Dec. 22, 1953 G. W. EVANS, JR., ET AL 2,663,547

CONDENSER DEAERATOR

Filed May 25, 1949 3 Sheets-Sheet 1

Fig. 1.

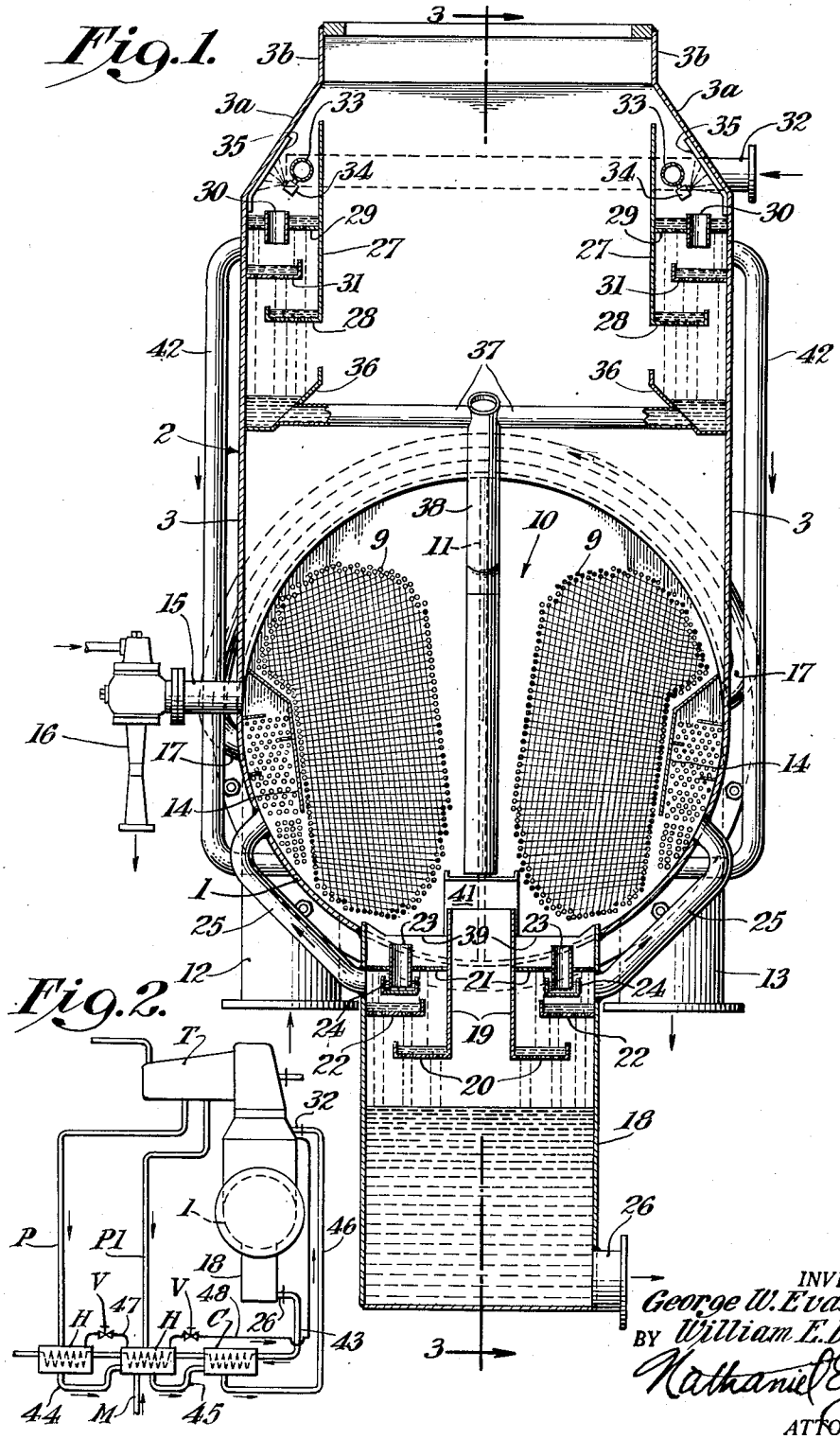


Fig. 2.

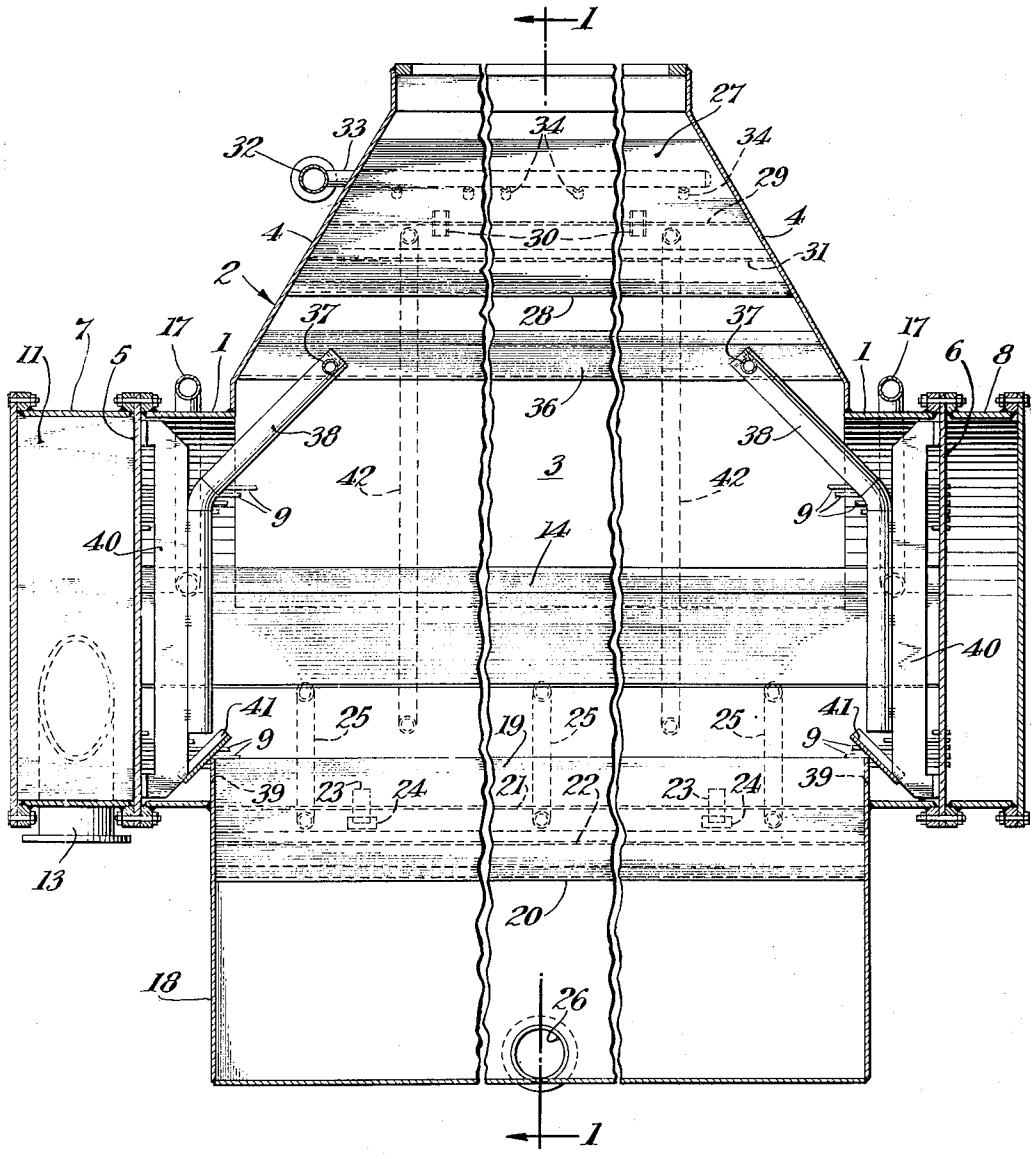
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Fig. 3.



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Fig. 4.

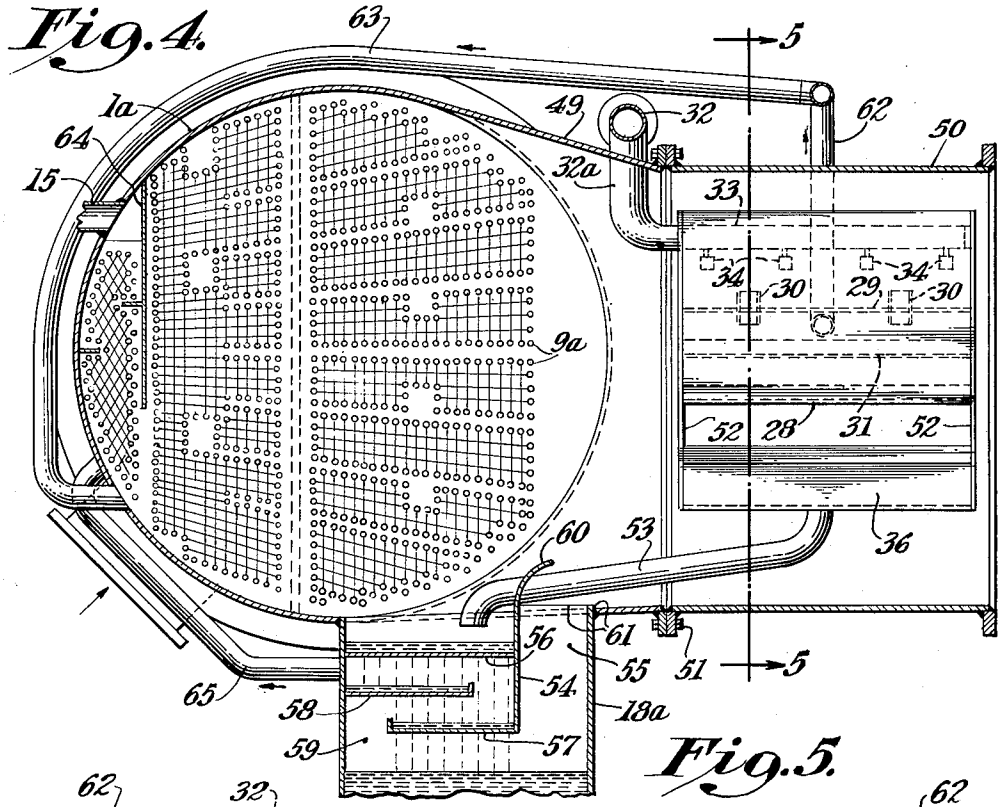
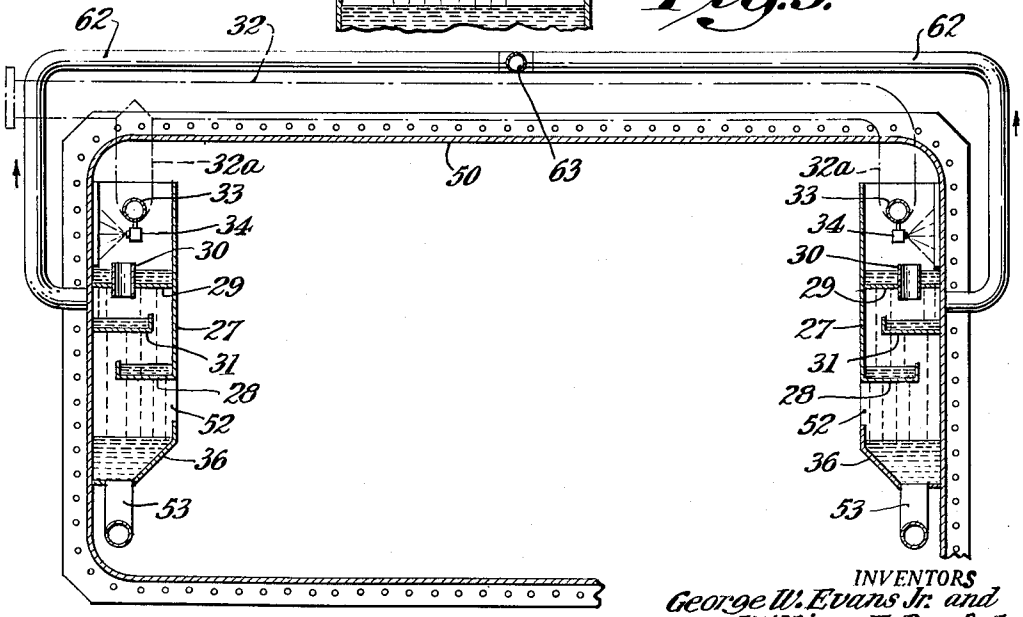


Fig. 5.



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CONDENSER DEAERATOR

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Application May 25, 1949, Serial No. 95,352

6 Claims. (Cl. 257—43)

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This invention relates to improvements in steam power plant equipment and more particularly to improved condensing and deaerating apparatus for such a plant. A steam power plant employing a turbine normally includes, in addition to a boiler or steam generator, a series of feed water heaters and a surface condenser for the exhaust steam from the turbine. Steam condensate is conducted from the hot well of the condenser through the feed water heaters in series and returned to the steam generator. Within the heaters the condensate is heated by steam which is tapped from one or more stages of the turbine. Such steam is condensed in its passage through the heaters, and the condensate is also returned to the steam generator. This condensate, together with make-up water, as required for the generator, should be deaerated before introduction to the generator and it is customary to provide a separate deaerator unit for that purpose. The deaerated water is pumped from said unit through one or more heaters to the boiler and it is often required that the unit be mounted at a high elevation above the pump in order to afford sufficient head to ensure proper operation of the pump. Such a unit with its mounting and connections is an objectionably costly part of the power plant equipment.

An important object of the present invention is to provide for satisfactory embodiment of deaerating apparatus for the heater condensate and/or the make-up water in the surface condenser unit and thereby simplify the plant equipment and reduce its cost.

A further object of the invention is to provide a combined steam condensing and deaerating apparatus devised to obtain advantageous cooperation of condenser features with the deaerating means.

A still further object of the invention is to provide an improved condensing and deaerating unit wherein one or more deaerating devices are located at the exhaust steam inlet passage of the condenser and are subject to the same vacuum or low pressure condition as that existing within the condenser and wherein the usual air-offtake means of the condenser is made to serve for exhausting the air from a charge of condensate from the feed water heaters and also from make-up water, and wherein the deaerated charge is conducted to the hot well of the condenser.

Further objects and advantages of the invention will appear from the following description taken in connection with the accompanying drawings.

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In the drawings:

Figure 1 is a vertical sectional view of a condenser unit embodying the invention, the section being on the line 1—1 of Figure 3;

Fig. 2 is a diagrammatic view of a portion of a steam power system embodying the invention;

Fig. 3 is a vertical section on the line 3—3 of Fig. 1, on a reduced scale and partly broken away;

Fig. 4 is a view similar to Fig. 1 showing the invention embodied in a condenser having an inlet passage arranged to deliver the steam laterally to one side of the tube nest; and

Fig. 5 is a vertical section on the line 4—4 of Fig. 4.

The structure of the condensing and deaerating unit shown in Figs. 1 and 3 includes a cylindrical shell 1 horizontally disposed and formed at its upper side with a dome portion 2 which provides an inlet passage for exhaust steam from the turbine and also provides support and housing for deaerating devices which will be described hereinafter. The dome is rectangular in horizontal section and has opposite side walls 3 which are vertical for most of their height and extend tangentially upward from the body of the shell, as shown in Fig. 1. These walls have upwardly converging upper portions 3a which terminate in vertical portions 3b. Opposite end walls 4 of the dome converge upwardly for most of their height and terminate in vertical portions similar to those 3b of the side walls and form therewith a frame for connection with the exhaust opening of the turbine.

The opposite ends of the shell are flanged and have secured thereto respectively, tube sheets 5 and 6 and water boxes 7 and 8. Tubes 9 connect the tube sheets and are arranged in a nest comprising two equal banks formed and spaced to define therebetween a vertical central lane 10. This lane tapers downwardly and is flared at its upper and lower ends. Water box 7 has a vertical, diametrically disposed pass partition 11 and two nozzles 12 and 13. Referring to Fig. 1, the nozzle 12 admits cooling water to the compartment at the left of the pass partition for flow through the tubes of the left-hand tube bank to the water box 8 and thence in reverse direction through the tubes of the right-hand bank to the water box compartment at the right of the partition and out through the nozzle 13. Thus, the condenser is a two-pass one but the number of passes may be varied by appropriate arrangements of pass partitions and nozzles.

Each tube bank has an air-offtake baffle 14 ex-

tending inwardly from the shell and downwardly into an intermediate portion of the bank. An air-offtake nozzle 15 is attached to the shell and leads outwardly from the space beneath the baffle 14 of the left-hand tube bank, with reference to Fig. 1. A steam jet ejector 16 is connected to the nozzle 15 to maintain a desired vacuum. Said ejector may deliver to the usual inter-and-after condenser combination, not shown. Offtake equalizing pipes 17 lead from the space beneath the baffle 14 of the right-hand bank, over the upper side of the end portions of the shell and downwardly to the space beneath the left-hand baffle 14 at a lower level than the offtake nozzle 15 so that non-condensible gases may be withdrawn substantially equally from both banks through the nozzle 15.

Beneath the shell 1 there is a hot well 18 which extends along the major portion of the shell length and is of quite substantial depth and width to give it relatively large storage capacity. Within the upper portion of the hot well there are deaerating means for the condensate drained from the tube bank. Such means includes a pair of plates 19 extending horizontally the full length of the hot well and secured thereto and arranged in spaced vertical planes. These plates define a steam passage which is a continuation of the steam lane 10 between the tube banks. Along their lower edges said plates have outwardly extending perforated shower trays 20 with upturned outer edges. These trays terminate short of the adjacent side walls of the hot well. Two other perforated shower trays or decks 21 extend from the plates 19 to the adjacent side walls of the hot well. At a level substantially midway between the trays 20 and 21, the opposite side walls of the hot well bear perforated shower trays 22 which extend inwardly and terminate short of the plates 19 and have upturned inner edges. All of said shower trays extend the full length of the hot well, and are welded or otherwise suitably secured to the adjacent walls of the hot well and the plates 19. The uppermost trays 21 have overflow down pipes 23 whose lower ends project into cup-shaped condensate traps 24 to prevent steam from passing through the pipes. Air offtake pipes 25 lead from opposite sides of the hot well, at points between the decks 21 and 22, to the shell and open into the tube banks at points adjacent the lower edges of the baffles 14. The hot well has a condensate discharge nozzle 26 leading from its lower portion.

Incorporated and coacting with the condensing apparatus there is apparatus for deaerating a charge of condensate from the feed water heaters and/or boiler make-up water. This deaerating apparatus includes a pair of deaerating devices mounted within the dome along the opposite side walls 3 and symmetrically arranged with respect to a vertical central plane. Each of said devices includes a plate 27 disposed in the vertical plane of the dome wall 3b and spaced downwardly therefrom. Along its lower edge said plate has an outwardly extending perforated shower tray 28 terminating short of said wall 3 and having an upturned outer edge. At an intermediate level in the height of the plate 27, there is a perforated shower tray or deck 29 which extends from the plate to the wall 3 and is provided with overflow downpipes 30 open at both ends. At a level between the tray 28 and the deck 29 there is a perforated shower tray 31. This tray extends inwardly from the wall 3, terminates short of the plate 27 and has an upturned

inner edge. The plate 27 and all of said trays extend the full distance between the dome walls 4 and are welded or otherwise suitably secured to the walls 3 and 4 and the plate 27.

At the outer side of one of the walls 4 there is a pipe 32 to deliver the charge to the deaerator devices. This pipe has two branches 33 each of which extends throughout most of the length of one of the deaerator devices within the chamber defined by the dome walls and the plate 27. Within each device the respective pipe 33 is spaced above the tray 29 and has a row of spray nozzles 34 directed upwardly and outwardly toward an impingement plate or wear plate 35 secured to the wall 3a.

A pair of collecting troughs 36 for the deaerated liquid extend along the inner side of the dome walls 3 and underlie the deaerator devices. Each trough 36 is spaced downwardly from the tray 28 thereabove and extends the full distance between the dome walls 4. The troughs are welded or otherwise suitably secured to the dome walls 3 and 4. A pair of cross pipes 37 connect the two troughs, near the ends thereof, and a drain pipe 38 leads downwardly from each cross pipe and through the lane 10 between the tube banks. The end walls of the hot well extend upwardly into the shell and form weirs 39 which, together with the end portions of the shell and the tube sheets, define wells to receive the liquid from the pipes 38. The liquid overflows the weirs and falls upon the shower trays 21 within the hot well. Between said trays the walls of the hot well are high enough to prevent overflow of the liquid into the space between the plates 19. Within each end portion of the shell there is a vertical strip 40 welded or otherwise suitably secured to the adjacent tube sheet and welded along one of its vertical edges to the adjacent drain pipe 38 to support the latter. A downwardly and outwardly inclined plate 41 is also welded to the lower end portion of each strip 41 in a position to receive the discharge from the drain pipe 38 and direct it into the adjacent well.

Air offtake pipes 42 lead from the space between the trays 29 and 31 of each deaerator device within the dome. These pipes extend downwardly outside of the shell and open into it at points adjacent the air-cooling tubes beneath the baffles 14.

In the operation of the apparatus, exhaust steam passes from the turbine T (Fig. 2) into the condenser, and condensate is withdrawn from the hot well 18 through a pipe 43 and passed in succession through the tube side of a drain cooler C and a plurality of feed water heaters H, enroute to the steam generator, not shown. Steam is tapped from one or more stages of the turbine through pipes P and P^1 and passed to the shell side of the heaters H respectively, to heat the water flowing through the tube side of the heaters by indirect heat exchange. Condensate of the steam within the heaters is passed through a pipe 44 from one heater to another, and through a pipe 45 to the drain cooler C and thence through a pipe 46 to the pipe 32. This pipe delivers said condensate to the deaerating devices within the dome of the condenser. Make-up water may be supplied, as needed, to the system at any suitable point. For example, it may, as shown, be supplied through a pipe M to the shell side of the second heater H.

The liquid delivered by pipe 32 will be passed through the pipes 33 and, within each deaerator device, the liquid will be discharged through the

spray nozzles 34. Usually, a vacuum ranging from 26 to 29 inches will be maintained within the condenser and this vacuum will exist within each deaerator owing to the fact that same is open, above and below its plate 27, to the interior of the condenser. Since the liquid discharged by the nozzles will, in most cases, be hotter than the steam passing through the condenser dome, at least some of the discharged liquid will be vaporized under the low pressure within the deaerator chambers and the vapor will scatter the unvaporized portion of the liquid and thereby assist in its deaeration. The liquid portion of the charge will be further divided by showering from tray to tray within the deaerators and be collected by the troughs 36. The vaporized portion can escape through the space between the upper edge of the plates 27 and the dome wall 3a to the stream of exhaust steam from the turbine. Steam can also flow across the showers between the troughs 36 and the trays 28 and also across the showers between the trays and thus heat the descending liquid. The plates 27 serve as shields and prevent the water from being swept from the trays by the inrushing stream of steam from the turbine. Air will be withdrawn through the pipes 42 then across the condenser tubes under the baffles 14 and out through the air off-take nozzle 15 of the condenser. In some cases, as for example, when all or a substantial portion of the charge is make-up water, the charge may not vaporize within the deaerating devices, due to lack of sufficient heat within the charge. However, the charge reduced to a divided state within the deaerators, will still be subjected to heating and deaeration both there and later within the hot well.

The deaerated liquid of the charge collected by the troughs 36 will be drained through the pipes 37 and 38 to the wells at the ends of the condenser shell and will flow over the weirs 39 to the shower trays or decks 21. There, the liquid will mingle with the condensate from the surface of the condenser tubes and be showered therewith from trays 21, 22 and 20. Thereby, said liquid will be subjected to further deaeration and the air will be withdrawn through the pipes 25 to the tube banks for exhaustion through the offtake nozzle 15. The liquid will also be reheated within the hot well, along with the exhaust steam condensate, by steam which passes downwardly from the lane 10, through the passage between the plates 19 and thence into contact with the showers from the hot well trays.

The invention provides for efficient deaeration of the liquid within a unit which also embodies the condenser and provides for advantageous cooperation of the deaerating apparatus with features of the condenser such as the air offtake feature, the condensate reheating feature, the condensate deaerating feature in the hot well and the storage space afforded by the hot well. The need for a separate deaerating unit with its own storage tank is eliminated with consequent economy in equipment.

As shown in Fig. 2, air within the heaters H may also be vented to the deaerating means within the steam inlet passage of the condenser. For that purpose, a line 47 leads from the shell of a high pressure one of the heaters to the shell of a lower pressure heater, and a line 48 leads from the latter heater to one or both of the deaerating devices within the condenser dome. Thence, the air from the heaters is conducted through the air offtake pipes to the tube nest along with the air

separated from the liquid charge delivered through the pipe 32. The lines 47 and 48 are provided with valves V to control flow through the lines.

Figs. 4 and 5 show an adaptation of the invention to a condenser unit designed for admission of the steam from the turbine laterally to one side of the tube nest instead of downwardly thereto. The condenser shell, designated 1a, has connecting laterally extending portions or sections 49 and 50 defining the steam inlet passage. Section 50 may be integral with the portion 49 and the body of the shell or it may, as shown, be what is known as a "transition piece" bolted, as at 51, to the portion 49 and forming part of the steam delivery connection between the turbine and the body of the shell. At any rate, the section 50 forms, in effect, part of the condenser unit. A pair of deaerating devices are located within the section 50 and secured by welding or other suitable means to opposite vertical side walls of this section.

These deaerators are, in general, similar to those of the previously described form of the invention, and similar parts are designated by corresponding reference characters. Each device has opposite end walls 52 welded or otherwise suitably secured to the ends of the shower trays 28, 29 and 31 and to the trough 36. These end walls shield the trays and the showers from the inrushing steam. A drain pipe 53 leads from each trough 36 to a deaerating device within the hot well 13a. The hot well deaerator includes a vertical wall 54 spaced inwardly from an opposed wall of the hot well and defining therewith a steam passage 55. Two vertically spaced, perforate shower trays 56 and 57 extend between the opposite wall of the hot well and the wall 54. The upper tray 56 extends clear across the space between said walls, and the lower tray 57 extends from wall 54 only part way across said space and has an upturned flange along it free edge. An intermediate perforated shower tray 58 extends from said opposite wall only part way across said space and also has an upturned flange along its free edge. All of said trays and the wall 54 are welded or otherwise suitably secured at their opposite ends to the end walls 52 of the hot well. Wall 54 has an outwardly curved upper extension which forms a baffle 60 to divert part of the entering steam into the hot well passage 55. The drain pipes 53 lead past the opposite ends of the baffle 60 and discharge upon the uppermost tray 56. The condensate from the nest of condenser tubes 9a also drains upon said tray. Any condensate which may collect within the lower portion of the inlet sections 49 and 50 will be directed by a weir 61 past the opposite ends of the baffle 60 and onto the tray 56.

An air offtake pipe 61 has its opposite ends opening respectively, into the deaerator devices within the section 50 of the steam passage, at points between the trays 29 and 31 of said devices. A pipe 63 leads from pipe 62 to the opposite side of the shell from the steam inlet and opens into an air cooler section of the tube nest partly segregated by a baffle 64. Another air offtake pipe 65 leads from the space between the hot well trays 56 and 58 to said air cooler section of the tube nest.

The operation of the apparatus shown in Figs. 4 and 5 is quite similar to that of the previously described form of the invention. The charge of heater condensate and/or make-up water delivered by the pipe 32 will be passed downwardly

through depending branches 32*a* to the pipes 33 and discharged through the spray nozzles 34 in the deaerators. Air will be evacuated from the deaerators through the pipes 61 and 62, the air cooler section of the tube nest and the air offtake nozzle 15 of the condenser. The deaerated liquid, heated by the steam of the inlet passage, will be collected by the troughs 36 and drained through pipes 53 to the upper tray of the hot well where it will join the condensate drained from the condenser tubes. Within the hot well, said two liquids will be heated by steam diverted through the passage 55. Air within said condensate and any air which may remain in the liquid delivered by the pipes 53 will be withdrawn through pipe 56, the air cooler section of the tube nest and the air offtake nozzle 15.

In the operation of either form of the apparatus the make-up water may, if desired, be introduced to the deaerators separately from the heater condensate.

While the invention is disclosed as employed in power plant service it may be employed advantageously in other services requiring surface condenser equipment and deaerating equipment. It is, of course to be understood that the present disclosure of the invention is merely illustrative and in nowise limiting and that the invention comprehends such modifications as will fall within the scope of the following claims.

In the claims, the word "steam," except where identified with a steam power system, is intended to comprehend other vapors also, and the word "air," wherever it occurs, is intended to comprehend also other non-condensible gaseous media.

We claim:

1. The combination of a surface condenser unit including a shell, a nest of substantially horizontal condensing tubes therein, means for circulating cooling water through the tubes, the shell having therein an inlet passage for conducting steam to the tube nest for condensation, a hot well below the tube nest to receive the steam condensate from the tubes, a deaerating device within the hot well, and air offtake means leading from a relatively cool portion of the tube nest spaced from said steam inlet passage; and deaerating apparatus integrated with said condenser unit and independent of the deaerating device within the hot well and comprising a chamber within said shell at said steam passage and spaced from the hot well, a water delivery conduit leading from outside of the condenser unit, said conduit being in delivery communication with said chamber and free from water-receiving communication with the condenser unit to deliver to the chamber heated water from an outside source, superposed, trough-like shower trays within said chamber below the delivery point of said outside water to discharge same downward therefrom in succession in fine streams, said chamber having a steam inlet below said trays open to said steam inlet passage, an air offtake conduit leading from said chamber at a level between the uppermost one of said trays and the next lower tray, said trays being arranged to cause serpentine flow of the steam from said inlet crosswise of said streams, and said air offtake conduit leading to said relatively cool portion of the tube nest for passage of the air to said air offtake means thereof, a trough beneath said trays and below said steam inlet to collect the water discharged from the trays, and a drain connection between said trough and the deaerating device within the hot well to deliver the water thereto for further deaeration.

2. The combination of a surface condenser unit including a shell, a nest of substantially horizontal condenser tubes therein, means for circulating cooling water through the tubes, the shell having an inlet passage for conducting steam to the tube nest for condensation, a hot well below the tube nest to receive the steam condensate from the tubes, and air offtake means leading from a relatively cool portion of the tube nest spaced from said steam inlet passage; and deaerating apparatus integrated with said condenser and comprising a chamber within said shell at said steam passage and spaced from the hot well, a water delivery conduit leading from outside of the condenser, said conduit being in delivery communication with said chamber and free from water-receiving communication with the condenser unit to deliver to the chamber heated water from an outside source, superposed, trough-like shower trays within said chamber below the delivery point of said outside water to discharge same downward therefrom in succession in fine streams, said chamber having a steam inlet below said trays open to said steam passage, an air offtake passage leading from said chamber at a level between the uppermost one of said trays and the next lower tray and extending to said relatively cool portion of the nest for passage of the air to said air offtake means thereof, said trays being arranged to cause upward serpentine flow of the steam from said inlet crosswise of said streams, a trough beneath said trays and below said steam inlet to collect the water discharged from the trays, and a drain connection between said trough and the hot well to deliver said outside water thereto.

3. The combination claimed in claim 2 wherein the said deaerating chamber has a steam inlet at the upper portion thereof open to said steam inlet passage and the said conduit for delivery of outside water has spray nozzles spaced therealong to discharge the water into said chamber in the presence of steam admitted through said upper steam inlet.

4. The combination claimed in claim 2 wherein the said steam inlet passage extends downward to the tube nest and the said deaerating chamber is located above the tube nest.

5. The combination claimed in claim 2 including another deaerating apparatus according to the one claimed in said claim, the deaerating chambers of said apparatuses being located at opposite sides of said steam passage.

6. The combination of a surface condenser unit including a shell, a nest of substantially horizontal condensing tubes therein, means for circulating cooling water through the tubes, the shell having therein an inlet passage for conducting steam to the tube nest for condensation, a hot well below the tube nest to receive the steam condensate from the nest, a deaerating device within the hot well, and air offtake means leading from a relatively cool portion of the tube nest spaced from said steam inlet passage and in air-receiving communication with said device; and deaerating apparatus integrated with said condenser unit and independent of the deaerating means within the hot well and comprising a chamber within the shell at said steam passage and spaced from the hot well, a water delivery conduit leading from outside the condenser unit, said conduit being in delivery communication with said chamber and free from water-receiving communica-

tion with the condenser unit to deliver to the chamber heated water from an outside source, superposed trays within the chamber below the delivery point of said outside water to collect the water and discharge it downward from tray to tray in fine streams, said chamber having a steam inlet located at one level of the space containing said trays, and an air offtake conduit leading from said space at a level substantially spaced from the level of said steam inlet, said offtake conduit leading to said relatively cool portion of the tube nest for passage of the air to said air offtake means thereof, and said chamber having a passage to conduct steam from said inlet toward said air offtake level and into contact with said streams of water, a trough beneath said trays to collect the water discharged therefrom, and a drain connection between said trough and the deaerating device within the hot well to conduct the water thereto for further deaeration.

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