

March 12, 1935.

E. G. BAILEY

1,994,443

METHOD OF BURNING FLUID FUEL

Original Filed Aug. 7, 1926 3 Sheets-Sheet 1

Fig. 2

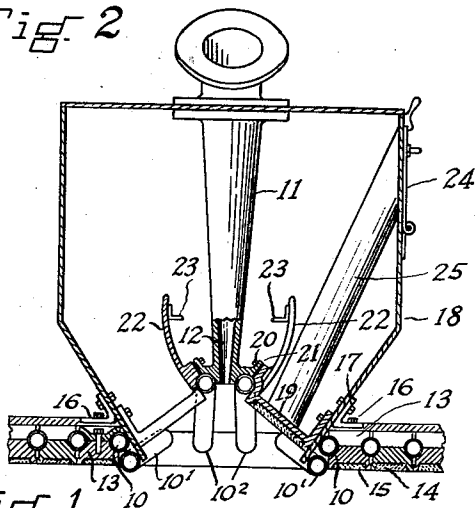


Fig. 3

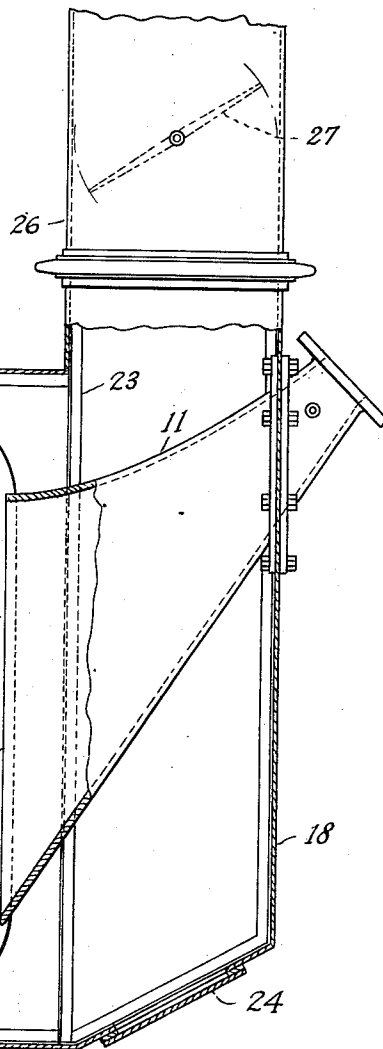
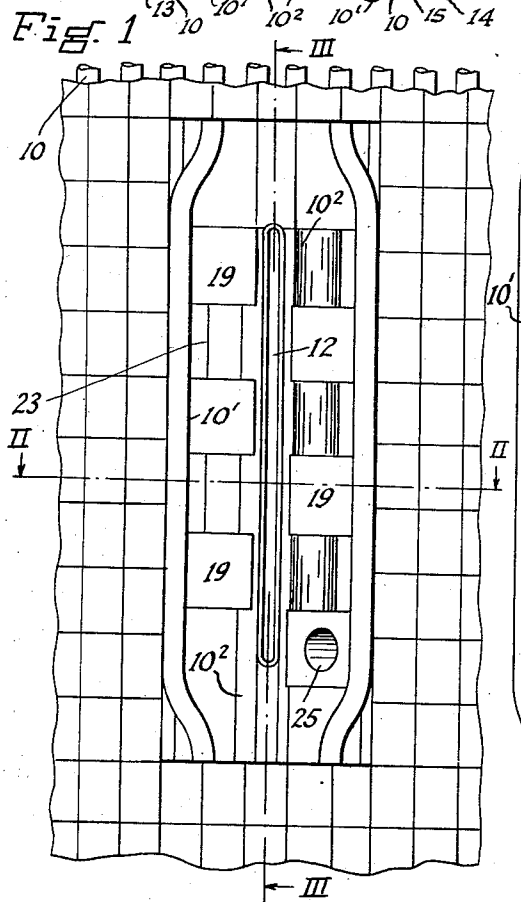


Fig. 1



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Fig. 5

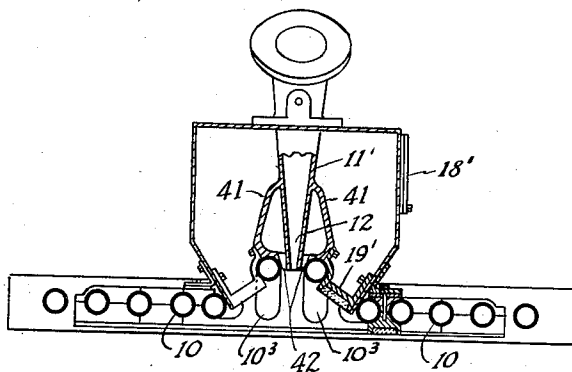


Fig. 4

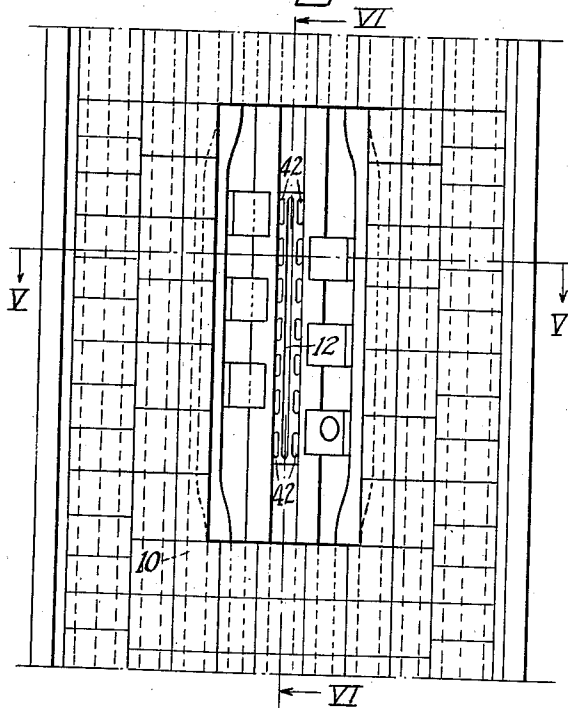
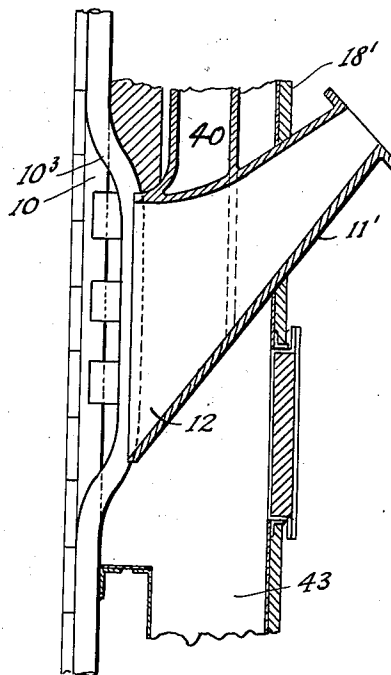


Fig. 6



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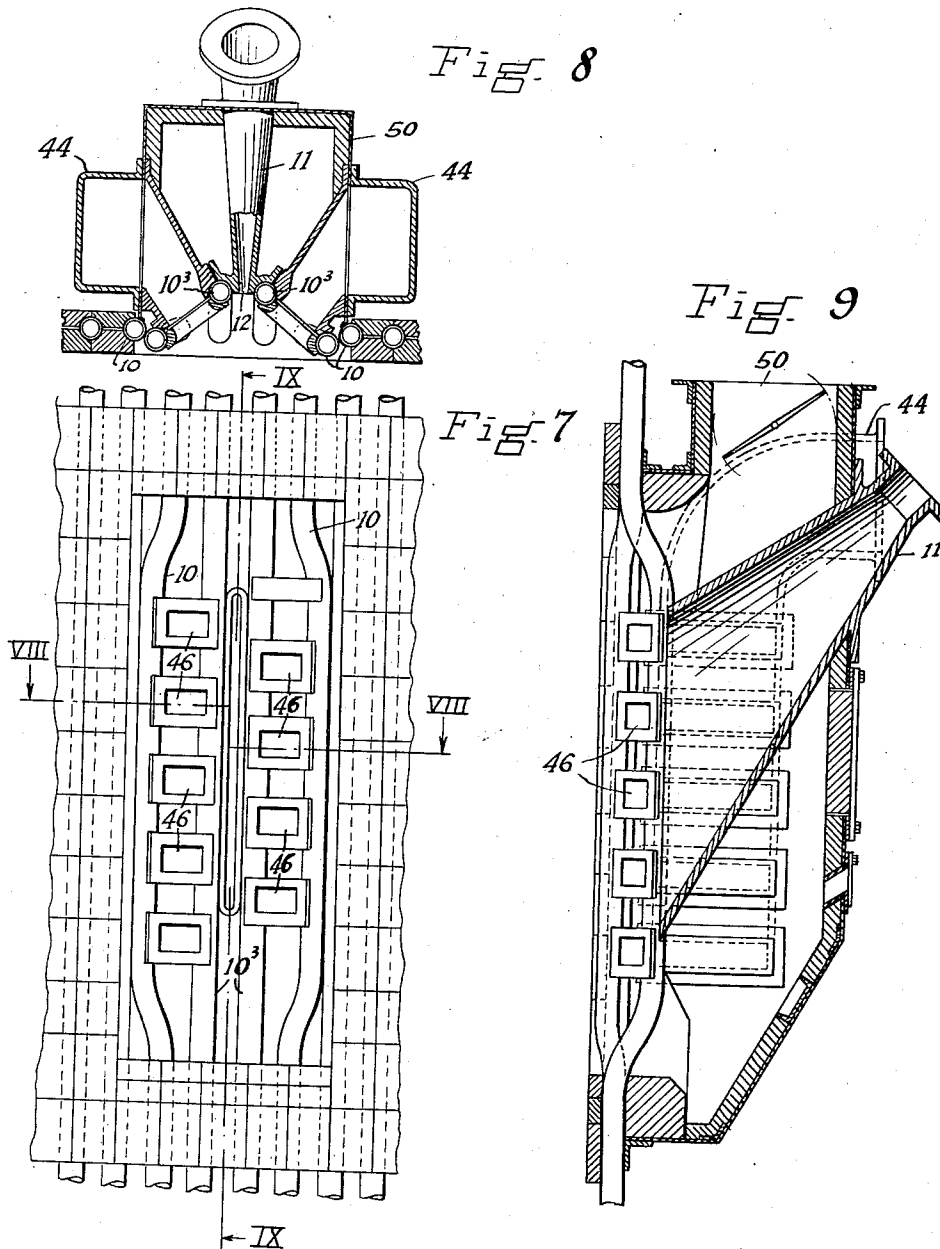
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METHOD OF BURNING FLUID FUEL

Original Filed Aug. 7, 1926 3 Sheets-Sheet 3



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METHOD OF BURNING FLUID FUEL

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Continuation of application Serial No. 127,791, August 7, 1926. This application July 20, 1932, Serial No. 623,520

18 Claims. (Cl. 110—28)

My invention relates to a method of burning fluid fuel and is a continuation of my copending application Serial No. 127,791, filed August 7, 1926 for Fuel burner. It is related to my copending patent application filed of even date herewith, Serial No. 623,519, wherein the apparatus is claimed.

One object of the present invention lies in providing a method of burning fluid fuel which will produce a shorter, more intense flame and more rapid combustion than has heretofore been possible. A further object is to enlarge the flame filled space and to reduce the amount of excess air required. Another object is to provide a method whereby the burner and its mounting may be adequately cooled by means of fluid cooling tubes in the wall. Other objects will appear upon further consideration of this specification.

One preferred form of the burner and associated parts is shown in the accompanying drawings wherein—

Figure 1 is an elevation of a burner constructed in accordance with the invention, showing a portion of the furnace wall as viewed from within the furnace,

Fig. 2 is a horizontal section on the line II—II of Figure 1,

Fig. 3 is a vertical midsection of the burner taken on the line III—III of Figure 1,

Figs. 4, 5, and 6 are views similar to Figs. 1, 2, and 3 respectively showing a modified form of the invention, and

Figs. 7, 8, and 9 are views similar to Figs. 1, 2, and 3 respectively showing another modified form of the invention.

By the words "fluid fuel" I intend to include any fuel which is or may be employed in fluid form whether admixed with primary air or not before emerging from the fuel opening of the burner. It is intended, for example, to include as fuel, either gas, oil in spray or finely divided form, vaporized liquid fuels, pulverized coal or other carbonaceous material admixed with primary air to form a preliminary fluid fuel mixture, or any combination of such fuels.

Beside the thorough mixing of fluid fuel and air, more fully described hereinafter, a second important feature of the invention lies in properly supporting and protecting the burner. Especially where pulverized coal is used as a combustible, the general burner opening is likely to become heated to a point at which the fuel will become partly fused and sticky in character, tending to clog the burner opening. This difficulty is overcome by protecting and water-cool-

ing the burner. In overcoming this difficulty provision is also made for suitably supporting the burner on the water-cooled furnace wall so that the burner may move with the furnace wall in any expansion or contraction thereof.

A third important feature of my invention lies in combining a furnace, having water-cooling tubes, with a burner or burners of the improved type which may be located at any desirable point or points therein or in connection therewith.

Referring more particularly to the drawings, wherein a burner is disclosed which is adapted for use in carrying out the present invention, the form of burner illustrated in Figs. 1, 2, and 3 includes an associated boiler furnace wall having spaced vertically extending water tubes 10 forming at least a portion thereof. Water is circulated through these tubes to cool the furnace wall, and also for heating the water or generating steam, the resulting hot water or steam being used for any desired purpose. In this form the spaces between the water tubes 10 are closed by rows of blocks, the outside blocks being marked 13, and the inside blocks being marked 14. Each row of blocks has recesses formed therein which fit partly around adjacent tubes, and the rows may be clamped in place by means of bolts 16. The inside blocks 14 are preferably of metal in the portion seating against the tubes and are shown as having portions 15 of refractory material facing the furnace chamber. Heat conducting cement of any known or desired composition may be interposed between the curved recessed portions of the blocks and the water tubes in order to provide closely fitting joints through which the furnace heat may be readily conveyed.

In this form of apparatus two adjacent water tubes 10² are bent directly outwardly of the furnace and parallel to each other to support and cool the elongated outlet 12 of a fuel nozzle 11. This outlet is preferably in the form of a long narrow slot, as best shown in Figure 1. Each water tube 10¹ adjacent each of the water tubes 10² is bent inwardly toward the furnace chamber and sidewise away from the adjacent water tube 10² and toward the adjacent unbent tube, to provide the general burner opening or port. (See Fig. 2).

The fuel nozzle 11, through which a rich mixture of pulverized fuel and primary air or other suitable fluid fuel is fed to the furnace, extends through a box-like casing 18 containing secondary air under pressure. This casing 18 is shown as having inwardly converging sides bolted to

angle irons 17 attached to the outside blocks 13. The fuel nozzle 11 which extends through the air chamber has its outlet portion 12 flanged and provided with concave recesses which fit against and are in intimate heat-conductive relation with the tubes 10². Bolts 20 pass through the flanges on the outlet portion 12 and also through lugs on spaced blocks 19, which are likewise recessed to fit snugly upon the tubes 10². Heat conducting cement is preferably used between the concave recesses in the outlet portion 12 of the fuel nozzle 11 and the tubes 10² and also between the blocks 19 and these tubes in order to assist the transfer of heat from the flanges and the blocks to the tubes.

Lugs or extensions 21 are preferably provided on the outside of the blocks 19, and these lugs or extensions may carry air-directing wings 22 extending outwardly of the blocks 19 into the air-box and preferably secured to vertical angle irons 23 which form vertical braces or supports. The blocks 19 are preferably composite in character, their outer portions being of metal, and the portions facing the furnace being of refractory material. These blocks 19 are fastened to the supports 23, as just described, and also to the walls of the air housing 18. The blocks 19 are here shown as spaced (see Figure 1) to provide air openings from the air-box into the furnace, these openings being shown (see Figure 1) as staggered on opposite sides of the outlet portion 12 of the fuel nozzle 11.

It is preferred to provide an access door 24 in the side of the air housing 18 and to construct a tubular port 25 leading from the access door 24 into the burner opening through which a torch for lighting the fuel may be thrust. An inlet 26 is provided for feeding air from any convenient source to the casing 18, and a damper 27 is preferably disposed in the inlet 26 to control the air admission.

In operation the fluid fuel, in this case pulverized coal and primary air, is introduced into the furnace through the fuel nozzle 11, passing the outlet portion 12 in the form of a thin vertically extending sheet. The mixture passing through the nozzle contains insufficient air for combustion, and additional or secondary air passes into the furnace from the inlet 26 past the damper 27 into the box-like casing 18 and thence through the staggered openings between the blocks 19 at inwardly converging angles on opposite sides of the fuel stream. In this form, therefore, the incoming secondary air streams are staggered on opposite sides of the central sheet.

Applying the term "fluid" to the rich coal and air mixture, which has been referred to as the fuel passing through the nozzle 11, it will be noted that at least one of the fluids is admitted through multiple ports in order to assist in the intermixing of the fuels and the spreading and shortening of the flame. The angular impingement and deflecting of the coating streams occur after the streams have left their respective openings, at least one of the fluids passing into the furnace through several ports. If these ports are positioned on opposite sides, the flame from the multi-ported burner is deflected in opposite directions in different portions thereof. Thus, it will be noted that the secondary air streams enter the furnace at angles to the fuel stream and impinge on the fuel stream after the latter has emerged from its outlet 12. Consequently the angular impingement of the staggered air streams on the central thin fuel stream tends to

deflect portions thereof in opposite directions. Further, such angular impingement not only causes thorough admixture of air and fuel, but also shortens the flame, and by forcing it side-wise in opposite directions, causes the flame to fill a much greater volume of the furnace space than would otherwise be possible. Finally, it will be noted that such angular impingement of the combustion air against the thin sheet of the fuel stream causes great turbulence, rapid admixture of fuel and air and shortening of the flame.

Referring now to the second set of features of my invention, namely, the proper supporting and protecting of the burner, it will be noted that the burner, as a whole, has its burner opening into the furnace partly screened from radiant heat by water tubes; that the unscreened portion is cooled by water tubes in close heat-contacting relation with metallic parts of the burner; and that the burner is fitted to be attached to and supported by the water tube wall structure. The sidewise bent tubes 10¹ and the adjacent tubes 10 partially screen the burner from the radiant heat of the furnace, while the outwardly bent tubes 10² serve to water-cool the nozzle portions of the burner, as well as also partially screen them. It will be noted that the fuel enters between water tubes—in the case shown, the tubes 10²—while the supplemental air enters the several ports between each tube 10² and the adjacent tube 10¹. Consequently, the tubes 10¹ and 10² serve to partially protect and also water-cool both the fuel and air-ports.

The burner is thus kept below such temperatures as would cause stickiness and clogging where pulverized coal is used as the combustible. This water-cooling of the partially exposed inner part of the burner, as a whole, is an important feature of my invention. Furthermore, by the construction shown, the burner or burners are supported on and may move with the water-cooled wall structure. Consequently, any expansion or contraction of the wall, as a whole, will cause a similar movement of the burner or burners, thus avoiding strains, etc. between them. Hence, overheating of the burner is prevented; and no separate supporting system is needed for the burner or burners.

In the construction illustrated, the burner does not project inside the furnace from the plane of the furnace wall and is preferably outside such plane, as shown, thus decreasing the heat to which it is subjected, while such heat as is received by the burner is rapidly conducted to and absorbed by the water in the tubes having intimate heat conductive contact with the burner and its connections. Further, the burner has its opening into the furnace partly screened from radiant heat by water tubes, the sidewise bent tubes 10¹ partially screening the burner from radiant heat.

The outwardly bent tubes 10² serve not only to cool the nozzle but also to support it, the burner being fitted for fastening to these tubes. Thus, the fuel enters between water tubes—in the case shown, the tubes 10²—while the secondary air passes through the several ports between each tube 10² and the adjacent tubes 10¹. Consequently the tubes 10¹ and 10² serve to partly protect and also water-cool both the fuel and the air-ports.

An important feature of the construction which has just been described and which is intended for use in connection with the invention, to which general reference has been made above, is that 75

the spaces between the water tubes are closed by blocks which are secured in place upon the tubes, and that the multi-ported burners may be placed wherever desirable and in any necessary number in the wall, all parts being carried by the water tube wall structure. In this manner an economical, simple and effective wall and burner structure is provided in which the burners may be positioned as desired in the wall, while the heat absorbed by the water tubes may be utilized for useful work.

In Figures 4, 5, and 6, there is shown a form generally similar to that of Figures 1, 2, and 3, except that provision is made for introducing gas along with the pulverized fuel and air. The burner 11' extends through the housing 18', the tubes and connections being substantially the same as in the first form. The opposite blocks 19' provide the angular inwardly converging air outlet ports which are preferably staggered, as in the first form; and a gas outlet conduit 40 extends into the air-box and is split and passes down on each side of the fuel nozzle, the two branches 41 having spaced ports or openings 42 between the fuel outlet and the adjacent tubes 10³. In this case, the angular secondary air jets impinge upon and bend successive portions of the fuel stream of pulverized coal, gas, and primary air and cause a thorough admixture, giving the spreading action, turbulence and shortening of the flame.

In the further form of Figures 7, 8 and 9, another arrangement is shown for introducing gas in connection with the primary fuel, which may be a rich mixture of pulverized coal and air, and in connection with the multi-ported angular air outlets. The wall, water tubes, burner connections and general assembly are about the same as in Figures 1, 2 and 3; but in this modification, gas conduits 44 are secured at the sides of the air-box having spaced outlets 46 which are shown as staggered on opposite sides of the pair of tubes 10³, so that gas for combustion purposes passes out of the openings 46. The secondary air for combustion purposes is supplied to the upper end of the air-box 50 and passes downwardly through the air-box on both sides of the fuel nozzle 11. The air enters the furnace at both sides of the nozzle 11 through the spaces between the gas outlets 46 and above and below the nozzle 11. In this manner, both the air and the gas enter in an angular relation to the thin sheet of primary fluid fuel, there being two rows of ports on each side thereof feeding in alternate air and gas. In this case, both the compressed air jets and the compressed gas jets serve to impinge upon the thin sheet of primary fluid fuel and deflect the same sidewise in opposite directions, thus further shortening and spreading the flame, while effecting a thorough and intimate mixture of all the combustion components.

The advantages of the present invention result from the general features which are illustrated in the particular apparatus above described, and the process will be claimed in its relation to each, both separately and in combination.

In actual practice it has been proven that the process above described greatly improves the mixing of the fluid fuel and air, reduces the length of flame and spreads the flame into large volume; also that it greatly reduces the amount of excess air required and thus enables a high furnace temperature to be maintained. The heat-conducting metallic contacts between the burners and water tubes, especially in connection with the

partial screening from radiant heat and arranging the burners so that they do not project inside the water wall and are preferably exterior thereof, are found to give the burners a long life, prevent clogging, and avoid injury by strains between the burners and water wall on which they are carried. The blocks close in substantially all the side walls of the furnace chamber and enclose it except as to the burners, which fill the remainder of the wall space.

The structures above described are presented merely to illustrate how the method may be carried into effect. Clearly other apparatus may be used for this purpose and variations in the detail of carrying out the method which depart in particular but not in principle from the specific description given, may be employed while still coming within the scope of the present invention.

With this understanding,

I claim:

1. A method of burning fluid fuel comprising feeding fuel in sheet form into a furnace, feeding air in converging directions on opposite sides of the fuel sheet, and subdividing the air into a plurality of jets staggered on one side with respect to the other.

2. A method of burning fuel in suspension in a furnace which comprises discharging the fuel into the furnace in a fuel stream tending to produce a flame elongated transversely of the direction of fuel discharge, and supplying air for combustion to the furnace in a plurality of high velocity jets directed towards opposite sides of the fuel stream and deflecting different portions thereof away from adjacent portions thereof at substantially the same distance from the point of fuel discharge.

3. A method of burning fuel in suspension in a furnace which comprises discharging one of the combustion components into the furnace in a high velocity stream tending to produce a flame elongated transversely of the direction of discharge of said stream, and supplying another combustion component to the furnace in a plurality of high velocity jets directed towards opposite sides of said stream and deflecting different portions thereof away from adjacent portions thereof at substantially the same distance from the point of discharge of said stream.

4. A method of burning fuel in suspension in a furnace which comprises discharging the fuel into the furnace in a fuel stream tending to produce a flame elongated transversely of the direction of fuel discharge, and supplying air for combustion to the furnace in a plurality of staggered high velocity jets directed towards opposite sides of the fuel stream and deflecting adjacent portions thereof in opposite directions at substantially the same distance from the point of fuel discharge.

5. A method of burning fuel in suspension in a furnace having its walls lined with cooling tubes which comprises discharging the fuel through one wall of said furnace in an elongated fuel stream passing between spaced wall tubes and tending to produce a flame elongated transversely of the direction of fuel discharge, and supplying air for combustion to the furnace in a plurality of high velocity jets directed towards the fuel stream and impinging on different portions thereof at substantially the same distance from the point of fuel discharge.

6. A method of burning finely divided fuel comprising projecting an elongated stream of the fuel into a chamber, and projecting combustion

air against the fuel stream in staggered streams on both sides of the fuel stream.

7. A method of burning finely divided fuel comprising projecting a vertically elongated stream of the fuel into a chamber, and projecting combustion air against the fuel stream in vertically staggered streams on both sides of the fuel stream.

8. The method of maintaining short flame combustion of fluid fuel in a combustion chamber which comprises supplying the fuel and air for combustion in separate high velocity streams, discharging one of said combustion components into the combustion chamber in a stream tending to produce a flame elongated transversely of the direction of discharge of said stream, and separately discharging the other combustion component into the combustion chamber in a plurality of high velocity jets at opposite sides of said transversely elongated stream and impinging on and deflecting different portions of said transversely elongated stream in opposite directions adjacent the point of entrance of said transversely elongated stream into the combustion chamber.

9. The method of maintaining short flame combustion of fluid fuel in a combustion chamber which comprises supplying the fuel and air for combustion in separate high velocity streams, discharging one of said combustion components into the combustion chamber in a substantially flat vertically elongated stream, and separately discharging the other combustion component into the combustion chamber in a plurality of relatively narrow high velocity jets at opposite sides of said vertically elongated stream and impinging on and deflecting different vertical portions of said vertically elongated stream in opposite lateral directions adjacent the point of entrance of said vertically elongated stream into the combustion chamber.

10. The method of maintaining short flame combustion of a fluid fuel in a combustion chamber which comprises discharging the fuel into the combustion chamber in a stream tending to produce a flame elongated transversely of the direction of discharge of said stream, and separately discharging air for combustion into the combustion chamber in a plurality of relatively narrow high velocity jets at opposite sides of said fuel stream and impinging on and deflecting different portions of said fuel stream in opposite directions adjacent its point of entrance into the combustion chamber.

11. The method of burning fluid fuel in a combustion chamber which comprises supplying the fuel and air for combustion in separate high velocity streams, subdividing and discharging the fuel into the combustion chamber in a plurality of staggered streams, and separately subdividing and discharging the air for combustion in a plurality of staggered streams, each impinging on a corresponding fuel stream.

12. The method of burning fluid fuel in a combustion chamber which comprises discharging the fluid fuel into the combustion chamber in a plurality of staggered streams, and separately discharging air for combustion into the combustion chamber in a plurality of relatively high velocity staggered streams intermediate said staggered fuel streams and each impinging on a corresponding fuel stream.

13. The method of burning fluid fuel in a combustion chamber which comprises discharging the fluid fuel into the combustion chamber

in a plurality of relatively high velocity vertically staggered streams, and separately discharging air for combustion into the combustion chamber in a plurality of relatively high velocity vertically staggered streams intermediate said staggered fuel streams and each impinging on a corresponding fuel stream.

14. The method of burning fluid fuel in a combustion chamber which comprises discharging the fluid fuel into the combustion chamber in two series of relatively high velocity spaced streams, the streams of said two series being arranged in staggered relation and discharging in converging directions, and separately discharging air for combustion into the combustion chamber in a plurality of relatively high velocity staggered streams at points intermediate said staggered fuel streams and each impinging on a corresponding fuel stream.

15. The method of maintaining short flame combustion of a fluid fuel in a combustion chamber into which the fuel and air for combustion are discharged in separate high velocity streams through a wall thereof, which comprises discharging one of said components into the combustion chamber in a stream tending to produce a flame elongated transversely of the direction of discharge of said stream, and separately discharging the other component into the combustion chamber in a relatively narrow high velocity jet at an acute angle to the plane of discharge of said transversely elongated stream into the combustion chamber and at a point alongside and closely adjacent to the plane of discharge of said transversely elongated stream and impinging on and deflecting an intermediate portion of said transversely elongated stream away from adjacent portions thereof adjacent its point of discharge into the combustion chamber.

16. The method of burning fluid fuel in a combustion chamber into which the fuel and air for combustion are discharged through a wall thereof, which comprises discharging the fuel in a plurality of relatively high velocity staggered streams at oblique angles to the plane of said wall, and separately discharging air for combustion through said combustion chamber wall in a plurality of relatively high velocity staggered streams intermediate said staggered fuel streams and at oblique angles to the plane of said wall opposite to corresponding fuel streams to cause corresponding fuel and air streams to impinge on one another.

17. The method of burning fluid fuel in a combustion chamber into which the fuel and air for combustion are discharged through a wall thereof, which comprises discharging the fuel in two series of relatively high velocity streams at oblique angles to the plane of said wall, the streams of said two series being arranged in staggered relation and discharging in converging directions, and separately discharging air for combustion through said combustion chamber wall in a plurality of relatively high velocity staggered streams at points intermediate said staggered fuel streams and at oblique angles to the plane of said wall opposite to corresponding fuel streams to cause corresponding fuel and air streams to impinge on one another.

18. The method of burning fluid fuel in a combustion chamber into which the fuel and air for combustion are discharged through a wall thereof, which comprises discharging the fuel in two series of streams at oblique angles to the

plane of said wall, the streams of said two series being arranged in staggered relation and discharging in converging directions, and separately discharging air for combustion through said combustion chamber wall in a plurality of relatively high velocity staggered streams at points intermediate said staggered fuel streams and at converging oblique angles to the plane of said wall opposite to corresponding fuel streams to cause corresponding converging fuel and air streams to impinge on one another at points adjacent said wall.

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