

June 5, 1951

B. DE LORENZO

2,555,322

HEATER

Original Filed April 21, 1943

5 Sheets-Sheet 1

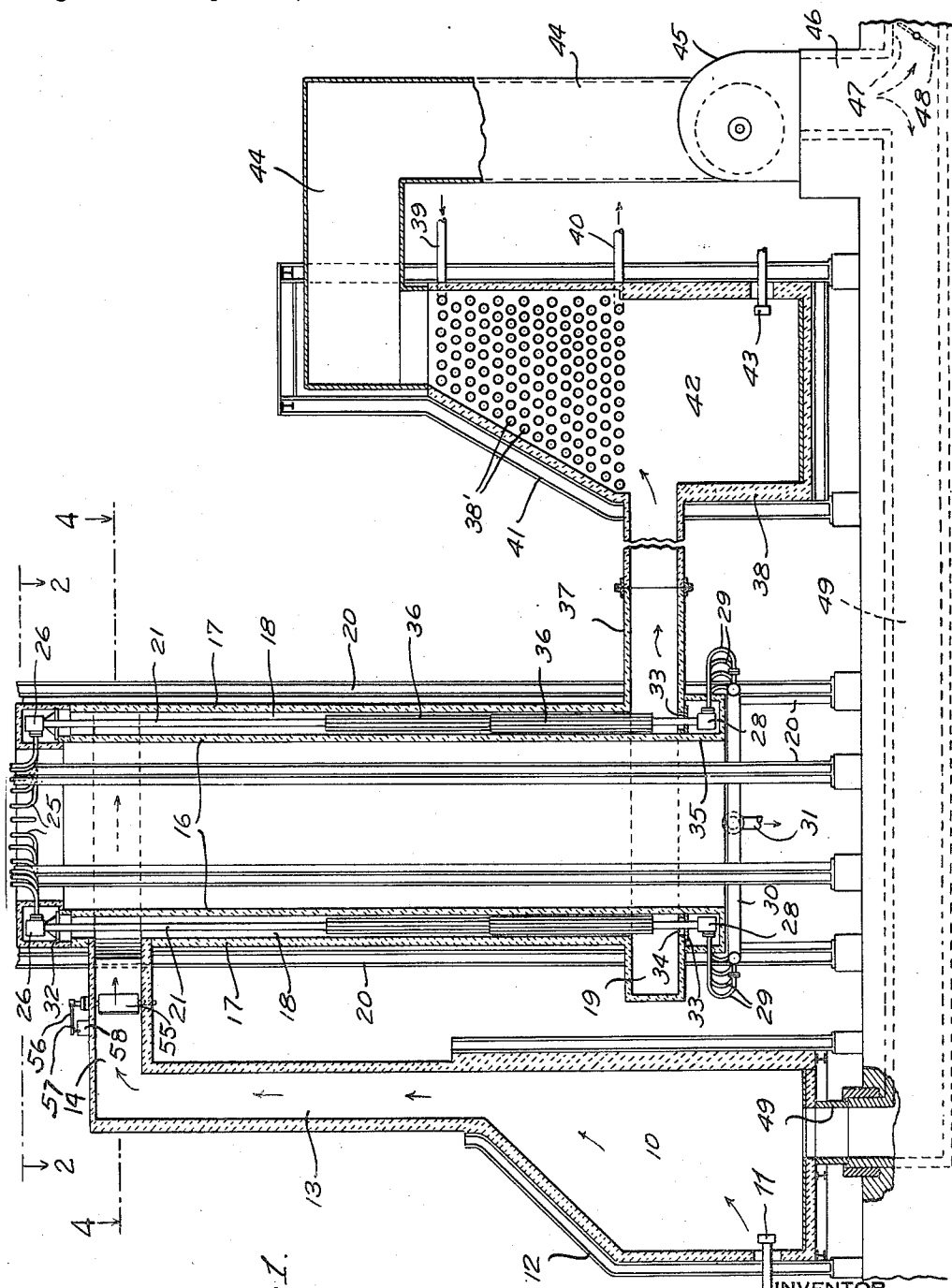


Fig. 1.

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Fig. 2.

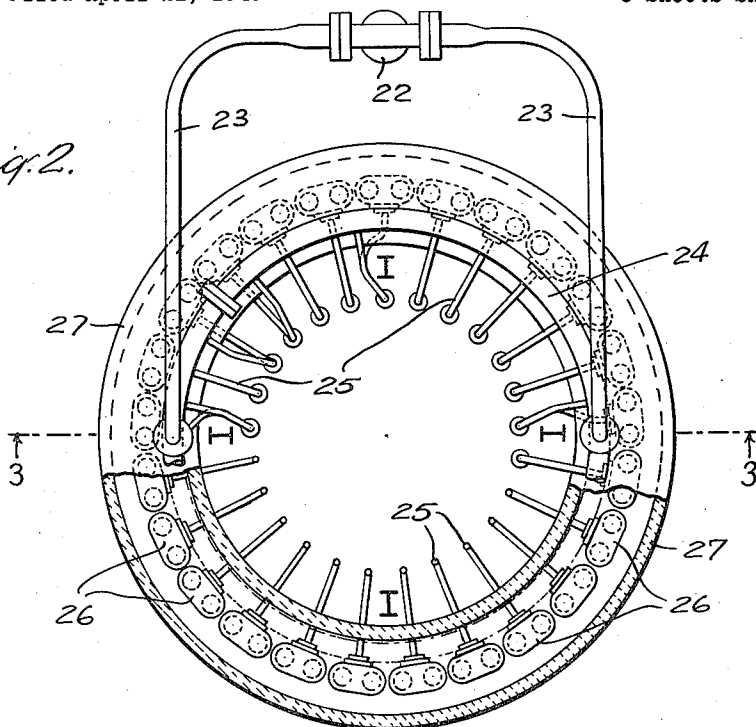
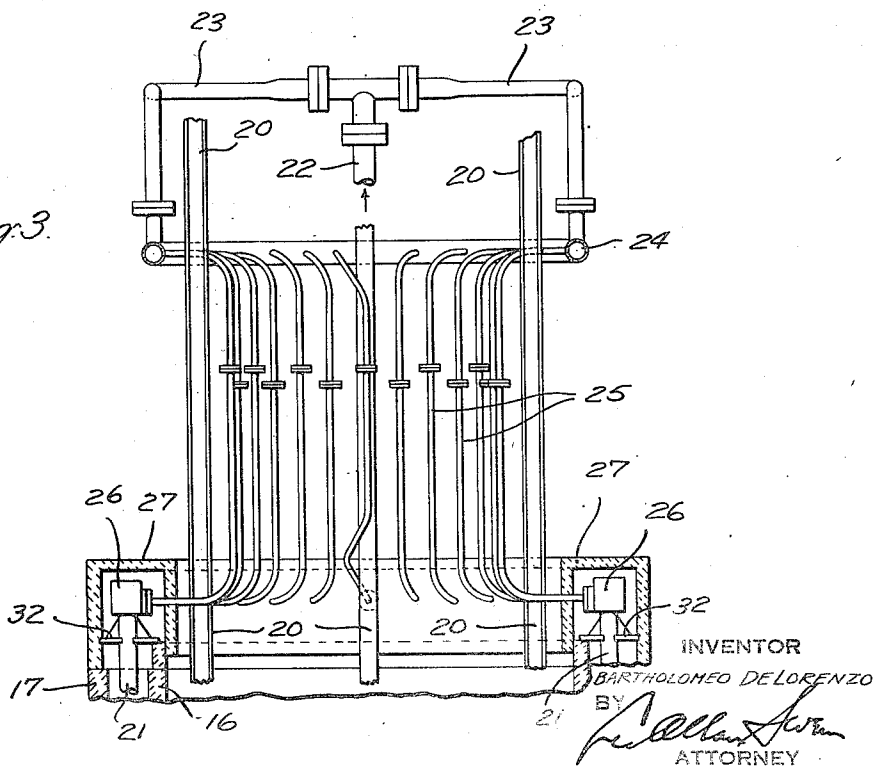


Fig. 3.



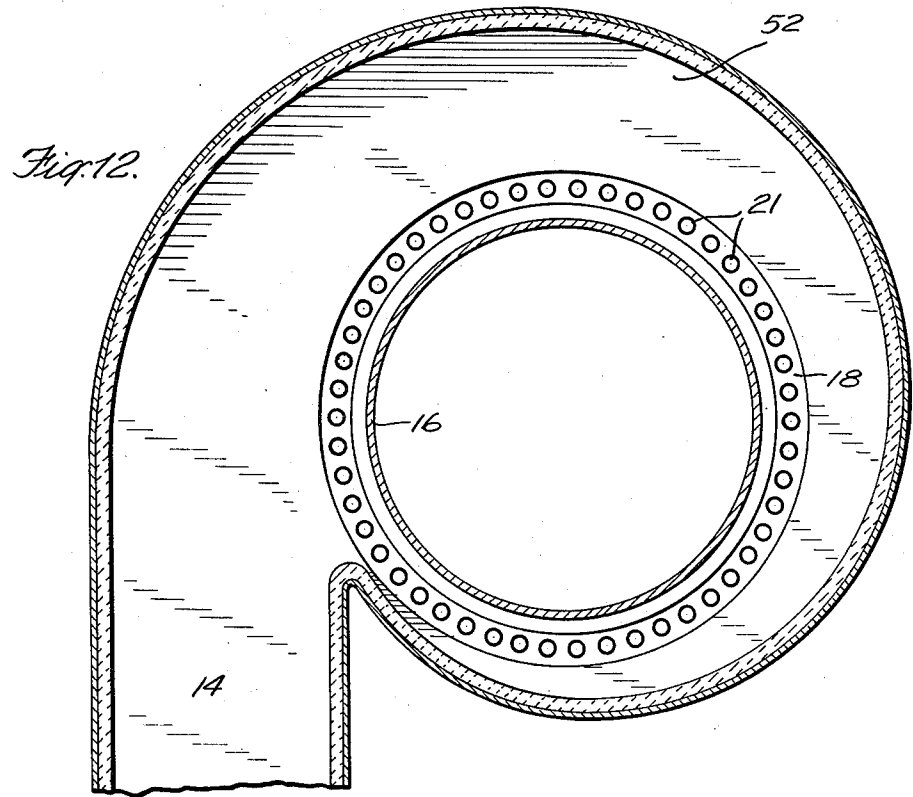
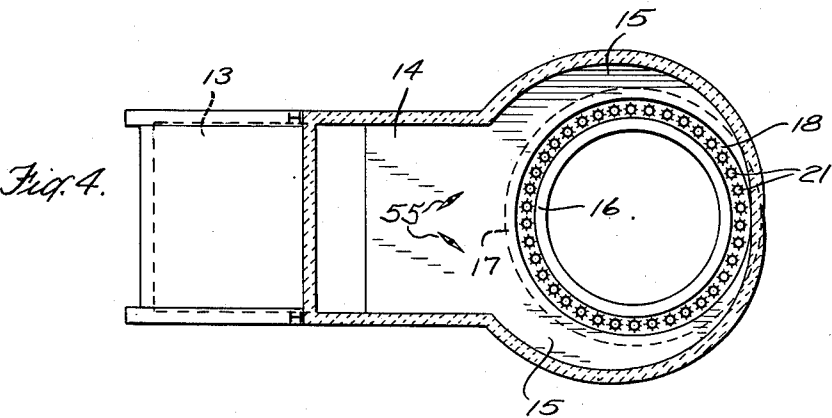
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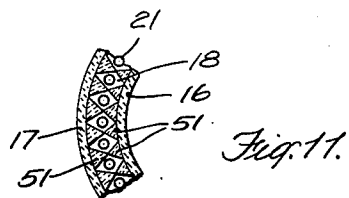
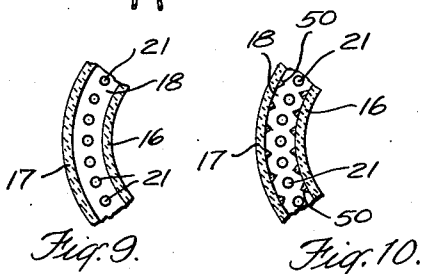
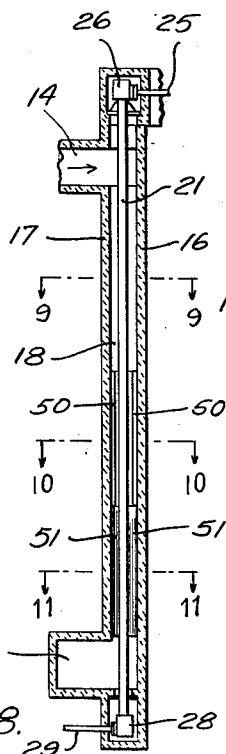
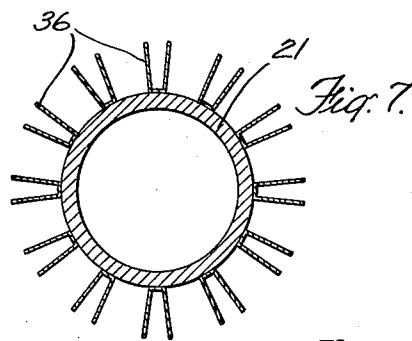
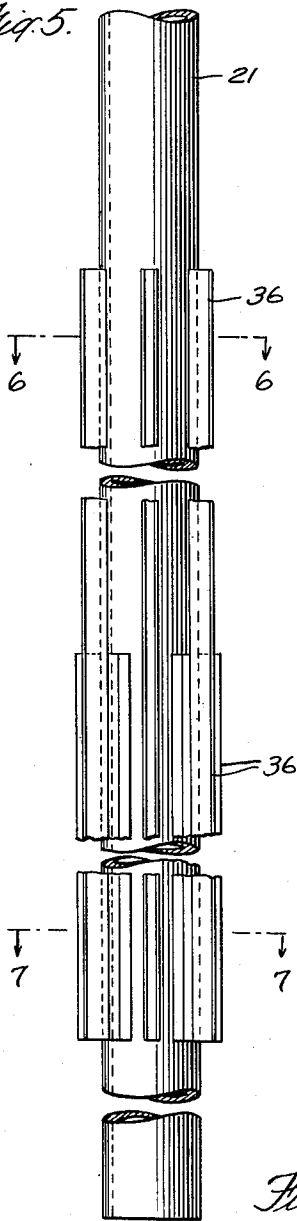
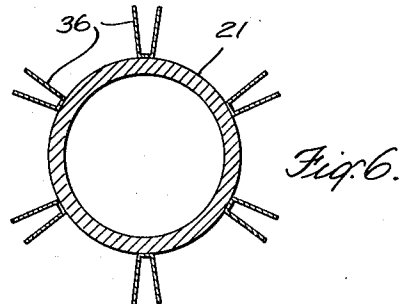
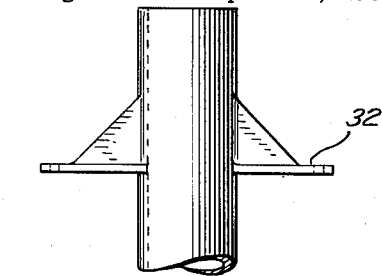
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2,555,322

HEATER

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5 Sheets-Sheet 4



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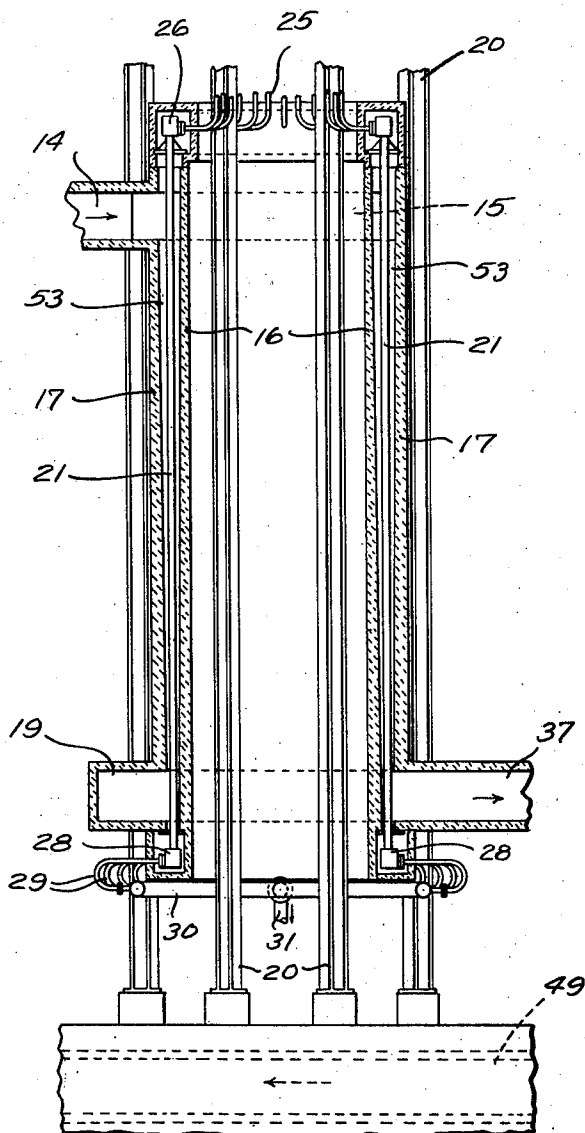
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Fig. 13.



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UNITED STATES PATENT OFFICE

2,555,322

HEATER

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Continuation of abandoned application Serial No.
483,871, April 21, 1943. This application Au-
gust 5, 1948, Serial No. 42,611

11 Claims. (Cl. 257—224)

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The invention relates to heaters and more particularly pertains to tubular heaters for heating fluids such as hydrocarbon oils and the like, although it is applicable to the heating of fluids generally.

The invention provides a tubular heater wherein the tubes are heated substantially uniformly about their circumferences and throughout their lengths, to prevent local overheating and high skin temperatures which will deleteriously affect the fluid being heated.

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 more or less diagrammatic view in vertical section, of a tubular heater embodying the invention;

Fig. 2 is a plan view of the tubular portion of the heater;

Fig. 3 is a partial vertical sectional view of the tubular portion of the heater taken on line 3—3 of Fig. 2;

Fig. 4 is a horizontal sectional view on line 4—4 of Fig. 1;

Fig. 5 is an elevational view, on an enlarged scale, of a tubular member of the heater;

Fig. 6 is a sectional view on line 6—6 of Fig. 5;

Fig. 7 is a sectional view on line 7—7 of Fig. 5;

Fig. 8 is an elevational view of part of another form of heater embodying the invention;

Figs. 9, 10 and 11 are sectional views on lines 9—9, 10—10 and 11—11 respectively of Fig. 8;

Fig. 12 is a horizontal sectional view similar to Fig. 4, showing another form of heater embodying the invention, and

Fig. 13 is a vertical sectional view of a further form of heater embodying the invention.

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

Referring to Figs. 1 to 7 of the drawings, reference character 10 designates a combustion and mixing chamber which is fired by one or more fluid fuel burners 11 and which is supported by suitable framework 12. The gases produced in the chamber 10 and any gases delivered thereto, flow upwardly through a duct 13 and horizontally through a duct 14 into a gas inlet chamber 15 for the heating section, which in this instance is in the form of a double volute. As shown, double, movable dampers 55 are located in the central part of duct 14 to assist the gases in flowing into each volute. Each damper has an arm 56 carrying a pin 57 which may be inserted in any one of a number of apertures in a block

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58 to retain the damper in adjusted position. The heating section comprises an inner annular wall 16 and a spaced outer annular wall 17 which provides between them an annular heating chamber 18 which connects at its upper end with the double volute gas inlet chamber 15 and at its lower end with an annular gas outlet chamber 19. The heating section is supported independently of the combustion and mixing chamber 10 by suitable framework 20.

Spaced, vertically disposed tubular members 21 extend through the annular heating chamber 18, and the fluid to be heated is supplied to these tubes through an inlet 22, Fig. 3, which delivers the fluid to conduits 23 which conduct the fluid to an annular header 24. Header 24 is connected by a plurality of vertically extending tubular members 25 with headers 26 into which the upper ends of the tubes 21 are expanded. Each of the headers 26 is connected to the upper ends of two adjacent tubes in the form of the invention illustrated in Figs. 1 to 7. The headers 26 are enclosed in an annular housing 27 which connects with the upper end of the annular heating chamber 18. After flowing downwardly through the tubes, the heated fluid is discharged into outlet headers 28, like headers 26, which are connected by a plurality of pipes 29 to an annular outlet header 30 which discharges into an outlet 31.

Tubes 21 are supported at their upper ends by plates 32 which are attached as by welding or the like, to the upper end portions of the tubes. These plates 32 rest upon suitable shoulders within the annular housing 27, and in addition to supporting the tubes, these plates serve to close the annular passage connecting the heating chamber with the interior of the housing 27. The lower ends of the tubes 21 pass through plates 33 which close the annular passage 34 connecting the circular outlet chamber 19 with the interior of the annular housing 35 for the outlet headers 28.

The tubes 21 are so disposed in the heating chamber 18 and they are so constructed and arranged, that the fluid flowing through the tubes is heated at a substantially uniform rate around the entire circumference of the tubes and substantially uniformly along the entire lengths of the tubes, with all the tubes having substantially the same heat input. This is accomplished in the form shown in Figs. 1 to 7, by disposing the tubes substantially evenly throughout the annular heating chamber, and by attaching extended surface members on the lower portions

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of the tubes so that as the gases flowing downwardly through the heating chamber drop in temperature, additional heat absorbing surface will be present to absorb more heat from the gases. The arrangement of the tubes in the annular heating chamber is such that each tube "sees" substantially the same amount of refractory wall surface.

As shown, the extended surface for the tubes 21 comprises U-shaped or channel members 36 which extend longitudinally of the tubes and are secured to the tubes, preferably by welding. As clearly shown in Figs. 1 and 5, the upper portions of the tubes are without extended surface members. The intermediate portions of the tubes have a certain number of channel members, six as shown, and the lower portions have a greater number of channel members, twelve as shown. It will be understood, of course, that the form shown is illustrative, and that the tubes may be provided with other types of extended surface members, and that their disposition with respect to the lengths of the tubes may be varied as desired to meet any particular heating requirements.

The gases flowing from the lower end of the annular heating chamber, flow into and through a duct 37, and into an economizer section 38 in the upper portion of which an economizer 38' is disposed. Fluid is introduced to the economizer through an inlet conduit 39 and is withdrawn through an outlet conduit 40. The economizer section is supported independently of the heating section and the combustion chamber 10 by suitable framework 41. The economizer section has a combustion chamber 42 in the lower portion thereof which is fired by one or more fluid fuel burners 43. From the economizer 38', the gases flow through a duct 44 into an induced draft circulating fan 45 which discharges the gases into a duct 46 from which they flow through a flue 47 controlled by a damper 48 to a stack not shown, and through a reciprocating flue 49 into the lower portion of the combustion and mixing chamber 10. The quantity of gases flowing to the stack and the quantity returned to the combustion chamber 10, will depend upon the position of damper 48. Sufficient fuel is burned in combustion and mixing chamber 10 by burners 11 to produce the desired temperature when cooled gases from duct 49 are properly mixed with the gases produced by the burners 11.

In operation, the fluid to be heated is introduced through inlet 22, Fig. 3, and flows through the piping disclosed, to the upper ends of the tubes 21, to which it is substantially uniformly distributed. Combustion gases are produced in combustion and mixing chamber 10 and these gases, together with the cooled gases introduced through conduit 49, flow through conduit 13 into the double volute 15 which functions to distribute these gases substantially uniformly to the upper end of the annular heating chamber 21. The dampers 55 assist the gases in flowing into each volute and also prevent the hot gases from impinging on the tubes directly in the path of the gases, thus avoiding or minimizing "hot spots" on the upper ends of the tubes. The gases flow downwardly in the annular heating chamber and transfer their heat to the tubes 21. Because the tubes 21 are substantially evenly distributed in the heating chamber 18, and because each tube "sees" substantially the same area of refractory wall surface, the fluid flowing through the tubes 21 will be heated at substantially a uniform rate around the entire circumferences of the tubes and

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substantially uniformly throughout the entire lengths of the tubes. The gases leaving the heating chamber 18 flow into the circular collecting duct 19 and through conduit 37 into the upper portion of the combustion chamber in the economizer section 38. The gases then flow either alone, or mixed with gases produced by burners 43, over the economizer 38', and thence through duct 44 to induced draft circulating fan 45 which discharges them into duct 46, from which they flow either through duct 47 to a stack or through duct 49 to the combustion and mixing chamber 10, or both, depending upon the position of damper 48.

If desired, the economizer section 38 may be employed as a separate auxiliary heater. Or, the economizer section may be eliminated and the gases from the heating chamber 18 may be conducted directly to the fan 45, with the understanding that the fan would be constructed of alloys which are sufficiently heat resisting to withstand the high gas temperatures.

Means other than extended surface elements on the tubes 21, may be employed to provide substantially uniform heating of the fluid flowing through these tubes for substantially the lengths of the tubes. One such other means is illustrated in Figs. 8 to 11 of the drawings. As shown, the upper part of the annular heating chamber 18 is unrestricted. The intermediate part has longitudinally extending projections 50 which extend from the walls 16 and 17 into the heating chamber 18 intermediate the tubes 21. These projections 50 are triangular in transverse cross-sectional configuration and serve to increase the radiating surface of the walls and to reduce the flow area of the gases passing through the intermediate part of the annular heating chamber and cause a higher heat transfer rate to the tubes. The lower part of the heating chamber 18 is provided with projections 51 which extend farther into the heating chamber 18 than the projections 50, and as shown, they extend into engagement with each other to increase further the radiating surface of the walls, to restrict further the flow of area of the heating chamber, and further to increase the velocity of flow of the gases through this part of the heating chamber to increase further the transfer rate of heat to the lower portions of the tubes. The projections will be constructed and arranged as to provide substantially uniform heating of the tubes 21 throughout their lengths and throughout their entire circumferences. The operation of this form of the invention is substantially the same as that described previously. In lieu of the double volute 15 for effecting the substantially uniform distribution of the gases from the combustion and mixing chamber 10 to the upper end of the annular heating chamber 18, a single volute designated 52, such as illustrated in Fig. 12, may be utilized if desired.

The form of the invention illustrated in Fig. 13 is the same as the form shown in Fig. 1, excepting that the tubes 21 are bare throughout their lengths, and the annular heating chamber 53 is of gradually decreasing flow area from its upper to its lower parts, to effect substantially equal heating of the tubes 21 throughout their lengths.

Heating apparatus embodying the invention is applicable to all processes requiring heater wherein the tubes through which the fluid to be heated is passed, must be substantially uniformly heated around the entire circumferences of the

tubes for approximately the full lengths thereof, and to prevent "hot spots" and high "skin" temperatures which might deleteriously affect the material being heated in the tubes.

Apparatus embodying the invention is particularly useful in operations involving catalysts where it is essential that the fluid to be catalytically treated, is preheated to the desired temperature, and flows through the heating tubes which are filled with catalyst and the fluid must be maintained at a substantially constant temperature while in contact with the catalyst in order to obtain the desired reaction. The invention is particularly useful with catalysts which are sensitive to high temperatures.

The invention is also useful for petroleum re-run units such as lube oil, naphtha and cracked distillates where it is essential that high "skin" or film temperatures be avoided. Generally, these products are sensitive to high "skin" temperatures which are encountered in the conventional direct fired heaters wherein the tubes in the radiant section are not uniformly heated around the entire circumferences of the tubes.

The invention is also useful in solvent extraction plants requiring heaters for removing the solvent from both the extracted and raffinate products. Also in cracking processes, both thermal and catalytic, which require uniform heating of the material inside the tubes.

The present application is a continuation of application Serial No. 483,871 filed April 21, 1943, now abandoned.

Since changes may be made in the form, location and relative arrangement of the several parts of the heating apparatus disclosed without departing from the principles of the invention, it will be understood that the invention is not to be limited excepting by the scope of the appended claims.

What is claimed is:

1. Fluid heating apparatus comprising substantially vertically extending, annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber; a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced therein from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber extending around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a bottom having an annular gas outlet opening therein in communication with said heating chamber through the entire circumference of the heating chamber, a curved outer wall disposed in spaced relationship with said inner wall and the gas outlet opening, the outer wall being eccentrically arranged with respect to said inner wall of the gas distributing chamber so that a gas passage is formed between the inner and outer walls which gradually decreases in area circumferentially thereof from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit

in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, means for delivering fluid to one end of the tubular members, and heat transfer means cooperating with portions of said members and the heating chamber to cause a greater transfer of heat to said portions over which heating gases flow after passing in heat exchange relationship with other portions of said tubular members.

2. Fluid heating apparatus comprising substantially vertically extending annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced therein from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber extending around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a substantially horizontally extending bottom member having an annular gas outlet opening therein coextensive with said heating chamber circumferentially thereof, a volute-shaped outer wall disposed in spaced relationship with the periphery of said gas outlet opening, said outer wall being so arranged with respect to said inner wall of the gas distributing chamber and said gas outlet opening that a gas passage is formed which gradually decreases in area circumferentially of the gas outlet opening from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, means for delivering fluid to one end of the tubular members, and heat transfer means cooperating with portions of said members and the heating chamber to cause a greater transfer of heat to said portions over which heating gases flow after passing in heat exchange relationship with other portions of said tubular members.

3. Fluid heating apparatus comprising substantially vertically extending, annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a single annular row of tubular members in the heating chamber, said tubular members being of a diameter slightly less than the distance between the spaced walls and extending longitudinally thereof and approximately evenly spaced therein from each other and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber around the row of tubular members and

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extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a bottom having an annular gas outlet opening therein in communication with said heating chamber throughout the entire circumference of the heating chamber, a curved outer wall disposed in spaced relationship with said inner wall and the gas outlet opening, the outer wall being eccentrically arranged with respect to said inner wall of the gas distributing chamber so that a gas passage is formed between the inner and outer walls which gradually decreases in area circumferentially thereof from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, means for delivering fluid to one end of the tubular members, and heat transfer means cooperating with portions of said members and the heating chamber to cause a greater transfer of heat to said portions over which heating gases flow after passing in heat exchange relationship with other portions of said tubular members.

4. Fluid heating apparatus comprising a substantially vertically extending, single annular row of tubular members, a heating chamber comprising annular, spaced, concentric side walls forming therebetween an annular heating chamber extending longitudinally of said members substantially throughout their entire length, said tubular members being disposed in the heating chamber and approximately evenly spaced from each other and evenly spaced from said walls, means forming a gas distributing chamber around the row of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber, extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a substantially horizontally extending bottom member having an annular gas outlet opening therein coextensive with said heating chamber circumferentially thereof, a volute-shaped outer wall disposed in spaced relationship with the periphery of said gas outlet opening, said outer wall being so arranged with respect to said inner wall of the gas distributing chamber and said gas outlet opening that a gas passage is formed which gradually decreases in area circumferentially of the gas outlet opening from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, means for delivering

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fluid to one end of the tubular members, and heat transfer means cooperating with portions of said members and the heating chamber to cause a greater transfer of heat to said portions over which heating gases flow after passing in heat exchange relationship with other portions of said tubular members.

5. Fluid heating apparatus comprising substantially vertically extending, annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced therein from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber extending around the groups of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a bottom having an annular gas outlet opening therein in communication with said heating chamber throughout the entire circumference of the heating chamber, a curved outer wall disposed in spaced relationship with said inner wall and the gas outlet opening, the outer wall being eccentrically arranged with respect to said inner wall of the gas distributing chamber so that a gas passage is formed between the inner and outer walls which gradually decreases in area circumferentially thereof from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, means for delivering fluid to one end of the tubular members, and longitudinally extending extended surface members positioned on portions of said tubular members over which heating gases flow after passing in heat exchange relationship with other portions of said tubular members to effect substantially uniform heating of the fluid substantially throughout the length of the tubular members.

6. Fluid heating apparatus comprising substantially vertically extending annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from said walls, means forming a gas distributing chamber extending around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas-distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing

chamber comprising a substantially horizontally extending bottom member having an annular gas outlet opening therein coextensive with said heating chamber circumferentially thereof, a volute-shaped outer wall disposed in spaced relationship with the periphery of said gas outlet opening, said outer wall being so arranged with respect to said inner wall of the gas distributing chamber and said gas outlet opening that a gas passage is formed which gradually decreases in area circumferentially of the gas outlet opening from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at the lower end thereof, means for delivering fluid to the upper end of the tubular members, and longitudinally extending extended surface members on the intermediate and lower portions of said tubular members with a greater number of extended surface members on the lower portions of the tubular members than on the intermediate portions.

7. Fluid heating apparatus comprising substantially vertically extending annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced therein from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber extending around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a bottom having an annular gas outlet opening therein in communication with said heating chamber throughout the entire circumference of the heating chamber, a curved outer wall disposed in spaced relationship with said inner wall and the gas outlet opening, the outer wall being eccentrically arranged with respect to said inner wall of the gas distributing chamber so that a gas passage is formed between the inner and outer walls which gradually decreases in area circumferentially thereof from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, and means for delivering fluid to one end of the tubular members, the walls of the heating chamber having portions substantially equi-lateral triangular shaped in transverse cross-sectional configuration projecting into the heating chamber between the tubular members in the intermediate and outlet portions of the heating chamber, said portions projecting farther into the heating cham-

ber in the outlet portions thereof than in the intermediate portions, whereby the radiating surface of the wall is increased and the velocity of flow of the heating gases is changed to effect substantial uniform heating of the fluid substantially throughout the lengths of the tubular members.

8. Fluid heating apparatus comprising substantially vertically extending annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced therein from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber extending around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a bottom having an annular gas outlet opening therein in communication with said heating chamber throughout the entire circumference of the heating chamber, a curved outer wall disposed in spaced relationship with said inner wall and the gas outlet opening, the outer wall being eccentrically arranged with respect to said inner wall of the gas distributing chamber so that a gas passage is formed between the inner and outer walls which gradually decreases in area circumferentially thereof from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, and means for delivering fluid to one end of the tubular members, the walls of the heating chamber converging gradually toward the outlet end thereof to cause the fluid to be heated substantially uniformly substantially throughout the lengths of the tubular members.

9. Fluid heating apparatus comprising substantially vertically extending, annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced therein from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber extending around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a

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horizontally extending bottom member having an annular gas outlet opening therein substantially coextensive with said heating chamber circumferentially thereof, a single volute-shaped outer wall disposed in spaced relationship with the periphery of said gas outlet opening, said outer wall being so arranged with respect to said inner wall of the gas distributing chamber and said gas outlet opening so that a gas passage is formed which gradually decreases in area circumferentially of the gas outlet opening from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, means for delivering fluid to one end of the tubular members, and heat transfer means cooperating with portions of said members and the heating chamber to cause a greater transfer of heat to said portions over which heating gases flow after passing in heat exchange relationship with other portions of said tubular members.

10. Fluid heating apparatus comprising annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced therein from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from the inner periphery of the side walls of the heating chamber, means forming a gas distributing chamber extending around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent one end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a substantially horizontally extending bottom member having an annular gas outlet opening therein coextensive with said heating chamber circumferentially thereof, a double volute-shaped outer wall disposed in spaced relationship with the periphery of said gas outlet opening, said outer wall being so arranged with respect to said inner wall of the gas distributing chamber and said gas outlet opening so that a gas passage is formed which gradually decreases in area circumferentially of the gas outlet opening from one side of the chamber, to a point diametrically opposite said one side, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, means for delivering fluid to

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one end of the tubular members, and heat transfer means cooperating with portions of said members and the heating chamber to cause a greater transfer of heat to said portions over which heating gases flow after passing in heat exchange relationship with other portions of said tubular members.

11. Fluid heating apparatus comprising substantially vertically extending annular, spaced, concentric side walls forming therebetween an annular longitudinally extending heating chamber, a group of tubular members in the heating chamber extending longitudinally thereof and approximately evenly spaced from each other circumferentially of the entire annular space between said concentric side walls and evenly spaced from said walls, means forming a gas distributing chamber around the group of tubular members and extending a predetermined distance axially of a portion of the tubular members of said group adjacent the upper end of the heating chamber, the innermost side wall of said heating chamber forming an annular inner wall for the gas distributing chamber extending axially of said portion of the tube group a distance at least equal to said predetermined distance, said distributing chamber comprising a bottom having an annular gas outlet opening therein in communication with said heating chamber throughout the entire circumference of the heating chamber, a curved outer wall disposed in spaced relationship with said inner wall and the gas outlet opening, the outer wall being eccentrically arranged with respect to said inner wall of the gas distributing chamber so that a gas passage is formed between the inner and outer walls which gradually decreases in area circumferentially thereof from one side of the chamber, the distributing chamber having a gas inlet opening at said one side thereof, a gas inlet conduit in communication with the gas inlet opening and arranged to introduce gases for horizontal flow in the distributing chamber, heating gas outlet means in communication with the heating chamber at a point to receive said gases after passage thereof in heat exchange relationship with said tubular members, an annular inlet header in communication with the upper end of said tubular members, a plurality of conduit means communicating with said header at a plurality of evenly spaced points around said header to deliver fluid substantially uniformly to said tubular members, and heat transfer means positioned on portions of the tubular members below said heating gas chamber over which portions gases flow after passing in heat exchange relationship with upper portions of said members.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,884,777	Lucke	Oct. 25, 1932
2,132,093	Bennett	Oct. 4, 1938
2,276,527	Throckmorton et al.	Mar. 17, 1942