Nov. 2, 1948. C. H. BERGQUIST 2,452,716

DEAERATING HEATER

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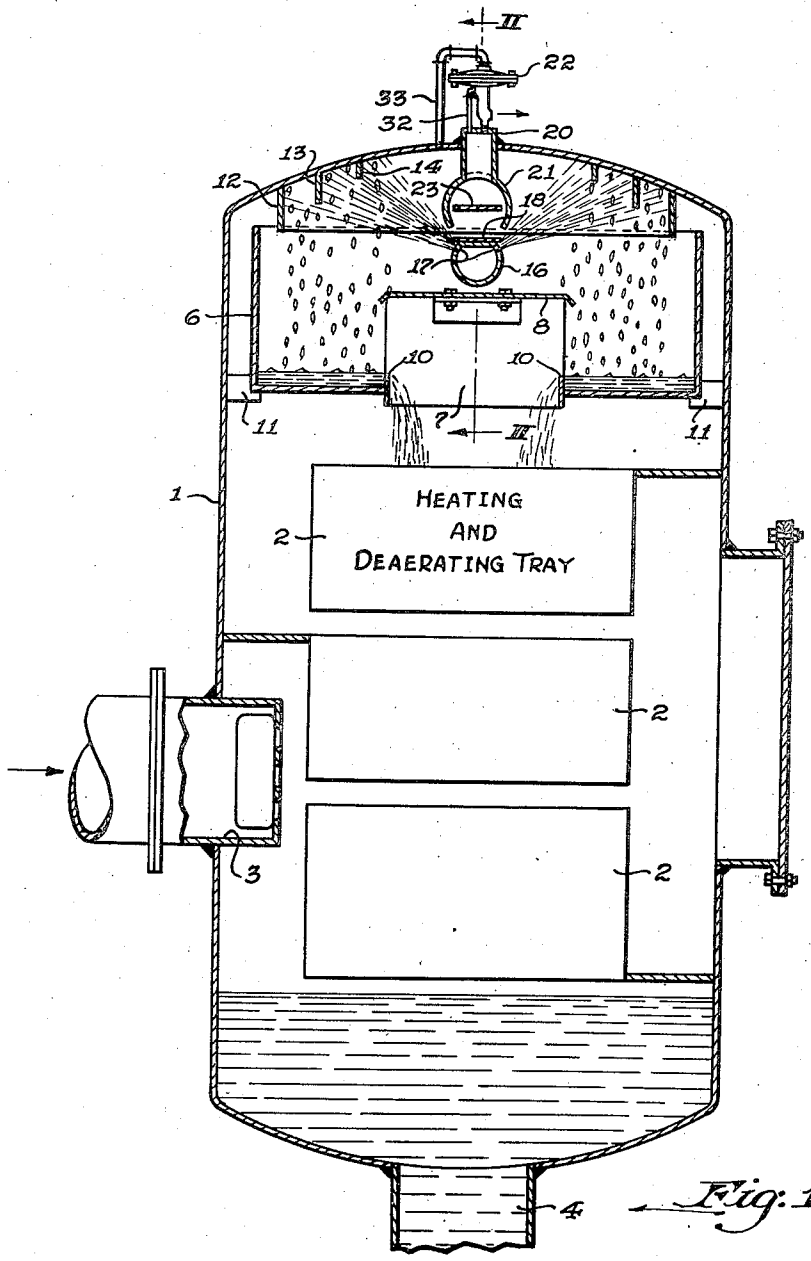


Fig. 1.

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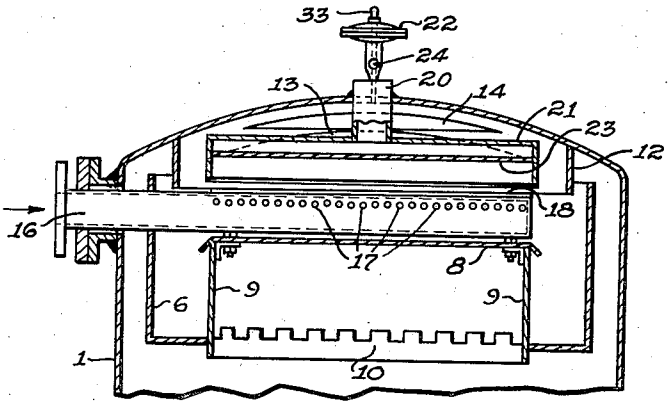


Fig. 2.

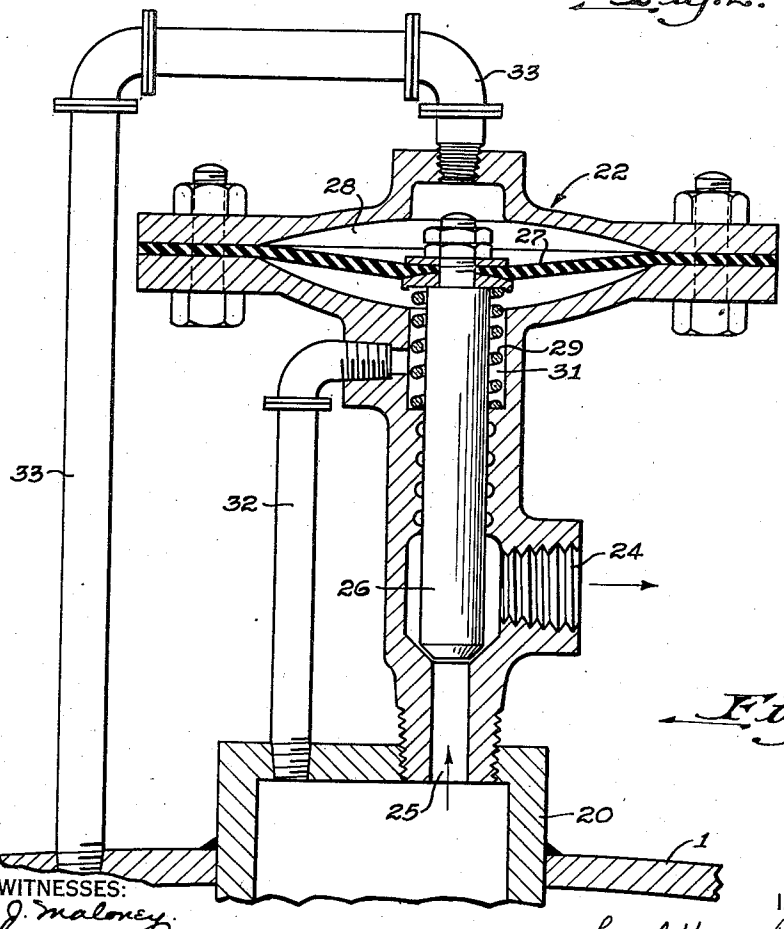


Fig. 3.

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UNITED STATES PATENT OFFICE

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DEAERATING HEATER

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Application August 4, 1945, Serial No. 608,999

18 Claims. (Cl. 183—2.5)

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This invention relates to a method and apparatus for heating and deaerating boiler feedwater by means of steam.

The reasons for deaerating boiler feedwater are well known and need not be repeated here. During the operation the water is heated by steam, and, as the temperature of the water approaches the saturation temperature, the solubility of such gases as oxygen and carbon dioxide in the water approaches zero. These non-condensible gases therefore are liberated from the water and are swept to the vent of the deaerating tank by the flow of steam. Since a considerable flow of steam is required to sweep the gases out of the deaerating tank, it is the customary practice in conventional deaerating heaters to induce this flow by the use of a vent condenser at the point at which the tank is vented. As the steam and the gases being swept with it pass through the vent condenser the steam is condensed by the incoming cold feed-water while the gases escape through the vent. The objections to vent condensers are that they are expensive to construct and to maintain, and they increase the size and weight of the deaerating equipment.

It is among the objects of this invention to provide a method of deaerating water according to which substantially all of the steam used in heating the water is condensed inside the deaerating tank without employing a vent condenser, and according to which steam is automatically prevented from escaping from the tank regardless of pressure variations inside the tank. Other objects are to provide a deaerating heater which has no need for a vent condenser and which automatically regulates the flow of steam-free non-condensible gases from the tank in accordance with pressure changes therein.

In apparatus constructed in accordance with this invention a spray pipe is mounted inside a deaerating tank adjacent the entrance to the vent through which the non-condensible gases escape. Below this pipe the tank is provided with an inlet for steam for heating water entering the tank through the spray pipe. The pipe is positioned to spray a curtain of water across the entrance to the vent in order to separate the steam from the vent. The water curtain need not be a solid sheet of water, but may be formed from a series of laterally spaced sprays that are close enough together so that steam will not pass between them and create cross flows. The flow or in-rush of steam toward the curtain carries with it the non-condensible gases which were released by the heating, since they can not flow counter-

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current to the large, sweeping flow of steam. This curtain is so related to the gas vent entrance that the gases liberated from the heated water can enter the vent only by passing through a limited portion of the water curtain, and this portion is an area of the curtain where substantially all of the steam reaching that area is condensed before it can pass through the curtain. Consequently, nothing but non-condensible gases pass through the water curtain into the vent. The area of the curtain that closes the vent entrance is in the coldest part, or nearly the coldest part, of the curtain, which is adjacent the spray pipe. The boundaries of this area are defined by the walls of the opening that gives access to the vent. Arriving at this area, the coldest spot in the heater, no further flow is induced by temperature differences or condensation. To bleed off the non-condensible gases carried to the entrance to the vent, a lower pressure is maintained within the vent. To avoid a pressure drop across the curtain to the vent great enough to blow water and steam out through the vent, means is provided for maintaining the pressure drop at the minimum necessary for bleeding off the non-condensible gases. This may be accomplished by restricting the outlet of the vent, preferably by a valve so that the amount of restriction can be changed to compensate for changes in pressure inside the tank. Most suitably the valve is automatically controlled by pressure variations inside the tank so as to maintain the pressure drop across the curtain substantially constant regardless of those variations in pressure.

The preferred embodiment of the invention is illustrated in the accompanying drawings in which Fig. 1 is a vertical section through my deaerating heater: Fig. 2 is a fragmentary vertical section turned 90° from the section in Fig. 1; and Fig. 3 is an enlarged vertical section through the control valve on top of the tank.

Referring to Fig. 1 of the drawings, a deaerating tank 1 is provided in its central portion with the usual heating and deaerating trays 2, the details of which are not shown because they may be of any conventional form. Cold boiler feedwater enters the upper end of the tank and trickles down through the trays while steam, admitted through an opening 3 in the side of the tank, flows upwardly through the water in contact with it for heating it. In place of trays 2, the water could be heated by spraying steam into it, as is well known. The bottom of the tank forms a storage section or reservoir for water that has been heated in the tank, and the tank is provided

with an outlet 4 from which the water is pumped to boilers. The usual automatic controls (not shown) may be provided.

Mounted in the tank above the top tray is a vertical cylinder 6 that is spaced from the side and top of the tank and that has a bottom wall provided with a large central opening 7 above which a rectangular plate 8 is supported by upright end plates 9. At the opposite sides of this opening there are serrated or notched strips 10 by which the flow of water over the sides of the opening is distributed throughout the length of those sides. The cylinder may be supported from the side of the tank by circumferentially spaced members 11. Extending downward a short distance into this cylinder from the top of the tank is a cylindrical baffle 12 inside of which two spaced pair of parallel straight baffles 13 and 14 are secured to the top of the tank. The cold feedwater enters one side of the tank and is conducted diametrically across it through a horizontal spray pipe 16 disposed above plate 8 as shown in Figs. 1 and 2. This pipe is provided with two parallel rows of closely spaced jets 17 extending along it for spraying the water in two sheets upwardly and outwardly in opposite directions against the straight and cylindrical baffles. The water flows from these baffles down into cylinder 6 and out through its bottom opening and onto the top tray 2. The upper wall of the spray pipe between the two rows of jets preferably is flat and may be covered by a flat plate 18 that projects a short distance laterally from the pipe to control the upper sides of the two sheets of water so that they will not spray up into the vent about to be described.

The center of the top of the tank is provided with an opening in which a short vertical vent pipe 20 is mounted. The lower end of this pipe communicates with the top of a narrow gas-receiving hood 21 extending horizontally across the tank directly above the spray pipe to which it is parallel. The bottom of this receiver or hood is provided with a long rectangular opening which forms the entrance to the vent. The lower side edges of the hood, which form opposite sides of the vent entrance, are so positioned relative to the spray jets in the pipe that the sheets of water issuing therefrom flow outwardly across those edges and thereby form a water curtain that closes the entrance to the vent. It will be observed that it is this part of the curtain of water that has the lowest temperature because it is closest to the spray pipe where the water is coldest, so the released non-condensible gases will be concentrated in this zone.

In accordance with this invention the distance from the pipe that the vent entrance extends out along the water curtain is limited to an area of the curtain that will condense substantially all of the steam reaching it before any steam can pass through the curtain. In other words, the distance between each row of spray pipe jets and the adjacent lower side edge of gas-receiving hood 21 is quite small. If this distance were great, by the time the water reached the lower side edges of the gas receiver its temperature would have been increased to such a point that the flow of steam and non-condensibles near the edges of the hood would be downwardly toward the colder spray pipe, thereby inducing cross currents that would interfere with proper venting of the gases. That is, with cross flows, more steam must be vented in order to sweep out the non-condensible gases. Also, when the spray pipe is too far from

the hood, the pressure drop required to sweep the gases collecting around the pipe up to the vent becomes so great as to draw steam through the water curtain and into the hood. Diffusion of the gases backwardly in the steam flow will occur otherwise. The coldest part of the water curtain is the end point of steam condensation, and unless this is the only area of the curtain that separates the steam from the vent, cross flows will develop which will require venting of steam in order to sweep out the non-condensible gases.

If the angle between the diverging sheets of water were changed from that shown, the width of the vent entrance would have to be changed accordingly in order for its side edges to be located the same distance from the spray pipe as before. The distance between the spray pipe and the lower edges of the hood will not be the same for all installations, the proper distance for any given tank depending on the water temperature and the water and steam pressures employed in the tank.

Even with a restricted entrance to the vent closed by a curtain of water, if there is a severe pressure drop across the portion of the curtain closing the entrance, the rush of steam to that area will be so great that it may blow some of the steam and water out of the vent. To prevent this from happening, the pressure drop across the curtain at the vent entrance is controlled so that it will be no more than enough to cause the non-condensible gases to flow into hood 21 from which they are bled off to the atmosphere. This is accomplished by restricting the outlet of the vent, preferably controllably by means of a valve 22, so that the pressure in the hood will be held nearly as high as that inside the rest of the tank. This valve can be automatically controlled by the pressure inside the tank in order to further restrict the passage through the valve as the pressure in the tank increases. This will raise the pressure in the hood and thereby keep the pressure drop into the hood substantially constant. To equalize the pressure drop along the length of the hood a horizontal baffle plate 23 is mounted inside the hood with its sides spaced therefrom.

As shown in Fig. 3, the body of the valve is screwed into the top of vent pipe 20, and is provided at its lower end with an inlet passage 25 communicating with an outlet 24 open to atmosphere. Above the inlet is an axial bore in which a valve stem 26 is slidably mounted. The lower end of this stem is tapered to fit on a valve seat at the top of the inlet passage. The upper end of the stem is secured to the center of a flexible diaphragm 27 extending across a chamber 28 in the valve body. This diaphragm is urged upwardly by a coil spring 29 on the stem compressed between the diaphragm and the bottom of a recess 31 encircling the upper portion of the stem. This recess is connected by a pipe 32 to the top of vent pipe 20. Another pipe 33 connects the top of chamber 28 with the top of the tank at one side of the vent pipe.

When this deaerating heater is operating, fluid pressure in the tank acts through pipe 33 to force diaphragm 27 down against the resistance of spring 29 and thereby moves the valve stem toward its seat. This restricts the fluid passage through the valve so that the pressure in hood 21 and vent pipe 20 is built up. This pressure, acting through pipe 32, keeps the diaphragm from bending down far enough to close the valve. The parts of the valve are so proportioned that the desired pressure difference will be maintained

between the inside of hood 21 and the inside of the tank surrounding it. If the pressure in the tank increases, valve stem 26 will be moved downwardly still further, thereby further restricting the valve passage and increasing the pressure in the hood so that the pressure drop into the hood will remain substantially constant. A reduction of pressure in the tank will allow spring 29 to move the valve stem upwardly, thus opening the valve wider and reducing the pressure in the hood to the point where the pressure drop into it will be the same as before. The valve therefore automatically regulates the vent so that it will pass a controlled amount of gases under varying pressure conditions inside the tank.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. In the method of deaerating water by heating it with steam in a tank having a vent for escape of non-condensible gases in the water, the steps comprising introducing said water into the tank in the form of a curtain, and separating the steam from the vent by means of only the coldest area of said water curtain which condenses substantially all of the steam reaching it before any steam can pass through the curtain.

2. In the method of deaerating water by heating it with steam in a tank having a vent for escape of non-condensible gases in the water, the steps comprising introducing said water into the tank in the form of a curtain, separating the steam from the vent by means of only the coldest area of said water curtain where substantially all of the steam reaching that area is condensed before it can pass through the curtain, and maintaining the pressure drop across said area of the curtain at the minimum necessary for bleeding off the non-condensible gases that have passed through it.

3. In the method of deaerating water by heating it with steam in a tank having a vent for escape of non-condensible gases in the water, the steps comprising introducing said water into the tank in the form of a curtain, separating the steam from the vent by means of said water curtain, restricting the portion of the curtain through which all of said gases must pass in order to enter the vent to the coldest area where substantially all of the steam reaching that area is condensed before it can pass through the curtain, restricting the vent to hold the pressure drop across said portion of the curtain at the minimum necessary for bleeding off the non-condensible gases that have passed through it and varying said vent restriction in accordance with pressure variations inside the tank, whereby to maintain said pressure drop substantially constant.

4. A deaerating heater comprising a deaerating tank having a vent for escape of non-condensible gases, and a spray pipe inside the tank adjacent the entrance to the vent, the tank being provided below the spray pipe with an inlet for steam, said pipe being adapted to be connected to a source of water outside the tank and being positioned to spray a curtain of water across said vent entrance to separate the steam from the vent, the entrance to the vent being restricted and

being closed by the coldest part of said water curtain next to the pipe, and the distance said vent entrance extends out along said coldest part of the curtain being limited to an area of the curtain having substantially uniform temperature so that substantially all of the steam reaching that area is condensed before it can pass through the curtain.

5. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a horizontal hood extending across the inside of the tank with its top communicating with said vent, the bottom of the hood being provided with a long narrow opening forming the entrance to the vent, and a spray pipe in the tank extending lengthwise of said hood opening and adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam, said pipe being located close to said hood and positioned to spray a curtain of water across said hood opening to separate the steam from the vent, and said opening being narrow enough to confine it to the coldest area of the curtain which will condense substantially all of the steam reaching it before the steam can pass through the curtain.

6. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a horizontal hood extending across the inside of the tank with its top communicating with said vent, the bottom of the hood being provided with a long narrow opening forming the entrance to the vent, and a spray pipe in the tank extending lengthwise of said hood opening and adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam, said pipe being located close to said hood below the center of its opening and being provided with two sets of closely spaced spray jets for spraying sheets of water outwardly across the opposite side edges of said hood opening to form a curtain of water closing said opening, and the width of said water curtain between said opposite edges of said opening being small enough that substantially all of the steam reaching that area of the curtain will be condensed before it can pass through the curtain.

7. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a horizontal hood extending across the inside of the tank with its top communicating with said vent, the bottom of the hood being provided with a long narrow opening forming the entrance to the vent, and a spray pipe in the tank extending lengthwise of said hood opening and adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam, said pipe being located close to said hood below the center of its opening and being provided with two sets of closely spaced spray jets for spraying sheets of water outwardly across the opposite side edges of said hood opening to form a curtain of water closing said opening, and the distance between the hood and said pipe being small enough that the pressure drop into the hood required for venting non-condensible gases from close to the pipe will be insufficient to vent an appreciable amount of steam with the gases.

8. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a horizontal hood extending across the inside of the tank with its top communicating with said vent, the bottom of the

hood being provided with a long narrow opening forming the entrance to the vent, a horizontal baffle member mounted in the hood above the center of said opening and extending lengthwise of it, and a spray pipe in the tank extending lengthwise of said hood opening and adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam, said pipe being located close to said hood and positioned to spray a curtain of water across its opening to separate the steam from the vent, and said opening being narrow enough to confine it to an area of the curtain where substantially all of the steam reaching that area is condensed before it can pass through the curtain.

9. A deaerating heater comprising a deaerating tank having a vent for escape of non-condensible gases, a spray pipe inside the tank adjacent the entrance to the vent, the tank being provided below the spray pipe with an inlet for steam, said pipe being adapted to be connected to a source of water outside the tank and being positioned to spray a curtain of water across said vent entrance to separate the steam from the vent, the entrance to the vent being restricted and being confined to the coldest portion of said curtain next to the pipe where substantially all of the steam reaching that portion is condensed before it can pass through the curtain, and means for maintaining the pressure drop across said portion of the curtain at the minimum necessary for bleeding off the non-condensible gases that have passed through it.

10. A deaerating heater comprising a deaerating tank having a vent for escape of non-condensible gases, a spray pipe inside the tank adjacent the entrance to the vent, the tank being provided below the spray pipe with an inlet for steam, said pipe being adapted to be connected to a source of water outside the tank and being positioned to spray a curtain of water across said vent entrance to separate the steam from the vent, the entrance to the vent being confined to the coldest portion of said curtain where substantially all of the steam reaching that portion is condensed before it can pass through the curtain, and a throttling valve restricting the outlet of the vent to hold the pressure drop across said portion of the curtain at the minimum necessary for bleeding off the non-condensible gases that have passed through it.

11. A deaerating heater comprising a deaerating tank having a vent for escape of non-condensible gases, a spray pipe inside the tank adjacent the entrance to the vent, the tank being provided below the spray pipe with an inlet for steam, said pipe being adapted to be connected to a source of water outside the tank and being positioned to spray a curtain of water across said vent entrance to separate the steam from the vent, the entrance to the vent being confined to a portion of said curtain where substantially all of the steam reaching that portion is condensed before it can pass through the curtain, a valve restricting the outlet of the vent to hold the pressure drop across said portion of the curtain at the minimum necessary for bleeding off the non-condensible gases that have passed through it, and means controlled by the pressure in the tank for regulating said valve whereby to maintain said pressure drop substantially constant regardless of pressure variations in the tank.

12. A deaerating heater comprising a deaerating tank having a vent for escape of non-condensible gases, a spray pipe inside the tank adjacent the entrance to the vent, the tank being provided below the spray pipe with an inlet for steam, said pipe being adapted to be connected to a source of water outside the tank and being positioned to spray a curtain of water across said vent entrance to separate the steam from the vent, the entrance to the vent being confined to a portion of said curtain where substantially all of the steam reaching that portion is condensed before it can pass through the curtain, a movable valve member for restricting the outlet of the vent, a spring urging said member toward wide open position, a flexible diaphragm connected to said member, means putting one side of the diaphragm in communication with the inside of said vent to assist the spring, and means putting the opposite side of the diaphragm in communication with the inside of the tank outside of the vent to urge said valve member toward closed position, whereby the pressure drop from the tank into the vent can be held at the minimum necessary for bleeding off non-condensible gases regardless of pressure variations in the tank.

13. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a horizontal hood extending across the inside of the tank with its top communicating with said vent, the bottom of the hood being provided with a long narrow opening forming the entrance to the vent, and a spray pipe in the tank extending lengthwise of said hood opening and adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam, said pipe being located close to said hood and being positioned to spray a curtain of water across the opposite side edges of said hood opening to close it, and the width of the area of said water curtain between said opposite edges of said opening being small enough that substantially all of the steam reaching that area of the curtain will be condensed before it can pass through the curtain.

14. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a hood inside the tank with its top communicating with said vent, the bottom of the hood being provided with a restricted opening forming the entrance to the vent, and a spray pipe in the upper portion of the tank adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam to heat water delivered by the spray pipe, said pipe being located close to the center of said hood opening and being provided with spray jets for spraying a curtain of water outwardly across the edge of said opening to close it, and the width of the area of said water curtain closing said opening being materially less than the inside width of said hood and small enough that substantially all of the steam reaching that area of the curtain will be condensed before it can pass through the curtain.

15. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a hood inside the tank with its top communicating with said vent, the bottom of the hood being provided with a restricted opening forming the entrance to the vent, and a spray pipe in the upper portion of the tank adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam to heat water delivered by the spray pipe, said pipe being lo-

cated close to the center of said hood opening and permanently closing the central portion of said opening to restrict its effective area still more, said pipe being provided with spray jets for spraying a curtain of water outwardly across the edge of said opening to close it, and the width of the area of said water curtain closing said opening being materially less than the inside width of said hood and small enough that substantially all of the steam reaching that area of the curtain will be condensed before it can pass through the curtain.

16. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a spray pipe in the upper portion of the tank adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam to heat the water delivered by said pipe and liberate non-condensible gases, and a gas receiver mounted in the upper portion of the tank in communication with said vent and having a narrow inlet opening through which there is a slight pressure drop from the tank into the receiver, said pipe being provided with a plurality of closely spaced spray jets in position to spray a curtain of water across said narrow inlet opening to close it with the coldest part of the water curtain in order to separate the steam from the inside of the receiver, and the width of the receiver inlet opening being narrow enough to restrict flow through the opening to non-condensible gases free of an appreciable amount of steam.

17. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a spray pipe in the upper portion of the tank adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam to heat the water delivered by said pipe and liberate non-condensible gases, and a gas receiver mounted in the upper portion of the tank in communication with said vent and having a narrow inlet opening through which there is a slight pressure drop from the tank into the receiver, said

pipe being provided with a plurality of closely spaced spray jets below the receiver in position to spray a curtain of water across the edge of said narrow inlet to close it with the coldest part of the water curtain in order to separate the steam from the inside of the receiver, and the width of the receiver inlet opening being only great enough to pass non-condensible gases free of an appreciable amount of steam.

18. A deaerating heater comprising a deaerating tank having a vent in its top for escape of non-condensible gases, a spray pipe in the upper portion of the tank adapted to be connected to a source of water outside the tank, the tank being provided below the spray pipe with an inlet for steam to heat the water delivered by said pipe and liberate non-condensible gases, and a gas receiver mounted in the upper portion of the tank in communication with said vent and having a narrow inlet opening through which there is a slight pressure drop from the tank into the receiver, said pipe being provided with a plurality of closely spaced spray jets below said narrow inlet opening in position to spray a curtain of water outwardly across the edge of said opening to close it with the coldest part of the water curtain in order to separate the steam from the inside of the receiver, and the width of the receiver inlet opening being only great enough to pass non-condensible gases free of an appreciable amount of steam.

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