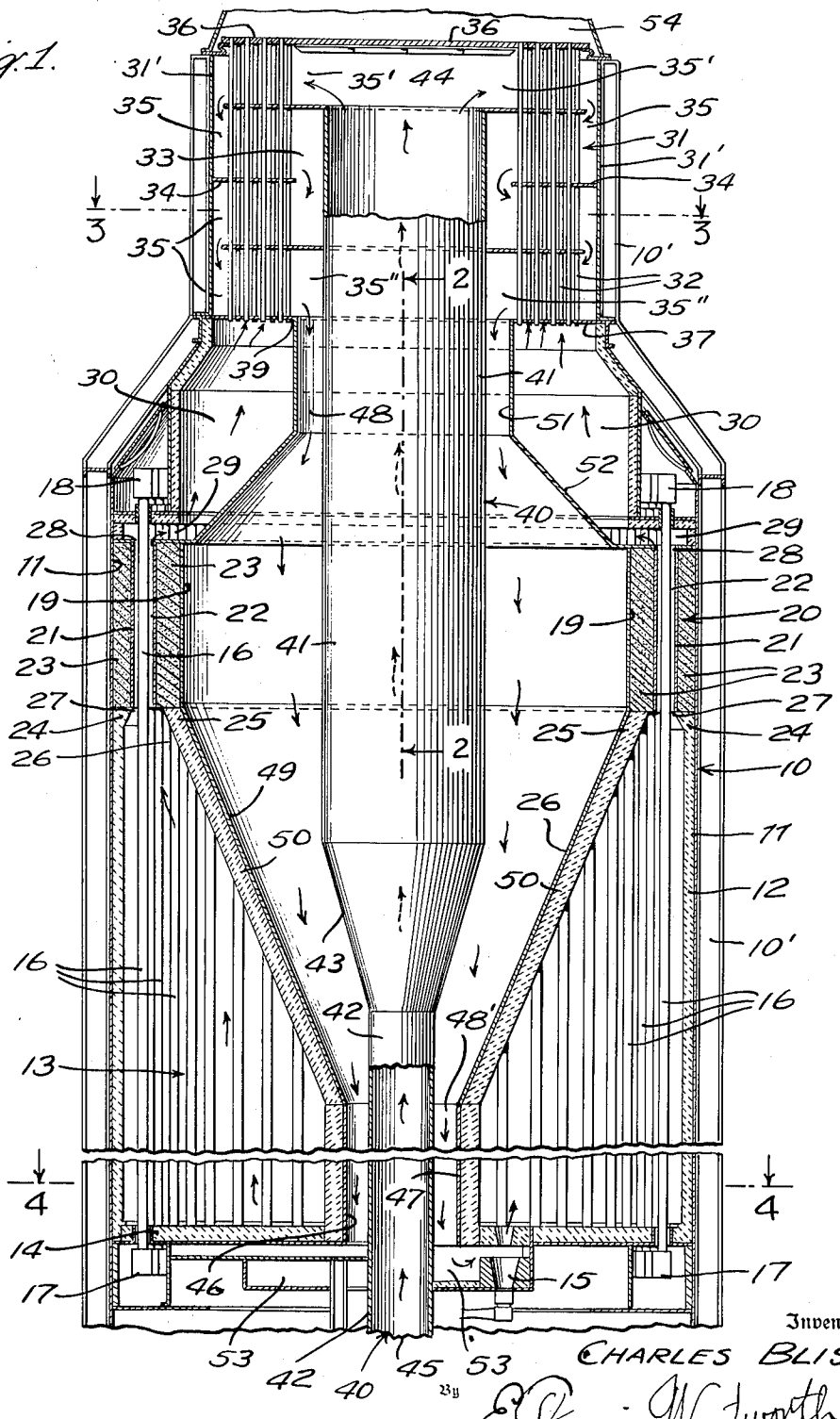
Nov. 15, 1955 C. BLISS 2,723,651

FLUID HEATERS

Filed Feb. 18, 1952 3 Sheets-Sheet 1

Fig. 1.



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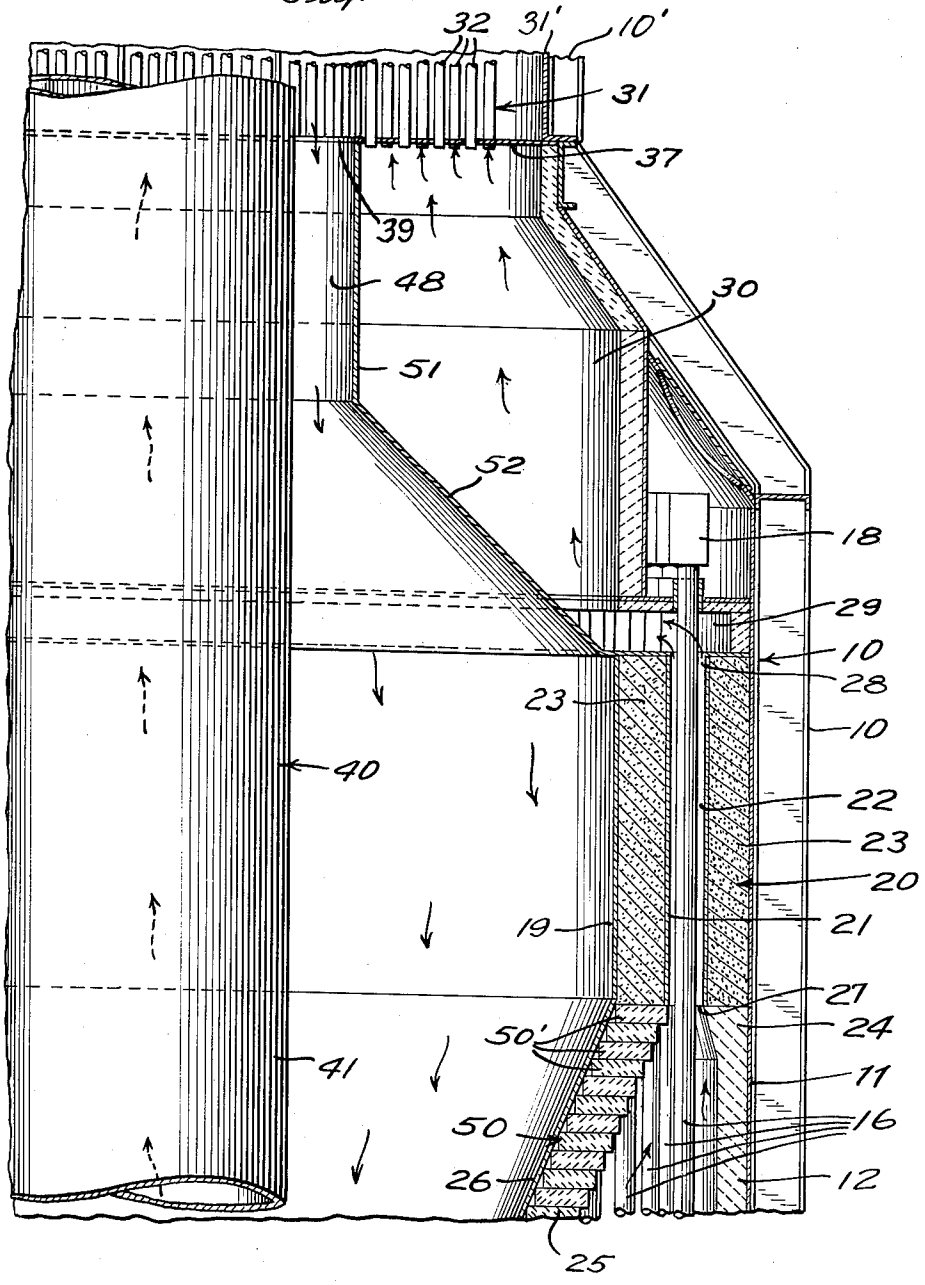
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FLUID HEATERS

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Fig. 2.



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FLUID HEATERS

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Fig. 3.

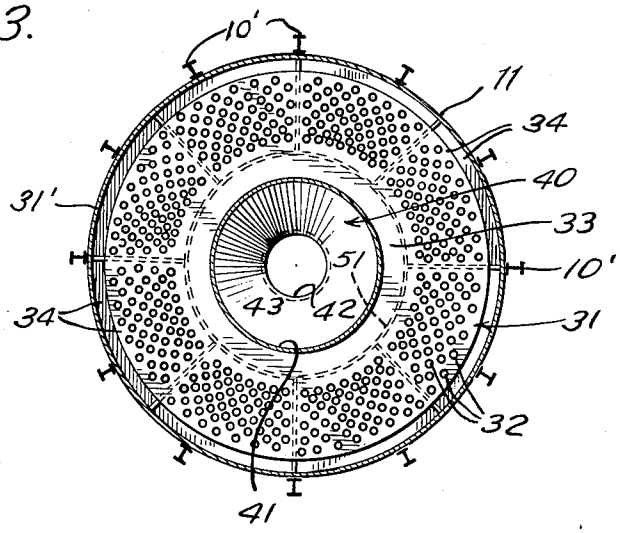
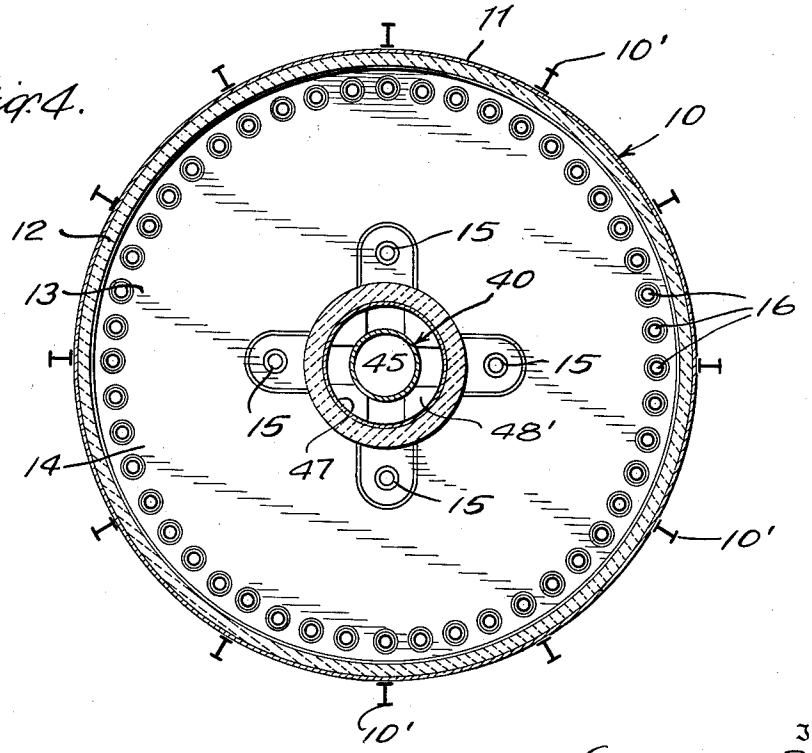


Fig. 4.



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2,723,651

FLUID HEATERS

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Application February 18, 1952, Serial No. 272,046

12 Claims. (Cl. 122—333)

This invention relates to heaters and more particularly pertains to fluid heating apparatus of the type in which the fluid to be heated is passed through tubular members in heat exchange relationship with a stream of products of combustion.

The present invention provides a heater used in the conversion of fluids, particularly in the conversion of hydrocarbon oil. Uniform heating of the tubular members both circumferentially and longitudinally thereof is provided in the heater of the present invention, and air to support combustion in the heater is heated to the proper temperature by passing the air in indirect heat exchange relationship with gases of combustion in the heater prior to using said air to support combustion.

The present invention provides a heater having an air heater therein by means of which air and gases of combustion are passed in indirect heat exchange relationship in an arrangement which is compact and economical.

The invention will be understood from the following description when considered in connection with the accompanying drawings forming a part thereof and in which:

Fig. 1 is a vertical sectional view of a heater embodying the present invention;

Fig 2 is a fragmentary enlarged view in vertical section of a portion of the upper part of the heater taken on line 2—2 of Fig. 1;

Fig. 3 is a plan view taken on line 3—3 of Fig. 1; and

Fig. 4 is a plan view taken on line 4—4 of Fig. 1.

Like characters of reference refer to the same or to similar parts throughout the several views.

Referring to the drawings, reference character **10** designates a cylindrically shaped setting of a heater supported by girders **10'** comprising a continuously circular metallic outer side wall **11** lined along its inner peripheral surface with a refractory brick lining **12**, thereby forming a cylindrical combustion chamber **13**. A substantially horizontal floor **14** is at the bottom of the chamber and has a plurality of burners **15** disposed in it, which burners are spaced concentrically about the center point of chamber **13** (Fig. 4) and positioned to direct a stream of gases of combustion generally vertically upwardly in the chamber. A circular row of spaced, generally vertically extending tubular members **16** is disposed along the refractory lining **12** of the circular side wall **11** in laterally spaced relationship therewith and spaced concentrically about the center point of the combustion chamber **13**. The tubular members **16** are connected at the lower end thereof to a lower circular header **17** and at the opposite end to an upper circular header **18**.

Fluid passing through tubular members **16** is heated by the gases of combustion flowing upwardly in chamber **13** in radiant heat exchange relationship with the portion of the tubes in the chamber, which chamber comprises a radiant heating section of the heater, and passing in convection heat exchange relationship with the upper portion of the tubes, which upper portion is in a convection heating section of the heater. The convection heating section

of the heater of the present invention is similar to the convection heating section of the heater disclosed in copending United States patent application Serial No. 251,046, filed October 12, 1951, which is a division of application Serial No. 632,159, now U. S. Patent No. 2,592,608, filed December 1, 1945, and comprises an inner annular metallic wall **19** concentric to outer side wall **11** and refractory **12** and of such diameter as to provide an annular chamber **20** through which the upper portion of the tubular members pass.

Metallic sleeves **21**, which have an inside diameter slightly larger than the outside diameter of tubular members **16**, are positioned about said members in chamber **20** so as to provide a vertical gas passage **22** axial of and concentric to that portion of a tubular member extending through chamber **20**. In this manner, a vertically extending circular passage **22** is formed around the upper portion of each tube, the inner surface of which passage is concentric to the tube and extends around the entire periphery of the tube closely adjacent thereto.

As shown, sleeves **21** are embedded in refractory filling **23** in chamber **20**, which refractory rests on enlarged top **24** of refractory brick lining **12** of wall **11** and refractory brick lining **25** at the top of outer heated air conduit **26**, hereinafter described. Each passage **22** has a gas inlet **27** and a gas outlet **28**. Circular wall **19**, sleeves **21** and refractory **23** extend upwardly to a point short of the top of upper header **18** to form a circular passage **29** between the top of chamber **20** and header **18**. Passage **29** is in communication with an annular gas outlet space **30** in setting **10**, the inner peripheral wall forming the peripheral boundary of said space. Gas outlet space **30** in turn communicates with a tubular air heater **31** positioned above said outlet space and in vertical alignment therewith.

Air heater **31** comprises a circular bank of spaced generally vertically extending tubular members **32** disposed along circular outer wall **31'** in circumferentially spaced relationship therewith and spaced from and concentrically about the center point of combustion chamber **13**, thereby providing an axial passage **33** centrally of the bank. A plurality of baffles **34** extends transversely of the tube bank in planes which are spaced from one another axially of tubular members **32**. The baffles are so arranged (Fig. 1) as to provide a plurality of passes **35** which communicate with one another serially and provide a flow path for air to be heated, which flow path has an air inlet end **35'** and an air outlet **35''**. The passes **35** extend transversely of the tube bank and communicate with one another so that air flows in opposite directions in adjacent passes and also flows axially of the tubular members **32**. Tubular members **32** are supported at their upper end by horizontal circular tube plate **36** forming the top of the heater **31** and at the lower end by horizontal circular tube plate **37** disposed concentrically about the center point of combustion chamber **13** and having a circular opening **39** therein. Tube plates **36** and **37** are supported by circular side wall **11**.

Extending into passage **33** in circular bank of tubular members **32** is a generally vertically extending annular inner air conduit **40** which is of lesser diameter than passage **33** and concentric therewith. Conduit **40** comprises an upper cylindrical portion **41** and a lower cylindrical portion **42** of lesser diameter than portion **41**. Portions **41** and **42** are connected by a frustoconical section **43**.

The uppermost end of conduit **40** is in spaced relationship with tube plate **36** of the air heater so that air from said conduit will be discharged into passage **44**. The lower portion **42** of conduit **40** extends longitudinally of the combustion chamber **13** in the central part

thereof and outwardly of the chamber 13 and setting 10 at the bottom thereof, the portion 42 receiving air to be heated through inlet end 45 thereof from a source of air, not shown.

A heated air passage 48 in communication at the upper end thereof with the air heater to receive heated air therefrom is formed around conduit 40 and comprises outer heated air conduit 26 which has an annular peripheral metallic wall 46, the lower portion 47 of which is of greater diameter than lower portion 42 and concentric therewith to provide passage 48'. Adjacent frustoconical section 43 of conduit 40, wall 46 is inclined outwardly and extends upwardly and outwardly to inner annular metallic wall 19 and is attached thereto by welding. As shown in Fig. 1, a frustoconical-shaped portion 49 is thereby formed around portion 43 of conduit 40 and around a part of upper portion 41 thereof. A refractory covering 50 surrounds wall 46, as shown in Fig. 1, and the refractory filling 23, adjacent the inner periphery thereof, is supported on covering 50. In the form of the invention shown in Fig. 2, covering 50 comprises a plurality of tiles 50' disposed one on top of the other while in the form of the invention shown in Fig. 1 it is in the form of a solid unitary covering.

The upper end of heated air passage 48 is formed by a metallic conduit 51 of greater diameter than upper portion 41 of conduit 40 and communicates with outlet end 35'' of the flow path of air through air heater 31 to receive heated air therefrom. Conduit 51 has a frustoconical-shaped section 52 which is inclined outwardly therefrom and downwardly into fluid-tight engagement with the upper edge of wall 19.

The lower end of heated air passage 48' communicates with wind box 53 beneath floor 14, which wind box in turn communicates with burners 15 to supply thereto heated air to support combustion in the chamber.

In operation, the gases of combustion flow generally vertically upwardly in the chamber 13 from burners 15 and in radiant heat exchange relationship with tubular members 16 in said chamber and with the lower portion 47 of outer air conduit 46, thereafter to impinge upon frustoconical portion 49 of said conduit, which portion 49 directs the gases toward said tubular members and toward gas inlets 27 of vertical gas passage 22 around the members. Gases from chamber 13 enter passage 22 and flow vertically upwardly therein axially of and in heat exchange relationship with the upper portion of tubular members 16. Since sleeves 21 are circular and concentric to the tubes which they surround, heat flows evenly around the entire circumference of the tubes. Heat is radiated evenly from the wall of each passage to the entire circumference of the tube which it surrounds. Gases from passage 22 flow into the restricted circular passage 29 through outlet 28, thereafter to pass in a generally horizontal direction in heat exchange relationship with the portion of the tubular members 16 in passage 29 toward gas outlet space 30. From gas outlet space 30 the gases flow upwardly through tubular members 32 of air heater 31 and outwardly of the setting through flue 54.

Cold air is forced by a blower, not shown, into inlet end 45 of conduit 40, thereafter to pass upwardly in the pipe 40 and be discharged from the upper end thereof into passage 44. From passage 44 the air flows into heat exchange relationship with tubular members 32 of air heater 31, the air entering an air flow path through the heater which comprises serially connected passes 35 through the air inlet end 35' of the flow path and, after passing transversely of tubular members 32 in opposite directions in adjacent passes, flows from the air flow path through outlet 35'' into passage 48 between outer air conduit 26 and inner air conduit 40. In passage 48 the heated air flows downwardly, passing in indirect heat exchange relationship with the air flowing upwardly through conduit 40. Thus, the air flowing upwardly in inner conduit 40 is preheated before it reaches air heater 31, preventing low metal temperatures in the heater tubes 32 and hence eliminating corrosion which results from condensation. After flowing through passage 48' the heated air passes into wind box 53 and burners 15, where it supports combustion in chamber 13.

Changes may be made in the form, location and relative arrangement of the several parts of the heater disclosed without departing from the principles of the invention. It will be understood that the invention is not to be limited except by the scope of the appended claims.

What is claimed is:

1. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrical shaped furnace chamber in said setting, which chamber has a gas outlet, a plurality of generally vertically extending tubular members in said chamber adjacent the outer periphery thereof and through which tubular members fluid to be heated passes, burner means capable of producing a stream of products of combustion, said burner means being so disposed in relationship to the tubular members and the chamber gas outlet that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members in passing to the gas outlet, air heating means in said chamber forming means comprising a vertically extending air conduit disposed substantially centrally of the chamber and air conducting means disposed in radiant heat exchange relationship with said stream of products as said products flow through the chamber to the gas outlet, said air conduit having an inlet through which air to be heated enters the conduit and an outlet through which heated air passes from the conduit, said inlet and outlet being so disposed in relationship to one another that air entering the conduit through said inlet flows in the conduit and is heated before passing therefrom through the air outlet, said air conduit outlet being in communication with the furnace chamber so as to supply heated air to the chamber and support combustion therein.

2. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrically shaped furnace chamber in said setting, which chamber has a gas outlet adjacent the upper end thereof, a plurality of generally vertically extending tubular members in said chamber adjacent the periphery thereof through which fluid to be heated passes, burner means positioned at the bottom of the chamber capable of producing a stream of products of combustion substantially vertically upwardly in the chamber, said burner means being so disposed in relationship to the tubular members that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members in passing to the gas outlet, air heating means in said chamber forming means comprising a vertically extending air conduit disposed substantially centrally of the chamber and air conducting means disposed in radiant heat exchange relationship with said stream of products as said products flow through the chamber to the gas outlet, said air conduit having an inlet at the lower end thereof through which air to be heated enters the conduit and an outlet at the upper end thereof through which heated air passes from the conduit, said air conduit outlet being in communication with said burner so as to supply heated air thereto and support combustion in the chamber.

3. In a furnace for heating fluids comprising a setting, means forming a vertical furnace chamber in said setting, which chamber has a gas outlet, a plurality of generally vertically extending tubular members in said chamber adjacent the outer periphery thereof and through which tubular members fluid to be heated passes, burner means capable of producing a stream of products of

combustion, said burner means being so disposed in relationship to the tubular members and the chamber gas outlet that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members in passing to the gas outlet, air heating means in said chamber forming means comprising air conducting means disposed in the chamber so as to be in radiant heat exchange relationship with said stream of products as said products flow through the chamber to the gas outlet, said air conducting means having an inlet through which air to be heated enters the conducting means and an outlet through which heated air passes from the conducting means, said inlet and outlet being so disposed in relationship with one another that air entering the conducting means through said inlet flows in the conducting means and is heated before passing therefrom through the air outlet, and an air heater in communication with said furnace gas outlet to receive products of combustion therefrom and with said air outlet to receive air from said air conducting means, the air heater being so constructed and arranged that said products of combustion and air pass in indirect heat exchange relationship with one another therein, said air conducting means outlet being in communication with the furnace chamber so as to supply air heated therein to the chamber and support combustion therein.

4. In a furnace for heating fluids comprising a setting, means forming a vertical furnace chamber in said setting, which chamber has a gas outlet, a plurality of generally vertically extending tubular members in said chamber adjacent the outer periphery thereof and through which tubular members fluid to be heated passes, burner means capable of producing a stream of products of combustion, said burner means being so disposed in relationship to the tubular members and the chamber gas outlet that the products of combustion are directed in the furnace chamber mainly in radiant heat exchange relationship with said tubular members in passing to the gas outlet, air heating means in said chamber forming means comprising air conducting means disposed in the chamber so as to be in radiant heat exchange relationship with said stream of products as said products flow through the chamber to the gas outlet, said air conducting means having an outer air conduit and an inner air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, the inner air conduit having an inlet through which air to be heated enters said inner air conduit and an outlet through which heated air passes from the inner air conduit, said inlet and outlet being so disposed in relationship with one another that air entering the inner air conduit through said inlet flows in the inner conduit and is heated before passing therefrom through the air outlet, said inner air conduit outlet being in communication with the passage between the inner air conduit and the outer air conduit, said passage having a heated air inlet in communication with the outer air conduit outlet and a heated air outlet in communication with the furnace chamber so as to supply heated air to the chamber and support combustion therein, said passage heated air inlet and heated air outlet being so disposed in relationship with one another that air entering said passage flows therethrough and is heated before passing into said chamber.

5. In a furnace for heating fluids comprising a setting, means forming an elongated vertically extending furnace chamber in said setting, which chamber has a gas outlet, a plurality of generally vertically extending tubular members in said chamber adjacent the outer periphery thereof and through which tubular members fluid to be heated passes, burner means capable of producing a stream of products of combustion, said burner means being so disposed in relationship to the tubular members and the chamber gas outlet that the products of combustion are

directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members in passing to the gas outlet, air heating means in said chamber forming means comprising air conducting means disposed in the chamber so as to be in radiant heat exchange relationship with said stream of products as said products flow through the chamber to the gas outlet, said air conducting means having a vertically extending cylindrically shaped outer air conduit and a vertically extending cylindrically shaped inner air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, the inner air conduit having an inlet through which air to be heated enters the inner air conduit and an outlet through which heated air passes from the inner air conduit, said inlet and outlet being so disposed in relationship with one another that air entering the inner air conduit through said inlet flows in the inner conduit and is heated before passing therefrom through the air outlet, said inner air conduit outlet being in communication with the passage between the inner air conduit and the outer air conduit, said passage having a heated air inlet in communication with the outer air conduit outlet and a heated air outlet in communication with the furnace chamber so as to supply heated air to the chamber and support combustion therein, said passage heated air inlet and heated air outlet being so disposed in relationship with one another that air entering said passage flows therethrough and is heated before passing into said chamber.

6. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrically shaped furnace chamber in said setting, which chamber has a gas outlet adjacent the upper end thereof, a plurality of generally vertically extending tubular members in the chamber adjacent the periphery thereof through which tubular members fluid to be heated passes, air heating means in said chamber forming means comprising a vertically extending cylindrically shaped outer air conduit disposed substantially centrally of the chamber, a vertically extending cylindrically shaped inner air conduit positioned within the outer air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, the inner air conduit having an inlet at the lower end thereof through which air to be heated enters said inner conduit and an outlet at the upper end thereof through which heated air passes from the inner conduit, the air passage between the inner and outer air conduits having an inlet at the upper end thereof in communication with the outlet of said inner conduit to receive heated air therefrom and an outlet at the lower end thereof communicating with the combustion chamber so as to provide heated air to support combustion therein, and burner means capable of producing a stream of products of combustion so positioned at the bottom of the chamber as to direct a stream of products of combustion substantially vertically upwardly in the chamber, the burner means being so located in the chamber in relationship to the tubular members and the air heating means that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members and said air heating means.

7. In a furnace for heating fluids comprising a setting, means forming a vertical furnace chamber in said setting, which chamber has a gas outlet, a plurality of generally vertically extending tubular members in said chamber adjacent the outer periphery thereof and through which tubular members fluid to be heated passes, burner means capable of producing a stream of products of combustion, said burner means being so disposed in relationship to the tubular members and the chamber gas outlet that the products of combustion are directed into the furnace

chamber mainly in radiant heat exchange relationship with said tubular members in passing to the gas outlet, air heating means in said chamber forming means comprising air conducting means disposed in the chamber so as to be in radiant heat exchange relationship with said stream of products as said products flow through the chamber to the gas outlet, said air conducting means having an outer air conduit and an inner air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, the inner air conduit having an inlet through which air to be heated enters said inner air conduit and an outlet through which heated air passes from the inner air conduit, said inlet and outlet being so disposed in relationship with one another that air entering the inner air conduit through said inlet flows in the inner conduit and is heated before passing therefrom through the air outlet, and an air heater in communication with said furnace gas outlet to receive products of combustion therefrom and with said outlet of the inner conduit to receive air from said inner conduit, the air heater being so constructed and arranged that said products of combustion and air pass in indirect heat exchange relationship with one another therein, the air heater being in communication with the passage between the inner air conduit and the outer air conduit to discharge heated air into said passage, the passage having a heated air inlet in communication with the air heater to receive said air discharged thereinto and a heated air outlet in communication with the furnace chamber so as to supply heated air to the chamber and support combustion therein, said passage heated air inlet and heated air outlet being so disposed in relationship with one another that air entering said passage flows therethrough and is heated before passing into said chamber.

8. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrically shaped furnace chamber in said setting, which chamber has a gas outlet adjacent the upper end thereof, a plurality of generally vertically extending tubular members in the chamber adjacent the periphery thereof through which tubular members fluid to be heated passes, air heating means in said chamber forming means comprising a vertically extending cylindrically shaped outer air conduit disposed substantially centrally of the chamber, a vertically extending cylindrically shaped inner air conduit positioned within the outer air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, the inner air conduit having an inlet at the lower end thereof through which air to be heated enters said inner conduit and an outlet at the upper end thereof through which heated air passes from the inner conduit, the air passage between the inner and outer air conduits having an inlet at the upper end thereof and an outlet at the lower end thereof communicating with the combustion chamber so as to provide heated air to support combustion therein, burner means capable of producing a stream of products of combustion so positioned at the bottom of the chamber as to direct a stream of products of combustion substantially vertically upwardly in the chamber, the burner means being so located in the chamber in relationship to the tubular members and the air heating means that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members and said air heating means, and an air heater at the upper end of the furnace, said air heater communicating with said furnace gas outlet to receive products of combustion therefrom and with said outlet of the inner conduit to receive air from said inner conduit, the air heater being so constructed and arranged that said products of combustion and air pass in indirect heat exchange relationship with one another therein, the air heater being in communication with said passage inlet so as to discharge heated air into the passage.

9. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrically shaped furnace chamber in said setting, which chamber has a gas outlet adjacent the upper end thereof, a plurality of generally vertically extending tubular members in the chamber adjacent the periphery thereof through which tubular members fluid to be heated passes, air heating means in said chamber forming means comprising a vertically extending cylindrically shaped outer air conduit disposed substantially centrally of the chamber, a vertically extending cylindrically shaped inner air conduit positioned within the outer air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, said outer air conduit having a frusto-conical-shaped portion adjacent the upper end thereof, said frusto-conical-shaped portion being inclined outwardly from said outer conduit toward the tubular members and upwardly in the chamber, the inner air conduit having an inlet at the lower end thereof through which air to be heated enters said inner conduit and an outlet at the upper end thereof through which heated air passes from the inner conduit, the air passage between the inner and outer air conduits having an inlet at the upper end thereof in communication with the outlet of said inner conduit to receive heated air therefrom and an outlet at the lower end thereof communicating with the combustion chamber so as to provide heated air to support combustion therein, and burner means capable of producing a stream of products of combustion so positioned at the bottom of the chamber as to direct a stream of products of combustion substantially vertically upwardly in the chamber, the burner means being so located in the chamber in relationship to the tubular members and the air heating means that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members and said air heating means.

10. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrically shaped furnace chamber in said setting, which chamber has a gas outlet adjacent the upper end thereof, a plurality of generally vertically extending tubular members in said chamber adjacent the periphery thereof through which tubular members fluid to be heated passes, burner means capable of producing a stream of products of combustion positioned at the bottom of the chamber to direct a stream of products of combustion substantially vertically upwardly in the chamber, said burner means being so disposed in relationship to the tubular members that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members in passing to the gas outlet, means forming a gas passage extending axially of the upper portion of an individual tubular member, said gas passage being in communication with the furnace chamber through a gas inlet and with the gas outlet means through a gas outlet, said passage gas inlet and outlet being at opposite ends of the passage, the passage being contiguous to said tubular members and providing a confined flow path through which gases pass from the furnace chamber to the chamber gas outlet, air heating means in said chamber forming means comprising a vertically extending air conduit disposed substantially centrally of the chamber and air conducting means disposed in radiant heat exchange relationship with said stream of products as said products flow through the chamber to the gas outlet, said air conduit having an inlet at the lower end thereof through which air to be heated enters the air conduit and an outlet at the upper end thereof through which heated air passes from the conduit, said air conduit outlet being in communication with said burner so

as to supply heated air thereto and support combustion in the chamber.

11. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrically shaped furnace chamber in said setting, which chamber has a gas outlet adjacent the upper end thereof, a plurality of generally vertically extending tubular members in the chamber adjacent the periphery thereof through which fluid to be heated passes, means forming a gas passage extending axially of the upper portion of an individual tubular member, said gas passage being in communication with the furnace chamber through a gas inlet and with the gas outlet means through a gas outlet, said passage gas inlet and outlet being at opposite ends of the passage, the passage being contiguous to said tubular members and providing a confined flow path through which gases pass from the furnace chamber to the chamber gas outlet, air heating means in said chamber forming means comprising a vertically extending cylindrically shaped outer air conduit disposed substantially centrally of the chamber, a substantially vertically extending cylindrically shaped inner air conduit positioned within the outer air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, the inner air conduit having an inlet at the lower end thereof through which air to be heated enters said inner conduit and an outlet at the upper end thereof through which heated air passes from the inner conduit, the air passage between the inner and outer air conduits having an inlet at the upper end thereof in communication with the outlet of said inner conduit to receive heated air therefrom and an outlet at the lower end thereof communicating with the combustion chamber so as to provide heated air to support combustion therein, and burner means capable of producing a stream of products of combustion so positioned at the bottom of the chamber as to direct a stream of products of combustion substantially vertically upwardly in the chamber, the burner means being so located in the chamber in relationship to the tubular members and the air heating means that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members and said air heating means.

12. In a furnace for heating fluids comprising a setting, means forming a vertically extending cylindrically shaped furnace chamber in said setting, which chamber has a gas outlet adjacent the upper end thereof, a plurality of generally vertically extending tubular members in the chamber adjacent the periphery thereof through which fluid to be heated passes, means forming a gas passage extending axially of the upper portion of an individual tubular member, said gas passage being in communication with the furnace chamber through a gas inlet and with the gas outlet means through a gas outlet, said passage gas inlet and outlet being at opposite ends of the passage, the passage being contiguous to said tubular members and providing a confined flow path through which gases pass from the furnace chamber to the chamber gas outlet, air heating means in said chamber forming means comprising a vertically extending cylindrically shaped outer air conduit disposed substantially centrally of the chamber, a vertically extending cylindrically shaped inner air conduit positioned within the outer air conduit, the relative diameters of said inner and outer conduits being such that an air passage extends between the outer periphery of the inner conduit and the inner periphery of the outer conduit, said outer air conduit having a frustoconical-shaped portion adjacent the upper end thereof, said frustoconical-shaped portion being inclined outwardly from said outer conduit toward the tubular members and upwardly in the chamber to a point closely adjacent the gas inlets of said passages around the individual tubular members, the inner air conduit having an inlet at the lower end thereof through which air to be heated enters said inner conduit and an outlet at the upper end thereof through which heated air passes from the inner conduit, the air passage between the inner and outer air conduits having an inlet at the upper end thereof in communication with the outlet of said inner conduit to receive heated air therefrom and an outlet at the lower end thereof communicating with the combustion chamber so as to provide heated air to support combustion therein, and burner means capable of producing a stream of products of combustion so positioned at the bottom of the chamber as to direct a stream of products of combustion substantially vertically upwardly in the chamber, the burner means being so located in the chamber in relationship to the tubular members and the air heating means that the products of combustion are directed into the furnace chamber mainly in radiant heat exchange relationship with said tubular members and said air heating means.

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