

Jan. 16, 1968

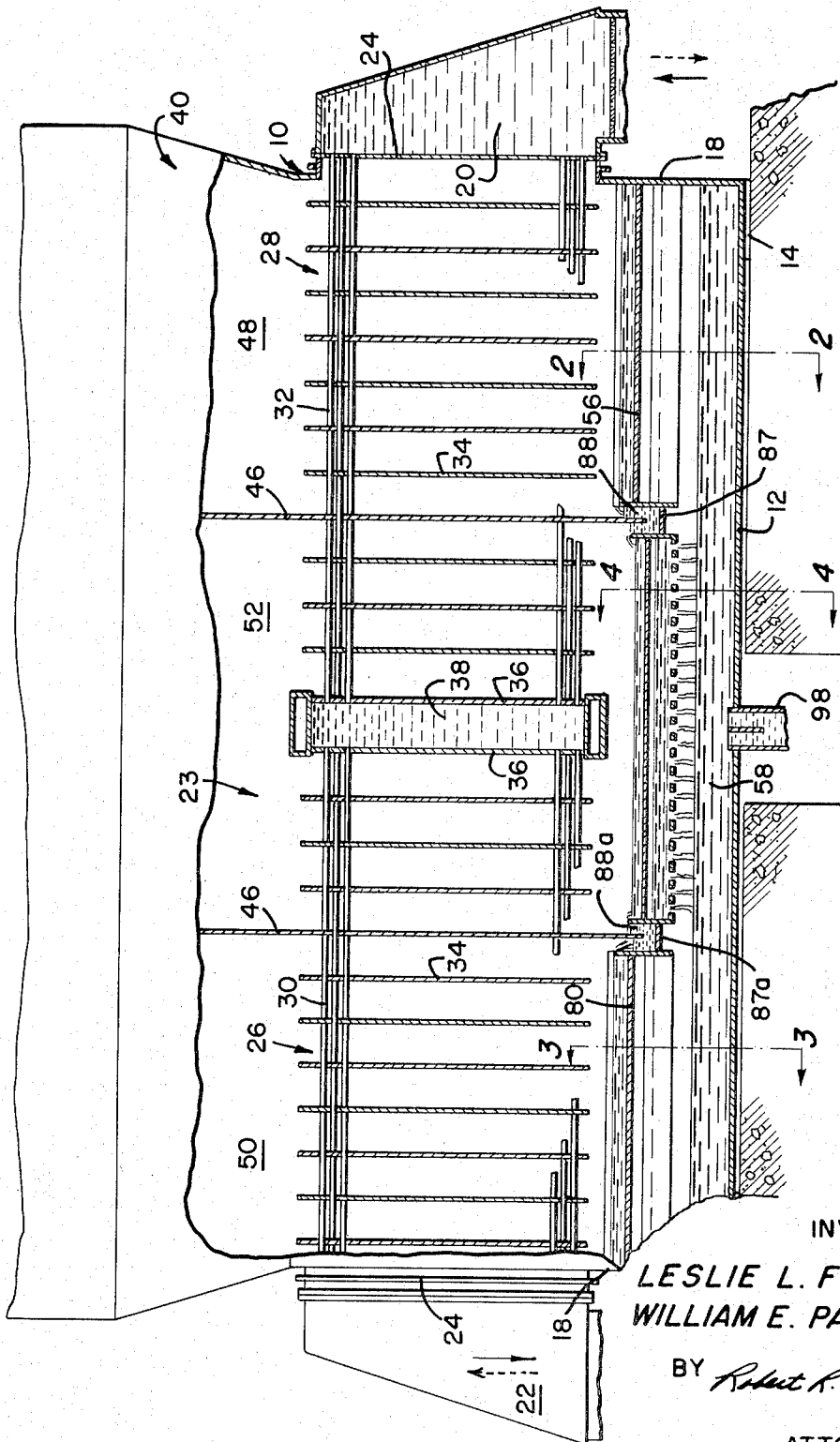
L. L. FORSTER ET AL

3,363,678

MULTI-PRESSURE SURFACE CONDENSER

Filed June 28, 1966

2 Sheets-Sheet 1



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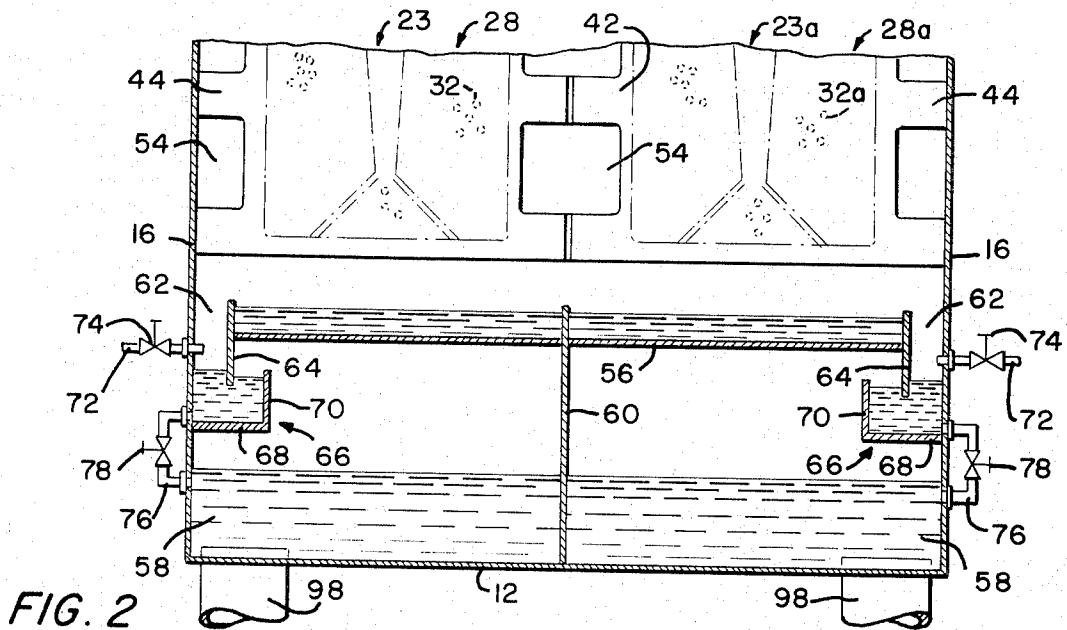
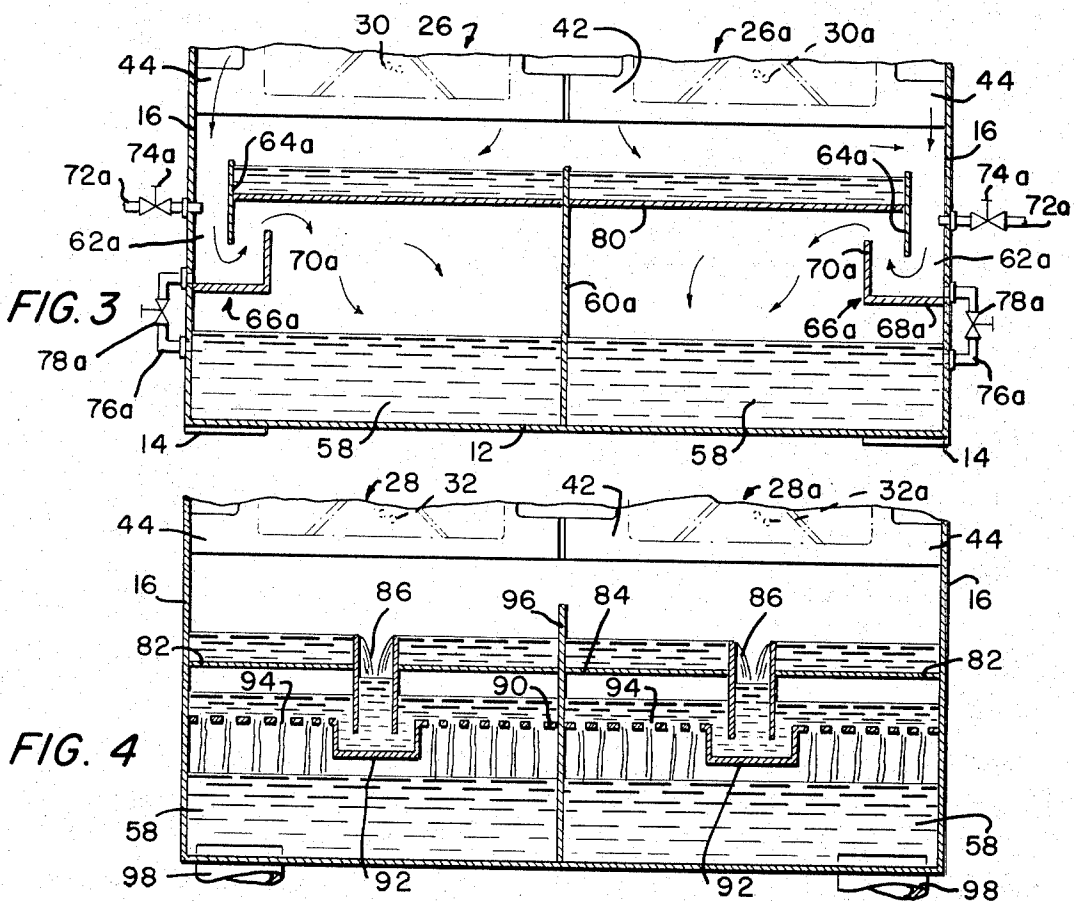
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MULTI-PRESSURE SURFACE CONDENSER

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Filed June 28, 1966, Ser. No. 561,091

13 Claims. (Cl. 165-112)

ABSTRACT OF THE DISCLOSURE

A multi-pressure steam surface condenser of the type wherein the flow of coolant fluid in the tubes is reversible. The condenser shell is divided into compartments by a plurality of baffle or division plates and includes fluid passages for supplying steam from each of the end compartments into heat exchange relationship with the condensate. A fluid seal is selectively provided in each of the fluid passages for closing the latter such that, regardless of the direction of the flow of coolant fluid, steam from the hottest end compartment is supplied to the condensate.

The disclosure

This invention relates to condensers and more particularly to multi-pressure surface condensers of the type wherein the flow of coolant fluid in the tube bundle is reversible in direction for backwashing the tube sheets.

It is desirable that the condensate, or water, produced as a result of the condensing action of the tube bundle of a steam surface condenser be reheated and deaerated by the steam in the condenser prior to its discharge from the condenser. In a conventional single-pressure steam surface condenser of the type wherein the flow of coolant fluid in the tube bundle is reversible for backwashing purposes, only steam at a single temperature and pressure is available for reheating and deaerating the condensate during both directions of coolant fluid flow. In a multi-pressure steam surface condenser, however, the pressure compartment farthest removed from the inlet coolant fluid end (i.e., the pressure compartment at the discharge end) is always at a higher condensing temperature than the other pressure compartments. Therefore, in such a condenser, maximum reheating and deaerating efficiency is obtained only when the steam in the pressure compartment of the condenser furthest from the inlet tube sheet is employed as the reheating and deaerating agent. As a result, in a conventional, multi-pressure steam surface condenser wherein the coolant fluid flow is reversible, maximum reheating and deaerating efficiency has generally been attainable only when the flow of coolant fluid is in the normal design direction.

An object of the present invention is to provide a new and improved multi-pressure surface condenser of the type set forth which is particularly constructed and arranged to provide maximum efficiency condensate reheating and deaeration during both directions of the flow of the coolant fluid in the condenser tube bundle.

Another object of the invention is to provide a new and improved multi-pressure surface condenser of the type set forth which is relatively simple and economical in construction and highly efficient and dependable in operation.

These objects, and the other objects and advantages of the invention which will be apparent from the following description taken in connection with the accompanying drawings, are obtained by the provision of a multi-pressure surface condenser comprising a shell, and a tube bundle including a plurality of coolant conveying tubes longitudinally extending within the shell. A means

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is provided for introducing coolant fluid into the opposing ends of the tube bundle such that coolant fluid may be alternatively directed in opposing directions through the tube bundle. A means is provided for introducing steam into the shell and on the tube bundle such that the latter condenses the steam into condensate; and a means is provided for receiving the condensate condensed from the steam by the tube bundle. A means is provided for directing steam alternatively from adjacent the opposing ends of the tube bundle into heat exchange relationship with the condensate such that steam adjacent to the end of the tube bundle opposite to that receiving coolant fluid from the coolant fluid introducing means may be directed into heat exchange relationship with the condensate in each direction of flow of the coolant fluid in the tube bundle. A means is provided for discharging the heated condensate from the shell.

Referring to the drawings:

FIG. 1 is an elevational view, partially broken away and in section, of a multi-pressure surface condenser constructed in accordance with the present invention;

FIG. 2 is an elevational, sectional view taken on line 2-2 of FIG. 1, looking in the direction of the arrows;

FIG. 3 is an elevational, sectional view taken on line 3-3 of FIG. 1, looking in the direction of the arrows; and

FIG. 4 is an elevational, sectional view taken on line 4-4 of FIG. 1, looking in the direction of the arrows.

Referring more particularly to the drawings wherein similar reference characters designate corresponding parts throughout the several views, FIGS. 1 through 4 illustrate a multi-pressure steam surface condenser comprising a shell or housing designated generally as 10. The shell 10 is formed from a horizontally extending bottom plate 12 which is ground supported by a plurality of supporting feet 14, a plurality of side plates 16 which project vertically from the opposing sides of the bottom plate 12, and a plurality of end plates 18 which project vertically from the opposing longitudinal ends of the bottom plate 12. The end plates 18 each carry a pair of tube sheets 24, located in side-by-side relationship, such that each of the tube sheets 24 at one longitudinal end of the bottom plate 12 directly opposes one of the tube sheets 24 at the opposing longitudinal end of the bottom plate 12. The tube sheets 24 at one longitudinal end of the bottom plate 12 are connected to a water box 20; the tube sheets 24 at the opposing longitudinal end of the bottom plate 12 are connected to a water box 22. The water boxes 20 and 22 are each suitably connected to a source (not shown) of cooling water such that they may selectively, and alternatively, receive water from, and discharge water to, such source.

A tube bundle 23 comprising a plurality of coolant conveying tubes is longitudinally disposed between one opposing pair of the tube sheets 24 for conveying water between the water boxes 20 and 22. In the illustrated embodiment of the invention, the tube bundle 23 comprises a pair of aligned tube banks 26 and 28 which include pluralities of substantially parallel, coolant conveying tubes 30 and 32, respectively. The coolant conveying tubes 30 and 32 are each supported intermediate their ends by a plurality of supporting plates 34. The remote ends of the coolant conveying tubes 30 and 32 extend through the beforesaid pair of opposing tube sheets 24 into fluid communication with the water boxes 22 and 20, respectively. The adjacent ends of the coolant conveying tubes 30 and 32 extend through respective adjacent tube sheets 36 of a water box 38 which is disposed intermediate the tube banks 26 and 28 for conveying water therebetween.

Similarly, a tube bundle 23a comprising a plurality of

coolant conveying tubes is longitudinally disposed between the other opposing pair of the tube sheets 24. The tube bundle 23a comprises a pair of aligned tube banks 26a and 28a which include pluralities of substantially parallel, coolant conveying tubes 30a and 32a, respectively. The coolant conveying tubes 30a and 32a are each supported intermediate their ends by the supporting plates 34 and communicate with the water boxes 20, 22 and an intermediate water box (not shown) in the aforesaid manner.

The beforedescribed construction of the tube bundles 23, 23a has been found to be particularly beneficial in many condenser applications as it enables the coolant circuit to be constructed substantially longer than is practical with tube lengths currently available in certain materials. It will be understood, however, that the tube bundles 23, 23a could, alternatively, each be formed from a single tube bank which extends longitudinally through the shell 10 and has its opposing ends extending through the tube sheets 24 into fluid communication with the water boxes 20 and 22, thus eliminating the intermediate water boxes 38 and the tube sheets 36.

The upper end of the shell 10 includes an inlet duct designated generally as 40 which is adapted for receiving steam discharged by a turbine or similar apparatus (not shown) and directing such steam onto the tube bundles 23 and 23a. The tube bundles 23, 23a are suitably spaced to provide a steam flow passage 42 which extends vertically between the tube bundles 23, 23a. The tube bundles 23 and 23a, furthermore, are suitably spaced from their respective adjacent side plates 16 to provide a steam flow passage 44 between each of the tube bundles 23, 23a and its respective adjacent side plate 16. Due to this construction, a minor portion of the steam flowing through the inlet duct 40 passes around the tube bundles 23, 23a through the steam flow passages 42 and 44.

A plurality of baffle or division plates 46 are disposed transversely within the shell 10 and the inlet duct 40. The division plates 46 divide the shell 10 and the inlet duct 40 into a first or end compartment 48 adjacent the water box 20, a second or end compartment 50 adjacent the water box 22, and a third or intermediate compartment 52 between the end compartments 48, 50. It will be understood, however, that, alternatively, the shell 10 may be divided into two compartments, four compartments, or more than four compartments as dictated by the turbine served by the multi-pressure condenser. The supporting plates 34 each include a plurality of openings 54 for facilitating longitudinal distribution of the steam in each of the compartments 48, 50, 52. The end of each of the compartments 48, 50, 52 in the inlet duct 40 is operatively connected to the low pressure outlet of a double flow turbine (not shown) to receive the steam discharged by the turbine through such outlet.

An imperforate, condensate receiving tray 56 is disposed within the end compartment 48 below the tube banks 28, 28a for receiving condensate condensed in the end compartment 48 by the tubes 32, 32a. The condensate receiving tray 56 is disposed above the bottom plate 12 to provide a condensate hotwell 58 between the condensate receiving tray 56 and the bottom plate 12. The condensate receiving tray 56 and the portion of the hotwell 58 therebelow are divided by a vertically extending, baffle or division plate 60 to separate the condensate falling from the tubes 32, 32a to facilitate the detection of any condensate contamination. The opposing sides of the condensate receiving tray 56 terminate in spaced relationship to their respective adjacent side plates 16 to provide a steam flow passage 62 between the condensate receiving tray 56 and each of the side plates 16. A depending baffle 64 is carried by each of the opposing lateral ends of the condensate receiving tray 56 for extending the steam flow passages 62 below the condensate receiving tray 56.

A fluid trough 66 is carried by each of the side plates 16 below the lower end of the respective adjacent baffle

64 such that steam flowing from the end compartment 48 through the steam flow passages 62 must flow through the fluid troughs 66 before passing into the hotwell 58. Each of the fluid troughs 66 extends substantially the length of the end compartment 48 and is formed with a horizontally extending base 68 and a side 70 which projects vertically above the lower end of the adjacent baffle 64 on the opposing side of the latter from the side plate 16 carrying the fluid trough 66. A water inlet conduit 72 is disposed through each of the side plates 16 for supplying water or other sealing fluid to the fluid troughs 66 for preventing steam flow through the steam flow passages 62 to the hotwell 58. A control valve 74 is interposed within each of the water inlet conduits 72 for controlling the flow of water through the water inlet conduits 72. A water discharge conduit 76 connects each of the fluid troughs 66 with the hotwell 58 for draining water from the fluid troughs 66 to the hotwell 58, each of the water discharge conduits 76 containing a control valve 78 for controlling the flow of water to the hotwell 58.

Similarly, an imperforate condensate receiving tray 80 is disposed within the end compartment 50 below the tube banks 26, 26a for receiving condensate condensed in the end compartment 50 by the tubes 30, 30a. The condensate receiving tray 80 is disposed above the bottom plate 12 such that the hotwell 58 extends between the condensate receiving tray 80 and the bottom plate 12; and the condensate receiving tray 80 and the portion of the hotwell 58 therebelow are divided by a vertically extending baffle or division plate 60a. The condensate receiving tray 80 is suitably spaced from the side walls 16 to provide a steam flow passage 62a between each of the side walls 16 and the condensate receiving tray 80 and carries a depending baffle 64a at each of its opposing lateral ends.

A fluid trough 66a is carried by each of the side plates 16 below the lower end of the respective adjacent baffle 64a such that steam flowing from the end compartment 50 through the steam flow passages 62a must pass through the fluid troughs 66a before flowing into the hotwell 58. Each of the fluid troughs 66a extends substantially the length of the end compartment 50 and includes a horizontal base 68a and a side 70a which projects vertically above the lower end of the adjacent baffle 64a on the opposing side of the latter from the side plate 16 carrying the fluid trough 66a. A water inlet conduit 72a extends through each of the plates 16 for supplying water or other sealing fluid to the fluid troughs 66a to prevent steam flow through the steam flow passages 62a to the hotwell 58. A control valve 74a is interposed within each of the water inlet conduits 72a for controlling the flow of water through the water inlet conduits 72a. A water discharge conduit 76a connects each of the fluid troughs 66a with the hotwell 58 for draining water from the fluid troughs 66a into the hotwell 58. A control valve 78a is interposed within each of the water discharge conduits 76a for controlling the flow of water therethrough.

The intermediate compartment 52 contains a bi-level tray assembly which is particularly adapted for receiving condensate and for discharging streams of the latter into the hotwell 58. The upper level of the tray assembly is formed by an imperforate, outer tray 82 carried by each of the side plates 16, and an imperforate, central tray 84 disposed between the outer trays 82. The central tray 84 is spaced from each of the outer trays 82 to provide a vertical, condensate well 86 upon each of the opposing sides of the central tray 84. As illustrated in FIG. 1, the trays 82, 84 are located below the condensate receiving trays 56, 80 and are connected to the latter by horizontally extending baffle plates 87 and 87a to provide troughs 88 and 88a, respectively. The division plates 46 extend into the troughs 88 and 88a, but terminate above the baffle plates 87, 87a to allow condensate to flow from

the condensate receiving trays 56, 80 to the trays 82, 84 through the troughs 88, 88a.

The lower level of the bi-level tray assembly in the intermediate compartment 52 is formed by a tray 90 which extends transversely in the shell 10 above the hotwell 58. The tray 90 includes a plurality of imperforate sections 92 which form the bottoms of the condensate wells 86, but otherwise contains a plurality of condensate flow openings or apertures 94 throughout. A vertical baffle or division plate 96 divides the bi-level tray assembly hereinbefore described and the portion of the hotwell 58 therebelow to facilitate contamination detection. A depending, condensate outlet conduit 98 communicates with the hotwell 58 on each side of the division plate 96 for discharging condensate from the hotwell 58.

In the operation of the beforedescribed steam surface condenser, with the flow of cooling water as shown by the solid arrows in FIG. 1, the water is introduced into the tubes 32, 32a by the water box 20 and is discharged from the tubes 30, 30a into the water box 22. In this direction of flow of the cooling water, the end compartment 48 contains the steam at the lowest temperature and pressure, the end compartment 50 contains the steam at the highest temperature and pressure, and the intermediate compartment 52 contains steam at an intermediate temperature and pressure. Thus, to reheat and deaerate the condensate by the steam at the highest temperature and pressure, the control valves 74a and 78 are closed to prevent fluid passage through the water inlet and water discharge conduits 72a and 76, respectively. The control valves 78a in the water discharge conduits 76a are opened to insure that no water remains in the fluid troughs 66a. The control valves 74 in the water inlet conduits 72 are opened sufficiently to fill the fluid troughs 66 with water and are then closed, thus providing water seals for preventing steam in the end compartment 48 from flowing into the hotwell 58.

Thereafter, steam flowing into the end compartment 48 is substantially completely condensed by the tubes 32, 32a into condensate which falls by gravity into the condensate receiving tray 56. Steam flowing into the intermediate compartment 52 is substantially completely condensed by the tubes 30, 30a, 32, 32a into condensate which falls by gravity into the bi-level tray assembly disposed in the intermediate compartment 52. The major portion of the steam flowing into the end compartment 50, similarly, is substantially completely condensed by the tubes 30, 30a into condensate which falls by gravity into the condensate receiving tray 80. The minor portion of the steam in the end compartment 50 which flows through the steam flow passages 42, 44, in the end compartment 50, however, as shown by the arrows in FIG. 3, passes through the steam flow passages 62a into the hotwell 58.

The condensate which falls directly into the trays 82, 84 and that flowing therein from the condensate receiving trays 56, 80 through the troughs 88, 88a, respectively, passes through the condensate wells 86 onto the tray 90. The condensate, thus received by the tray 90, flows in streams through the openings 94 into the hotwell 58 and is reheated and deaerated during such passage by the steam admitted to the hotwell 58 in the beforedescribed manner. The majority of the steam performing this reheating and deaerating action simultaneously condenses in the hotwell 58, with any of this latter steam remaining uncondensed and any noncondensibles being vented back to a region of lower pressure within the condenser. Thus, in this direction of the flow of the water in the tube bundles 23, 23a, the condensate is reheated and deaerated by steam from the end compartment 50 which is the compartment containing steam at the highest temperature and pressure.

When the flow of water through the tube bundles 23, 23a is reversed, such as for backwashing purposes, to cause the cooling water to flow as indicated by the dotted

arrows in FIG. 1, the end compartment 48 becomes the compartment containing steam at the highest temperature and pressure, and the end compartment 50 becomes the compartment containing steam at the lowest temperature and pressure. Thus, in order to direct steam from the end compartment 48 into heat exchange relationship with the condensate streams, the control valves 74a are opened sufficiently to fill the fluid troughs 66a with water and thus provide a water seal for preventing steam from the end compartment 50 from flowing into the hotwell 58. Simultaneously, the control valves 78 are opened to permit the water in the fluid troughs 66 to drain into the hotwell 58. Thus, during the subsequent operation of the steam surface condenser, steam from the end compartment 48 flows through the steam flow passages 62 into the hotwell 58 to provide the heating and deaeration of the condensate streams.

From the foregoing, it will be seen that we have provided new and improved means for accomplishing all of the objects and advantages of our invention.

It will be understood, however, that, although only a preferred embodiment of our invention has been illustrated and described in detail, the invention is not limited simply to this described embodiment but contemplates other embodiments and variations which utilize the concepts and teachings of our invention.

Having thus described our invention, we claim:

1. In a multi-pressure surface condenser, the combination of:

a shell;

a tube bundle longitudinally extending within said shell; means for introducing coolant fluid into the opposing ends of said tube bundle such that coolant fluid may be alternatively directed in opposing directions through said tube bundle;

means for introducing steam into said shell and on said tube bundle such that the latter condenses the steam into condensate;

means for receiving condensate condensed from said steam by said tube bundle;

means for directing steam alternatively from adjacent the opposing ends of said tube bundle into heat exchange relationship with said condensate; and

means for discharging condensate from said shell.

2. A multi-pressure surface condenser according to claim 1, wherein said means for directing steam into heat exchange relationship with said condensate comprises a fluid passage for conveying steam from adjacent each of the opposing ends of said tube bundle to said condensate, and means are provided for alternatively closing said fluid passages to restrict the flow of steam there-through.

3. A multi-pressure surface condenser according to claim 2, wherein said fluid passage closure means comprises means for independently providing a fluid seal in each of said fluid passages.

4. A multi-pressure surface condenser according to claim 2, wherein means divide said shell into an end compartment adjacent each of the opposing ends of said tube bundle, and each of said fluid passages communicates with one of said end compartments to receive steam therefrom.

5. A multi-pressure surface condenser according to claim 4, wherein said fluid passages are constructed to bypass steam around said tube bundle such that steam is directed from said steam introducing means to said condensate without being directed onto said tube bundle.

6. A multi-pressure surface condenser according to claim 4, wherein said condensate receiving means includes a plurality of openings for discharging streams of condensate, and said fluid passages are formed to direct steam into heat exchange relationship with said streams of condensate.

7. A multi-pressure surface condenser according to claim 6, wherein said condensate receiving means com-

prises a tray disposed adjacent each of the opposing ends of said tube bundle and a tray disposed intermediate said end trays, said end trays and said intermediate tray are relatively arranged such that condensate flows from said end trays into said intermediate tray, and said intermediate tray includes said plurality of openings for discharging said streams of condensate.

8. In a multi-pressure surface condenser, the combination of:

a shell;

a tube bundle including a plurality of coolant conveying tubes extending longitudinally within said shell; means for selectively introducing coolant fluid into the opposing ends of said tube bundle such that coolant fluid may be alternatively directed in opposing directions through said tube bundle;

means for introducing steam into said shell and on said tube bundle such that the latter condenses the steam into condensate;

means for receiving condensate condensed from the steam by said tube bundle and discharging streams of condensate;

baffle means transversely in said shell dividing said shell into an end compartment at each of the opposing ends of said tube bundle;

a first fluid passage for conveying steam from one of said end compartments into heat exchange relationship with said condensate streams;

a second fluid passage for conveying steam from the other of said end compartments into heat exchange relationship with said condensate streams;

first sealing means for closing said first fluid passage to prevent steam flow therethrough;

second sealing means for closing said second fluid passage to prevent steam flow therethrough;

said first and second sealing means being operative to permit steam flow alternatively through said first and second fluid passages; and

means for discharging condensate from said shell.

9. A multi-pressure surface condenser according to claim 8, wherein said condensate receiving means comprises a tray disposed below each of the ends of said tube bundle and a tray disposed intermediate said end trays, said end and intermediate trays are relatively arranged such that condensate flows into said intermediate

tray from said end trays, and said intermediate tray includes a plurality of openings for discharging streams of condensate.

10. A multi-pressure surface condenser according to claim 9, wherein said trays are disposed above the bottom of said shell such that condensate discharged by said intermediate tray flows onto the bottom of said shell, and said first and second fluid passage means convey steam intermediate said trays and the bottom of said shell.

11. A multi-pressure surface condenser according to claim 10, wherein said first and second sealing means comprises means for forming a fluid seal in said first and second fluid passages, respectively, and said intermediate tray is disposed below said end trays such that condensate flows by gravity from said end trays into said intermediate tray.

12. A multi-pressure surface condenser according to claim 11, wherein said baffle means are arranged to provide an intermediate compartment between said end compartments, said end trays are disposed within said end compartments, said intermediate tray is disposed within said intermediate compartment, and said end trays are spaced from the walls of said shell such that said first and second fluid passages extend between said end trays and the walls of said shell.

13. A multi-pressure surface condenser according to claim 11, wherein said first and second sealing means comprise means for introducing a sealing liquid into said first and second fluid passages, respectively, and means are provided for draining such sealing liquid between said trays and the bottom of said shell.

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