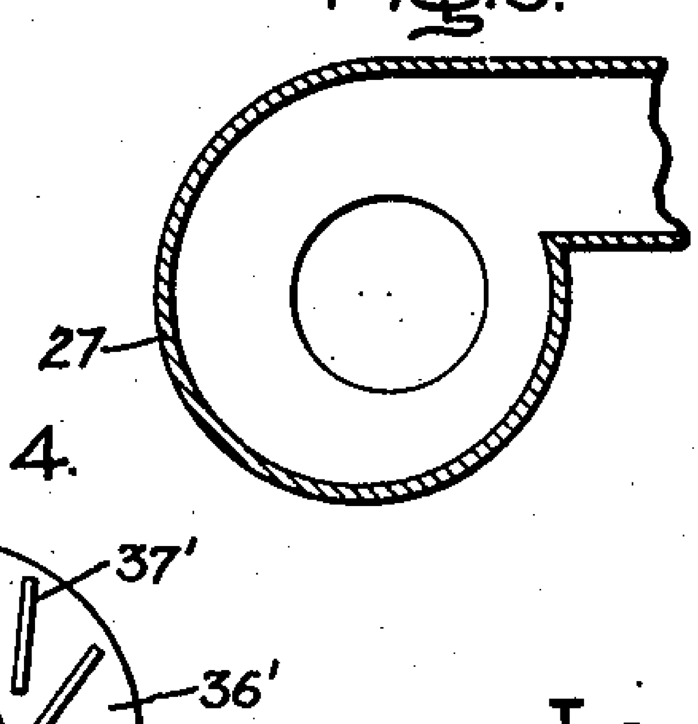
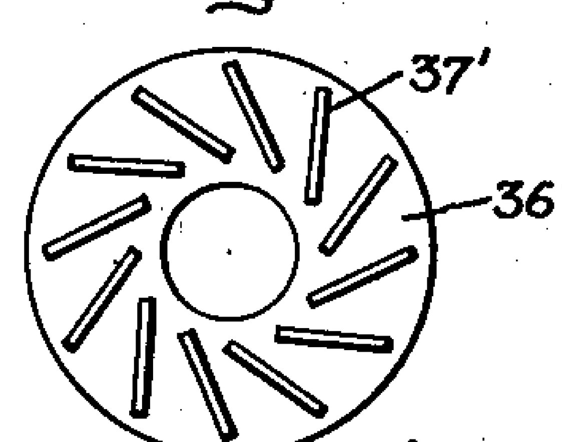


Fig. 4.



Inventor:
Aldo Macchi,
by Charles E. Mullar
His Attorney.

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2,022,512

COMBUSTION METHOD AND APPARATUS

Aldo Macchi, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application December 31, 1930, Serial No. 505,867

18 Claims. (Cl. 158—4)

My invention relates to fuel burners and more particularly to improved methods of combustion to be used therewith.

It is a principal object of my invention to provide an improved method and apparatus for obtaining progressive and substantially complete combustion of liquid fuel, such for example as oil.

Another object of my invention is to stabilize the combustion of the fuel symmetrically and thereby materially decrease the noise usually present during combustion within liquid fuel burners.

A still further object of my invention is to increase the combustion efficiency of a liquid fuel burner.

Other objects will appear hereinafter.

Briefly, the preferred embodiment of my invention consists of an oil burner provided with a combustion chamber of symmetrical design. While not necessarily limited thereto, the present invention is particularly adapted for use in my improved type of boiler furnace described and claimed in my divisional application, Serial No. 676,106, filed June 16, 1933. Mounted at the top of the combustion chamber and centrally thereof is an atomizing nozzle for spraying fuel and air under pressure in a gradually expanding stream vertically downward within the chamber along the axis thereof. Surrounding the atomizing nozzle is an air nozzle for directing a column of air around the oil spray within the combustion chamber. The oil spray is sufficiently atomized to be ignited by means of an electric spark. Due to the fact that insufficient air is supplied through the air nozzle for complete combustion the resulting flame does not completely burn the gradually expanding stream of atomized oil but produces sufficient heat whereby the oil particles sprayed from the nozzle are vaporized into a very fine mist and then gasified. Mounted at the bottom of the combustion chamber and coaxially with the nozzle is an air box provided with radially offset vanes and a nozzle at the top thereof for directing a whirling column of preheated air upwardly to meet the downwardly directed flame in a plane of impact adjacent the air box. The air thus introduced is in sufficient quantity to produce complete combustion of the gasified oil vapors, it being possible to closely regulate the amount of air coming from the air box which mixes with these gases and the air has the further effect of spreading the flame laterally and outwardly to the sides of the combustion chamber, the flame returning upwardly around itself in all directions adjacent the sides of the combustion chamber radiating heat to the refractory walls of the chamber and further assisting in gasifying the downwardly directed stream of atomized oil. By this method as outlined progressive, symmetrical and complete combustion is assured, testing showing no trace of CO in the flue gases, and the flame is stabilized and therefore substantially noiseless.

The products of combustion pass out at the top of the combustion chamber and downwardly through a heat extracting passage in which are mounted a plurality of short water heating coils having inlet and outlet passages to the boiler. This results in many small cycles of water circulation, thus permitting better steam release. Placing the coils at an angle increases the turbulence of the products of combustion and hence the heat transfer. The increased path of travel for the products of combustion also results in a greater absorption of heat from the products of combustion, since instead of passing upwardly in the combustion chamber and out the flue, the products of combustion have a triple path to follow, that is down, up, and down through the coil drum before going to the flue.

In the drawing Fig. 1 shows a cross secton of an oil burning boiler furnace provided with the preferred embodiment of my invention; Fig. 2 shows a cross section taken on line 2—2 and shows the coil drum in section, and Fig 3 is a cross section taken on line 3—3 of Fig. 1 and shows the scroll which introduces the secondary air into the air box at the bottom of the combustion chamber. Fig. 4 is a view of the air box cover and the fins attached thereto.

In the drawing, the casing 10 of the boiler furnace is covered with a heat insulating material 11. A vertically extending cylindrical combustion chamber 12 is mounted within the boiler and completely surrounded by water as shown, the particular boiler shown being of the steam heating type. Around the inside of the combustion chamber and at the upper end thereof is placed the bracket ring 13 for supporting the rods 14 upon which is mounted the removable sectionalized fire-brick refractory material 15. This feature of the removable refractory material is described and claimed in a copending application of mine, Serial No. 505,866, filed December 31, 1930, and assigned to the same assignee as the present invention. The purpose of this refractory is to form a high temperature zone in the bottom portion of the combustion chamber to assist in promoting even combustion of the flame.

The burner is provided with a safety door 10' connected to the combustion chamber which permits inspection of the interior of the combustion chamber and has a further function of relieving pressure within the furnace should an explosion ever occur therewithin. A passage 12' connected to the top of the combustion chamber is for the purpose of leading the products of combustion to the secondary heating surfaces in the coil drum 41 for abstracting further heat therefrom. A riser pipe 49 and a return pipe 50 are provided for the boiler.

Mounted at the top of the combustion chamber and centrally thereof for discharging a spray of liquid fuel downwardly along and around the vertical axis of the combustion chamber is the atomizing nozzle 16 to which oil and atomizing air under suitable pressure are directed by means of the conduits 17 and 18 for spraying the fuel into the furnace in a steady stream without pulsation. An electrically controlled valve (not shown) is mounted within the nozzle and energy supplied thereto by means of the cable 19. The nozzle is controlled by apparatus not shown and not forming a part of this invention. Surrounding the atomizing nozzle is the casing 20 having at its lower end the combustion air nozzle 21 provided with sloping sides terminating in the opening 21' through which a column of low pressure combustion air is introduced into the combustion chamber around the spray, the column of combustion air thus introduced being insufficient in quantity to support complete combustion and assisting in directing the stream of atomized oil into the combustion chamber, in cooling the nozzle and maintaining the electrodes 16' clean. Connected to the casing 20 is another casing 23 connected in turn to an air duct 24. The casing 20 is provided with a series of ports or openings 22 around the nozzle for admitting air into the casing 20 and thence to the opening 21' in the nozzle 21. Mounted within the duct 24 is the butterfly valve 25 for controlling the admission of low pressure combustion air around the nozzle 16. The atomizing nozzle used is designed to furnish the proper amount of oil and air under pressure for atomizing sufficient oil for the combustion chamber with which it is used. The atomization of the oil, the velocity of the oil jet, the amount of secondary air, and the arrangement of the combustion chamber are all factors entering into the proper combustion of the fuel to obtain maximum efficiency.

Placed at the bottom of the combustion chamber and coaxially with the nozzle 16 is the air box 36 connected with the scroll 27 by means of the opening 35. The air box 36 supports therein the baffle member 37 the purpose of which is to assist in producing an even flow of air through the air nozzle 38 of refractory material. Other refractory material 39 and 40 protects the air box from the intense heat of the flame. Balls 26 of refractory material cover the bottom of the combustion chamber for the same purpose.

The scroll 27 has a spiral shape as shown in Fig. 3 and air is introduced therein by means of the duct 28 extending through the hot water compartment thereby preheating the air and in which is mounted the butterfly valve 30. A duct 29 connected to a suitable source of air furnished by some blower not shown directs air into the ducts 24 and 28. The purpose of the scroll at the bottom of the combustion chamber is to feed secondary air at a uniform radial pressure through the opening 35. It also permits delivery of air at the bottom of the boiler with a flat air duct.

The air box 36 having the top 36' provided with a series of radially offset vanes 37' is for the purpose of changing the radial pressure in the opening 35 to a uniform air pressure through the air nozzle 38. This air is swirling and after passing through the nozzle 38 in an upwardly directed column expands in the combustion chamber in all directions without the action of the spray from the burner. The fins 37' attached to the underside of the air box cover are placed at the proper angle to cause the air coming from the refractory ring or nozzle 38 to have the wanted swirl. Some of the air rolls down along the side of the refractories 39 and 40 to the bottom of the combustion chamber. The air velocity at and above the air nozzle is preferably made sufficient to balance the spray velocity and hence prevents any of the oil from entering the air nozzle or orifice 38. By thus directing the whirling column of air upwardly and coaxially with the downwardly directed stream of oil and air from the nozzle 16 a zone of impact is produced above the air nozzle 38 as indicated diagrammatically by the line A—A in Fig. 1. By properly controlling the air, this zone of impact is brought as close to the air box as possible to avoid a noisy flame which is so prevalent in the usual oil burner. By providing sufficient secondary air at this point to the gasified spray of oil complete combustion takes place and noise is eliminated. Very fine control of this air is possible so that excess air is not present in sufficient quantities to reduce the efficiency of combustion.

Adjacent the combustion chamber and connected thereto by means of the duct 12' is the tube chamber 41 in which are mounted the water coils 42 each having an inlet 43 and an outlet 44 for providing many small cycles of water circulation. Stay rods 45, which may be in the form of metal tubes, help to stay the tube chamber. The products of combustion on passing down through the tube chamber will exhaust to the flue by means of the duct 46. A cover 47 is provided on top of the tube chamber which may be removed and after removing the layers of insulation 48 a brush may be inserted into the tube chamber for cleaning the water coils.

The water coils have been slanted at an angle as shown in Fig. 1 to increase the turbulence of the products of combustion as they pass down through the tube chamber. Small cycles of water circulation are provided which increase the heat transfer from the water coils, thereby providing a quick steam release. There is no chilling of the flame in the water tube chamber since complete combustion has taken place in the combustion chamber. Therefore, the coils operate at maximum efficiency since they merely absorb heat from the products of combustion without chilling the flame which would cause incomplete combustion and a waste of heat up the flue.

By providing the downwardly directed gradually expanding stream of atomized fuel in the combustion chamber with the surrounding column of air insufficient to support complete combustion and the upwardly directed whirling column of air and heat insulating them within the combustion chamber by means of the refractory lining, stabilized, progressive and substantially complete combustion takes place within the chamber, the products of combustion passing upwardly along the sides of the refractory lining of the combustion chamber through the opening 12' and then downwardly to the water tube chamber. This increases the length of the path of the products of combustion, providing more surface for contact of the products of combustion with the waterback surfaces of the boiler and thereby increasing the amount of heat transferred to the water within the boiler. The result is an increased efficiency in the heat absorbing qualities of the boiler as well as quicker heating. The arrangement of the various parts of the burner permits easy access to the interior thereof for the purpose of cleaning or repair.

The operation of the device is as follows: Air and oil are furnished under equalized pressures to the nozzle 16 by means of the conduits 17 and 18 and are projected into the combustion chamber to produce a fine spray or gradually expanding stream of atomized oil in a downward direction along and around the axis of the downwardly extending cylindrical combustion chamber. Air in insufficient quantity to support complete combustion is led from the duct 29 to duct 24, casing 23 through the openings 22 in the casing 20 and projected in a column around and coaxial with the stream of atomized oil and atomizing air issuing from the nozzle 16 through the opening 21' in the combustion air nozzle 21. The amount of this air is properly adjusted by means of the butterfly valve 25. The rest of the low pressure combustion air coming through the duct 29 passes into duct 28, being controlled by the butterfly valve 30, and thence into the scroll 27 through the air box into the combustion chamber. The oil spraying nozzle arrangement produces a mixture of atomized oil and air and the air duct 24 and low pressure combustion air nozzle 21 supplies a deficiency of air so that although the spray of oil can be easily ignited by the electrodes 16' only incomplete combustion of the spray at this point and for some distance into the combustion chamber is obtained. The velocity of the atomized oil is greater for a distance of some few inches than the rate of propagation of the flame, the object being to keep the flame away from the tip of the oil burner nozzle so that it will not heat up and break down the oil before it is sprayed into the furnace. The electrodes 16' are energized by suitable means (not shown). It is, of course, understood that when the spray is properly ignited the ignition electrodes are deenergized and the flame maintains itself.

Due to the insufficient air column around the atomized oil stream only partial combustion takes place in the top part of the combustion chamber the heat from this partial combustion vaporizing the fuel and gasifying it with the assistance of the heat from the flame coming up from the bottom of the combustion chamber and radiated from the refractory lining. The flame, as the spray opens out, gradually loses velocity as it approaches the bottom of the combustion chamber until the impact zone is reached as indicated diagrammatically at A—A. At this point the secondary air coming up from the air box supplies the deficient air to cause complete combustion, this air causing a whirling motion of the flame at the point of impact, part of the flame rolling down along the sides of the refractory covering the air box and returning with the rest of the flame up the sides of the refractory material 15. The flame changes from a semi-transparent orange gradually to a colorless gas. This condition can be produced only with a very low excess of air and the flue gas shows by analysis that substantially complete combustion has been obtained, practically no CO being present. The flame produced is noiseless and is stable.

By this method of combustion the maximum heat is obtained from the fuel and in addition thereto noise, which is a very undesirable feature in the usual oil burner, is absent. As was pointed out above, complete combustion takes place in the furnace, the refractory assisting to insure complete combustion by maintaining an intense heat in the combustion chamber. The longer path for the products of combustion and the arrangement of the tube chamber in which are mounted the water coils, which increase the turbulence of the products of combustion, result in a quicker heat transfer, a quicker steaming due to the small cycles of water circulation and to a greater efficiency in combustion and heat absorption than heretofore has been possible in an oil burner or gas burner to which the present apparatus is readily adaptable. It will thus be seen that I have provided an improved method of combustion for liquid fuels, such as oil and the like, and have provided a burner having a very high efficiency.

The embodiment of the invention illustrated and described herein has been selected for the purpose of clearly setting forth the principles involved. It will be apparent, however, that the invention is susceptible of being modified to meet the different conditions encountered in its use, and I, therefore, aim to cover by the appended claims all of the modifications within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The method of burning liquid fuel which comprises spraying a stream of atomized fuel verically downwardly and igniting the same in the presence of air to provide a flame, adding combustion air to said downwardly directed spray symmetrically around said spray in insufficient quantities to support complete combustion, and directing an upward whirling column of air into opposing relation with said downwardly directed flame to spread the flame laterally and return the flame upwardly around itself to complete combustion of said fuel.

2. In combination with a combustion chamber, an atomizing nozzle for projecting an expanding stream of atomized oil centrally into the chamber, means for projecting a surrounding column of air into the combustion chamber to mix with said oil stream progressively in insufficient quantity to support complete combustion thereof, means for igniting said atomized oil stream into an expanding flame in the combustion chamber, and means for projecting a whirling column of air into the combustion chamber from the opposite direction to mix with progressively and spread said expanding flame outwardly and return the expanding flame back around itself symmetrically and thereby complete combustion of said atomized stream of oil.

3. In combination with a combustion chamber, an air pressure atomizing nozzle for projecting an expanding stream of atomized oil and atomizing air under pressure centrally and downwardly into the combustion chamber, means including an air nozzle concentric with said atomizing nozzle for projecting a surrounding column of air coaxially with said oil and atomizing air stream to mix with progressively and support only incomplete combustion of the atomized oil stream, means adjacent said atomizing nozzle for ignit-

ing said atomized oil stream into an expanding flame in the combustion chamber, and means including a second air nozzle oppositely and coaxially disposed with respect to said first air nozzle for projecting into the combustion chamber a whirling column of air of sufficient quantity to complete combustion of the oil and turn said expanding flame back around itself symmetrically and thereby stabilize the combustion of said atomized stream of oil.

4. In combination with a combustion chamber, means for spraying a stream of atomized oil centrally into said combustion chamber, means for igniting said atomized oil stream, means for supplying air around said ignited oil stream to mix therewith progressively in insufficient quantity to support complete combustion and means for projecting a swirling column of air sufficient to complete combustion of said oil oppositely and coaxially with respect to said ignited oil stream to spread outwardly and turn the expanding ignited oil stream back around itself symmetrically and thereby stabilize the combustion of said atomized stream of oil.

5. The method of progressively burning liquid fuel comprising spraying the fuel in an atomized stream having an initial velocity greater than the rate of propagation of flame, projecting air symmetrically around said stream to mix therewith in insufficient quantity to support complete combustion, igniting said stream to produce a semi-combustion flame, and projecting a whirling column of air against said semi-combustion flame from the direction opposite said stream gradually to mix with and return said flame back around itself symmetrically to complete the combustion of the fuel.

6. A furnace having a cylindrical combustion chamber, a nozzle disposed at one end of said chamber for projecting a stream of fluid fuel along the axis of said comubstion chamber, means associated with said nozzle for supplying combustion air with said stream of fuel in insufficient quantities to support complete combustion of the fuel, means for igniting said fuel stream, and means including an air box provided with a series of radially offset vanes and a nozzle for directing a swirling column of air from the opposite direction along the axis of said combustion chamber to meet said ignited stream of fuel and mix therewith and return the ignited stream of fuel back around itself symmetrically to stabilize combustion of the fuel.

7. The method of progressively burning liquid fuel in a stabilized and substantially noiseless flame which comprises spraying the fuel downwardly in an expanding stream, directing air around said stream to mix therewith in insufficient quantity to support complete combustion thereof, igniting said stream, and projecting a whirling column of air upwardly in opposed relationship to said ignited stream to complete combustion thereof and cause said ignited stream to return back around itself symmetrically to stabilize the combustion of said fuel stream.

8. A furnace having a symmetrical combustion chamber with a vertical axis, a fuel projecting nozzle extending centrally into the top of said chamber for providing a downwardly directed flame along the axis of said chamber, an air box located at the bottom of said combustion chamber and provided with radially offset vanes and a nozzle for directing a column of swirling air upwardly and coaxially with respect to said downwardly directed flame, and means for supplying air both to said air box and downwardly around said fuel projecting nozzle to support incomplete combustion of the downwardly directed flame adjacent said fuel projecting nozzle and to complete the combustion of the fuel adjacent said air box with the flame spread laterally outwardly and returned back around itself symmetrically adjacent the sides of said combustion chamber.

9. The method of combustion consisting in projecting fuel in a path extending along and around an axis of combustion, igniting the fuel, projecting air along and into the border of the path of the fuel to mix therewith in insufficient quantity to complete combustion of the fuel, and supplying the additional air required to complete combustion from the opposite direction in a whirling expanding column projected along and around the same axis of combustion to mix with and reverse the travel of the opposing fuel and air and complete the combustion symmetrically in surrounding spaced apart relation with the initial path of the fuel.

10. The method of combustion consisting in projecting an expanding stream of finely divided fuel in a path extending along and around an axis of combustion, igniting the fuel, projecting air symmetrically along the path of the fuel to mix therewith in insufficient quantity to complete combustion of the fuel, and supplying the additional air required to complete combustion from the opposite direction in a whirling expanding column directed along and around the same axis of combustion at a velocity sufficient to reverse symmetrically the travel of the opposing fuel and air and gradually complete the combustion symmetrically in surrounding spaced apart relation with the initial path of the fuel.

11. The method of combustion consisting in projecting finely divided fuel downwardly in an expanding path extending along and around a vertical axis of combustion, igniting the fuel, projecting an annular column of air along said axis to enter the expanding path of said fuel and mix therewith in insufficient quantity to complete combustion of the fuel, and supplying the additional air required to complete combustion from the opposite direction in a whirling expanding column projected along and around the same axis of combustion with a velocity sufficient to reverse symmetrically the travel of the opposing fuel and air and complete the combustion symmetrically in surrounding spaced apart relation with the initial path of the fuel.

12. The method of combustion consisting in projecting a stream of atomized fuel in an expanding path extending along and around an axis of combustion, projecting air symmetrically around the same axis as the atomized fuel to enter the path thereof and mix therewith in insufficient quantity to complete combustion of the atomized fuel, igniting the fuel and supplying a whirling expanding column of air sufficient to complete combustion from the opposite direction along and around the same axis of combustion and at a velocity sufficient to reverse symmetrically the stream of atomized fuel and complete the combustion thereof symmetrically in surrounding spaced apart relation with the expanding path of the atomized fuel.

13. The method of combustion consisting in atomizing liquid fuel with high pressure air, projecting a stream of the atomized liquid fuel downwardly in a path extending along and around a vertical axis of combustion, projecting low pressure air symmetrically along and around the bor-

ders of the path of the atomized fuel in insufficient quantity to complete combustion thereof, igniting the fuel and supplying the additional quantity of air required to complete combustion in a whirling expanding column from the opposite direction along and around the same axis of combustion at a velocity sufficient to reverse symmetrically the stream of atomized fuel and complete the combustion thereof symmetrically in surrounding spaced apart relation with the initial path of the atomized fuel.

14. The method of combustion consisting in atomizing liquid fuel with high pressure air, projecting an expanding stream of the atomized liquid fuel in a path extending along and around an axis of combustion, projecting a surrounding column of air along said axis to enter the stream of fuel and mix therewith in insufficient quantity to complete combustion of the fuel, igniting the fuel, projecting a whirling expanding column of air from the opposite direction along and around the same axis of combustion to complete combustion of the fuel and return the products of combustion back in surrounding spaced apart relation with the initial path of the fuel to cause the heat of said products of combustion to assist in gasifying the atomized stream of fuel.

15. The method of combustion consisting in atomizing liquid fuel with high pressure air, projecting a stream of the atomized liquid fuel in a path extending along and around an axis of combustion, projecting low pressure air symmetrically along the same axis as the fuel to enter the stream of fuel and mix therewith in insufficient quantity to complete combustion of the fuel, igniting the fuel, projecting a whirling expanding column of air to complete the combustion of the fuel from the opposite direction along and around the same axis of combustion at a velocity sufficient to reverse symmetrically the ignited stream of atomized fuel, and maintaining a high temperature zone surrounding the reversed stream of fuel to complete the combustion thereof.

16. A furnace having a combustion chamber, refractory walls lining a portion of said combustion chamber and forming a symmetrical combustion space therein, means for projecting a stream of fuel into said combustion space in a path extending along and around an axis thereof, means for directing air symmetrically along and into the border of the path of the fuel in insufficient quantity to complete combustion of the fuel, and means for supplying the additional air required to complete combustion from the opposite direction along and around the same axis of the combustion space in a whirling expanding column traveling at a velocity sufficient to reverse symmetrically the travel of the opposing fuel and air, said refractory walls assisting in guiding the reversed fuel and air and in maintaining a high combustion temperature zone to complete combustion within that portion of the combustion chamber provided with the refractory wall.

17. An oil burning furnace having a vertically extending cylindrical combustion chamber, a refractory lining surrounding the bottom portion of said combustion chamber, an air pressure oil atomizing nozzle extending into the top of said chamber for directing an atomized stream of oil downwardly along the axis thereof, means for projecting combustion air around said atomized oil stream in insufficient quantity to complete combustion of the oil, and an air box in the bottom of said combustion chamber having a series of radially offset vanes and a nozzle for directing a whirling column of air upwardly along the axis of said chamber for spreading and reversing the path of the atomized oil and for completing combustion of the atomized oil, said refractory lining assisting in maintaining a high temperature zone in the bottom portion of said combustion chamber to insure complete combustion of the oil taking place substantially within said zone.

18. An oil burning furnace having a vertically extending cylindrical combustion chamber, a refractory lining surrounding the bottom portion of said combustion chamber for providing a high temperature combustion zone therein, an air pressure oil atomizing nozzle extending centrally into the top of said combustion chamber for projecting a stream of atomized oil downwardly into said high temperature combustion zone along and around the axis of the combustion chamber, a combustion air nozzle surrounding said atomizing nozzle for directing low pressure combustion air symmetrically along and around the path of the atomized oil stream in insufficient quantity to complete combustion of the atomized oil, and an air box having a series of radially offset vanes and a nozzle extending upwardly into the bottom of said combustion chamber for directing a whirling expanding column of air upwardly along and around the axis of the combustion chamber progressively to mix with and reverse symmetrically the travel of the atomized oil and air and complete the combustion of the atomized oil symmetrically in said high temperature zone.

ALDO MACCHI.