Oct. 2, 1962 F. GETHING 3,056,389

BOILER

Filed Oct. 1, 1959 2 Sheets-Sheet 1

Fig. 1

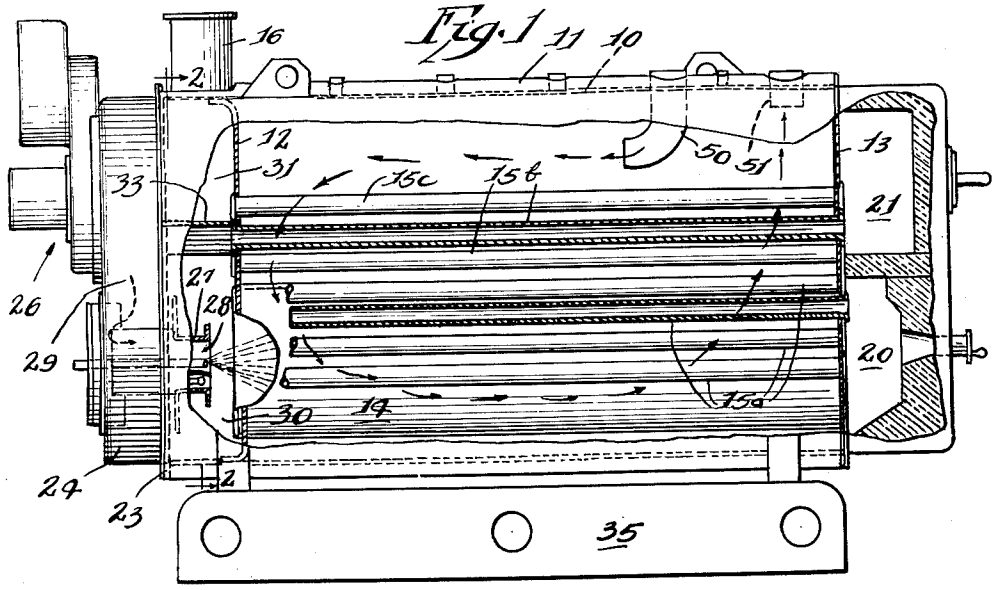


Fig. 2

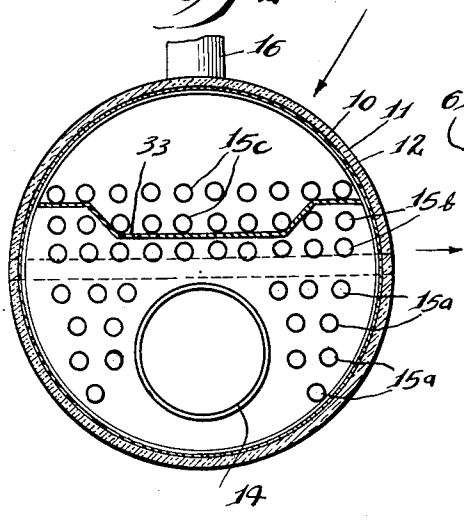
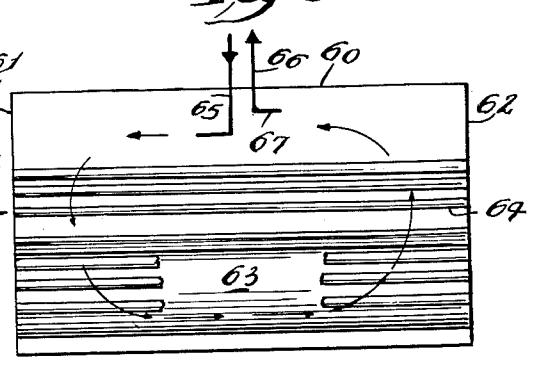


Fig. 9



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BOILER

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Fig. 3

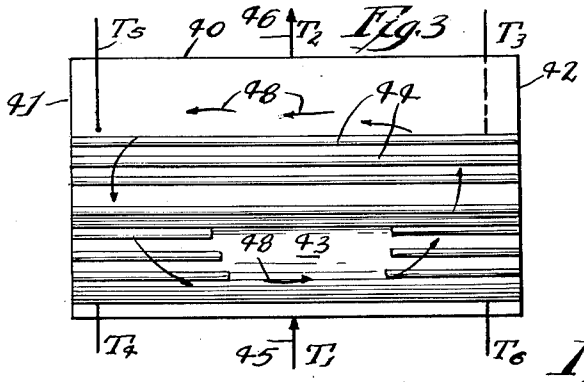


Fig. 4

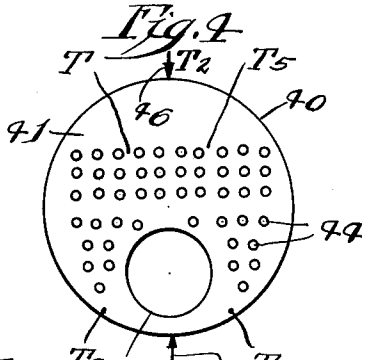


Fig. 5

T_1	T_2	SYS. TEMP. DROP Δt	T_3	T_4	T_5	T_6	MAX TEMP. DIFFERENCE IN BOILER	GPM RATE	FIRING RATE
174	204	30°F	194	176	196	173	23°F	32.5	LOW
90	120	30°F	122	98	122	98	24°F	32.5	LOW
168	208	40°F	199	169	199	169	30°F	130	HIGH
112	203	91°F	177	113	174	112	65°F	65	HIGH
93	206	113°F	199	107	199	108	92°F	32.5	HIGH

Fig. 6

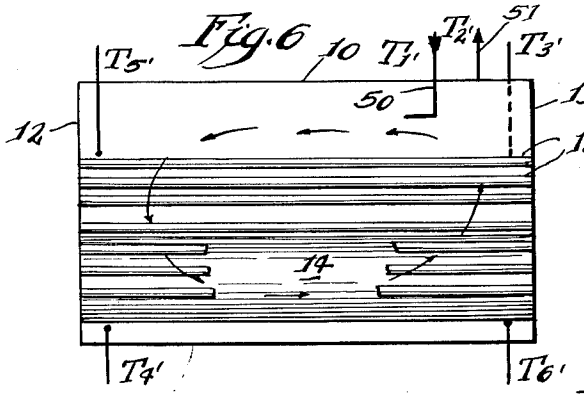


Fig. 7

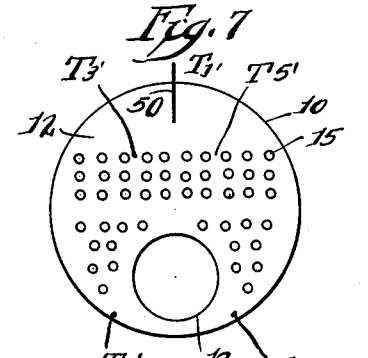


Fig. 8

T_1'	T_2'	SYS. TEMP. DROP Δt	T_3'	T_4'	T_5'	T_6'	MAX TEMP. DIFFERENCE IN BOILER	GPM RATE	FIRING RATE
164	201	37°F.	204	203	201	201	3°F	130	HIGH
138	199	61°F	200	195	199	194	6°F	32.5	LOW
83	152	69°F	154	147	152	147	7°F	32.5	LOW
104	202	98°F	203	198	193	203	10°F	65	HIGH
74	206	132°F	207	197	206	192	15°F	32.5	HIGH

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BOILER

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2 Claims. (Cl. 122—406)

This invention relates to boilers, as for heating systems or the like, and more particularly to hot water boilers of the type including a tank or vessel for water and tubes passing through the vessel for hot gases which heat the water.

It is a general object of the invention to provide a new and improved boiler of the type described.

Another object is to provide a new and improved means assuring circulation of water in a boiler of the character mentioned.

A preferred embodiment chosen for illustration comprises a horizontal fire tube boiler of a type including a horizontally disposed generally cylindrical shell providing a water tank or vessel having an inlet and an outlet, a plurality of tubes passing through the vessel and suitable baffles providing a plurality of vertically spaced passes for conducting hot combustion gases from a burner at the front of the boiler to the rear of the boiler and thence toward the front of the boiler, and if desired back to the rear and again to the front, for exhaust through a suitable exhaust stack. At opposite ends of the shell, adjacent the baffles referred to, the fire tubes passing through the vessel are supported by suitable tube sheets which are secured to opposite ends of the boiler shell. In boiler constructions of this type, problems have been experienced with the tube sheets, particularly rear tube sheets which fail or break down after rather limited periods of use. The failure sometimes appears in the form of leaks in the welds between the tube sheet and the tubes; in some cases the tube sheet has cracked, and in other cases the tubes have become loose in the tube sheets. It appears that the cause of failure is due to temperature differences between various parts of the boiler and poor circulation of water in the boiler, the temperature differences arising because of the rather large amount of relatively cool water returning to the boiler from a hot water heating system.

With the above and other considerations in mind, it is an object of the present invention to provide a new and improved boiler construction which produces an improved circulation of water in the boiler to maintain substantially uniform temperatures throughout regardless of the boiler firing rate, regardless of the rate of flow of water through the boiler and regardless of the differences in temperatures between the incoming and outgoing water.

It was ascertained that in a four pass boiler of the type illustrated, thermal conditions alone within the boiler tend to cause a circulation of water in the boiler which follows substantially the same path irrespective of varying rates of boiler firing. This was ascertained by utilizing a boiler model with a glass shell and utilizing opaque particles held in suspension in the water to indicate the circulation. With the burner located adjacent the front of the boiler, the rear tube sheet, and particularly its lower region, is generally the hottest part of the boiler, and probably due largely to this condition the circulation of water in the boiler due to thermal conditions alone is generally upwardly at the rear of the boiler, forwardly at the top of the boiler, downwardly at the front and rearwardly at the bottom in a continuously curving pattern.

It is an object of this invention to provide a new and improved boiler of the type described including an inlet to the water vessel for admitting cool water which inlet is aimed in the direction of circulation due to thermal conditions alone so that incoming water assists the natural circulation in the vessel.

Another object is to provide a new and improved boiler of the type described including a water outlet from the vessel which opens toward upstream of the path of circulation due to thermal conditions so that water flowing out of the vessel also assists the natural circulation.

A further object is to provide a new and improved boiler of the type described including means providing a water inlet to the top of the boiler aimed forwardly in the direction of thermal circulation, and an outlet slightly to the rear of the inlet opening either downwardly or rearwardly toward upstream of the thermal circulation.

The improved construction described herein increases the circulation of water in the boiler by assisting the circulation due to thermal conditions alone and provides about the longest possible tempering path for the incoming cool water before this water comes in contact with the rear tube sheet. Tests on models as well as full scale installations indicate that the improved construction provides substantially uniform temperatures throughout the boiler.

Other objects and advantages will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a side elevational view, partly broken away and in section, illustrating an improved boiler construction embodying the principles of the present invention;

FIG. 2 is a sectional view taken at about the line 2—2 of FIG. 1;

FIG. 3 is a diagrammatic illustration of a prior boiler construction shown for the purpose of indicating temperature differences in such boilers;

FIG. 4 is an end elevational view of the boiler illustrated in FIG. 3;

FIG. 5 is a table indicating temperature differences in the boiler of FIGS. 3 and 4 under varying conditions of burner firing rate, flow rate through the boiler, and temperature difference between incoming and outgoing water;

FIG. 6 is a diagrammatic illustration of a boiler, such as that in FIGS. 1 and 2, constructed according to the principles of the present invention, shown for the purpose of indicating temperature differences in the boiler;

FIG. 7 is an end elevational view of the boiler illustrated in FIG. 6;

FIG. 8 is a table indicating temperature differences in the boiler of FIGS. 6 and 7 under varying conditions of burner firing rate, flow rate through the boiler, and temperature drop between the incoming and outgoing water; and

FIG. 9 is a diagrammatic illustration somewhat similar to that in FIG. 6, indicating a modified construction embodying the principles of the present invention.

While illustrative embodiments of the invention are shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms, and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated. The scope of the invention will be pointed out in the appended claims.

Referring now to the drawings in more detail, and particularly to FIGS. 1 and 2, a boiler embodying the principles of the present invention includes a generally cylindrical shell as at 10 which is suitably encased in insulation as at 11. Tube sheets 12 and 13 are suitably affixed respectively at the front and rear of the shell 10 and these, together with the shell, form a substantially cylindrical tank or vessel for containing the water to be heated. Centrally in the lower portions of the shell, a rather large fire tube 14 has opposite ends mounted in

the tube sheets and this tube constitutes a combustion chamber in which most of the burning occurs in the boiler. Additionally, a plurality of smaller tubes 15 are horizontally and vertically spaced within the shell and these also have opposite ends secured respectively to the tube sheets 12 and 13. The large fire tube 14 and the smaller tubes 15, together with suitable baffles to be described provide a plurality of vertically spaced passes for conducting hot combustion gases from the front of the boiler toward the rear, thence toward the front, again toward the rear and finally toward the front to an exhaust stack as at 16.

More specifically, the hot combustion gases pass rearwardly through the fire tube 14, forwardly through the smaller tubes 15*a*, rearwardly through tubes 15*b* and forwardly through tubes 15*c*. At the rear of the boiler, the right as viewed in FIG. 1, a suitable refractory or insulating material is mounted to provide a pair of chambers as at 20 and 21. The lower chamber and the parts which provide this chamber serve to turn the gases from the tube 14 into the tubes 15*a*. The chamber 21 and the parts providing this chamber serve to turn the gases from the tubes 15*b* into the tubes 15*c*.

At the front of the boiler, a flat circular door as at 23 is suitably secured to the shell 10 to close the same and the door is spaced from the front tube sheet 12 as best seen in FIG. 1. Outwardly of the door 23, a circular or somewhat cylindrical, dish-shaped door 24 is suitably mounted to provide a plenum chamber through which air is introduced to the boiler to support combustion. A sutiable motor and fan unit as at 26 is mounted on the outside of the door 24 for forcing air through inlet openings (not shown) in the door 24 to the plenum chamber. The door 23 supports a suitable tube as at 27 which houses a burner structure generally designated 28 including one or more main burner nozzles, a pilot nozzle if desired and an electrical ignition means if desired. Air is introduced to the tube 27 from the plenum chamber in a path designated by the arrow 29 and from the tube 27 the air flows to a lower chamber 30 between the tube sheet 12 and the door 23 and then to the fire tube 14.

The space between the front tube sheet 12 and the inner door 23 is divided into a lower chamber as at 30 and an upper chamber as at 31 by means of a baffle or divider as at 33. The chamber 30 and the means providing it serve to direct the hot gases from the lower tubes 15*a* into the tubes 15*b*. The upper chamber 31 and the means providing it serve to conduct the gases from the tubes 15*c* to the stack 16.

If desired the entire boiler structure may be mounted on a suitable support such as the skids, one indicated at 35.

Referring now to FIGS. 3 and 4, these indicate diagrammatically a typical prior boiler construction including a shell 40 of cylindrical or other shape and tube sheets 41 and 42 closing opposite ends of the shell 40. The shell and the tube sheets provide a vessel for the water to be heated. A fire tube as at 43 and a plurality of additional smaller tubes 44, all extending through the vessel provide a plurality of passes for conducting hot gases to heat the water in the vessel. Incoming water is admitted to the boiler through an inlet at the bottom as indicated by the arrow 45 and water passes out of the vessel as through an outlet indicated at 46. By the tests previously described, it was ascertained that the natural circulation of the water in the boiler due to thermal conditions alone followed a path indicated by the arrows 48, that is, upwardly at the rear, forwardly at the top, downwardly at the front, and rearwardly at the bottom.

Temperature conditions throughout the boiler illustrated in FIGS. 3 and 4 were determined by taking temperature readings at various positions within the boiler under varying conditions of operation, and the results are indicated in the table of FIG. 5. In the table, the first column entitled T1 indicates the temperature of incoming water at the inlet 45, the second column entitled T2 indicate the temperature of outgoing water at the outlet 46 and the third column the difference between the temperatures T1 and T2. Temperature readings were taken at various positions in the boiler at the positions indicated by the reference characters T3, T4, T5 and T6, and these values are given in the fourth, fifth, sixth and seventh columns in the table. The eighth column indicates the maximum temperature difference between the highest and lowest temperatures in the fourth, fifth, sixth and seventh columns. The ninth column indicates that the temperature readings were taken under various flow rates of water through the boiler. The last column indicates that the temperatures were taken under varying conditions of burner firing rate.

The table in FIG. 5 illustrates that in a prior art boiler of the type illustrated in FIGS. 3 and 4, where the temperature difference between the inlet and outlet varied from 30° to 113° F. as indicated in column 3 and where the flow rate of water through the boiler varied between 32.5 and 130 gallons per minute and where the firing rate varied between low and high, temperature differences as great as 23° to 92° F. existed within the boiler.

Referring again to FIG. 1, in the improved construction, a water inlet is located at the top center line of the boiler as indicated at 50 and an outlet is located on the top center line of the boiler as indicated at 51. As seen in FIG. 1, the inlet 50 comprises a curved pipe having a nozzle outlet located about half way between the top of the tubes and the top of the shell and directed forwardly of the boiler in the direction of circulation due to thermal conditions alone (as indicated by the arrows 48 in FIG. 3) so that the flow of incoming water assists the thermal circulation. Additionally, the inlet, located at this position, provides for flow of incoming water through substantially the longest possible tempering path before it encounters the lower portion of the rear tube sheet 13 which is generally the hottest part of the boiler. Further, the outlet 51, it will be noted opens downwardly in a direction facing toward upstream in the thermal circulation so that the flow of water from the boiler also assists the thermal circulation.

Referring now to FIGS. 6 and 7, which illustrate diagrammatically the boiler construction illustrated in FIGS. 1 and 2, temperature readings were taken throughout the boiler at positions T3′, T4′, T5′, and T6′ in positions corresponding to the temperature readings at T3, T4, T5 and T6 in FIGS. 3 and 4. The table in FIG. 8 indicates that the temperature readings were again taken under varying conditions of operation, but where the temperature differences between inlet and outlet varied between 37° and 132° F. and the flow rate of water through the boiler varied between 32.5 and 130 gallons per minute and the firing rate was varied from high to low, the maximum temperature difference occurring in the boiler was only as great as 3° to 15° F. a marked reduction over the temperature differences in the prior boilers. This indicates the advantage provided by the new construction over the prior art construction.

FIG. 9 illustrates diagrammatically another embodiment incorporating the principles of the present invention. As seen there, a boiler construction including a shell as at 60, tube sheets 61 and 62, a fire tube 63 and smaller gas tubes 64 is provided with an inlet positioned approximately midway of the length of the boiler as at 65, instead of rearwardly in the boiler as in FIGS. 1, 2, 6 and 7. An outlet as at 66 is positioned immediately rearwardly of the inlet 65 instead of being positioned substantially at the rear of the boiler as illustrated in FIGS. 1, 2, 6 and 7. The inlet includes a forwardly directed nozzle portion which is aimed in the direction of thermal circulation and assists the thermal circulation as in the previously described construction. The outlet, being spaced somewhat forwardly from the rear of the boiler, includes a rearwardly extending portion 67 which opens toward upstream in the thermal circulation so that

the flow of water from the boiler also assists the circulation. In tests of an actual installation, under varying conditions of operations similar to those described in FIGS. 5 and 8, it was found that the maximum temperature differences within the boiler did not exceed those indicated in column 8 of FIG. 8.

The improved construction described herein provides for a water inlet to the boiler which is aimed in the direction of the natural circulation due to thermal conditions alone so that the flow of incoming water assists the thermal circulation. The incoming cool water is also introduced to the boiler at a place where the water is normally hottest, and at a position providing substantially the longest possible tempering path before the cool water encounters the hottest part of the boiler so that the tendency to bring the coldest water into contact with the hottest metal is minimized. The inlet nozzle is positioned in the boiler at a position between the upper level of tubes and the top of the boiler where there is a free mass of water so that the incoming jet of water has the greatest possible effect on the water circulation and temperature, greater than that possible if the incoming jet were introduced to water in a confined space. Additionally, the outlet from the boiler is positioned and aimed in a direction to further assist the thermal circulation. As a result of the improved construction, temperature differences throughout the vessel have been reduced to inconsequential differences which are unlikely to cause failures in the boiler, and particularly in the rear tube sheet, which were attributable to the prior art constructions.

The foregoing detailed description is given for clearness of understanding only and no unnecessary limitations are to be understood therefrom, as some modifications will be obvious to those skilled in the art.

I claim:

1. In a horizontal hot water boiler apparatus, in combination: an outer shell having transverse tube sheets secured thereto adjacent opposite ends thereof thereby providing a closed vessel for water to be heated, baffle means adjacent each end of the shell defining with the

tube sheets hot gas chambers at each end of the vessel, a plurality of tubes extending horizontally through the shell and mounted in the tube sheets, said tubes opening into said chambers to provide therewith passages for conducting hot gases through at least two horizontal passes from end to end of the vessel, said tubes being positioned below the top of the vessel to provide a substantially unobstructed region of substantial proportions extending horizontally generally from end to end of the vessel, means to introduce hot gases into one of said chambers at one end of the vessel, whereby hot gases from the source pass through at least one tube to a chamber at the other end of the vessel and back through other tubes to a chamber at said one end serving to establish thermal conditions such that water in the vessel tends to circulate in a predetermined path horizontally across the bottom of the vessel from said one end toward said other end, upwardly at said other end, horizontally across said region at the top of the vessel toward said one end and then downwardly at said one end, means providing a water inlet to the vessel opening in said upper region and aimed horizontally in the direction of thermal circulation of water in said vessel, and means providing a water outlet from said vessel upstream from said inlet, said inlet directing water admitted therethrough parallel to said path and causing said admitted water to travel a substantial distance while intermingling freely with other water in the vessel before reaching said outlet to establish more uniform water temperatures in said vessel.

2. The hot water boiler of claim 1 in which said outlet is aligned with said path so that outgoing water assists thermal circulation in the vessel.

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