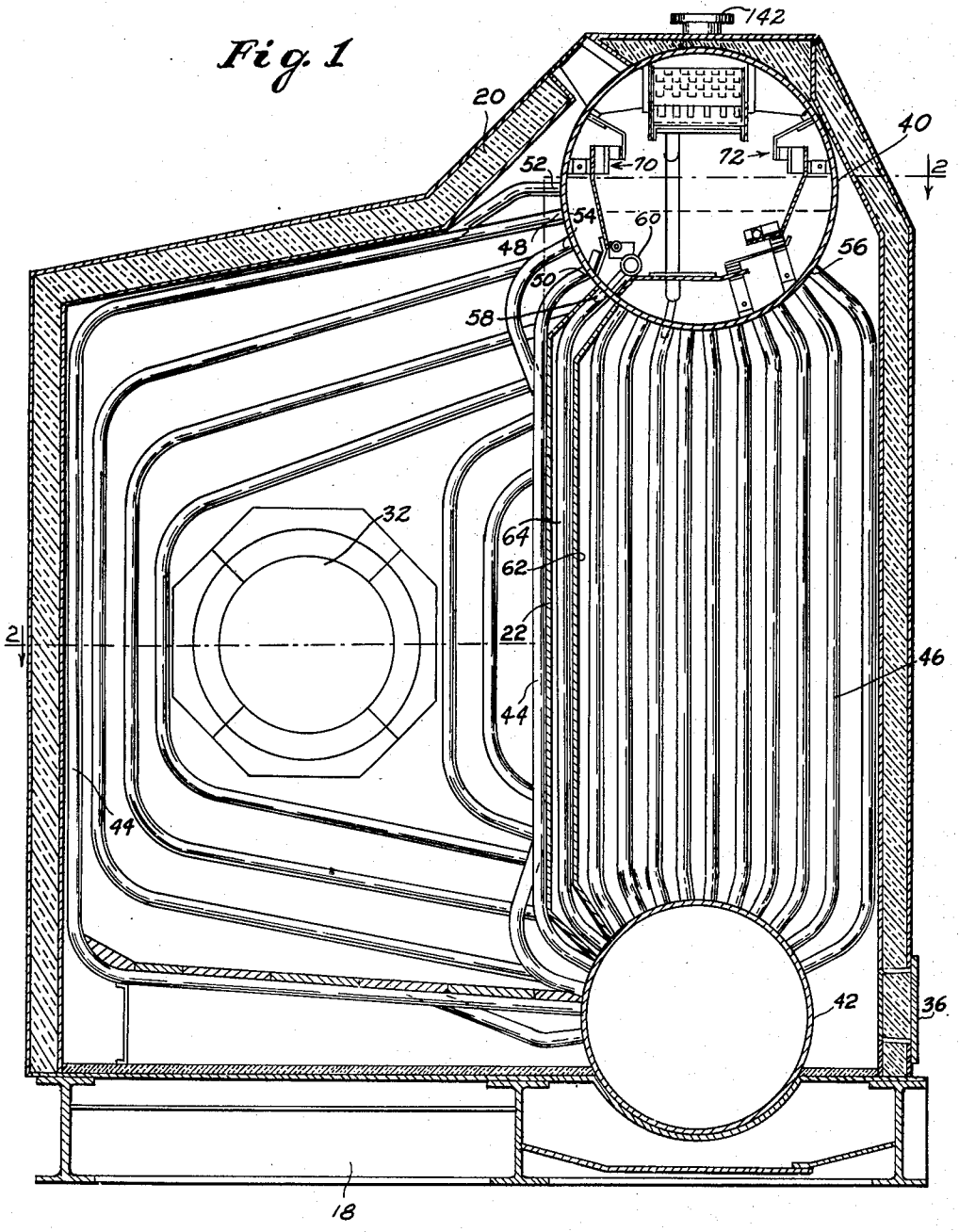
Sept. 27, 1960 G. A. REHM 2,954,014

WATER LEVEL CONTROL FOR PACKAGED BOILERS

Filed July 1, 1957 4 Sheets-Sheet 1

Fig. 1



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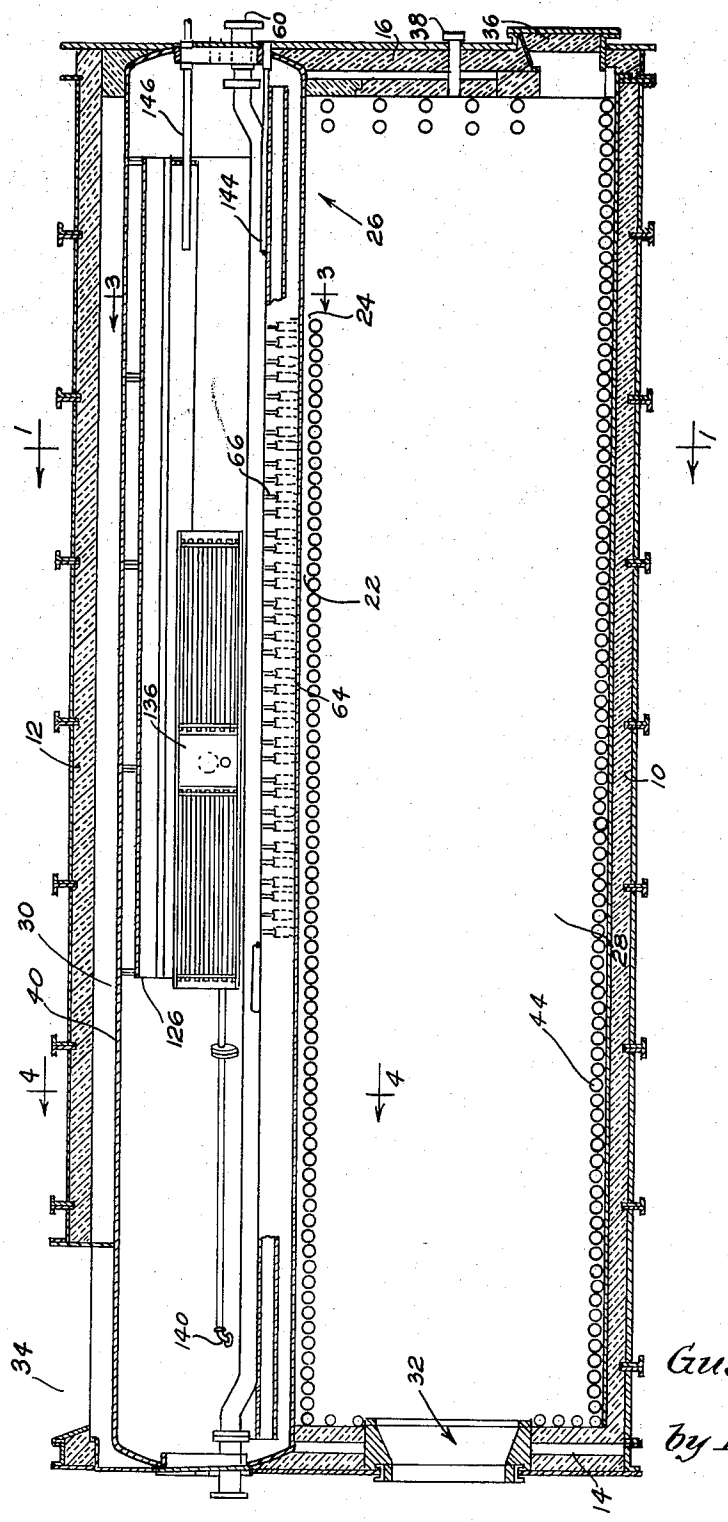

Fig. 2

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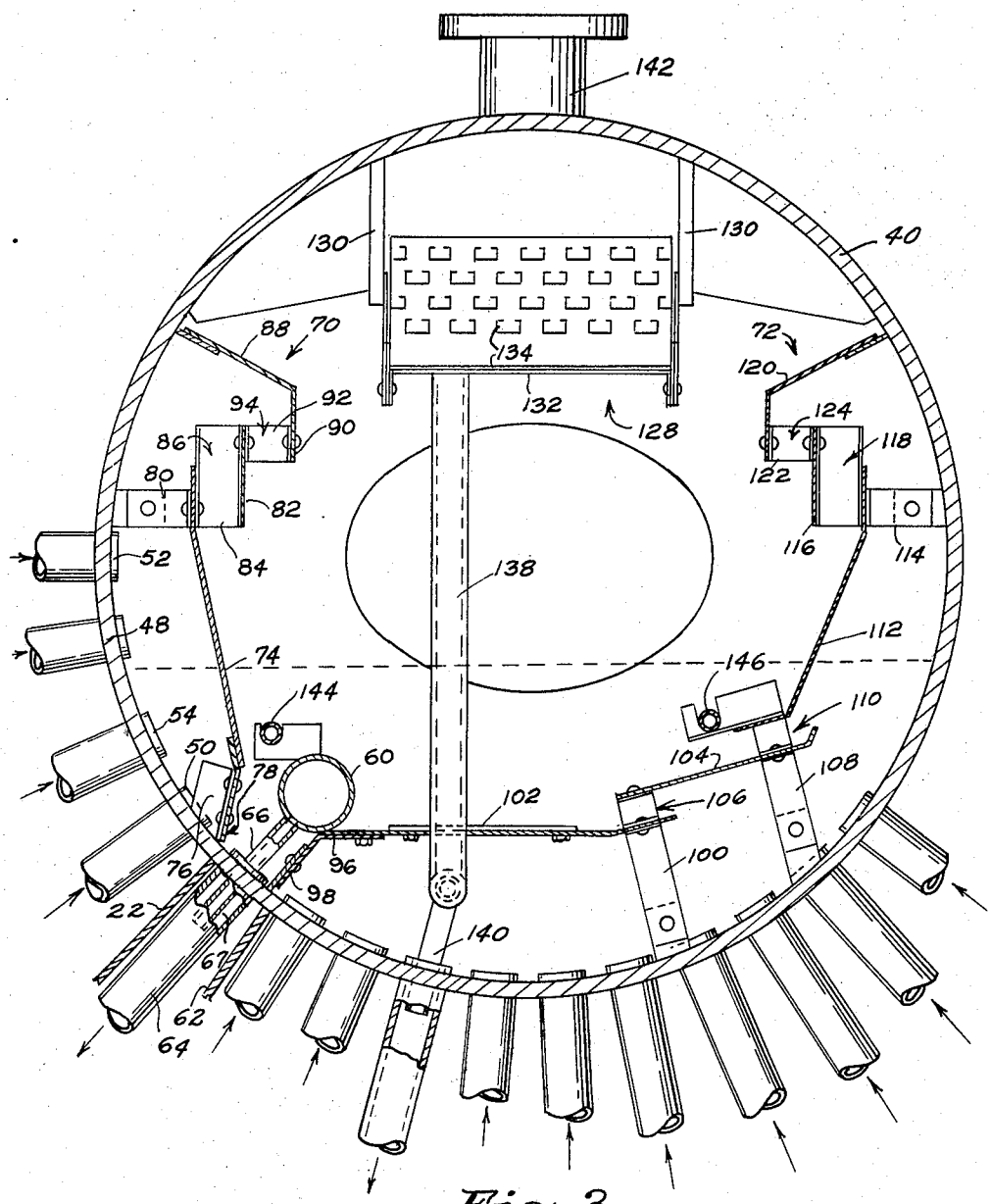

Fig. 3

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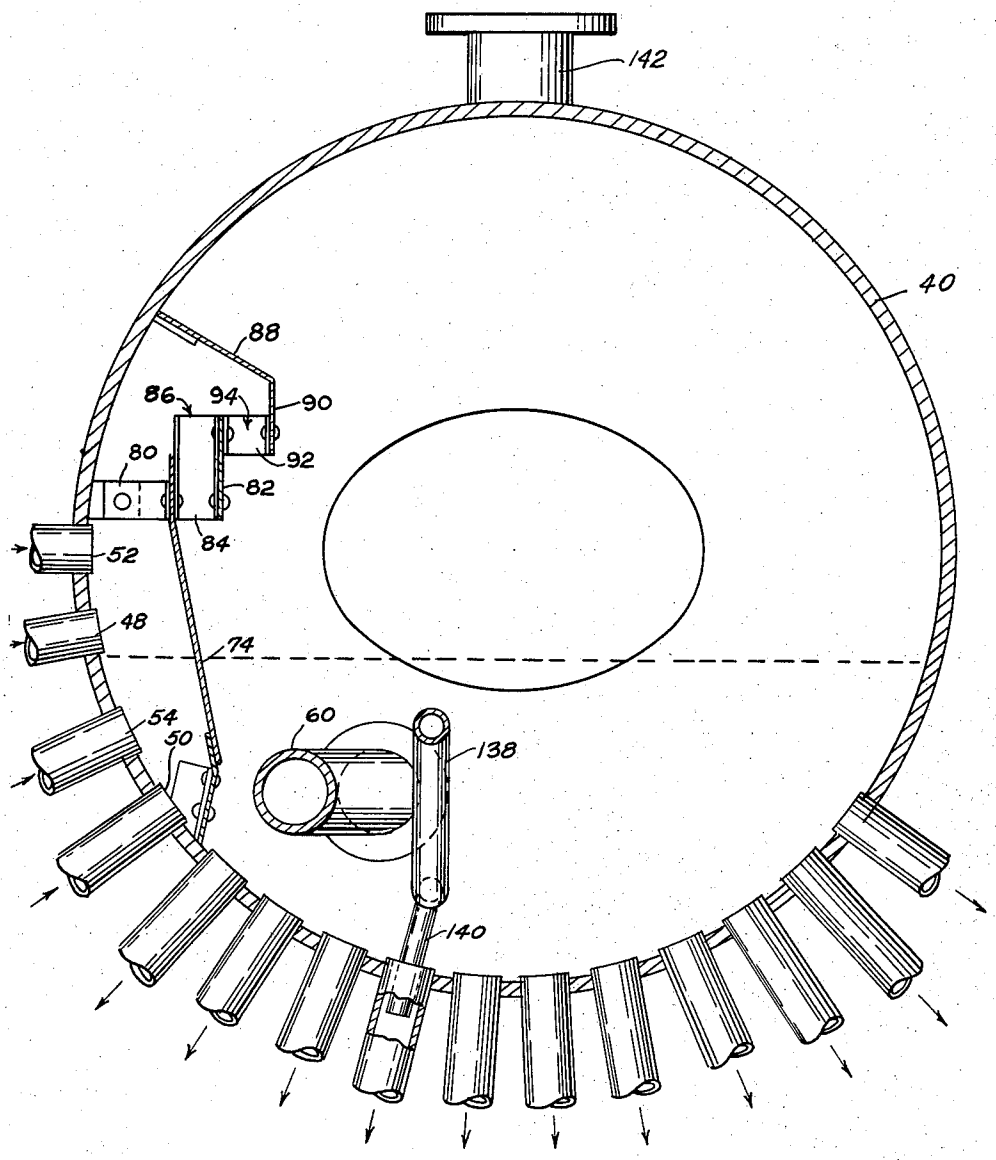
Fig. 4



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WATER LEVEL CONTROL FOR PACKAGED BOILERS

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2 Claims. (Cl. 122—407)

My invention is in the field of boilers and is primarily concerned with the so-called packaged boiler, although many of the principles and features are not necessarily restricted thereto. In any event, my invention is concerned with what I shall refer to as hot water and steam boilers, an example of which is a unit designed and constructed to provide hot water for cooking, heating, washing, and the like, as well as steam for the generation of power, heating, or what have you.

The invention is concerned with a water level control problem. Boilers of this type generally have a so-called upper drum which is a combination steam and hot water drum. When in operation, due to various factors explained in detail hereinafter, the water in the drum has a tendency to be high at one end and low at the other resulting in a substantial longitudinal water flow, which is highly undesirable.

Accordingly, a primary object of my invention is a boiler of the above type constructed and arranged to minimize variations in the water level in the drum.

Another object is a packaged boiler arranged with a water level control constructed to prevent variations in water level.

Another object is a water level control for an upper drum of a hot water and steam boiler constructed to control the water level preventing excess longitudinal water flow without the use of dams, weirs, and the like, which detrimentally affect the operation of the unit.

Another object is a boiler with an automatic water level control.

Another object is a water level control constructed to maintain approximately constant water level with rapid load changes, either when firing is increased or decreased.

Another object is a boiler of the above type constructed to prevent water level variations caused by bad water conditions, thereby eliminating extreme carry-over when the boiler water has a foaming tendency.

Another object is a water level control for a boiler of the above type that will not otherwise affect its operation detrimentally.

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

Figure 1 is a lateral section through a packaged boiler with my invention, taken generally along line 1—1 of Figure 2;

Figure 2 is a section taken along line 2—2 of Figure 1, on a reduced scale;

Figure 3 is a section taken along line 3—3 of Figure 2, on an enlarged scale; and

Figure 4 is a section taken along line 4—4 of Figure 2, on an enlarged scale.

In Figures 1 and 2, the boiler is shown with a housing which may include suitable side walls **10** and **12**, a front and rear wall **14** and **16**, a floor or base **18** and a suitable roof **20**. The details of the housing are unimportant. Suffice it to say that the walls, roof and floor may be

made of any suitable material, preferably insulation, and constructed in any suitable manner.

In the housing I may provide what I shall refer to as an intermediate wall **22** extending longitudinally from the front wall, as shown in Figure 2, and terminating at **24** in spaced relation to the rear wall, thereby providing an opening **26**. The chamber **28** on one side of the intermediate wall is constructed to operate as the furnace space and on the other side as a gas path **30**. A suitable burner, indicated generally at **32**, may be suitably disposed in the front wall to create combustion in the furnace space, and while I have shown generally a mounting for a gas or liquid type injector, it should be understood that the invention is not restricted to any particular type of firing. The hot products of combustion flow longitudinally toward the rear wall in the furnace space and pass through the opening **26** into the gas path. The gas path may be provided with suitable baffling so that the hot gases flow through a tortuous path, preferably up and down in the particular boiler shown, to a suitable outlet **34** at the end of the gas path adjacent the front wall. The housing may be provided with suitable access doors **36** and observation ports **38**, arranged as desired.

A hot water and steam system includes an upper hot water and steam drum **40** and a lower or mud drum **42** interconnected by a plurality of water wall tubes **44** which surround the combustion space and convection tubes **46** which extend up through the gas path. It will be understood that the water wall tubes connect to the upper drum in what I shall refer to as a longitudinal row extending approximately the full length of the drum or housing. In Figure 1, the connection is designated at **48** for the water wall tubes extending along the side wall **10** and at **50** for the water wall tubes that rise along the intermediate wall **22**, and I may also stagger the connections as at **52** for the water wall tubes of the outer wall and at **54** for the intermediate water wall tubes. In any event, the area extending from the connection for the lower tubes **50** to the upper tubes **52** may be considered as a longitudinal row of connections that extend approximately the full length of the drum.

The convection tubes connect to the upper drum in a row or bank of connections that extend from a row of tubes **56** on one side, in Figure 1, to a row of tubes **58** on the other side, it being understood that the convection tubes extend approximately the full length of the drum. Both the water wall tubes and the convection tubes connect in any suitable manner to the mud drum and the details are unimportant.

A substantial number, if not all, of the water wall tubes function as risers, and the hot water and steam from the water wall tubes entering the upper drum is at quite a high temperature. When the hot gases from the furnace space pass through the opening **26**, it will heat the initial convection tubes to a high temperature. Accordingly, the majority, if not all, of the convection tubes at the rear of the drum also function as risers. On the other hand, the hot gases lose their heat as they move through the gas path, therefore, the convection tubes at the front end of the drum adjacent the hot gas outlet **34** will be relatively cool and will function as downcomers. Therefore, the water at the rear end of the drum will be high because all the tubes connected at that end function as risers. At the same time, the water at the front end of the drum will be lower because the majority, if not all, of the convection tubes function as downcomers. Accordingly, the boiler has a water level differential which will result in a substantial longitudinal water flow from the high end to the low end.

Hereinafter, I may refer to one end of the drum as the

hot or high end, and the other end as the low, or cool, or cold end. While in the drawings and in the description thus far I have referred to the hot or high end as being the rear of the drum, and the front as being the low or cool end, it should be understood that this could be reversed, or the drum could be disposed laterally. Accordingly, the terms "front," "rear," "lateral," "longidinal," "high," low," etc., are merely given as relative terms and should not be restrictively interpreted.

I connect an inlet pipe **60** to the upper drum which may extend from end to end. I also provide a baffle, shield, or shroud **62** in the gas path surrounding and protecting what I shall refer to as a section of what would otherwise be conventional convection tubes. This section or series of tubes, designated **64**, may extend from the edge **24** of the intermediate wall a suitable distance toward the front wall of the housing. The shield or wall **62**, together with the intermediate wall **22**, encloses this series of tubes so that they are otherwise shielded from the hot gases flowing through the convection space. Therefore, these tubes will be relatively cool and will tend to function as downcomers, rather than risers, to draw hot water from the high or hot end of the drum.

At the same time, the pipe **60** for make-up water may be formed to pass relatively adjacent this section of tubes, as shown in Figure 3. I provide a plurality of nozzles or jets or nipples **66** on the inlet pipe, one such nozzle for each tube of the masked or enclosed section, so that water from the inlet pipe will be ejected into the tubes **64**. The nozzles or jets are substantially less in diameter than the inside diameter of the tubes **64** so that an annular clearance **67** exists allowing hot water from the drum to be drawn down into the pipes **64**. It should be remembered that the make-up water from the inlet pipe **60** is relatively cold, while the water in the drum is relatively hot. Accordingly, the resulting mixture will be at an intermediate temperature. At the same time that I draw water out of the high end of the drum and pass it directly to the lower or mud drum, I also prevent the relatively cold water from the make-up or inlet pipe from directly contacting the tubes and the connections between the tubes and the drums which, due to the temperature differential, might result in damage, such as leaks, cracks, and the like.

I have only shown the section of tubes **64** taken from one row of the convection tubes, but in some cases I might use tubes from two or more rows. While it is not absolutely necessary that the convection tubes selected be on the furnace side of the upper drum, nevertheless, I prefer this arrangement because the water withdrawn in such tubes will more efficiently compensate for the excess hot water and steam supplied to the upper drum by the water wall tubes.

I also provide a baffle structure in the upper drum to control the water level. As shown in Figures 3 and 4, longitudinal baffles are provided along both sides of the upper drum. The baffles **70** along the furnace side of the drum shall be referred to as the furnace side baffles while the baffles **72** along the boiler side of the drum shall be referred to as the boiler side baffles, merely for purposes of designation.

In Figure 3, the water wall tube connections are shown at **48**, **50**, **52** and **54**. The furnace side baffles **70**, masking these openings or connections, include a main or lower baffle **74** which is connected at its lower edge by any suitable number of brackets **76** or the like, bolted or otherwise suitably secured to the wall of the drum, but at the same time providing a bottom opening or longitudinal slot **78** below the lower edge of the baffle **74**. The upper edge of this baffle may be held by any suitable brackets **80** or the like which are welded or otherwise secured to the inner surface of the drum. Spaced from and generally parallel to the upper edge of the baffle **74**, I provide an intermediate or second baffle **82** which may be held by suitable brackets **84** connected by riveting, welding, or otherwise, to the baffles **74** and **82**. This spaced relation provides a longitudinal slot or opening **86**, and on top I provide a top baffle or shield **88** which may be welded or otherwise secured along its upper edge to the inner surface of the drum, flush so as not to provide an opening and terminating in a lower portion **90** held by brackets or the like **92** by any suitable connection, such as welding or the like, providing an opening or longitudinal slot **94**.

As shown in Figure 2 and in lateral section in Figures 3 and 4, the furnace side baffles masking the outlet of the water wall tubes extend approximately the full length of the drum and cover the entire longitudinal row of entering water wall tubes. This is desirable because the water wall tubes will be hot at all times and will function as risers.

The boiler side baffles **72** on the other side include a lower baffle or plate **96** connected by a suitable bracket or the like at **98** to the inner surface of the drum and not providing an opening. The other end or side of this baffle is held by a suitable bracket **100** and a suitable manhole or inspection access may be covered by a plate **102** to allow access to the tubes under the baffle **96**.

The second or intermediate baffle **104** is held in spaced relation to the baffle **96** providing a return opening **106**. This baffle is held by brackets or the like **108** at its other end and defines a return opening **110** with a third baffle **112**. The upper end of this baffle may be bent or otherwise formed and held by suitable brackets **114** through any suitable connection in spaced relation to a fourth baffle **116** by suitable brackets, thereby providing another return opening or slot **118**. A top baffle or cover **120** is held in spaced relation by brackets or the like **122**, thereby providing an additional return opening **124**.

The boiler side baffles cover a greater arcuate distance of the inner surface of the drum to mask the opening of the convection tubes. It should be noted that the two sets of baffles, the boiler side baffles and the furnace side baffles, come together, as shown in Figure 3, adjacent the masked tubes **64** which are provided with jets of make-up water to draw hot water down from the high end of the drum.

While the furnace side baffles extend approximately the full length of the drum, I prefer that the boiler side baffles terminate, as at **126**, in substantial spaced relation to the front end of the drum at the low or cool end. The length of the boiler side baffles may be selected on the basis of the temperature of the gases flowing through the gas path causing the change over from risers to downcomers in the convection tubes.

A steam separator **128** may be mounted in the top of the drum, generally intermediate or between the ends of the drum, and held in place by suitable legs or struts **130**. The steam separator may include, in essence, a housing **132** enclosing a plurality of upwardly opening troughs or the like **134**, staggered in relation to each other and sloping from one end to the other. As shown, the separator has two banks of such tubes, each bank sloping toward a center sump **136** or the like, and the moisture deposited in the troughs after separation from the steam may be carried by a pipe **138** or the like which should extend longitudinally inside of the drum with a nozzle **140** at its end at the cold or low end of the drum projecting into a convection tube functioning as a downcomer. The bottom of the steam separator housing is relatively open so that the steam, on its way to a suitable steam outlet **142**, must pass through the staggered rows of troughs where the moisture carried in the steam is removed.

The drum may be provided with a chemical feed pipe **144** and a continuous blow down connection **146**, if desired, but these are unimportant to the invention.

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

Normally, a longitudinal water flow is set up in the upper drum of this type of boiler due to one end of the drum being relatively hot while the other end is relatively

cold. This hot and cold condition in the upper drum is set up by the arrangement of the drum and the convection and water wall tubes relative to the furnace space and gas path. The tubes at the hot end serve as risers, this being true of both the convection tubes and the water wall tubes. At the cold end, the water wall tubes will still serve as risers but the convection tubes will function as downcomers. At the hot end all the tubes bring water to the drum while at the cold end the convection tubes take water away from the drum. Therefore, one end will be high and the other low. This causes a longitudinal water flow.

This movement of the water in the drum causes a constant charge of water level in accordance with load variation and firing rate changes, independent of the water supplied to the boiler. At high loads or at rapid load acceleration, the water at the high or hot end will rise rapidly and will be higher than the water in the cold or low end. When the firing rate is reduced or when the load drops off, the level of the water in the upper drum tends to equalize again and on occasion it has been known to reverse itself. In any event, the variations in the level of the water, accentuated by bed water conditions, can and have become intolerable resulting in a very high carry-over of water in the steam, particularly when the boiler water has a foaming tendency. This sometimes has caused firing cut off by false low water reaction.

I have solved this problem by isolating a section of preferably convection tubes at the high end of the drum and discharging or ejecting cold make-up water into these tubes in a manner such that hot water from the hot end of the drum will be drawn down to form a relatively warm mixture, preventing damage. This mixture of hot boiler water and cold make-up water takes place at a point immediately below the shell of the drum and inside of the tube itself in such a manner that the hot water surrounds the cold feed water. This mixture, including hot water taken from the hot end of the drum, is then supplied to the lower or mud drum at a point where it may be immediately taken upwardly through the furnace water wall tubes and the convection tubes at the hot end of the drum, without flowing longitudinally in either drum.

The longitudinal baffle structure in the upper drum also controls the water level variation. The furnace side baffles are arranged so that the steam and water mixture discharged by the water wall tubes is directed upwardly along the inner surface of the drum and is then thrown back on top of the water level by the top deflector or baffle. In addition, at intermediate points I provide relief areas or slots or ports which allow the water to drop down at various intermediate points. This intermediate water relief eliminates the necessity of having all water separated out of the steam and water mixture moving longitudinally in the drum. The water may readily escape through the relief areas as well as below the bottom of the initial or main baffle **74** of the furnace side baffles. This is particularly true at the low or cool end of the drum where the water merely has to drop down through the downcomer convection tubes into the lower or mud drum again.

The same is also true of the boiler side baffles which direct the steam and water mixture along the inner surface of the drum up to the top where it is thrown back on top of the normal water level by the top plate or deflector or hood. The intermediate openings or relief areas allow the water to flow immediately toward the center of the drum without requiring it to flow the full length of the drum behind the baffles. I provide the boiler side baffles longitudinally from the hot or high end of the drum a substantial distance toward the low end, but at a suitable intermediate point I terminate them because the convection tubes at the low end will function as downcomers.

Water from the water wall tubes is allowed to flow to the masked convection tubes **64** through the openings **78** below the furnace side baffles. It should be understood that by my invention I provide a simple but reliable water level control for a hot water and steam drum. The parts required are relatively conventional. The baffling, nozzles and pipes may be easily purchased or fabricated. No extensive controls, other than those normally found on boilers and easily purchased, are required. At the same time, my unit is quite reliable and solves a problem, the need for which has been felt in this industry for many years.

While I have shown and described the preferred form and suggested several variations of my invention, it should be understood that suitable modifications, substitutions, alterations and changes may be made without departing from the invention's fundamental theme. For example, the exact type of firing is unimportant. Whether the boiler is referred to as longitudinal or lateral is also unimportant and the term "longitudinal" as used in the appended claims is purely relative. The baffles, pipes, boiler arrangement, steam separator and brackets might be otherwise than as shown. I, therefore, wish that my invention be unrestricted, except as by the appended claims.

I claim:

1. In a boiler for maintaining a relatively level water level in its upper drum, a housing having a longitudinal wall therein defining a generally parallel furnace space and gas path, an opening at one end of the wall allowing the gases developed in the furnace space to flow into the gas path, an outlet for the gas path for venting the hot gases, a water and steam system for the housing including an upper drum with a normal water level, the drum being disposed generally parallel to the furnace space and gas path and adapted to contain hot water and steam, water wall tubes positioned around the furnace space and convection tubes positioned in the gas path connected to the upper drum, the water wall tubes extending generally the length of the upper drum whereby relatively hot water and steam from these tubes enters the upper drum throughout the length thereof, the convection tubes also extending generally the length of the upper drum, a portion of the convection tubes adjacent the opening at the said one end of the wall being heated sufficiently by the hot gases entering the gas path that they act as risers and carry hot water and steam to one end of the upper drum and the remaining convection tubes acting as downcomers and draining water from the other end of the drum, thereby normally causing the water to be higher at the said one end of the drum than at the other resulting in a substantial longitudinal flow of water in the upper drum from the said one end to the other, a longitudinal section of the convection tubes adjacent the wall opening and connected to the upper drum below the normal water level being masked within the gas path from the rest of the convection tubes and shielded from the hot gases so that the tubes in the longitudinal section will otherwise tend to function as downcomers, a feed water pipe extending into the upper drum for supplying relatively cold make-up water to the system terminating in a plurality of nozzles, the nozzles extending into the tubes in the longitudinal section, an opening between each nozzle and its tube in the longitudinal section disposed in the upper drum so that the jet effect of make-up water from the nozzle will draw hot water from the upper drum down into the tubes in the longitudinal section to force a mixture of relatively cold make-up water from the supply pipe and relatively hot water from the upper drum into the convection tubes of the longitudinal section tending to lower the water level in the high end of the drum by withdrawing hot water from the high end and, at the same time, by supplying the make-up water down the tubes and not directly into the upper drum.

2. The structure of claim 1 further characterized in that each nozzle has a smaller outside diameter than the inside diameter of the masked tube into which it extends thereby providing an annular clearance between the outside of the nozzle and the inside of the tube, the annular clearance defining the opening between each nozzle and its tube in the longitudinal section through which hot water will be drawn from the upper drum due to the jet effect of the make-up water from the nozzle.

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