Sept. 27, 1966 E. H. PALCHIK ETAL 3,274,978

VERTICAL TUBE FLUID HEATER

Filed Feb. 24, 1964 3 Sheets-Sheet 1

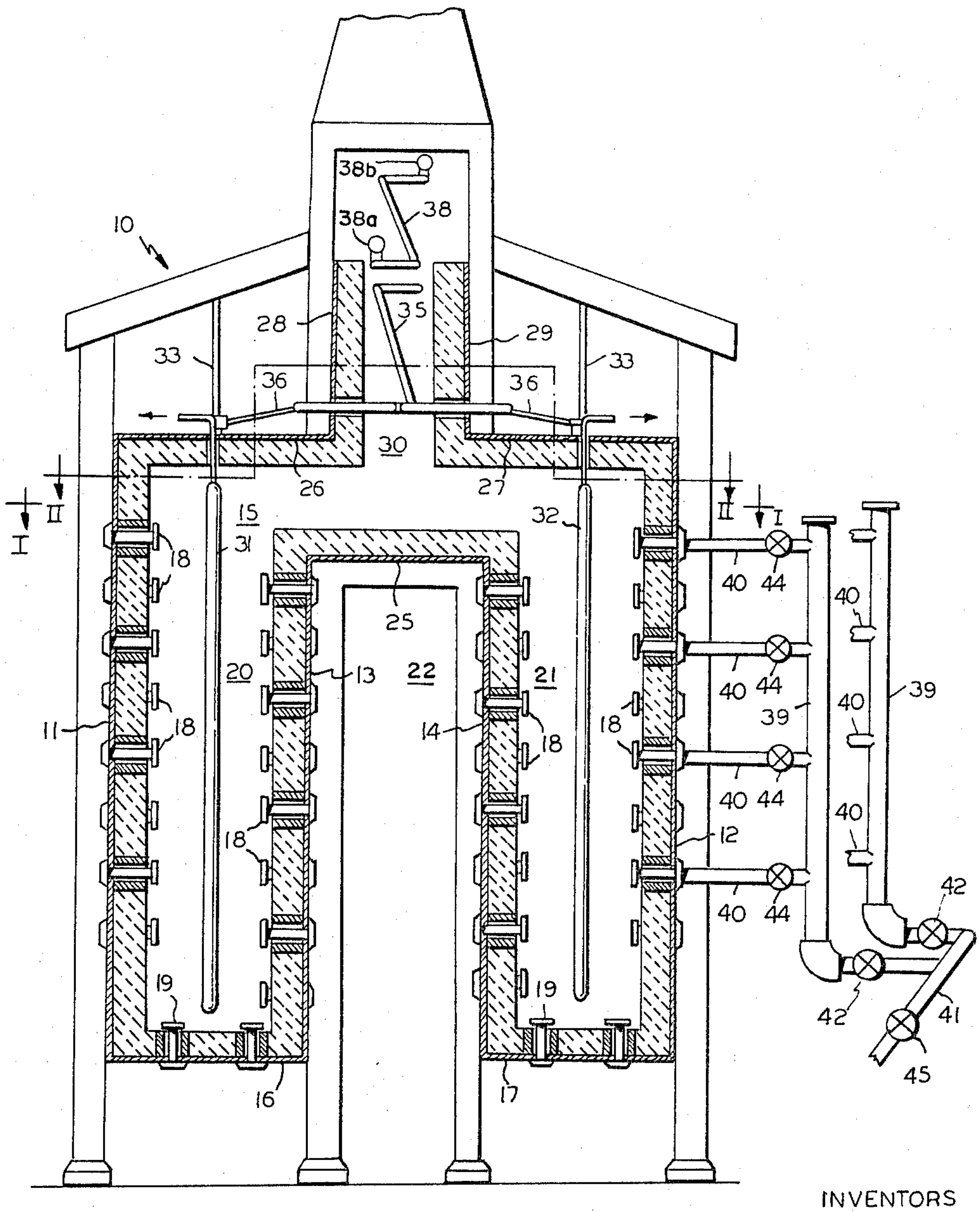

FIG.1

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VERTICAL TUBE FLUID HEATER

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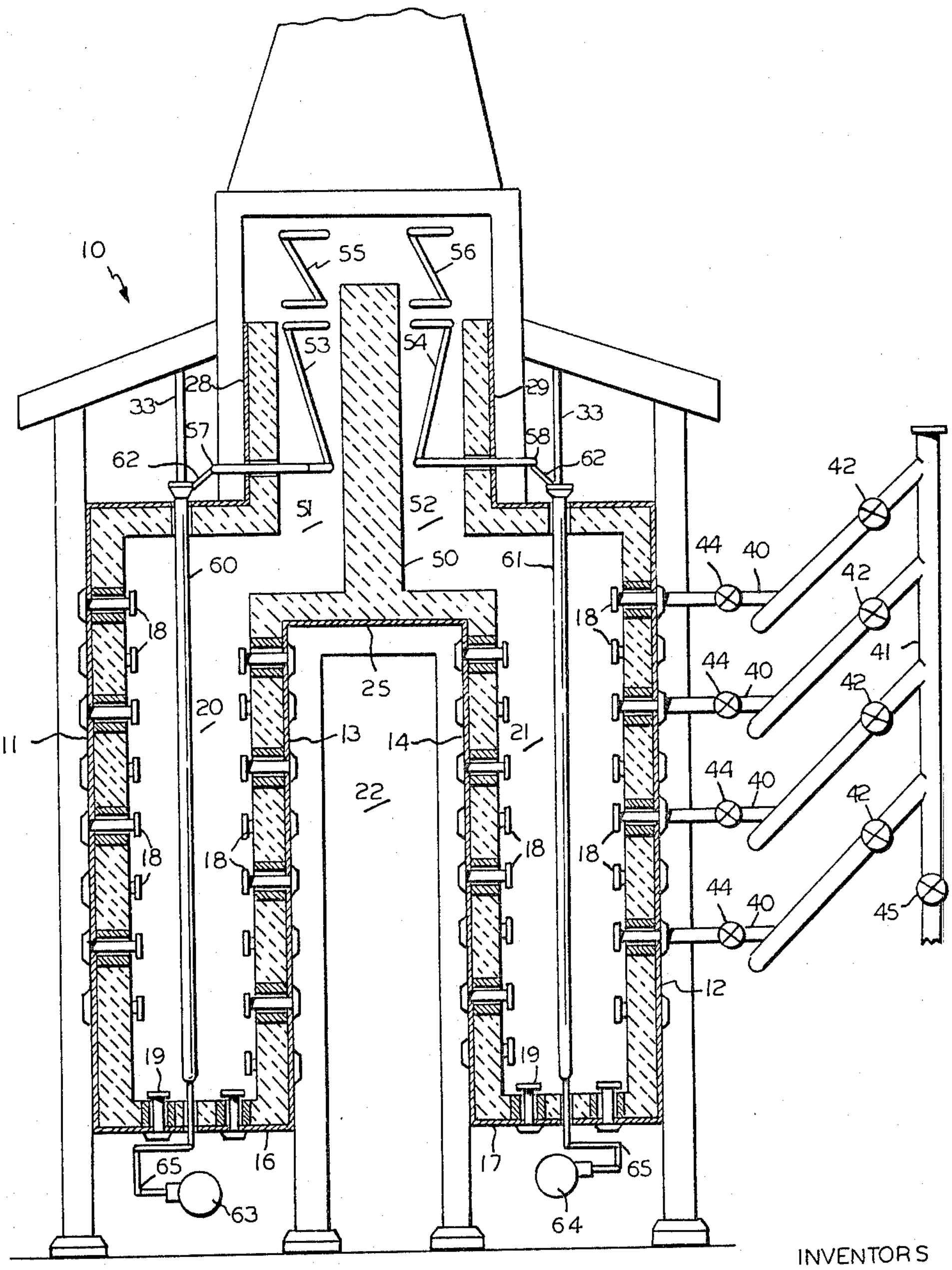

FIG. 2

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VERTICAL TUBE FLUID HEATER

Filed Feb. 24, 1964 3 Sheets-Sheet 3

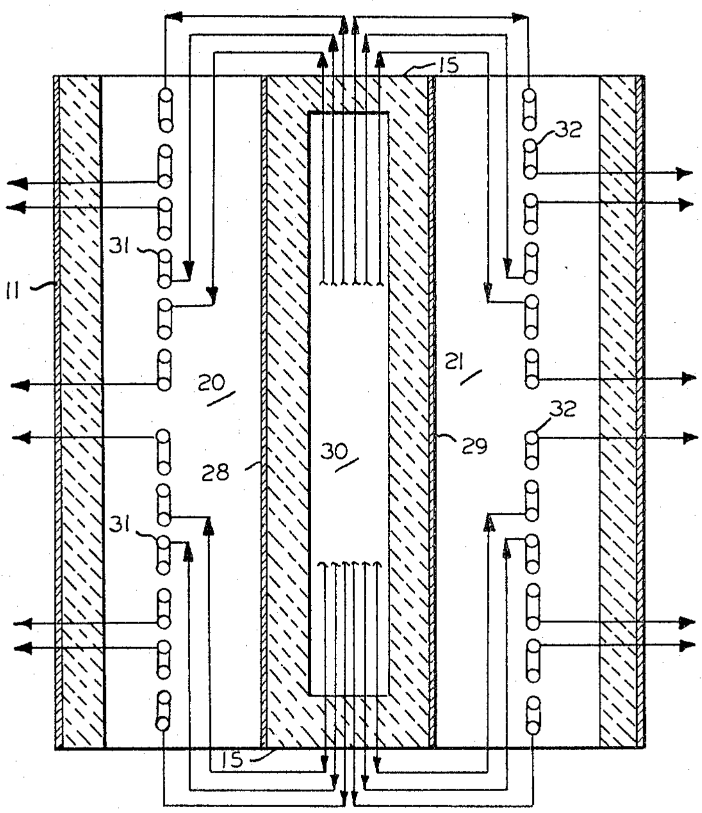

FIG. 4

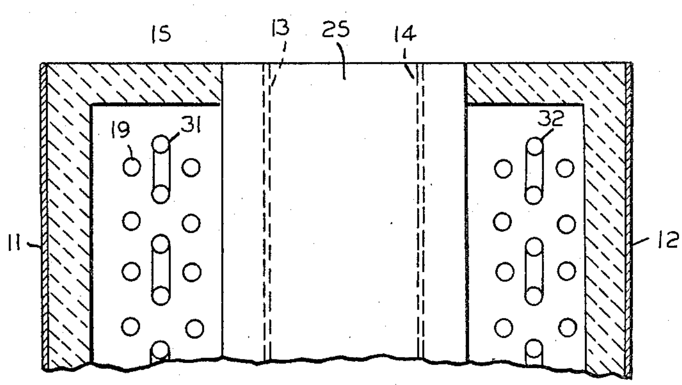

FIG. 3

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VERTICAL TUBE FLUID HEATER

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Filed Feb. 24, 1964, Ser. No. 346,733
6 Claims. (Cl. 122—356)

This application is a continuation-in-part of application Serial No. 334,216 filed December 30, 1963, now abandoned.

This invention relates to a heater of the vertical tube type which is well adapted for use in the conversion of hydrocarbons, and more particularly relates to a low residence time heater for the production of ethylene from hydrocarbons, particularly naphtha.

Prior heater designs for effecting the pyrolysis of naphtha to form ethylene have operated on low heat rates where the conversion of naphtha to ethylene ranges from about 12 to 26 percent. Such heaters have included two parallel coils and a two zone radiant section to permit varying the heating curve. Horizontal tube type heaters have metallurgical limitations of the tube supports when firing such heaters at intense service conditions as well as presenting serious expansion problems.

It is a primary object of our invention to provide a low residence time vertical tube heater.

It is a further object of our invention to provide a vertical tube type heater wherein higher yields of ethylene are obtained than heretofore.

Another object of our invention is to provide a vertical tube type heater wherein higher yields of ethylene are obtained than heretofore with a concomitant lowering of the yields of undesirable products.

Other advantages of our invention may be had by reference to the drawings in which,

FIGURE 1 is a sectional elevation of a preferred form of vertical tube heater for the pyrolysis of a hydrocarbon wherein the heater is provided with a common convection section.

FIGURE 2 is a sectional elevation of a vertical tube heater for the reforming of a hydrocarbon wherein each radiant section is provided with a convection section.

FIGURE 3 is a partial sectional plan view of the heater of FIGURE 1 taken along the line I—I.

FIGURE 4 is a partial sectional and schematic plan view of the heater of FIGURE 1, taken along the lines II—II illustrating the piping for such a heater where individual streams are preheated and passed through crossovers to separate coils in the radiant heating zones.

In accordance with our invention, a vertical tube type heater is constructed with two parallel radiant heating zones, with a single convection zone disposed above the radiant heating zones, or with a divided convection zone, part in communication with each radiant heating zone. A plurality of coils in a single row are vertically disposed within each of the radiant heating zones. On each wall of the radiant heating zone, there is provided a plurality of vertical rows of high intensity radiant burners. By locating high intensity radiant burners on either side of a single row of absorbing surfaces, we are able to obtain high heat absorption rates and operate at lower residence times than heretofore obtained. Additionally, floor burners are provided in each of the radiant heating zones. The limitation of heat rates in horizontal tube type heaters, i.e., tube supports, is obviated by our design which limits the points of support.

By firing each coil from both sides any number of parallel coils may be utilized limited only by reasonableness and flexibility requirements. The feed to the heater includes naphtha, light catalytic cycle oil and natural gas condensates boiling up to 1000° F. The coil is designed for residence times of about 0.3 second, generally from about 0.2 to 0.5 second at average heat rates of 20,000 to 30,000 B.t.u./hr./sq. ft. At such low residence times, high outlet temperatures in the order of about 1500 to 1550° F. are required for the decomposition of the feed and result in the formation of the desired olefins before the coke condensation reactions become significant.

Thus, the yields of ethylene and butadiene are increased as compared to conventional heaters, while providing the additional advantages of lower yields of methane, and hydrogen. With lower yields of methane, hydrogen, etc., there is a decrease in the operating and investment cost for the recovery section of the plant.

Referring to FIGURE 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**, and 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 the 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**. All the walls, floors and roofs are provided with suitable refractory material.

In the radiant heating zones **20** and **21** there is provided a plurality of vertical coils **31** and **32**, respectively, suitably mounted from supporting structure **10** by hangers **33**. The plurality of vertical coils **31** and **32** are positioned intermediate the outer and inner walls **11** and **13**, and outer and inner walls **12** and **14**, respectively. The coils are arranged for a plurality of passes, and are provided with suitable return bends and outlet means.

Mounted within the convection zone **30** are horizontally disposed conduits, schematically illustrated and generally indicated as **35**. The conduits **35** are in fluid communication with the tubes **31** and **32** through crossovers **36**. Also positioned within the convection section **30** is a second section of horizontally disposed conduits generally indicated as **38**. Inlet and outlet manifolds **38*a*** and **38*b*** are in fluid communication with the conduits **38**.

The burners **18** are supplied with the fuel through lines **40** from a plurality of manifolds **39**. The fuel is introduced into manifolds **39** through a manifold **41** under control of valves **42**. The flow of fuel to burners **18** may be varied in vertical rows depending on the desired severity of firing of the tubes **31** and **32**. Individual burners may be further adjusted by hand valves **44** in lines **40** with the total flow of fuel to the heater being controlled by valve **45**. It is understood that the burners mounted in outer wall **11** and inner walls **13** and **14** have similar manifold means.

It is understood that the number of passes of the fluid through the vertical tubes within the radiant heating zone may be varied depending on the feed, product specification, etc., i.e., the tubes represent a multiplicity of parallel coils vertically disposed within the radiant heating zones. The fluid may make one pass or a multiplicity of passes. In this regard, it will be appreciated that the outlet of the coils **31** and **32** may be positioned in the upper, intermediate or lower portions of the heater.

In FIGURE 2, the heater is similar to the general arrangement of the vertical tube heater of FIGURE 1, except that the former heater is designed for the reforming of hydrocarbons. Further, the combustion gases from each radiant heating zone are passed through separate convection sections prior to venting to the atmosphere. Referring to FIGURE 2, wherein like numerals designate like parts of FIGURE 1, there is provided a refractory center partition **50** vertically mounted on inner roof **25** and extending the length of the heater. The center wall **50** forms convection sections **51** and **52** with end walls **15** and upper walls **28** and **29**, respectively. Horizontally mounted in each convection sections **51** and **52** are conduits, schematically illustrated and indicated as **53** and **54**, respectively. Also horizontally mounted within the convection sections are a second section of conduits, constituting an economizer section, schematically illustrated and indicated as **55** and **56**. The conduits **55** and **56** are in fluid communication with inlet and outlet manifolds (not shown). Positioned in the radiant heating zones **20** and **21**, there are provided a plurality of vertical tubes **60** and **61**, respectively, suitably mounted from the supporting structure **10** by hangers **33**. The tubes **60** and **61** contain a suitable reforming catalyst. Manifolds **57** and **58** are provided which are in fluid communication with conduits **53** and **54**, and tubes **60** and **61**, respectively, through flexible conduits **62**. Positioned below the radiant heating zones **19** and **20** are manifolds **63** and **64** mounted on suitable supports (not shown). The manifolds **63** and **64** are in fluid communication with vertical tubes **60** and **61**, respectively, through flexible conduits **65**.

Another important feature of our invention is the ability to shut down one radiant heating zone for decoking or repair and maintenance while the other radiant heating zone is on stream. From the drawing, it is apparent that the radiant burners **18** in outer walls **11** and **12** are not directly opposite the radiant burners **18** in the inner walls **13** and **14**; however, other burner configurations may be provided. Since the heater design of FIGURE 2 is for reformer service, it will be appreciated that the firing of the burners are controlled in a vertical plane since the hydrocarbons to be reformed make only one pass through the radiant heating zone.

FIGURE 3, represents a partial sectional view through the line I—I of FIGURE 1 to illustrate the end walls **15**.

FIGURE 4 is a partial sectional and a schematic plan view of the heater through line II—II of FIGURE 1 wherein radiant heating zones **20** and **21** are provided with six separate coils. The feed to each radiant heating zone in the heater is divided into six streams and passed through separate conduits **35** in the convection section **30** prior to being passed to the coils **20**. Such an arrangement for a pyrolysis heater eliminates costly manifolds and provides for less expensive crossover means.

In operation, the feed is introduced into the conduits **35** to be preheated by combustion gases passing from the radiant heating zones. The preheated feed is thereupon passed through crossovers to the vertical coils **31** and **32**, respectively. The residence time of the preheated feed through the vertical coils **31** and **32** vary from about 0.2 to about 0.5 second. The heat flux around the tubes varies from about 20,000 to 30,000 B.t.u./hr./sq. ft. resulting in outlet temperatures within the range of about 1500 to 1550° F. A pyrolysis gas is withdrawn from the coils for further processing in a separation and purification plant (not shown).

The following Table 1 provides a comparison of the products distribution (mole percent) obtained from a conventional heater as compared to the low residence time heater utilizing naphtha fuel.

Table 1

	Conventional Heater	Low Residence Heater
CO_2	0.2	0.1
H_2	0.7	0.7
CH_4	14.6	11.6
C_2H_4	19.4	22.6
C_2H_6	5.4	3.6
C_3H_6	12.6	14.1
C_3H_8	0.5	0.4
C_4H_6	3.2	3.2
C_4H_8	3.8	4.9
C_4H_{16}	0.1	0.1
C_5–320° F. Gasoline	23.8	22.2
320–650° F. Gasoline	8.1	8.2
Fuel Oil	7.6	5.5

It is noted that on an ethylene basis, the methane yields for the low residence heater is less than 70% of a conventional heater with a concomitant increase in butadiene yields.

While we have described a preferred form of invention, we are aware that variations may be made thereto, and we, therefore, desire a broad interpretation of our invention within the scope of the disclosure herein and the following claims.

We claim:

1. A heater for fluids comprising:

(a) end walls and a floor;

(b) a side wall disposed between said end walls;

(c) a second side wall of smaller height disposed parallel to said first side wall and forming a radiant heating section;

(d) a roof mounted on said end walls and said first side wall and forming an opening between said roof and the upper portion of said second side wall;

(e) upper side and end walls mounted on said roof and around said opening and defining a convection section with said end walls, the axis of said convection section being offset from the axis of said radiant section, and said convection section being in flue gas communication only with said radiant section via said opening;

(f) vertical process tube means positioned intermediate said side walls in said radiant section;

(g) a plurality of rows of radiant burners positioned in said side walls of said radiant section, each row of burners having a manifold associated therewith and each manifold having valve means whereby each row of burners is individually controlled;

(h) convection heating means in said convection section, said means comprising first and second serpentine conduit means;

(i) crossover means in fluid communication with said vertical process tube means and said first serpintine conduit means, one serpentine conduit means being in fluid communication with a single process tube means;

(j) inlet means for said first serpentine conduit means;

(k) inlet and outlet means for said second serpentine conduit means; and

(l) outlet means for said vertical process tube means.

2. A heater for fluids comprising:

(a) outer side walls;

(b) end walls and floors;

(c) interior side walls, each interior side wall facing an outer side wall and defining radiant heating zones with said end walls and floors;

(d) an intermediate roof mounted on and positioned between said interior side walls;

(e) roofs mounted above each of said radiant zones on said outer side wall and said end walls and extending inwardly above said intermediate roof and forming with said intermediate roof passageways for combustion products of said radiant heating zones;

(f) a plurality of rows of radiant burners positioned in said side walls, each said row having a single manifold associated therewith and each manifold having valve means, whereby each row of burners is individually controlled;

(g) a plurality of vertical process tube means positioned intermediate said outer and inner side walls within each of said radiant zones;

(h) upper side walls mounted on said roofs and defining a convection zone with said end walls, and said convection zone being in flue gas communication only with said radiant zones via said passageways;

(i) convection heating means in said convection zone, said means comprising first and second serpentine conduit means;

(j) means in fluid communication with said first serpentine conduit means and with the inlets of said process tube means in each of said radiant zones;

(k) inlet means associated with said first serpentine conduit means;

(l) inlet and outlet means associated with said second serpentine conduit means; and

(m) outlet means associated with said process tube means.

3. The heater as claimed in claim 2, and additionally comprising:

a dividing wall parallel to said side walls mounted on said intermediate roof and dividing said convection zone into two sections;

third and fourth serpentine conduit means in said convection section;

said first and second serpentine conduit means being in one of said sections and said third and fourth serpentine conduit means being in the other of said sections;

said first serpentine conduit means being in fluid communication with process tube means in the adjoining radiant zone only;

said third serpentine conduit means being in fluid communication with process tube means in the other radiant zone;

inlet means associated with said third serpentine conduit means; and

inlet and outlet means associated with said fourth serpentine conduit means.

4. The heater as claimed in claim 2, wherein means (j) comprise crossover means having one serpentine conduit means in fluid communication with a single process tube means.

5. The heater as claimed in claim 2, wherein said process tube means are arranged in a single row in each of said radiant zones.

6. The heater as claimed in claim 5, and additionally comprising radiant burners mounted in said floors on either side of said row of tube means, and the burners in one side wall are vertically and horizontally offset from burners in the opposite wall.

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