May 25, 1965 R. M. SHERMAN 3,185,200

COMBUSTION CHAMBER WITH HOLLOW DUCT AND MEANS TO RECIRCULATE COMBUSTION PRODUCTS THEREAROUND

Original Filed June 28, 1954 2 Sheets-Sheet 1

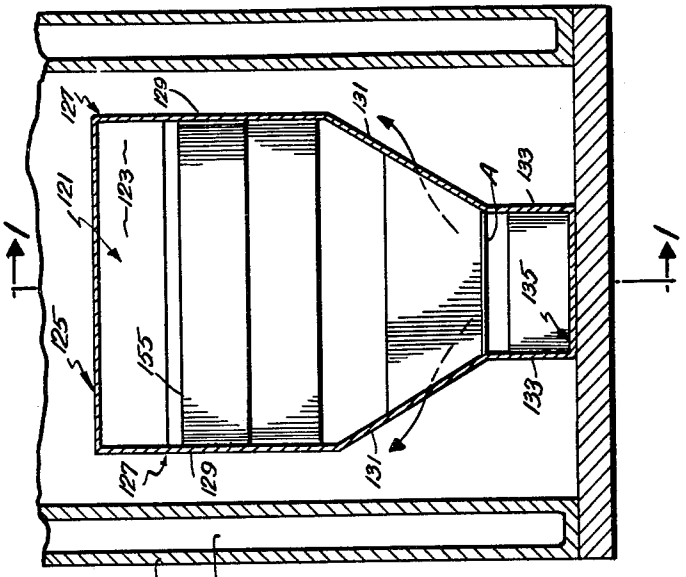


FIG. 2.

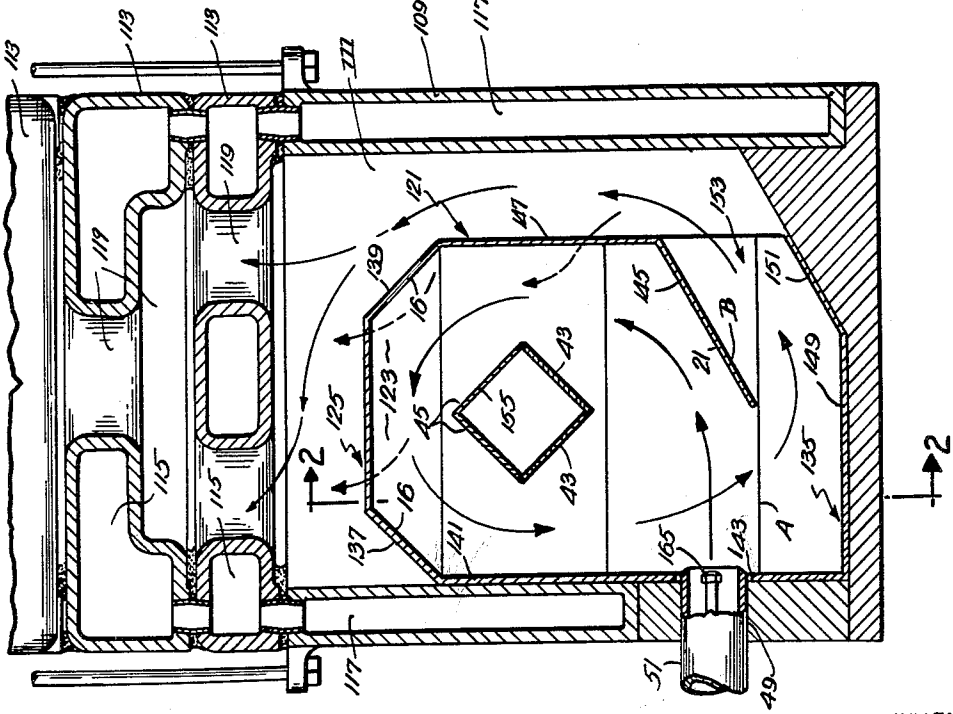


FIG. 1.

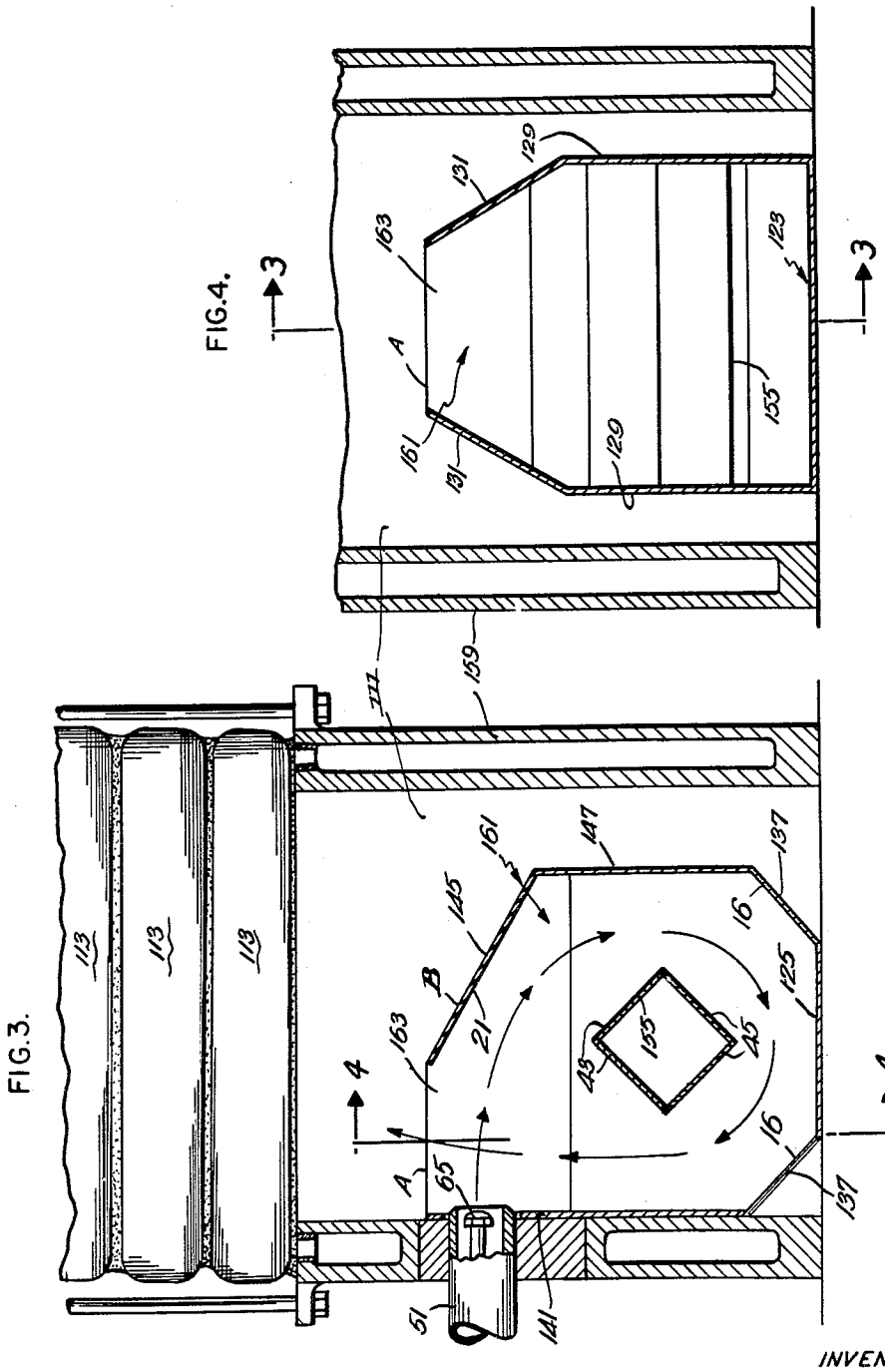
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3,185,200

COMBUSTION CHAMBER WITH HOLLOW DUCT AND MEANS TO RECIRCULATE COMBUSTION PRODUCTS THEREAROUND

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Continuation of application Ser. No. 127,197, July 27, 1961, which is a division of application Ser. No. 439,654, June 28, 1954, now Patent No. 2,994,367, dated Oct. 1, 1961. This application June 16, 1964, Ser. No. 376,302

1 Claim. (Cl. 158—1)

This application is a continuation of my copending parent application Serial No. 127,197, filed July 27, 1961, now abandoned, which parent application is in turn a copendent division of my prior application Serial No. 439,654, filed June 28, 1954, now Patent No. 2,994,367, dated October 1, 1961.

My invention relates to combustion apparatus. It has, among its objects, projecting a mixture of fuel such as gas or oil and combustion air into a chamber in which it is burned to produce a flame and hot combustion products, and, to secure better and more complete combustion of the fuel, guiding said products through a looped path which causes them to travel through the path of said flame for contact therewith for burning the residual fuel values of such products.

The invention and its above and other objects will however be best understood from the following description when read in the light of the accompanying drawings, while the scope of the invention will be more particularly pointed out in the appended claim.

In the drawings:

FIG. 1 is a vertical medial section, corresponding to a section as on line 1—1 of FIG. 2, showing a form of apparatus according to the invention and adapted for the practice of the method thereof;

FIG. 2 is a section on the line 2—2 of FIG. 1;

FIG. 3 is a vertical medial section, corresponding to a section on the line 3—3 of FIG. 4, showing a still further modified form of apparatus according to the invention; and

FIG. 4 is a section on the line 4—4 of FIG. 3.

FIGS. 1 and 2 show an application of the invention to a heater, for example, a boiler for generating steam, or for heating water or other liquid, it being understood however that, instead of the specific heater illustrated, one for heating air or other gaseous medium may be employed.

The boiler illustrated comprises a lower section 109 which may be square in transverse cross-section and encloses a firebox 111. Resting on this lower section are shown superimposed upper sections 113 provided with water spaces 115 in communication with each other and the water space 117 of the lower section, and provided with flue passages 119 in communication with each other and the firebox for conducting products of combustion from the firebox to a stack or other place of disposal or utilization.

As shown, there is positioned in the firebox a box-like structure 121 which provides a combustion chamber 123. This structure may be formed of sheets of heat refractory metal, such as sheet stainless steel, built up in assembled relation by welding. As illustrated, the structure comprises a top wall 125 and opposite side walls 127, the side walls having portions 129 which extend vertically downward from the outer side edges of the top wall to an intermediate portion of the height of the combustion chamber where they joint the top edges of inclined portions 131 of the walls extending downwardly and inwardly to the upper edges of short vertical side wall portions 133, the portions 133 being connected at their lower edges to the opposite edges of the bottom wall 135 of the structure.

As further shown in FIG. 1, the top wall 125 of the structure at one end has a downwardly and outwardly inclined, transversely extending portion 137 and at its opposite end a like portion 139, the portion 137 at its lower edge being connected to the upper edge of the vertical end wall 141 of the structure, this portion 141 extending downwardly to the bottom wall 135 of the structure where it joins the left hand end of said bottom wall as viewed in FIG. 1.

The end wall portion 141 of the structure 121 is shown as provided with an opening 143 for removably receiving the end of the air blast conduit 51 of an oil or gas burner. The inclined side wall portions 131 and vertical side wall portions 133 of the structure form an elongate flow-directing passage or trough into which the air and gas or oil mixture from the gas or oil burner is projected. At its right hand end, as viewed in FIG. 1, the portion of the trough between the inclined wall portions 131 is closed by a baffle plate 145 extending to the end wall 147 of the structure, which end wall extends upwardly from the upper edge of the baffle plate to the lower edge of the inclined wall portion 139 at the top of the structure. The bottom wall 135, as shown in FIG. 1, has a portion 149 extending horizontally from the vertical end wall portion 141 to a position beneath the baffle plate 145 where it joins an upwardly inclined portion 151 which extends upward to the right hand end of the trough as viewed in FIG. 1. In this way there is formed beneath the baffle plate 145 a conduit 153 for discharging the products of combustion from the combustion chamber into the firebox, these products of combustion being deflected upwardly through the firebox about the outer sides of the combustion chamber, as indicated by the arrows in FIG. 1, to the flues of the boiler.

Interiorly the combustion chamber of FIGS. 1 and 2 is shown as provided with a tubular member 155, of square cross-section, extending across it above and transversely of the trough above described, and joined at opposite ends of the side wall portions 129 of the structure 121 forming the combustion chamber.

The inner surfaces of the inclined portions 137 and 139 at the top of the combustion chamber provide the baffle surfaces 16 such as referred to in my said Patent No. 2,994,367, while the outer surfaces of the tubular member 155 provide the pairs of downwardly and upwardly facing inclined baffle surfaces 43 and 45, also as referred to in said patent, while the upper surface of the baffle plate 145 forms the baffle surface 21 again as referred to in said patent.

In the operation of the combustion chamber shown in FIGS. 1 and 2, similarly as in said patent, the burning mixture projected into the combustion chamber by the gas or oil burner strikes the baffle surface 21 so that the flame and products of combustion will be deflected and guided upwardly and then downwardly to cross the initial path of travel of the gas-air or oil-air mixture and flame horizontally between the inclined walls of the trough-like bottom portion of the combustion chamber, so as to burn the residual fuel values contained in the downwardly traveling combustion products.

FIGS. 3 and 4, like FIGS. 1 and 2, show an application of the invention to a boiler or other heater. The boiler illustrated in FIGS. 3 and 4 is identical with that illustrated in FIGS. 1 and 2, except that the lower boiler section 159 forming the firebox 111 is designed to permit the air blast conduit 51 of the gas or oil burner to discharge into the combustion chamber 161 at a higher level.

The combustion chamber illustrated in FIGS. 3 and 4 is identical with that illustrated in FIGS. 1 and 2, except that in FIGS. 3 and 4 it is inverted so that what is the top wall of the combustion chamber in FIGS. 1 and 2 becomes the bottom wall of the combustion chamber in FIGS. 3 and 4, and except that the entire portion of the combustion chamber below the horizontal plan indicated by the line A, at the bottom of the inclined side wall portions **131** forming the elongate passage or trough, and below the intersecting plane indicated by the line B at the under side of the baffle plate **145** of FIGS. 1 and 2, is entirely omitted in the structure according to FIGS. 3 and 4, to provide in FIGS. 3 and 4 an exit opening **163** for upwardly discharging the combustion products into the firebox.

It will be observed in the construction shown by FIGS. 3 and 4 that the baffle surface **21** provided by the baffle plate **145** deflects the burning mixture projected into the combustion chamber downwardly into the lower portion thereof, in which latter the products of combustion are guided by the baffle surfaces **16** and **45** and bottom wall **125** of the combustion chamber to the left as viewed in FIG. 3, and then are guided upwardly into the trough formed by the inclined walls **131** where said products contact the flame being projected through said trough by the gas or oil burner, the parts acting and functioning internally of the combustion chamber in the similar way to secure the like results as the apparatus of FIGS. 1 and 2 and as described in more detail in my said Patent No. 2,994,367.

In the operation of my invention apparatus the burning mixture projected by the oil burner gun or other flame-issuing burner travels left to right, FIGS. 1 and 2, horizontally through the trough or elongate flow-directing passage which is formed by the inclined walls **131** toward the inclined baffle surface **21**, which latter deflects such mixture and the flame upwardly, or downwardly in FIGS. 3, 4, out of the trough into the space between the cross member **155** and the end wall **147** of the combustion chamber. The top (or bottom) wall and adjacent end wall of the combustion chamber together with the opposing baffle surfaces **16** and **45** define a passage in which the products of combustion are turned reversely horizontally toward the left as viewed in FIGS. 1 and 3; similarly, the top (or bottom) and left hand end walls, together with the baffle surfaces **16** and **45** opposite them, then turn and pass such products downwardly, or upwardly, into the trough, where they contact with the flame, and then into the discharge passage for discharge from the combustion chamber. Thus the flame and the products of combustion produced by it, considered as a whole, are under this invention made to follow the general path indicated by the arrows in FIGS. 1 and 3, that is to say, to travel in a closed loop for causing the products of combustion produced by the flame again to be acted upon by the flame prior to their discharge from the combustion chamber. The converging horizontally extending surfaces **131** of the trough-like member act to permit ready deflection, vertically of the trough, of the expanding flame when it strikes the inclined baffle surface **21**. At the same time these surfaces **131** act to guide into the trough the combustion products traveling toward the converging sides thereof and into contact with the flame being projected horizontally through the trough. In the trough these combustion products play over the burning oil-air or gas-air mixture and pass around it and, to some extent, pass through the outer tenuous confines of the flame. Further, the walls of the trough are heated to high incandescence by the flame, the latter and the approaching combustion products contacting such walls as they are guided by them and as such products pass about the flame to the opposite portion of the trough, and such contact acts further to promote combustion particularly as such products, as they pass about the flame, are acted upon by both the flame and said walls. The burning mixture forming the flame being of greater density, particularly at its longitudinally extending center portion, than the combustion products passing to the trough, and being projected horizontally with considerable velocity, is not materially deflected downwardly or upwardly by such combustion products. The flaming mixture, particularly the portion thereof adjacent the discharge end of the air blast conduit, acts ejector-like, by reason of its high velocity, materially to augment and enforce the flow of the combustion products to and into the trough. Also this blast of burning mixture, by such ejector action and by its contact with the products of combustion as they pass around it, acts to sweep such products over the hot walls of the trough when in contact with such walls. A finger of the primary flame may be deflected so as to pass into the discharge conduit from the trough, and some of the vertically traveling combustion products may be caught by the burning mixture and recirculated one or more times through the looped path in the combustion chamber, but in such case without deleteriously affecting the efficiency of the operations and in fact acting to insure complete combustion. It will be noted that the flaming blast supplied the combustion chamber, and the voluminous amount of combustion products produced therein, create a positive pressure in the combustion chamber which acts to cause a rapid discharge of such products from said chamber.

In practice, the amount of air supplied by the oil burner, where such is employed, is preferably, but not necessarily, so adjusted with relation to the amount of oil supplied by it as to secure the maximum primary flame temperature, and maximum degree of combustion of the oil prior to the combustion products being looped back into contact with the primary flame. Under these conditions a bright orange primary flame, indicating the maximum flame temperature and degree of combustion possible, will be produced, and, when the oil is the so-called No. 2 oil usually used in domestic gun type oil burners, the amount of such air will be that which will supply to the oil an amount of oxygen which is about 10 to 12 percent in excess of that stoichiometrically necessary to secure complete combustion of the oil. Adjusting the air in this preferred way it has been found secures best results in respect to securing maximum completeness of combustion by looping the combustion products back to the flame. However, the air may be adjusted to secure other colors of flame, in which case the amount of excess oxygen may be anywhere from 6 to 15 percent depending on such color and the particular quality of fuel oil employed. Depending upon the quality of the oil and air adjustment the temperature of the primary flame may be from about 2000 to 3000° F., and the temperature of the combustion products discharged from the apparatus from about 1500 to 2400° F. Where conditions warrant, secondary air may be supplied the combustion products, for example, as in the mentioned Patent No. 2,994,367.

The gaseous products of combustion of the primary flame will consist mostly of nitrogen admixed with much smaller amounts of carbon dioxide and carbon monoxide, and commonly will contain small amounts of illuminants, hydrogen, ethane and methane, together with the excess oxygen. These gaseous products ordinarily will also contain finely divided soot forming carbon particles and usually particles of the heavy end fractions of the oil. The carbon monoxide, illuminants hydrogen, ethane, methane, carbon particles, and said heavy end fractions constitute residual fuel values of the oil, and the amount of such residual values is a measure of the incompleteness of the combustion of the oil. In the usual case of a gun type oil burner operated in the conventional manner this residual fuel value may amount to as much as 25 percent of the total fuel value of the oil. On the other hand, the amount of carbon dioxide present indicates the degree of completeness of combustion of the oil. It has been found from flue gas analysis that

passing the flame and products of combustion, considered as a whole, in the above described looped path results in many cases in increasing the combustion of the oil 20 or more percent over that which can be secured under most favorable conditions when using a gun type oil burner in the conventional way, and with a corresponding increase in the temperature and volume of the combustion products being discharged from the apparatus.

When the combustion products produced by the primary flame are looped back and brought into contact with that flame in the way herein described the intense heat of the flame and walls of the trough raises the temperature of the combustion products sufficiently to cause the residual oxygen in the cross-flowing combustion products to burn the residual fuel values of those products. The products of combustion discharged from the combustion chamber are substantially free from soot forming particles, and are entirely odorless. In practice, when burning oil with a bright orange flame, commonly the flame deflected by the baffle surface **21** will disappear at a position about midway the height of the cross member **155**, and through the remainder of the path of travel of the combustion products no flame indicating burning of those products will reappear until said products contact the primary flame produced by the gun burner in the trough and the adjacent walls of the trough. In the trough at and across the primary flame the secondary flame will reappear and commonly will substantially fill the portion of the trough between its vertical surfaces and also the associated discharge passage.

Instead of the apparatus burning oil, it may burn a fuel gas, which may be done by connecting the nozzle with a pipe leading from a source of fuel gas under pressure, provision being made for regulating the amount of gas so supplied the burner for regulating the amount thereof supplied the combustion chamber by the nozzle **65** and in any of the ways commonly employed in connection with gas burners for supplying furnaces with fuel gas. Also, instead of utilizing a fluid fuel, the burner may utilize a pulverulent solid fuel, for example sawdust or pulverized coal, in such case the pulverulant fuel being projected through and from the blast tube into the trough admixed with a blast of combustion air to form the flame, burners of the gun type for so projecting a blast of pulverulent solid fuel and combustion air being well known.

In the exemplary embodiments of the drawings the primary flame or blast of burning mixture of air and oil, gas or other fuel, and the associated elongate transversely open trough-like passage are in FIGS. 1 and 2 at a lower portion of the total chamber and the looped path is largely thereabove and back into and across the entering primary flame, while in FIGS. 3 and 4 the apparatus including said trough is in effect inverted and the looped flow path is largely therebelow and then back into and across the entering primary flame. For some installations and purposes such vertically reversed or upside-down arrangement such as in FIGS. 3 and 4 is found especially suitable, while in other instances the form as in FIGS. 1 and 2 may be preferable. Hence it will be understood that as to the broader aspects of the invention directional expressions herein such as "up," "down," "above," "below" and the like are to be understood as being for purposes of identification and convenient description of the respective embodiments and without intent of limitation of the invention to a particular or absolute directional arrangement or use.

It is also to be noted that the exemplary embodiments of FIGS. 1 and 2 and of FIGS. 3 and 4 while shown as particularly applied to heater purposes are adaptable, as regards the combustion provisions, to other uses and combinational arrangements involving the burning of secondary or also tertiary fluid or solid fuels as for the incineration of waste or other matter, as more fully disclosed and claimed in my said Patent No. 2,994,367.

It will be understood, that within the scope of the appended claim, wide deviations may be made from the forms of the invention herein described without departing from the spirit of the invention.

I claim:

For installation and use in a fluid heating medium heater of the type having a lower section defining a firebox with enclosing bottom and vertical walls and a top opening to an upper heater section containing fluid medium space and flue provision for passage of combustion products from the firebox, a combustion chamber for installation in such firebox for burning mixtures of fuel and air in the chamber and for discharging the products of substantially complete combustion from the combustion chamber through surrounding space of the firebox and upwardly into such upper heater section,

said combustion chamber comprising a box-like structure including bottom, top, side and end walls formed of heat refractory metal sheets adapted to be heated to incandescence and being shaped and proportioned for installation within such firebox upon one bottom wall thereof and in spaced relation to the vertical walls thereof at least at the side walls and one end wall of the chamber and with the chamber top wall spaced below the top of the lower section of the heater so as to provide flow passage for combustion products discharging from the combustion chamber and between it and the firebox vertical walls to the upper heater section,

said chamber structure including inwardly inclined side wall portions forming a generally horizontal, elongate, trough-like, flow-directing passage extending between said chamber end walls,

means at one said end wall of said chamber for projecting initially horizontally into and along the length of said passage a primary flame blast of burning mixture of fuel and combustion air, said primary flame burning mixture having combustion products and heating the walls of said passage to incandescence,

inclined first baffle means closing said trough-like passage at the other said end wall of said chamber and for deflecting said blast vertically from said trough-like passage,

said chamber structure including a tubular cross member extending horizontally across it vertically and transversely of said trough-like passage and joined at its opposite ends to said chamber side walls, said cross member formed to present downwardly and upwardly facing inclined baffle surfaces,

said baffle surfaces of said cross member forming with said chamber end walls and of one of said chamber top and bottom walls a passage turning said blast and the products of combustion thereof vertically from said first baffle means and then horizontally and then vertically again in a closed loop flow in which said combustion products are returned to cross said trough-like passage, passing through and around said primary flame and between it and said incandescent-heated trough-like passage walls, said primary flame and said trough-like passage walls thereby acting upon the looped back combustion products to raise the temperature of said combustion products sufficiently to produce a secondary flame by which the residual oxygen of said combustion products burns the residual fuel values of those products,

and means defining an exit passage opening from said chamber into said firebox, said exit passage arranged to receive said closed-loop-returned combustion products following their said cross flow through said primary flame and trough-like passage and to discharge said combustion products to the exterior of said combustion chamber and into said surrounding

space of said firebox and thereupon into said upper section of said heater.

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