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BURNER MEANS FOR FURNACES

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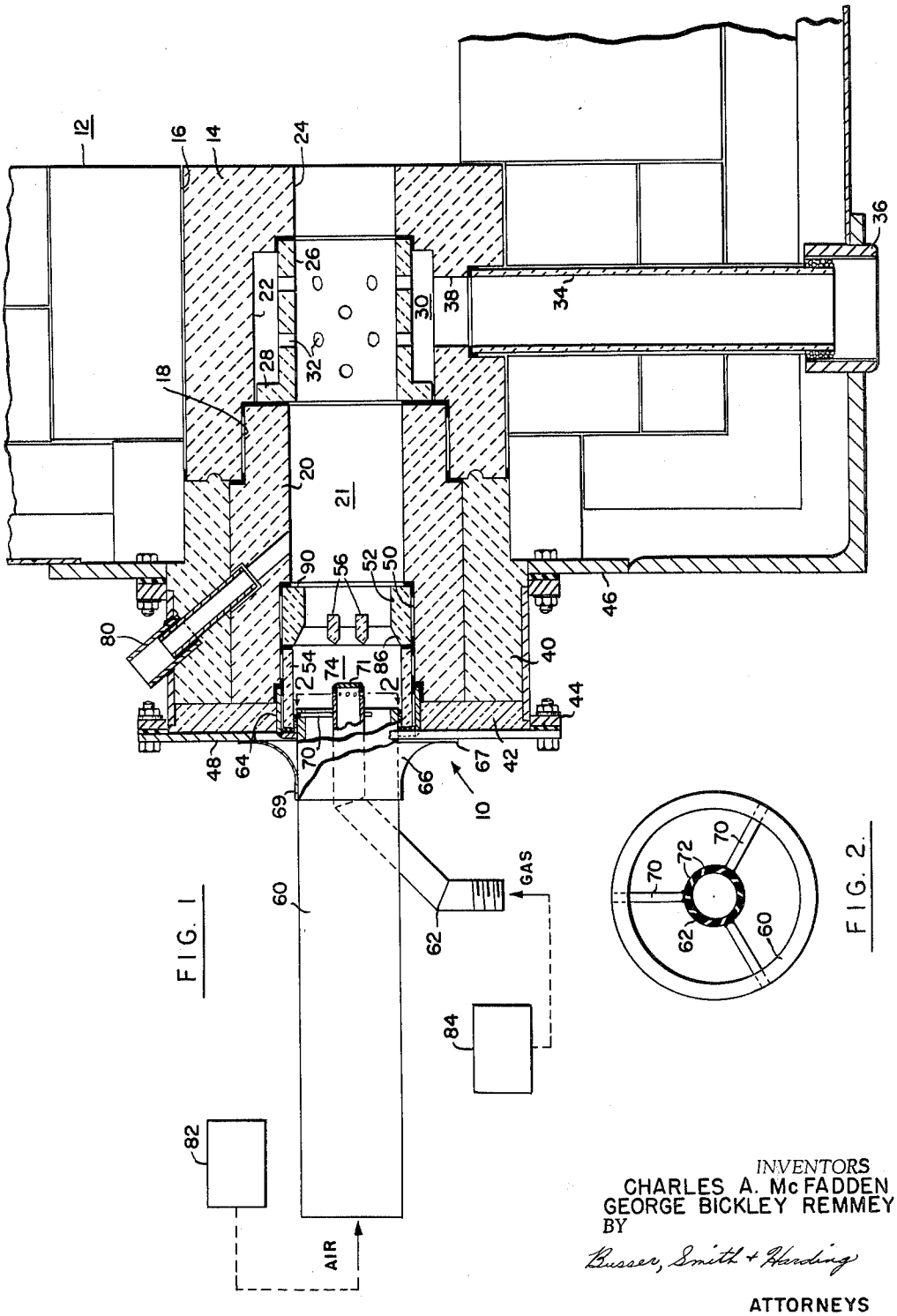


FIG. 1

FIG. 2.

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BURNER MEANS FOR FURNACES

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This invention relates generally to burner means for furnaces and, more particularly, to burner means for use in high temperature fuel fired furnaces.

It is the general object of this invention to increase the flame temperature of burner means of the indicated type. By increasing the flame temperature of the burner means in accordance with this invention, several important advantages of furnace operation may be achieved, namely, higher firing temperatures, increased rate of furnace heating, and improved fuel economy.

It is generally understood and agreed that the ultimate practical flame temperature of a burner will always be several hundred degrees less than the calculated theoretical flame temperature. This is explained by dissociation of the reaction products (primarily carbon dioxide and water vapor), by radiation of heat energy from the mass of flame itself, and because the burning reaction is less than instantaneous as assumed by the theoretical calculation. Since the combustion process requires a certain amount of time and does not in fact occur instantaneously, actual flame temperatures are lower than theoretical calculations would indicate. By way of example, the theoretically calculated flame temperature for a standard natural gas-air mixture will be approximately 3700° F. After correction for dissociation, the flame temperature will be approximately 3570° F. Moreover, in practice, the maximum usable flame temperature under ideal conditions will be from 3300° F. to 3400° F.

Various techniques are used in the art to elevate flame temperatures. These techniques include thorough premixing of the fuel gas with air, oxygen enrichment of the air, electrical boosting of the flame energy, preheating of the combustion air and/or gas, and other techniques. Combustion air preheating offers the best overall economy for flame temperature boosting since the air for combustion can be preheated without expending additional energy by the provision of a recuperator assembly which will extract available heat from the waste gases of the furnace and transfer heat energy to the combustion air stream.

While it is recognized that thorough and intimate premixing of the fuel gas and the combustion air serves to increase the flame temperature, the fuel gas and preheated air cannot be premixed at resultant temperatures above three or four hundred degrees Fahrenheit because of the danger of pre-ignition or flashback of the flame into the piping system.

While the burner to be described is specifically constructed and arranged for use with preheated combustion air at temperatures as high as 2000° F., it will be apparent that it has broader application.

In accordance with the present invention, the flame temperature is increased by a burner arrangement which has improved flame stability and increased flame ignition speed and in which the air and gas are joined together at the nozzle or port of the burner. In accordance with the invention means are provided for effecting an intimate mixture of the fuel gas and combustion air, this intermixing occurring very rapidly. There is also provided a restricting orifice which accelerates and completes the intimate mixing of the fuel gas and combustion air.

The above and other objects and features of the invention will become apparent from the following description

when read in conjunction with the accompanying drawing in which:

FIGURE 1 is a sectional view of a burner in accordance with this invention incorporated in the wall of a furnace; and

FIGURE 2 is a view taken on lines 2—2 of FIGURE 1 and showing a detail of the invention.

While the present invention as described below relates primarily to gas-air burners it is to be noted that the same general principles will also apply to distillate oil fuel burners. The oil fuel burners would require means for atomizing the fuel oil prior to its mixture with the combustion air. The following description will be concerned with a gas-air type of burner for use with a kiln such as that shown in U.S. Patent No. 3,055,652. In this kiln, a plurality of burner assemblies are mounted in the vertical walls thereof to direct their heating gas streams so as to encircle the ware to be heated.

Referring to FIGURE 1, the burner assembly is indicated generally at 10 and is mounted in the kiln vertical wall indicated generally at 12. The furnace wall 12 is provided with suitable layers of refractory blocks in accordance with well known techniques of furnace construction. The vertical wall 12 is provided with a rectangular block 14 of refractory material positioned in a rectangular opening 16 in the inner layer of blocks in wall 12. Block 14 has a recess 18 in the outer end thereof adapted to receive the downstream end of a burner block 20 which extends to the exterior of the kiln and defines a combustion chamber 21 therein. Block 14 is provided with a cavity 22 in a medial portion thereof and a bore 24 at the downstream end thereof. The cavity 22 provides communication between the recess 18 and the end bore 24. A cylindrical diffuser member 26 is mounted in central cavity 22 and defines at the inner wall thereof a passageway between chamber 21 and bore 24. The inner wall of diffuser member 26, the combustion chamber 21 and the bore 24 are all in axial alignment. Diffuser member 26 has a radially extending flange 28 which positions the diffuser member within cavity 22 so that the diffuser member outer wall is spaced from the wall of the cavity 22 to define an annular chamber 30 therebetween. Diffuser member 26 has a plurality of radial openings 32 extending therethrough and circumferentially and longitudinally spaced thereabout. Openings 32 serve to meter or control the amount of air passing from chamber 30 through the diffuser member 26 into the products of combustion passing from the burner as will be described hereafter. Diffuser member 26 is made of a material which can withstand extreme thermal shock and stress.

A ceramic conduit 34 is mounted in the wall of the kiln to extend from a coupling member 36 to a passage 38 in the block 14, passageway 38 communicating with the annular chamber 30. As is described in said patent, coupling 36 is connected to an air supply for the kiln. Accordingly, conduit 34 and passageway 38 provide a path for the flow of air from the air supply to the annular chamber 30 for diffusion with the burner products of combustion within diffuser member 26.

While the burner assembly in accordance with this invention is described herein as involving a diffuser ring and a diffusion air supply, it is to be noted that the burner assembly in accordance with this invention is usable per se with or without a diffusion air system.

The burner block 20 is mounted on one end within the recess 18 and is enclosed by a suitable ramming mix 40 and insulation 42. A rectangular burner mounting bracket 44 is secured to the outer lining 46 of the kiln and comprises a front plate 48.

Burner block 20 has an annular recess 50 in the upstream end thereof. Mounted in the recess 50 adjacent

the chamber 21 is a centering ring 52 of a high temperature refractory material. Mounted in recess 50 adjacent ring 52 and upstream thereof is a tube 54 of a temperature resistant ceramic material. Ring 52 has a pair of bars 56 extending in parallel relation transversely thereacross. These bars 56 may be termed flame holders for reasons which will appear hereafter. The bars 56 are also made of a high temperature refractory material.

A burner nozzle assembly is mounted to extend through an opening in the front plate 48 and communicate with the upstream end of the tube 54. The burner nozzle assembly comprises an air pipe 60, a gas pipe 62 and a cup-shaped mounting member 64. Member 64 is mounted on the end of pipe 60 and is adapted to contain the upstream end of tube 54 as is shown in the drawing. By this arrangement, the downstream end of air pipe 60 is supported to extend within the tube 54. An expansion piece 66 is mounted on the exterior of pipe 60 in the region where it projects through the front plate 48. In the assembled position, the expansion piece 66 has a plate portion 67 which is secured to the front plate 98 as by welding and a cylindrical tube portion 69 which is secured to the exterior of pipe 60 to thereby enclose the burner nozzle assembly at its junction with the kiln. The expansion pipe is made of a thin heat resistant steel and is flexible to permit movement of the air pipe 60 as a result of thermal expansion.

The gas pipe 62 has a portion which is threaded to receive a suitable fitting which is connected to the gas supply, a medial portion which extends into the air pipe at an angle relative to the axis thereof and a terminal portion extending longitudinally of the air pipe 60 at its downstream end. The terminal portion of the gas pipe 62 and the air pipe 60 are mounted so that their axes are coincident by means of three radial centering pins 70 as is shown in FIGURE 2. The terminal portion of the gas pipe extends beyond the downstream end of the air pipe 60 and is closed by a disc 71. As is best shown in FIGURE 2, a plurality of outlet ports 72 are provided in the gas pipe 62 adjacent the disc 71, these ports extending transversely through the gas pipe. The ports 72 extend through the pipe at an angle relative to radii of the gas pipe and are spaced circumferentially thereabout. The ports 72 are located downstream of the end of the air pipe 60 to provide a communication between the gas pipe 62 and the chamber 74 within tubular member 54. This chamber may be termed the mixing chamber since it is here that the air and gas are intermixed initially as will be described hereafter.

The parts of the nozzle assembly which will be subjected to high temperature during operation are made of thermal resistant metal. Thus, the air pipe 60, the portions of the gas pipe 62 within the air pipe, the pins 70 and disc 71 may be made of Inconel.

The burner is provided with the usual pilot connection 80 for ignition of the fuel-air mixture in the combustion chamber 21.

In the operation of the burner means, air is supplied to pipe 60 under pressure by suitable means indicated schematically by block 82 and a gaseous fuel is supplied to the gas pipe under pressure by a suitable means indicated schematically by block 84. The air may be preheated or at room temperature, however, it will be apparent that the combustion rate will accelerate as the air temperature is raised as was discussed previously.

The air under pressure flows into the burner proper at mixing chamber 74 through an annular orifice provided between the exterior of the gas pipe 62 and the inner wall of the air pipe 60, the air flow being directed along the longitudinal axis of the burner. The fuel gas under pressure is directed from the outlet ports 72 into the chamber 74 in a direction transversely to the stream of air flow. Accordingly, the small gas streams passing from the ports 72 slice through the air stream causing almost instantaneous mixing of the fuel gas and the combustion air in the chamber 74. The angular port arrangement increases the turbulence and enhances the mixing action. The mixed gases then flow into the restricted orifice provided by the centering ring 52 and the bars 56, these members serving to accelerate and assist the mixing action. It is noted that the centering ring 52 has a tapered inlet portion 86 which converges in the direction of flow through the burner and that the bars 56 extend across the centering ring in this region and extend in the direction of flow. Each bar 56 has an upstream end which is substantially knife-shaped or tapered so that the thickness of the bars increases in the direction of flow through the burner. This configuration serves to form a restriction to flow and to create a back pressure in the mixing chamber which enhances the mixing action by causing turbulence and eddy currents therein. The gas-air mixture then passes from the restricting orifice through the centering ring 52 and into the combustion chamber 21. As shown in FIGURE 1, the cylindrical internal wall of the centering ring 52 is about the same as the internal diameter of the air pipe 60 whereby there will not be any excessive blockage of the flow as the gases pass axially from the air pipe 60 through the orifice. It is noted that the combustion chamber 21 is larger than the downstream end of the centering ring 52, there being provided an exposed flat annular portion 90 at the junction of these chambers. Moreover, the downstream ends of the bars 56 are flat. Thus, low pressure areas are formed in the region downstream of these sharp discharge areas of the bars 56 and in the centering ring 52. These low pressure regions serve to enhance the flame retention properties of the burner and hold the flame toward the upstream portion of the burner. It is noted that the flame proper will occupy the combustion chamber 21 and the combustion reaction and flame are completed before the gases exit from the combustion chamber, the flame front starting in the vicinity of the bars 56.

The products of combustion leave combustion chamber 21 and pass into the central opening in diffuser member 26. The secondary air passes from conduit 34 into annular chamber 30 from which the air passes through openings 32. Diffuser member 26 serves to meter the air and cause it to mix in small jets with the fully burned combustion products passing from the combustion chamber 21. The diffuser member 26 insures that there is a thorough mixture or diffusion of the air and the products of combustion by reason of the plurality of openings 32 which direct the small jets of air into the products of combustion. Since the air is at room temperature which is considerably lower than the burner combustion products, the air will serve to lower the temperature of the gas stream passing into the furnace heating chamber in accordance with objectives discussed in said patent.

The burner in accordance with this invention will produce higher than normal flame temperatures with maximum flame temperature being achieved by the use of preheated combustion air. The higher flame temperatures are achieved by reason of the restricting orifice construction and by the construction whereby the fuel gas is directed transversely into the air, the result of these constructions being the complete intimate mixing of the fuel gas and the combustion air. The flame front initiates in the vicinity of the flame retaining bars 56 but the position of the flame front will shift downstream to some extent as the burner is adjusted from low fire input to high fire input. However, the intimacy of the mixing and the stability of flame retention are such that even at extreme high fire inputs, the flame is still maintained in the region of the flame retention bars.

Another feature of the invention is that the nature of the flame produced by the burner has all the desirable properties of the flame produced by a pre-mix burner in which the fuel gas and air are thoroughly and mechanically mixed prior to being delivered to the burner. The important and desirable characteristics of this flame are

its extreme high flame temperature, its stability over a wide operating range, the sharp clear blue color without incandescence from unburned carbonaceous particles and the elimination of noxious intermediate combustion products. These desirable characteristics combine to produce maximum combustion and thermal efficiency and, as a result, the flame temperature more closely approaches the maximum theoretical flame temperature of the gas being burned.

Also, the burner in accordance with this invention exhibits combustion characteristics similar to a pre-mix burner which is not the case with the conventional nozzle mixing burner. The conventional nozzle burner will produce a long flame whereas the burner disclosed herein produces a short flame. Since flame length and flame temperature are related, the flame temperature being lower for a longer flame, the conventional nozzle mixing burner cannot achieve the flame temperatures of the burner in accordance with this invention.

It will be apparent that various changes may be made in the construction and arrangement of parts without departing from the scope of the invention wherefore it is not desired to be limited except as set forth by the following claims.

What is claimed is:

1. A burner assembly for the heating of furnaces comprising a burner block adapted to be mounted in a furnace wall and defining a combustion chamber therein, a burner nozzle assembly mounted on the furnace and including an air pipe and a gas pipe having a portion within said air pipe extending along the axis of said air pipe and a plurality of gas outlet ports therein extending in a plane substantially perpendicular to the axis of said air pipe, means for supplying air under pressure to said air pipe whereby the air flows through said air pipe and along the exterior of said gas pipe, means for supplying fuel gas under pressure to said gas pipe whereby fuel gas flows through said gas pipe and said ports to enter the air stream perpendicularly to the direction of air flow so that thorough intermixing of air and gas occurs, means defining a mixing chamber arranged to receive the intermixing air and gas, and orifice means providing communication between said mixing chamber and said combustion chamber, said orifice means being constructed to provide a restriction to flow from said mixing chamber and including a member defining a passage a portion of which converges in the direction of flow of the gas-air mixture and a bar extending transversely across said orifice passage and elongated in the direction of flow thereby to restrict flow from said mixing chamber, said mixing chamber being immediately adjacent the upstream end of said orifice means, said gas outlet ports being located within said mixing chamber and close to said restricted orifice passage so that the gas stream entering said mixing chamber is subjected to a back pressure provided by said restricted orifice passage which produces turbulence and eddy currents in the region of the gas entrance to enhance the mixing action of the gas and air within said mixing chamber.

2. A burner assembly according to claim 1 wherein said bar has a tapered upstream end increasing in width in the direction of gas-air flow.

3. A burner assembly according to claim 2 wherein said bar has a downstream end extending transversely to the direction of gas-air flow whereat low pressure occurs for retarding the flow of the gas-air mixture.

4. The burner assembly according to claim 1 including another flame holder bar extending transversely across the orifice passage and having a tapered upstream end increasing in width in the direction of flow through the orifice means.

5. A burner assembly according to claim 1 wherein said gas outlet ports extend at an angle relative to the radii of the gas pipe, and are spaced circumferentially about the gas pipe.

6. A burner assembly according to claim 5 wherein the downstream end of said gas pipe extends transversely to provide a low pressure region as gas flows therepast.

7. A burner assembly according to claim 1 wherein an annular air passageway is formed between the exterior of the gas pipe and the inner wall of the air pipe, said annular passage, said mixing chamber, said orifice means and said combustion chamber being arranged in axial alignment, said orifice means having a conical wall portion converging in the direction of gas flow and joining with a cylindrical wall portion, said cylindrical wall portion having an internal diameter approximating the internal diameter of said air pipe.

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