(12) UK Patent Application (19) GB (11) 2 079 925 A

(21) Application No 8117154
(22) Date of filing 4 Jun 1981
(30) Priority data
(31) 156309
156308
(32) 4 Jun 1980
(33) United States of America (US)
(43) Application published 27 Jan 1982
(51) INT CL[3] F23D 15/00
(52) Domestic classification F4T GC
(56) Documents cited
GB 1383505
GB 1271358
GB 473096
(58) Field of search F4T

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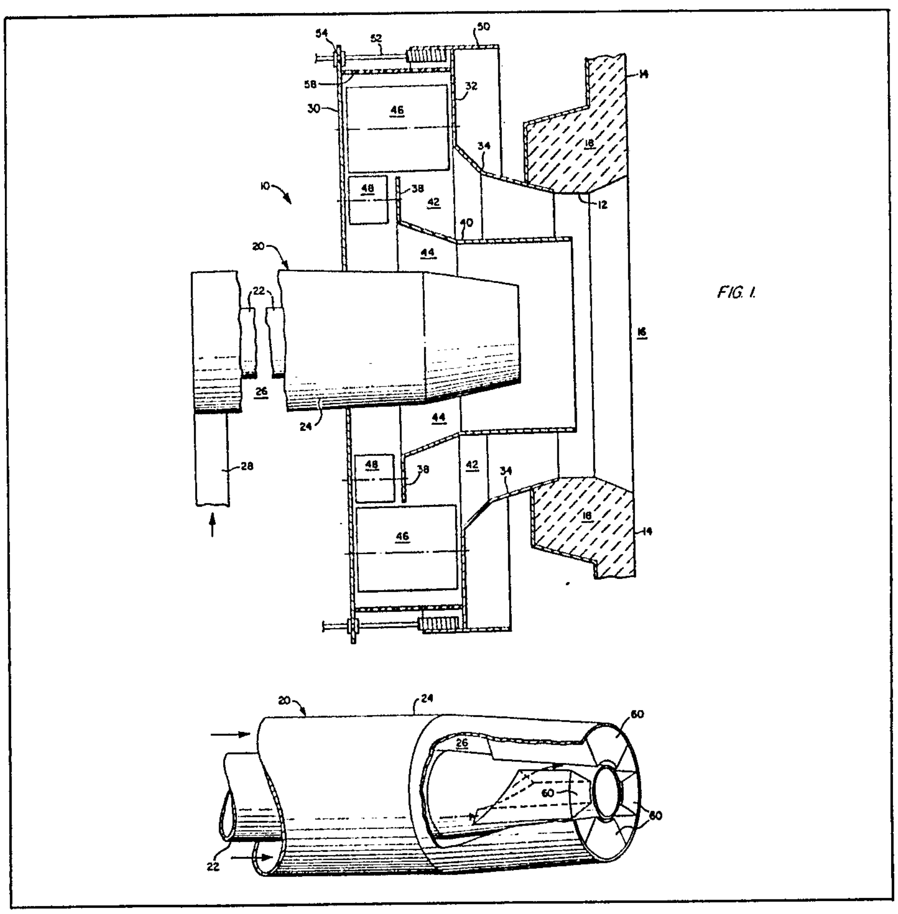
(54) Dual register, split stream burner assembly

(57) A burner assembly 10 in which an inlet is located at one end of an annular passage 26 for receiving fuel, and an outlet is located at the other end of the passage for discharging the fuel. A plurality of members 60 are disposed within the annular passage for splitting up the fuel discharging from said outlet so that, upon ignition of said fuel, a plurality of flame patterns are formed. A register assembly is provided which includes an enclosure for receiving air and a divider 40 for directing the air from the enclosure towards the outlet in two parallel paths extending around the burner. Registers 46, 48 are disposed in each of the paths for regulating the quantity of air flowing through the paths. According to an alternative embodiment, a divider cone is disposed within the annular passage for dividing the stream of fuel passing through the passage into two parallel coaxial streams and additional secondary air is introduced into the outer stream.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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FIG. 1.

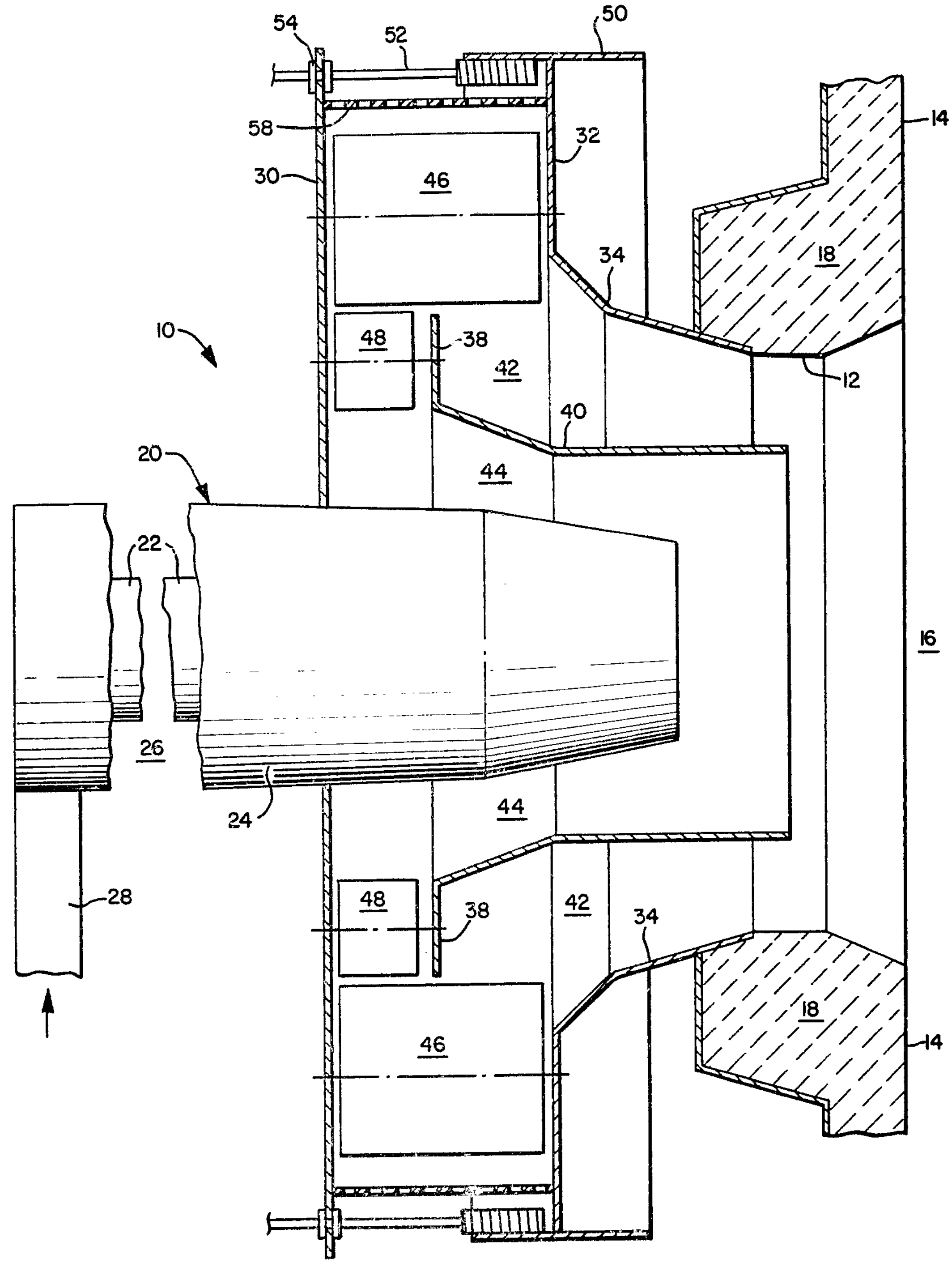


FIG. 2.

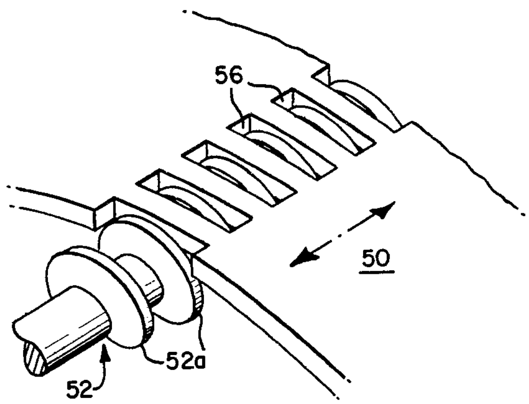


FIG. 3.

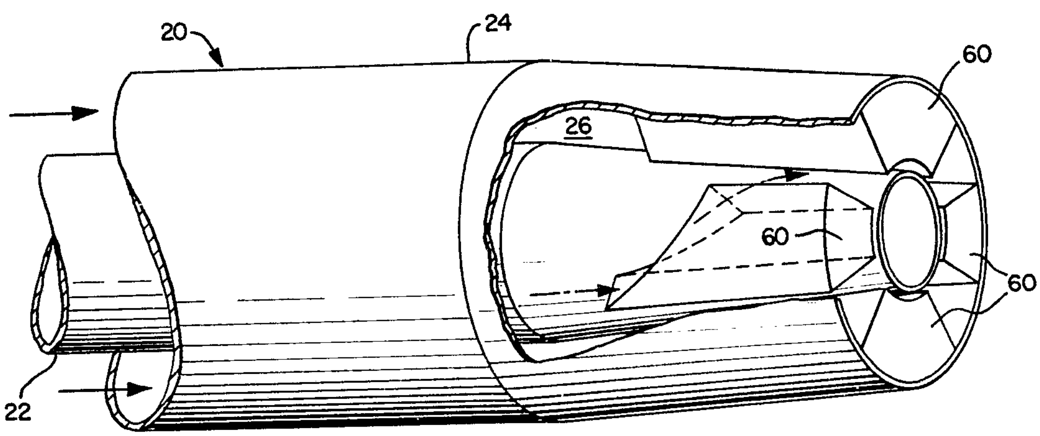


FIG. 4.

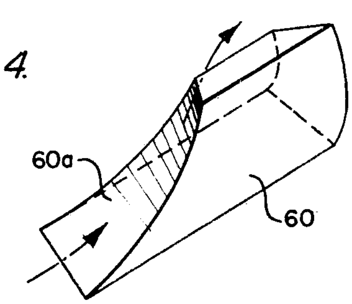
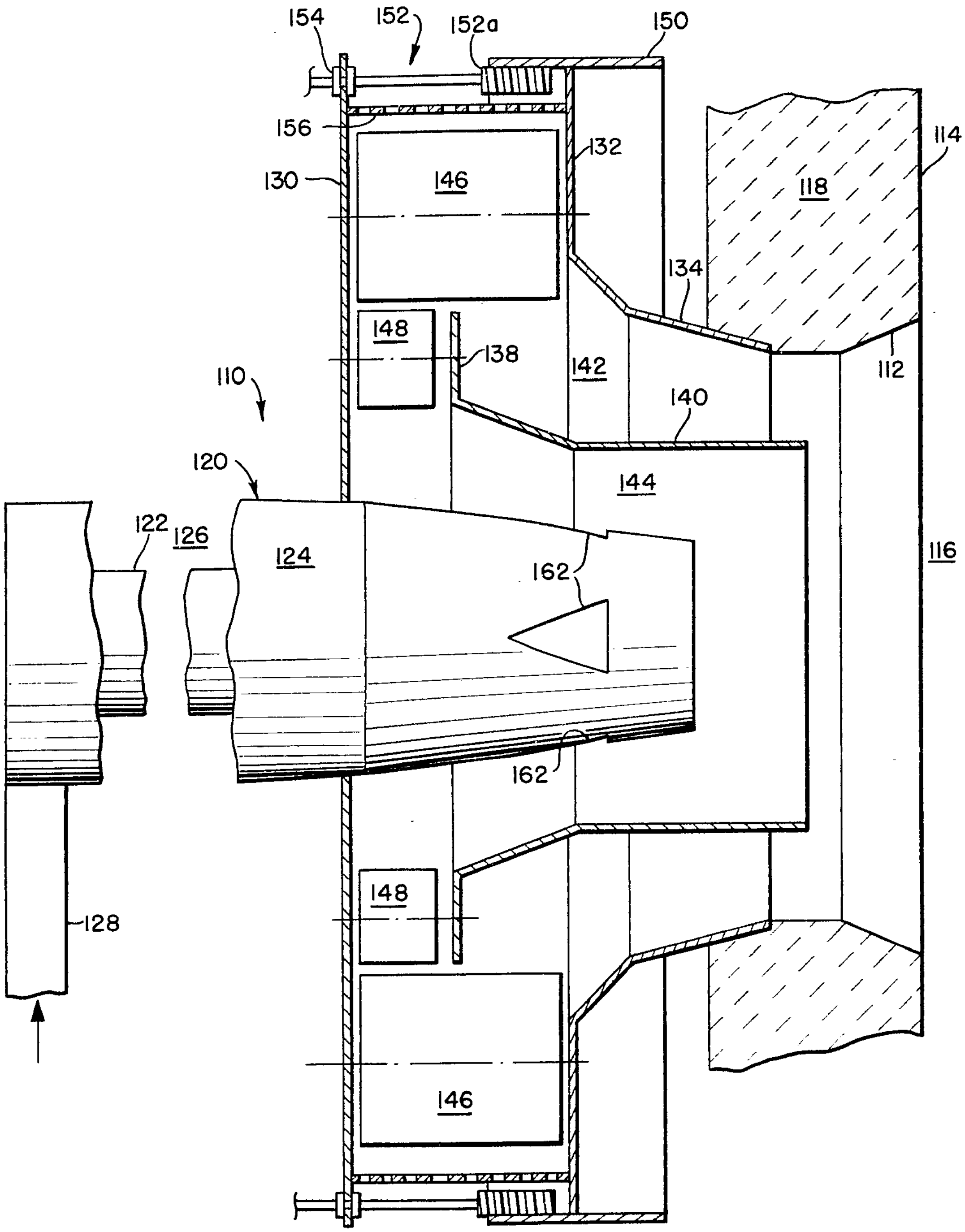


FIG. 5.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152a
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156
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FIG. 7.

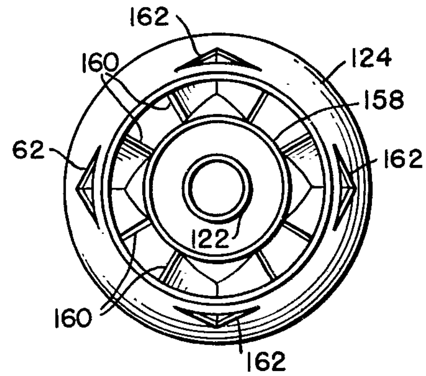


FIG. 6.

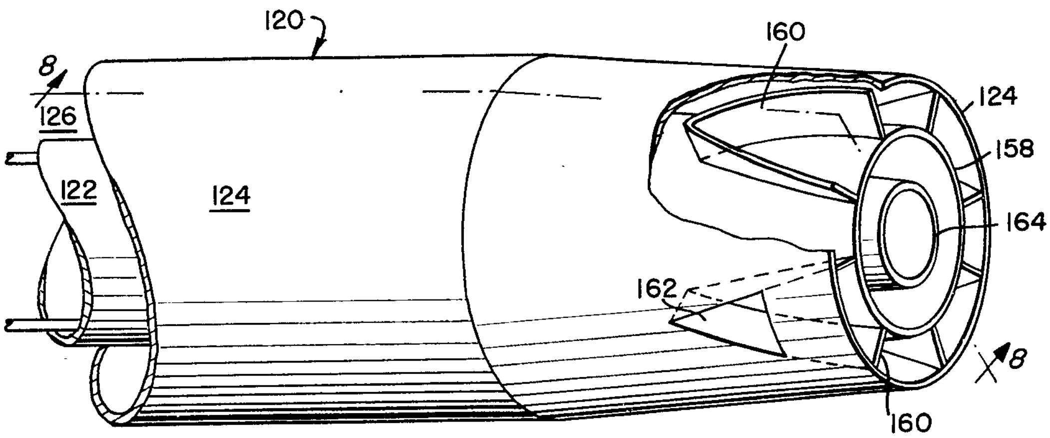
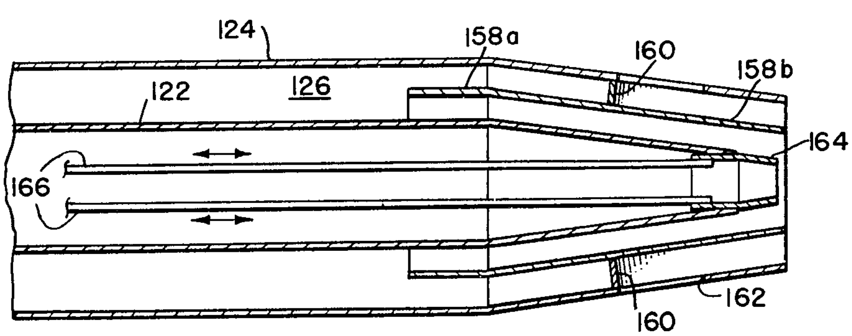


FIG. 8.



SPECIFICATION

Dual register, split stream burner assembly

Background of the Invention

This invention relates generally to a burner assembly and more particularly to an improved burner assembly which operates in a manner to reduce the formation of nitrogen oxides as a result of fuel combustion.

Considerable attention and efforts have recently been directed to the reduction of nitrogen oxides resulting from the combustion of fuel, and especially in connection with the use of coal in the furnace sections of relatively large installations such as vapor generators and the like. In a typical arrangement for burning coal in a vapor generator, several burners are disposed in communication with the interior of the furnace and operate to burn a mixture of air and pulverized coal. The burners used in these arrangements are generally of the type in which a fuel air mixture is continuously injected through a nozzle so as to form a single relatively large flame. As a result, the surface area of the flame is relatively small in comparison to its volume, and therefore the average flame temperature is relatively high. However, in the burning of coal, nitrogen oxides are formed by the fixation of atmospheric nitrogen available in the combustion supporting air, which is a function of the flame temperature. When the flame temperature exceeds 2800°F, the amount of fixed nitrogen removed from the combustion supporting air rises exponentially with increases in the temperature. This condition leads to the production of high levels of nitrogen oxides in the final combustion products, which causes severe air pollution problems.

Nitrogen oxides are also formed from the fuel bound nitrogen available in the fuel itself, which is not a direct function of the flame temperature, but is related to the quantity of available oxygen during the combustion process.

In view of the foregoing, attempts have been made to suppress the burner and flame temperatures and reduce the quantity of available oxygen during the combustion process and thus reduce the formation of nitrogen oxides. Attempted solutions have included techniques involving two stage combustion, flue gas recirculation, the introduction of an oxygen-deficient fuel-air mixture to the burner and the breaking up of a single large flame into a plurality of smaller flames. However, although these attempts singularly may produce some beneficial results they have not resulted in a reduction of nitrogen oxides to minimum levels. Also, these attempts have often resulted in added expense in terms of increase construction costs and have lead to other related problems such as the production of soot and the like.

Summary of the Invention

It is therefore an object of the present invention to provide a burner assembly which operates in a manner to considerably reduce the production of nitrogen oxides in the combustion of fuel without any significant increase in cost or other related problems.

It is a more specific object of the present invention to provide a burner assembly in which the surface area of the flame per unit volume is increased which results in a greater flame radiation, a lower flame temperature, and a shorter residence time of the gas component within the flame at maximum temperature.

It is a more specific object of the present invention to provide a burner assembly of the above type in which the fuel is passed through an annular passage and is split into separate streams by a plurality of members disposed in the annular passage.

It is a still further object of the present invention to provide a burner assembly of the above type in which the stoichiometric combustion of the fuel is regulated to reduce the quantity of available oxygen during the combustion process and achieve an attendant reduction in the formation of nitrogen oxides.

Another more specific object of the present invention is to provide a burner assembly of the above type in which secondary air is directed toward the burner outlet in two parallel paths with register means being disposed in each path for individually controlling the flow of air through each path.

It is a more specific object of the present invention to provide a burner assembly of the above type in which the fuel is passed through an annular passage and is divided into two separate coaxial streams with one of the streams being split up to form a plurality of flame patterns.

Still another object of the present invention is to provide a burner assembly of the above type in which a stream of fuel and air is introduced into the burner in a tangential direction.

Toward the fulfillment of these and other objects, the burner assembly of the present invention includes an annular passage having an inlet located at one end thereof for receiving fuel, and an outlet located at the other end of the passage for discharging the fuel. A plurality of members are disposed in the path of the outer stream for splitting up the stream so that, upon ignition of the fuel, a plurality of flame patterns are formed. Secondary air is directed towards the outlet in two parallel paths extending around the burner, and a plurality of register vanes are disposed in each of the paths for regulating the quantity and swirl of the air flowing through the paths. According to an alternative embodiment, a divider cone is disposed within the annular passage for dividing the stream of fuel passing through the passage into two parallel coaxial streams and additional secondary air is introduced into the outer stream.

Brief Description of the Drawings

Fig. 1 is a sectional view depicting the burner assembly of the present invention;

Fig. 2 is a partial perspective view of a component of the burner assembly of Fig. 1;

Fig. 3 is an enlarged elevational view, partially cut-away, of the burner portion of the assembly of the present invention;

Fig. 4 is a perspective view of a component of the burner portion of Fig. 3;

Fig. 5 is a sectional view depicting the burner assembly according to an alternative embodiment of the present invention;

Fig. 6 is an enlarged elevational view, partially cut-away, of the nozzle of the assembly of Fig. 5;

Fig. 7 is a front elevational view of the nozzle of Fig. 6; and

Fig. 8 is a longitudinal cross-sectional view of the nozzle of Fig. 6.

Description of the Preferred Embodiments

Referring in general to the embodiment of Figs. 1—4 of the drawings and specifically to Fig. 1, the reference numeral 10 refers in general to a burner assembly which is disposed in axial alignment with a through opening 12 formed in a front wall 14 of a conventional furnace. It is understood that the furnace includes a back wall and side walls of an appropriate configuration to define a combustion chamber 16 immediately adjacent the opening 12. Also similar openings are provided in the furnace front wall 14 for accommodating additional burner assemblies identical to the burner assembly 10. The inner surface of the wall 14 as well as the other walls of the furnace are lined within an appropriate thermal insulation material 18 and, while not specifically shown, it is understood that the combustion chamber 16 can also be lined with vertically extending boiler tubes through which a heat exchange fluid, such as water, is circulated in a conventional manner for the purposes of producing steam.

It is also understood that a vertical wall is disposed in a spaced parallel relationship with the furnace wall 14 in a direction opposite that of the furnace opening 12 along with correspondingly spaced top, bottom and side walls to form a plenum chamber, or wind box, for receiving combustion supporting air, commonly referred to as "secondary air", in a conventional manner.

The burner assembly 10 includes a nozzle 20 having an inner tubular member 22 and an outer tubular member 24. The outer tubular member 24 extends over the inner tubular member 22 in a coaxial, spaced relationship thereto to define an annular passage 26 which extends towards the furnace opening 12.

A tangentially disposed inlet 28 communicates with the outer tubular member 24 for introducing a stream of fuel into the annular passage 26 as will be explained in further detail later.

A pair of spaced annular plates 30 and 32 extend around the burner 20, with the inner edge of the plate 30 terminating on the outer tubular member 24. A liner member 34 extends from the inner edge of the plate 32 and in a general longitudinal direction relative to the burner 20 and terminates adjacent the insulation material 18 just inside the wall 14. An additional annular plate 38 extends around the burner 20 in a spaced, parallel relation with the plate 30. An air divider sleeve 40 extends from the inner surface of the plate 38 and between the liner 34 and the nozzle 20 in a substantially parallel relation to the burner 20 in a substantially parallel relation to the burner 20 and the liner 34 to define two air flow passages 42 and 44.

A plurality of outer register vanes 46 are pivotally mounted between the plates 30 and 32 to control the swirl of secondary air from the wind box to the air flow passages 42 and 44. In a similar manner a plurality of inner register vanes 48 are pivotally mounted between the plates 30 and 38 to further regulate the swirl of the secondary air passing through the annular passage 44. It is understood that although only two register vanes 46 and 48 are shown in Fig. 1, several more vanes extend in a circumferentially spaced relation to the vanes shown. Also, the pivotal mounting of the register vanes 46 and 48 may be done in any conventional manner, such as by mounting the vanes on shafts (shown schematically in Fig. 1) and journalling the shafts in proper bearings formed in the plates 30, 32 and 38. Also, the position of the vanes 46 and 48 may be adjustable by means of cranks or the like. Since these types of components are conventional they are not shown in the drawings nor will be described in any further detail.

The quantity of air flow from the wind box into the register vanes 46 is controlled by movement of a sleeve 50 which is slidably disposed on the outer periphery of the plate 32 and is movable parallel to the longitudinal axis of the burner nozzle 20. An elongated worm gear 52 is provided for moving the sleeve 50 and is better shown in Fig. 2. The worm gear 52 has one end portion suitably connected to an appropriate drive means (not shown) for rotating the worm gear and the other end provided with threads 52a. The worm gear 52 extends through a bushing 54 (Fig. 1) which is attached to the plate 30 to provide rotatable support. The threads 52a of the worm gear 52 mesh with appropriate apertures 56 formed in the sleeve 50 so that, upon rotation of the worm gear, the sleeve moves longitudinally with respect to the longitudinal axis of the burner 20 and across the air inlet defined by the plates 30 and 32. In this manner, the quantity of combustion supporting air from the wind box passing through the wind box passages 42 and 44 can be controlled by axial displacement of the sleeve 50. A perforated air hood 58 extends between the plates 30 and 32 immediately downstream of the sleeve 50 to permit the air flow to the burner 20 to be independently determined by means of static pressure differential movements, in a conventional manner.

As shown in Fig. 3, which depicts the details of the burner nozzle 20, the end portion of the outer tubular member 24 and the corresponding end portion of the inner tubular member 22 are tapered slightly radially inwardly toward the furnace opening 12. A plurality of divider blocks 60 are circumferentially spaced in the annular space between the tubular members 22 and 24 in the outlet end portion of the burner. As shown in Fig. 3, four such blocks are spaced at 90° intervals and extend from the outlet to a point approximately midway the tapered portions of the members 22 and 24. The side portion of the blocks 60 are curved to complement the corresponding curved surfaces of the tubular members 22 and 24 and the blocks are tapered radially inwardly. As shown in Figure 4, the leading end portion of each block 60 is configured in a curved relationship so that the fuel flowing in the passage 26 and impinging against the leading ends of the blocks 60 will be directed into the adjacent spaces defined between the blocks to facilitate the splitting of the fuel stream into four separate streams.

In operation of the burner assembly of the present invention, the movable sleeve 50 associated with each burner is adjusted during initial start up to accurately balance the air to each burner. After the initial balancing, no further movement of the sleeves 50 are needed since normal control of the secondary air to the burners is accomplished by operation of the outer register vanes 46.

Fuel, preferably in the form of pulverized coal suspended or entrained within a source of primary air, is introduced into the tangential inlet 28 where it swirls through the annular chamber 26 and is ignited by suitable igniters (not shown) appropriately positioned with respect to the burner nozzle 20. The stream of fuel and air encounters the blocks 60 at the end portion of the nozzle 20 whereby the stream is split into four equally spaced streams which, upon ignition, form four separate flame patterns. The igniters are shut off after steady state combustion has been achieved and secondary air from the wind box is admitted through the perforated hood 58 and into the inlet between the plates 30 and 32. The axial and radial velocities of the air is controlled by the register vanes 46 and 48 as it passes through the air flow passages 42 and 44 and into the furnace opening 12 for mixing with the fuel from the burner 20.

As a result of the foregoing, several advantages result from the burner assembly of the present invention. For example, since the pressure drop across the perforated air hoods 58 associated with burner assemblies can be equalized by balancing the secondary air flow to each burner by initially adjusting the sleeves 50, a substantially uniform gas distribution can be obtained across the furnace. This also permits a common wind box to be used and enables the unit to operate at lower excess air with significant reductions in both nitrogen oxides and carbon monoxides. Also, the provision of separate register vanes 46 and 48 for the outer and inner air flow passages 42 and 44 enables secondary air distribution as well as flame shape to be independently controlled resulting in a significant reduction of nitrogen oxides, and a more gradual mixing of the primary air coal stream with the secondary air since both streams enter the furnace on parallel paths with controlled mixing.

Further, the provision of multiple flame patterns results in a greater flame radiation, a lower average flame temperature and a shorter residence time of the gas components within the flame at a maximum temperature, all of which, as stated above, contribute to reduce the formation of nitric oxides.

Also, the use of the curved surface 60a on the blocks results in a more streamline flow of the fuel stream before it discharges from the outlet of the nozzle 20. Still further, the provision of the tangential inlet 26 provides excellent distribution of the fuel around the annular space 26 in the burner 20 resulting in more complete combustion and reduction of carbon loss and making it possible to use individual burners with capacities significantly higher than otherwise could be used.

An alternative embodiment of the present invention is depicted in Figs. 5—8. Referring specifically to Fig. 5 the reference numeral 110 refers in general to a burner assembly which is disposed in axial alignment with a through opening 112 formed in a front wall 114 of a conventional furnace. It is understood that the furnace includes a back wall and a side wall of an appropriate configuration to define a combustion chamber 116 immediately adjacent the opening 112. Also, similar openings are provided in the furnace front wall 114 for accommodating additional burner assemblies identical to the burner assembly 10. The inner surface of the wall 114 as well as the other walls of the furnace are lined within an appropriate thermal insulation material 118 and, while not specifically shown, it is understood that the combustion chamber 116 can also be lined with boiler tubes through which a heat exchange fluid, such as water is circulated in a conventional manner for the purposes of producing steam.

It is also understood that a vertical wall is disposed in a parallel relationship with the furnace wall 14 along with connecting top, bottom, and side walls to form a plenum chamber, or wind box, for receiving combustion supporting air, commonly referred to as "secondary air", in a conventional manner.

The burner assembly 110 includes a nozzle 120 having an inner tubular member 122 and an outer tubular member 124. The outer tubular member 124 extends over the inner tubular member 122 in a coaxial, spaced relationship thereto to define an annular passage 126 which extends towards the furnace opening 112. A tangentially spaced inlet 128 communicates with the outer tubular member 124 for introducing a stream of fuel and air into the annular passage 126 as will be explained in further detail later.

A pair of spaced annular plates 130 and 132 extend around the nozzle 120, with the inner edge of the plate 130 terminating on the outer tubular member 124. A liner member 134 extends from the inner edge of the plate 132 and in a general longitudinal direction relative to the nozzle 120 and terminates adjacent the insulation material 118 just inside the wall 114. An additional annular plate 138 extends around the nozzle 120 in a spaced, parallel relation with the plate 130. An air divider sleeve 140 extends from the inner surface of the plate 138 and between the liner 134 and the nozzle 120 in a substantially parallel relation to the nozzle and the liner 134 to define two air flow passages 142 and 144.

A plurality of outer register vanes 146 are pivotally mounted between the plates 130 and 132 to control the swirl of secondary air from the wind box to the air flow passages 142 and 144. In a similar manner a plurality of inner register vanes 148 are pivotally mounted between the plates 130 and 138 to further regulate the swirl of the secondary air passing through the annular passage 144. It is understood that although only two register vanes 146 and 148 are shown in Fig. 5, several more vanes extend in a circumferentially spaced relation to the vanes shown. Also, the pivotal mounting of the vanes 146 and 148 may be done in any conventional manner, such as by mounting the vanes on shafts (shown schematically) and journalling the shafts in proper bearings formed in the plates 130, 132 and 138. Also, the position of the vanes 146 and 148 may be adjustable by means of cranks or the like. Since these types of components are conventional they are not shown in the drawings nor will be described in any further detail.

It is understood that the quantity of air flow from the wind box into the vanes 146 is controlled by movement of a sleeve 150 which is slidably disposed on the outer periphery of the plate 132 and is movable parallel to the longitudinal axis of the nozzle 120. This movement can be achieved by using an elongated worm gear and associated apparatus in a manner identical to that disclosed in the previous embodiment. Thus, the quantity of combustion supporting air from the wind box passing rhrough the air flow passages 142 and 144 can be controlled by axial displacement of the sleeve 150. A perforated air hood 156 extends between the plates 130 and 132 immediately downstream of the sleeve 150 to permit determination of the secondary air flow to the burner as in the previous embodiment.

As shown in Figs. 6—8, which depict the details of the nozzle 120, the end portion of the outer tubular member 124 and the corresponding end portion of the inner tubular member 122 are tapered slightly radially inwardly toward the furnace opening 112. A divider cone 158 extends between the inner tubular member 122 and the outer tubular member 124. The divider cone 158 has a straight portion 158a (Fig. 8) which extends between the straight portions of inner tubular member 122 and the outer tubular member 124, and a tapered portion 158b which extends between the tapered portions of the tubular members for the entire lengths thereof. The function of the divider cones 158 will be described in greater detail later.

A plurality of V-shaped splitters 160 are circumferentially spaced in the annular space between the outer tubular member 124 and the divider cone 158 in the outlet end portion of the nozzle 120. As shown in Figs. 6 and 7, four such splitters 160 are spaced at 90° intervals and extend from the outlet to a point approximately midway between the tapered portions of the tubular members 122 and 124. Each splitter 160 is formed by two plate members welded together at their ends to form a V-shape. The plate members are also welded along their respective longitudinal edges to the outer tubular member 124 and the divider cone 158 to support the splitters and the divider cone in the nozzle 120. The apex of each splitter 160 is disposed upstream of the nozzle outlet so that the fuel-air stream flowing in the annular space between the divider cones 158 and the outer tubular member 124 will be directed into the adjacent spaced defined between the splitters to facilitate the splitting of the fuel stream into four separate streams.

Four pie-shaped openings 162 are formed through the outer tubular member 124 and respectively extend immediately over the splitters 160. These openings are for the purpose of admitting secondary air from the inner air flow passage 144 (Fig. 1) into the annular space defined between the divider cone 158 and the outer tubular member 124 for reasons that will be explained in detail later.

As shown in Fig. 8, a tip 164 is formed on the end of the tapered portion of the inner tubular member 122 and is movable relative to the latter member by means of a plurality of rods 166 extending within the tubular member and affixed to the inner wall of the tip. The other ends of the rods 166 can be connected to any type of actuator device (not shown) such as hydraulic cylinder or the like to effect longitudinal movement of the rods and therefore the tip 164 in a conventional manner.

It can be appreciated from a view of Fig. 8 that the longitudinal movement of the tip 164 varies the effective outlet opening defined between the tip and the divider cone 158 so that the amount of fuel-air flowing through this opening can be regulated. Since the divider cone 158 divides the fuel-air mixture flowing through the annular passage 126 into two radially spaced parallal streams extending to either side of the divider cone 158, it can be appreciated that movement of the tip 164 regulates the relative flow of the two streams while varying their velocity.

It is understood that appropriate igniters can be provided adjacent the outlet of the nozzle 120 for igniting the coal as it discharges from the nozzle. Since these igniters are of a conventional design they have not been shown in the drawings in the interest of clarity.

In operation of the embodiment of Figs. 5—8, the movable sleeve 150 associated with each burner is adjusted during initial start up to accurately balance the air to each burner. After the initial balancing, no further movement of the sleeves 150 are needed since normal control of the secondary air flow to the burners is accomplished by operation of the outer burner vanes 146. However, if desired, flow control can be accomplished by the sleeve.

Fuel, preferably in the form of pulverized coal suspended or entrained within a source of primary air, is introduced into the tangential inlet 128 where it swirls through the annular chamber 126. Since the pulverized coal introduced into the inlet 128 is heavier than the air, the pulverized coal will tend to move radially outwardly towards the inner wall of the outer tubular member 124 under the centrifugal forces thus produced. As a result, a great majority of the coal along with a relatively small portion of air enters the outer annular passage defined between the outer tubular member 124 and the divider cone 158 (Fig. 8) where it encounters the apexes of the splitters 160. The stream is thus split into four equally spaced streams which discharge from the nozzle outlet and, upon ignition, form four separate flame patterns. Secondary air from the inner air passage 144 (Fig. 5) passes through the inlets 162 formed in the outer tubular member 124 and enters the annular passage between the latter member and the divider cone 158 to supply secondary air to the streams of coal and air discharging from the outlet.

The remaining portion of the air-coal mixture passing through the annular passage 126 enters the annular passage defined between the divider cone 158 and the inner tubular member 122. The mixture entering this annular passage is mostly air due to the movement of the coal radially outwardly, as described above. The position of the movable tip 164 can be adjusted to precisely control the relative amount, and therefore velocity, of the air and coal discharging from the nozzle 120 from the annular passages between the outer tubular member 124 and the divider cone 158 and between the divider cone and the inner tubular member 122.

Secondary air from the wind box is admitted through the perforated hood 156 and into the inlet between the plates 130 and 132. The axial and radial velocities of the air are controlled by the register vanes 146 and 148 as it passes through the air flow passages 142 and 144 and into the furnace opening 112 for mixing with the coal from the nozzle 120. The igniters are then shut off after steady state combustion has been achieved.

As a result of the foregoing, several advantages result from the burner assembly of the present invention. For example, since the pressure drop across the perforated air hoods 156 associated with the burner assemblies can be equalized by balancing the secondary air flow to each burner by initially adjusting the sleeves 150, a substantially uniform flue gas distribution can be obtained across the furnace. This also permits a common wind box to be used and enables the unit to operate at lower excess air with significant reductions in both nitrogen oxides and carbon monoxides. Also, the provision of separate register vanes 146 and 148 for the outer and inner air flow passages 142 and 144 enables secondary air distribution and flame shape to be independently controlled resulting in a significant reduction of nitrogen oxides, and a more gradual mixing of the primary air coal stream with the secondary air since both streams enter the furnace on parallel paths with controlled mixing.

Further, the provision of multiple flame patterns results in a greater flame radiation, a lower average flame temperature and a shorter residence time of the gas components within the flame at a maximum temperature, all of which, as stated above, contribute to reduce the formation of nitric oxides.

Still further, the provision of the tangential inlet 126 provides excellent distribution of the fuel around the annular space 126 in the nozzle 120, resulting in more complete combustion and reduction of carbon loss and making it possible to use individual burners with capacities significantly higher than otherwise could be used. Provision of the inlet openings 162 in the outer tubular member permits the introduction of a portion of the secondary air to be entrained with the fuel-air stream passing through the annular passage between the outer tubular member 124 and the divider cone, since the majority of this stream will be primarily pulverized coal. As a result, a substantially uniform air-coal ratio across the entire cross-section of the air-coal stream is achieved. Also, the provision of the movable tip 164 to regulate the flow of the coal-air mixture passing through the inner annular passage defined between the divider cone 158 and the inner tubular member 122 enables the air flow on both sides of the divider cone to be regulated thereby optimizing the primary air velocity with respect to the secondary air velocity.

It is understood that several variations and additions may be made to both embodiments of the present invention within the scope of the invention. For example, since the arrangement of the present invention permits the admission of air at less than stoichiometric, overfire air ports, or the like can be provided as needed to supply air to complete the combustion.

As will be apparent to those skilled in the art, other changes and modifications may be made to the embodiments of the present invention without departing from the spirit and scope of the present invention as defined in the appended claims and the legal equivalent.

CLAIMS

1. A burner assembly comprising means defining an annular passage, an inlet located at one end of said annular passage for receiving fuel, and an outlet located at the other end of said passage for discharging said fuel; means disposed within said annular passage for splitting up the fuel discharging from said opening so that upon ignition of said fuel, a plurality of flame patterns

are formed; and a register assembly associated with said burner, said register assembly comprising an enclosure extending over said annular passage for receiving air, means for directing said air from said enclosure towards said outlet in two parallel paths extending around said annular passage and register means respectively disposed in each of said paths for regulating the quantity of air flowing through said paths.

2. The burner assembly of claim 1 wherein said passage defining means comprises an inner tubular member and an outer tubular member extending around said inner tubular member in a coaxial relation thereto.

3. The burner assembly of claim 1 or 2 further comprising means for directing fuel through said inlet and into said annular space in a tangential direction relative to said annular space.

4. The burner assembly of claim 1 further comprising means for regulating the quantity of air entering said enclosure.

5. The burner assembly of claim 4 wherein said latter regulating means comprises a sleeve movable across the inlet to said enclosure to vary the size of said inlet.

6. The burner assembly of claim 1 wherein said splitting means comprises a plurality of blocks extending in a circumferentially spaced relationship in said annular passage, one end of each of said blocks extending in said outlet, and the other end of each of said blocks having a curved surface against which said fuel impinges, said curved surfaces directing said fuel into the spaces between said blocks.

7. The burner assembly of claim 6 wherein said passage defining means comprises an inner tubular member and an outer tubular member extending around said inner tubular member in a coaxial relation thereto, and wherein said blocks extend between said tubular members and are tapered in a direction from said outer tubular member to said inner tubular member.

8. A burner assembly comprising means defining an annular passage, and inlet located at one end of said annular passage for receiving fuel, and an outlet located at the other end of said passage for discharging said fuel through said opening and into said furnace; means disposed within said annular passage for splitting up the fuel discharging from said opening so that upon ignition of said fuel, a plurality of flame patterns are formed; and enclosure extending around said annular passage for receiving air; and a sleeve movable across the inlet to said enclosure to vary the size of said inlet and the quantity of air entering said enclosure, said air flowing towards said outlet for mixing with said fuel.

9. The burner assembly of claim 8 further comprising a perforated hood extending across said enclosure inlet and cooperating with said movable sleeve to vary the size of said inlet and the quantity of air entering said enclosure.

10. The burner assembly of claim 9 further comprising means disposed within said enclosure for directing said air from said enclosure towards said outlet in two parallel paths extending around said annular passage, and register means respectively disposed in each of said paths for regulating the quantity of air flowing through said paths.

11. The burner assembly of claim 8 wherein said passage defining means comprises an inner tubular member and an outlet tubular member extending around said inner tubular member in a coaxial relation thereto.

12. The burner assembly of claim 8 or 11 further comprising means for directing fuel through said inlet and into said annular space in a tangential direction relative to said annular space.

13. The burner assembly of claim 8 wherein said splitting means comprises a plurality of blocks extending in a circumferentially spaced relationship in said annular passage, one end of each of said blocks extending in said outlet and the other end of each of said blocks having a curved surface against which said fuel impinges, said curved surfaces directing said fuel into the spaced between said blocks.

14. The burner assembly of claim 13 wherein said passage defining means comprises an inner tubular member and an outer tubular member extending around said inner tubular member in a coaxial relation thereto, and wherein said blocks extend between said tubular members and are tapered in a direction from said outer tubular member to said inner tubular member.

15. A burner assembly comprising an inner tubular member; an outer tubular member extending around said inner tubular member in a coaxial relation thereto to define an annular passage; an inlet located at one end of said annular passage for receiving fuel, an outlet located at the other end of said passage for discharging said fuel through said opening into said furnace; and a plurality of blocks extending in a circumferentially spaced relationship in said annular passage, one end of each of said blocks extending in said outlet, and the other end of said blocks having a curved surface against which said fuel impinges, said curved surfaces directing said fuel into the spaces between said blocks for splitting up the fuel discharging from said opening so that upon ignition of said fuel, a plurality of flame patterns are formed, said blocks extending between said tubular members and being tapered in a direction from said outer tubular member to said inner tubular member.

16. The burner assembly of claim 15 further comprising an enclosure extending around said tubular members for receiving air, means for directing said air from said enclosure towards said outlet in two parallel paths extending around said tubular members, and register means respectively disposed in each of said paths for regulating the quantity of air flowing through said paths.

17. The burner assembly of claim 15 further comprising means for directing fuel through said inlet and into said annular space in a tangential direction relative to said annular space.

18. The burner assembly of claim 15 further

comprising means for regulating the quantity of air entering said enclosure.

19. The burner assembly of claim 4 wherein said latter regulating means comprises a sleeve movable across the inlet to said enclosure to vary the size of said inlet.

20. A burner assembly comprising means defining an annular passage, an inlet located at one end of said passage for receiving fuel, and an outlet located at the other end of said passage for discharging said fuel, means disposed within said annular passage for dividing the stream of fuel passing through said passage into two parallel streams, means for splitting up one of said streams as it discharges from said opening so that upon ignition of said fuel, a plurality of flame patterns are formed, and a register assembly associated with said burner, said register assembly comprising an enclosure extending over said passage for receiving air, and means for directing said air from said enclosure towards said outlet in two parallel paths extending around said passage, and a plurality of vanes respectively disposed in each of said paths for regulating the spin and/or quantity of air flowing through said paths.

21. The burner assembly of claim 20 wherein said passage defining means comprises an inner tubular member, and an outer tubular member extending around said inner tubular member in coaxial relation thereto.

22. The burner assembly of claim 21 wherein said stream dividing means comprises a tubular divider member disposed in said passage to divide said stream into an inner stream, and an outer stream extending around said inner stream.

23. The burner assembly of claim 22 wherein said splitting means extends between said outer tubular member and said divider member.

24. The burner assembly of claim 20 wherein said splitting means comprises a plurality of V-shaped members extending in circumferentially spaced relationship in said passage and disposed in said passage so that the apex of each member faces upstream and said one stream impinges against said members which direct said stream into the spaces between said members.

25. The burner assembly of claim 22 further comprising an air inlet opening formed in a portion of said outer tubular member extending over said splitting means for admitting air from one of said paths to said outer stream.

26. The burner assembly of claim 20 further comprising means for regulating the flow rate of at least one of said streams.

27. The burner assembly of claim 26 wherein said flow rate regulating means comprises a movable tip disposed on the end of said inner tubular member and movable relative to said inner tubular member.

28. The burner assembly of claim 20 further comprising means for directing fuel through said inlet and into said passage in a tangential direction relative to said passage.

29. The burner assembly of claim 20 further comprising a sleeve movable across the inlet to said enclosure to vary the size of said inlet and regulate the quantity of air entering said enclosure.

30. A burner assembly comprising means defining an annular passage, an inlet located at one end of said passage for receiving fuel, and an outlet located at the other end of said passage for discharging said fuel; a divider member disposed within said annular passage for dividing the stream of fuel passing through said passage into two radially-spaced parallel streams, and means for splitting up one of said streams as it discharges from said opening so that, upon ignition of said fuel, a plurality of flame patterns are formed.

31. The burner assembly of claim 30 wherein said passage defining means comprises an inner tubular member, and an outer tubular member extending around said inner tubular member in a coaxial relation thereto, said divider member extending between said inner tubular member and said outer tubular member.

32. The burner assembly of claim 31 wherein said splitting means extends between said outer tubular member and said divider member in the path of said outer stream.

33. The burner assembly of claim 32 further comprising an air inlet opening formed in a portion of said outer tubular member extending over said splitting means for admitting air to said outer stream.

34. The burner assembly of claim 30 wherein said splitting means comprises a plurality of V-shaped members extending in a circumferentially spaced relationship in said passage and disposed in said passage so that the apex of each member faces upstream and said one stream impinges against said members which direct said stream into the spaces between said members.

35. The burner assembly of claim 30 further comprising means for regulating the flow rate of at least one of said streams.

36. The burner assembly of claim 35 wherein said flow rate regulating means comprises a movable tip disposed on the end of said inner tubular member and movable relative to said inner tubular member.

37. The burner assembly of claim 30 further comprising means for directing fuel through said inlet and into said passage in a tangential direction relative to said passage.

38. The burner assembly of claim 30 further comprising a register assembly associated with said burner, said register assembly comprising an enclosure extending over said passage for receiving air, means for directing said air from said enclosure towards said outlet, and a sleeve movable across the inlet to said enclosure to vary the size of said inlet and regulate the quantity of air entering said enclosure.

39. A burner assembly comprising an inner tubular member, and an outer tubular member extending around said inner tubular member in a coaxial relation thereto to define an annular passage, inlet means located at one end of said

passages for directing a mixture of pulverized coal and air into said passage in a tangential relation relative to said passage, an outlet located at the other end of said passage for discharging said fuel; means disposed with said annular passage for dividing the stream of fuel passing through said passage into two radially spaced parallel streams, a substantial portion of said coal flowing into the outer stream by centrifugal forces, and an air inlet opening formed in a portion of said outer tubular member for admitting air from one of said paths to said outer stream as said outer stream discharges from said outlet.

40. The burner assembly of claim 39 wherein said stream dividing means comprises a tubular divider member disposed in said passage between said inner tubular member and said outer tubular member.

41. The burner assembly of claim 40 further comprising means for splitting up one of said streams as it discharges from said opening so that upon ignition of said coal, a plurality of flame patterns are formed.

42. The burner assembly of claim 41 wherein said splitting means extends between said outer tubular member and said divider member and splits up said outer stream.

43. The burner assembly of claim 41 wherein said splitting means comprises a plurality of V-shaped members extending in a circumferentially spaced relationship in the annular space between said outer tubular member and said divider member and disposed in said passage so that the apex of each member faces upstream and said outer stream flows against said members which direct said stream into the spaces between said members.

44. The burner assembly of claim 39 further comprising a register assembly associated with said burner, said register assembly comprising an enclosure extending over said passage for receiving air, means for directing said air from said enclosure towards said outlet, and a sleeve movable across the inlet to said enclosure to vary the size of said inlet and regulate the quantity of air entering said enclosure.

45. The burner assembly of claim 39 further comprising means for regulating the flow rate of at least one of said streams.

46. The burner assembly of claim 45 wherein said flow rate regulating means comprises a movable tip disposed on the end of said inner tubular member and movable relative to said inner tubular member.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1982. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.