Feb. 16, 1932. J. H. SMITH 1,845,542

CONDENSER

Filed June 23, 1930 2 Sheets-Sheet 1

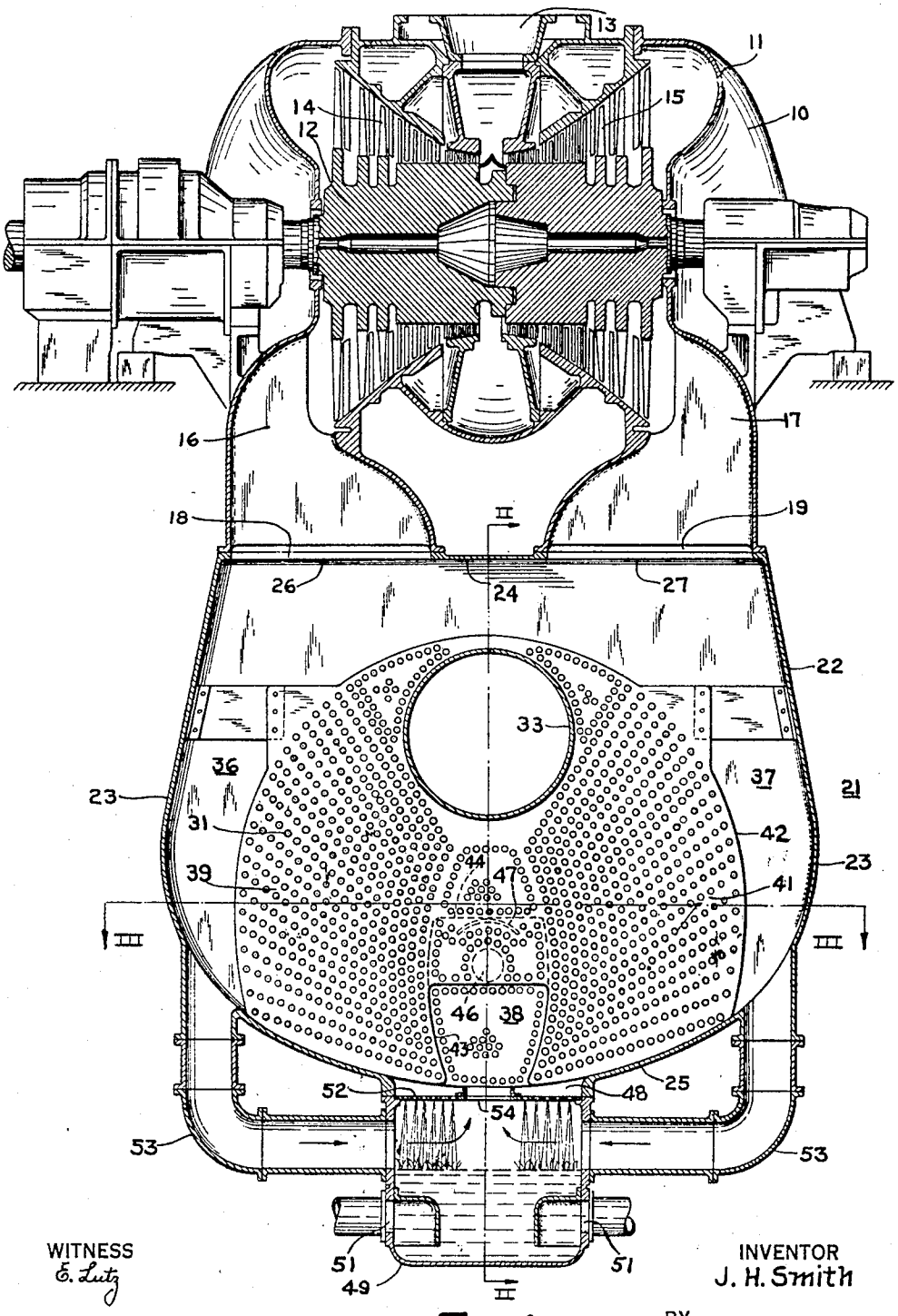


FIG. 1.

WITNESS
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43

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CONDENSER

Filed June 23, 1930 2 Sheets-Sheet 2

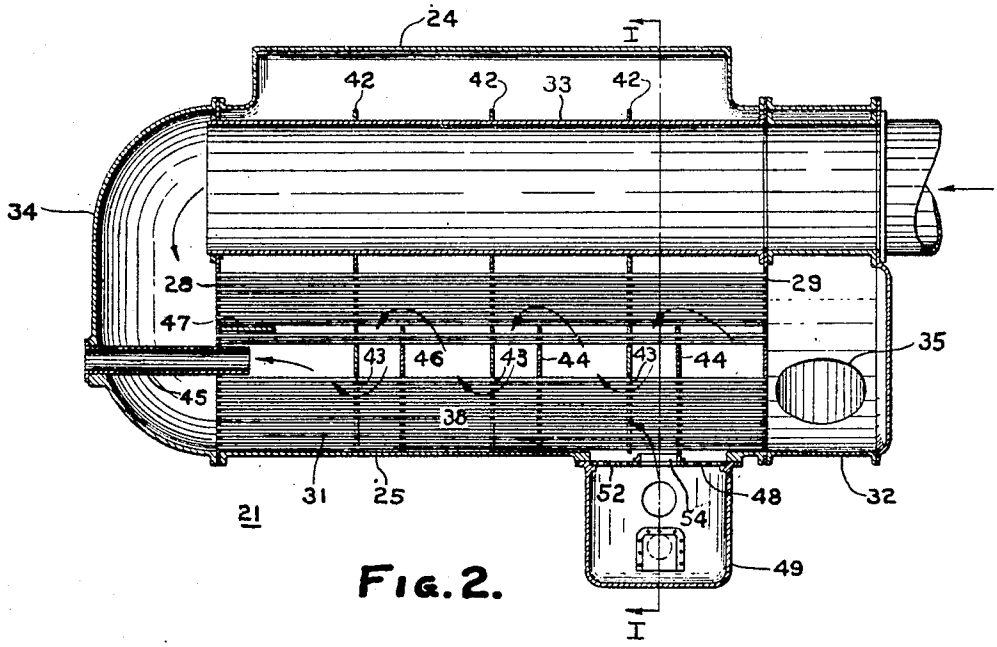


FIG. 2.

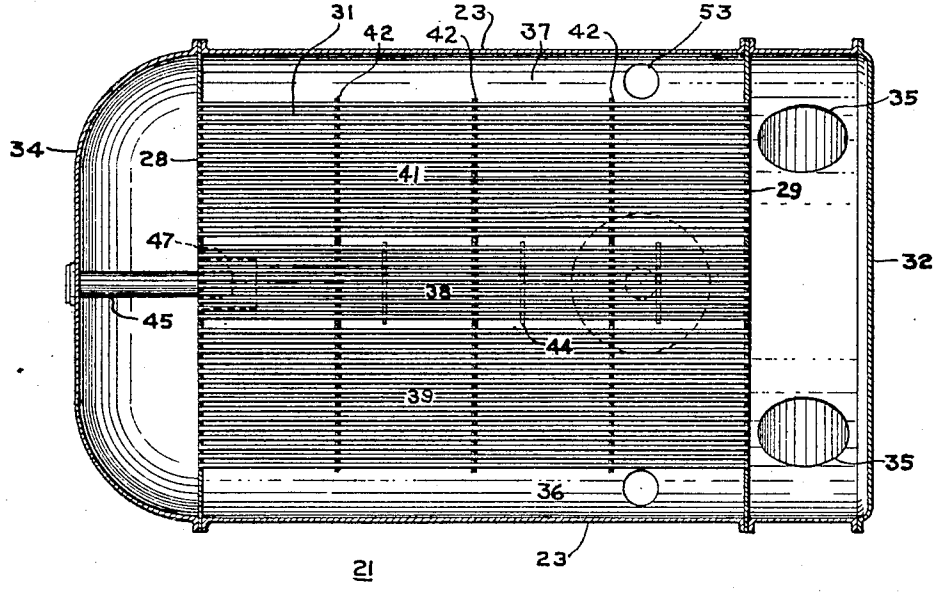


FIG. 3.

WITNESS
E. Lutz.

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Patented Feb. 16, 1932 1,845,542

UNITED STATES PATENT OFFICE

JOHN H. SMITH, OF LANSDOWNE, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

CONDENSER

Application filed June 23, 1930. Serial No. 463,121.

My invention relates to apparatus for condensing gaseous media and particularly to apparatus of the surface type intended primarily for condensing steam and it has for an object to provide apparatus of the character designated which shall be so constructed and arranged as to effectively utilize the entire cooling surface of the apparatus in order that it may operate at a very high heat transfer rate.

It has heretofore been proposed, as disclosed and claimed in United States Patent No. 1,748,676, issued February 25, 1930, for condenser and assigned to the Westinghouse Electric and Manufacturing Company, to locate, in a single-pass condenser, both the inlet and outlet circulating water connections in a common water box located at one end of the condenser. In such a condenser, there is provided, interiorly of the condenser shell structure, a longitudinally-extending pipe or trunk conduit of substantial flow area for connecting the remote end of the tube nest to one of the water connections provided in the water box. Such a condenser is especially applicable to power plants wherein the intake and discharge tunnels for supplying cooling water to and discharging cooling water from the condenser are located at a common end of the condenser. The latter condition prevails in all power plants where the condenser is installed in a vertical position and it also prevails in some power plants where the condenser is installed in a horizontal position.

More particularly, therefore, my invention has for an object to provide a condenser of the foregoing character which shall be so constructed and arranged as to utilize, to the fullest extent possible, the heat absorbing capacity afforded by the relatively large circulating water trunk conduit extending through the condenser shell.

Still more particularly, my invention has for an object to provide a condenser of the foregoing character wherein the relatively large circulating water trunk conduit extending through the condenser shell is located in a peripheral portion of the tube nest adjacent to the opening through which the exhaust steam to be condensed is admitted to the condenser shell.

Still more particularly, my invention has for an object to provide a condenser of the foregoing character wherein the relatively large circulating water trunk conduit is disposed in a substantially central position with respect to the exhaust steam inlet or inlets and wherein the tube nest is symmetrically disposed on opposite sides of the trunk conduit and in spaced relation with respect to the side walls of the condenser shell so as to provide an extended tube nest periphery directly exposed to the exhaust steam entering the shell structure from the turbine exhaust connection.

My invention has for still another object to provide a form of tube nest embodying a central portion through which the gaseous media travels in a longitudinal direction and side portions in which the gaseous media travels in a transverse direction, the central portion intervening between the trunk conduit and the condenser shell and serving, not only to condense steam, but to cool the non-condensable gaseous media.

My invention has for still another object to provide a form of condenser wherein the non-condensable gaseous media shall be removed at minimum temperature and the condensate at maximum temperature, and I, therefore, propose to remove the air from the longitudinal portion of the tube nest and from the cold or cooling water entrant end thereof and to remove the condensate from a portion of the shell structure disposed adjacent to the warm or cooling water exit end of the tube nest.

My invention has for still another object to provide a condenser embodying a hotwell

structure so arranged as to deaerate the condensate formed in the condenser in order that gases having a tendency to corrode the piping of the power plant may be separated from the condensate by the condenser.

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

Fig. 1 is a view, in sectional elevation, of a turbine of the divided flow type having associated therewith one form of condenser arranged in accordance with my invention, the condenser portion of the view being taken on the line I—I of Fig. 2;

Fig. 2 is a longitudinal, sectional elevation of the condenser shown in Fig. 1 and is taken on the line II—II of Fig. 1; and,

Fig. 3 is a plan view, in section, and is taken on the line III—III of Fig. 1.

Referring now to Fig. 1 of the drawings, I show a turbine 10 embodying a stationary casing 11 and a rotating element 12. Motive steam is admitted to the turbine through an inlet 13 and is expanded, axially, in opposing directions, through rows of blading 14 and 15. The steam finally enters the exhaust end portions 16 and 17 and is discharged from the turbine through transversely-spaced exhaust nozzles 18 and 19 to a condenser, generally represented at 21.

The condenser 21 embodies a shell structure 22 having side walls 23, a top wall 24 and a bottom wall 25, all joined by substantial radii of curvature so as to form a shell structure of maximum rigidity. While, in the specification and claims, I term the wall structures 24 and 25 as "top" and "bottom" walls, it is to be distinctly understood that these terms are employed in merely a relative sense and that they apply equally well whether the condenser be finally installed in a horizontal position, that is, the position illustrated, or in a vertical or any other position.

The top wall 24 of the shell structure is provided with transversely spaced inlets 26 and 27 connecting, respectively, with the exhaust nozzles 18 and 19 of the turbine. Disposed at each end of the shell structure are tube sheets 28 and 29 having a tube nest 31 extending therebetween. Provided adjacent to the tube sheet 29 is a water box 32 communicating with one end of the tube nest for receiving cooling water from the tube nest. Cooling water is supplied to the tube nest by a trunk conduit 33 which extends longitudinally through the water box 32 as well as the shell structure 22 and terminates, beyond the tube sheet 28, in the interior of a return water box 34. Cooling water discharged from the tube nest is withdrawn from the water box 32 through suitable outlets 35.

As shown particularly in Fig. 1, the trunk conduit 33 is preferably disposed in a portion of the shell structure adjacent to and centrally of the exhaust inlets 26 and 27. Furthermore, the tube nest 31 is symmetrically arranged with respect to the trunk conduit 33 and the rows of tubes project radially outward on opposite sides of the trunk conduit toward the side walls 22 of the shell structure, the periphery of the tube nest extending about the trunk conduit and being spaced from the side walls of the shell structure so as to provide intervening steam delivery spaces 36 and 37. By means of the foregoing arrangement, a relatively large portion of the exterior surface of the trunk conduit as well as an extended peripheral portion of the tube nest is directly exposed to the exhaust steam admitted through the inlets 26 and 27.

The tube nest 31 is preferably divided into a central, longitudinal flow portion 38 and side, transverse flow portions 39 and 41, the central and longitudinal flow portion 38 being located between the bottom wall 25 of the shell structure and the trunk conduit 33. For supporting the tube nest intermediate of the end tube sheets, suitable intermediate tube supporting sheets 42 are provided, which intermediate tube supporting sheets divide the tube nest, longitudinally, into a plurality of sections. The outer boundary of the intermediate tube sheets 42 preferably conforms with the outer boundary of the tube nest in order that the steam delivery spaces 36 and 37 may freely distribute the steam to be condensed to the entire longitudinal length of the tube nest.

In order to afford longitudinal circulation of gaseous media through the central portion 38 of the tube nest, the intermediate tube sheets 42 are provided with lower, centrally-disposed cut-away portions forming openings 43 of substantial flow area. However, as the cooling tubes passing through the openings 43 must be supported intermediate of the end tube sheets, I provide, for these tubes, supplementary intermediate tube sheets 44 which are displaced, longitudinally, from their associated main intermediate tube sheets 42. The supplementary tube sheets 44 project upwardly from the bottom of the shell and they preferably extend above the upper margins of the openings 43 so as to effect, as indicated by the arrows in Fig. 2, a somewhat tortuous path of travel for the gaseous media flowing longitudinally through the central section 38 of the tube nest.

An air offtake conduit 45 extends through the return water box 34 and connects with the cold or cooling water entrant end of the tube nest. A portion of the tube nest is omitted to accommodate the air offtake, thereby providing a longitudinally-extending cavity or core space 46. For preventing condensate from "raining" down into the entrant

portion of the offtake conduit 45, an arcuate baffle 47 is provided.

Condensate is removed from the condenser shell through an outlet 48 which is preferably located at the warm or cooling water exit end of the tube nest. The outlet 48 has associated therewith a hotwell 49 provided with condensate outlets 51 disposed in a lower portion thereof. Associated with the condensate outlet 48 of the condenser is some means such as, for example, a perforated plate 52 for delivering the condensate to the hotwell in a finely divided state. In order that heating and deaeration of the condensate may take place in the hotwell, the latter is connected by means of conduits 53 to the steam delivery spaces 36 and 37 of the shell structure. The hotwell is vented into the warm or cooling water exit end of the central portion 38 of the tube nest by an opening 54 provided in a central portion of the perforated plate 52, the arrangement being such that steam is constantly being circulated from the conduits 53 through the hotwell to the vent 54 while the condensate in the finely divided state is being drained into the path of the steam circulating through the hotwell.

From the foregoing description, the operation of my invention will be apparent. Steam exhausted from the turbine 10 enters the shell structure 22 through the inlets 26 and 27 and surrounds the greater portion of the tube nest in the steam delivery spaces 36 and 37. The location of the trunk conduit 33 is such that it also is directly exposed to the exhaust steam entering the shell structure. In view of the fact that the trunk conduit 33 must be of such ample proportions as to convey adequate cooling water for the tube nest, it is evident that, by means of the arrangement disclosed, the trunk conduit 33 serves to materially supplement the cooling action of the tube nest. In this connection it is noted, that, while in the present embodiment, I show a single trunk conduit 33 for conveying water for all of the tubes of the nest, it will be obvious that it is within the purview of my invention to utilize more than one trunk conduit in which case the number of such trunk conduits would be only a small percentage of the total number of cooling tubes and, consequently, the flow-area of each of such trunk conduits would be equivalent to the total flow-area of a group of condensing tubes.

Cooling water for the tube nest enters the trunk conduit 33 and is conveyed to the return water box 34 from which it is supplied to the tube nest, the end 28 of the tube nest constituting the entrant end and the end 29 the exit end. The cooling water is finally removed from the condenser through the outlets 35. It will, therefore, be apparent that such an arrangement provides a condenser having an odd number of passes of cooling water through the tube nest and wherein both the cooling water inlet and outlet connections are located in a common water box.

Owing to the very large flow-area of the trunk conduit 33, the water therein assumes only a slight increase in temperature in passing through the shell structure and, hence, there is very little difference in temperature between the inlet end of the conduit 33 and its outlet end. However, when the cooling water from the trunk conduit 33 enters the numerous tubes of the nest, it is divided into many relatively small streams and, consequently, absorbs heat quite rapidly. As a result, the water in the tube nest assumes materially increasing temperatures as it circulates from the entrant end 28 of the tube nest to the exit end 29.

The steam first enters the side sections 39 and 41 of the tube nest and flows toward the central section 38. Because of the relatively lower temperature prevailing in the entrant end 28 of the tube nest, a higher heat head prevails in this end than at the exit end 29 and there is a natural tendency for steam in the delivery spaces 36 and 37 to move longitudinally toward the cold or entrant end 28 of the tube nest. Consequently, more steam is delivered to the cold end 28 and less to the warm end 29.

In traversing the side sections 39 and 41 of the tube nest, a considerable portion of the steam is condensed and drains to the outlet 48. That portion of the steam which remains uncondensed and also that portion which is uncondensable, enter the central section 38 of the tube nest and flow longitudinally through the openings 43 in the intermediate tube sheets and around the supplementary sheets 44, toward the air offtake 45. During this longitudinal circulation, the remaining quantity of steam is condensed while the non-condensable gaseous media is ultimately removed from the coldest portion of the tube nest by the offtake 45. Hence, the non-condensable gases are removed from the shell structure at minimum temperature.

In circulating longitudinally through the central section 38 of the tube nest, the air and non-condensable gaseous media are brought into intimate contact not only with the tubes in the central section 38 but with the adjacent tubes in the side sections 39 and 41 and with the adjacent surface of the trunk conduit 33. The idea of circulating gaseous media longitudinally through the shell structure in contact with a trunk conduit, such as 53, has been previously disclosed in my co-pending application, Serial No. 439,388, entitled Condenser, and assigned to the Westinghouse Electric and Manufacturing Company.

In order that the condensate may leave the shell structure at maximum temperature, the outlet 48 and hotwell 49 are located at the warm or cooling water exit end of the

tube nest. For heating and for effecting deaeration of the condensate in the hotwell, the condensate is delivered into the hotwell in a finely divided state by the spray plate 52. Steam from the shell structure of the condenser is supplied to the hotwell by the conduits 53. The latter conduits connect with the steam delivery spaces 36 and 37 while the vent 54 of the hotwell connects with the central section 38 of the tube nest and, the latter section being located nearer to the offtake 46, a relatively lower pressure prevails in the vicinity of the vent 54 than in the steam delivery spaces 36 and 37. Hence, a constant circulation of steam is created through the conduits 53, the hotwell 49 and the vent 54, the gaseous media liberated in the hotwell 49 commingling with the steam and passing through the vent 54. As will be apparent, the liberated gases are finally removed from the shell structure through the offtake 45. As shown, I prefer to vent the gases into the warmest portion of the shell structure and to remove the non-condensable gases from the coldest portion of the shell structure and, in addition, to compel the gases vented from the hotwell to pass over a substantial portion of the tube nest prior to their removal from the shell structure.

From the foregoing, it will be apparent that I have provided a form of condenser which is of the single or odd-pass type and wherein both the inlet and outlet cooling water connections are located in a common end of the condenser. It will be further apparent that I provide a condenser of the foregoing character wherein the trunk conduit for conveying cooling water through the shell structure of the condenser is utilized to the fullest extent to supplement the cooling action of the tube nest. In addition, I provide a condenser having facilities for deaerating the condensate so that gases having a tendency to corrode the power plant piping are separated from the condensate prior to the removal thereof from the condenser.

While I have shown my 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 various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In a condenser, the combination of a shell structure having inlet means for gaseous media to be condensed, a tube nest extending longitudinally through the shell structure, and a trunk conduit for conveying cooling water for the tube nest extending through the shell structure and disposed in a peripheral portion of the tube nest adjacent to the inlet means.

2. In a condenser, the combination of a shell structure having inlet means for gaseous media to be condensed, a tube nest extending longitudinally through the shell structure and spaced from the side walls thereof and from the inlet means so as to provide, between the tube nest and the shell structure, a steam delivery space, and a trunk conduit for conveying cooling water for the tube nest extending longitudinally through the shell structure, said trunk conduit being disposed in substantially a central position with respect to the side walls of the shell structure as well as adjacent to the gaseous media inlet means.

3. In a condenser, the combination of a shell structure having inlet means for gaseous media to be condensed, a trunk conduit for conveying cooling water extending longitudinally through the shell structure and disposed toward the side thereof embodying the gaseous media inlet means, and a tube nest extending longitudinally through the shell structure on opposite sides of the trunk conduit and between the trunk conduit and the shell structure.

4. In a condenser, the combination of a shell structure having a pair of transversely spaced inlets for gaseous media to be condensed, a tube nest extending longitudinally through the shell structure and exposed to the gaseous media from both inlets, and a trunk conduit for conveying cooling water for the tube nest extending longitudinally through the shell structure, said trunk conduit being located adjacent the side of the shell structure embodying the inlets and in substantially a central position with respect to the inlets.

5. In a condenser, the combination of a shell embodying first and second oppositely-disposed wall structures, means provided in the first wall structure for admitting gaseous media to be condensed, a trunk conduit for conveying cooling water for the tube nest extending longitudinally through the condenser shell and spaced from the second wall structure, a tube nest extending longitudinally through the condenser shell and occupying a substantial portion of the transverse area thereof including the transverse area intervening between the trunk conduit and the second wall structure, and means for affording longitudinal circulation of gaseous media in the portion of the tube nest interposed between the trunk conduit and the second wall structure.

6. In a condenser, the combination of a shell structure embodying first and second oppositely-disposed wall structures, means provided in the first wall structure for admitting gaseous media to be condensed, a trunk conduit for conveying cooling water

for the tube nest extending longitudinally through the condenser shell and spaced from the second wall structure, a tube nest extending longitudinally through the condenser shell and occupying a substantial portion of the transverse area thereof including the transverse area intervening between the trunk conduit and the second wall structure, means for connecting one end of the trunk conduit to one end of the tube nest and providing for circulation of cooling water through the latter in a single, longitudinal direction, means for affording longitudinal circulation of gaseous media in the portion of the tube nest interposed between the trunk conduit and the second wall structure, and means connecting with the interior of the shell structure for removing non-condensed gaseous media from the cooling water entrant end of the tube nest.

7. In a condenser, the combination of a shell embodying first and second oppositely-disposed wall structures, means provided in the first wall structure for admitting gaseous media to be condensed, a trunk conduit for cooling water extending longitudinally through the condenser shell and spaced from the second wall structure, a tube nest extending longitudinally through the condenser shell and occupying a substantial portion of the transverse area thereof including the transverse area intervening between the trunk conduit and the second wall structure, means for connecting one end of the trunk conduit to one end of the tube nest and providing for circulation of cooling water through the latter in a single, longitudinal direction, tube sheets disposed at each end and intermediate of the ends of the tube nest for supporting the latter, said intermediate tube support sheet embodying an opening located between the trunk conduit and the second wall structure for affording longitudinal circulation of gaseous media through the tube nest, and means for removing non-condensable gaseous media from the cooling water entrant end of the tube nest.

8. In a condenser, the combination of a shell embodying first and second oppositely-disposed wall structures, means provided in the first wall structure for admitting gaseous media to be condensed, a trunk conduit for cooling water extending longitudinally through the condenser shell and spaced from the second wall structure, a tube nest extending longitudinally through the condenser shell and occupying a substantial portion of the transverse area thereof including the transverse area intervening between the trunk conduit and the second wall structure, means for connecting one end of the trunk conduit to one end of the tube nest and providing for circulation of cooling water through the tube nest in a single, longitudinal direction, tube sheets disposed at each end and intermediate of the ends of the tube nest for supporting the latter, said intermediate tube support sheet embodying an opening located between the trunk conduit and the second wall structure for affording longitudinal circulation of gaseous media through the tube nest, a supplementary intermediate tube sheet spaced, longitudinally, from the main intermediate tube sheet for supporting the portion of the tube nest passing through the opening in the main intermediate tube sheet, and means for removing non-condensable gaseous media from the cooling water entrant end of the tube nest and from that portion interposed between the trunk conduit and the second wall structure.

9. In a condenser, the combination of a shell structure having opposed side walls and opposed top and bottom walls, admission means for gaseous media to be condensed provided in the top wall, a tube nest extending longitudinally through the shell structure, said tube nest being disposed adjacent to the bottom wall and spaced from the side and top walls, a trunk conduit for conveying cooling water for the tube nest extending longitudinally through the shell structure, said trunk conduit being disposed in a peripheral portion of the tube nest facing the top wall of the shell structure, passageway means for affording longitudinal circulation of gaseous media through the tube nest, said passageway means being located, transversely, between the trunk conduit and the bottom wall of the shell structure, means for connecting one end of the trunk conduit to an adjacent end of the tube nest and providing for circulation of cooling water through the tube nest in a single, longitudinal direction, and means connected with said passageway means near the cooling water entrant end of the tube nest for removing non-condensable gaseous media from the shell structure.

10. In a condenser, the combination of a shell structure having inlet means for gaseous media to be condensed, a tube nest extending longitudinally through the shell structure and exposed to the gaseous media from the inlet, a trunk conduit extending longitudinally through the shell structure for conveying cooling water for the tube nest, said tube nest embodying a central portion disposed on one side of the trunk conduit for the circulation of gaseous media in a longitudinal direction and side portions extending from the central portion toward the oppositely-disposed side wall of the shell structure for the circulation of gaseous media in transverse directions, means connecting one end of the trunk conduit to the adjacent end of the tube nest for conveying cooling water for the tube nest, and means connecting with the central portion of the tube nest for re-

moving non-condensable gaseous media from the shell structure.

11. In a condenser, the combination of a shell structure having top, side and bottom walls, admission means for gaseous media provided in the top wall of the shell structure, a trunk conduit for conveying cooling water extending longitudinally through the shell structure and disposed in spaced relation with respect to the bottom wall of the shell structure, a tube nest extending longitudinally through the shell structure, said tube nest embodying a central portion extending between the trunk conduit and the bottom wall of the shell structure for the longitudinal circulation of gaseous media and side portions radiating outwardly from the central portion for the transverse circulation of gaseous media, said side portions having an outer boundary spaced from the top and side walls of the shell structure so as to form an intervening gaseous media delivery space, and means connecting with the central portion of the tube nest for removing non-condensable gaseous media from the shell structure.

12. In a condenser, the combination of a shell structure having top, side and bottom walls, admission means for gaseous media provided in the top wall, a trunk conduit for conveying cooling water extending longitudinally through the shell structure and disposed adjacent to the top wall thereof, a tube nest extending longitudinally through the shell structure, said tube nest embodying a central portion extending, transversely, between the trunk conduit and the bottom wall of the shell structure for the longitudinal circulation of gaseous media and said tube nest also embodying side portions radiating outwardly from the central portion for the transverse circulation of gaseous media, said side portions forming an outer boundary for the tube nest substantially enclosing the trunk conduit and spaced from the top and side walls of the shell structure so as to form an intervening gaseous media delivery space, means for connecting one end of the trunk conduit to the adjacent end of the tube nest and providing for circulating cooling water through the latter in a single, longitudinal direction, and means communicating with the central portion of the tube nest in the cooling water entrant end thereof for removing non-condensable gaseous media from the shell structure.

13. In a condenser, the combination of a shell structure having an inlet for exhaust steam to be condensed and an outlet for condensate, a tube nest extending longitudinally through the shell structure, and means for conveying cooling water longitudinally through the tube nest, a hotwell for receiving condensate from the shell structure, means for venting gaseous media from the hotwell into a portion of the shell structure adjacent to the cooling water discharge end of the tube nest, and means for withdrawing non-condensable gaseous media from a portion of the shell structure adjacent to the cooling water entrant end of the tube nest.

14. In a condenser, the combination of a shell structure having an inlet for exhaust steam to be condensed and an outlet for condensate, a tube nest extending longitudinally through the shell structure, means for conveying cooling water longitudinally through the tube nest, a hotwell for receiving condensate from the shell structure, means for circulating steam through the hotwell for deaerating the condensate therein, means for venting the hotwell into a portion of the shell structure adjacent the cooling water outlet end of the tube nest and means for withdrawing non-condensable gaseous media from a portion of the shell structure adjacent the cooling water entrant end of the tube nest.

In testimony whereof, I have hereunto subscribed my name this 16th day of May, 1930.

JOHN H. SMITH.