This invention relates to fuel burners and more particularly to an improved multi-fuel burner capable of burning a plurality of fuels, such as gas, oil and pulverized coal, which may be fired separately and/or in combination as desired or as determined by the amount of the particular fuel available.

In multi-fuel burners of the spud type wherein a plurality of elongated, circumferentially spaced, gas burner tubes are arranged around a pulverized coal burner assembly, the burner unit is relatively large and cumbersome. In addition, such burners fail to provide optimum combustion of the gas as well as stable ignition due to the incomplete and non-uniform mixing of the gas and combustion air. In an attempt to provide a spud type burner capable of more efficient combustion of gas, it has been proposed to position a supplemental air impeller member adjacent the gas burner tips. However, such construction has increased the complexity of the burner structure, particularly with respect to the provision for burning pulverized coal.

A further disadvantage of the heretofore known spud type multi-fuel burners is the flow of combustion gases from the furnace chamber into the gas manifold through the gas burner tubes and the gas burner tube supporting sleeves upon the shut down of the burner, and the attendant danger to an operator upon removal of one or more of the gas tubes for inspection and/or repair.

Accordingly, it is an object of the present invention to provide an improved multi-fuel burner of the spud type of a more compact construction than heretofore known multi-fuel burners wherein optimum combustion of all the fuels is achieved.

Another object of the invention is a multi-fuel burner having a gas fuel burner assembly which provides efficient and stable operation over a wide range of secondary air and fuel pressure and under sudden fluctuations of secondary air and/or fuel flow. A further object of this invention is to provide a spud type multi-fuel burner wherein optimum combustion of gas fuel is achieved without the need for supplemental combustion air control means, such as impellers, in addition to the main secondary air register assembly.

A still further object of the present invention is to provide a spud type multi-fuel burner wherein the gas burner tubes may be readily disconnected and removed and replaced without danger to an operator.

More specifically, the instant invention contemplates an improved multi-fuel burner which comprises a pulverized coal burner assembly disposed with the nozzle thereof extending through a windbox and terminating adjacent the outside of a burner port in the wall of a furnace chamber. A plurality of elongated gas burner tubes are arranged in circumferential spaced relationship to each other and are disposed to extend through the central portion of the pulverized coal burner nozzle. Each of the gas burner tubes is connected at one end to a gas manifold and terminates at the opposite end adjacent the outlet end of the coal burner nozzle. Each of the gas burner tubes is supported in a sleeve which extends from a point inwardly spaced from the gas burner tube tips and through the involute section of the pulverized coal burner assembly. An oil burner assembly is disposed and suitably supported to extend through the involute section of the pulverized coal burner section and coaxially through the coal burner nozzle. The oil burner assembly terminates adjacent the outlet end of the coal burner nozzle and is provided with a suitable fuel atomizing nozzle at the end thereof. This novel arrangement of various fuel burning means effects a conservation of space without detriment to the efficient function of the pulverized coal burner assembly and results in a multi-fuel burner characterized by its simplicity and compactness.

The invention further provides a novel arrangement of the gas burner nozzles disposed at the tips of the gas burner tubes whereby optimum combustion of the gas is achieved. The gas burner nozzles are disposed at equidistant points along the periphery of an imaginary circular plane which extends parallel to the plane of the burner port. Each of the gas burner nozzles are so constructed and arranged so as to direct a stream of gas extending from the nozzle toward the next adjacent gas burner nozzle at an angle of about 60° to 90° from the radius of the imaginary circular plane and outwardly of the latter toward the burner port. The stream of gas from each burner is directed toward the burner port so as to pass immediately adjacent the peripheral surface of the burner port. The gas nozzles are constructed and arranged to direct the streams of gas with respect to the center of the imaginary circular plane in the same direction which direction is the same as the direction of rotation imparted to the secondary air by the air register. While improved results are achieved with gas burner nozzles constructed and arranged to direct gas streams between about 60° to 90° of the radius of the imaginary circular plane, it has been found that optimum gas combustion and stable fuel burning is achieved with gas streams directed to the next adjacent nozzle at an angle of 60° from the radius of the imaginary circular plane and outwardly toward the burner port. With gas burner nozzles arranged to emit gas streams extending toward the next adjacent nozzle at an angle between 60° and less than 90° and outwardly toward the burner port, the gas flow pattern is one of convergence and divergence (in the nature of an hour glass configuration), with maximum convergence occurring before the streams of gas enter the burner port. The aforesaid novel gas burner nozzle arrangement provides for improved gas combustion and flame stability without the need for supplemental air control means or apparatus.

The multi-fuel burner according to this invention is also provided with means for flowing air under pressure through the gas burner tubes and supporting sleeves to prevent combustion gas flow from the furnace chamber, through the burner port, and into the supporting sleeves when the burner is shut down and a gas burner tube is to be removed for inspection or repair. In addition, each gas burner tube is provided at its connection with the gas manifold with a check valve which allows flow of gases from the manifold into the gas burner tubes, but prevents flow of combustion gas from the furnace chamber, through the burner port, into and through the gas burner tubes to the manifold when the burner is taken out of service.

The invention will be more fully understood from the following description thereof when considered in connection with the accompanying drawings in which:

FIG. 1 is a view in cross-section taken substantially along line 1—1 of FIG. 2 of the multi-fuel burner according to this invention;

FIG. 2 is an end view in elevation of the multi-fuel burner shown in FIG. 1;

FIG. 3 is a partial sectional view taken along line 3—3 of FIG. 1, somewhat enlarged;

FIG. 4 is an end view in elevation of the gas fuel discharge end of the multi-fuel burner, somewhat enlarged;

FIG. 5 is an enlarged fragmentary view, partly in section, showing the means for supplying gas to the gas...
burner tubes and the means for supplying air to the sleeve air sealing chamber; FIG. 6 is a fragmentary view on an enlarged scale showing the distal end of one of the sleeves; FIG. 7 is a transverse section taken along line 7—7 of FIG. 6; FIG. 8 is a fragmentary view showing the orifices for admitting air from the air sealing chamber into the gas burner tube supporting sleeves; FIG. 9 is an enlarged fragmentary view, in section, of the means for connecting the gas burner tubes to the manifold and the check valve disposed therein for controlling flow of fluid between the tube and manifold; FIG. 10 is a plan view of the check valve seal plate and FIG. 11 is a sectional view taken substantially along line 11—11 of FIG. 9; FIG. 12 is a diagrammatic view showing the gas burner nozzle arrangement according to this invention.

Referring now to the drawings, and more particularly to FIGS. 1, 2 and 3, the reference numeral 10 designates the novel multi-fuel burner, according to this invention, which is suitably supported by a wall 11 which wall extends in spaced parallel relationship with a furnace wall 12 of a furnace chamber. Wall 11 defines with wall 12 a window or plenum chamber 13 which is connected to receive combustion air from a suitable source thereof (not shown) to supply combustion air to a burner port or throat 14 in furnace wall 12.

The multi-fuel burner 10 comprises a pulverized fuel burner 15 which has a volute section 16 and a slightly tapered burner nozzle 17. Burner nozzle 17 is connected at one end to volute section 16 by means of a plurality of bolts 18 which extend through flanges provided on the volute section 16 and burner nozzle 17. The pulverized fuel 19 is disposed with 17 extending through an opening 19 in wall 11 toward the burner port 14 with the longitudinal axis of the nozzle in coaxial relationship to the longitudinal axis of burner port 14. The pulverized fuel burner 15 is supported in opening 19 by a ring 20 having at one end an annular flange 21. Ring 20 is secured, as by welding, at one end to wall 11, adjacent the periphery of opening 19 and to pulverized fuel burner 15 by means of above mentioned bolts 18 which pass through annular flange 21. Burner nozzle 17 is dimensioned so that the discharge end thereof is disposed in close spaced relationship with burner port 14. The distal or discharge end portion of burner 17 is supported by an air register assembly 22.

Air register assembly 22 is of any suitable design as is well known to those skilled in the art and, for illustration purposes, is shown as comprising a wall 25 having a plurality of radially extending fingers 26 and a ring member 27 spaced from wall 25 to define therebetween an annular, peripheral inlet opening 28 communicating with an outlet opening 29 defined by ring member 27. A plurality of vanes or doors 30 (only two of which are shown in FIG. 1) are pivotally supported circumferentially within said inlet opening 28 between the distal ends of fingers 26 of wall 25 and ring member 27. The assembly is supported by wall 12 with outlet opening 29 disposed in coaxial relation to burner port 14 by means of a plurality of brackets 31 which extend from wall 25. Brackets 31 are suitably secured to a cylindrical baffle 32 which is secured, as by welding, to wall 12 to project normal to wall 12 in super-imposed spaced relationship to inlet opening 28. Wall 25 is provided with an axial opening 33 to receive burner nozzle 17 of the pulverized fuel burner to support the latter.

Disposed within the volute section 16 and burner nozzle 17 is a frusto-conical shaped baffle or tubular member 34 which extends in coaxial relationship to the axis of burner nozzle 17. Baffle or tubular member 34 has a taper corresponding to the taper of burner nozzle 17 and is of smaller cross-sectional dimensions so that an annular pulverized fuel passageway 35 is defined between the outer surface of baffle or tubular member 34 and the inner surface of burner nozzle 17. The outer end of baffle or tubular member 34 is provided with an annular outwardly extending flange 36 which is secured between side wall 37 and the flange of wall 33 of volute section 16 by means of bolts 39.

A cup shaped member 40 is secured, by means of bolts 23 (FIG. 2), to the exterior surface of end wall 37 of volute section 16 to form with end wall 37 an air sealing chamber 41. The function and purpose of chamber 41 will be described fully hereinafter.

An annular or ring shaped gas manifold 42, having a diameter somewhat larger than the diameter of volute section 16 is secured to the cup shaped member 49 by means of a plurality of bolts 43 which pass through holes in radial lugs 44 extending inwardly from the inner circumference of manifold 42 (see FIG. 2). Gas manifold 42, as shown in FIGS. 2 and 5, is provided with an inlet connection 42A to which is connected a pipe (not shown) for delivery of a gaseous fuel under pressure to the manifold.

To provide for conducting the gaseous fuel from manifold 42 to the burner port 14, a plurality of elongated gas burner tubes 45 is disposed in close spaced relationship to each other within baffle or tubular member 34. Each of the elongated burner tubes 45 is shown as provided at the outer end with an integral U shaped end portion 46 while a fuel nozzle 60 is disposed at the proximate end of the burner tube. Each of the gas burner tubes 45 is supported and dimensioned to extend from manifold 42 through baffle or tubular member 34 with nozzles 60 of each gas burner tube lying slightly beyond the discharge outlet end of pulverized fuel burner nozzle 17. The baffle or tubular member 34, shown, is an unbroken member which abuts the bCourse surface around the gas burner tubes. By "continuous", it is meant free of apertures or perforations for the passage of air, so that there is no way for air or pulverized fuel to flow within the baffle or tubular member and directly around the burner tubes. The novel disposition and arrangement of nozzles 60 will be hereinafter described in full.

An enlarged mounting head 47 is secured in a suitable manner, as by welding or threading, to the end of U shaped end portion 46 of each gas burner tube 45. Each mounting head 47 is provided with a bore 47A which communicates with the interior of the gas burner tube to which it is secured. Manifold 42 is provided on wall 12 with a plurality of circumferentially spaced openings 42B (corresponding in number to the number of gas burner tubes 45, see FIGS. 1, 5 and 9). Each mounting head 47 is secured by means of bolts 43 (FIG. 2) to manifold 42 over an opening 42B in manifold 42 to communicate the interior of the manifold with the interior of the gas burner tubes through bore 47A in the mounting head 47. To provide a fluid-tight seal between the face of mounting head 47 and manifold 42, a gasket 49 of the O ring type is provided in the face of each of the mounting heads (see FIG. 9). Each of the mounting heads is also provided with a check valve 50.

As best shown in FIGS. 9, 10 and 11, each check valve comprises a circular plate 51 which is disposed across the flow area of bore 47A of mounting head 47 and is seated against an annular shoulder 52 spaced slightly inwardly from the face of the mounting head. Plate 51 is extendible end to the center of plate 51 and extends normal to the surface thereof. A sealing disc 54 is slidably mounted on pin 55 for movement relative to plate 51. Pin 55 is provided at its distal end with an enlarged head 55A which serves as a stop to limit the movement of disc 54 away.
from plate 51. Sealing disc 54 is provided with segmental slots 56 to reduce the restriction to gas flow from manifold 42 caused by sealing disc 54 when the disc is in the full line position shown in FIG. 9. The slots 56 in sealing disc 54 are disposed to lie between the two sets of concentric slots 53 in plate 51 as shown in FIG. 11 so that when sealing disc 54 is pressed against the surface of plate 51, slots 56 are sealed closed to prevent flow of combustion gas into manifold 42 from gas burner tubes 45. The function and purpose of check valve 50 will be more fully described hereinafter.

As best shown in FIGS. 1 and 3, each gas burner tube 45 is supported within baffle or tubular member 34 by an elongated sleeve 61. Sleeves 61 extend from a point adjacent the outer surface of cup shaped member 49, through registered openings in member 49 and side wall 37 of volute section 16, to a point inwardly spaced from gas nozzles 69 of gas burner tubes 45. Each sleeve 61 is secured within the adjacent openings in member 49 and side wall 37 in a fluid-tight manner to support the sleeve at one end. As best shown in FIG. 3, the distal ends of sleeves 61 are interconnected by spacer members 62 and the sleeve bundle formed thereby is supported in concentric spaced relationship to baffle or tubular member 34 by a plurality of bolts 63. Each bolt 63 is turned in a threaded hole in a spacer member 62 until the end of the Shank of the bolt bears against the inner surface of baffle or tubular member 34. As best illustrated in FIGS. 6 and 7, the inner end portion of each sleeve 61 is provided with a plurality of circumferentially spaced, longitudinally extending slots 64. Slots 64 are provided to allow for differential expansion between burner tube 45 and sleeve 61. Three spacer members 65 are disposed in each of three equidistant slots 64 and are secured on one side to sleeve 61 to prevent radially inwardly from the inner surface sleeve 61. Spacer members 65 support the sleeve 61 in concentric spaced relationship to burner tube 45 so that an annular passageway 66 is formed between the outer surface of the burner tube and the inner surface of the sleeve. As shown in FIGS. 1 and 8, the portion of each sleeve 61, where it extends through air sealing chamber 61, is provided with a plurality of circumferentially spaced holes 67 which communicate air sealing chamber 41 with annular passageway 66 formed between the sleeve 61 and gas burner tube 45. The outer end of each sleeve 61, adjacent cup shaped member 48, is sealed in a fluid-tight manner by a passage of a threaded pipe cap 67A and packing material, such as asbestos plotted between cap 67A, the end of the sleeve, and the surface of gas burner tube 45.

As best shown in FIGURES 3 and 5, two pipes 68 are shown connected to cup shaped member 49 to supply air to sealing chamber 41. While two pipes 68 are shown, it is to be understood one larger pipe would be sufficient. Each pipe 68 is connected to a valve 69 which is actuated by a handle 70. Valves 69 are each connected by means of a pipe (not shown) to a suitable source of air under a pressure greater than the furnace combustion gas pressure. Valves 69 are closed during operation of multi-fuel burner 10 to prevent air flow to air sealing chamber 41 and are opened to allow flow of air into chamber 41 when the multi-fuel burner is taken out of service and a gas burner 45 is removed from its supporting sleeve 61. The air flows from sealing chamber 41, through holes 67 in sleeve 61, into passageways 66 defined by a gas burner tube 45 and its supporting sleeve 61, and thence through passageways 65 and out of the inner end portion of sleeves 61. The flow of air through sleeve 61, as the gas burner tube is withdrawn from the sleeve, protects the repairman or insulator from the hot furnace combustion gases which would otherwise flow through the sleeve when the gas burner tube is removed.

As best shown in FIG. 5, a "peep" sight 71 extends at one end through cup shaped member 48 and end wall 37 of volute section 16 and is provided with a viewing glass cap 72 at the opposite end. The interior of pipe 71 is in communication with air sealing chamber 41 between a plurality of holes 73 to supply air to the pipe 71 and prevent hot combustion gases from flowing from the outer end of the pipe when viewing glass cap 72 is removed.

The multi-fuel burner 10 is provided with an oil burner assembly 75 which comprises an elongated burner tube 76 having an atomizing nozzle 77 at the end thereof. Oil burner assembly 75 is disposed with the tube extending through cup shaped member 49 and end wall 37 of volute 16 and coaxially through burner nozzle 77 of the pulverized fuel burner, the atomizing nozzle 77 being positioned adjacent the outlet of burner nozzle 77. The end of tube 76, adjacent nozzle 77, is supported by baffle or tubular member 34 by a nut turned on the threaded ends of rods 78. If it is not desired to provide means for burning oil, oil burner assembly 75 may be eliminated and in place thereof, an ignitor may be placed. A pipe 80, as shown in FIG. 2, is in communication at one end with the interior of baffle or tubular member 34 and extends therethrough along side wall 37 and through a plate shaped member 49 and through casing wall 11 to communicate at the opposite end with plenum chamber 13. Pipe 80 conducts combustion air from plenum chamber 13 to the interior of baffle or tubular member 34 so that flow of combustion air through baffle or tubular member 34 and around sleeves 61 and gas burner tubes 45 is provided to thereby prevent "pockets" of gas from developing within baffle or tubular member 34.

Efficient gaseous fuel combustion and combustion of improved stability over a wide range of fuel and combustion air load is achieved by the novel manner in which gas nozzles 69 of the gas burner tubes 45 are arranged. As shown in FIG. 4, each of the gas nozzle 69 has a planar face 81 which is obliquely positioned with respect to the longitudinal axis of the gas burner tube to which it is suitably attached. Each planar face 81 is provided with a plurality of spaced orifices 82 through which the gaseous fuel discharges. As best illustrated in the diagramatic view in FIG. 12, each gas nozzle 69 is arranged with the center of the planar face 81 lying at the periphery of an imaginary circular plane 83 which extends normal to the longitudinal axis of burner port 14. The planar faces 81 of each nozzle 69 is arranged so that direct gas toward the next adjacent nozzle 69 is at an angle of 60° to 90° from the radius 84 of imaginary circular plane 83 and outwardly of the latter to a point 85 within the furnace chamber adjacent burner port 14 so that the gas stream is directed to pass immediately adjacent the inner peripheral surface of the burner port. Each gas nozzle 69 is positioned to direct gas toward the next adjacent nozzle in the same direction with respect to the center of imaginary circular plane 83, the direction about the center of the imaginary plane 83 being the same direction as the rotation imparted by air register 22 to the combustion air flowing into burner port 14. This novel arrangement of gas nozzles 69 achieves uniform mixing of the gaseous fuel with the combustion air as the gaseous fuel is directed into the whirling combustion air flowing into burner port 14 and thereby provides improved combustion of the gaseous fuel as well as combustion of high stability over a wide range of fuel and combustion air load.

Nozzles 60 are dimensioned to have a peripheral surface flush with the outer surface of gas burner tubes 45 so that gas burner tubes 45 may be withdrawn from sleeves 61. When the multi-fuel burner 13, according to this invention, is taken out of service for inspection and/or repair, the other fuel burners may be operated without danger of
hot combustion gas flowing from the furnace chamber through sleeves 61 and/or gas burner tubes 45 of the multifuel burner which is shut down. When one or more gas burner tubes 45 is to be removed for inspection and/or repair, valves 59 are opened to allow flow of air under pressure to flow through pipes 86 into air sealing chamber 41. The air from sealing chamber 41 flows into the passageways 66, between each gas burner tube 45 and the sleeve 61 in which it is supported, through openings 67 in sleeves 61 (FIG. 8). This flow of air into passageways 66 removes any combustion gas which may have accumulated therein and prevents further combustion gas from flowing into sleeve 61. Flow of combustion gas, through gas burner tubes 45, into manifold 42 is prevented by check valves 50. With the flow of gaseous fuel to manifold 42 shut-off, the combustion gas which may flow into the gas burner tubes acts against discs 54 of check valves 50 causing the discs to move against plates 51. With the discs 54 against plates 51, as shown by the broken line in FIG. 9, orifices 53 are sealed closed to prevent flow of combustion gas into manifold 42. Thus, when the mounting bolts 48 are removed from an enlarged mounting head 47 of a gas burner tube 45 preparatory to the latter's removal, combustion gas will not flow from the manifold through opening 42B. The gas burner tube which has been disconnected from manifold 42 may now be withdrawn through its supporting sleeve 61. With the flow of air through sleeve 61 from sealing chamber 41, combustion gas is prevented from flowing out of the open end of sleeve 61, at pipe cap 67A, when the gas burner tube is fully withdrawn.

From the foregoing description, it can be readily seen that an improved multi-fuel burner has been provided which is relatively simple and compact in construction, and which provides for efficient combustion of gaseous fuel separately or simultaneously from the combustion of pulverized fuel and/or liquid fuel. The multi-fuel burner in addition, may be taken out of service without shut down of other burners, and gas burner tubes removed for inspection and/or repair without danger to the operating personnel from hot combustion gas flow through the gas burner tubes and their supporting sleeves.

Although, but one embodiment of the invention has been illustrated and described in detail, it is to be understood that the invention is not limited thereto. Various changes can be made in the arrangement of parts without departing from the scope and spirit of the invention, as the same will now be understood by those skilled in the art.

What is claimed is:
1. A multi-fuel burner for providing combustion fuel to a furnace chamber having a wall and a burner port therein comprising, an air register means for the flow of combustion air into the furnace, said air register means having an air inlet opening, an outlet opening, and means to impart to the combustion air a rotating helical flow through said outlet opening; a pulverized fuel burner having a tubular nozzle section including a first end adapted to receive a stream of pulverized fuel and air and a discharge end disposed substantially concentrically within said outlet opening of said air register means and in axial alignment therewith; a gas manifold disposed exteriorly of said pulverized fuel burner and connected to a source of gas under pressure; a plurality of circumferentially spaced elongated gas burner tubes connected at one end to said manifold and extending gas nozzle section of the pulverized fuel burner in spaced relationship to the inner surface of said nozzle section and terminating at the opposite end thereof adjacent to the discharge end of the nozzle section, each of said gas burner tubes having a gas nozzle disposed at said opposite end for the discharge of gas; baffle means disposed around said tubes in spaced relation with said nozzle section to provide with said nozzle section an annular passageway for said pulverized fuel and air, said nozzles being arranged approximately at the periphery of an imaginary circular plane transverse to said nozzle section and disposed obliquely with respect to said plane to direct streams of gas in outwardly diverging paths from said outlet opening towards the next adjacent air nozzle at an angle between about 60° and about 90° with a radius of said circular plane, said nozzles further being disposed to discharge gas in substantially the same direction as the direction of rotation of said combustion air.
2. In a furnace assembly having a furnace chamber, a wall, and a burner port therein, a burner assembly for providing combustion fuel to the furnace chamber comprising, an air register for the flow of combustion air into the furnace including an air inlet opening and an outlet opening the latter adjacent the burner port; an array of circumferentially spaced elongated gas burner tubes extending into said air register in spaced relation thereto having nozzle means disposed adjacent said outlet opening for the discharge of gas, said nozzle means being arranged approximately at the periphery of an imaginary circular plane transverse to said outlet opening; said burner assembly comprising means, including an unbroken tubular member coaxial with the array of gas burner tubes providing a continuous surface extending into said air register in spaced relation thereto and said burner tubes, means arranged to provide an annular whirling motion to the combustion air flowing through said outlet opening and around said tubular member, said tubular member at one end thereof being disposed sufficiently close to the nozzle means to provide a quiescent area adjacent said nozzle means; said nozzle means being disposed obliquely with respect to said circular plane to direct streams of gas towards the next adjacent gas nozzle and to a point adjacent the inner periphery of said burner port, said gas streams further being directed at an angle between about 60° and about 90° with respect to a radius of said plane and in the general direction of rotation of the combustion air.
3. In a furnace assembly having a furnace chamber, a wall, and a burner port therein, a multi-fuel burner for providing combustion fuel to the furnace chamber comprising, an air register means in communication with said burner port through which combustion air flows, said air register means having an air inlet opening, an outlet opening, and means to impart to the combustion air an annular rotating helical flow pattern through said burner port; a pulverized fuel burner having a tubular nozzle section extending into said air register means at one end adapted to receive a stream of pulverized fuel and air and a discharge end disposed substantially concentrically within said outlet opening of said air register means and in axial alignment with the axis of said burner port; a gas manifold disposed exteriorly of said pulverized fuel burner and connected to a source of gas under pressure; a plurality of circumferentially spaced elongated gas burner tubes connected at one end to said manifold and extending into said air register means at one end adapted to receive a stream of pulverized fuel and air and a discharge end disposed substantially concentrically within said outlet opening of said air register means; in axial alignment with the axis of said burner port.
gas at an angle between about 60° and about 90° with respect to a radius of said circular plane and in substantially the same direction as the direction of rotation of the combustion air through said burner port.

4. A multi-fuel burner according to claim 3 and including check-valve means in said gas burner tubes for preventing the flow of combustion gases from the furnace chamber into said gas manifold when the gas burner tubes are not in service.

5. A multi-fuel burner according to claim 4 and including elongated sleeves supporting said gas burner tubes and means for supplying air under pressure to the interior of said sleeves greater than the combustion gas pressure in said furnace to prevent the flow of combustion gases from the furnace when said tubes are removed from said sleeves.

6. In a furnace assembly having a furnace chamber, a wall, and a burner port therein, a multi-fuel burner for providing combustion fuel to the furnace chamber comprising, an air register means in communication with said burner port through which combustion air flows, said air register means having an air inlet opening, an outlet opening, and means to impart to the combustion air an annular rotating helical flow pattern through said burner port; a pulverized fuel burner having a tubular nozzle section extending into said air register means including a first end adapted to receive a stream of pulverized fuel and air and a discharge end disposed substantially concentrically within said outlet opening of said air register means and in axial alignment with the axis of said burner port; a gas manifold disposed exteriorly of said pulverized fuel burner and connected to a source of gas under pressure; a plurality of circumferentially spaced elongated gas burner tubes connected at one end to said manifold and extending into and through said nozzle section of the pulverized fuel burner in spaced relationship to the inner surface of said nozzle section and terminating at the opposite end thereof adjacent to the discharge end of the nozzle section but spaced from said burner port, each of said gas burner tubes having a gas nozzle disposed at said opposite end for the discharge of gas, said nozzles being arranged approximately at the periphery of an imaginary circular plane transverse to the axis of said pulverized fuel burner nozzle and disposed obliquely with respect to said plane to direct a stream of gas towards the next adjacent gas nozzle and to a point adjacent the inner periphery of said burner port, said nozzles further being disposed to direct said streams of gas at an angle between about 60° and about 90° with respect to a radius of said circular plane and in substantially the same direction as the direction of rotation of the combustion air through said burner port, and baffle means disposed annularly about said gas burner tubes and within said burner nozzle and concentric therewith arranged to separate said burner tubes from the flow of pulverized fuel and air in said burner nozzle.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,115,851

December 31, 1963

Frederick J. Ceely

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 27, for "gears" read -- bears --; column 8, line 6, for "air" read -- gas --; line 62, for "either" read -- said --.

Signed and sealed this 2nd day of June 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents