

Oct. 6, 1953

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2,654,350

COMBUSTION CHAMBER

Filed Jan. 14, 1948

3 Sheets-Sheet 1

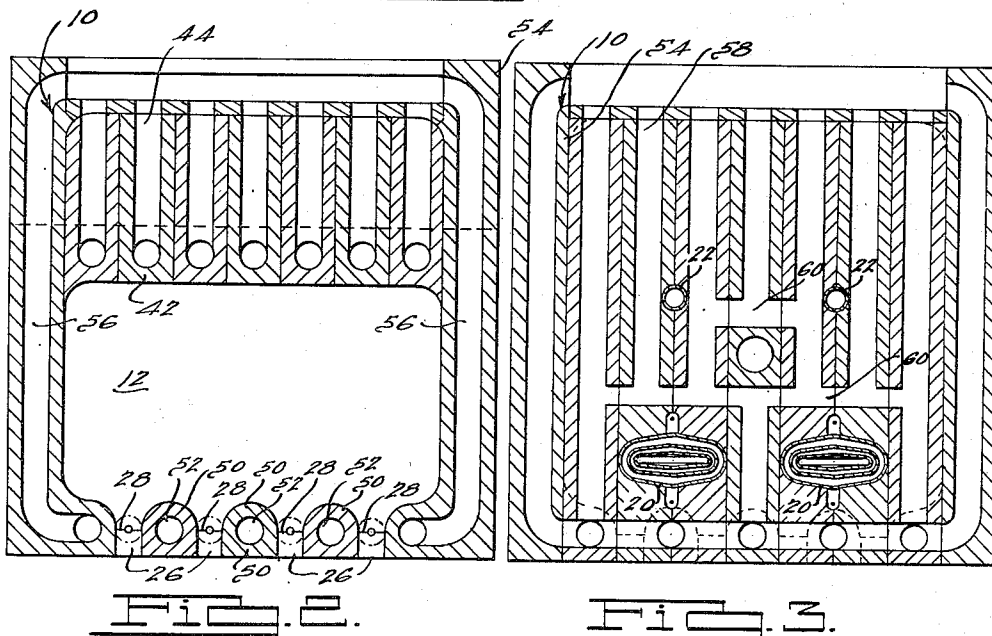
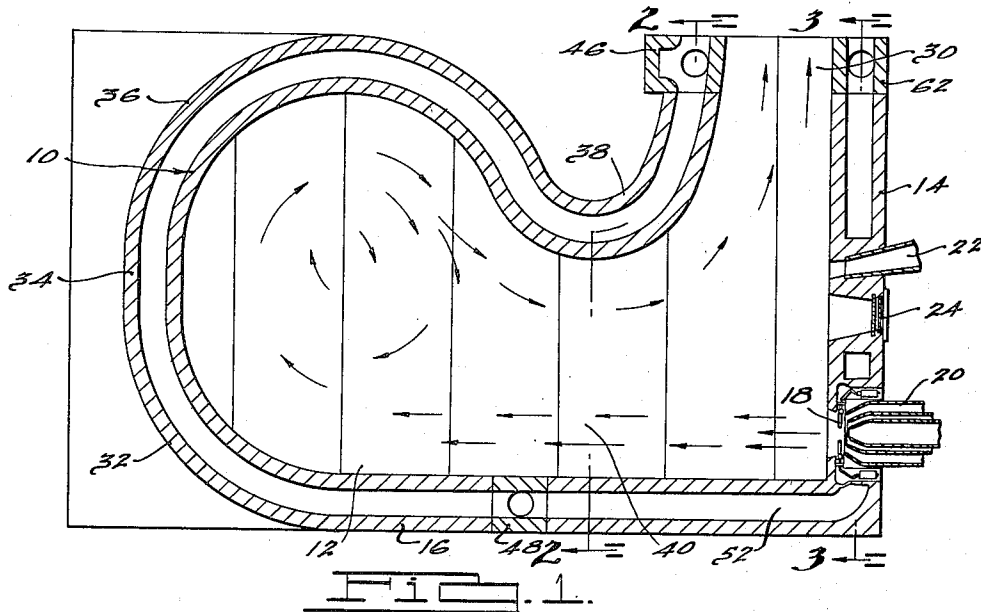


FIG. 3.

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3 Sheets-Sheet 2

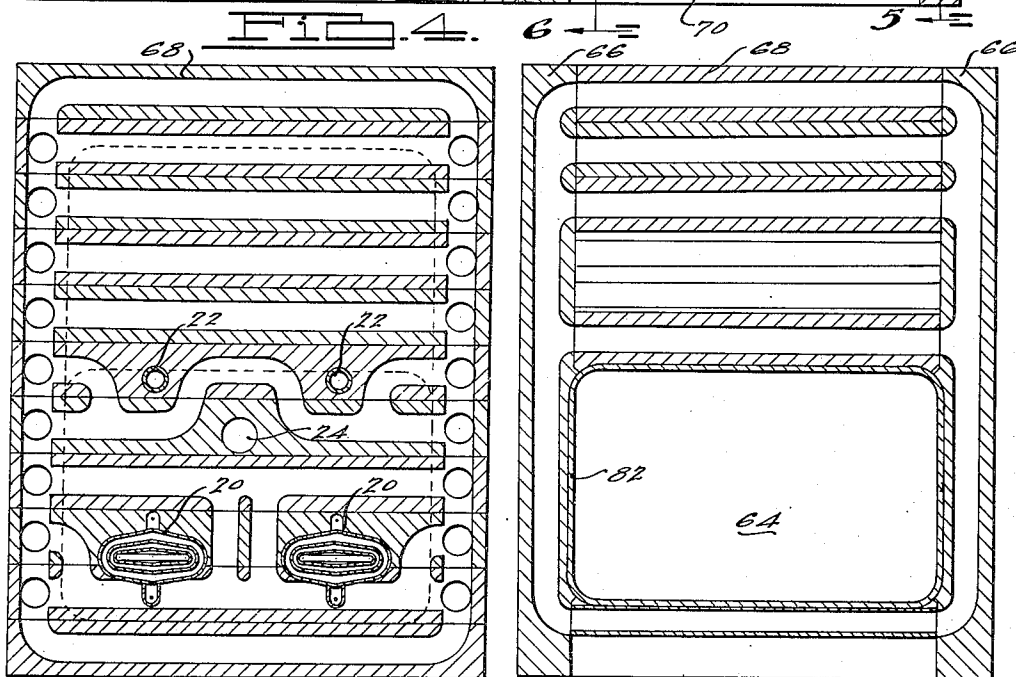
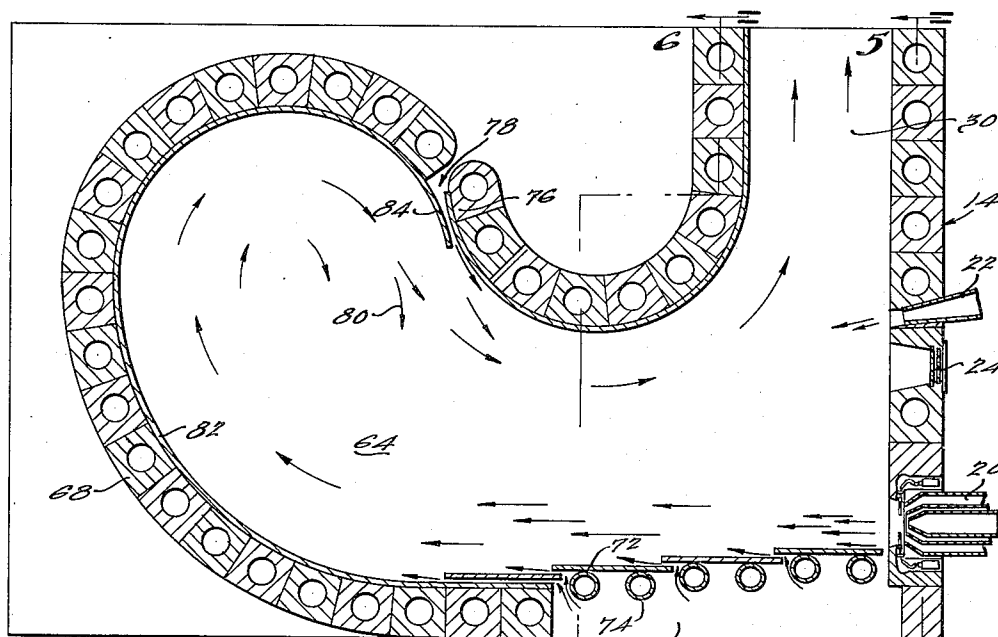


FIG. 5.

FIG. 6.

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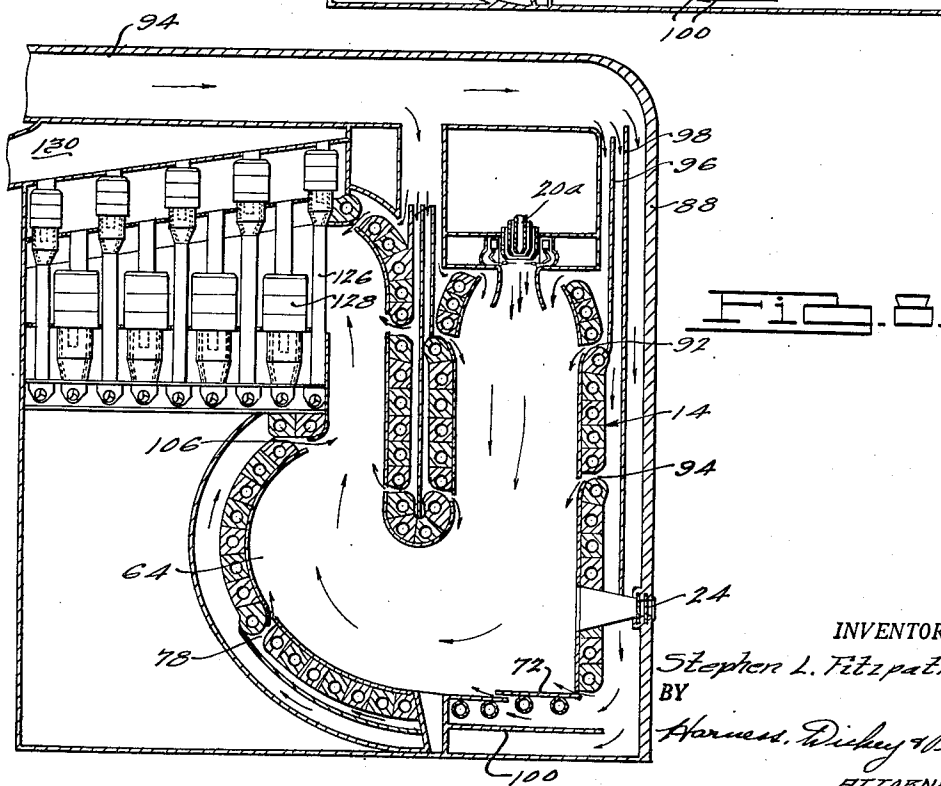
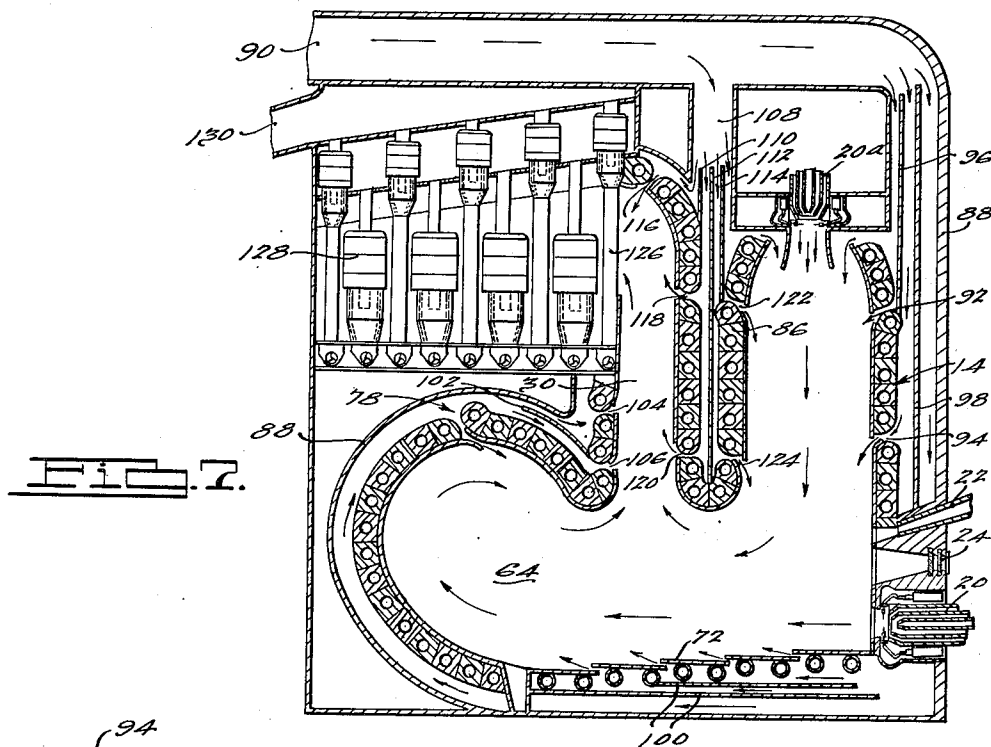
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3 Sheets-Sheet 3



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2,654,350

COMBUSTION CHAMBER

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Application January 14, 1948, Serial No. 2,313

3 Claims. (Cl. 122-4)

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This invention relates broadly to new and useful improvements in furnaces for solid pulverulent fuel such as powdered coal and the like and more particularly to a furnace of this character having an improved form of combustion chamber which is relatively small and compact and at the same time permits complete combustion of the fuel particles to occur.

An important object of the present invention is to provide a furnace having a combustion chamber which is primarily adapted and preeminently suited for small scale domestic installations.

Another object of the invention is to provide a furnace in which the combustion chamber is uniquely shaped to provide a relatively long travel for the products of combustion before the same pass into the stack.

Still another object of the invention is to provide a furnace of the above-mentioned character which is suitable for either high or low pressure operation.

Yet another object of the invention is to provide a furnace of the above-mentioned character having provision for introducing air at strategic points to assure complete combustion of the fuel before the same leaves the combustion chamber.

A further object of the invention is to provide a furnace of the above-mentioned character having provision for circulating a fluid in heat exchange relation with the combustion chamber.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the drawing forming a part of this specification and wherein like numerals are employed to designate like parts throughout the same,

Figure 1 is a vertical, longitudinal, sectional view through a furnace embodying the invention;

Fig. 2 is a vertical, transverse sectional view taken on the line 2-2 of Fig. 1;

Fig. 3 is a vertical, transverse sectional view taken on the line 3-3 of Fig. 1;

Fig. 4 is a vertical, longitudinal, sectional view showing a modified furnace construction embodying the invention;

Fig. 5 is a vertical, transverse sectional view taken on the line 5-5 of Fig. 4;

Fig. 6 is a vertical, transverse sectional view taken on the line 6-6 of Fig. 4;

Fig. 7 is a vertical, longitudinal, sectional view through another modified furnace construction embodying the invention; and

Fig. 8 is a vertical, longitudinal, sectional view

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through still another modified furnace construction embodying the invention.

Referring now to the drawings, attention is first directed to Figs. 1-3 which illustrate a small domestic-type furnace adapted primarily for low pressure operation. In general, the furnace may be made of any suitable refractory material 10, and the latter is fashioned to define a combustion chamber 12. The present invention resides primarily in the shape of the combustion chamber 12 and the manner in which it functions to assure substantially complete combustion of the fuel. The furnace here shown by way of illustration is adapted for horizontal operation, i. e., the fuel is injected horizontally into the combustion chamber 12; however, it will be readily apparent that the furnace can be adapted for vertical or other operation if desired.

More specifically, the furnace here shown has a vertical wall 14 at one end of the combustion chamber 12 and a horizontal bottom 16 which defines the floor of the combustion chamber. Fuel inlets 18 are provided in the lower portion of vertical wall 14 and fuel injection nozzles 20 in the inlets deliver fuel and air at a controlled rate to the combustion chamber 12. While two inlets 18 are here shown, it will be understood that a greater or lesser number of inlets may be provided depending on the size of the furnace and the exigencies of the particular situation. Any suitable or conventional apparatus may be used to deliver the fuel to the combustion chamber, but I prefer to use equipment of the type shown in my copending applications, Serial No. 787,765, which was filed on the 24th day of November, 1947, and Serial No. 791,037, which was filed on the 11th day of December, 1947, now abandoned. The fragmentary nozzle assemblies here shown correspond to the nozzle assembly shown in the last-mentioned application and include auxiliary air inlets 22 above the fuel openings 18. A window 24 is provided in the wall 14 between the auxiliary inlets 22 and the fuel injection nozzles 20.

The powdered coal is blown into the combustion chamber 12 in a forced draft of air and the fuel is ignited as soon as it enters the chamber. When the fuel is injected horizontally in the manner here shown, it travels above the floor of the combustion chamber to the remote or distal end thereof. According to the present invention, the bottom 16 of the furnace is formed with a plurality of laterally spaced parallel elongated openings 26 immediately in front of the injection nozzles 20 and each opening 26 is closed by a

pivoted, rotatable plate 28, as shown in Fig. 2. As the flame travels above the floor of the combustion chamber 12 a small amount of fly ash settles out and accumulates on the plates 28 which normally are positioned horizontally as shown in the drawings to close the openings 26. The closure plates or traps 28 may be rotated continuously or intermittently in any suitable manner to dump the fly ash into a suitable chamber or receptacle (not shown) disposed below the openings 26.

The combustion chamber 12 is generally rectangular in transverse section as shown in Fig. 2 and is horizontally elongated in longitudinal section as shown in Fig. 1. Also, it will be observed that the exhaust stack or opening 30 is located at the inlet end of the combustion chamber adjacent the vertical wall 14 and directly above the fuel inlets 18. At the end thereof remote from fuel inlets 18 the floor 16 curves upwardly, as at 32, and the upper portion of the distal end wall 34 is reversely curved at 36. The reversely curved top portion 36 merges smoothly with a downward protuberance or re-entrant portion 38 adjacent the exhaust opening or stack 30. The protuberance 38 extends downwardly into the combustion chamber 12 and defines a restricted opening or passage 40 between the distal end 34 of the furnace and the inlet and exhaust openings 18 and 30.

In operation, flame sweeps above the floor of the combustion chamber and is deflected upwardly by the portion 32. The upwardly deflected flame is again deflected by the upper curved portion 36 so that it doubles back and completes a 180° turn. At this point, the flame is deflected downwardly by the protuberance 38 before passing back through the restricted passage 40 into the exhaust opening 30. The opening 30 may lead directly to a stack or it may lead to a heat exchange unit where further heat is extracted from the flue gases. In most instances the latter condition will prevail. However, all of the flaming products of combustion do not pass directly into the exhaust opening 30. The downward deflection of the flame by protuberance 38 causes some of the combustion products to sweep downwardly, as indicated by the arrows in Fig. 1, so that they merge with the flame sweeping along the floor of the combustion chamber. Thus, a constant eddying or circulation of the flame occurs in the relatively large distal end of the combustion chamber to assure substantially complete combustion of the fuel.

Also, it is significant to note that the auxiliary air inlet 22 is located to supply air to the combustion chamber just before the products of combustion enter the exhaust opening 30 so that any unburned fuel which may be carried over to this point is completely burned before it leaves the combustion chamber.

The particular shape of the combustion chamber provides a relatively long travel for the fuel and this factor is exceedingly important in maintaining complete combustion within the chamber. Also, the constant circulation and turbulence of the flame in the rearward or distal end of the combustion chamber maintains the fuel particles in constant agitation and prevents particles of fuel from clinging together or accumulating on the floor of the combustion chamber. This condition is largely due to the fact that the flame is deflected through an angle greater than 180° but less than 270° since this particu-

lar configuration provides the necessary long travel and causes the products of combustion to circulate in a turbulent condition in the rearward portion of the furnace.

To obtain complete burning of a fuel, it is necessary that the fuel be intimately mixed with air and that every bit of the fuel come in contact with oxygen in the air. Also, for best efficiency and control, it is necessary that the correct proportion of coal and air be uniformly present throughout the combustion chamber at all times. These conditions can be maintained in the furnace construction here shown, if the fuel is properly pulverized and delivered together with a proper amount of air in the manner disclosed in my previous applications hereinabove referred to.

On the other hand, the above conditions cannot be obtained in a stoker or hand-fired coal furnace. In the latter type furnaces, lumps of coal are mixed with slack and ashes and it is not possible for every particle of coal to come in contact with the air. Air flows erratically and unevenly through the large bed of coal so that part of the fuel burns slowly and part burns rapidly. Moreover, inadequate distribution of air causes clinker formation; and the clinkers usually include substantial amounts of unburned coal. Further, combustible gases released in areas where air flow is restricted may escape unburned. Also, if there is a local excess of air, the lowered temperature may prevent complete combustion of the carbon and volatile matter in the coal.

It is generally recognized in the art that one pound of coal burning to carbon dioxide liberates 14,545 B. t. u. On the other hand, one pound of coal burning to carbon monoxide liberates only 4,375 B. t. u. These statistics clearly point out the importance of providing an adequate supply of air in the combustion chamber and of maintaining uniform distribution of the coal particles in the air. It is impossible to obtain an even mixture of air with the coal in hand or stoker fired furnaces. As a result, much of the carbon in the coal is converted to carbon monoxide instead of carbon dioxide. Each pound of carbon converted to carbon monoxide represents a loss of 10,170 B. t. u. The system of which the combustion chamber embodying the present invention is a part, assures sufficient oxygen in the combustion chamber to convert all of the coal particles to carbon dioxide and thus obtain maximum heat from the fuel. The particular shape and construction of the combustion chamber assures an adequate supply and proper distribution of air in the chamber, and the manner in which the fuel is circulated and recirculated in the rear portion of the combustion chamber assures ample time for complete combustion before the products of combustion are exhausted from the chamber.

When coal is properly pulverized, 180,000,000 particles are produced from each cubic inch of solid fuel. The millions of tiny particles have 550 times as much burning surface area as a corresponding amount of the original solid fuel. When the finely divided coal particles are uniformly distributed in an air stream, the combustible mixture thus produced will flow in the same manner as a liquid fuel. It is contemplated that finely divided fuel of this type properly mixed with air be injected into the combustion chamber 12. If the flow of the combustion mixture to the chamber is properly controlled, every

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particle of coal is completely burned within the chamber; and a maximum amount of heat is extracted from the fuel. There is no waste of heat and black sooty smoke is not exhausted from the combustion chamber to plague the adjacent community.

Preferably, the combustion chamber 12 is surrounded by a network of passages or pipes through which water circulates. The purpose of these pipes is to maintain the walls of the combustion chamber at a temperature well below the fusion point of the refractory material or of fly ash which might come in contact with it. This prevents warping of the combustion chamber wall and prevents clinkering of the fly ash. The water may be circulated through the pipes or passages in any suitable or conventional manner and the heat absorbed by the water may be salvaged when the water is cooled.

In a hot air furnace, water drawn from the furnace is circulated through cooling coils before being returned to the chamber walls. Air blown across the cooling coils becomes heated and may be used as the intake air of a hot air system. At the same time, the water in the coils is cooled before being returned to the furnace. Thus, the air receives initial heat from the coils before passing to the main heating element.

Alternatively, if the combustion chamber is used in a steam heating system, the preheated water drawn from the furnace is directed to a boiler where it is turned into steam in the conventional manner. The condensate from the radiators is returned to the pipes or passages in the furnace to complete the cycle.

A third suggested procedure for salvaging heat absorbed into the water which flows through the walls of the combustion chamber would be to use such water for domestic hot water.

Any suitable means may be employed for circulating the water in heat exchange relation with the wall of the combustion chamber 12. A typical means for accomplishing this result is shown in the drawings. According to the present invention, the top, distal end, and bottom of the furnace are made up of individual vertical sections 42 placed side by side as shown in Fig. 2. Each section 42 is provided with a longitudinal passage 44 which communicates at opposite ends thereof with upper and lower headers 46 and 48 (Fig. 1). Forwardly of the bottom header 48 are parallel sections 50 which are laterally spaced apart to define the elongated openings 23. Each section 50 is provided with a longitudinal passage 52 which communicates with the header 48.

The two sides of the furnace and the front wall 14 are similarly formed of independent vertical sections placed side by side. Each of the side sections 54 is formed with a longitudinal passage 56 which communicate with the longitudinal passage 44 in the adjacent section 42.

The front sections 54 also are formed with longitudinal passages 58 and these passages are connected by transverse passages 60 which are located as required to by-pass the window 24 and fuel inlets 18 (Fig. 3). It will be observed that the vertical and transverse passages 58 and 60 form a network of passages which communicate at the lower end thereof with certain of the passages 52 in the bottom of the furnace and at the upper end thereof with a suitable header 62.

Connections (not shown) are adapted to be coupled to headers 46 and 62 to charge relatively cool water to the heat exchange system of the furnace and to withdraw heated water therefrom.

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Preferably, the relatively cool water is charged to header 46 and as the water is circulated through the walls of the furnace, heated water is removed from the header 62. However, it will be readily apparent that, if desired, the water may be circulated in a reverse direction through the furnace.

Reference is now had to Figs. 4-6 which show a modified furnace construction having a high pressure combustion chamber 64 which is capable of giving greater heat for a given size. This type of furnace is particularly adapted for larger installation than the furnace first described or for use in installations where quick heat pick-up is desired. The greater heat is obtained by charging the fuel and air mixture to the combustion chamber under higher pressure.

In general, the furnace here shown has substantially the same shape as the furnace hereinabove described, but it is constructed somewhat differently to provide a different arrangement of the heat transfer passages. In the latter form of the invention, the sides 68 of the furnace preferably are made from single units and the top, distal end and bottom preferably are made up of a plurality of individual units 68 laid side by side, as shown in Fig. 4. Also, it will be observed that the sides 68 and the units 68 are formed with passages which intercommunicate to provide a water circulatory system through the walls of the furnace.

Also, in this form of the invention, the forward bottom sections 50 are omitted, and the opening 70 produced by their omissions is covered by a plurality of vertically spaced, stepped, overlapping plates 72. The series of plates 72 preferably extends rearwardly for a short distance across the floor of the combustion chamber substantially to the point where the latter begins to slope upwardly. Pipes 74 arranged transversely across the opening 70 and preferably incorporated in the water circulation system of the furnace, supports those plates 72 which cover the opening. The plate or plates disposed above the floor of the combustion chamber may be supported in any suitable manner.

A forced draft of air is blown upwardly through the opening 70, past the pipes 74, and between the plates 72 into the combustion chamber, as shown by the arrows in Fig. 4. This air may be obtained from any suitable source and preferably is preheated to assure satisfactory combustion. In this connection, it will be readily apparent that air entering the combustion chamber 64 through the opening 70 supplies available oxygen to the fuel injected through nozzle assemblies 20 and thus promotes combustion of the fuel immediately upon entering the chamber. The particular arrangement of the plates 72 directs the air rearwardly in the combustion chamber 64, and the current of air thus created sweeps along any fly ash that might tend to settle. Since the combustion chamber begins to slope upwardly immediately adjacent the endmost plate 72, the rising current of air carries any fly ash that may be present upwardly and does not permit it to settle on the floor of the chamber.

Advantages also are obtained by supporting the plates 72 on the pipes 74, since the water traversing the pipes cools the plates and keeps them from warping. I have found that, by arranging the pipes and passages horizontally in the manner here shown, the furnace is easier

to assemble and maintain and a more complete cooling capacity is obtained. Also, the individual sections which make up the furnace are less expensive to make than sections which follow the contour of the furnace as in the form of the invention first described.

Water circulated through the walls of the furnace and through the pipes 74 is heated, and the heat conveniently can be salvaged in the manner hereinabove described by transfer to hot air, by using the water for a boiler, or by using it for domestic hot water.

As the flame circulates up and around the back of the combustion chamber 64 a great deal of heat is developed due to the high pressure system of operation. As a result, a hot spot tends to develop near the top of the combustion chamber 64 at the point where the hot gases have completely doubled back and are moving toward the exhaust opening or stack 30. The general location of this spot is designated by the numeral 75 in Fig. 4. In order to prevent the concentrated heat from burning out the furnace, I provide an air opening 78 immediately behind the point at which the hot spot tends to develop. Air is sucked into the combustion chamber 64 through the opening 78 and the inrushing air accomplishes several important results. It cools the hot spot 76, it helps draw down hot gases which otherwise might be trapped at the top of the back of the combustion chamber 64, it adds fresh air to assure complete combustion before the flaming gases pass into the exhaust opening or stack 30, and it tends to force the gases to make a complete circle before flowing away from the rear of the combustion chamber. Since the fuel flows into the combustion chamber under relatively high pressure it moves along rapidly, and, consequently, an occasional particle of fuel might pass entirely through the combustion chamber without complete burning if some provision were not made to extend the travel in the chamber. In the instant arrangement, the downdraft created by air entering through opening 78 deflects the hot gases of combustion downwardly; and, as shown by the arrow 80 in Fig. 4, tends to induce circulation of the fuel in the rear portion of the combustion chamber 64.

In this form of the invention the combustion chamber 64 preferably is lined with a suitable refractory material 82 in order to assure ample protection against the terrific heat which is developed therein. The portions of the liner at opposite sides of opening 78 preferably overlap, as shown in Fig. 4, to provide a baffle 84 which deflects the air entering through the opening forwardly and across the hot area 76. Also, the depending baffle 84 assists the downdraft of air traversing opening 78 to induce circulation of the combustion gases in the rearward portion of the furnace.

Attention is now directed to Fig. 7 wherein is shown still another modified furnace construction which is preeminently suited for high pressure operation and is primarily intended to be used in relatively large installations. The furnace here shown is generally similar to the one shown in Figs. 4-6 but it is horizontally elongated to move the front wall 14 farther away from the rearward portion of the furnace and to provide room for a vertical generally tubular stack 86 in front of the exhaust opening 30. A fuel injection nozzle assembly 20 is mounted in

the forward wall 14 to project a combustible mixture of fuel and air horizontally across the floor of the combustion chamber 64, and a second nozzle injection assembly 20a is mounted in the top of stack 86 to project a combustible mixture of fuel and air downwardly into the combustion chamber through the stack. It is contemplated that the nozzle assemblies 20 and 20a be operated either independently or simultaneously depending on the exigencies of the particular situation.

In this form of the invention, the furnace is surrounded by an air jacket 88 having an air inlet duct 90. Air under pressure is forced into the duct 90 in any suitable manner and a portion of this air is conducted downwardly outside the forward wall 14 where it enters the combustion chamber 64 through slots 92 and 94. A vertical partition 96 directs air to slot 92 and a vertical partition 98 directs air to the slot 94. In addition, the air travels downwardly behind partition 98 and enters the portion of jacket 88 disposed under the furnace. A portion of this air is directed upwardly between the stepped plate 72 in the manner hereinabove described by vertically spaced horizontal baffles 100, while a portion of the air passes under the lowermost baffle 100 and continues upwardly around the rearward wall of the furnace. A portion of the latter air enters the opening 78 for the purpose hereinabove set forth, and the air which passes over the opening 78 is divided by a baffle 102 and directed to openings 104 and 106 in the wall of exhaust stack 30.

In addition to the above, a portion of the air entering the jacket through duct 90 passes downwardly through a by-pass 103 between the two stacks 30 and 86. Spaced vertical baffles 110, 112, and 114 divide the air and direct it to slots 116, 118, 120, 122 and 124 provided in the stacks 30 and 86.

The flue gases escape from the furnace through an opening 126, thence pass through fly ash precipitators 128 which trap any fly ash which is carried along to this point by the flue gases, and then exit through an exhaust passage 130.

The air blown into the jacket 88 becomes heated as it flows along the walls of the furnace. As a result of heat exchange between the walls of the furnace and the air in jacket 88, the walls are cooled and the air is heated. This has the double advantage of preventing overheating of the furnace walls and of increasing the combustion efficiency in the furnace by injecting heated air therein. The various slots or openings through which air is introduced into the combustion chamber are strategically located to assure complete combustion of the fuel before the latter reaches the exhaust passage 130.

Attention is now directed to Fig. 8 which shows still another modified type of furnace construction embodying the invention. The furnace here shown is generally similar to the larger form shown in Fig. 7, but is adapted primarily for use in somewhat smaller installations. In general, the rearward portion of the combustion chamber is shortened considerably to provide a shorter passage for the combustion gases. The shorter distance is ample in this case since the horizontal fuel injection nozzle assembly 20 is omitted and only the single vertical fuel injection nozzle assembly 20a is used. Also, a somewhat simplified baffle arrangement is employed in this case. For example, one of the baffles 100 can be omitted due to the fact that the bottom of the furnace is considerably shorter, and the baffle 102 is entirely

omitted for obvious reasons. Otherwise, the operation and advantages inherent in this form of the invention are identical to those described in connection with the form shown in Fig. 7.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same and that various changes in the size, shape, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A furnace comprising refractory material forming a combustion chamber having right-angulantly related inlet and exhaust openings, the major portion of the combustion chamber disposed in front of the inlet and laterally of the exhaust opening, the wall of said chamber adjacent to the exhaust opening formed with a re-entrant portion and the latter defining a relatively restricted passage between the major portion of the chamber and said inlet and exhaust openings, whereby products of combustion charged to the combustion chamber through said inlet and said restricted passage are circulated in the combustion chamber before being returned through said restricted passage to the exhaust opening, the side of said re-entrant portion remote from said exhaust opening having an air inlet, a baffle arranged to deflect air entering the combustion chamber through said air inlet against the surface of said re-entrant portion and into said exhaust opening, the wall of the combustion chamber immediately in front of said fuel inlet having an opening exteriorly of the furnace, a plurality of plates covering said opening, said plates arranged in stepped relation and spaced from each other so that air from outside the furnace enters the combustion chamber through said opening and the spaces between the individual plates.

2. A furnace having a combustion chamber provided with a fuel inlet and an exhaust opening for discharging combustion gases from the chamber, a wall of the combustion chamber along which combustion gases pass to the exhaust opening being formed with a re-entrant portion and the side of said re-entrant portion remote from the exhaust opening having an air inlet through which atmospheric air enters the combustion chamber, a baffle in the chamber disposed in spaced generally parallel relation with respect to the mentioned side of said re-entrant portion for deflecting incoming air across said side of the re-entrant portion and into said exhaust opening, a wall of the combustion chamber immediately in front of said fuel inlet having an opening

communicating exteriorly of the furnace, a plurality of plates covering said opening, said plates arranged in stepped relation and spaced from each other so that air enters the combustion chamber through the spaces between the individual plates, and means for circulating coolant liquid across said opening including pipes supporting said plates.

3. A furnace having a combustion chamber provided with a fuel inlet and an exhaust opening for discharging combustion gases from the chamber, a wall of the combustion chamber along which combustion gases pass to the exhaust opening being formed with a re-entrant portion and the side of said re-entrant portion remote from the exhaust opening having an air inlet, a baffle in the chamber disposed in spaced generally parallel relation with respect to the mentioned side of said re-entrant portion for deflecting air entering the combustion chamber through said air inlet across said side of the re-entrant portion and into said exhaust opening, a wall of the combustion chamber immediately in front of said fuel inlet having an opening, and a plurality of plates covering said opening, said plates arranged in stepped relation and spaced from each other so that air enters the combustion chamber through said opening and the spaces between the individual plates.

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