Aug. 19, 1958 G. W. EVANS, JR., ET AL 2,848,197

CONDENSER

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Fig. 1.

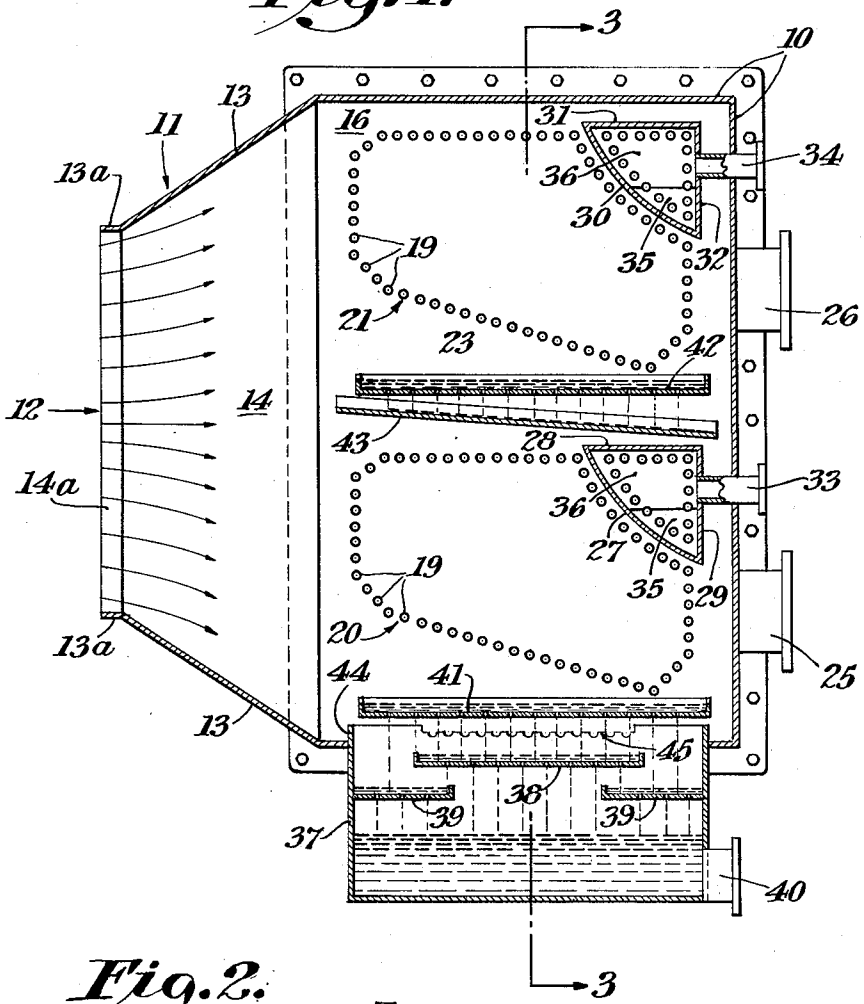
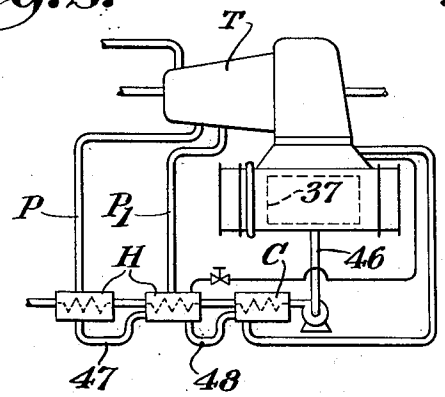


Fig. 2.



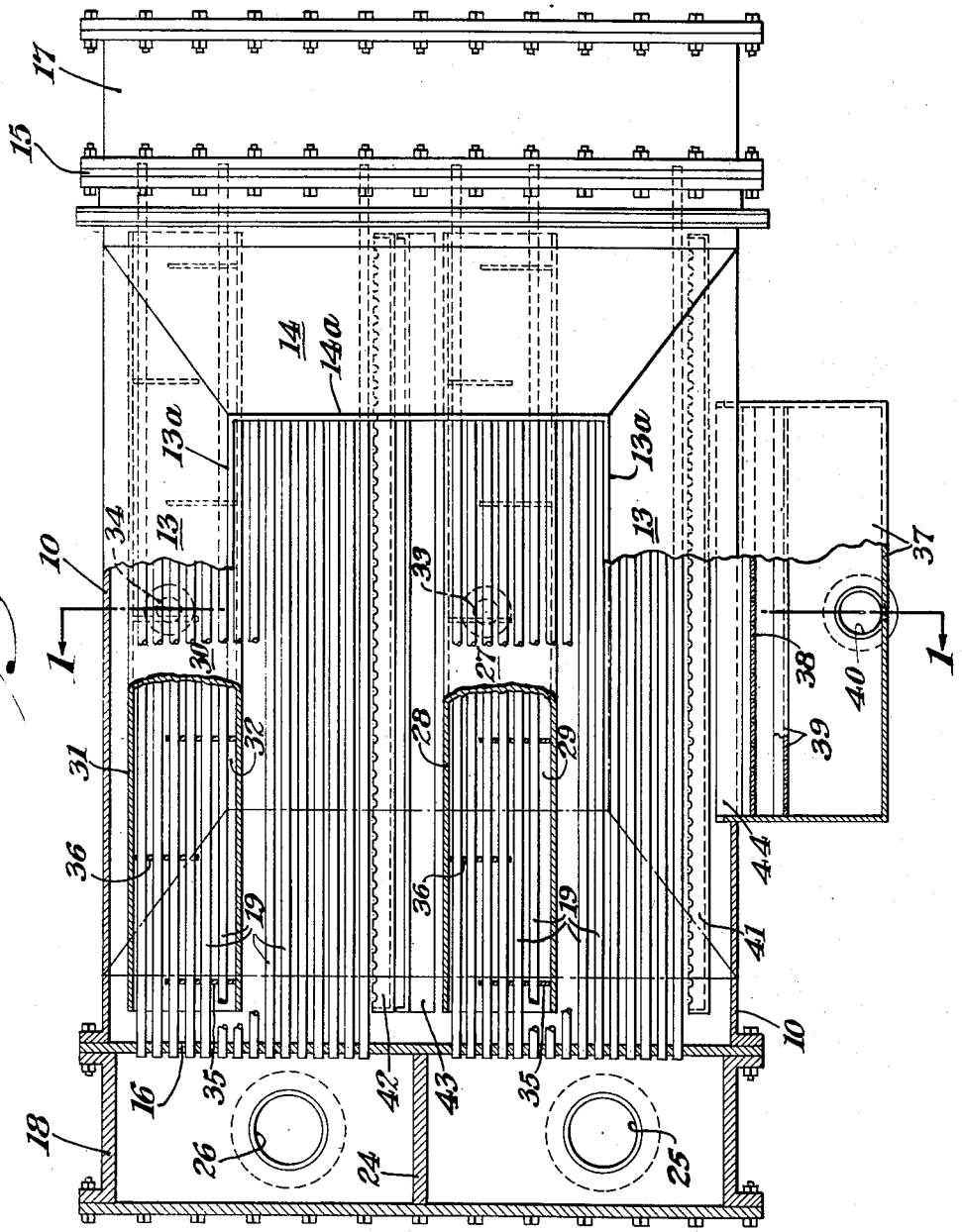
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Fig. 3.



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United States Patent Office 2,848,197 Patented Aug. 19, 1958

2,848,197

CONDENSER

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Application September 2, 1955, Serial No. 532,176

3 Claims. (Cl. 257—43)

This invention relates to improvements in steam power plant equipment and more particularly to improved condensing 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 is condensed in the condenser and the condensate is conducted from the hot well of the condenser through the feed water heaters in series and returns to the boiler. Within the heaters, the condensate is heated by steam which may be bled 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 boiler. This condensate, together with make-up water, as required for the boiler, should be deaerated before introduction to the boiler and it is customary to provide a separate deaerator unit for that purpose. The deaerated water is then pumped from such unit through one or more heaters to the boiler.

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

A further object of our invention is to provide a construction of, high vacuum, surface condenser adapted especially for large sizes in which each condenser tube contributes the maximum area possible to active condensation of steam.

A still further object of our invention is to provide an improved condensing unit wherein exhaust steam from a side exhaust or end exhaust turbine may be conveniently introduced through a side inlet in the unit with a resultant substantial saving in supporting structure and head room and wherein the inlet area of the nest of condensing tubes is at a maximum so that the velocity of the steam entering the nest of tubes is materially reduced and the paths of steam flow converge toward points of complete condensation.

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

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;

Figure 2 is a diagrammatic top view of a portion of a steam power system embodying a side exhaust turbine and the invention; and

Figure 3 is a vertical section on the line 3—3 of Figure 1, partly broken away.

The structure of the condensing unit shown in Figs. 1 and 3 includes a shell **10** horizontally disposed and formed at one side with a portion **11**, which provides an inlet passage for exhaust steam from the turbine. The steam inlet **12** in portion **11** may be rectangular in vertical section having opposite walls **13**, which converge outwardly from the shell to the steam inlet and terminate in horizontal portions **13***a*. Opposite walls **14** may converge outwardly from the shell to the steam inlet and terminate in vertical portions **14***a*, similar to portions **13***a* of the walls **13**, and form therewith a frame for connection with the exhaust opening of the turbine.

The opposite ends of the shell are provided with flanges and have secured thereto respectively tube sheets **15** and **16** and water boxes **17** and **18**. Tubes **19** connect to the tube sheets and are arranged in a nest comprising two or more equal banks **20** and **21** formed one above the other and spaced to define therebetween a horizontal central lane or lanes **23**. Water box **18** has a horizontally, diametrically disposed pass partition **24** and two nozzles **25** and **26**. Referring to Fig. 1, the nozzle **25** admits cooling water to the compartment below the pass partition for flow through the tubes of the lower tube bank **20** to the water box **17** and thence in reverse direction through the tubes of the upper bank **21** to the water box compartment above the partition and out through the nozzle **26**. Thus, the condenser as illustrated is a two-pass unit but the number of passes may be varied by appropriate arrangements of pass partitions and nozzles.

Each tube bank has an air offtake baffle structure which includes walls **27**, **28** and **29** and **30**, **31** and **32** respectively; the ends of each baffle structure being open so that non-condensible gases may be withdrawn from both banks through nozzles **33** and **34**. Within each baffle structure is a portion of the tubes of the respective bank which act as an air cooler section. Also within each baffle structure are transversely disposed interleaving baffle plates **35** and **36**, which are spaced to provide a tortuous path of flow for the non-condensible gases. A steam jet ejector, not shown, may be connected to nozzles **33** and **34** to maintain a desired vacuum. Such an ejector may deliver to the usual inter-and-after condenser combination, not shown.

Beneath the shell **10** there is a hot well **37**, 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 perforated shower trays **38** and **39** with upturned outer edges. These trays extend horizontally the full length of the hot well but do not individually span the full width of the hot well. All of the shower trays are welded or otherwise suitably secured to the adjacent walls of the hot well. Air offtake pipes, not shown, may lead from opposite sides of the hot well, at points between trays **38** and **39**, to the air offtake baffle structures. The hot well has a condensate discharge nozzle **40** leading from its lower portion.

Incorporated and coacting with the condenser tube banks **20** and **21** are condensate shower trays **41** and **42** for deaerating condensate from the respective tube banks. Tray **42**, which is positioned within the horizontal central lane **23**, receives most of the condensate from the tube bank **21** and showers such condensate to an underlying imperforate plate **43**, which is shaped to direct the condensate to the rear side of the condenser shell where it falls to a point below the lower tube bank and is thereafter directed to the hot well. In showering from tray **42** to plate **43**, the condensate from the upper tube bank is substantially reheated and deaerated. A weir **44** at the top of the hot well **37** and within shell **10** is provided with notched end portions **45** whereby condensate from plate **43** is directed toward the ends of the hot well and discharges in divided streams to tray **38**. Final deaeration of the upper tube bank condensate occurs as it showers from trays **38** and **39** to the hot well with condensate from the lower tube bank. Tray **41**, which underlies tube bank **20**, receives most of the condensate

from such lower tube bank and showers such condensate to the trays **38** and **39** in the hot well. In showering from the tray **41** to trays **38** and **39**, the condensate from the lower tube bank is substantially reheated and deaerated. Final deaeration of the lower bank condensate occurs as it showers from trays **38** and **39** to the hot well with condensate from the upper tube bank.

All of the shower trays have their free edges turned up so that the condensate will collect sufficiently on the trays for passage through the perforations rather than spill ineffectually from one edge. The upper edge of the upturned tray portion is notched so that in the event of tray flooding, condensate pouring over a tray edge will fall in a plurality of streams.

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 **37** through a pipe **46** and passed in succession through the tube side of a drain cooler C and a plurality of feed water heaters H, en route to the boiler, not shown. Steam is bled from one or more stages of the turbine through pipes P and P_1 and passed to the shell side of 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 may be passed through pipe **47** from one heater to another, and through a pipe **48** to the drain cooler C and thence through deaerating means before joining the condenser condensate in the hot well **37**. Make-up water may be supplied, as needed, to the system at any suitable point.

Usually a vacuum ranging from **26** to **29** inches will be maintained within the condenser and this vacuum will exist within each deaerator.

It is known that in order to obtain the necessary condensing surface without unduly increasing the size of the condenser, the tube spacing adjacent the steam inlet perimeter of the nest of tubes must of necessity be such as to occasion no objectional loss in vacuum between the point or points of complete condensation within the tube nest and the steam inlet to the condenser. To overcome objectionable losses of vacuum, the cooling tubes **19** are distributed so as to increase the inlet area of the nest of tubes so that the velocity of steam flow entering the nest of tubes is materially reduced below that employed in ordinary condensers. Likewise the condensing surface is so distributed that the paths of steam flow converge toward the air offtake baffle structures.

To accomplish the above and primarily to eliminate the massive structure generally required to support the turbine above the condensing unit, the present invention utilizes a side inlet to the condenser with the tubes divided into separate independent groups having separate primary condensate deaerating means and separate air offtake structures. With such an arrangement the condenser may be positioned adjacent to the turbine affording better maintenance opportunity and substantially less supporting structure. The tubes are arranged for maximum inlet area for the steam with the condenser steam inlet facing directly into the turbine exhaust. The tubes of each group are distributed to obtain the advantage gained by having the condensing surface so distributed that the areas of steam flow diminish from the steam space toward the air offtakes in substantially direct proportion to the decrease in condensation taking place along the paths of steam flow, or in direct proportion to the decrease in volume of uncondensed vapor along the path of flow.

While the invention is disclosed as employed in power plant service, it may be employed advantageously in other services requiring surface condenser equipment where it is particularly desirable to support the prime mover on the same level with such condenser. It is, of course, to be understood that the present disclosure of the invention is merely illustrative and in no wise limiting and that the invention comprehends such modifications as will fall within the scope of the following claims.

In the claims, the words "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 within the shell, means for circulating cooling water through the tubes, the shell having a side steam inlet passage for conducting steam in a substantially horizontal direction to the tube nest for condensation, a hot well positioned below the tube nest to receive partially deaerated steam condensate from said tubes, a substantially horizontal baffle plate located within the shell and dividing the nest into separate groups of tubes, one above the other, said baffle plate being so disposed as to collect condensate from the upper group of tubes and direct such condensate in a separate path away from said inlet passage for discharge into said hot well, a horizontally disposed perforated tray located below said upper group of tubes and above said baffle plate to intercept condensate from said upper group of tubes and shower it in divided streams to said plate whereby said condensate is substantially reheated and partially deaerated by steam passing between said groups of tubes, a second horizontally disposed perforated tray located beneath the lower group of tubes and above said hot well to collect condensate from said tubes and shower it in divided streams downwardly for discharge into said hot well whereby said condensate is substantially reheated and partially deaerated by steam passing under said lower group of tubes, a deaerating device within said hot well to complete deaeration of condensate from the separate discharge paths, and air off-take means leading from a relatively cool portion of each group of tubes and spaced from said side steam inlet passage for removing non-condensable vapors.

2. The combination of a surface condenser unit including a shell, a nest of substantially horizontal condensing tubes within the shell, a steam inlet passage in one side of the shell for conducting steam in a substantially horizontal direction to the tube nest for condensation, means for circulating cooling water within the tubes, a hot well positioned below the tube nest to receive partially deaerated steam condensate therefrom, a substantially horizontal baffle plate located within the shell and dividing the tube nest into separate groups of tubes, one above the other, said baffle plate being so disposed as to collect condensate from the upper group of tubes and direct said condensate along said plate away from said inlet passage for discharge downwardly in a separate path to said hot well, a horizontally disposed perforated tray located below said upper group of tubes and above said baffle plate to intercept condensate from said upper group of tubes and shower it in divided streams to said plate whereby said condensate is substantially reheated and partially deaerated by steam passing between said groups of tubes, a second horizontally disposed perforated tray located beneath the lower group of tubes and above said hot well to collect condensate from said tubes and shower it in divided streams downwardly for discharge into said hot well whereby said condensate is substantially reheated and partially deaerated by steam passing under said lower groups of tubes, a deaerating device within the hot well to complete deaeration of condensate from the separate discharge paths, and air off-take means leading from a relatively cool portion of each group of tubes for removing non-condensable vapors, said off-take means being spaced from said side stream inlet and including a portion of the tubes of each group.

3. The combination of a surface condenser unit including a shell, a nest of substantially horizontal con-

densing tubes within the shell, said nest comprising at least two separate groups of tubes, one above the other, a steam inlet passage in one side of the shell for conducting steam in a substantially horizontal direction to the tube nest for condensation, means for circulating cooling water through the tubes, a hot well positioned below the tube nest to receive partially deaerated steam condensate from separate condensate discharge paths, substantially horizontal baffle plates located within the shell and between adjacent groups of tubes, each of said plates being so disposed as to collect condensate from the next upper group of tubes and direct such condensate along said plate away from said inlet passage for discharge downwardly in a separate path to said hot well, a horizontally disposed perforated tray located above each of said baffle plates to intercept condensate from the group of tubes next above each plate and shower it in divided streams to said plate whereby condensate from each upper group of tubes is substantially reheated and partially deaerated by steam passing between said adjacent groups of tubes, a horizontally disposed perforated tray located beneath the lower group of tubes and above said hot well to collect condensate from said tubes and shower it in divided streams downwardly for discharge into said hot well whereby said condensate is substantially reheated and partially deaerated by steam passing under said lower group of tubes, a deaerating device within the hot well to complete deaeration of condensate from the separate discharge paths, and air off-take means leading from a relatively cool portion of each group of tubes and spaced from said side steam inlet passage for removing non-condensable vapors.

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