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This invention resides in the field of hot water and steam boilers and is a new and improved boiler structure having first stage forced circulation. The unit can be termed a high pressure high temperature hot water and steam boiler although it is not restricted in that respect.

A primary object of my invention is a new and improved boiler structure with first stage forced circulation constructed so that the water wall tubes around the furnace space will not burn out or be damaged if the power to the pump fails.

Another object is a boiler of the above type constructed and arranged to reduce any steam bubbles in the hot water drum.

Another object is a boiler of the above type constructed so that the water wall tubes around the furnace space can be easily flushed or cleaned by a suitable compound when the boiler is not in service.

Another object is a boiler structure of the above type having a cold water shield or spray condensing the steam bubbles from the water wall tubes ahead of the outlet pipe on the hot water drum.

Another object is a boiler of the above type which does not require a separate expansion tank or drum in its forced circulation system.

Another object is a unit of the above type having a first stage forced circulation and a second stage natural circulation with auxiliary and main connections between them.

Other objects will appear from time to time in the ensuing specification and drawings in which:

Figure 1 is a sectional view taken along lines 1—1 of Figure 3 showing the general lateral disposition of the unit;

Figure 2 is a sectional view taken along line 2—2 of Figure 3 showing the longitudinal arrangement of the unit;

Figure 3 is a longitudinal section taken along lines 3—3 of Figure 1;

Figure 4 is a sectional view, with parts omitted, taken along lines 4—4 of Figure 3; and

Figure 5 is a sectional view taken along line 5—5 of Figure 2.

In Figure 1 the boiler housing includes the usual side walls 10 and 12 with a roof or top wall 14 and a bottom wall 16, the entire structure being supported by a suitable foundation 18. The side walls are composed of spaced plates or the like with a suitable insulating material between them as at 20, this material being a mineral wool felt or the like. In Figure 2 the ends of the units are closed by a front wall 22 and a rear wall 24. The front and rear walls are also lined with a suitable wool felt or the like 26 and 28 and an inner layer 30 and 32 of a suitable refractory material which can be tile or the like. In Figure 1 the top wall or roof shelf has a suitable felt lining 34 or the like as does the floor or bottom wall at 36.

The housing encloses a lower or water drum 38 and an upper or water and steam drum 40, these drums being interconnected by a plurality of tubes. A center wall 42 extends longitudinally from the front wall dividing the housing into a furnace or combustion space 44 and a boiler or water space 46. The front wall of the housing has a suitable or gas burner 48 so that fuel will be burned in the combustion space. The intermediate wall 42 terminates short of the rear wall at 50 in Figure 2 leaving a space or connection to the gas path through which the products of combustion flow, the gas path being divided into a tortuous route by alternate baffles 52, 54, and 56, in Figure 3 leading to a suitable gas outlet 58.

The combustion space or furnace is surrounded or enclosed by a water wall including a bank of tubes 60 along the outside wall and a shorter bank of tubes 62 lining the intermediate wall 42. Water wall tubes 64 cover the front wall and are spaced from each other to allow for the fuel burner 48 and a single or multiple row of tubes 66 cover the rear wall of the housing. These water wall tubes completely enclose the furnace space and extend between and are connected to both the upper and lower drum.

The lower drum has a cold water box 68 formed from variously sized and shaped plates so that the drum is divided into the box 68 and a main portion 69. A longitudinal pipe or tube 70 forms a part of the box and communicates with it by a plurality of holes or openings 72 as shown in Figures 1 and 3. This pipe is connected to any suitable cold water source and in effect forms a cold feed water source for the boiler. The pipe could be the return line from the pump of a process system or the like. The water will flow from the pipe 70 into the box 68 and into the drum 35. The water in the box flows into the water wall tube surrounding the combustion space where it is heated. Due to the heat the water will flow upwardly through the water wall tubes into the upper drum.

The box has a cross section similar to that shown in Figure 5 throughout its length except at each end where extensions are formed as at 74 next to the front wall and 76 next to the rear wall so that the water wall tubes along the front and rear walls can be brought into the box. For example Figure 1 shows the cross section through one of the extensions of the box—the front wall extension—and this illustrates how the water wall tubes along the front wall are brought in and connected to the box. The same is true of the rear wall tubes and the extension 76 on the box.

Thus all of the water wall tubes that surround the combustion space are connected to the box which, in effect, forms a connection with the cold water inlet.

The water from the water wall tubes empties into the upper drum 46 behind baffle 80 and goes into the normal circulation system. The upper and lower drums are interconnected by a plurality of generally upright normal circulation tubes 78 which extend through the gas path 46.

The water from the upper drum then flows through the natural circulation tubes between the upper drum and lower drum where it is additionally heated by the gases flowing through the gas path to the outlet. The normal circulation tubes connect to the lower drum on its main portion 69 so that only warm water circulates through these tubes. In effect the box contains only cold water and has no direct communication with the main portion 69 of the drum and the normal circulation tubes.

The upper drum is provided with a longitudinal baffle 88 which extends generally its full length as shown in Figure 3. This baffle is positioned across the outlet from the water wall tubes and deflects the hot water and steam discharged from them through the normal circulation tubes of the baffle. Any large steam bubbles carried in the hot.
water from the water wall tubes will be broken up by this screen.

A suitable hot water outlet connection 84 is provided in the upper drum shell or heads but is positioned generally midway between the ends of the drum as shown in Figure 3. This connection includes a pipe 86 which extends well below the normal water level in the drum as shown in Figure 4. The lower end of the pipe is provided with a baffle 88 which is positioned between the hot water outlet and the hot water and steam coming from the water wall tube. This baffle extends a short distance on each side of the outlet pipe in Figure 3 so that the outlet from the water wall tubes directly opposite the outlet pipe will be blocked or shielded, and the hot water and steam from the water wall tubes will first be deflected downwardly through the screen 82 and then it will be forced around the baffle 88 before it reaches the outlet pipe. Thus the water from the water wall tubes will be thoroughly mixed with the contents of the upper drum before it is taken off through the outlet pipe. Additionally, any large steam bubbles will be broken up by the screen 82.

The box in the lower drum is provided with a middle or intermediate extension 90 as shown in Figure 4 which communicates with the box through a plurality of perforations or holes 92. In this figure all such holes have been eliminated for clarity. This extension extends generally along the center or intermediate portion of the box as shown in Figure 3 and connects a section or a group of auxiliary tubes 94 to the cold water in the box. These auxiliary tubes 94 are taken from the normal circulation tubes and are diverted to the box by the extension 96.

Thus these tubes 94 extend behind the wall 42 and are connected to the upper drum as at 96 inside of the screen 82. This group of auxiliary tubes ends where the center box extension ends as shown in Figure 3.

It should be noted that these auxiliary tubes 94 are brought into the first stage forced circulation system as they are in direct communication with the high pressure cold water in the box. The cold water will be forced upwardly through these tubes; however, it will not be heated to as high a temperature as the cold water flowing through the water walls surrounding the combustion space because the auxiliary tubes 94 are shielded from the combustion space by the intermediate wall 42. Therefore, cold water, or relatively cold water, will enter the upper drum from the auxiliary tubes. Cold water is thereby supplied cold water to the primary tube. The cold water from these auxiliary tubes extends longitudinally on both sides of the hot water outlet as shown in Figure 3, so that any hot water and steam from the water wall tubes will flow through this cold water shield before going to the outlet 86.

The discharged drum can be provided with auxiliary steam outlets 98 at each end and with suitable manholes 99 and closure elements 102 for cleaning and inspection purposes, and also a safety valve connection 98.

It should be noted and understood that the cold water inlet pipe 70 is connected to an electrically driven pump which supplies cold water to the pipe and box at a relatively high pressure. This high pressure forces the water from the box up through the water wall tubes around the combustion space where it is heated. This high pressure also forces water from the box up through the auxiliary tubes 94. Therefore, this stage of the circulation system is termed first stage forced circulation. After the water enters the upper drum, the pressure of the pump is no longer present, and normal circulation takes place between the upper and lower drum through the normal circulation tubes. The cold water inlet pipe 70 can be provided with suitable drainage and cleaning connections if desired.

The various other standard items in a boiler of this type have been shown, for example the observation port 104 in Figure 2; however, these features are standard and unimportant. The lower drum can also be provided with a manhole and cover as at 106 in Figure 3. It should also be noted in Figure 3 that the inlet pipe 70 begins in from the left hand side and terminates in the right side. However this of course could be reversed.

The use, operation, and function of my invention are as follows:

All of the furnace tubes, the water wall tubes, surrounding the combustion space, receive their cold water from the cold water box in the lower drum. The water in this box is under relatively high pressure from a system circulating pump which brings cold water to the box from the longitudinal inlet pipe. This pipe can enter either end of the drum or through the shell. All of the water wall tubes discharge into a boxed-in space in the upper drum defined by a longitudinal baffle closed at its lower end by a screen. All of the water discharging from the water wall tubes is deflected downwardly and must pass through the screen before entering and mixing with the water in the drum. The screen is below the normal water level in the upper drum, and therefore serves to break up any large steam bubbles and to condense the steam.

This portion of the system can be characterized as the first stage of circulation, a forced circulation stage due to the pump.

The second or natural circulation stage takes place through the generally upright pipes interconnecting the upper drum and the lower drum. This second stage does not communicate with the box in the lower drum, and the lower drum is filled with hot water except for the box. Natural circulation takes place through the generally upright pipes, and the water in them is additionally heated by the hot gas flowing around the end 50 of the intermediate wall 42 through the tortuous path shown in Figure 3.

Hot water is taken out of the upper drum by the connection 84 and auxiliary steam can also be taken out by suitable auxiliary steam connections 98 as desired.

A steam space exists above the normal water level in the upper drum. With this steam space, I only have to provide a steam safety valve and not a water safety valve, because the water can rise in the upper drum and will only compress the steam trapped above it. This provision of a steam space in the upper drum eliminates the necessity of the usual separate expansion tank or drum in the forced circulation system beyond the boiler.

The box is provided with an intermediate extension which cuts off a group of the normal circulation tubes and connects them to the first stage of circulation. The cold water will flow into this extension of the box and will be forced up through these auxiliary tubes into the boxed-in space behind the baffle in the upper drum. Cold water from the auxiliary tubes will flow across the steam and hot water discharged from the water wall tubes as it is directed downwardly by the baffle. This further—in addition to the action of the screen 82—condenses and eliminates the steam bubbles carried in the hot water.

These auxiliary tubes also have another important function. In the event of a power failure, the pump supplying pressure to the box will stop. Heat will continue to be supplied to the combustion space by the burner and all of the cold water in the first stage including the water wall tubes and the box will be heated and forced into the upper drum. If the tubes in the first stage run out of water, they will quickly burn up or be damaged and will have to be replaced or repaired. But it should be noted that the upper drum is connected to the box through the auxiliary tube. Therefore the water from the upper drum can flow back through the auxiliary tubes into the
box and back up through the water wall tubes. This will prevent the water wall tubes around the furnace spaces from burning out or being damaged. It should be noted that the auxiliary tubes are behind the intermediate wall and are therefore not subjected to the high temperatures of the combustion space. This is a very desirable emergency feature.

Another function of the auxiliary tubes is that the cold water pump can be disconnected or stopped while the furnace is operating. A suitable detergent or cleaning compound could be inserted in the circulation system and the furnace or burner, by heating the water wall tubes would act as a pump and would force the cleaning compound up through the water wall tubes into the upper drum from where it would flow back through the auxiliary tubes into the box. The furnace in effect acts as a pump during this flushing or cleaning operation while the main pump has been shut off.

The upper drum can have the usual connections for venting, a water column, an auxiliary feed, connections for continuous blowdown, and feed water regulation, however, all of the feed is on the upper drum and have not been illustrated. The lower drum can also have blow off connections.

While I have shown and described the preferred form of my invention, it should be understood that numerous modifications may be made in the size, shape, number and disposition of parts without departing from the spirit of my invention. I, therefore, wish my description and drawings to be taken as in a broad sense illustrative or diagrammatic, rather as limiting me to my precise showing.

I claim:

1. A boiler assembly, a boiler housing and unit including longitudinally disposed generally parallel upper and lower drums, means in the housing defining a longitudinal hot gas path between the drums and a longitudinal furnace space next to it, baffle means in the lower drum dividing it into at least two parts, convection tubes extending through the gas path and connected to the upper drum and one part of the lower drum for natural circulation, a cold water inlet to the other part of the lower drum, a pump connected to the inlet for forced circulation, water wall tubes extending along the sides of the furnace space and connecting the other part of the lower drum and the upper drum, a plurality of auxiliary tubes extending through the gas path and connected to the other part of the lower drum and the upper drum below the water level, and a hot water outlet for the upper drum.

2. The structure of claim 1 characterized by and including a baffle in the upper drum extending a substantial longitudinal distance on each side of the hot water outlet, and including means to direct the discharge from the adjacent water wall tubes through the discharge from the auxiliary tubes during normal operation.

3. The structure of claim 2 in which the lower edge of the baffle is closed by a screen.

4. In a boiler assembly, a housing having means defining a furnace space and a hot gas path, drum and header structure including an upper drum with a hot water outlet, a lower drum structure having at least two parts, a forced circulation system including water wall tubes around the furnace space connected to one part of the lower drum structure and also connected to and discharging into the upper drum, a natural circulation system including circulation tubes in the hot gas path connected to the other part of the lower drum structure and also connected to the upper drum, a cold water inlet connected to the one part of the lower drum structure and adapted to be connected to a pump for forced circulation, and an auxiliary connection between and connected to the upper drum and the one part of the lower drum structure and adapted to be connected to a pump for forced circulation, and an auxiliary connection between and connected to the upper drum and the one part of the lower drum structure and connected to the upper drum below the normal water level so that relatively cold water will be forced through the bypass connection directly into the upper drum by the pump.

5. A boiler structure, a housing, a boiler unit in the housing including at least one upper drum, lower drum means divided into at least two sections, means defining a furnace chamber and a hot gas path in the housing leading from the furnace chamber to an outlet, a cold water inlet connected to one of the sections of the lower drum means and adapted to be connected to a pump, a first stage forced circulation system including water wall tubes around the furnace space connecting the one section of the lower drum means to the upper drum, a second stage natural circulation system including convection tubes in the gas path connected to the upper drum and to the other section of the lower drum means, and a plurality of otherwise open tubes located outside of the furnace chamber between the first and second stages of circulation, the plurality of tubes being connected to the second stage in the upper drum at a point below the normal water level in the upper drum and to the one section of the lower drum means and functioning as riser tubes during normal operation, but, upon failure of the pump, functioning as downcomer tubes to feed water from the second stage back to the one section of the lower drum means of the first stage to prevent the water wall tubes around the furnace space.

6. The structure of claim 5 in which the plurality of otherwise open tubes extend through the gas path and are connected directly to the upper drum.

7. The structure of claim 5 characterized by and including a centrally located hot water outlet on the upper drum, the plurality of otherwise open tubes being connected to the upper drum adjacent the hot water outlet so as to discharge relatively cold water, during normal operation, as a cold water screen between the hot water discharge from any adjacent water wall tubes and the hot water outlet.

8. The structure of claim 5 further characterized in that the lower drum means includes one lower drum, and the two sections include a box-type baffle in the lower drum constructed and arranged to divide the lower drum into the two sections.

9. The structure of claim 8 further characterized in that the plurality of otherwise open tubes are connected to the upper drum adjacent the water wall tubes and directed so as to supply a cold water screen, for effective mixing, across the hot water discharge from the water wall tubes.

10. The structure of claim 9 further characterized by and including a deflector in the upper drum including means to direct the discharge from the water wall tubes through the cold water screen supplied by the plurality of otherwise open tubes.

11. In a boiler unit, a boiler assembly including upper and lower drum structure with at least one upper drum and at least two lower drum chambers, means defining a furnace space and a hot gas path between it and a gas outlet, a cold water inlet connected to one of the lower drum chambers and adapted to be connected to a pump for forced circulation, water wall tubes around the furnace space connecting the one lower drum chamber to the upper drum and forming therewith a first stage forced circulation system, convection tubes extending through the gas path connected between the upper drum and another of the lower drum chambers forming therewith a second stage natural circulation system, and an auxiliary connection located outside of the furnace space, the auxiliary connection being connected between the one lower drum chamber and the second stage natural circulation system in the upper drum at a point below the normal water level in the upper drum to function as a safety feature providing a feed back of water from the second stage natural circulation system to the one lower drum chamber of the
first stage forced circulation system in the event of a power failure of the pump.

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