March 14, 1950 J. A. SCHUURMAN 2,500,499

FURNACE FOR AND METHOD OF HEATING FLOWING MEDIA

Filed Feb. 21, 1948 2 Sheets-Sheet 1

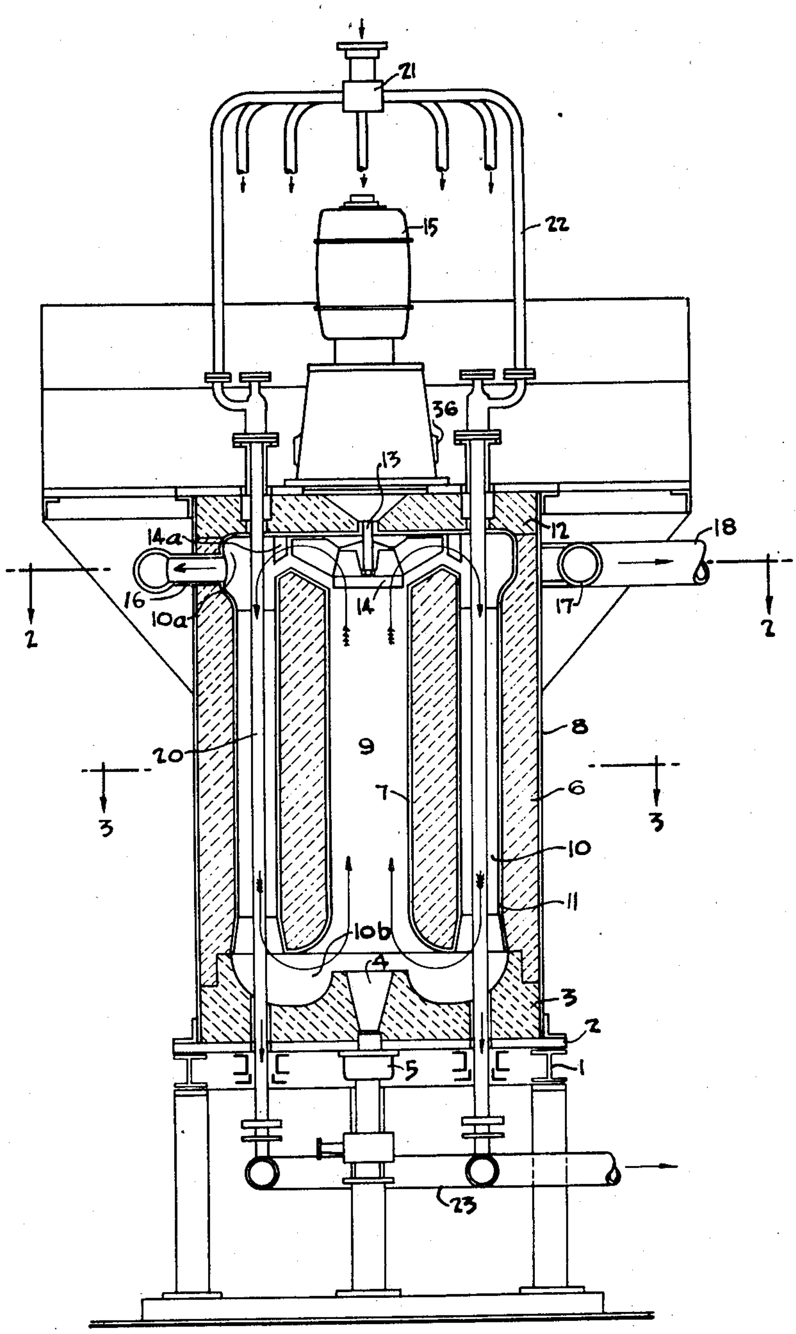

Fig. 1

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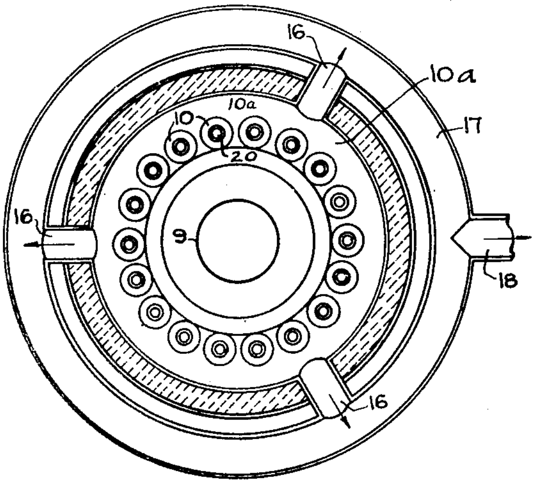

Fig. 2

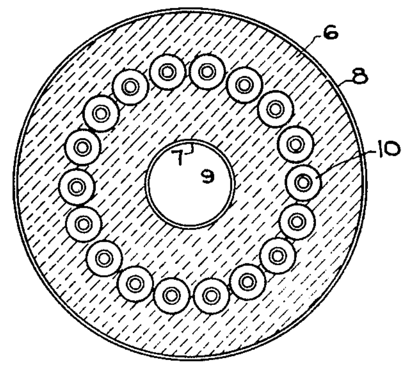

Fig. 3

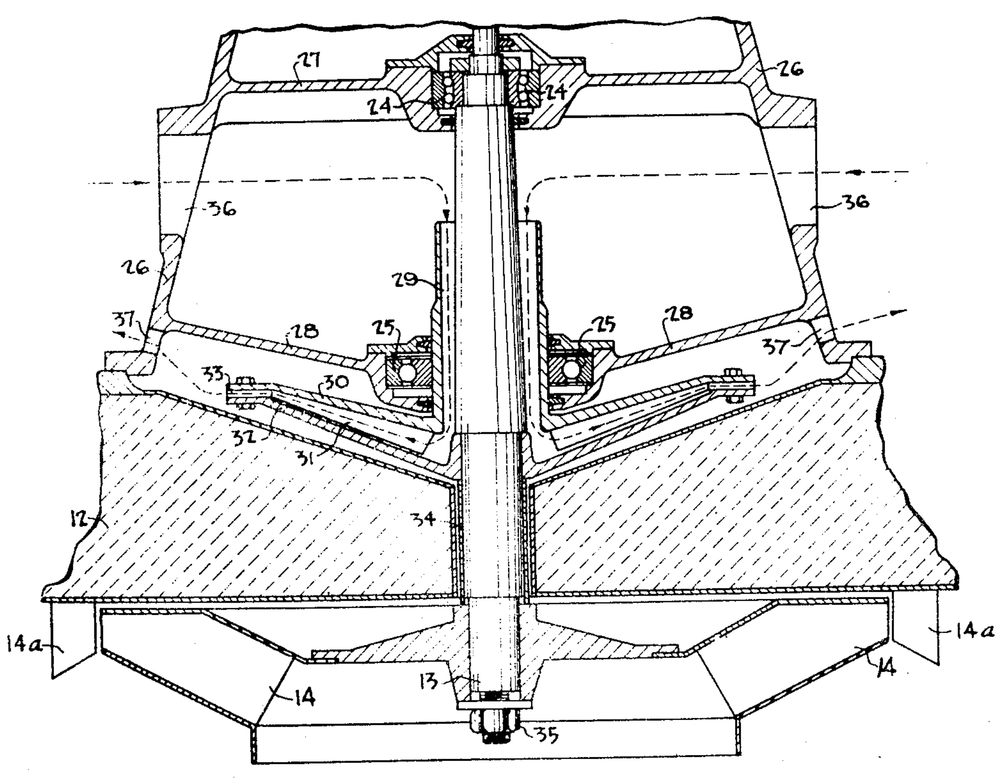

Fig. 4

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FURNACE FOR AND METHOD OF HEATING FLOWING MEDIA

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15 Claims. (Cl. 263—41)

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This invention relates to a heating furnace and to a heating method in which the medium to be heated flows through a number of tubes arranged vertically or practically vertically around a central combustion chamber, and which is designed to prevent the heating of the medium to an excessive temperature. A furnace constructed according to this invention is, for example, particularly useful in the conversion of dichloro-ethane into vinyl chloride and hydrochloric acid, which is an endothermic reaction taking place at about 500° C. Another example of the use to which such a furnace may be put is the cracking of hydrocarbon oil.

In furnaces designed for heating flowing media to elevated temperature difficulty is frequently experienced due to uneven heating of the tubes, resulting frequently in local overheating and in temperature fluctuations in the flowing media within the heating tubes as they pass from points having different temperatures. Also, fluctuations in the operation of the burners and in the rate of flow of the media to be heated often leads to unsteady operations.

When combustion gases are circulated by means of fans or ventilators, difficulties are often experienced in supporting the revolving shaft in the bearings, e. g., ball, roller or sliding bearings, because even though the bearings are located outside of the high temperature space it is desirable, for obtaining adequate support, to mount the bearing as near as possible to the fan blades operating within the high temperature space. As a result of heat flow through the fan shaft the bearing temperature often rises to an undesirable level.

It is an object of the present invention to provide an improved tube furnace and an improved method of heating flowing media wherein heat of substantially uniform intensity is distributed throughout the lengths of the heating tubes and about their circumferences.

Another object is to provide an improved tube furnace wherein an appreciable part of the heat is transferred to the tubes by radiation in a manner that fluctuations in the rate of flow of the medium to be heated and/or in the rate of heat generation in the combustion zone will result in only minor variations in the temperature of the medium to be heated.

Still another object is to provide a furnace of the type described wherein combustion products are recirculated through a plurality of separate elongated heating passages or channels enclosing individual heating tubes, whereby the tubes

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are heated in part by convection and in part by radiation from the surrounding walls of the heating passages.

A further object is to provide an improved heating furnace wherein combustion gases are circulated through a combustion chamber and through a series of heating passages or channels, the furnace having a fan for inducing such circulation. Ancillary thereto, it is an object to provide an improved mounting for the fan, permitting its bearings to be located near to the combustion chamber without danger of overheating such bearings.

Additional objects will become apparent from the following description, wherein one specific form of the invention is described by way of example.

The furnace according to the invention is constructed to preclude excessive heating of the medium to be heated and to effect the transfer of the greatest practicable amount from the combustion gas to the medium to be heated. To this end each of the heating tubes is housed in a separate channel or heating passage through which hot gases are flowed; the top and bottom ends of these channels are connected to a centrally located combustion chamber within which one or more burners and ventilators are fitted, the latter serving to circulate the heating gases through the channels and the combustion chamber. The circulation of the hot gases makes it possible to maintain their temperature economically and easily within desired limits, and the central location of the combustion chamber and its symmetrical construction insure an even distribution of the gases among the various channels. Axial symmetry is maintained as far as possible also in the discharge of the spent heating gases from the furnace, and in the supply and withdrawal of the medium to be heated, so as to obtain the same temperature conditions in the different heating tubes.

The burner or burners may be suitably arranged in the bottom of the combustion chamber, so that the circulation may be aided by thermosyphonic action. The ventilator or fan may be fitted at any part within the combustion chamber, but is preferably near the top to facilitate mounting the bearings outside of the combustion space and avoid the use of long drive shafts which are injured by overheating. Consequently, the heating gases flow downwards through the heating channels. The medium to be heated may be flowed through the heating tubes in either direction: If less heat is desired in the last portion of the heating operation, the medium is flowed through the heating tubes concurrently with the heating gases, i. e., downwardly; if, however, the medium requires the greatest supply of heat at the end of its path through the furnace, it is passed countercurrently to the heating gases. The former requirement would arise, for example, in the case of most endothermic reactions, wherein the reactants must be brought up to reaction temperature in the first portion of their travel through the furnace, but only the heat of reaction needs to be added during its subsequent passage. The latter requirement would arise in the case that the reactants are brought up to reaction temperature by a pre-heater and/or where an increased reaction temperature is desired after the complete or partial consumption of one of the reactants in the initial part of the reaction.

Because the heating tubes are housed in channels the walls of which are heated to a high temperature by the heating gases passing therethrough, an appreciable portion of the heat is transferred to the heating tubes by radiation from the walls of these channels. This has the great advantage that if, by some cause or other, convectional heating of the tubes is less or more than normal, the total heating will deviate less from the normal value. This is due to the fact that the surrounding refractory, fire-proof or insulating material forming the walls of the channels has a high heat capacity, as a result of which the temperature of such walls will not fluctuate rapidly from the normal, but will tend to maintain a more or less steady temperature. Since the transfer of heat from such walls to the heating tubes by radiation takes place at a rate which is highly dependent upon the difference between the temperatures of the heating tube and the wall of the channel, a slight fluctuation in the temperature of the heating tube will already effect an appreciable compensation by a change in the rate of radiant heat transfer.

To permit mounting the supporting bearing for the fan near to the combustion chamber the bearing is not directly in contact with the fan shaft, but is connected to a sleeve or bushing which is spaced from the shaft to provide a passage for the circulation of a cooling agent between the shaft and the bushing, thereby keeping the latter and the bearing comparatively cool. As a cooling agent use is preferably made of air which can be sucked or forced through the space between the shaft and the bushing by any means, such as an auxiliary fan connected to the bushing or to the shaft itself. The shaft is supported from the bushing through the auxiliary fan or by radial fins bridging the aforesaid space. Such a bearing arrangement may be applied also to other installations wherein a device is mounted on a revolving shaft which extends into heated surroundings; for example, it may be used for shafts which drive stirrers for hot liquids, gas or steam turbines, rotary pumps for hot liquids, etc.

The invention will be described more particularly by reference to the accompanying drawings forming a part of this specification and illustrating a specific embodiment, wherein:

Fig. 1 is a vertical cross-sectional view of a furnace according to the invention, parts being shown in elevation;

Figs. 2 and 3 are sectional views taken on line 2—2 and 3—3, respectively, of Fig. 1; and

Fig. 4 is an enlarged fragmentary vertical sectional view of the shaft mounting for the fan.

The furnace is supported by uprights carrying I-beams 1 and a base 2 supporting the lower wall 3, which may be refractory material and is provided with one or more openings 4 for burners 5. The burners may be of any desired type, for example, of the type admitting gaseous fuel and air. The intermediate furnace section is formed as an annular wall 6 of heat insulating material enclosed, if desired, in fire-proof alloy sheathing 7 and 8 which is capable of withstanding combustion temperatures. I may, however, dispense with the sheathing on the inside, or on both inside and outside, and use conventional refractory. The central space 9 within the wall 6 constitutes the combustion chamber. Within the wall 6 and regularly distributed over the circumference are a plurality of vertical cylindrical channels 10 of circular cross-sections, optionally lined with alloy sheathing 11 of the type described above. These vertical channels form heating spaces and are joined at the top to an annular space 10*a* which is connected to the combustion chamber 9 through radial passages supporting stationary fan blades 14*a*. The lower ends of channels 10 are connected to combustion chamber 9 through radial passageways 10*b*. The top wall 12 may likewise be lined with sheathing and made of heat insulating material, or may be unlined and of rigid, refractory. It has a central opening through which a shaft 13, supporting the rotating blades 14 of the fan, extends into the combustion chamber. The fan shaft is driven by an electric motor 15. A plurality of radial ports 16, preferably at least three in number, and uniformly spaced circumferentially, pierce the wall 6 and connect the space 10*a* to an annular pipe 17 connected to a flue 18. The fan 14 maintains a constant circulation of hot gases upwardly through the combustion chamber; radially outwardly into the space 10*a*, from which the gases are evenly distributed into the several heating channels 10; and into the bottom of the combustion chamber through the passageway 10*b*. Additional combustion gases are continually supplied by the burner 5 and a corresponding amount of excess gas is drawn off through the ports 16 and circular pipe 17.

A vertical heating tube 20 extends from the top to the bottom of each heating channel and is mounted concentrically therein, leaving sufficient space between the tube and the wall of the channel to permit hot gases to circulate. The medium to be heated is supplied to a manifold 21 connected by tubes 22 to the heating tubes 20. A circular discharge line 23 is mounted beneath the heating tubes and connected thereto. These connections insure an equal distribution of the medium to be heated over the several heating tubes. Since moreover, the symmetrical arrangement of the heating channels about the central combustion chamber causes the hot gases to be equally distributed among the heating channels, the conditions for an equal supply of heat to the medium to be heated in the various tubes are thereby fulfilled. By the rapid circulation of the heating gases caused by the fan 14 the temperature difference between the gas which enters and that which leaves the heating channels may be comparatively slight, for example, about 30° C. Any point on the outer walls of the heating channels will have a higher temperature than the opposite wall, i. e., than the wall of the heating tube through which the medium to be heated flows. This results in the absorption of heat by the heating tube not only by convection from the hot gases but also by radiation from the outer wall of the heating channel enclosing the tube; this is a factor of great importance in the furnace and in the improved method of heating according to the invention, because thereby a fluctuation in the temperature of the heating gases does not cause a proportional fluctuation in the heat absorption of the heating tube. This is explained by the fact that a decrease (or increase) in the heat absorbed directly by convection from the heating gas is partially compensated automatically by an increase (or decrease) of the heat absorbed by radiation, which is due to the circumstance that the temperature of the wall of the channel follows changes in the temperature of the heating gas only slowly. The outer walls of the heating channels have sufficiently high heat capacity to maintain a more or less even temperature despite fluctuations in the temperature of the heating gases. The heat transmitted from the outer walls to the heating tubes by radiation is strongly dependent on the difference in temperature between the emitting body (in this case the outer wall of the channel) and the absorbing body (in this case the heating tube **20**); consequently, a slight temporary change in the temperature of the latter causes a comparatively great change in the rate of heat transfer by radiation.

Referring to Fig. 4, the shaft **13** is supported by two bearing blocks **24** and **25** carried by a rigid structure or block housing **26** mounted over the top of the combustion chamber. This construction also carries the motor **15**. The upper bearing block **24** is fitted in a horizontal partition **27** and supports the shaft **13** in the conventional manner through a bearing race. The bearing **25**, nearer the combustion chamber, is fitted in a frusto-conical partition **28** and has its rotatable race connected to a bushing **29**, which surrounds the shaft **13** but is spaced therefrom to provide an annular space therebetween. The bushing **29** is formed integrally with (or may be formed separately and rigidly attached to) an auxiliary impeller fan, having an upper, flat conical disc **30** forming the upper wall of the fan, and having fan blades **31** on its lower surface. A second, flat, conical disc **32**, forming the lower wall of the fan is bolted to the rim of the disc **30**, the latter having downward projections to provide a plurality of radial ports **33** between the two rims. The central portion of the disc **32** has a bushing fitting snugly about the shaft **13** and up against a shoulder of the shaft, as shown, thereby affording support for the shaft **13** from the lower bearing block **25**. A spacer sleeve **34** on the shaft **13** abuts the disc **32** and the hub of the fan **14** when a nut **35** is tightened. Fan blades **31** are shaped to draw air in through the space between the bushing **29** and the shaft **13** and discharge it through the openings **33**. This air is sucked into the housing **26** through one or more openings **36** and is expelled therefrom through one or more openings **37**. The ball bearing block **25** is thereby kept cool because the cooling air circulates not only between it and the shaft **13** but also between it and the upper wall **12** of the combustion chamber. This cooling of the shaft **13** also lessens the heat transmitted to the bearing block **24**. It will be noted that the partition **28** divides the housing **26** into an upper supply chamber and a lower discharge space for the cooling air. It is evident that any other cooling fluid, other than air, may be used by applying supply and discharge conduits to the openings **36** and **37** respectively.

In the furnace illustrated and described above, the heating gases and the medium to be heated flow concurrently, i. e., downwards. Such an arrangement is useful, for example, in the conversion of dichloro-ethane into vinylchloride and hydrochloric acid gas, which endothermic reaction takes place at approximately 500° C., and the combustion gases may, for example, be maintained at from 500–600° C. The conversion temperature is to be maintained as uniformly as possible, and it is important to avoid too great a difference in temperature between the reaction gas mixture and the heating gas in the part of the heating tube where the reaction takes place, i. e., the lower part of the tube. In the upper part, wherein the dichloro-ethane is heated to the reaction temperature, greater differences in temperature between the heating gas and the reaction mixture are permissible without causing any detrimental effect. In this particular case, heating in concurrent flow is most suitable. For other applications of the furnace countercurrent flow may, of course, be more appropriate, wherein the medium to be heated is flowed upwardly through the heating tubes.

The furnace may be modified in several respects. Thus, for example, the discharge of excess combustion gases may be effected from the bottom of the heating channels, where a lower temperature prevails, whereby less heat is discharged with the spent gases. If rapid circulation is not required, the fan **14** may be omitted and thermosyphonic action may be relied upon for circulation.

The shaft mounting is claimed in divisional application Ser. No. 137,131, filed January 6, 1950.

I claim as my invention:

1. A furnace for heating flowing media comprising, in combination, a combustion chamber having a source of combustion gases, a plurality of heating tubes for the passage therethrough of the medium to be heated, radiant walls substantially surrounding each of said heating tubes and providing a separate annular heating channel between each tube and its surrounding wall, passageways between the ends of said heating channels and said combustion chamber, and a fan for circulating hot combustion gases through said passageways, heating channels, and combustion chamber.

2. The furnace according to claim 1 wherein the source of combustion gases comprises a fuel burner at the bottom of the combustion chamber and the fan is located within and at the top of the combustion chamber.

3. The furnace according to claim 1 wherein the radiant walls surround the individual heated tubes completely and each heating channel constitutes a separate closed channel having external flow connection for the passage of gases only through said passageways.

4. A furnace for heating flowing media comprising, in combination, a combustion chamber having a source of combustion gases, a plurality of substantially vertical heating tubes for the passage therethrough of the medium to be heated, said heating tubes being arranged around the combustion chamber, radiant walls substantially surrounding each of said heating tubes and providing a separate annular heating channel between each tube and its surrounding wall, and radial passageways between the upper and lower ends of each of said heating channels and said combustion chamber.

5. A furnace for heating flowing media comprising, in combination, a combustion chamber

having a source of combustion gases, a plurality of substantially vertical heating tubes for the passage therethrough of the medium to be heated, said heating tubes being arranged around the combustion chamber, radiant walls substantially surrounding each of said heating tubes and providing a separate annular heating channel between each tube and its surrounding wall, radial passageways between the upper and lower ends of each of said heating channels and said combustion chamber, and a fan for circulating hot combustion gases radially outwardly from the combustion chamber to the top ends of said heating channels.

6. The furnace according to claim 5 wherein the fan is located within and at the top of the combustion chamber and is provided with blades discharging hot combustion gases radially outwardly through said radial passageways at the upper ends of said heating channels.

7. In combination with the furnace according to claim 5, a motor for said fan mounted outside and above the combustion chamber, a shaft extending downwardly from the motor into the combustion chamber and connected at the bottom to said fan, a bearing mounted about said shaft outside of the combustion chamber, a bushing surrounding said shaft and rotatably supported by said bearing, and means supporting said shaft from said bushing, said shaft and bushing being spaced apart to provide a passage therebetween for the passage of a cooling agent.

8. In combination with the furnace according to claim 5, a circular discharge line for spent heating gases surrounding the heating channels, and a plurality of at least three passageways connecting the furnace with said discharge line, said passageways being equally spaced along the circumference of the furnace.

9. In combination with the furnace according to claim 5, a supply conduit for the medium to be heated, and a manifold connected to said supply conduit, each of said heating tubes being connected at their upper ends to said manifold.

10. In combination with the furnace according to claim 5, a circular discharge line for the heated medium substantially opposite the ends of said heating tubes, each of said heating tubes being connected to said circular discharge line.

11. A furnace for heating flowing media comprising, in combination a combustion chamber having a source of heat and a top wall, a plurality of heating tubes for the passage therethrough of the medium to be heated, radiant walls substantially surrounding each of said heating tubes and providing a separate annular heating channel between each tube and its surrounding wall, passageways between the ends of each of said heating channels and said combustion chamber, a fan within the combustion chamber near the top thereof for circulating hot combustion gases through said passageways, heating channels and the combustion chamber, a drive shaft for said fan extending through said top wall, means for driving said shaft, a bearing surrounding said shaft outside the combustion chamber and in close proximity to said top wall, a bushing surrounding said shaft and rotatably supported by said bearing, said shaft and bushing being paced apart to provide a passage therebetween for the passage of a cooling agent, means supporting said shaft from said bushing, and a fan on said drive shaft outside of said combustion chamber arranged to circulate a cooling agent through said passage.

12. A furnace for heating flowing media comprising, in combination, an annular wall of heat insulating material providing therewithin a central, vertical combustion chamber, a source of combustion gases for said combustion chamber, a plurality of separate vertical heating channels formed in said wall, said heating channels being distributed evenly along said annular wall, passageways between the upper and lower ends of each of said heating channels and said combustion chamber, a fan for circulating hot combustion gases through said passageways, heating channels and combustion chamber, and a heating tube for the medium to be heated within each of said heating channels and spaced from the walls thereof.

13. The furnace according to claim 12 wherein each heating channel is of substantially circular cross-section and is concentric with the heating tube mounted within it.

14. A method of heating flowing media comprising flowing the medium to be heated through an elongated tube, flowing hot combustion gases through an annular heating channel surrounding said heating tube and providing an elongated radiant surface surrounding said heating tube, thereby heating said heating tube and said radiant surface by convection and heating said heating tube uniformly circumferentially by radiation from said radiant surface, and recirculating said hot gases through a combustion chamber to maintain the desired temperature of said gases.

15. A method of heating flowing media comprising flowing different portions of the medium to be heated through a plurality of elongated heating tubes connected in parallel, flowing hot combustion gases concurrently with the medium to be heated through separate annular heating channels surrounding each of said heating tubes, said heating channels providing elongated radiant surfaces surrounding the several tubes, thereby heating said heating tubes and radiant surfaces by convection and heating said heating tubes uniformly circumferentially by radiation from said radiant surfaces, and recirculating said hot gases through a combustion chamber to maintain the desired temperature of said gases.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,828,373	Mekler	Oct. 20, 1931
2,226,986	Wechsberg et al.	Dec. 31, 1940
2,229,799	Dean	Jan. 28, 1941