Nov. 5, 1940. A. L. BAKER 2,220,387

METHOD AND APPARATUS FOR FIRING FURNACES

Filed Jan. 6, 1937

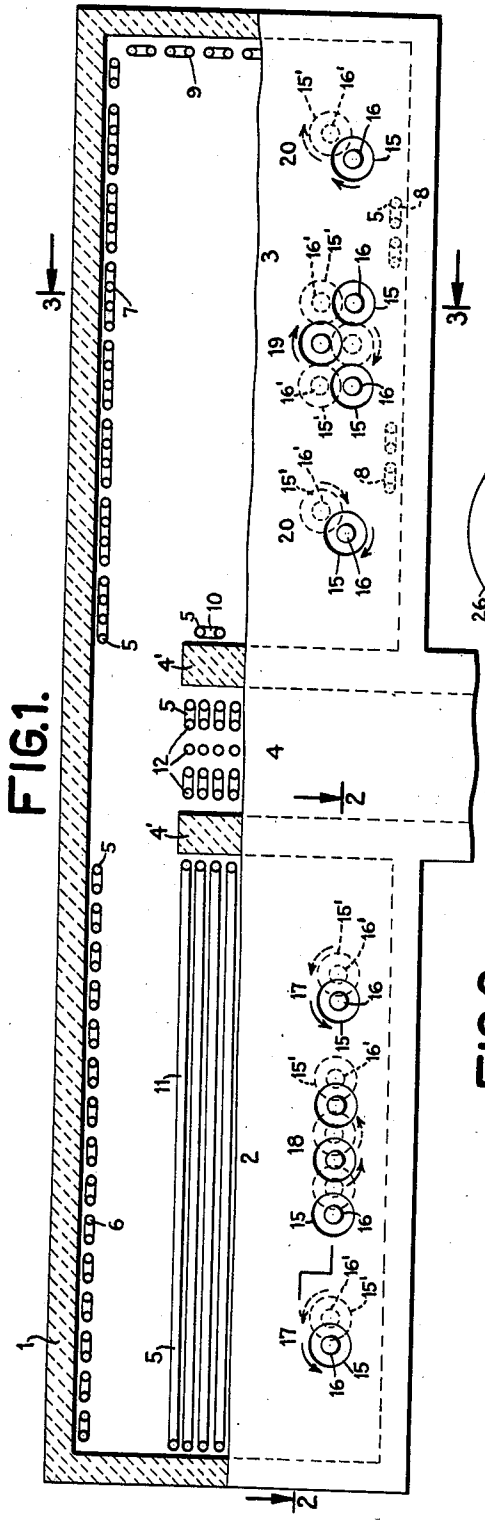


FIG. 1.

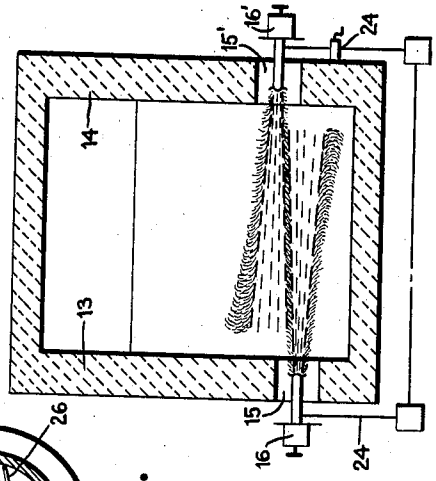


FIG. 3.

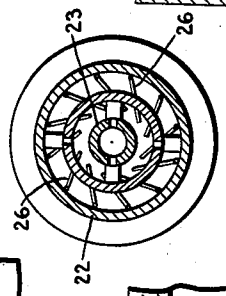


FIG. 4.

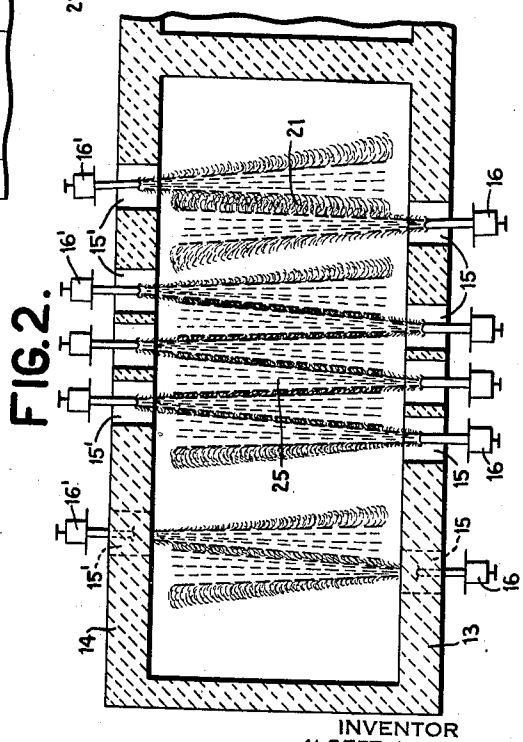


FIG. 2.

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Patented Nov. 5, 1940

2,220,387

UNITED STATES PATENT OFFICE

2,220,387

METHOD AND APPARATUS FOR FIRING FURNACES

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Application January 6, 1937, Serial No. 119,202

20 Claims. (Cl. 196—116)

My invention relates in general to heating apparatus employing hot products of combustion as a heating medium and refers in particular to an improvement in the firing of such apparatus.

It is an object of my invention to improve the firing of furnaces provided with burners or the like on opposite sides of the combustion or heating chamber by so controlling the direction and manner in which the hot products of combustion from said burners are supplied to such chamber as to avoid or minimize concentrated zones of heating within the combustion or heating chamber and produce a more uniform distribution of heat to all parts of the chamber. Other objects and advantages will be apparent from the following description and the attached drawing which illustrates an embodiment of the invention, and in which:

Fig. 1 is a diagrammatic elevation partly in section of a furnace having the burners arranged in accordance with my invention;

Fig. 2 is a horizontal section on line 2—2 of Fig. 1;

Fig. 3 is a vertical section corresponding to a view taken on line 3—3 of Fig. 1 with the tubes omitted for simplicity and diagrammatically illustrating a means for simultaneously adjusting opposed burners; and

Fig. 4 shows a universally adjustable support for the burners and also illustrates vanes for imparting a rotating motion to air supplied to the furnace for the combustion of the fuel therein.

My invention is applicable to any heating apparatus in which hot products of combustion are supplied by means of burners or the like to the interior of a combustion or heating chamber from opposite sides thereof, but it has particular utility with furnaces, such as a box type furnace, employed in the pyrolytic treatment of hydrocarbon oils and gases. In such furnaces it is often desirable or necessary in order to decrease the size of the furnace or to produce a high rate of cracking as in the production of relatively high antiknock gasoline from higher boiling oils and in the production of liquid polymers from fixed gases and the like, to provide the combustion or heating chamber of the furnace with burners positioned on opposite sides of said chamber. When in the past, however, a furnace has been fired by means of burners located in opposing walls of the combustion or heating chamber, a burner on one side has been positioned substantially directly opposite a burner on the opposite side. The streams or columns of hot products of combustion introduced into the combustion or heating chamber by such burners thus meet in the central portion of the furnace, and the combustion products in one stream collide substantially directly with those in the opposing stream, thus resulting in a concentration of heat and turbulence at this particular portion of the furnace. The direct collision between said columns also causes the flames and other hot combustion products contained in the streams to be deflected towards the tubes or plates containing the medium undergoing heating, thus augmenting the concentration of heat at this portion of said medium.

When the hot products of combustion are withdrawn from one end and at the top portion of a combustion chamber, such as in a furnace provided with a combustion heating section and a convection heating section separated by a bridge wall, I have found that there is also a concentration of heat in the lower portion of the combustion chamber adjacent the end wall and in the upper portion of such chamber adjacent the bridge wall dividing the combustion chamber from the convection section of the furnace and that there is a deficiency of desired heat at the upper corner of the combustion chamber adjacent the end wall and in the lower portion of such chamber adjacent the bridge wall. I have also found that when combustion air introduced into a furnace from opposite sides thereof is given a rotating or swirling motion, and when, as in the past, the air introduced from one side is given the same direction of rotation as that introduced from the opposite side, when viewed from the respective sides of the chamber, there is a tendency for the hot products of combustion to form horizontally rotating streams around the walls of the combustion section. Such tendency may cause local overheating and hot spots within the combustion chamber and thus make temperature balance at different points in the furnace difficult.

Such concentration of heat within the heating chamber of the furnace, as hereinabove described, may result in an inefficient utilization of the available heating area, and, in the case of hydrocarbon material undergoing treatment, may limit the total amount of heat which may be provided by the burners without deleteriously affecting said hydrocarbon material. Thus it is well known that overheating such products may produce excessive coke, tar, excessive gas and other undesirable constituents depending upon the particular stock and treatment, and accordingly, heat which the burners might otherwise provide for the furnace as a whole is limited by the concentrated heat existing in particular zones thereof.

In order to avoid or minimize such concentration of heat within the furnace and to obtain a more uniform distribution of the hot products of combustion to all parts of the furnace with the consequent even heating of the fluid being processed, it is an object of my invention to arrange the opposed burners or the like in such manner that the respective streams or columns of hot products of combustion are directed along paths which are somewhat separated and substantially parallel to each other instead of in substantial alignment. In this manner the respective streams or columns from opposite sides of the furnace are so directed that the hot products of combustion contained in the central or more concentrated portions of opposing streams or columns along their longitudinal axes slide past each other without substantial direct contact between heated products in one stream and those in the opposing stream. It is generally desirable, however, to create limited turbulence in the main heating chamber. As a further object of my invention, I accomplish this turbulence by directing said streams or columns along paths which are sufficiently close together to permit the hot products of combustion contained in the outer or less dense portion of a stream or column along its length to directly collide with products of combustion contained in a similar portion of an opposing stream or column. By thus firing the combustion chamber, concentrated heating in particular zones of the chamber produced by direct contact between combustion products contained in the hottest or more concentrated portion of opposing columns is avoided or minimized while the direct contact or collision between heated products contained in the relatively cooler and less dense portions of the opposing columns along their length produces the desired turbulent condition within the furnace which assists in more uniformly distributing the hot gases and other combustion products to all parts of the same. By adjusting or regulating the spacing between the longitudinal axes of opposing columns or streams the desired degree of overlapping and turbulence can be obtained and maintained, and it is an object of my invention to provide any desired degree of overlap between the transverse portions of opposing columns, short of substantially direct axial contact between the columns or streams, which will provide the desired turbulence and at the same time avoid or minimize concentrated heating in particular zones of the chamber.

In order to assist in more uniformly distributing the heat and avoiding concentrated heating in particular zones of the chamber, particularly in the corners and along the walls of the combustion chamber, it is a further object of my invention to impart a swirling or rotating motion to the streams of hot products of combustion introduced into the combustion chamber from opposite sides of the chamber and to rotate such streams in a clockwise direction on one side of the furnace and in a counterclockwise direction on an opposite side of the furnace. As a further object the direction of rotation on both sides is made such as to direct the hot products of combustion away from those portions of the furnace which tend to become excessively heated and towards those portions which require more heat.

The streams of combustion products may be caused to thus rotate or swirl by any desired means, but it is an object of my invention to cause such motion by means of the air introduced to burners or the like for combustion of the fuel. Thus, air introduced to the furnace through ports or the like on one side of the combustion chamber is given a clockwise direction of rotation while that introduced from the opposite side is given a counterclockwise direction of rotation, looking into the combustion chamber from the respective opposite sides thereof. Air supplied to all of the ports or the like on the same side of the furnace is given the same direction of rotation. The burners or other means for supplying fuel may be positioned directly in the path of the rotating air so that the combustion products are introduced into the combustion chamber with a swirling motion, or they may be positioned within the chamber for admixture with the rotating air after it enters the chamber. In either case the air imparts a swirling motion to hot products of combustion on both sides of the furnace. The direction of rotation of the air and combustion products is such that the circular flow is away from the bridge wall and towards the end wall of the combustion chamber at the top side of the stream of air and combustion products while it is directed towards the bridge wall and away from the end wall at the under side of such stream. Since the respective air streams introduced into the furnace from opposite sides of the combustion chamber are rotated in opposite directions as viewed from the respective sides of the chamber it is evident that within the combustion chamber the circular flow of all streams of combustion products from both sides will be in the same direction with respect to the bridge and end walls of the combustion chamber, as indicated by the solid and dashed arrows in Fig. 1 of the drawing wherein streams from both sides are viewed from one side of the chamber.

By causing the hot products of combustion to rotate in this manner such products will be more thoroughly and uniformly distributed into the upper spaces of the furnace, and the heat concentration in the lower portion of the furnace adjacent the bridge wall and in the upper portion of the furnace adjacent the end wall will be increased while at the same time the heat concentration in the lower portion of the furnace at the end wall and in the upper portion of the furnace adjacent the top of the bridge wall will be decreased. Such rotation of the air and combustion products also prevents horizontal rotational flows of the hot products of combustion within the combustion chamber since the opposed rotating streams, while rotating in the same direction as far as the end and bridge walls are concerned, are directed in opposite directions as far as a horizontal rotation of combustion products around the wall of the combustion chamber is concerned, and thereby break up any tendency for such flow. Introducing the air in this manner has a further advantage with furnaces fired by burners arranged in such manner as to direct the respective opposing streams of hot products of combustion along paths which are staggered or offset with respect to each other, as hereinabove described, in that it provides better distribution of heat along the entire length of the tubes arranged along the end wall of the combustion chamber.

Firing in such manner as to avoid localized or concentrated heating in particular zones of the heating chamber and to distribute the heat uniformly to all parts of a heating chamber is

of particular benefit with furnaces in which tubes located in a heating chamber are heated predominantly by radiant heat, and accordingly my invention is particularly adapted for use with such furnaces.

It is also evident that by firing a furnace in the manner taught by my invention the size of the furnace may be decreased or the heating capacity increased, which is an important advantage of the invention.

Referring to the drawing in which like reference characters refer to similar parts in the different views, the reference numeral 1 refers to a furnace which is illustrated as a box type furnace suitable for the pyrolytic treatment of hydrocarbon materials and which is provided with two side combustion or heating chambers 2 and 3 directly communicating with a common central convection section 4 formed by bridge walls 4'. The furnace as thus shown and described is for illustrative purposes enabling a ready showing of various arrangements of the burners, but my invention is equally applicable to a furnace of any desired shape and type and used for any desired purpose, such, for example, as a box type furnace provided with a single radiant section and a single convection section. The interior of the furnace is provided with a plurality of pipes or tubes 5 for conveying fluid therethrough, those in the chambers 2 and 3 being disposed to be heated preponderantly by radiant heat while those in the convection chamber 4 are heated preponderantly by convection heat. The various tubes 5 may be connected in any desired manner for causing single or plural streams of fluid to pass therethrough in the selected sequence. In Fig. 1 I have shown several typical arrangements of such tubes in which 6 and 7 are banks of roof tubes, 8 is a bank of floor tubes, 9 a bank of end wall tubes, 10 a bank of bridge wall tubes, 11 a bank of tubes extending around the side, end and bridge walls, and 12 is one or more banks of convection tubes. These arrangements, however, are for purpose of illustration and may be interchanged or varied at will, or the furnace may be provided with boiler plates instead of tubes.

Arranged in two opposite walls 13 and 14 of the combustion or heating chambers are a plurality of ports 15 and 15', respecitvely, through which the burners 16 and 16', respectively, are inserted. The burners 16 and 16', as illustrated, are purely diagrammatic and may be burners of any desired shape or type or any other heating means adapted to project a stream or column of hot products of combustion into the interior of the combustion or heating chamber. For instance, separate muffle combustion chambers, wherein the desired combustion is effected, may feed hot products of combustion through the ports 15 and 15'. The ports 15' and burners 16' arranged in the wall 14 are positioned on center lines which are offset with respect to the center lines of the respective opposed ports 15 and burners 16 arranged in the opposite wall 13. The burners may be offset in a horizontal plane, as illustrated at 17 and 18, in a vertical plane as illustrated at 19, or in both horizontal and vertical planes, as illustrated at 20. The burners 16 and 16', respectively, are so positioned that they direct the respective streams of hot combustion products along substantially parallel paths, as shown in Figs. 2 and 3 of the drawing. The distance, or offset, between the center lines of the respective opposed burners is such that the combustion products contained in the central or dense portions of the respective streams along their length slide past each other without substantial direct contact, while the products in the outer transverse portions of opposing streams along the length thereof collide to a limited extent to create a turbulent condition within the combustion chamber, as illustrated in Figs. 2 and 3 and hereinabove described. This distance varies with the size of the burners and the degree of overlap and turbulence desired. In many cases the actual offset or staggering between the axes of two opposed burners or the like need not be large, apparently for the reason that once the opposing streams are given a material start the natural tendency is for the streams to slide past each other without substantial overlap or direct contact between hot products of combustion contained in the respective opposing streams. I have found that with ports, such as 15 and 15', having a minimum throat diameter of 19 inches a horizontal offset of 8 inches between the center lines of two opposed burners is satisfactory and operates successfully.

The distance between the respective longitudinal axes of opposing streams may also be increased or decreased by turning or tilting opposed burners through similar angles but in opposite directions from the perpendicular to the planes of the opposite furnace walls, as illustrated at 21 in Fig. 2. In this manner the degree of turbulence can be varied and adjusted to obtain the desired degree throughout operation of the burners and irrespective of changes in fuel consumption. By turning opposing burners in opposite directions through substantially similar angles the paths of hot products of combustion may be maintained substantially parallel.

An adjustable support for the burner may be provided for this purpose. Such a support is illustrated in Fig. 4 in which 22 designates a flanged collar adapted to fit into the ports 15 and 15', and 23 is a ring adapted to receive and support the burner. The ring 23 is supported in the collar 22 by a typical gimbal mounting which permits the burner to be universally adjusted to any angle in a horizontal and/or vertical plane. The burner may be secured in the ring 23 and maintained in its adjusted position by any suitable clamping means (not shown). Any desired support which permits adjustment of the burner in one or more planes may be substituted for that of Fig. 4.

Each burner may be individually adjusted, or two or more opposed burners may be interconnected by any desired means, such as shafts, links, gearing, etc., or a suitable electrical control, for simultaneous adjustment, as diagrammatically indicated at 24 in Fig. 3.

It is also preferable to so adjust the velocity or force with which the hot products of combustion contained in the respective columns or streams are projected into the interior of the heating chamber that the columns or streams, or at least the hotter and more dense portions thereof, stop short of the opposite furnace wall, and said products do not directly impinge upon said wall and tubes located thereon.

The burners may be arranged in groups of two as illustrated at 17 and 20 in Fig. 1, or a plurality of burners in one wall may be arranged in staggered relationship with respect to a plurality of burners in the opposite wall, as illustrated at 18 and 19 in Fig. 1. At 18 the burners are staggered in a single plane, while at 19 they are

staggered both horizontally and vertically. When arrangements of the type illustrated at 18 and 19 are used, it is preferable to place the burners, or at least the outlet portions thereof, in one wall on center lines so spaced that the central portions of the respective columns projected by the burners in the opposite wall just fit between the corresponding portions of the columns projected by said first burners, while the less dense outer portions of the respective adjacent columns overlap to the desired limited extent, as illustrated at 25 in Fig. 2.

The air required for combustion is supplied to the fuel outlets of burners 16 and 16' through the ports 15 and 15', respectively, and may be caused to rotate by providing the respective ports with an air register provided with vanes arranged to rotate the air in the desired direction. Such vanes are diagrammatically illustrated at 26 in Fig. 4 of the drawing. The vanes may be fixed in position or rotatably adjustable. In my copending application Serial No. 119,201 filed January 6, 1937, Apparatus for firing furnaces, which has become Patent No. 2,144,098 granted January 17, 1939, I have illustrated and disclosed an air register which is suitable for this purpose and which I prefer to use in practicing my invention. I contemplate, however, using any desired means for giving the desired direction of rotation to the air. It is evident that when an air register is used with the type of support illustrated in Fig. 4 sufficient clearance between the respective parts must be allowed to permit the desired adjustment of the burners.

In accordance with my invention the air which is introduced into combustion chamber 2 of furnace 1 by means of ports 15 in the front wall 13 thereof is given a counterclockwise direction of rotation while that introduced into the combustion chamber 2 by means of the ports 15' located in the rear wall 14 thereof is given a clockwise direction of rotation. In the combustion chamber 3, however, the air introduced through ports 15 positioned in the front wall 13 is given a clockwise direction of rotation whereas that introduced by the ports 15' located in the rear wall of this section is given a counterclockwise direction of rotation. These directions of rotation are indicated on Fig. 1 of the drawing by means of the solid arrows for air introduced through ports 15 located in the front wall 13 and by the dashed arrows for ports 15' located in the rear wall 14. Both arrows indicate the direction of rotation as it would be seen looking into the combustion sections from the front, or wall 13, side of the furnace. The air registers have been omitted in Figs. 1, 2 and 3 for clearness in illustrating other features of my invention.

In the foregoing description of my invention I have referred to the motion of the air and combustion products as being a rotational motion about the longitudinal axes of their respective streams or columns for the purpose of enabling a ready description and understanding of the invention. It is not essential to this aspect of my invention, however, that the particles of air and combustion products actually follow a rotational or spiral path around the axis. It is only necessary that particles of air and combustion products contained within a stream or column be caused to have components of motion in planes transverse to the stream and the longitudinal axis thereof and that such components as distributed about the axis be directed in the desired clockwise or counterclockwise direction relative to the axis. By causing particles of air and combustion products contained in a given stream to follow a path having such transverse components of motion relative to the axis of the stream the same effects and results are accomplished, as far as the objects of my invention are concerned, as if the particles were caused to follow a curvilinear path relative to the axis. Thus, when an air register of the type hereinabove described and diagrammatically illustrated in Fig. 4 of the drawing is used it may possibly be found that neither the particles of air nor the combustion products actually follow a rotational or spiral path relative to the axis of the stream or column for any great distance beyond the inside edge of the port through which the stream or column of air and/or hot products of combustion is supplied to the combustion chamber. Yet the vanes of such register will at least cause the particles of air and combustion products to follow paths within the stream or column which have transverse components of motion distributed around the longitudinal axis of the stream or column and so directed as to simulate a predetermined clockwise or counterclockwise rotation of the stream or column about such axis and give the same effects and results as hereinabove described for such rotating streams or columns. Such transverse components of the air stream will also tend to cause the combustion products to actually follow a rotational or spiral path for some distance beyond the burner outlet. It is accordingly my intention that such terms as "rotating" or "rotational" when used in the specification for describing the motion of the particles of air and combustion products, or of the streams or columns containing the same, are illustrative only and should be interpreted as descriptive of a condition in which such particles do not actually travel in curvilinear paths but have transverse components of motion so directed as to simulate the effect and results of such curvilinear motion.

I have described and illustrated a preferred form of my invention in which the combustion chamber of a heating apparatus is fired by opposing streams of hot products of combustion which are staggered with respect to each other, and which are also caused to rotate in predetermined opposite directions, to obtain the desired uniform distribution of such products throughout the combustion chamber. I contemplate, however, the separate employment of either of these features, when desired, with the advantageous results in firing produced thereby. My invention also contemplates the use of any arrangement of burners, or the like, in which the outlet portions of opposed burners are offset or turned with respect to each other to direct a stream of hot products of combustion from one burner along a path which is spaced from, but substantially parallel to, the path of a similar stream from an opposed burner and in which there is only limited overlap between such streams. Thus two or more opposed burners could be located on center lines which are in substantial alignment with each other and the burners turned in opposite directions through substantially equal angles with respect to a perpendicular to the planes of the furnace walls to direct the streams along substantially parallel paths, as hereinabove described. The burners may also be supported in any desired parts of the furnace and by any desired means.

Combustion air, or hot combustion products, may be caused to rotate, or have transverse com-

ponents of motion, in the manner of my invention when supplied to a furnace of any desired type or structure. In applying this feature of my invention to such furnace structures the same principle for determining the direction of rotation, or of such components, would be followed as hereinabove described in connection with my preferred embodiment, and the direction would be made such that the combustion products are directed towards cooler portions and away from hotter portions of the combustion chamber. Thus, the direction of rotation, or of the transverse components, is made such that the hot combustion products tend to direct heat away from portions of the heating chamber adjacent the opening for withdrawing hot combustion products from the combustion chamber and away from the diagonally opposed corner edge of the chamber at the end wall while at the same time directing heat towards the other corner edge of the chamber at the end wall and portions of the combustion chamber diagonally opposite to such last-mentioned corner edge. For example, if the bridge wall extended downwardly from the roof of the combustion chamber and the hot combustion products were withdrawn from the bottom portion of the chamber, the direction of rotation would be reversed from that described for the furnace illustrated in the drawing, and the transverse components, or the circular flow of combustion products, would be directed towards the bridge wall at the top sides and away from the bridge wall at the bottom sides of the respective streams. As a further possible modification of this feature of my invention, air and products of combustion may be introduced from one side of a combustion chamber and caused to rotate in the desired direction while relatively cooler flue gases may be recirculated to said chamber in a manner well known in the art and introduced from the opposite side thereof with an opposite direction of rotation. The hot products of combustion may be directly caused to rotate by suitable vanes or the like after combustion of the fuel and air mixture. Where it is only desired to prevent the formation of streams of hot combustion products which rotate in horizontal planes around the walls of the combustion chamber, two or more streams of hot products of combustion on the same side of the combustion chamber may be given opposite directions of rotation. In this case, however, the advantageous result of directing heat away from excessively heated corners and towards the cooler portions of the chamber is not obtained.

Many other modifications and variations may be made without departing from the spirit of my invention, and it should be limited solely by the scope of the appended claims.

I claim:

1. The method of applying heat to hydrocarbon fluids passing through conduits in a heating chamber which comprises supplying a stream of hot products of combustion to the interior of said heating chamber, supplying a second stream of hot products of combustion to the interior of said heating chamber in a direction substantially opposite to that of the first stream, directing said streams along paths in which the longitudinal axes of the respective streams are separated and substantially parallel, and adjusting the distance between said axes to permit sufficient overlay between said streams to produce a desired turbulent condition within said heating chamber.

2. The method of applying heat to hydrocarbon fluids passing through conduits in a heating chamber which comprises supplying a column of hot products of combustion to the interior of said heating chamber, supplying a second column of hot products of combustion to the interior of said heating chamber in a direction substantially opposite to that of the first column, and directing said columns of combustion products along paths in which the products contained in only the outer transverse portions of one column have direct contact with products contained in similar portions of the opposing column.

3. The method of supplying air to a heating chamber for the combustion of fuel therein to heat hydrocarbon fluids passing through conduits which comprises introducing streams of air and fuel into said chamber from opposite sides of the chamber to produce hot products of combustion, causing the air introduced from one side as viewed from that side to have components of motion in planes transverse to the longitudinal axis of the stream which are directed in a clockwise direction relative to said axis and causing air introduced from the opposite side to have transverse components of motion directed in a counterclockwise direction relative to the longitudinal axis of the stream as viewed from said opposite side.

4. A method of applying heat to hydrocarbon fluids passing through conduits in a heating chamber which comprises supplying streams of hot products of combustion to the interior of said chamber from opposite sides of the chamber, causing products of combustion introduced from one side as viewed from that side to have components of motion in planes transverse to the longitudinal axis of the stream which are directed in a clockwise direction about said longitudinal axis and causing products introduced from the opposite side to have transverse components of motion directed in a counterclockwise direction about the longitudinal axis of the stream as viewed from said opposite side.

5. The method of applying heat to hydrocarbon fluids passing through conduits in a heating chamber which comprises supplying a column of hot products of combustion to the interior of said heating chamber, supplying a second column of hot products of combustion to the interior of said heating chamber in a direction substantially opposite to that of the first column, causing combustion products in each of said columns to have transverse components of motion tending to impart a rotational motion of combustion products in opposite directions about the respective longitudinal axis of the columns as viewed from the respective sides of said heating chamber, and directing said columns of combustion products along paths which prevent substantial direct contact between combustion products contained in a longitudinal central portion of one column and those in a longitudinal central portion of the opposing column but permit substantial direct contact between combustion products contained in the outer transverse portions of one column and products in the outer transverse portions of the other column to create a turbulent condition within the heating chamber.

6. The method of applying heat to hydrocarbon fluids passing through conduits in a heating chamber defined by boundary surfaces including an end surface and having an exit for hot combustion products adjacent one of the

corners of the chamber opposite to said end surface, which comprises introducing fuel into the interior of said heating chamber, introducing streams of air for admixture with said fuel into said heating chamber from opposite sides thereof and along paths substantially parallel to said end surface and to two corner edges of the chamber formed thereby, causing the air in each of said streams thus introduced from both sides to have components of motion which are transverse to the respective longitudinal axes of the streams and so directed as to direct heat away from portions of said heating chamber adjacent said exit and said corner edge at the end surface which is diagonally opposite thereto and direct heat towards the other of said corner edges of the chamber at said end surface and the portion of the chamber diagonally opposite to said corner edge last mentioned.

7. The method of applying heat to hydrocarbon fluids passing through conduits in a heating chamber defined by boundary surfaces including an end surface and having an exit for hot combustion products adjacent one of the corners of the chamber opposite to said end surface, which comprises supplying streams of hot products of combustion to the interior of heating chamber from opposite sides thereof, causing combustion products in all of said streams to have transverse components of motion about the respective longitudinal axes of the streams so directed as to direct heat away from portions of said heating chamber adjacent said exit and said corner edge at the end surface which is diagonally opposite thereto and direct heat towards the other of said corner edges of the chamber at said end surface and the portion of the chamber diagonally opposite to said corner edge last mentioned and directing said streams of combustion products along substantially parallel paths so spaced as to prevent substantial direct contact between combustion products contained in the center portion of adjacent opposing streams while permitting direct contact between such combustion products contained at the outer transverse portions of adjacent opposed streams to create a turbulent condition within the heating chamber.

8. In a heating apparatus employing hot products of combustion as a heating medium, means whereby a column of hot products of combustion is supplied to the interior of said heating apparatus, means whereby a second column of hot products of combustion is supplied to the interior of said heating apparatus in a direction substantially opposite to that of the first column, and means for preventing substantial direct contact between the combustion products contained in a longitudinal central portion of one column and those contained in a longitudinal central portion of the opposing column while permitting direct contact between combustion products contained in the outer transverse portions of one column along the length thereof and such combustion products contained in the outer transverse portions of the opposing column along the length thereof to create a turbulent condition within the heating apparatus.

9. In a heating apparatus employing hot products of combustion as a heating medium, means whereby a column of hot products of combustion is supplied to the interior of said heating apparatus, a second means whereby a second column of hot products of combustion is supplied to the interior of said heating apparatus in a direction substantially opposite to that of the first column, means for preventing substantial direct contact between the combustion products contained in a longitudinal central portion of one column and those contained in a longitudinal central portion of the opposing column while permitting direct contact between combustion products contained in the outer transverse portions of one column along the length thereof and such combustion products contained in the outer transverse portions of the opposing column along the length thereof to create a turbulent condition within the heating apparatus, and means for adjusting the degree of overlap between said columns to adjust the degree of turbulence.

10. In a heating apparatus employing hot products of combustion as a heating medium, means whereby a column of hot products of combustion is supplied to the interior of said heating apparatus, a second means whereby a second column of hot products of combustion is supplied to the interior of the heating apparatus in a direction substantially opposite to that of the first column, and means for directing said columns along substantially parallel paths so spaced as to prevent substantial direct contact between combustion products contained in a longitudinal central portion of one column and such combustion products contained in a similar portion of the opposing column while permitting direct contact between combustion products contained in the outer transverse portions of one column along the length thereof and such combustion products contained in the outer transverse portions of the opposing column along the length thereof to create a turbulent condition within the heating apparatus.

11. In a heating apparatus employing hot products of combustion as a heating medium, means whereby a column of hot products of combustion is supplied to the interior of said heating apparatus, a second means whereby a second column of hot products of combustion is supplied to the interior of the heating apparatus in a direction substantially opposite to that of the first column, means for causing combustion products in each of said columns to have transverse components of motion in opposite directions about the respective longitudinal axes of the columns, and means for directing said columns along substantially parallel paths so spaced as to prevent substantial direct contact between combustion products contained in a longitudinal central portion of one column and such combustion products contained in a similar portion of the opposing column while permitting direct contact between combustion products contained in the outer transverse portions of one column along the length thereof and such combustion products contained in the outer transverse portions of the opposing column along the length thereof to create a turbulent condition within the heating apparatus.

12. In a heating apparatus employing hot products of combustion as a heating medium, means having an outlet whereby a stream of hot products of combustion is supplied to the interior of the heating apparatus, a second means having an outlet whereby a second stream of hot products of combustion is supplied to the interior of the heating apparatus, and means for positioning said first and second means with said outlets in opposed relationship and offset with respect to each other by an amount sufficient to direct said streams along paths which prevent substantial

direct contact between combustion products contained in a longitudinal central portion of one stream and such combustion products contained in a similar portion of the opposing stream while permitting direct contact between combustion products contained in the outer transverse portions of one stream along the length thereof and such combustion products contained in the outer transverse portions of the opposing stream along the length thereof to create a turbulent condition within the heating apparatus.

13. In a heating apparatus comprising a combustion heating section defined by boundary surfaces including an end surface and having an exit for hot combustion products adjacent one of the corners of the heating section opposite to said end surface, means arranged on one side of the combustion heating section and adapted to supply a stream of hot products of combustion to the interior of said combustion heating section along a path substantially parallel to said end surface and to two corner edges of the chamber formed thereby, a second means arranged on the opposite side of said combustion heating section and also adapted to supply a stream of hot products of combustion to the interior of said combustion heating section along a path substantially parallel to said end surface and to said two corner edges of the chamber formed thereby, and means for causing combustion products contained in each of said streams to have transverse components of motion about the respective longitudinal axis of the streams so directed as to direct heat away from portions of said heating section adjacent said exit and said corner edge at the end surface which is diagonally opposite thereto and direct heat towards the other of said corner edges of said heating section at said end surface and the portion of said heating section diagonally opposite to said corner edge last mentioned.

14. In a heating apparatus employing hot products of combustion as a heating medium, means whereby a plurality of columns of hot products of combustion is supplied to the interior of said heating apparatus, other means arranged in opposed relationship to said first-mentioned heating means whereby a plurality of columns of hot products of combustion is supplied to the interior of the heating apparatus, and means for directing said columns along paths in which the respective opposed columns are staggered and the respective longitudinal axes of the columns from each of said means for supplying combustion products are substantially parallel to each other and to the axes of the opposing columns and spaced apart by a distance sufficient to permit combustion products contained in portions relatively close to the axes of adjacent opposed columns to pass each other without substantial direct contact while permitting direct contact between combustion products contained in the transverse portions outside of said first-mentioned portions of the adjacent opposed columns.

15. In a heating apparatus comprising a combustion heating section defined by boundary surfaces including an end surface and having an exit for hot combustion products adjacent one of the corners of the heating section opposite to said end surface, a plurality of means arranged on one side of the combustion section and adapted to supply a plurality of streams of hot products of combustion to the interior of said combustion section along paths substantially parallel to each other and to said end surface and to two corner edges of the chamber formed thereby, a second plurality of means arranged in opposed relationship to said first-mentioned heating means and also adapted to supply streams of hot products of combustion to the interior of the combustion heating section along paths substantially parallel to each other and to the paths of the first-mentioned streams, means associated with said means for supplying combustion products for causing combustion products in all of said streams to have transverse components of motion about the respective longitudinal axes of the streams so directed as to direct heat away from portions of said heating section adjacent said exit and said corner edge at the end surface which is diagonally opposite thereto and direct heat towards the other of said corner edges of said heating section at said end surface and the portion of said heating section diagonally opposite to said corner edge last mentioned, adjacent opposed streams being staggered a distance sufficient to prevent substantial direct contact between combustion products contained in longitudinal central portions of such adjacent opposed streams while permitting direct contact between such combustion products contained in the outer transverse portions of the adjacent opposed streams along the length thereof.

16. In a heating apparatus employing hot products of combustion as a heating medium, means disposed in a boundary surface of said heating apparatus whereby a column of hot products of combustion is supplied to said heating apparatus, means disposed in an opposite boundary surface of said heating apparatus whereby another column of hot products of combustion is supplied to said heating apparatus in a direction opposite to said first-mentioned column, each of said means being arranged to direct the central portion of the column of hot products of combustion therefrom in a path substantially parallel to but separated from the central portion of the column of hot products of combustion from the opposite means while permitting direct contact between combustion products contained in the outer adjacent portions of the columns of combustion products to create a turbulent condition of combustion products within said heating apparatus.

17. In a heating apparatus employing hot products of combustion as a heating medium, means disposed in a boundary surface of said heating apparatus whereby a column of hot products of combustion is supplied to said heating apparatus, means disposed in an opposite boundary surface of said heating apparatus whereby another column of hot products of combustion is supplied to said heating apparatus in a direction opposite to said first-mentioned column, the means disposed in one boundary surface being staggered with respect to the means disposed in the opposite boundary surface to thereby direct the central portion of the column of hot products of combustion from one means in a path substantially parallel to but separated from the central portion of the column of hot products of combustion from the opposite means, said means being arranged to create turbulence between portions of said columns of products of combustion.

18. In a heating apparatus employing hot products of combustion as a heating medium, means disposed in a boundary surface of said

heating apparatus whereby a column of hot products of combustion is supplied to said heating apparatus, means disposed in an opposite boundary surface of said heating apparatus whereby another column of hot products of combustion is supplied to said heating apparatus in a direction opposite to said first mentioned column, each of said means being arranged to direct the central portion of the column of hot products of combustion therefrom in a path substantially parallel to but separated from the central portion of the column of hot products of combustion from the opposite means, and means for effecting components of motion transverse to each of the columns introduced into the heating apparatus.

19. A heating apparatus of the character described including a heating chamber, means whereby a column of hot products of combustion is supplied to the interior of said heating chamber, means whereby a second column of hot products of combustion is supplied to the interior of said heating chamber in a direction substantially opposite to that of the first column, said means including burners for supplying fuel, and means whereby air is admitted for supporting combustion of the fuel from said burners to produce hot products of combustion, said burners being offset with respect to each other whereby the opposed columns of hot combustion products are directed along parallel paths which are spaced to prevent substantially direct contact between the columns, said means for admitting air being adapted to impart transverse components of motion to the combustion products in each of the columns.

20. An apparatus of the character described adapted for heating hydrocarbon fluids including a heating chamber, means disposed in boundary surfaces of said heating chamber for introducing fuel into the interior of said heating chamber from opposite sides thereof, means whereby air is supplied for the combustion of the introduced fuel to produce substantially parallel opposed columns of hot products of combustion, said fuel introducing means including burners, said burners in one boundary surface being offset with respect to said burners in the opposite boundary surface, whereby there is substantially no direct contact between the combustion products contained in a longitudinal central portion of one column and those contained in a longitudinal central portion of an opposing column while there is direct contact between combustion products contained in the outer portions of opposing columns and along at least a portion of the length thereof to create turbulence and better mixing of the fuel undergoing combustion and air, said air supplying means being so arranged to impart rotational motion to the opposed columns of products of combustion so that the outer portions of opposing columns of products of combustion move in opposite directions to further improve mixing of the fuel and air in the heating chamber.

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