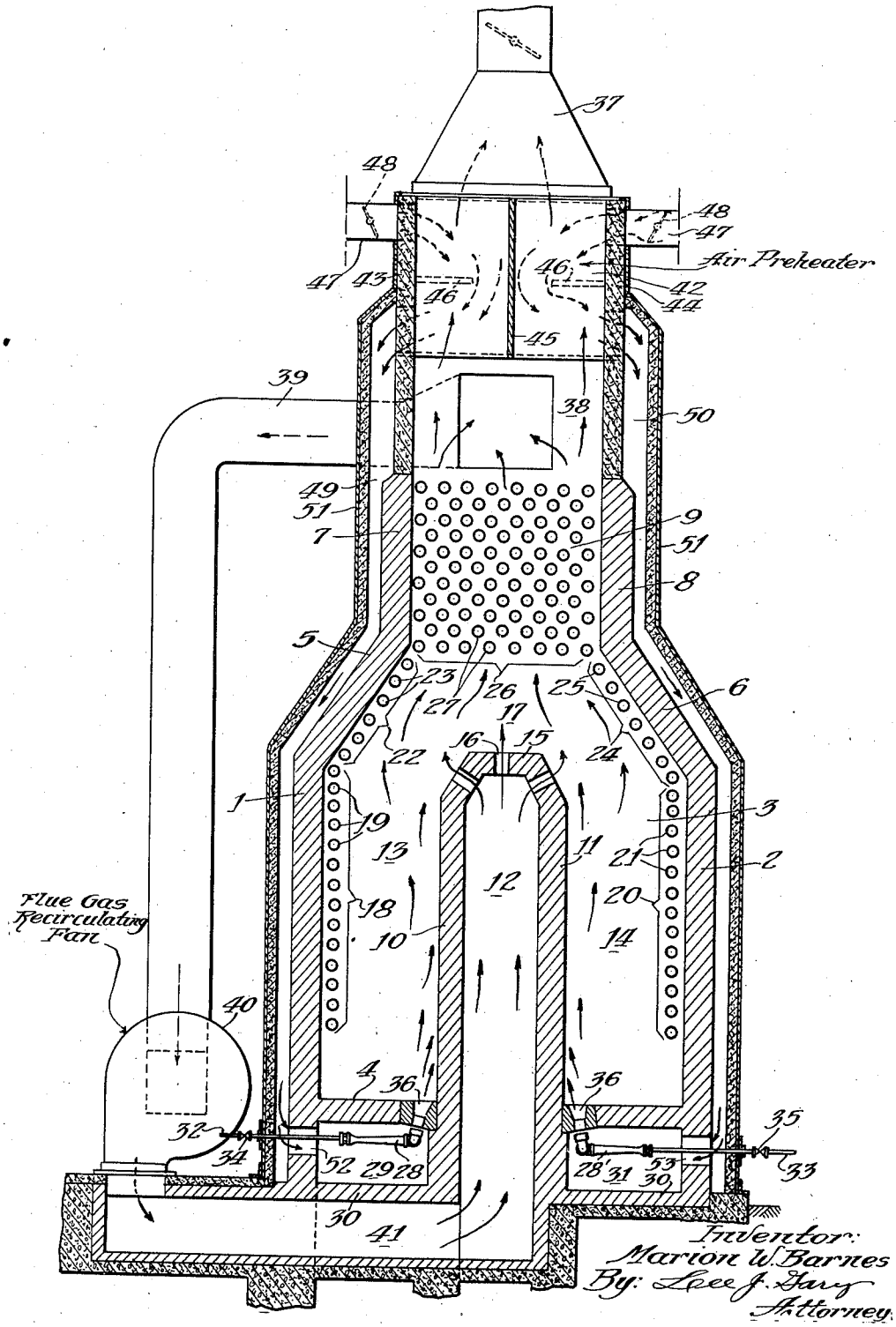
Oct. 31, 1944. M. W. BARNES 2,361,812

HEATING OF FLUIDS

Filed Oct. 23, 1942



Patented Oct. 31, 1944

2,361,812

UNITED STATES PATENT OFFICE

2,361,812

HEATING OF FLUIDS

Marion W. Barnes, Chicago, Ill., assignor to Universal Oil Products Company, Chicago, Ill., a corporation of Delaware

Application October 23, 1942, Serial No. 463,055

6 Claims. (Cl. 122—356)

The invention is directed to an improved form of heater of the radiant and convection type which will be found particularly advantageous as applied to heating hydrocarbon vapors, normally gaseous hydrocarbons or other vaporous or gaseous materials to high temperatures. The invention also embraces the improved method of heating which may be conducted in heaters such as herein provided.

Numerous industrial processes, including, for example, operations conducted for effecting the catalytic or thermal conversion of hydrocarbons, involve heating relatively large quantities of gas or vapor to high temperatures, such as, for example, of the order of 800 to 1200° F. In some instances it is necessary to fire heaters employed for this class of service with fuels, such as blast-furnace gas, producer gas, etc., which have a low calorific value and give a relatively low flame-burst temperature as compared with the more preferable fuels, such as natural gas, fuel oil, refinery gases and the like.

It is well known that the use of radiant heat energy from flames and hot combustion gases is practically mandatory to obtain quick heating of heavy hydrocarbon oils, gases and vapors to high reaction temperatures due to the high heat transfer rates required. However, the high heat transfer rates obtainable by radiant heating with fuels of high calorific value cannot be achieved with low grade or diluted fuels due to their low calorific value and low flameburst temperature. Consequently, the best types of heaters commonly employed by the refining industry in thermal cracking installations, which were designed to operate on fuels of high calorific value to give high radiant heat liberation and employing a relatively high ratio of radiant heat surface to convection surface, are not so successful as applied to the present problems above outlined.

It is the primary object of the present invention to provide an improved form of heater and method of heating which obviate the difficulties above mentioned, permitting the use of relatively low grade fuels and providing high rates of heat transfer from the flames and freshly generated combustion gases which closely approach the maximum rates obtainable with the particular fuel employed.

It is well known that the attainment of high heat transfer rates by convection can be accomplished with flue gas recirculation. However, the rates thus obtainable are not as high as those which can be achieved by direct radiation from flames and nascent hot combustion gases even when employing fuels of relatively low calorific value. Therefore, in the heater herein provided I employ flue gas recirculation and also employ direct radiation from the flames and nascent hot combustion gases, but limit flue gas recirculation to that section of the heater in which combustion gases which have given up a large portion of their radiant energy are directly contacted with the fluid conduits through which the material undergoing treatment is passed. In another section of the heater, through which no flue gases recycled, I provide fluid conduits disposed outside the direct path of travel of the flames and freshly generated hot combustion gases and transmit radiant heat directly to these conduits from said flames and hot combustion gases and from refractory surfaces over which the flames and hot combustion gases are passed before being commingled with the recycled flue gas. Thus, the radiant and convection heating sections are maintained separate and rates of heat transmission, closely approaching the highest obtainable with the particular type of fuel and type of heating employed, are obtained in each of these sections.

The features and advantages of the invention will be more apparent with reference to the accompanying diagrammatic drawing which is an elevational view, shown principally in section, of one specific form of the improved heater provided by the invention.

The heater illustrated in the drawing is of the general type now widely used in the oil refining industry and known as a "center-wall updraft" heater. This type of heater, without the improvements herein provided, is described in U. S. Patent 2,147,662 to L. A. Mekler.

Referring to the drawing, the heater here illustrated comprises substantially vertical refractory side walls 1 and 2, refractory end walls, one of which is indicated at 3, a floor 4, inwardly sloping refractory side walls 5 and 6 which connect the substantially vertical walls 1 and 2, respectively, with other vertical refractory walls 7 and 8 between which is disposed a convection or fluid heating zone 9 of smaller cross-sectional area than the lower portion of the heater.

Within the heater a pair of substantially vertical refractory walls 10 and 11, extending from beneath floor 4 to an elevation substantially corresponding to the base of the sloping walls 5 and 6, are disposed. Walls 10 and 11 are spaced from each other to provide a fluid passageway 12

therebetween for recycled flue gases and are spaced from the adjacent side walls 1 and 2 to provide a combustion and radiant heating zone 13 between walls 1 and 10 and a similar combustion and radaint heating zone 14 between walls 2 and 11. Walls 10 and 11 are bridged at the top by a refractory wall 15, having a plurality of openings 16 provided therethrough at spaced points along its length through which recycled flue gases supplied to fluid passageway 12, as will be later described, are introduced into the zone 17 between walls 5 and 6.

A bank 18 of tubular fluid conduits comprising, in the case illustrated, a single vertical row of horizontally disposed tubes 19 is located in zone 13 adjacent wall 1. Another tube bank 20, also comprising, in the case illustrated, a single substantially vertical row of horizontally disposed tubes 21 is located in zone 14 adjacent wall 2. Another tube bank 22, comprising a single row of horizontally disposed tubes 23, is located adjacent the sloping wall 5 and another similar bank 24 of horizontally disposed tubes 25 is located adjacent the sloping wall 6. Another tube bank 26 comprising, in the case illustrated, a plurality of superimposed horizontal rows of horizontally disposed tubes 27, is located in fluid heating zone 9.

A row of burners, one of which is indicated at 28, is disposed beneath zone 13 in the space 29 provided between floor 4 and sub-floor 30 and a similar row of burners, one of which is indicated at 28', is disposed beneath zone 14 in the space 31 provided between floor 4 and sub-floor 30. Burners 28 and 28' are supplied with fuel through the respective lines 32 and 33 in quantities regulated by the respective valves 34 and 35, and air for combustion of the fuel is supplied to zones 29 and 31 and to the combustion zones, as will be later described. The burners project the combustible fuel-air mixture through the firing ports 36, disposed adjacent walls 10 and 11 upwardly against the surfaces of the latter within the respective zones 13 and 14. The resulting flames and nascent hot combustion gases pass upwardly over the surfaces of walls 10 and 11, heating the same to a highly radiant condition. Radiant heat is transmitted from the highly heated surface of wall 10 and from the flames and hot combustion gases passing upwardly thereover directly to one side of the tubes 19 in bank 18 and the adjacent surface of wall 1 reradiates heat to the opposite side of the tubes 19. In a similar manner the heated surface of wall 11 and the flames and nascent hot combustion gases passing thereover transmit radiant heat directly to one side of tubes 21 of bank 20, and the opposite side of these tubes is heated by reflected radiant heat from the adjacent surface of wall 2.

The combustion gases leaving zones 13 and 14 and entering zone 17 are commingled with recirculated flue gases which pass from zone 12 through openings 16 into zone 17. In passing through zone 17 the commingled gases transmit most of their remaining available radiant heat energy to the tubes of banks 22 and 24 and these tubes are also washed by the commingled gases passing through zone 17, thereby receiving a substantial component of convection heat.

When the heater is fired, as contemplated by the invention, with fuel of relatively low calorific value, most of the readily available radiant heat energy of the combustion gases will be expanded in zones 13 and 14 and it will be apparent from the arrows in the drawing, which indicate the general direction of travel of the gases, that the tubes of banks 18 and 20 are disposed without the main path of travel of the flames and hot combustion gases through zones 13 and 14 and receive heat predominantly by radiation. In previous heaters of this general type, without the provisions of the present invention for recycling flue gases to zone 17, the tubes of banks 22 and 24 may be excessively heated, particularly when a fuel of high calorific value is employed, due to the superimposing of radiant and convection heat on these tubes. In the heater herein provided, when fired with low grade fuel, a considerable portion of the radiant heat energy of the freshly generated hot combustion gases is expended in zones 13 and 14 and, in any event, the gases leaving these zones are commingled with recycled flue gases. Thus, the tubes of banks 22 and 24 receive a much smaller component of radiant heat energy end, although the convective component is increased, are not as susceptible to excessive heating as in previous designs of this type of heater.

The commingled combustion gases and recycled flue gases pass upwardly from zone 17 through zone 9 in direct and in intimate contact with the tubes 27 of bank 26 and transmit fluid heat to these tubes at a relatively high rate, principally by convection. A portion of the gases leaving zone 9 are directed from the heater to stack 37, while another regulated quantity of the gases is directed from the zone 38, disposed above zone 9, through duct 39 to a suitable hot gas fan or blower indicated at 40. The blower directs the gases through duct 41 to zone 12 between walls 10 and 11 and therefrom through openings 16 into zone 17, thus establishing a flue gas cycle through zones 17 and 9 and increasing the heat supplied by convection to the tubes of banks 22, 24 and 26 so as to maintain relatively high heat transfer rates in these banks.

As another feature of the invention, I provide, in the case illustrated, for preheating the air employed for combustion of the fuel. This is not to be considered a limiting feature of the invention but is preferably employed when the heater is fired with fuel of relatively low calorific value, in order to increase the flame temperature and thereby increase radiant heating in zones 13 and 14. Preheating of the air may be accomplished, when desired, in any well known manner and the particular means illustrated in the drawing comprise an air preheater 42 disposed between zone 38 and stack 37 between the substantially vertical walls 43 and 44 which are composed of suitable refractory insulating material. The air preheater is divided into right-hand and left-hand sections separated by the partition 45, each section comprising a plurality of relatively flat metal plates spaced from each other to provide relatively narrow openings therebetween, alternate openings being open at their top and bottom to permit the passage of flue gases therethrough from zone 38 to stack 37, while the intervening openings are closed at the top and bottom and are provided with suitable baffles 46. This type of air preheater is well known in the industry and a more detailed illustration and description is, therefore, considered unnecessary to an understanding of the invention.

Air is admitted to the spaces of preheater 42 which are closed at the top and bottom through suitable air inlet ducts 47, in amounts controlled by the dampers 48, and is preheated by direct contact and heat exchange with the gases passing through the preheater from zone 38 to stack

37. The air is directed through the preheater as indicated by the dotted arrows and is directed therefrom into spaces 49 and 50 provided between the walls of the heater and an outer housing 51. This housing, in the case illustrated, comprises sheet metal lined with suitable insulation or refractory insulating material. The air from the preheater passes downwardly through spaces 49 and 50, wherein it is further preheated by contact with the refractory walls of the heater, and enters the zones 29 and 31 through suitable ports 52 and 53 provided through the side walls 1 and 2. The preheated air passes, in part, from zones 29 and 31 through burners 28 and 28' and, in part, directly through firing ports 36 into the combustion and radiant heating zones 13 and 14 wherein it serves to support combustion of the fuel. Air may be drawn through the preheater and through the spaces 49 and 50 by the inspirating action of the burners or, when desired, it may be supplied through ducts 47 from a suitable fan or blower, not illustrated.

The present invention is not concerned with the particular flow employed for the fluid undergoing heating in the various tube banks or the particular sequence of the tube banks in the flow. There are numerous possibilities, some of which are illustrated and described in the aforementioned Mekler Patent 2,147,662, and the particular flow employed may be selected to suit requirements. It is worthy of note, however, that the improved heater herein illustrated retains the advantages of former center-wall up-draft heaters in that it permits wide flexibility of operation with respect to the flow of fluid undergoing heating through the heating coil and permits the treatment of two parallel streams of fluid under either substantially identical or different heating conditions or the treatment of a single stream of fluid, passed in series through the various tube banks in any desired sequence, or the treatment of two or more streams in a portion of the heating coil and treatment of a single stream in other portions of the coil.

I claim as my invention:

1. A heater for fluids comprising, in combination, spaced substantially vertical refractory walls, other substantially vertical refractory walls spaced from each other to define a passageway for recirculated combustion gases therebetween, the last named walls being disposed between and spaced from the first named walls to define separate combustion and radiant heating zones, a bank of tubular fluid conduits disposed adjacent one of said walls in each of the combustion and radiant heating zones, burners disposed adjacent one end of each of said combustion and radiant heating zones to direct flames and hot combustion gases vertically over the surface of that wall in each of said zones opposite said fluid conduit therein, a fluid heating zone disposed adjacent and in communication with that end of the combustion and radiant heating zones remote from said burners to receive combustion gases therefrom, a bank of tubular fluid conduits disposed within said fluid heating zone in the direct path of travel of combustion gases passing therethrough from said combustion and radiant heating zones, means for discharging combustion gases which have passed through said fluid heating zone therefrom, and means for directing regulated quantities of the last named gases through the aforesaid passageway disposed between the second named refractory walls, out of direct contact with the flames and hot combustion gases passing through said combustion and radiant heating zones, and therefrom into direct contact with the combustion gases passing from the latter zones to said fluid heating zone.

2. A heater such as defined in claim 1, provided with an air preheater disposed within a flue leading from said fluid heating zone to a stack, and means for directing air through said preheater to said combustion and radiant heating zones to support the combustion of fuel supplied to the latter from said burners.

3. A heater such as defined in claim 1, provided with an air preheater disposed in a flue leading from said fluid heating zone to a stack, a housing spaced from and disposed adjacent the first named refractory walls and means for directing air through said preheater and through the space provided between said housing and the adjacent walls into said combustion and radiant heating zone to provide preheated air for supporting the combustion therein of fuel supplied thereto by said burners.

4. A heater for fluids comprising a furnace structure having a radiant heating zone, a convection heating zone, and an intermediate heating zone between said radiant and convection zones, means for firing said radiant zone and means for passing combustion gases from the last-named zone through said intermediate zone and said convection zone, a tube bank disposed in the radiant zone to be heated predominantly by radiation, a tube bank arranged in the intermediate zone for heating thereof by radiation and convection, a tube bank in the convection zone disposed in the path of the combustion gases passing therethrough, means for removing the combustion gases from the convection zone and means for introducing a regulated portion thereof to said intermediate zone to commingle therein with the combustion gases from said radiant zone.

5. A fluid heating furnace comprising refractory vertical walls forming a radiant heating section, additional vertical walls defining a convection heating section in vertical alignment with and spaced from the radiant section, the convection section being of smaller cross-sectional area than the radiant section, sloping refractory walls joining the first-named walls with said additional walls, and defining an intermediate zone in the furnace, heating tubes in said radiant section adjacent the first-named walls and means for applying radiant heat thereto, heating tubes in said intermediate zone adjacent said sloping walls, means for passing combustion gases from the radiant section through said intermediate zone in heat exchange relation with the last-mentioned tubes and then through the convection section, heating tubes in the convection section disposed in the path of travel of the combustion gases therethrough, means for removing the combustion gases from the convection section and means for introducing a regulated portion thereof to said intermediate zone to commingle therein with the combustion gases from the radiant section.

6. The furnace as defined in claim 5, further characterized in that said means for applying radiant heat comprises a refractory partitioning member disposed in the radiant section between and spaced from the first-named vertical walls and burners arranged to project combustion products in a vertical direction along the opposite sides of said member.

MARION W. BARNES.