Nov. 9, 1948. H. M. GRAHAM 2,453,662

CONDENSER

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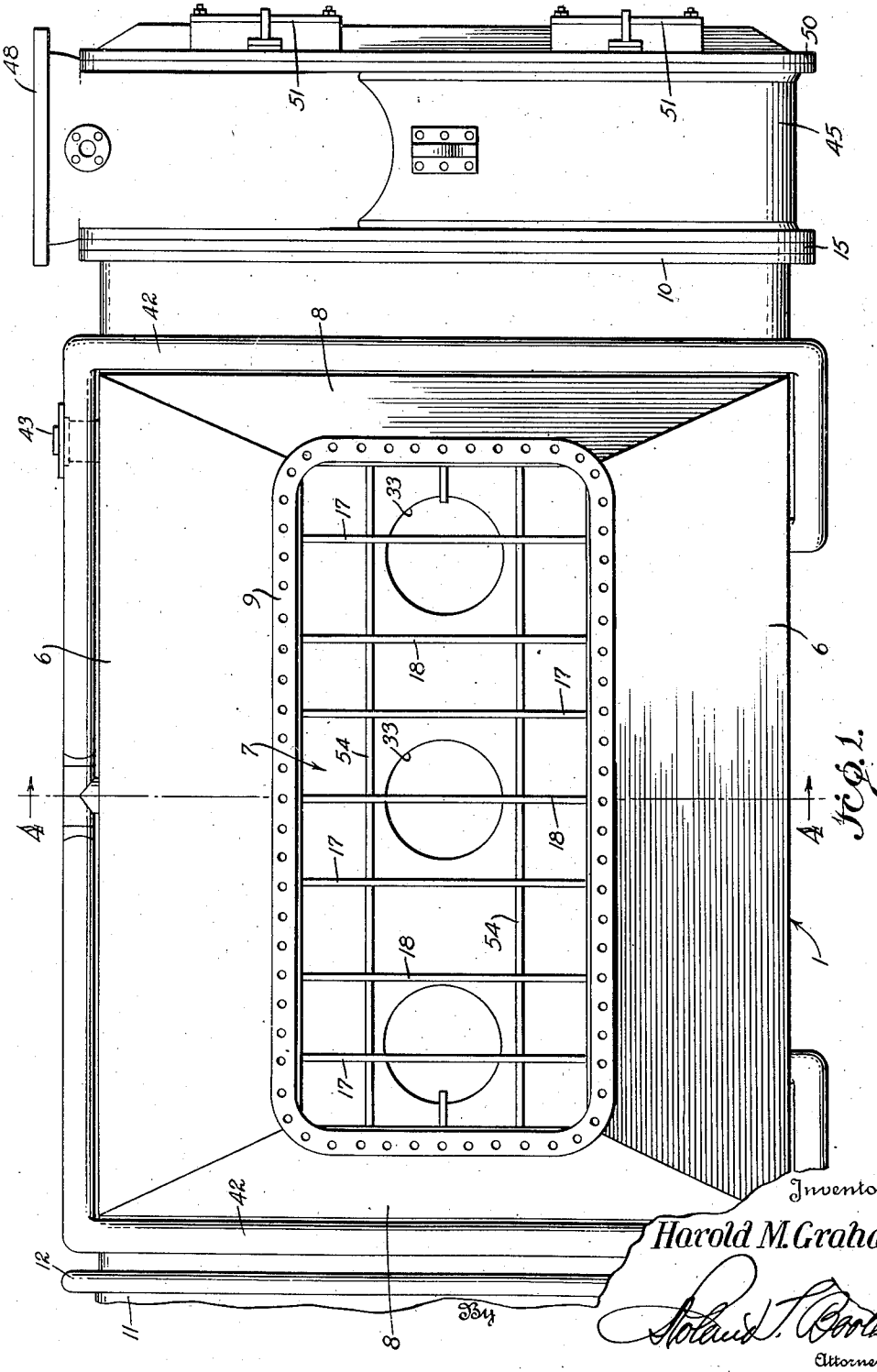


Fig. 1.

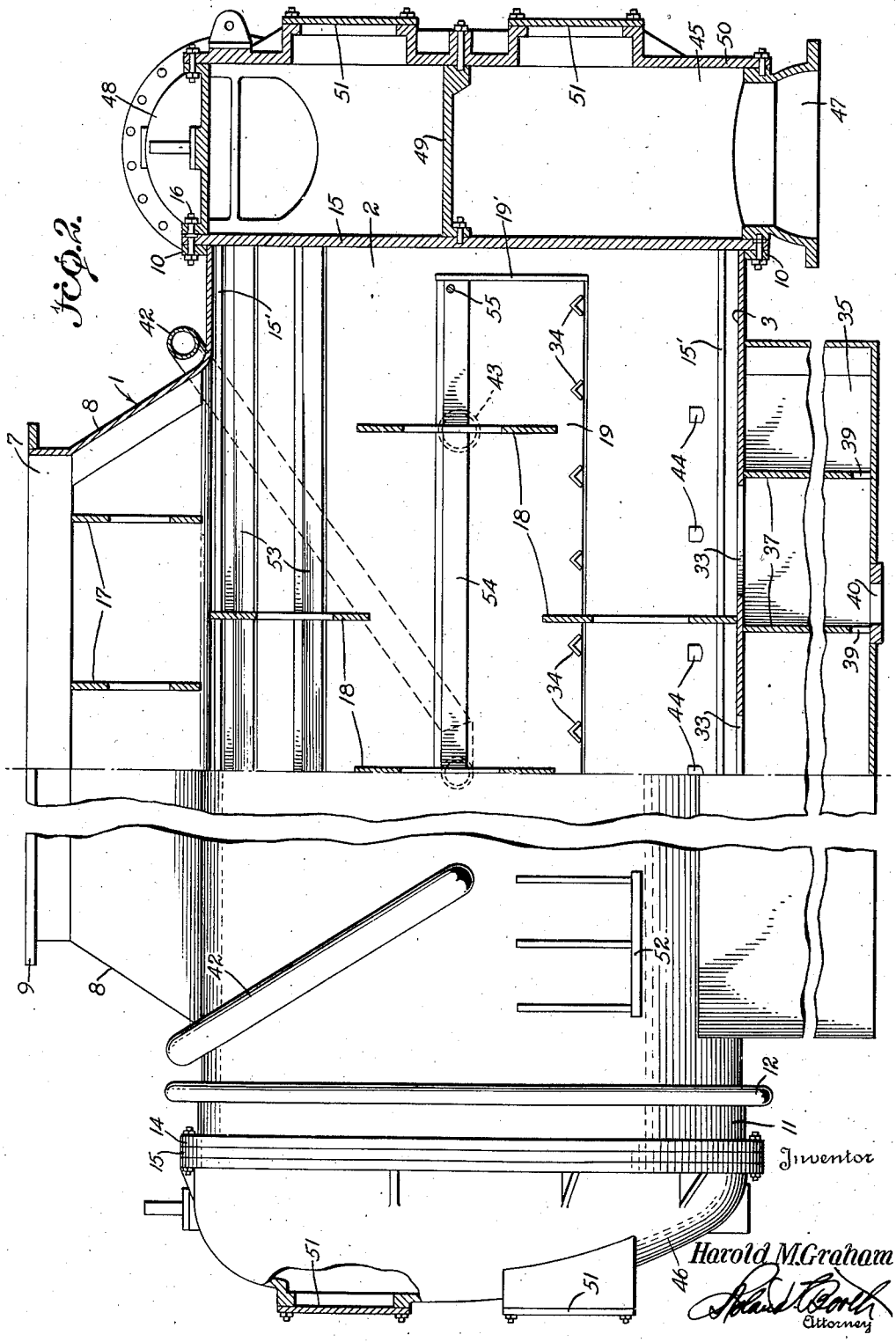
Inventor
Harold M. Graham
By Roland T. Bond
Attorney

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CONDENSER

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Fig. 2.



Inventor

Harold M. Graham

Attorney

Nov. 9, 1948. H. M. GRAHAM 2,453,662

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Fig. 3.

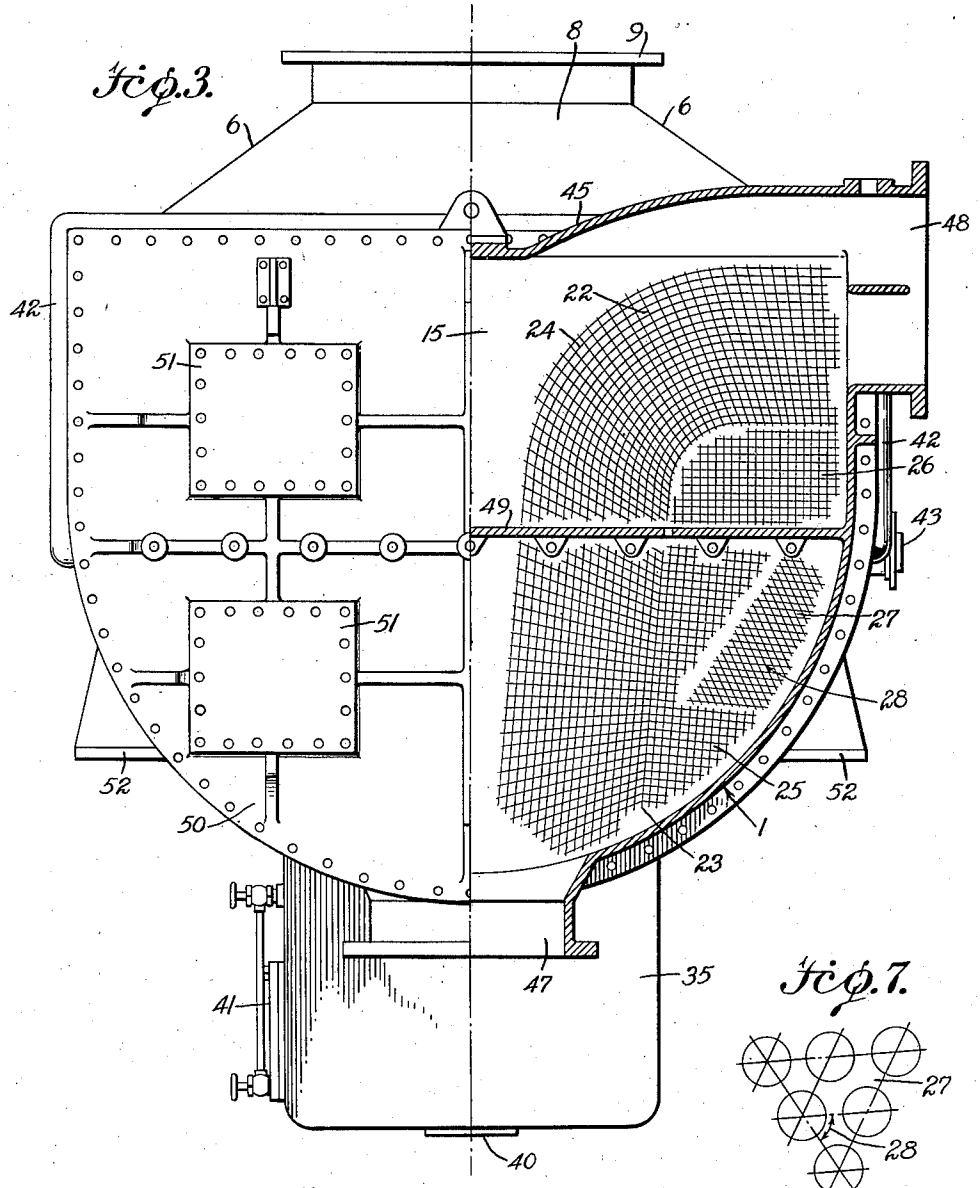


Fig. 7.

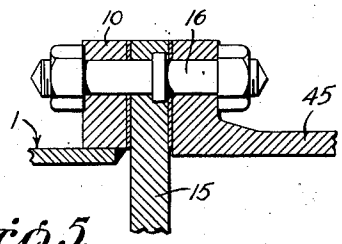


Fig. 5.

Inventor
Harold M. Graham

By Edward T. Booth
Attorney

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Fig. 4.

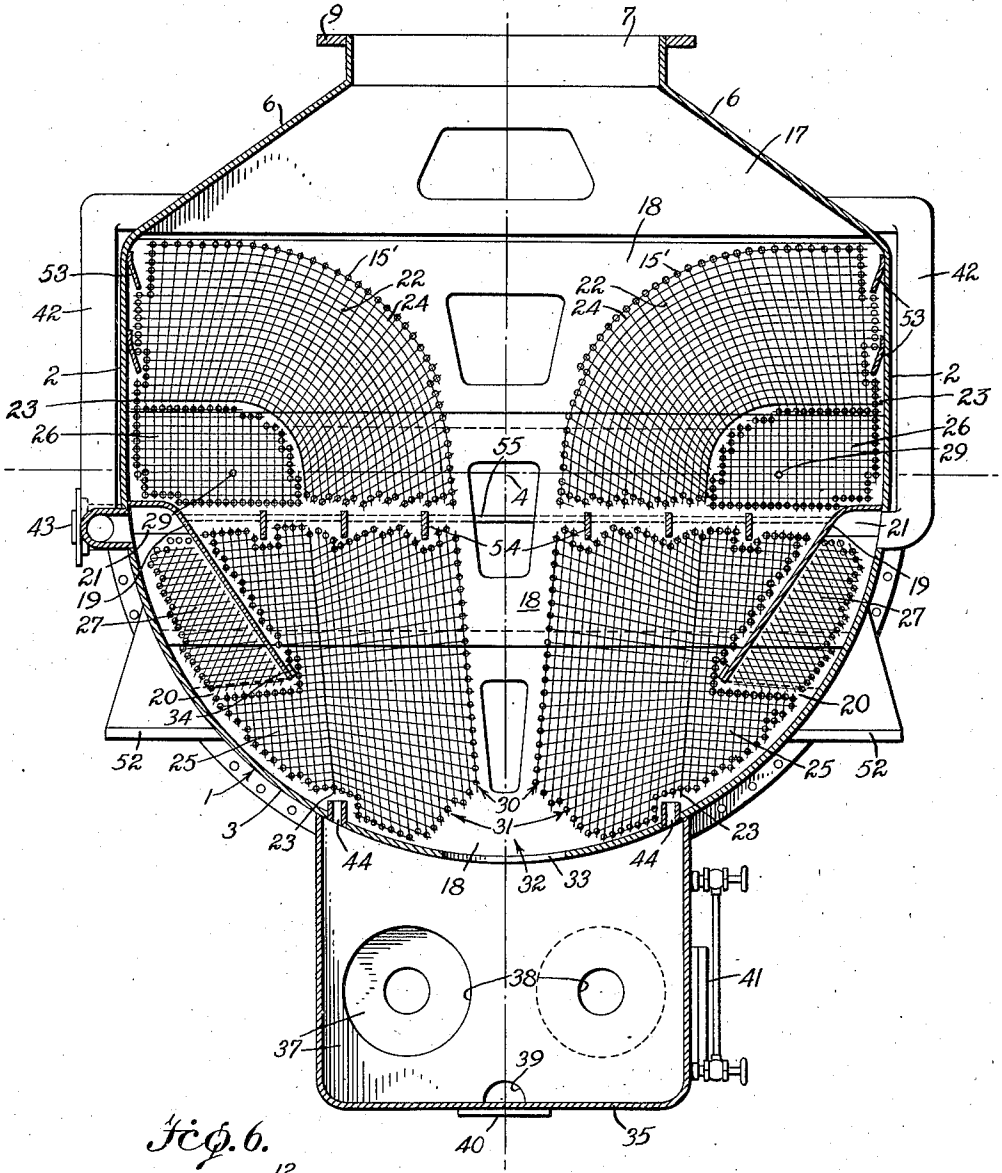
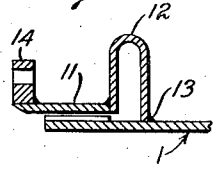


Fig. 6.



Inventor

Harold M. Graham

By Robert W. Barth

Attorney

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UNITED STATES PATENT OFFICE

2,453,662

CONDENSER

Harold M. Graham, Kenmore, N. Y., assignor to Graham Manufacturing Co., Inc., New York, N. Y., a corporation of New York

Application March 2, 1944, Serial No. 524,741

4 Claims. (Cl. 257—43)

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The present invention relates to improvements in condensers and more particularly to surface condensers for condensing steam and other vapors.

The invention improves condenser construction and operation by providing a tube bank and shell construction cooperating to form a vapor lane and a reheating chamber wherein vapor entering the inlet to the condenser at high velocity will have a portion conducted directly into the reheating chamber for increasing the pressure in the reheating chamber to an amount higher than the inlet pressure for effectively using the heat in said vapor for heating the condensate to a higher temperature than the vapor temperature at said inlet.

The invention provides a condenser constructed to provide increased efficiency by utilizing part of the heat in the steam being condensed to reheat the condensate to a higher temperature than the steam temperature entering the condenser.

The invention further provides for improving the construction and operation of a condenser to increase its efficiency by having a pair of tube banks arranged one in each side of the shell extending inwardly from the side walls thereof to provide condensing zones substantially filling the shell. Each bank of condenser tubes has radially arranged steam passages through the condensing zones radiating upwardly and inwardly from the central side portions of the shell. The condenser banks terminate in spaced relation in the central portion of the shell with the inner faces diverging upwardly from the bottom portion at an approximate 10° angle to the upper central portion where each bank then curves outwardly in arcuate relation to the upper top side portions of the shell to form a central vertical funnel-shaped vapor lane through said shell. The bottom portions of the condenser banks terminate in spaced relation above the bottom of said shell to form a condensate reheating chamber below the banks having the lower end of the vapor lane communicating therewith. With the width of the narrow portion of the vapor lane equal to about one-twelfth of the width of both condenser tube banks, a cooperation is obtained in the condenser between the radiating steam passages in the condensing zone, the steam lane and condensate reheating chamber for condensing a large volume of steam or the like and reheating the condensate to a higher temperature in the reheating chamber than the temperature of the vapor at the inlet. The forming of a top portion on the condenser with a long narrow inlet and top walls inclined outwardly away from the inlet to the side walls of the shell provide for further improvements in the condenser to aid in obtaining the rapid condensing of a large volume of steam and reheating of the condensate.

The invention provides for improvements in

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the construction of condenser tube banks to secure more efficient condensation of vapor by having the tubes in each bank arranged in rows to provide a cross-sectional tube pattern in which transverse rows radiate from the central outside portion of the bank upwardly and inwardly in substantially radial relation to provide steam passages through said banks that are wider at the inner face of the bank, while curved intersecting rows of the tubes in the bank are arranged concentrically in uniform spaced relation and extend inwardly from the outer upper side portion of the bank and then curve into downwardly extending relation in the central portion of the shell merging into spaced parallel rows of tubes inclined inwardly and downwardly to the bottom of the tube bank.

In the drawings:

Fig. 1 shows a top plan view of a condenser with the water box on one end broken away and omitting illustration of the condenser tubes.

Fig. 2 is a view showing the condenser partly in side elevation and partly in vertical longitudinal cross-section with portions broken away for convenience in illustrating the invention, with only portions of a few condenser tubes illustrated.

Fig. 3 shows the condenser in end elevation with a portion of the water box broken away and shown in cross-section for illustrating details of construction with the cross-sectional pattern of the condenser tubes shown diagrammatically by center lines.

Fig. 4 is a vertical transverse section taken on line 4—4 of Fig. 1 showing the cross-sectional tube bank pattern diagrammatically by the intersecting center lines.

Fig. 5 is an enlarged fragmentary detail cross-section through the margin of a tube sheet, water box and the flange on one end of the shell showing how the tube sheet and water box are bolted to the shell.

Fig. 6 is an enlarged fragmentary detail cross-section showing the expansion joint at one end of the shell.

Fig. 7 is an enlarged fragmentary diagrammatic illustration showing the cross-sectional tube pattern in the air cooler including the angular relation between intersecting center lines through the tube centers.

The condenser constructed according to the present invention has a metal shell 1 open at opposite ends. The shell is formed to provide spaced parallel vertical side walls 2 merging into downwardly and inwardly curved bottom portions 3 illustrated in semi-cylindrical form in the drawings with the radius for the bottom portion having the center on a horizontal center line at 4, see Fig. 4. The radius of a typical condenser from center 4 to the outer edge of the flange as illustrated is fifty and three-fourths inches.

The shell is formed to provide a top having inclined top wall sections 6 extending inwardly and

upwardly from the upper edges of side walls 2 and formed at the top to provide a narrow inlet 7. The top also has inclined top wall portions 8 connecting the ends of sections 6 and formed at the top edges to provide the end portions of inlet 7. As shown in Fig. 1, inlet 7 is substantially rectangular in form having the ends terminating close to the end portions of the shell and having a width equal to about one-third of the condenser width. The top wall portions 6 and 8 in forming inlet 7 are provided at the upper edges with a flange 9 welded thereon and formed with a plurality of openings for forming one part of a flange joint to which the exhaust end of a turbine, vapor conduit or other apparatus may be bolted to provide a tight joint at the inlet to the condenser.

The right-hand end of the shell has a flange 10 welded thereon in the manner shown in Fig. 5. The left-hand end of the condenser as shown in Figs. 1, 2 and 6 has a sleeve 11 slidably mounted thereon and connected to the end portion of the shell by means of a sheet metal ring 12 of U-shape in cross-section having one part of the ring welded at 13 to the shell and the other part of the ring welded to the inner end of sleeve 11. This provides a bellows type expansion joint. A flange 14 is welded to the other end of sleeve 11 where it projects beyond the end of the shell. Flange 14 is formed with a plurality of openings for receiving securing bolts. This structure provides means for compensating for the difference in expansion between the shell and the condenser tubes.

A pair of tube sheets 15 are mounted one at each end of the shell with the periphery of the tube sheets engaged against flanges 10 and 14. The tube sheets are bolted to flanges 10 and 14 by collar bolts 16, as shown in Fig. 5, having the collars engaging in recesses in the outer faces of the tube sheets so that when the nuts are threaded on the ends of the bolts passing through flanges 10 and 14 the tube sheets will be rigidly secured in sealed relation against flanges 10 and 14 on the ends of the condenser shell. Suitable gaskets may be placed between tube sheets 15 and the flanges on the condenser shell to seal the joints in a manner well-known in the art. A sufficient number of collar bolts 16 are used around the flanges on the shell to firmly secure the tube sheets thereon. Illustration of most of these collar bolts and other bolts are omitted in the several figures of the drawings for convenience in illustration.

A plurality of baffle plates 17 are arranged in vertical transversely extending spaced parallel relation in the top portion of the shell and are secured at the ends by welding or the like to top wall sections 6. These baffles 17 direct steam entering through the inlet in a downward path toward the bottom of the shell and also cooperate in reinforcing the top structure of the shell. These baffles have central openings, partly shown in Fig. 4.

A plurality of tube support plates 18 are mounted in vertical transversely extending relation with opposite ends secured to the side wall and bottom portions 2 and 3 of the shell by welding or the like. It will be noted from Fig. 2 that the centrally located tube support plates are in staggered relation with respect to the upper and lower tube support plates 18. These tube support plates are provided with a plurality of perforations (not shown) to receive and support the condenser tubes at spaced intervals between the

tube sheets. The central sections of plates 18 are apertured as shown in Fig. 4 to provide communication throughout the central portion of the shell. A pair of air baffles 19 of angle form in cross-section is formed of sheet metal and has one free edge welded or otherwise suitably secured to the lower portions of side walls 2 of the shell, one at each side thereof. The other portion of the angle extends inwardly and downwardly toward the curved bottom portion 3 of the shell and terminates in spaced relation to the inside of the shell to provide an air inlet 20 along the lower edge. Air baffles 19 are slotted to receive and engage over tube support plates 18 and the centrally located group of tube support plates 18 are apertured at 21 inside air baffles 19 on each side of the condenser shell to provide continuous interior air manifolds throughout the full length of baffles 19 which are closed at the ends near the tube sheets by blank-off plates 19'.

The condenser is provided with a pair of condenser tube banks having a plurality of tubes arranged in longitudinally extending relation throughout the length of the shell with opposite ends secured in tube sheets 15 so that the interior of the tubes open at the ends of the condenser on the outside faces of the tube sheets in a manner well-known in the art. The condenser tubes are indicated by the numeral 15'. The illustration of the tube banks in the drawings is substantially diagrammatic due to the small scale required for illustration. The tube banks are therefore illustrated by showing the cross-sectional pattern produced by the intersecting center lines of the transverse and intersecting curved rows in which the tubes are arranged, without illustrating the tubes in cross-section. Circles have been drawn on some of the tube centers outlining the tube banks to further aid in illustrating the arrangement of the tubes in the condenser.

Each tube bank is formed with the tubes arranged in the same but opposite manner as clearly shown in Fig. 4. The tubes are arranged to provide transverse rows of tubes radiating substantially from air baffles 19 toward the central and upper portions of the shell, these radiating transverse rows of tubes being indicated by the numeral 22 referring to the transversely extending and radiating center lines. The transverse center lines 22 for the tube rows at the bottom of the condenser bank incline inwardly and downwardly to a slight extent and then as the rows progress upwardly the center lines 22 radiate inwardly and upwardly until they extend in a vertical relation adjacent the upper portions of side walls 2 of the shell. These radiating center lines 22 for the transverse rows of tubes start with an intersecting curved center line indicated at 23 and extend inwardly to the center line 24 defining the shape of the inner face of the condenser banks and the centers for the inner row of tubes.

For example, in a typical full-sized condenser constructed as illustrated in the drawings, the centers for the condenser tubes along the line 23 are spaced an inch apart and the tubes will be spaced successively greater distances apart, progressing outwardly to the inner face of the condenser bank along the intersecting curved center line 24 where centers of the tubes will be spaced approximately one and nine-sixteenths inches apart. This provides tapering steam passages through the condensing zones arranged in substantially radial relation extending toward

the central side portions of the condenser shell which are gradually reduced in size from the inner faces of the tube banks until the passages reach a minimum size at the center line 23. Between the center line 23 and the side and outer bottom portions of the shell the tube pattern indicated by the center lines intersecting at right angles as indicated at 25 and 26 are arranged in right angular relation to show a spacing between tubes on center in both directions of one inch thereby being equal to the minimum spacing along center line 23.

A group of condenser tubes in each bank pass through the condenser between air baffles 19 and shell side portions 2 above entrance 20 to form an air cooler having the tubes arranged slightly closer together as shown by the group of intersecting center lines showing the positions of the tube centers as indicated at 27. The angle between intersecting center lines indicated at 28 is 60° and measured along each of the intersecting center lines the tube centers are spaced approximately one inch apart in a typical condenser thereby bringing the tubes slightly closer together in the air cooler section than in the portions indicated by numerals 25 and 26 by reason of the acute angular relation of the center lines.

The tube banks have the intersecting curved center lines 23 and 24 in the upper portion of the condenser arranged in concentric arcuate relation with the radius of each center line having a center at 29 on the horizontal center line through the condenser on which center 4 is located. The radius from center 29 to center line 24 in a typical condenser is twenty-seven inches. Below the center line on which center 29 is located, the center lines for the tubes between center lines 23 and 24 extend in spaced parallel inclined relation toward the bottom central portion of the condenser at an angle of five degrees to the vertical center line through the typical condenser. The center line 24 defining the inner face of the tube bank curves outwardly at the top on each side for each condenser tube bank toward the upper edges of side walls 2 and beyond the vertical plane through centers 29, these center lines 23 and 24 are in spaced parallel horizontal relation with center lines 24 terminating at the top edges of the side walls. In the typical condenser the distance between centers 4 and 29 is thirty-four inches and from center 29 to the outer vertical transverse center line is twelve inches. There is a partial row of tubes spaced inwardly one inch from line 24 located at the top portions of each tube bank as shown in Fig. 4.

The condenser tube banks have the inner face formed by the inner row of tubes along center lines 24 terminating in spaced relation to each other on opposite sides of the vertical center line through the condenser shell with the tubes at the bottom central portion of the banks terminating in spaced relation above the bottom of the shell to provide a narrow throat portion at 30. The tubes at the bottom of the condenser bank are arranged to provide an outwardly and tapering bottom portion to the tube bank indicated at 31 below throat 30 on each side thereof forming a condensate reheating chamber 32 having throat 30 communicating therewith. Reheating chamber 32 extends across the bottom of the condenser under the bottom portions of both tube banks and on opposite sides of throat 30. The reheating chamber 32 extends uniformly throughout the length of the shell between tube sheets 15. The bottom of the condenser shell is formed with a

plurality of apertures 33 in longitudinally extending relation.

The width of the throat portion 30 at the bottom portion between the condenser banks is equal to approximately one-twelfth of the width of the condenser banks at the top of the condenser, that is the over-all dimension as shown, equalling ninety-six and three quarters inches in the typical condenser. The opening between the condenser banks forms a funnel-shaped lane in cross-section extending longitudinally throughout the length of the shell between the tube sheets. The upper end of this lane opens into a wide space extending to the upper edges of the side walls so that the top portion of the condenser is open to provide for the steam entering through inlet 7 expanding outwardly to the upper edges of the side walls under the inclined top wall sections 6 and 8 to fill the top portion of the condenser above the tube banks with steam expanding from the elongated narrow inlet. The steam can then pass downwardly through the steam lane with only a small portion passing through narrow throat portion 30 into condensate reheating chamber 32.

A space is left between the inner face of air baffles 19 and the condenser tube banks to provide air lanes for the air and steam drawn through the condenser tube banks to follow down along the inner surfaces of air baffles 19 into the openings 20 at the lower ends thereof. A plurality of inverted V-shaped deflector strips 34 are mounted along the lower inner edges of air baffles 19 for deflecting condensate dripping on and flowing down the baffles to the opposite sides thereof for eliminating interference with the operation of the suction or vacuum in the interior air manifolds.

The manner of securing the ends of condenser tubes in the tube sheets 15 is not illustrated because conventional methods well-known in the art are used for this purpose.

A casing 35 encloses the bottom central portion of the condenser to provide a hot well for receiving condensate flowing downwardly through the condenser shell and through openings 33.

The condenser tube banks form the condensing zone within the shell where steam, vapor and the like are condensed into liquid form which flows downwardly and drops from one tube to the next, like rain. The condensate drips from the upper tubes near the side walls 2 on baffles 19 and then through the lower tubes through reheating chamber 32 and on the bottom curved portion 3 of the shell. All of the condensate flows through reheating chamber 32 to openings 33 where the condensate passes into casing 35 forming a hot well on the bottom of the shell.

Hot well casing 35 is provided with a plurality of transverse baffles 37 formed with perforations 38 of varying size arranged in alternate relation in successive partitions. Apertures 39 are formed in the lower edges of partitions 37 to provide for the draining of the condensate toward outlets 40 constructed for the attachment of suitable outlet pipes to drain off condensate from the hot well. The hot well is provided with a manhole cover 41 detachably mounted over an opening in the side of casing 35 that may be removed when desired to obtain access to the interior of the hot well and the condenser casing through openings 33.

A pair of equalizer pipes 42 are formed to extend around the outer upper portions of the condenser shell and to communicate with the in-

terior air manifold on opposite sides of the shell to provide for equalization of the vacuum in the manifolds. An air outlet connection is provided at 43 having communication with the interior air manifold at the right side of the shelf as shown in Fig. 3, so that a pipe connection can be made to air outlet connection 43 for connecting it with a vacuum pump or ejector designed to create the desired amount of vacuum in the interior air manifolds to secure the desired operation of the condenser. A plurality of pipe sections 44 are mounted in spaced relation at opposite sides of the bottom center portion of the condenser shell and communicate with the side portions of the compartments in hot well casing 35 between the various partitions 37, for venting the sides of the hot well into the shell so that the vacuum in the manifolds will maintain effective operation on the vapor in the hot well without interference from the condensate running into the hot well. The pipe sections 44 extend above the inner bottom face of the shell so condensate cannot clog the openings therein.

A gauge glass of conventional form may be provided on one side portion of casing 35 for indicating the level of condensate in the hot well as shown in Figs. 3 and 4.

Water boxes of substantially conventional construction are provided on opposite ends of the condenser, a combined inlet and outlet water box being indicated at 45 and the return water box at 46. Water box 45 has inlet 47 at the bottom portion of the water box while the outlet 48 is at the top side portion as clearly shown in Fig. 3. Collar bolts 16 are used to detachably secure water box 45 in sealed relation against the tube sheet 15, as clearly illustrated in Fig. 5. Water box 45 has a central horizontal partition 49 extending therethrough for dividing the water box into inlet and outlet chambers while return water box 46 does not use a partition. This provides for the circulation of cooling water or other fluid into the bottom of water box 45 through inlet 47 and then through the lower group of tubes in both banks to return water box 46. The fluid then travels upwardly in return water box 46 to the upper group of tubes in both tube banks and through them to the upper chamber in water box 45 and then out through outlet 48. A cover 50 is bolted on water box 45 to close the end of the box in the usual conventional manner. Cover 50 is provided with a plurality of manholes, having covers 51, also of conventional construction, in order to provide for access to the interior of the water box and the tube sheets. The return water box is constructed in a similar manner, well-known in the art. Supporting brackets 52 are mounted on the outside lower central portions of the condenser shell to provide supports for mounting the condenser in the location in which it is to operate.

In order to guard against the passage of steam or other vapor downwardly between the inner faces of side wall portions 2 of the shell and the outer row of condenser tubes, deflector strips 53 are secured in inwardly and downwardly inclined relation on the inner faces of the upper portions of side walls 2 as clearly shown in Fig. 4, and extend longitudinally throughout the length of the shell. These deflector strips 53 deflect steam entering between the outside portion of the tube banks and shell into the tube banks for condensation. In the central portion of the tube banks it will be noted that there is an absence of tubes in a transversely extending portion of the tube banks in horizontal alignment with partition 49 in water box 45. The use of the partition in the water box prevents tubes from being mounted in this portion of the tube sheets thereby leaving a transversely extending space between upper and lower portions of both tube banks. To prevent steam or other vapor to be condensed from passing through the condensing zone without contacting with the tubes in the banks, a plurality of longitudinally extending baffle plates 54 are mounted in spaced parallel relation on rods 55 extending in transverse relation in the shell with opposite ends secured to the upper portions of air baffles 19. Plates 54 are also engaged in slots and secured in support plates 18. Plates 54 block the passages in the tube banks so that steam or other vapor entering the same will be deflected into contact with the tubes in the banks and subjected to the condensing operation of the condensing zone.

The condenser herein disclosed is adapted for operation with steam turbines of all sizes including turbines used on ships for propulsion as well as large steam turbines used for industrial purposes. It is customary to mount the turbine over the condenser with the exhaust end of the turbine secured to the condenser inlet to directly discharge steam from the turbin into the condenser inlet. The condenser is tightly sealed at all joints to prevent leakage of air or cooling fluid into the inside of the shell. In operating a condenser of the character shown in the drawings with a steam turbine it will be understood that the steam exhausting from a turbine into inlet 7 is being received in inlet 7 at high velocity and in substantial quantities. A high vacuum is applied to the interior air manifolds which results in the high velocity steam entering into the funnel-shaped lane at the top of the condenser and by reason of the inclined top wall sections the steam spreads out within the top of the condenser over the tube banks. Steam entering the central portion of the condenser through inlet 7 flows downwardly at high velocity into the narrow portion between the tube banks in the central portion of the shell and has rapidly decreasing velocity as it flows through throat 30 into condensate reheating chamber 32. As the steam passes downwardly through the lane the vacuum in the interior air manifolds operating through the condenser banks causes a large volume of the steam to be drawn laterally through the radial passages between the transversely extending rows of tubes and into contact with the surface of the tubes maintained at a cold temperature by the cooling water circulated through the water boxes from the inlet to the outlet. This causes the vapors to condense on the tubes. The arrangement of the tube banks with the tubes in the pattern as hereinabove described provides an efficient condensing structure for rapidly condensing large volumes of steam. The condensed steam falls like rain through the condensing zone until it reaches the bottom where it flows into and passes through condensate reheating chamber 32 and into casing 35 forming the hot well. Steam passing downwardly through throat 30 into condensate reheating chamber 32 also passes through openings 33 into the hot well. Since there is no outlet for the steam at the bottom of the condenser the small portion of steam passing into condensate reheating chamber 32 and the hot well will have the velocity reduced to a substantial extent and converted into building up pressure in the condensate reheating chamber greater than

the pressure of the steam at the inlet end of the condenser. This provides for increasing the temperature in reheating chamber 32 so that condensate passing through condensate reheating chamber 32 will be heated to a temperature which has been found to be higher than the temperature of the steam entering at the inlet. Steam entering reheating chamber 32 through throat 30, turns outwardly in both directions into the tube banks in the condensing zone under the suction created in the interior air manifold and by reason of the inclination of the rows of tubes at the bottom of the tube banks shown as inclining inwardly and downwardly and having passages between the rows of tubes gradually decreasing in size from the inner face of the tube banks outwardly toward the vacuum channels is drawn toward the tube banks. The steam therefore curls back under the bottom of the tube banks and is condensed as it flows through the condensing zone toward opening 20 into the air cooler. Pipe sections 44 also provide for the vacuum in the interior air manifold drawing steam and air from the upper portions of hot well casing 35 in maintaining effective operation of the vacuum in all parts of the condenser.

In all steam systems there is a certain percentage of air mixed with the steam vapor and in the operation of a condenser such as herein shown and described the steam will be substantially entirely condensed in passing through the condensing zones. Any remaining steam and air that passes through the tube banks into the space between the banks and baffles 19 will flow downwardly along the inner faces of the baffles and through the openings 20 at the lower ends of the air baffles into air cooler tube banks 27. The air will be cooled and any steam, the saturation component of the air, and other condensable products will be condensed in his air cooler section while uncondensable gases such as air will pass through the air cooler unit and be substantially cooled to reduce its volume and temperature to as near the cooling fluid temperature as possible, whereupon it will pass into the interior air manifolds and then subsequently be evacuated through air outlet 43.

The condensate passes from the condensate reheating chamber 32 through openings 33 into the hot well and is drained off through openings 39 in the bottoms of the partitions and through the outlets 40 for return to the boiler to be reconverted into steam.

In a typical installation of a condenser as shown in the drawings and hereinabove described, with steam entering the condenser at the inlet at a temperature of 70° F., and a vacuum of 29.26 inches of mercury at the top of the condenser shell, a steam pressure of .74 inch of mercury was measured at the steam inlet. A pressure of 1.03 inches of mercury was measured in the condensate reheating chamber 32 and the condensate was heated to a temperature of 80° F. Steam was being condensed at an approximate volume of 71,000 pounds per hour while circulating water was pumped through the condenser at the rate of approximately 15,600 gallons per minute entering at a temperature of 46° F. Many examples of this character have been recorded in the operation of condensers of the character disclosed herein connected to the main turbines on merchant ships and it has been found to be a rather common occurrence to find that the condensate is reheated in the condensate reheating chamber to a temperature approximately 10° F.

higher than the temperature of the steam at the inlet. It will therefore be understood that a considerable increase in efficiency is obtained in the operation of the present condenser over many varieties of condensers heretofore known in the art where it has been found most difficult to prevent excessive sub-cooling of the condensate to temperatures more than 1° F. below the temperature of the steam at the inlet.

The arrangement of the tube rows in the tube banks, the shaping of the tube banks in providing the funnel-shaped lane in the central portion of the condenser shell with a long narrow portion extending throughout a substantial part of the height of the shell and getting gradually narrower toward the throat 30 near the bottom of the tube banks with the width of the space between the condenser banks forming the steam lane proportioned to approximately one-twelfth of the overall width of the condenser banks provide a cooperation in the condenser structure herein disclosed with the formation of the reheating chamber at the bottom of the condenser for obtaining the increase in efficiency of operation of the condenser to provide the condensate heated to a higher temperature than that of the steam entering at the inlet.

It will be understood that condensers designed in accordance with the disclosure herein may also find application for condensing vapors of other types than steam where a similar saving in heat with the increase of efficiency obtained may be found useful.

The invention claimed is:

1. A steam condenser comprising a shell, having a steam inlet at the top and a condensate outlet at the bottom, an interior air manifold along each side of said shell in the central portion, a pair of condenser tube banks mounted in said shell, each bank extending between the ends of said shell along one side, substantially filling said side of said shell from the top to the bottom portions thereof, and extending about the adjacent air manifold to provide a substantial tube bank section in all directions inside said shell from said air manifold through which steam must pass toward said manifold, each bank being formed of a plurality of spaced parallel condenser tubes having a cross-sectional pattern wherein each tube lies in a transverse row and also in an intersecting row, the transverse tube rows radiating from said air manifolds to provide tapering steam passages extending transversely through each bank decreasing in size toward said manifolds, said intersecting tube rows in the central portion and lower end of each bank extending in spaced parallel relation and slightly inclined to the vertical central plane of said shell and the upper ends of said intersecting tube rows curving outwardly in concentric spaced relation into substantially horizontal portions where said intersecting tube rows end adjacent the upper inner sides of said shell, said tube banks being spaced apart in the central portion of said shell and cooperating to form a central funnel-shaped steam lane having a wide upper portion curving inwardly about the inner faces of said tube banks into a narrow and downwardly extending passage in the central portion to the bottom of said shell, said banks being formed to provide outwardly tapering lower inner portions at the bottom of said shell for cooperation therewith to form a central condensate reheating chamber under the lower inner portions of said banks, said tube banks and shell providing the only means forming said

reheating chamber in said shell, and said tube banks providing the only obstruction in said shell between said reheating chamber and air manifolds whereby said shell and tube banks cooperate to condense steam in all parts of said banks and provide a higher steam pressure in said condensate reheating chamber than at the steam inlet for heating condensate passing therethrough to a higher temperature than the steam temperature at said inlet.

2. A steam condenser comprising a shell having a steam inlet at the top and a condensate outlet at the bottom, a pair of interior air manifolds each located along one side of said shell in the central portion, a pair of condenser tube banks mounted in said shell, each bank having a plurality of tubes extending between the ends in spaced substantially parallel relation and substantially filling said shell along one side from the top to the bottom portions thereof about the adjacent air manifold to provide a substantially uniform tube bank section in all directions from said air manifold within said shell through which steam must pass toward said manifold, each tube bank having a cross-sectional pattern wherein each tube lies in a transverse row and an intersecting row, said transverse rows at the lower end of each bank extending inwardly in radiating relation from the adjacent air manifold to provide substantially radial steam passages transversely through each bank of progressively reduced size from the inner edge of each bank toward the adjacent air manifold, said intersecting rows of tubes at the lower end of each bank extending in spaced parallel relation inclined at a small acute angle to the vertical central plane of said shell, said tube banks being in spaced relation at the central portion of said shell with the innermost intersecting rows of tubes cooperating to define the inner face of said bank and a central steam lane of gradually reduced size progressing toward the bottom central portion of said shell, said tube banks having outwardly and downwardly inclined lower inner portions for cooperation with said shell to form a central condensate reheating chamber in the bottom of said shell extending under the lower inner portions of said banks, said tube banks and shell cooperating to provide the only means forming said reheating chamber, and said tube banks forming the only obstruction to steam passage between said reheating chamber and said manifolds, whereby said shell and tube banks cooperate to condense steam in all parts of said banks and provide a higher steam pressure in said condensate reheating chamber than at the steam inlet for heating condensate passing therethrough to a higher temperature than the steam temperature at said inlet.

3. A steam condenser comprising a shell having a steam inlet at the top and a condensate outlet at the bottom, a pair of interior air manifolds each located along one side of said shell in the central portion, a pair of condenser tube banks mounted in said shell, each bank extending between the ends of said shell along one side substantially filling said side of said shell from the top to the bottom portions thereof and extending about the adjacent air manifold to provide a substantially uniform tube bank section in all directions from said air manifold through which steam must pass toward said manifold, said tube banks defining condensing zones in opposite sides of said shell extending inwardly to the central portion thereof and cooperating to define a central funnel-shaped steam lane extending between the sides at the top of said shell and tapering inwardly and downwardly into a narrow portion between said banks opening between the bottom portions thereof, said shell and tube banks being the only means arranged in spaced relation at the bottom to form a condensate reheating chamber below said condensing zone having the lower end of said steam lane communicating with the central portion thereof, whereby high velocity steam will pass through said steam lane into said reheating chamber and provide increased pressure therein for heating condensate from said condensing zone passing therethrough to a higher temperature than steam entering said steam lane at said inlet while steam will pass outwardly from all portions of said steam lane and reheating chamber through said banks of condenser tubes forming said condensing zone for condensation.

4. A steam condenser comprising a shell having a steam inlet at the top and a condensate outlet at the bottom, a pair of interior air manifolds each located along one side of said shell in the central portion, a pair of condenser tube banks mounted in said shell, each bank extending between the ends of said shell along one side substantially filling said side of said shell from the top to the bottom portions thereof and extending about the adjacent air manifold to provide a substantially uniform tube bank section in all directions from said air manifold through which steam must pass toward said manifold, said tube banks defining condensing zones and substantially filling the side portions of said shell and terminating in spaced relation to each other in the central portion of said shell to form an upright funnel-shaped steam lane having a wide upper portion extending inwardly into an elongated narrow vertical central portion converging in inclined relation to a narrow throat at the lower portion between said banks having a width of approximately one-twelfth of the total width of said banks, said tube banks being formed at the bottom central portion in cooperation with the bottom of said shell to provide a condensate reheating chamber and forming the only means to provide said longitudinally extending condensate reheating chamber having said steam lane communicating with the central portion thereof through said narrow throat, whereby high velocity steam will pass through said steam lane into said reheating chamber and provide increased pressure therein for heating condensate from said condensing zone passing therethrough to a higher temperature than steam entering said steam lane at said inlet.

HAROLD M. GRAHAM.

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