United States Patent

Cross

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[54] FIRED HEATER

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[52] **U.S. Cl.** ....**122/240 B,** 122/356

[51] **Int. Cl.** **F22b 21/30**

[58] **Field of Search** ....122/240 R, 240 B, 276, 356

[56] **References Cited**

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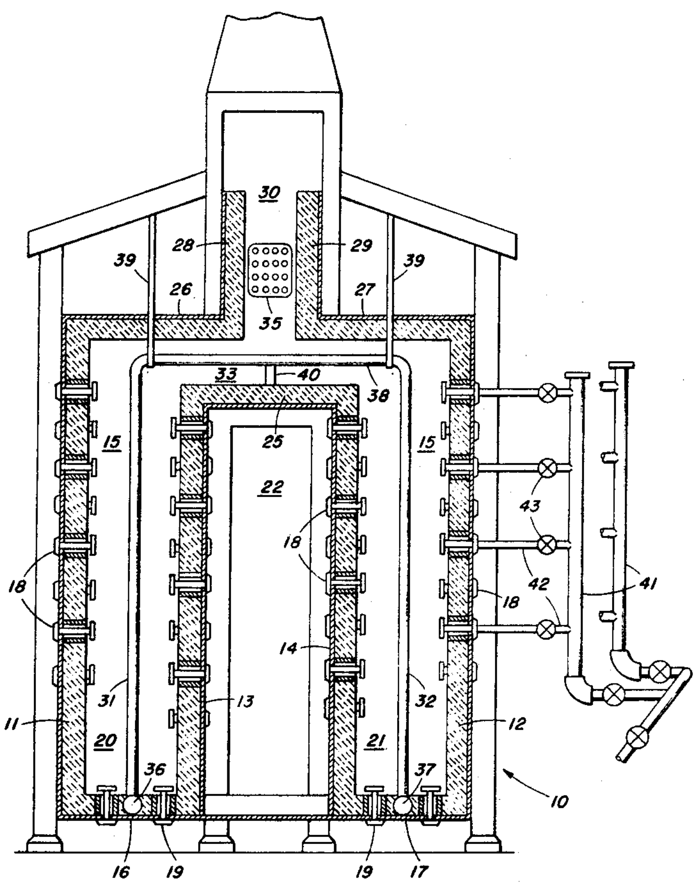
[57] **ABSTRACT**

A fired heater having two parallel vertical radiant sections essentially completely separated from each other and a convection section above and offset from both radiant sections with each radiant section having a single row of process tubes which are fired from both sides, with tubes of each section being interconnected with each other by horizontal crossover tubes to provide for flow of process fluid from inlet to outlet through both sections. The inlet radiant section may be fired at higher heat rates to heat a fluid to be processed from an inlet temperature to an intermediate temperature in a short residence time. The heater may be employed for: heating a mixture of carbon monoxide and hydrogen; pyrolysis of hydrocarbons; or steam reforming of hydrocarbons.

17 Claims, 2 Drawing Figures



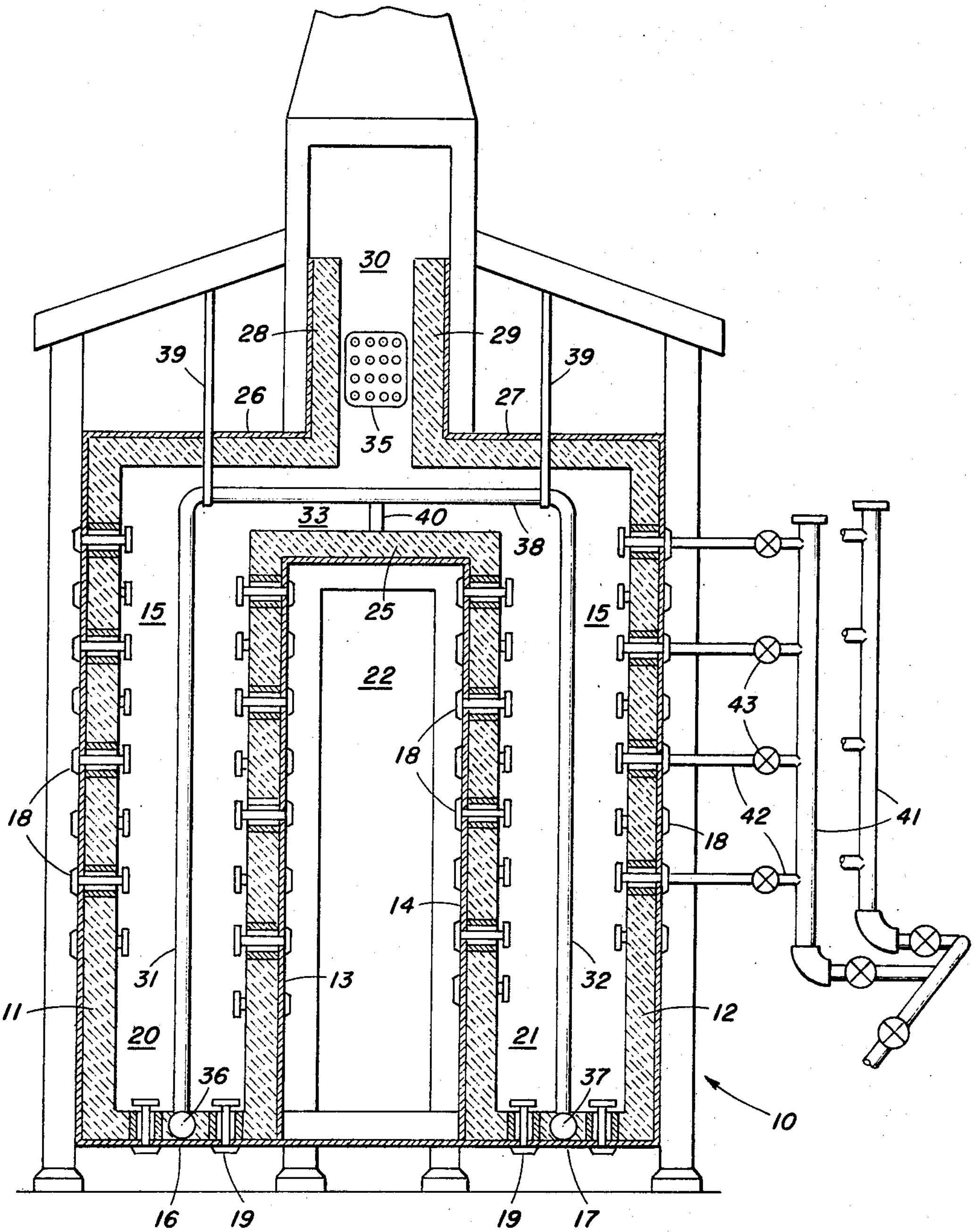


Fig. 1.

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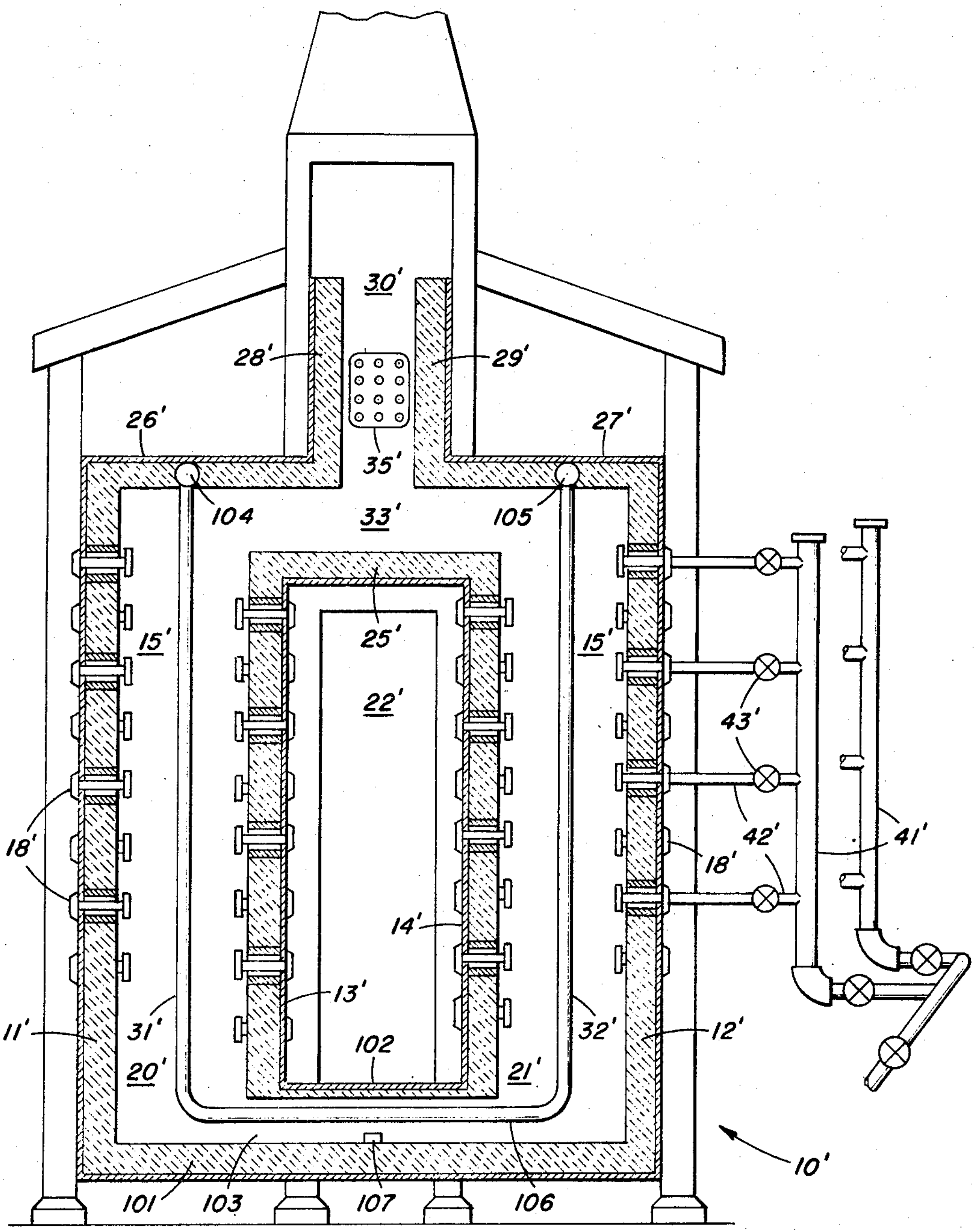

Fig. 2.

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FIRED HEATER

This invention relates to a fired heater and more particularly to a new and improved fired heater for rapidly heating a process fluid. This invention further relates to a new and improved process for the rapid heating of fluids.

In recent years there has been developed numerous heaters for effecting rapid heating of process fluids, such as for example, the pyrolysis of hydrocarbons; in particular, for the production of ethylene. In general such heaters are designed for high intensity cracking at short residence time and a particularly effective heater for such purposes is exemplified by U. S. Pat. No. 3,274,978, granted on Sept. 27, 1966. The present invention is directed to a new and improved heater for high intensity-short residence time heating of a process fluid, which may be employed for purposes other than the pyrolysis of hydrocarbons.

An object of this invention is to provide a new and improved fired process heater.

Another object of this invention is to provide a new and improved fired heater for effecting rapid heating of a process fluid.

A further object of this invention is to provide a new and improved process for effecting rapid heating of a process fluid.

Still another object of this invention is to provide a fired heater and process for heating fluids in which heating must be effected through a critical temperature range.

These and other objects of this invention should be more readily apparent from the following detailed description thereof with reference to the accompanying drawings wherein:

FIG. 1 is a sectional elevation view of an embodiment of the heater of the invention; and

FIG. 2 is a sectional elevation view of another embodiment of the heater of the invention.

The objects of this invention are broadly accomplished, in one aspect, by providing a heater which includes two radiant sections with the radiant sections being substantially completely separated from each other. Each radiant section includes a single row of vertical process tubes which are fired on both sides and a fluid to be heated is passed in series through both radiant heating sections. The firing rates in each radiant section may be separately controlled to provide the heat intensity, in each section, most suitable for the desired fluid processing conditions, and as a result of the radiant heating sections being substantially completely separated from each other, the firing rate employed in one does not have a significant effect on the firing rate in the other.

The invention will be described in more detail with respect to the accompanying drawings which are illustrative of embodiments of the invention. It is to be understood, however, that the scope of the invention is not to be limited thereby.

Referring to FIG. 1, there is provided a vertical tube type heater, supported on structural steel framework, generally indicated as **10**, mounted on piers and comprised of outer walls **11** and **12**, inner walls **13** and **14**, end walls **15** and floors **16** and **17**. Outer walls **11** and **12** are substantially parallel to inner walls **13** and **14** with the height of outer walls **11** and **12** extending above the height of inner walls **13** and **14**. Mounted in outer walls **11** and **12** and inner walls **13** and **14** are a plurality of vertical rows of high intensity radiant type burners generally indicated as **18**. The floors **16** and **17** extend between the outer walls **11** and **12**, the inner walls **13** and **14**, respectively. The floors **16** and **17** are provided with floor burners, generally indicated as **19** and are preferably of the flame type.

The outer wall **11**, inner wall **13**, and floor **16** together with end walls **15** form a radiant heating zone, generally indicated as **20**, while outer wall **12**, inner wall **14** and floor **17** together with end walls **15** form a second radiant heating zone, generally indicated as **21**. End walls **15** are in the shape of an inverted U thereby forming an open area **22** permitting access to the burners **18** mounted in the inner walls **13** and **14**.

Horizontally positioned and mounted on inner walls **13** and **14** is inner roof **25**. Horizontally positioned and extending inwardly from outer wall **11** is upper roof **26** mounted on outer wall **11** and end walls **15**, while similarly positioned and mounted on outer wall **12** and end walls **15** is upper roof **27**. Extending upwardly from upper roofs **26** and **27** are upper walls **28** and **29** which form with the upper extending portions of end walls **15**, a convection zone, generally indicated as **30**. A horizontal passage **33** places the radiant chambers **20** and **21** in fluid flow communication with the convection section **30**. All the walls, floors and roofs are provided with suitable refractory material.

The convection section **30** includes a plurality of horizontal convection tubes, schematically indicated as **35**, the tubes being positioned therein to prevent direct line of sight between the convection tubes and the radiant heating sections **20** and **21**.

In the radiant heating zone **20** there is provided a single row of vertical process tubes **31** extending in a plane parallel to and equidistant form the inner side wall **13** and the outer side wall **11**, the lower portion of each tube **13** being connected in fluid flow communication with an inlet manifold **36** positioned in the floor **16** of the radiant chamber **20**. Similarly, there is provided a single row of vertical process tubes **32** extending in a plane parallel to and equidistant from the inner side wall **14** and the outer side wall **12**, the bottom of each tube **32** being connected in fluid flow communication with an outlet manifold **37** positioned in the floor **17** of the radiant chamber **21**.

A plurality of parallel horizontal crossover tubes **38** are positioned in the horizontal passage **33** to interconnect in fluid flow communication a single process tube **31** of the radiant heating section **20** with a single process tube **32** of the radiant heating section **21**, whereby a fluid to be processed may be passed through the heater in a plurality of separate streams over a flow path which consists of upward movement through the vertical process tubes **31** in the radiant section **20**, horizontal movement through the crossover tubes **38** in horizontal passage **33** and downward movement through the process tubes **32** in radiant section **21**. The vertical tubes **31** and **32** in radiant heating sections **20** and **21** are supported from the framework **10** by hangers **39** and the horizontal tubes **38** rest on a spring support **40** which prevents sagging of the horizontal tubes **38**, but permits expansion thereof at the high operating temperatures.

The burners **18** are aligned in a plurality of spaced vertical rows over the entire depth of the inner walls **13** and **14** and the outer walls **11** and **12**, whereby the row of tubes **31** and **32** in the radiant sections **20** and **21** are fired from both sides along the entire length of each row, and each tube of each row is fired on both sides over substantially its entire vertical length. Each vertical row of burners **18** is supplied with fuel through a separate manifold **41** and each burner **18** in a vertical row is provided with fuel through a line **42**, including a valve **43**, which is connected to the manifold **41** for the row. In this manner, each row of burners **18** and each burner **18** in each row may be separately regulated to control the rate of firing. The manifolds **41** have been illustrated for only the burners **18** in outer side wall **12** in order to facilitate description of the overall embodiment and it is to be understood that the burners in the inner side wall are similarly supplied.

A further embodiment of the invention is illustrated in FIG. 2 which is similar to the embodiment of FIG. 1 and in which like parts are designated by like prime numerals.

Referring to FIG. 2, there is provided a vertical tube heater, supported on structural steel framework generally indicated as **10'**, mounted on piers and comprised of end walls **15'**, outer walls **11'** and **12'** and inner walls **13'** and **14'**, the outer walls **11'** and **12'** extending both above and below the inner walls **13'** and **14'**.

A horizontal inner floor **101** is connected to the end walls **15'** and the inner walls **13'** and **14'** and a horizontally extending outer floor **102**, parallel to inner floor **10'** is connected to the end walls **15'** and the outer walls **11'** and **12'**, the inner floor **101** and the outer floor **102** defining in conjunction with the end walls 15' a substantially horizontal lower passage 103 connecting a pair of radiant heating sections or zones 20' and 21'; the radiant heating zone 20' being defined by the lower floor 102, the outer side wall 11', the inner side wall 13' and the end walls 15', and the radiant heating zone 21' being defined by the lower floor 102, the outer side wall 12', the inner side wall 14' and the end walls 15'. A plurality of vertical rows of radiant burners 18' are mounted in inner walls 13' and 14' and outer walls 11' and 12'.

A horizontal inner roof 25' is connected to the end walls 15' and the inner walls 13' and 14' and a pair of horizontal outer roofs 26' and 27', each connected to end walls 15', extend inwardly in the same plane from outer walls 11' and 12', respectively, substantially parallel to the inner roof 25', with the inner ends of the outer roofs 26' and 27', being spaced from each other and above the interior of inner roof 25'. A pair of parallel side walls 28' and 29' extend vertically upwardly from the inner end of outer roofs 26' and 27', respectively, and are connected to upper extending portions of end walls 15' defining a convection section or zone 30', which is completely offset from both radiant sections 20' and 21' and which is connected in flue gas communication with the radiant sections 20' and 21' by a horizontal passage 33' defined by end walls 15', inner roof 25' and the outer roofs 26' and 27'. The convection section 30' includes a plurality of horizontal convection tubes, schematically indicated as 35', with the tubes being positioned therein out of direct line of sight of the radiant heating sections 20' and 21'. The end walls 15' correspond to the overall configuration of the heater thereby providing an open area 22' between the inner side walls 13' and 14', the lower roof 25' and the upper floor 101, permitting access to the burners 18'. The various walls, floors and roofs are provided with suitable refractory material, as known in the art.

In the radiant heating zone 20', there is provided a single row of vertical process tubes 31' extending in a plane parallel to and equidistant from the inner side wall 13' and the outer side wall 11', the upper portion of each tube being connected in fluid flow communication with an inlet manifold 104 positioned in the roof 26' of the radiant chamber 20'. Similarly, there is provided a single row of vertical process tubes 32' extending in a plane parallel to and equidistant from the inner side wall 14' and the outer side wall 12', the top of each tube 32' being connected in fluid flow communication with an outlet manifold 105 positioned in the roof 27' of the radiant chamber 21'.

A plurality of parallel horizontal crossover tubes 106 are positioned in the horizontal passage 103 to interconnect in fluid flow communication a single process tube 31' of the radiant heating section 20' with a single process tube 32' of the radiant heating section 21', whereby a fluid to be processed may be passed through the heater in a plurality of separate streams over a flow path which consists of downward movement through the vertical process tubes 31' in the radiant section 20', horizontal movement through the crossover tubes 106 in horizontal passage 103 and upward movement through the process tubes 32' in radiant section 21'. The lower floor 102 is provided with a support 107 which extends over the depth thereof at a point midway between and immediately below the ends of the horizontal crossover tubes 106. The crossover tubes 106 at the high operating temperatures which occur during operation of the heater expand onto the lower support 107, with the support 107 preventing the horizontal tubes 106 from sagging at such high operating temperatures. It should be readily apparent that more than one support may be provided or the support may be positioned at a point other than the center point of the horizontal tubes 106.

The burners 18 are aligned in a plurality of spaced vertical rows over the entire depth of the inner walls 13' and 14' and the outer walls 11' and 12', whereby the row of tubes 31' and 32' in the radiant sections 20 and 21', respectively, are fired from both sides along the entire length of each row and each tube of each row is fired on both sides over substantially its entire length. Each vertical row of burners 18' is supplied with fuel through a separate manifold 41' and each burner 18' in a vertical row is provided with fuel through a line 42', including a valve 43' which is connected to the manifold for the row. In this manner, each row of burners 18' and each burner 18' in each row may be separately regulated to control the rate of firing. The manifolds 41' have been illustrated for only the burners 18' in outer side wall 12' in order to facilitate description of the invention and drawings and it is to be understood that the burners in the inner side walls 13' and 14' and the outer side wall 11' are similarly supplied.

It should be readily apparent that numerous modifications and variations of the hereinabove described preferred embodiments are possible within the spirit and scope of the invention. Thus, for example, the tubes of the convection section in the hereinabove described embodiments are illustrated as being employed for heating a fluid other than the fluid to be passed through the radiant sections. It should be apparent that the convection tubes could be employed for preheating a fluid to be passed though the radiant heating sections in which case the outlet of the convection tubes would be connected by suitable crossover tubes to the inlet manifold of the radiant heating section; or instead of employing an inlet manifold a plurality of crossover tubes could be provided for placing the convection tubes in direct fluid flow communication with various vertical process tubes in the inlet radiant heating section.

As a further modification, the convection section could be offset to one side of the heater instead of being centrally offset as particularly shown. Similarly, the convection section could be arranged in a manner such that the convection section is not offset from the radiant heating sections and the convection tubes are not maintained out of direct line of sight of the radiant section, but such an arrangement is not preferred in that such an arrangement limits the capabilities of the heater.

As another modification, various process tubes in the single row of each radiant section may be interconnected to provide for passage of a plurality of process streams therethrough for more than a single pass, as particularly described. Thus, for example, two adjacent tubes could be interconnected in the first radiant section by a return bend, whereby the fluid to be processed makes two passes through the first radiant section prior to being passed through the horizontal crossover tubes for introduction into the second radiant section, which similarly to the first radiant section may have two adjacent tubes interconnected by a return bend whereby the fluid to be processed also makes two passes through the second radiant heating section. Thus, each fluid stream which is processed in the heater would make two passes through each of the first and second radiant heating sections. In such a modification, the inlet and outlet manifolds would be repositioned to provide for such a flow pattern. Similarly, more than two tubes in each row could be interconnected to provide for more than two passes in each radiant heating section and it is to be understood that the number of passes made in each radiant section may be equal or unequal to each other.

As yet a further modification, the tubes positioned in a single row of each of the radiant heating sections may be of a different diameter and may be interconnected with each other in a manner such that the number of parallel streams passed through the heater is reduced between the inlet and outlet manifolds. Thus, for example, the first radiant heating section may include a single row containing 24 tubes, 16 of which have a tube size of 2 inches I.D. and eight of which have a tube size of 3 inches I.D. and the second radiant section may include a single row containing 6 tubes of which four have a tube size of 4 inches I.D. and two have a tube size of 6 inches I.D. A fluid to be processed is introduced in sixteen parallel streams into the 2 inches I.D. tubes for a first pass through the first radiant heating section and each pair of such tubes is interconnected to a single 3 inches I.D. tube for a second pass through the first radiant heating section. Each pair of 3 inches I.D. tubes is interconnected to a single 4 inches horizontal crossover tube with each horizontal crossover tube being connected to a single 4 inches I.D. tube in the second radiant section, through which the fluid makes a first pass through the second radiant section. Each pair of 4 inches I.D. tubes is connected to a single 6 inches I.D. tube through which the fluid to be processed makes a second pass through the second radiant section to the outlet manifold. The use of a plurality of small diameter tubes as the inlet portion of the process fluid stream facilitates rapid heating at the inlet with a more gradual heating at the outlet. It is also contemplated within the spirit and scope of the invention to increase the tube diameters from inlet to outlet without reducing the number of parallel processing streams.

The above modifications and others should be apparent to those skilled in the art from the teachings herein.

The hereinabove described heater of the invention is particularly advantageous in that the overall design permits firing in two separate zones at different heat rates. Thus, the two radiant heating sections are substantially completely separated from each other; i.e., the vertical processing tubes in one radiant section substantially over the entire length thereof are substantially out of direct line of sight of the other radiant section, whereby each may be separately controlled to provide two different heat rates, with the heat rate being employed in one, as a result of the substantially complete separation, having little effect on the heat rate in the other. In general, the heater is operated to provide for a substantially uniform tube metal temperature over the length of each tube, and the achievement of such a result is facilitated by firing of the tubes on both sides in a plane perpendicular to the row of tubes, with the burners in each vertical row generally being controlled to decrease the rate of firing over the length of each row of burners in the direction of processing fluid flow. Each of the vertical rows of burners is generally fired in the same manner in order to produce the same temperature in each of the vertical processing tubes, whereby each stream of processing fluid is subjected to the same conditions. Thus, the radiant heating section in which the fluid is initially introduced is operated at a high rate of heat input to rapidly bring the temperature of the fluid being processed to a particularly desired temperature in a minimum of time, and the outlet radiant heating section is operated at a lower rate of heat input, such that excessive tube metal temperatures are not obtained at the higher temperatures prevailing in the outlet radiant heating section. Thus, by providing two separate radiant heating sections and passing a fluid to be processed through both sections, a higher heat rate may be used for initially heating the fluid to thereby rapidly raise the temperature of the fluid through a particular temperature range, followed by a lower heat rate for further heating of the fluid to the desired outlet temperature over a higher and generally less critical temperature range. In the absence of two separate radiant heating sections; i.e., the fluid to be processed is heated from an inlet temperature to the desired outlet temperature in a single radiant chamber or two radiant chambers which are not essentially completely separated from each other, the maximum heating rate at the inlet end of the tubes positioned in a single radiant heating section is limited in that without such limitation the additive effect of the higher heating rates prevailing at the inlet end of the tube, and the lower heating rate prevailing at the outlet end of the tube could produce a peak point at the outlet end of the tubes which would exceed the metallurgical limit thereof. Thus, the separation of the two radiant zones permits an overall firing rate at the inlet end of the processing stream which is higher than the one which could be achieved by passing the processing stream through a single radiant heating section. In other words, the processing fluid in each tube in each zone, as a result of the firing of vertical tubes from both sides in each zone to thereby establish essentially uniform temperatures over the length of the tube, may be heated in the tube to the highest temperature permitted by the known and available tube metallurgy, and as a result of passing the fluid through two separate radiant sections, the fluid may be heated to a desired higher temperature in less time; in particular, more rapid heating is effected at the inlet end, than if the fluid was passed through a single radiant heating section.

The convection section of the heater, as hereinabove described, is preferably completely offset from both radiant section, with the convection tubes being positioned therein out of direct line of sight of the radiant chambers. In this manner the cooler tubes of the convection section do not "-see" the hotter radiant sections, whereby the convection tubes are not a limiting factor in the operation of the radiant sections. In the absence of this feature, as a result of the additive effect of radiant and convection heat, there may be a peak point on the convection tubes which is greater than the peak point on the radiant tubes which would limit the overall capabilities of the heater.

The heater of the present invention may be employed in a wide variety of processes for rapidly heating a fluid from an inlet temperature to a temperature intermediate the inlet and outlet processing temperatures. Thus, for example, a gaseous mixture containing a high content of carbon monoxide and hydrogen, obtained for example from a hydrocarbon steam reforming process, must be reheated before being used in an extraneous process, such as the reduction of iron ore, and such reheating, as the result of the carbon monoxide content, generally presents serious coking problems. In the iron ore reducing process, the carbon monoxide in the reducing gas is partially oxidized to carbon dioxide and the reducing gas withdrawn from the reducing process is regenerated by removing a portion of its carbon dioxide. The regenerated reducing gas, which generally contains from about 40 to about 80 mol percent, preferably from about 40 to about 60 mol percent hydrogen; about 10 to about 30 mol percent, preferably from about 15 to about 25 mol percent carbon monoxide; and less than about 5 mol percent, preferably less than about 1 mol percent carbon dioxide, must also be reheated and recycled to the ore reduction. In accordance with the present invention, the hereinabove described heater is employed to rapidly heat such reducing gases i.e., either the effluent form a reformer or the regenerated reducing gas from the iron ore reducing process to the ore reduction temperatures.

In particular, the reducing gas, containing carbon monoxide and hydrogen, is generally introduced into the first radiant section of the heater at a temperature from about 800° F. to about 1,000° F., preferably from about 850° F. to about 900° F., and is rapidly heated in the first radiant section of the heater to a first radiant section outlet temperature from about 1,200° F. to about 1,400° F. The reducing gas is then further heated in the second radiant section of the heater to a second radiant section outlet temperature of from about 1,400° F. to about 1,700° F. Accordingly, the reducing gas is introduced into the radiant section of the heater at a temperature from about 800° F. to about 1,000° F., and is withdrawn from the heater at a temperature from about 1,400° F. to about 1,700° F., with the heating being effected in a manner such that at least 50 percent of the overall temperature rise from the inlet to the outlet of the heater, preferably from about 60 percent to about 80 percent, is effected in the first radiant section of the heater by employing a higher heating rate in the first section.

The overall residence time for the heating is generally less than 1 second, with the residence time of the reducing gas in the first radiant section being less than 70 percent of the overall residence time, and preferably from about 30 percent to about 60 percent of the overall residence time. In general, the overall residence time ranges from about 0.02 second to about 0.40 second, with the residence time in the first radiant section generally ranging from about 0.01 second to about 0.20 second.

The heater is generally operated at a radiant tube inlet pressure from about 50 to about 140 psig, with the overall pressure drop through the tubes being less than 50 psi and generally from about 10 to about 30 psi. The interior of the tubes, in particular the tubes in the first section, are preferably formed from or coated with a material which is non-catalytic to the coking reaction.

The rapid heating of the reducing gas, containing hydrogen and carbon monoxide, to thereby reduce or essentially eliminate coking problems is made possible by the heater design of the present invention which permits the use of high heat rates at the inlet end of the tube.

The heater of the present invention may also be used for the pyrolysis of a hydrocarbon feed, for example, the pyrolysis of ethane, propane, naphtha, gas oils and like feeds, in particular for the production of ethylene, in which case the two radiant heating sections are separately controlled to rapidly heat the feed in the first section, followed by a slower heating in the second section. Thus, for example, pyrolysis may be effected in an overall total residence time of less than 1 second, preferably within the range from 0.2 to about 0.9 second, with the fluid being in the first section for less than 70 percent of the overall residence time and preferably from 50 to 65 percent of the overall residence time. The hydrocarbon feed is generally preheated to a temperature which is at about the incipient cracking temperature thereof, generally no less than about 100° F. below the incipient cracking temperature, with the incipient cracking temperature varying with each feedstock and generally being at a temperature ranging from 900° to 1,250° F. The preheated feed is introduced into the first radiant heating section and rapidly heated therein to a temperature within the preferred cracking temperature range, generally a temperature from about 1,350° to 1,450° F. The feed is then further heated in the second radiant heating section to an outlet temperature about 1,500° F., generally from about 1,500° F., to about 1,625° F., preferably from about 1,500° F. to about 1,570° F.

The pyrolysis is generally effected in the presence of steam to reduce the partial pressure of the hydrocarbon with the steam being employed in amounts which range from 0.3 to about 1.0 pound of steam per pound of hydrocarbon feed. The total inlet pressure to the radiant tubes is generally from 45 to about 25 psig., with the pressure drop from inlet to outlet generally ranging from about 10 to about 30 psig.

Thus, in accordance with the present invention a fluid to be pyrolyzed is rapidly heated from a temperature just below the incipient cracking temperature thereof to a temperature within the preferred cracking temperature range, whereby the overall residence time may be reduced.

The heater of the present invention may also be used for the reforming of hydrocarbons with an oxidizing gas, either steam, carbon dioxide or a mixture thereof, preferably steam, to produce an effluent containing hydrogen and carbon monoxide; in particular for the steam reforming of a carbon monoxide rich hydrocarbon feed; e.g., the gaseous by-product containing methane, hydrogen and carbon monoxide produced in the reforming of ethane, propane, naphtha and like feeds, in that such feeds present serious coking problems. In accordance with the present invention, a carbon monoxide rich hydrocarbon feed gas and steam, the steam being employed in an amount which ranges from 0.1 to about 25 Vol. percent, are heated in the first radiant heating section from an inlet temperature ranging from about 800° F. to about 950° F. to a temperature above about 1,300° F., preferably a temperature from about 1,300° to about 1,400° F. in a residence time of less than 0.25 second, generally a residence time from about 0.01 to about 0.15 second. The reforming mixture is then further heated in the second radiant section to an outlet temperature from about 1,500° F. to about 1,750° F. with the overall residence time being less than 0.50 second, and generally from about 0.10 second to about 0.25 second. The inlet pressure of the mixture generally ranges from about 50 to about 140 psig, with the pressure drop, from inlet to outlet, generally ranging from 10 to 30 psi. The rapid heating of the feed in the first section to a temperature above 1,300° F. greatly reduces coke formation. The heating in the first radiant heating section is preferably effected in the absence of catalyst whereas the heating in the second radiant heating section is effected in the presence of a suitable reforming catalyst, such as nickel.

Thus, in accordance with the present invention, a feed to be subjected to steam reforming may be rapidly heated through a critical temperature range at which coking is likely to occur to thereby reduce such coking.

The hereinabove described processing applications of the present heater are illustrative of preferred operations, but it is to be understood that the scope of the invention is not to be limited thereby in that other processing applications are well within the scope of those skilled in the art from the teachings herein.

It is further to be understood that numerous modifications and variations of the present invention are possible in light of the above teachings and, therefore, within the scope of the appended claims the invention may be practiced other than as particularly described.

What is claimed is:

1. A process heater, comprising:

a. a first radiant heating section, said first radiant heating section including a single row of vertical process tubes and a plurality of vertical rows of radiant burners positioned on both sides of the single row of tubes for firing in a plane substantially perpendicular to the plane of process tubes and along substantially the entire length of the row;

b. a second radiant heating section, said second radiant heating section including a single row of vertical processing tubes and a plurality of vertical rows of radiant burners positioned on both sides of the single row of tubes for firing in a plane substantially perpendicular to the plane of process tubes and along substantially the entire length of the row; said first and second radiant heating sections being substantially completely separated from each other;

c. inlet means for introducing a processing fluid into the tubes in the first radiant section;

d. outlet means for withdrawing processing fluid from the tubes in the second radiant section; and

e. crossover tubes connecting tubes in the first radiant section with tubes in the second radiant section, whereby processing fluid is passed from the inlet means through tubes in the first and second radiant sections to the outlet means.

2. The process heater, as defined in claim **1** and further comprising control means for controlling firing of the radiant burners in the first and second radiant heating sections in both a horizontal and vertical direction.

3. The process heater as defined in claim **1** wherein a single tube in the first radiant heating section is connected to a single tube in the second radiant heating section by a single crossover tube whereby the process fluid flows in a single pass in each of the first and second radiant heating sections.

4. The process heater as defined in claim **1** and further comprising a convection section positioned above and completely offset from the first and second radiant heating sections and in flue gas communication therewith, said convection section including convection tubes positioned therein substantially out of line of sight with the first and second radiant heating sections.

5. The process heater as defined in claim **1** wherein the first and second radiant sections are vertically positioned and are interconnected by a horizontal passage, said crossover tubes being positioned in said horizontal passage.

6. A process heater as defined in claim **5** wherein the horizontal passage connects the upper portions of the first and second radiant heating sections.

7. The process heater as defined in claim **5** wherein the horizontal passage connects the lower portions of the first and second radiant heating sections.

8. A process heater, comprising:

a first radiant heating section comprised of a floor, vertical end walls, a first vertical outer side wall and a first vertical inner side wall shorter than and facing the first outer side wall; a second radiant heating section comprised of a floor, said vertical end walls, a second vertical outer side wall and a second vertical inner side wall shorter than and facing the second outer side wall; a generally horizontal lower roof connecting the first and second inner side walls and said vertical end walls; spaced vertical upper side walls connected to said end walls, said upper side walls facing each other and being spaced vertically above said lower roof, said upper vertical side walls and end walls defining a convection section; a first horizontal upper roof connecting the first outer side wall and the vertical end walls to one of said upper side walls; a second horizontal upper roof connecting the second outer side wall and the end walls to the other of said upper side walls, whereby the first and second radiant heating sections and the convection section are in fluid flow communication through a substantially horizontal passage defined by the end walls, the lower roof and the first and second upper roofs; a plurality of vertical rows of radiant burners in the first and second outer side walls and the first and second inner side walls; a first single row of vertical process tubes positioned in the first radiant heating section in a plane parallel to the first inner side wall and the first outer side wall; a second single row of vertical process tubes positioned in the second radiant heating section in a plane parallel to the second inner side wall and the second outer side wall; inlet means for introducing fluid into the first row of process tubes; outlet means for withdrawing fluid from the second row of process tubes; and crossover tubes interconnecting process tubes of the first row with process tubes of the second row, whereby fluid is passed in series through the first and second radiant heating sections.

9. The process heater as defined in claim **8** wherein the crossover tubes are positioned in the horizontal passage.

10. The process heater as defined in claim **8** wherein the first and second radiant heating sections have a common floor and further comprising an upper floor positioned above said common floor in a plane parallel thereto connecting the lower portion of said first and second inner side walls and the end walls, said common floor and said upper floor with said end walls defining a substantially horizontal lower passage interconnecting the first and second radiant heating sections, said crossover tubes being positioned in the horizontal lower passage.

11. The process heater as defined in claim **8** wherein the upper side walls are positioned inwardly from the first and second inner side walls whereby the convection section is completely offset from the first and second radiant heating sections, said convection section including convection tubes positioned therein substantially completely out of line of sight of said first and second radiant heating sections.

12. The process heater as defined in claim **8** and further comprising control means for controlling firing of the radiant burners in the first and second radiant heating section in both a horizontal and vertical direction.

13. The process heater as defined in claim **12** wherein a single tube in the first radiant heating section is connected to a single tube in the second radiant heating section by a single crossover tube whereby the process fluid flows in a single pass in each of the first and second radiant heating sections.

14. A process for heating a gas containing carbon monoxide, comprising:

a. introducing the gas into a first radiant heating section of a fired heater;

b. heating the gas in said first radiant heating section to a temperature from about 1,200° to about 1,400° F. at a rate such that the residence time for such heating is less than 0.20 second;

c. passing the heated gas from the first radiant heating into a second radiant heating section in said fired heater;

d. heating the gas in said second radiant heating section to a temperature from about 1,400° to about 1,700° F., said heating being effected at a rate such that the overall residence time is less than 0.4 second; and

e. withdrawing the heated gas from said second radiant heating section.

15. The process as defined in claim **14** wherein said mixture is introduced into the first radiant heating section at a temperature from about 800° to about 950° F.

16. The process as defined in claim **14** wherein the residence time in the first radiant heating section is from about 0.01 to about 0.20 second and the overall residence time is from about 0.02 to about 0.40 second.

17. The process as defined in claim **16** wherein the gas is a reducing gas and further includes hydrogen.

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