C. G. CURTIS.

SURFACE CONDENSER.

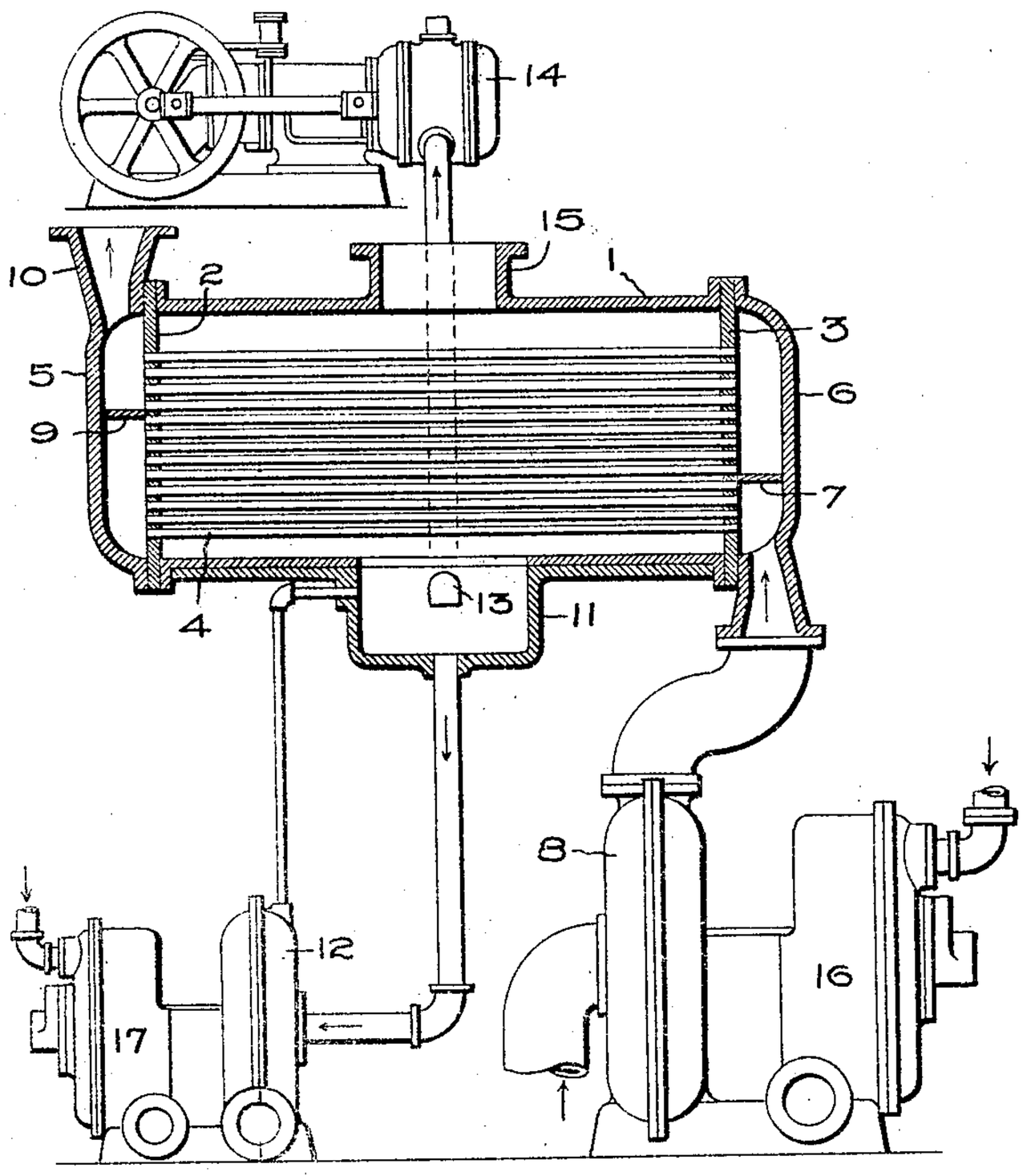
APPLICATION FILED JULY 3, 1908.

952,102.

Patented Mar. 15, 1910.

2 SHEETS—SHEET 1.

Fig. 1.



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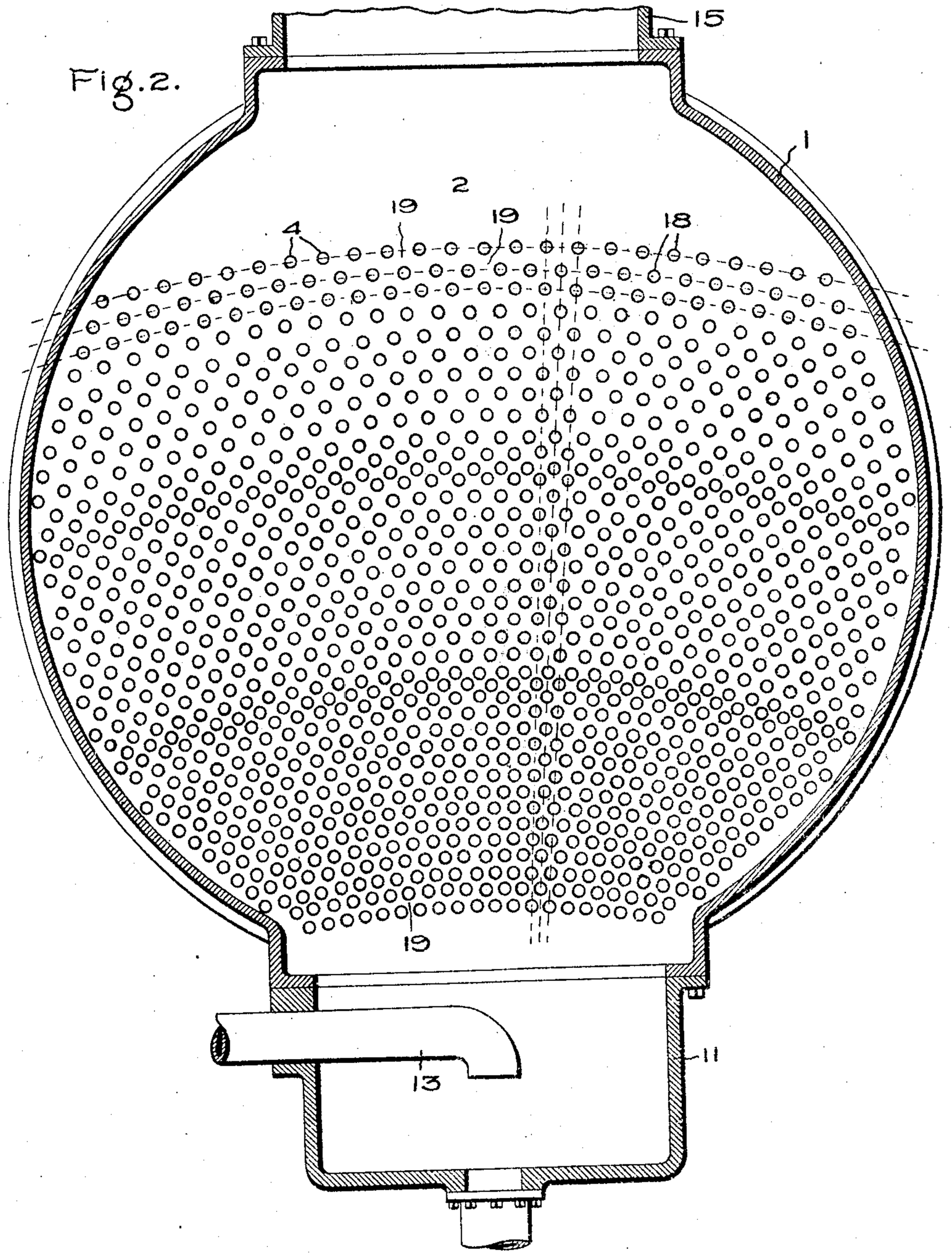
2 SHEETS—SHEET 2.

Fig. 2.



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UNITED STATES PATENT OFFICE.

CHARLES G. CURTIS, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SURFACE CONDENSER.

952,102.

Specification of Letters Patent. Patented Mar. 15, 1910.

Application filed July 3, 1908. Serial No. 441,796.

To all whom it may concern:

Be it known that I, CHARLES G. CURTIS, a citizen of the United States, residing at New York, county of New York, State of New York, have invented certain new and useful Improvements in Surface Condensers, of which the following is a specification.

The present invention relates to surface condensers and has for its object to improve their construction.

It is well understood that the efficiency of a steam turbine installation is largely dependent upon the vacuum which can be produced by its condenser. As ordinarily constructed the tubes through which the cooling medium passes are of the same size and are equally spaced throughout the condenser. In other words the various passages through which the steam passes in being condensed are of uniform cross-section or as nearly so as possible considering the nature of the various parts. This arrangement while satisfactory for a comparatively poor vacuum is, I have discovered, objectionable for a high vacuum for the reason that the velocity of the steam over certain of the tubes and particularly those nearest the inlet is abnormally great. Since this velocity can only be attained by causing a substantial pressure difference to exist between the top and bottom of the condenser, it follows that the air pump has to maintain a considerably better vacuum at the bottom of the condenser than at the top and the amount of work to be performed is considerably increased. The resistance to the passage of steam is further increased by the close and staggered relation of the tubes, which causes eddy currents as the steam follows a more or less tortuous path. To overcome these objections I arrange the tubes carrying the cooling medium in such manner that the spaces or passages between them are greatest where the volume of steam is greatest and decrease more or less gradually as the steam becomes more and more condensed. By enlarging the spaces or passages between tubes in this manner at the receiving ends, the velocity of the steam can be reduced to a value which is not objectionably high, while at the lower end the spaces or passages are reduced as much as is practicable. Reducing the velocity reduces friction and eddy losses and results in the production of a better vacuum for a given expenditure of energy and a given temperature of the cooling medium.

In carrying out my invention a shell or casing of any desired construction can be employed having an inlet for the steam to be condensed and an outlet for the water of condensation. Generally speaking its shape will depend upon the particular use for which it is intended. When used for marine purposes it may be desirable to adopt a different shape from that used for land purposes owing to the limited space available for such apparatus. Inside of the shell are one, two, three or more banks of cylindrical tubes supported by tube sheets at their ends in the usual way and through which the cooling medium passes. Where the tubes are long they may be supported at intermediate points. Baffling means may be provided for directing some or all of the entering steam against any one or more of the banks of tubes. The tubes, assuming for convenience of description and example a horizontal condenser, are separated from each other by a greater distance at the top where the exhaust steam enters the shell from the turbine or other apparatus than they are at the bottom, the spacing preferably decreasing gradually from top to bottom to obtain the best results. Since the number of tubes used in such a condenser is large it is important to arrange them in some simple manner so that no difficulty will be experienced in laying out and drilling the tube-sheets. As an illustration of this idea the tube sheet is laid off with concentric arcs extending from side to side thereof. The space between these arcs, measured radially, instead of being constant, decreases by steps from the top to the bottom for the purpose of proportioning the cross-sectional area of the passages to the volume of fluid to be handled. For convenience in manufacture the number of steps is made small, three being shown in the present embodiment. On one of the arcs the centers for one row of holes are laid off. From the points thus determined lines radial to the center of said arcs are drawn. The points of intersection of each of these radial lines with alternate arcs determines the position of one set of tube holes. The pitch of the holes in a given arc is then subdivided and other radial lines are drawn through the subdivisions. The points of intersection of

these radial lines and the remaining arcs will give the positions of the remaining set of tube holes. The holes and therefore the tubes will thus be arranged in two concentric sets, those in one set being staggered with respect to those of the other by an amount equal to half the pitch. Since the tubes are arranged in concentric rows and the pitch of each row gradually decreases from the top to the bottom, and since the distance between the rows also decreases, it follows that the vertical passages between the tubes will have their greater cross-sectional area at the top and gradually decrease to the bottom. The total cross-sectional area of the passages near the inlet of the condenser will be determined by the volume of steam that is to be handled per unit of time, due regard being given to the desirability of having a low steam velocity to avoid undue friction and eddy losses. Since the volume of fluid is less in the lower part of the casing due to condensation, the total cross-sectional area of the passages can be and is made progressively less without, however, increasing the velocity of flow, or at least by any substantial amount. This arrangement of parts affords the necessary passage area to permit the steam to flow with relatively low velocity and without undue friction or eddy losses. In other words, where the volume of the steam being condensed is large, the passages are large, and where the volume is small the passages are small. The passages also gradually become more tortuous toward the outlet, which insures good contact between the cold walls of the tubes and the fluid being condensed. The circulating water may with advantage be forced through the banks of tubes by means of a turbine-driven centrifugal pump. By means of suitable partitions the water may be caused to flow through the banks of tubes in series or multiple, or in any other desired manner. The cold water may first act on the coolest tubes or on the hottest, as best suits the conditions of service. The water of condensation may be removed from the shell or casing by a turbine-driven centrifugal pump. Air and uncondensed gases may be removed from a point just above the level of the water in the outlet by a suitable pump.

In the accompanying drawings which illustrate one of the embodiments of my invention, Figure 1 is a general view of a condenser with the necessary pumping apparatus, and Fig. 2 is a sectional view of the condenser showing a tube sheet, and to simplify the illustration I have shown a less number of tubes than will usually be employed.

1 indicates the shell or casing and 2 and 3 the tube sheets for supporting the ends of the cylindrical tubes 4. On the ends of the shell are chambered heads 5 and 6. In the head 6 is a partition 7, preferably concentric with the rows of tubes, to cause the circulating water from the centrifugal pump 8 to flow through the lower tubes. In the head 5 is a similar partition 9 to cause the water above the level of the partition 7 to flow through the intermediate tubes into the head 6 from which it flows through the upper tubes to the outlet 10.

11 indicates the outlet from which the water of condensation is drawn off by the centrifugal pump 12. Tapped into the outlet above the water level is a pump 13 that is connected to the air pump 14 for removing air and other uncondensed gases. The exhaust steam from the turbine or other apparatus enters the condenser shell by the conduit 15.

The circulating and condensation pumps are driven by steam turbines 16 and 17 respectively. The exhaust from these turbines may enter the main or other condenser or the atmosphere as desired. Each turbine is or may be provided with a governor arranged to hold the speed constant, or the governors may be arranged to increase the speed of the turbines as the amount of the exhaust steam to be condensed increases, and vice versa.

Referring to Fig. 2, 1 indicates the shell of the condenser, 2 one of the tube sheets, 15 the inlet conduit, and 11 the outlet. The tubes are arranged in concentric rows 18 which have the same center. The centers of the tubes are located in radial planes that pass through the said center. The concentric arcs and radial lines employed in laying out the tube sheet are shown in dotted lines. Between the tubes are downwardly extending passages 19 whose cross-sectional area gradually decreases from the inlet toward the outlet, and since the tubes become more closely associated as the distance from the inlet increases, it follows that the passages become somewhat more tortuous toward their lower ends.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative, and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In a surface condenser, the combination of a shell having an inlet and an outlet, conduits for the cooling medium whose spacing is greatest where the volume of fluid being condensed is greatest and decreases as the volume of the fluid decreases, and supporting means for the conduits.

2. In a surface condenser, the combination of a shell having an inlet and an outlet, conduits therein through which the cooling medium circulates, the said conduits being arranged with passages between whose cross-sectional area decreases from the inlet toward the outlet, and a support for the conduit.

3. In a surface condenser, the combination of a shell having an inlet for the fluid to be condensed and an outlet, tubes located therein through which the cooling medium circulates, the pitch of said tubes being greater near the inlet than near the outlet, and means for supporting the tubes.

4. In a surface condenser, the combination of a shell having an inlet and an outlet, tubes of similar diameter located therein whose spacing is greatest where the volume of fluid being condensed is greatest and decreases as the volume of the fluid decreases, and sheets for supporting the tubes at their ends.

5. In a surface condenser, the combination of a shell having an inlet and an outlet, tubes for the cooling medium arranged in rows with the pitch of the tubes in the rows decreasing toward the outlet, and means for supporting the tubes.

6. In a surface condenser, the combination of a shell having an inlet and an outlet, tubes for the cooling medium arranged in rows, the distance between the rows and the pitch of the tubes in the rows decreasing toward the outlet, and means for supporting the tubes.

7. In a surface condenser, the combination of a shell having an inlet and an outlet, tubes for the cooling medium arranged in rows, the tubes in alternate rows being staggered, the pitch of the tubes in the rows progressively decreasing toward the outlet, and tube-sheets for supporting the tubes.

8. In a surface condenser, the combination of a shell having an inlet and an outlet, chambered heads for the shell, conduits in the shell for the cooling medium whose spacing is greatest where the volume of fluid being condensed is greatest and decreases as the volume of fluid decreases, and means for supporting the conduits.

9. In a surface condenser, the combination of a shell having an inlet and an outlet, chambered heads for the shell, tubes located in the shell and communicating with the chambers, the said tubes being arranged in rows, the pitch of the tubes in each row being constant and decreasing by rows toward the outlet as the volume of fluid being condensed decreases, and tube-sheets for supporting the ends of the tubes.

10. In a surface condenser, the combination of a shell having an inlet and an outlet, chambered heads for the shell, tubes located in the shell and communicating with the chambers, the said tubes being arranged in rows, the spacing of which decreases toward the outlet, while the pitch of the tubes decreases row-by-row toward the outlet, and means for supporting the tubes.

11. In a surface condenser, the combination of a shell having an inlet and an outlet, chambered heads for the shell, tubes located in the shell and communicating with the chambers, the said tubes being arranged in concentric staggered rows, the tubes of alternate rows occupying radial planes so that the pitch of the tubes in said rows decreases as the volume of the fluid being condensed decreases, and supporting means for the tubes.

12. In a surface condenser, the combination of an inclosure to which the fluid to be condensed is admitted, an inlet and an outlet therefor, and cooling surfaces located within the inclosure and spaced apart to provide passages for the fluid, the said surfaces being so arranged that the total cross-sectional area of the passages gradually diminishes as the volume of the fluid diminishes.

13. In a surface condenser, the combination of an inclosure to which the fluid to be condensed is admitted, an inlet and an outlet therefor, and cooling tubes within the inclosure for condensing the fluid whose proximity change with changes in the volume of the fluid.

14. In a surface condenser, the combination of an inclosure to which the fluid to be condensed is admitted, an inlet and an outlet therefor, and cooling tubes within the inclosure over which the fluid flows at a relatively low velocity, the spaces between the adjacent tubes gradually decreasing as the volume of fluid to be handled decreases.

In witness whereof, I have hereunto set my hand this 30th day of June, 1908.

CHARLES G. CURTIS.

Witnesses:
HOWARD MCWILLIAMS,
ALEX. F. MACDONALD.