Nov. 21, 1939. C. B. TULEY ET AL 2,180,840

CONDENSER APPARATUS

Filed Nov. 27, 1937 2 Sheets-Sheet 1

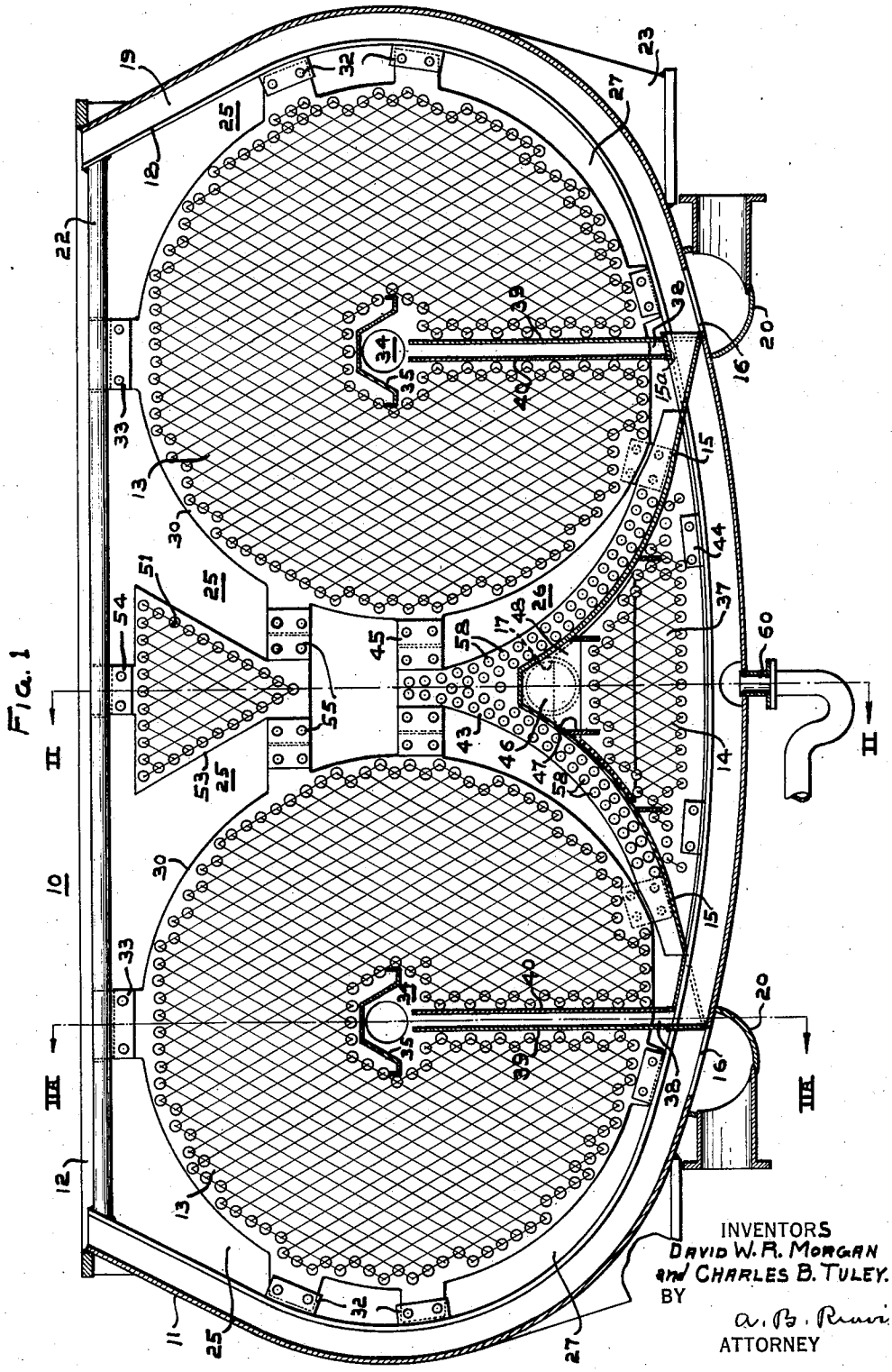


FIG. 1

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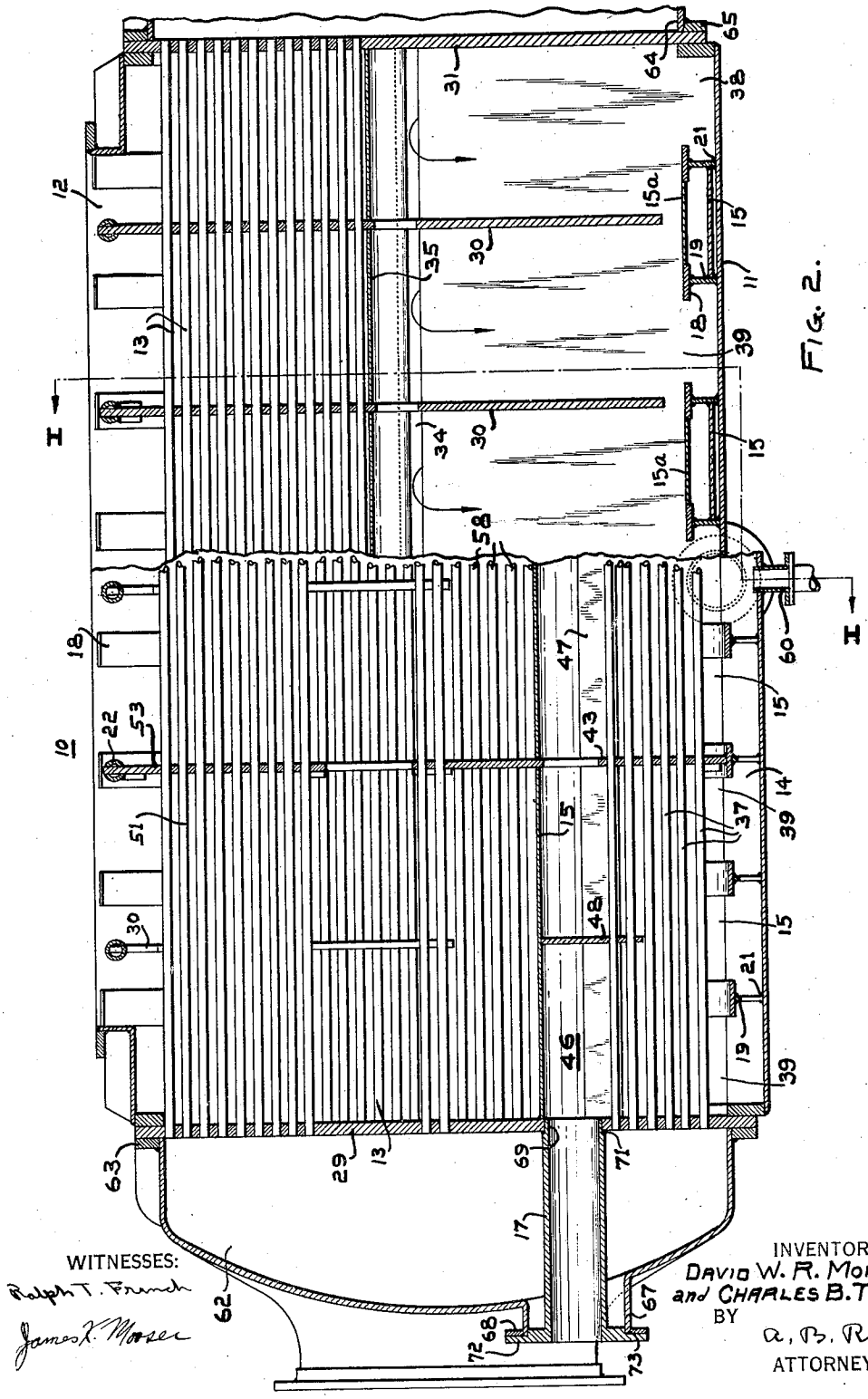


FIG. 2.

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2,180,840

CONDENSER APPARATUS

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Application November 27, 1937, Serial No. 176,898

9 Claims. (Cl. 257—43)

Our invention relates to steam condensers and more particularly to surface condensers of the radial-flow type.

An object of our invention is to provide a condenser having an improved construction involving a novel arrangement of tubes whereby additional heat absorbing surface is provided.

A further object of our invention is to provide a condenser having a pair of radial flow tube nests arranged in a shallow shell, there being disposed at the bottom and between the tube nests a group of air cooler tubes separated from the main shell interior by means of a triangular baffle forming an air cooler space of novel construction.

A further object of our invention is to provide an offtake pipe which may be attached and detached without removal of the waterbox.

These and further objects are effected by our invention as will be apparent from the following disclosure and claims taken in connection with the accompanying drawings forming a part of this application in which:

Fig. 1 is a view in transverse section taken along the line I—I of Fig. 2 showing a preferred constructional form of the invention; and

Fig. 2 is a view in longitudinal section, the left hand portion being taken along the line II—II of Fig. 1 and the right hand portion being taken along the line IIA—IIA of Fig. 1.

Referring now to the drawings more in detail, reference numeral 10 indicates, in its entirety, a surface condenser comprising a shell 11 having a steam inlet opening 12 at the top thereof. Within the shell 11 are two tube nests, 13, 13 of the radial-flow type and an air cooler 14 located at the bottom of the condenser and between the two tube nests 13, 13 and separated therefrom by a baffle 15 of generally triangular shape. The shell 11 is provided with a pair of openings 16, 16 extending lengthwise of the shell, one beneath each of two tube nests 13, 13. These two openings 16, 16 provide for flow of the condensate from the interior of the shell. An air offtake pipe 17 constitutes an outlet for the air and non-condensable gases from this air cooler.

The tubes herein shown are of the single-pass type with the result that, in operation, the tubes are cooler at the inlet end than elsewhere. This is of particular advantage in the cooling of the air and non-condensing gases, as will be hereinafter explained. However, it is to be understood that our invention is not limited to tube structure of the single-pass type as it can also be used to advantage with other types of tube structure.

The shell 11, as illustrated in the drawings, is made from steel plate and welded together. The shell is curved in cross-section as clearly shown in Fig. 1 and is reenforced internally by steel shapes welded thereto. We have shown circumferentially-extending shapes 18, preferably of T-shape, having their webs 19 welded at 21 (Fig. 2) to the interior of the shell, and being joined at their upper ends by transversely extending shapes 22. Fabricated lateral feet 23 are welded to the shell externally thereof. Inlet opening 12 extends the full width of the shell and for a major portion of the length thereof.

The two symmetrical cylindrical nests of tubes 13,13 are the main condensing surface. These tube nests are so arranged with respect to the condenser shell 11 that a liberal steam space 25, 26 and 27 surrounds them, providing for steam flow into the nests on the entire peripheries thereof. As clearly shown in Fig. 1 the tube nests 13,13 are eccentrically located within the shell; i. e., the nests are closer to the bottom of the shell than to the sides or center thereof. This results in the provision of steam paths 26 and 27 which are of diminishing cross-sectional area as the bottom of the nests are approached. The tube nests are supported by end tube sheets 29 and 31 and intermediate tube support sheets 30 in a manner well known in the art. The tube support sheets 30 are in turn supported by attachment to the shell reenforcing shapes 18 and 22, as shown at 32 and 33 (Fig. 1). Each tube nest 13 is provided with a central air offtake opening 34 extending the entire tube length. This opening 34 is protected from falling condensate by a baffle 35.

The air cooler 14 comprises a generally triangular nest of tubes 37 separated from the remainder of the condenser interior by baffle 15 of the same generally triangular shape. At each side of the air cooler, near the bottom, vertical channels 38, extending the entire tube length and formed by parallel baffle plates 39 and 40, connect the air cooler 14 with the central air offtake openings 34, thereby forming passageways for the flow of air and non-condensable gases from the central air offtake openings 34 to the air cooler 14. The two outer baffle plates 39 form the opposite sides of the air cooler chamber, the inclined sides of the baffle 15 being connected thereto as best shown in Fig. 1. At spaced regions along the juncture of plates 39 with baffle 15, openings are provided for flow of condensate from the inclined sides of baffle 15, past plate 39, to the condensate trough 20, as shown at the right in Fig. 1. The channels 38 are closed at these regions by horizontal plates 15a. The structure at alternative points, where air passages 38 are uninterrupted, is shown at the left in Fig. 1. The triangular nest of tubes 37 is supported by end tube sheets 29 and 31 and intermediate tube support sheets 43 in a manner well known in the art. The tube support sheets 43 are in turn supported by attachment to the shell reenforcing

shapes 18 and to the main intermediate tube sheets 30 as shown at 44 and 45.

The free space 46 above the tubes 37 of the air cooler under the baffle 15 at the top thereof constitutes an exit path for the air and non-condensable gases. To insure proper cooling of the air during its passage through the cooler, baffles 47 are provided at suitable points on the interior of the triangular baffle 15 to direct the flow of air into and through the triangular nest of tubes 37. (Fig. 1.) These baffles 47, in the form of the invention herein disclosed, are of steel plate welded to the inner side of baffle 15.

An additional vertical cross-baffle 48 (Fig. 2) is provided in the exit path 46 at the top of the air cooler beneath the baffle 15 near the inlet end of the condenser, whereby air and non-condensable gases are caused to flow down across the tubes 37 and upwards again into the exit path, thus obtaining a final cooling from contact with the coldest tubes before flowing out the air outlet pipe 17 at the inlet tube plate.

In addition to the two main tube nests 13, 13 we provide additional and novel condensing surface by means of two other groups or nests of tubes. A triangular nest of tubes 51 is located centrally at the top of the condenser. This nest serves as a guide for the entering steam, directing it downwardly in the two radial flow lanes surrounding the halves of the main tube nests 13, 13 nearest the center of the condenser. Where the condenser is used with a turbine of the double-flow type, such as illustrated in Fig. 1 of the patent to Smith, 1,845,542, February 16, 1932, most of the steam enters the condenser at two separated points substantially directly above the centers of the main radial-flow tube nests. This arrangement produces a central area or zone at the exhaust steam inlet wherein the flow of steam is much less than that at the two points previously mentioned. It is the present practice to provide the partitions separating this central zone from the side zones with openings or perforations permitting a limited flow of steam to said central zone and directly downward to the region in the condenser occupied by the triangular or wedge-shaped tube nest. This limited volume of steam from the central zone of the turbine exhaust casing is, in applicant's condenser arrangement, condensed by the tube nest 51. The two main volumes of steam, entering directly over the two radial-flow tube nests, tend to flow towards the central zone of the condenser occupied by the triangular tube nest. However, this tube nest 51, in addition to condensing the steam from the central zone, serves as a baffle to prevent flow from the two main volumes of steam to this portion of the condenser and to direct the same downwardly into the vapor paths 25 and into the tube nests 13. Since this triangular tube nest 51 is located at the steam outlet, the natural heat head existing between the steam and the water in the tubes will cause this nest to be highly active condensing surface. This triangular tube nest 51 is supported by end tube sheets 29 and 31 and intermediate tube support sheets 53 in a manner well known in the art. Tube support sheets 53 are in turn supported at the top from the transversely extending shapes 22 and at the bottom from the main tube sheets 30 as indicated at 54 and 55.

Above and alongside the triangular shaped baffle 15 which encloses the air cooler space 14, there are one or more rows of tubes 58 on each side of the vertical center line of the condenser. These tubes are supported by the same tube sheets 29, 31 and 43 that support the air cooler tubes 37. As these tubes 58 are located in the direct flow of steam the heat transfer will be as high as that of the outer tubes of the main tube banks, thus further increasing the overall heat transfer. While we have herein shown two rows of tubes 58, it will be obvious that our invention contemplates the use of any desired number of rows.

As previously pointed out, the main condenser shell 11 is provided with a pair of openings 16, 16 serving as exhausts for the condensate and extending lengthwise of the shell for substantially the full tube length, one beneath each of the main tube nests 13, 13. Condensate from the outer halves of the main tube nests will flow along the outer wall of the shell 11 to the openings 16. In a similar manner condensate from the inner halves of the main tube nests 13, 13 and from the auxiliary nests 51 and 58 will flow down the inclined sides of the baffle 15 to the same openings 16, 16. Beneath the openings 16 are collecting troughs 20 secured to the outside of shell 11.

Any condensate which may find its way into, or be formed within the air cooler 14 flows through exhaust opening 60.

It should be noted that the condensate which drains into the collecting troughs 20 falls through a belt of steam at entrance pressure and temperature, and temperature of the condensate leaving the condenser is, therefore, very close to that of the entering steam.

In the embodiment herein illustrated, we have shown, in Fig. 2 an inlet waterbox 62 attached by flange 63 to the end tube sheet 29. An outlet waterbox 64 is attached by flange 65 to the end tube sheet 31. Extending from the outside of end tube sheet 29 to the outside of inlet waterbox 62 is the air offtake pipe 17. Inlet waterbox 62 is provided with a neck 67 having an external flange 68. Offtake pipe 17 has an external flange 69 at its inner end adapted to form a water tight seal with the end tube sheet 29. Such a seal may be effected by use of a compressible gasket 71 between the flange 69 and the tube sheet 29. At the outer end of the offtake pipe 17 is an external flange 72 of materially greater diameter than the flange 69. Flange 72 is recessed as shown at 73 in order to center the offtake pipe 17 in relation to the neck 67 and the air exit path 46 from the air cooler. Flange 72 may be bolted or otherwise secured to flange 68. The length of pipe 17 is of such length that bolting together of flanges 72 and 68 compresses gasket 71 to produce the desired seal. The internal diameter of neck 67 is slightly greater than the external diameter of flange 69, whereby the offtake pipe 17 can be removed or assembled without the necessity of removing the waterbox 62.

While we have shown our invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of changes and modifications, without departing from the spirit thereof, and we desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or as are specifically set forth in the appended claims.

What we claim is:

1. In a condenser, a shell having an exhaust steam inlet and outlet means, a pair of radial-flow tube nests, and means to direct flow of vapor

against said tube nests comprising a wedge-shaped tube nest.

2. In a condenser, a relatively wide and shallow shell having an inlet for exhaust steam at the top thereof, means dividing the shell interior into condensing and cooling spaces and cooperating with an intermediate portion of the shell bottom to define said cooling space, a pair of radial-flow tube nests in the condensing space and arranged above and exteriorly of the cooling space, a nest of tubes in the cooling space, an air offtake communicating with said cooling space, means for conducting media from the central portion of each radial-flow nest to said cooling space for passage among the tubes of the nest therein before entering the offtake, and offtake means for condensate communicating with the lowermost portions of said condensing space.

3. In a condenser, a shell having an exhaust steam inlet and condensate outlet means, a main condensing surface therein comprising a pair of tube nests of the radial-flow type arranged parallel in a horizontal plane and spaced apart whereby a vapor path is provided therebetween, a supplemental condensing surface of generally inverted V-shape cross-section adjacent the bottom of the shell between the radial flow tube nests, and an air cooler between the V-legs of said supplemental condensing surface.

4. In a condenser, shell having an exhaust steam inlet and condensate outlet means, condensing surface therein comprising a pair of tube nests of the radial-flow type arranged parallel to each other in a horizontal plane and spaced apart and from the shell whereby both tube nests are completely surrounded circumferentially by vapor paths, an air cooler comprising a tube nest of generally triangular cross-section adjacent the bottom of the shell between the said pair of tube nests, said air cooler being separated from the remainder of the shell interior by a baffle of generally triangular shape, pairs of baffles defining air passages from the central portions of the radial-flow tube nests to the air cooler, the air cooler having an exit consisting of an air offtake pipe extending from said cooler to the exterior of the shell, and additional condensing surfaces within said shell, one of said additional surfaces comprising one or more rows of tubes adjacent and above each side of the triangular baffle and another of said surfaces comprising a triangular tube nest adjacent the top of the shell and between the pair of radial-flow tube nests.

5. In a condenser, a shell having an exhaust steam inlet and condensate outlet means, condensing surface therein comprising a pair of tube nests of the radial flow type arranged parallel in a horizontal plane and spaced apart whereby a vapor path is formed therebetween, an air cooler adjacent the bottom of the shell between the tube nests, additional condensing surfaces within said shell, one of said surfaces comprising one or more rows of tubes at each side of and above said air cooler between the latter and the radial-flow tube nests and another of said surfaces comprising a tube nest of generally triangular cross-section adjacent the top of the shell with its apex extending downwardly between said pair of radial-flow tube nests, said triangular tube nest serving to guide vapors into the vapor path between the radial-flow tube nests, an offtake for the air cooler, and means for conducting air and non-condensable gases from said condensing surface to the cooler.

6. In a surface condenser, a shell enclosing a vapor space and having an exhaust steam inlet and condensate outlet means, condensing surface therein comprising a pair of substantially circular cross-sectional tube nests of the radial-flow type extending transversely of the vapor space, said pair of tube nests being arranged parallel to each other in a horizontal plane and spaced from each other and from the shell, whereby both tube nests are surrounded by a vapor path, an air cooler adjacent the bottom of the shell between the tube nests, pairs of baffles defining air passages from the central portions of the tube nests to the air cooler, and an additional condensing surface comprising a tube nest of triangular cross-section near the top of the shell and between and parallel to the pair of radial-flow tube nests, said triangular nest serving as a guide to direct entering vapor into the paths surrounding the radial-flow tube nests.

7. In a condenser, a shell having an exhaust steam inlet and condensate outlet means, a main condensing surface therein comprising a pair of tube nests of the radial-flow type, said tube nests being parallel to each other in a horizontal plane and spaced from each other and from the shell whereby both tube nests are completely surrounded circumferentially by vapor paths, a condensing surface comprising a tube nest of triangular cross-section near the top of the shell and between and parallel to the pair of radial-flow tube nests, said triangular tube nest serving as a guide to direct entering vapor into the paths surrounding the radial-flow tube nests and an additional condensing surface comprising a tube nest arranged between the lower portions of the radial-flow tube nests and means providing for the discharge of air and non-condensable gases from the shell.

8. In a condenser, a shell having an exhaust steam inlet and condensate outlet means, condensing surface therein comprising a pair of tube nests of the radial-flow type, said tube nests being parallel to each other in a horizontal plane and spaced apart, thereby providing a vapor path therebetween, an air cooler adjacent the bottom of the shell between the tube nests, pairs of baffles defining air passages from the central portions of the tube nests to the air cooler and an additional condensing surface comprising one or more rows of tubes located in the space between the lower portions of the radial-flow tube nests and diverging downwardly between said radial-flow tube nests and the air cooler.

9. In a condenser, a shell having an exhaust steam inlet and condensate outlet means, a main condensing surface therein comprising a pair of substantially circular cross-sectional tube nests of the radial-flow type, said tube nests being parallel to each other in a horizontal plane and spaced from each other and from the shell whereby both tube nests are completely surrounded circumferentially by vapor paths, and an additional condensing surface comprising a tube nest arranged between the lower portions of the radial-flow tube nests and diverging downwardly and having its tubes which are directly exposed to the vapor paths so disposed as to provide concave faces on said additional condensing surface, which faces, together with the opposed convex faces of the radial-flow tube nests, define vapor paths of decreasing cross-sectional area as the bottom of the shell is approached.

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