APPARATUS FOR BURNING LOW HEAT VALUE FUELS

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FIG. 1

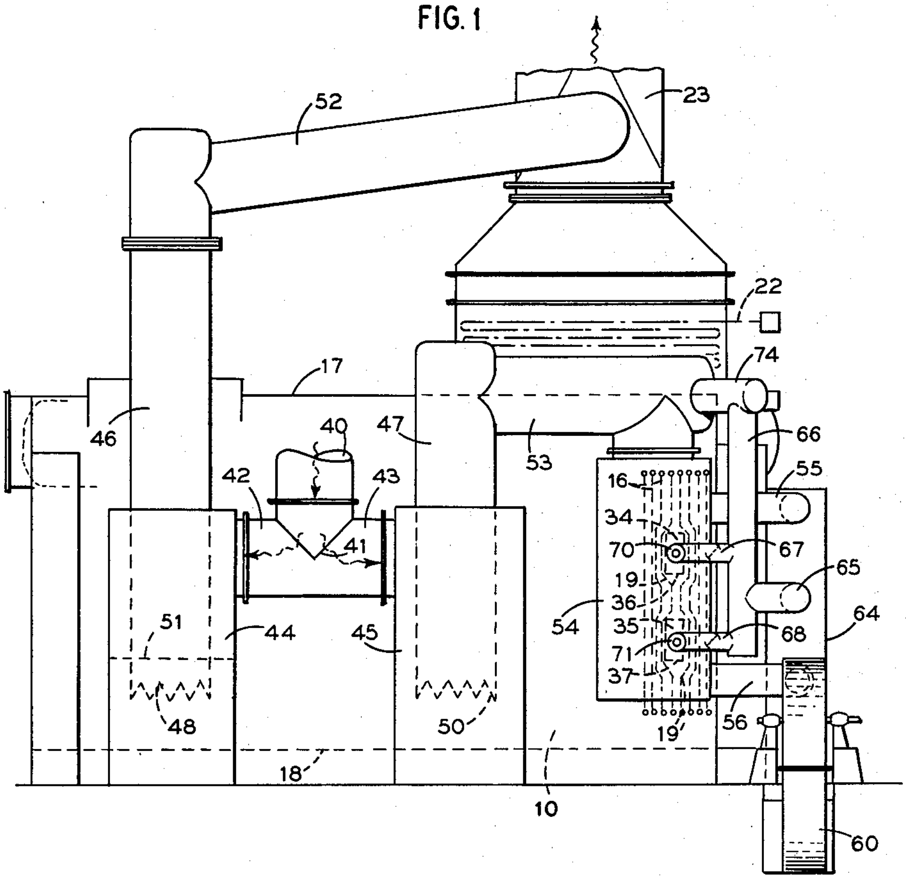

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FIG. 2

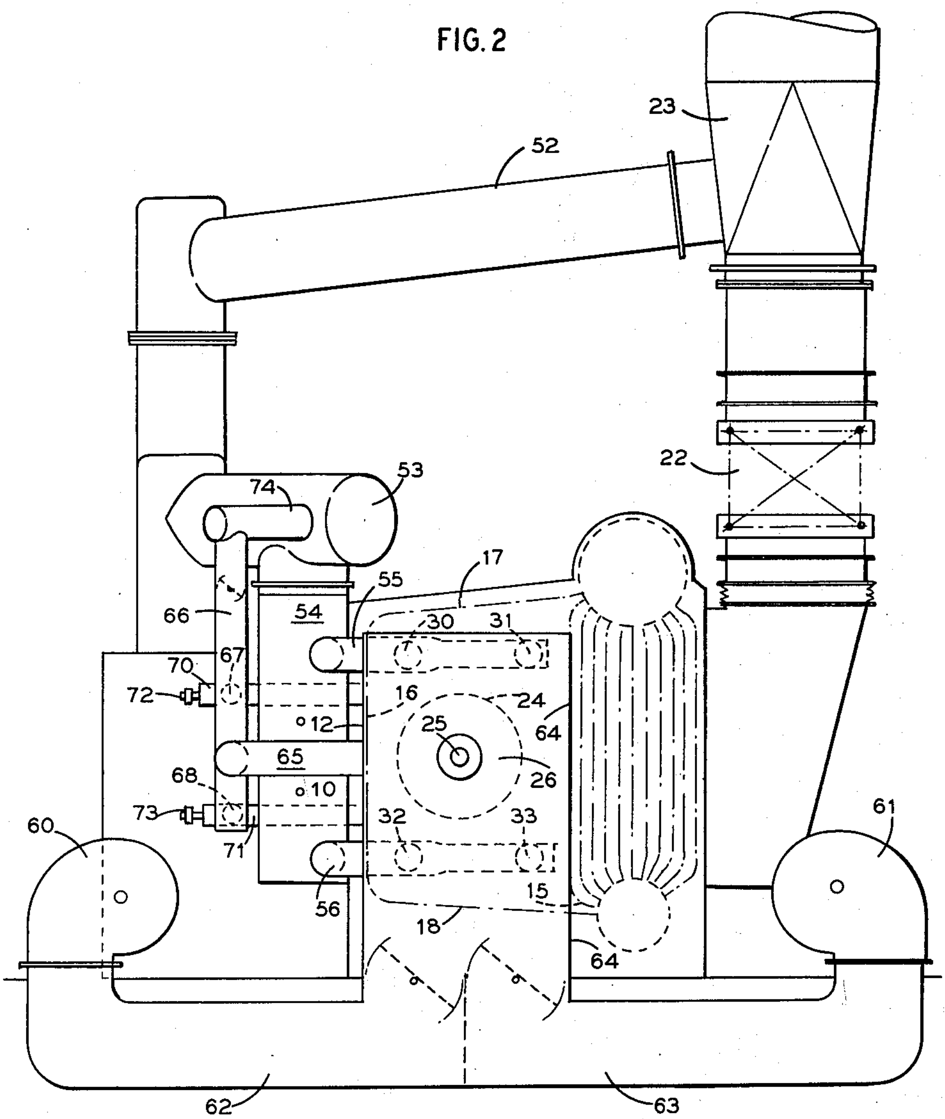

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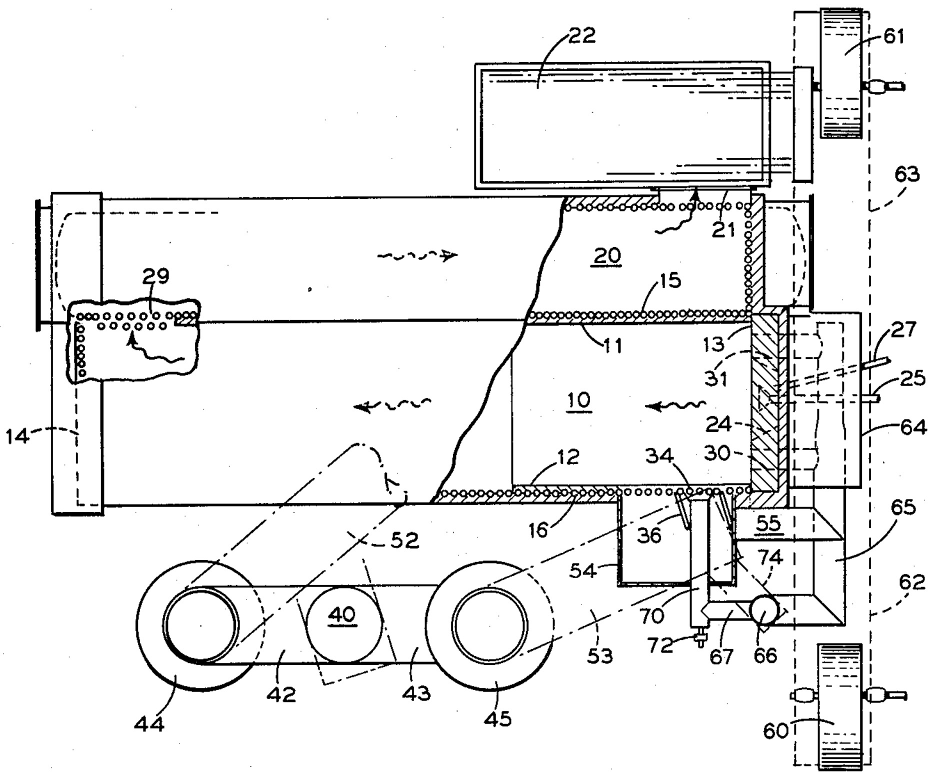
FIG. 3



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APPARATUS FOR BURNING LOW HEAT VALUE FUELS

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The present invention relates to the combustion of low heat value fluent fuel incapable of self-sustaining combustion, where the low heat value fuel is burned in conjunction with a high heat value fuel. More particularly, the invention relates to the recovery of the heat of combustion and the sensible heat contained in a low heat value fuel in a shop assembled or package steam boiler or vapor generator.

An example of the low heat value fuel is found in the effluent gases from a catalytic regenerator kiln in a hydrocarbon process wherein the catalyst is regenerated or reactivated by burning the carbon therefrom. The resulting gases contain 5 to 10% (by volume) CO, with trace amounts of other combustibles, and will usually be at a temperature of 1000 F. or more leaving the kiln. Complete reduction of these gases necessitates the burning of a high heat value supplementary fuel, such as fuel oil or natural gas, to establish and maintain within the combustion zone temperatures of 1700 to 1800 F., so that the CO bearing gases introduced into the combustion zone will burn and thus oxidize all of the CO to CO_2.

It is known that in such combustion zones, with combustion processes of this nature the supplementary fuel must be given an opportunity to ignite and to at least partially complete its combustion before mixing with the effluent CO containing gas, otherwise the relatively large quantity of comparatively inert gas may smother the supplementary fuel flame. In addition, it has been found that the hot gaseous products of combustion deriving from the supplementary fuel must be intimately mixed with the CO containing gases, at a sufficiently high temperature and in the presence of sufficient oxygen, to complete the conversion of the CO to CO_2. Heretofore, the mixing of the gases has been accomplished in large upright combustion chambers of circular or substantially square horizontal cross-section, where the axial length of the combustion chamber was at least equal to and usually greater than the maximum horizontal dimension of the chamber. Such combustion chambers have been specially constructed for the combustion of the low heat value fuels, and it has been the considered opinion of those skilled in this art that with this special construction it was uneconomical to build such combustion chambers with associated heat recovery units for relatively small steam outputs, of the order of 60,000 pounds per hour or less, depending on the fuel fired.

However, it has now been found that relatively small capacity units can be made economically attractive by using the shop assembled or package type steam generator, wherein the furnace is horizontally elongated to afford a relatively long gas flow path. The furnace is provided with high heat value burner means in an end or front wall with ports for the introduction of the low heat value fuel in the same wall positioned above and below the burner means and substantially equally spaced from the boundary walls. The CO fuel streams are initially introduced in parallel horizontal direction at high velocities so that the high heat value fuel will have an opportunity to ignite and at least partially complete its combustion before mixing with the low heat value fuel. To attain adequate mixing of the gaseous products, low heat value fuel is also injected at high velocities into the furnace through ports in a wall normal to the plane of the end wall and in directions to intersect the gaseous products moving through the furnace from the front wall of the furnace. In general, the quantity of low heat value fuel is equally distributed between the end wall ports and the wall ports in the wall normal thereto. The interaction of the impinging streams of gaseous products within the furnace causes intimate mixing to complete the combustion process, prior to passing the heating gases over convection heating elements or surfaces associated with the vapor generator unit. Supplemental high heat value fuel and air may be admitted in conjunction with the CO gases introduced through the furnace wall normal to the front wall, to give a torch effect and thereby promote ignition, if such is desirable.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

FIG. 1 is a side elevation, of a package furnace and vapor generator constructed and arranged in accordance with the present invention;

FIG. 2 is a front view of the apparatus shown in FIG. 1; and

FIG. 3 is a plan, partly in section, of FIG. 1.

The invention as illustrated is applied to a package or shop assembled boiler, where the maximum steam capacity is of the order of 60,000 pounds per hour. Such a boiler unit may be operated by burning high heat value fuel alone or by the combusion of a combination of both high and low heat value fuels. However, in burning the combined fuels, the steaming capacity of the unit will be of the order of 40,000 pounds per hour, due to comparatively low temperature heating gases resulting from the high percentage of inerts in the CO containing fuel.

As shown in the drawings, and by particular reference to FIGS. 1 and 3, the furnace **10** of the boiler unit is provided with side walls **11** and **12** extending from an end or front wall **13** to a rear wall **14**. The side walls **11** and **12** are each provided with an upright row of fluid cooled tubes **15** and **16**, with the sidewall tubes **16** connected in flow relationship to fluid cooled tubes **17** and **18** to form the furnace roof and floor, respectively. Certain of the tubes **16** in the wall **12**, adjacent the front wall **13**, are displaced as at **19** and **19'** to provide space for ports for admitting additional air and fuels. The front wall **13** is of refractory construction and is provided with openings therethrough for the admission of the low and high heat value fuels and air for combustion.

To promote stability of ignition and combustion, the portion of the furnace wall tubes adjacent the front wall **13** is covered with ceramic refractory material.

The heating gases generated in the furnace **10** move through an outlet **29** positioned in side wall **11** adjacent the end wall **14** into a convention gas pass **20**, move forwardly therein to discharge through an opening **21** adjacent the front of the unit. Thereafter the gases pass upwardly over economizer tubes **22** into the stack **23** for discharge to the atmosphere.

As shown particularly in FIGS. 2 and 3, a burner port **24** is formed in the front wall **13** to accommodate a fuel oil burner **25** and associated air register **26** of conventional construction. The port is centrally located and substantially equally spaced relative to the walls **11** and **12**, and the roof **17** and the floor **18**. A gas-electric spark igniter tube **27** is positioned to extend through the port **24** for initial ignition of the high heat value oil fuel in the presence of the combustion air as they are discharged from the port **24**.

Four low heat value fuel ports **30**, **31**, **32** and **33** are located in the front wall 13 of the furnace, the ports being laterally and radially spaced from the burner port 24 and positioned with the ports 30 and 31 at a common level above the port 24 and the ports 32 and 33 at a common level below the port 24. Each of the fuel ports is thus located in the proximity of the corners of the front wall 13 and spaced from the sidewalls 11 and 12 of the furnace 10.

Additional low heat value fuel ports 34 and 35 are at position 19 and 19' in the side wall 12. The ports 34 and 35 consist of upwardly elongated refractory lined metal nozzles or sleeves 36 and 37 which are inclined away from the rear of the furnace at an angle of approximately 75° with respect to the plane of the side wall 12 (see FIG. 3). The inclination is such as to direct the fuel issuing from these ports generally toward the rear of the furnace prior to its impinging upon and merging with the combustion products produced by the fuel and air which are admitted through the front wall ports 24 and 30 to 33, inclusive. The upper port 34 is located below the elevation of the ports 30 and 31, the lower port 35 above the elevation of the ports 32 and 33, while at the same time each is spaced more or less symmetrically with respect to the burner 25. It will be understood a greater or lesser number of ports may be used, depending on the size of the unit.

The CO gases from the catalyst regenerator kiln (not shown) are reduced from the regenerator discharge pressure of about 15 to 25 p.s.i. to approximately 1 p.s.i. and pass through a refractory lined duct 40 (see FIG. 1). The duct delivers the CO gases to a T fitting adjacent the vapor generating unit with the discharge end 41 of the duct 40 opening to branch outlets 42 and 43 which connect with seal tanks 44 and 45, respectively. The seal tanks are of cylindrical shape arranged with their axes upright and each has a smaller diameter duct portion 46 and 47 extending downwardly within each tank to a position spaced from the bottom of the respective tanks. The lower ends of the ducts are serrated as at 48 and 50 so that when water is passed into the seal tank, the rising level 51 of the water will gradually close off the end of the discharge duct 46 leading from the seal tank 44, for example. One of the tanks 44 is provided with an outlet extension 52 leading directly to the stack 23. The other tank 45 is provided with a duct extension 53 which directs the flow of CO gas to a gas chamber 54 positioned on the side of the vapor generating unit. From the gas chamber 54, the CO gases are distributed to the burner ports positioned in the front and side walls of the furnace.

The purpose of the seal tanks is to provide a positive means for directing the flow of the CO containing gases either to the stack 23 or to the chamber 54 of the vapor generating unit. Thus, if the tank 44 contains water, say, to the level 51 covering the lower serrated end 48 of the duct, flow of gases to the stack 23 is completely cut off and all of the CO gases will then pass to the chamber 54, thence to the inlet ports of the vapor generating unit. When, however, maintenance and repair of the vapor generating unit are necessary, it is possible to drain the water from the seal tank 44 and to supply sufficient water to the seal tank 45 to prevent leakage of gas through the seal, and into the furnace 10. With this arrangement all of the CO gas will then pass to the stack 23 and will be discharged directly to the atmosphere. It is, of course, understood that the CO containing gas, when closely confined, is toxic and no maintenance work could be done in the vapor generator so long as the CO containing gases are present.

The CO gas chamber 54 positioned on the side of the vapor generating unit encloses the ports 34 and 35 and is arranged so that the gases delivered to the chamber will pass into the furnace 10 through the ports 30 to 35, inclusive. Separate ducts 55 and 56 lead from the gas chamber 54 to the burner ports 30 to 33, inclusive, positioned in the front wall 13 of the furnace. The duct 55 serves the burner ports 30 and 31 while the duct 56 serves the burner ports 32 and 33. It will be noted that none of the ducts connecting the seal tank with the burner ports is provided with a damper although it is possible that in some applications dampers may be desirable. Actually, the ports 30 to 35, inclusive, are sized for a preferred distribution of gas flow through each of the ports. In the construction shown, the ports 30 to 33, inclusive, will receive approximately ½ of the total CO gas received through the duct 53 while the ports 34 and 35 will receive the remaining quantity of CO gas. An exact fuel distribution between the ports in the front and side walls is not necessarily essential, so long as the discharge velocity of the CO gas through each of the ports is sufficient to insure turbulent mixing of the CO gases with the products of combustion produced by the high heat value fuel.

The CO containing gas ordinarily will also include some oxygen, although the quantity may be extremely low, as, for example, $\frac{1}{10}$ of 1%. It is, of course, understood the oxygen content of the CO gas may reach as much as 3%, however, it is unusual to have as high a percentage of oxygen in these gases. Under these conditions, the oxygen necessary for the combustion of the CO gas, as well as that necessary for the supplementary high heat value fuel must be separately introduced to the furnace. As shown in the drawings, two forced draft blowers 60 and 61 are provided with their discharge conduits 62 and 63 opening to an air housing 64 positioned on the exterior side of the front wall 13. The air housing encloses not only the burner port 24, but also the gas inlet ports 30 and 33, inclusive. The air housing supplies combustion air only to the burner port 24 for use with the supplementary fuel. As shown in FIG. 2, as off-take duct 65 leads from the air housing 64 to an upright tubular member 66 installed exteriorly adjacent the CO gas chamber 54. Branch ducts 67 and 68 extend from the member 66 to air pipes 70 and 71 extending through each of the ports 34 and 35. As shown in the drawings, each of the air pipes 70 and 71 is also provided with an oil atomizer assembly 72 and 73 respectively which extends through the air pipe to the vicinity of the inner face of the furnace wall 12.

With the arrangement described, additional supplementary fuel and air may be supplied to the furnace through each of the ports 34 and 35. As shown, each of the ducts 67 and 68 is provided with a control damper to regulate the flow of air through the side wall ports, so as to provide at least sufficient combustion air for the complete combustion of the supplementary fuel. Additional air may be supplied through these ports to burn the CO gas admitted through the sleeves 36 and 37. The purpose of the duct 74, interconnecting the air supply with the CO gas chamber 54, is to insure flow of a gaseous medium outwardly through the burner ports 30 to 35, inclusive, when the supply of CO gas to the furnace is discontinued by manipulation of the water flow valves to the gas flow cut-off seal tank 45.

In the operation of the unit described, with CO gas and supplementary fuel oil, a total input to the furnace of 52,400,000 B.t.u. per hour was divided between 10,000,000 B.t.u. added due to the combustion of the fuel oil, while 42,400,000 B.t.u. was added by the combination of the sensible heat value and the heat of combustion of the CO gas. The total air required for the combustion of both fuels was 29,000 pounds per hour resulting in 106,000 pounds of flue gas per hour, which produced 40,000 pounds per hour of saturated steam at 220 p.s.i.g.

When burning fuel oil alone, 3,960 pounds of oil per hour, corresponding to an input of 73,000,000 B.t.u. per hour, produced 60,000 pounds of saturated steam at 220 p.s.i.g. with a corresponding air weight of 6,630 pounds per hour and a weight of flue gas of 70,260 pounds per hour.

With two forced draft fans provided to serve the boiler unit, either fan may be operated when CO gas and oil are burned in combination, while both fans will be available for use in the combustion of the fuel oil alone. Both fans are of the same capacity, and the provision of two fans aids in the flexibility and overall economy of operation, since the fans are sized for operation at or near their most efficient capacity range. If desired, both fans may be provided with electric motor and/or steam turbine drive, or one may be motor driven with the other turbine driven, as local conditions dictate.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. Apparatus for the combustion of low heat value fuel comprising walls defining a horizontally elongated furnace, burner means disposed substantially centrally of and in an end wall of said furnace for introducing a stream of high heat value fuel and combustion air into said furnace in a generally horizontal direction, a plurality of port means disposed in the wall of and laterally spaced around said burner means for introducing a plurality of streams of low heat value fuel into said furnace in a direction parallel to said stream of high heat value fuel, said fuels mixing at a position spaced from said end wall, port means for introducing additional low heat value fuel into said furnace through a side wall of and substantially normal to the end wall of said furnace and in a generally horizontal direction impinging upon the mixture of high heat value fuel and low heat value fuel introduced through said end wall, said ports being spaced above and below the central horizontal axis of said furnace and means associated with said side wall port means for separately introducing high heat value fuel and combustion air into said furnace.

2. In a shop assembled boiler having a horizontally elongated furnace and a convection gas pass, wall means including fluid cooled tubes defining the rear, sides, roof and floor of said furnace, and means for introducing high heat value fuel and combustion air into said furnace including a burner port centrally positioned in the front wall of said furnace, a plurality of low heat value fuel inlet ports in the front wall of said furnace and radially spaced about said burner port, additional low heat value fuel inlet ports positioned in a wall of said furnace normal to said front wall, said additional ports being spaced adjacent said front wall and being spaced above and below the central horizontal axis of said furnace, each of said additional ports being inclined toward the rear of said furnace to project a stream of low heat value fuel in impinging relation to the streams of low and high heat value fuels discharged into said furnace from said burner port and said front wall low heat value ports, and means for introducing high heat value fuel and combustion air separately into said furnace through said additional low heat value fuel inlet ports in a direction substantially normal to the central horizontal axis of said furnace.

3. Apparatus for the combustion of low heat value gaseous fuel comprising walls defining a horizontally elongated furnace having a gas outlet adjacent a rear wall thereof, a burner positioned in the front wall of said furnace for the introduction of high heat value fuel and combustion air in a generally horizontal direction, means for introducing low heat value fuel into said furnace through said front wall from positions spaced above and below said burner, said high and low heat value fuels entering said furnace in generally parallel relationship and mixing within said furnace at a position spaced from said front wall for generally horizontal movement toward said gas outlet, and means for introducing additional high heat value and low heat value fuels and combustion air into said furnace in a generally horizontal direction through a furnace wall positioned generally normal to said front wall and directed in impinging relationship with the mixture of said first named fuels within said furnace.

4. Apparatus for the combustion of low heat value fuel comprising wall means defining the front, rear and sides of a horizontally elongated furnace, and means for introducing high heat value fuel and combustion air into said furnace including a burner port centrally positioned in the front wall of said furnace, a plurality of low heat value fuel inlet ports in the front wall of said furnace and radially spaced about said burner port, additional low heat value fuel inlet ports positioned in a wall of said furnace normal to said front wall, said additional ports being spaced adjacent said front wall and being spaced above and below the central horizontal axis of said furnace, each of said additional ports being inclined toward the rear of said furnace to project a stream of low heat value fuel in impinging relation to the streams of low and high heat value fuels discharged into said furnace from said burner port and said front wall low heat value ports, and means for introducing high heat value fuel and combustion air separately into said furnace through said additional low heat value fuel inlet ports in a direction substantially normal to the central horizontal axis of said furnace.

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