Sept. 23, 1930. A. DELAS 1,776,349

SURFACE CONDENSER

Filed Sept. 30, 1925

FIG.1.

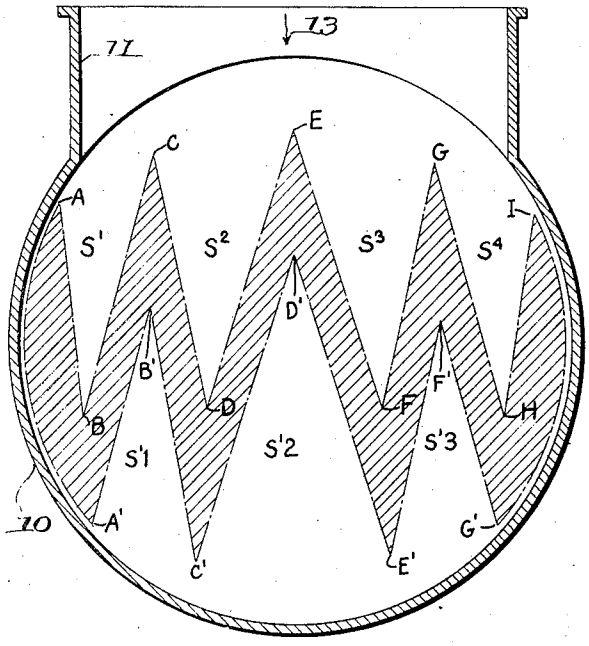


FIG.3.

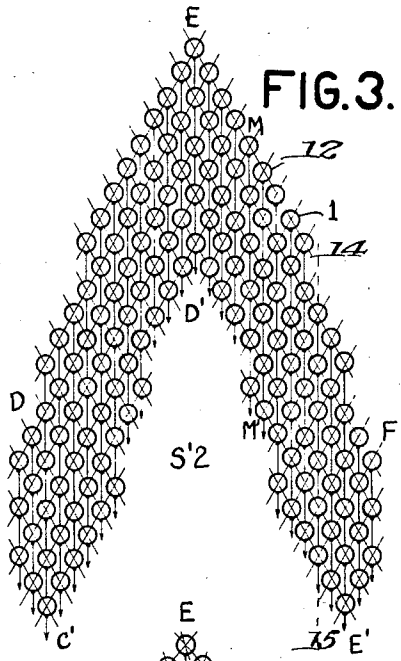


FIG.2.

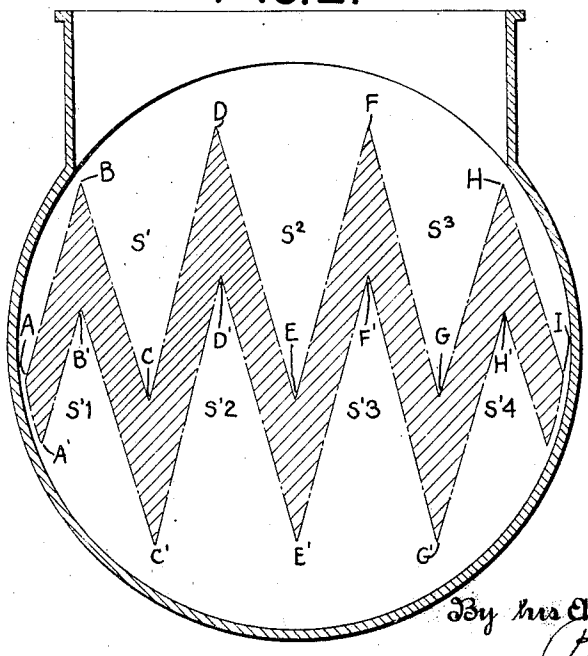
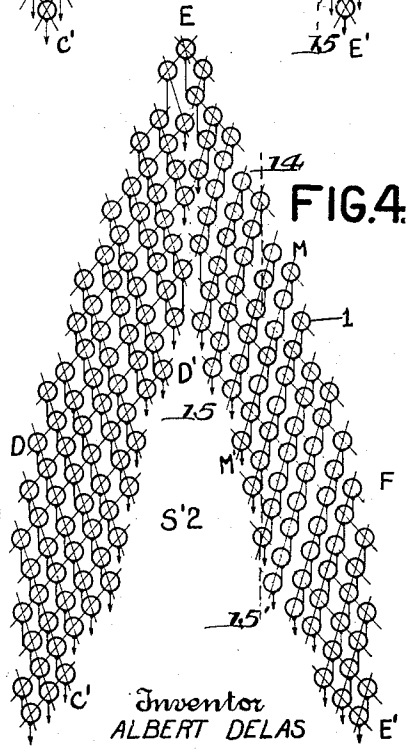


FIG.4.



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Patented Sept. 23, 1930 1,776,349

UNITED STATES PATENT OFFICE

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SURFACE CONDENSER

Application filed September 30, 1925, Serial No. 59,447, and in France January 2, 1905.

In surface condensers designed to condense steam on the outside of a nest of tubes through which cooling water flows, the thermic conductivity of the exchange or cooling surface is limited or impaired, among other influences, (1) by the evaporation of the condensate on the tubes, (2) by the great difficulty encountered by the steam in finding access to the tubes situated in the center of the nest, and (3) by the presence of non-condensible gases mixed with the steam.

(1) To reduce the insulating action of the evaporating condensate on tubes, it has been proposed to place in a nest baffle plates to collect the condensed water coming from the tubes above and to lead the same directly to the lower part, thus preventing evaporation on the tubes placed below. These baffles have the defect of constituting an obstacle to the flow of the steam and to create a loss of power which is directly contrary to the purpose aimed at, for instance when the condenser receives the exhaust of a thermal motor. On the other hand devices exist in which the tubes, instead of being placed one below the other in vertical rows, are so staggered that the condensed liquid falling from the lower generating surface of one of the tubes strikes the tubes positioned immediately below at a tangent or practically so. The condensate travels therefore on a slant, that is in an oblique manner, from tube to tube and the surface of each tube exposed to the dripping of the condensate is reduced to a fraction of the total surface. However, it is impossible to prevent in this manner the effects of an accumulation of the condensate on the lower tubes, and even less so than by the adoption of the baffles mentioned above, the inconvenience of which has been described.

(2) With respect to the second cause for the limitation of the thermal efficiency of the surface exchange, experience has shown that it is of advantage to expose the greatest possible number of tubes to the direct flow of the steam to be condensed and, consequently, to provide in the nest suitably located spaces without any tubes.

(3) Finally, to eliminate the non-condensible gases, they are drawn by means of a suitable extractor to the lower part of the nest where they collect by reason of the difference in density, being nearly always heavier than the steam to be condensed. Nevertheless, these gases create always in the apparatus a certain tension which added to that of the steam is detrimental in a condenser of a thermal engine, and their presence produces an insulating effect on the exchange or cooling surface.

The present invention has for its subject matter a special arrangement of the nest of tubes in such manner that on the one hand a great number of tubes are exposed to the direct flow of the steam to be condensed and, on the other hand, the water of condensation drips only on a very small number of tubes and falls freely to the lower part of the condenser without the use of baffles and, finally, that the momentum acquired by the freely falling water of condensation is utilized to carry the non-condensible gases to the lower part of the condenser. To this end, the tubes are positioned in such manner that the nest, generally of saw teeth formation, is limited in its upper part by an outline leaving between the individual elements or groups of the nest trenches converging in downward direction and in the lower part by an outline leaving trenches that diverge in downward direction.

Further objects, features and advantages of my invention will more fully appear from the detailed description below taken in connection with the accompanying drawings, in which,

Fig. 1 is a cross sectional view of a condenser illustrating a nest of tubes arranged in accordance with the invention.

Fig. 2 illustrates a modified form of the nest of tubes.

Fig. 3 represents in detail an arrangement of the tubes within one of the elements or groups of the nest illustrated in Fig. 1.

Fig. 4 represents another arrangement of the tubes within the elements or groups of the nest illustrated in Fig. 2.

Referring to the drawings in detail the reference numeral 10 designates a condenser cas-

ing provided with a suitable inlet 11 and a plurality of cooling tubes 12. The end plates, the exit port or ports for the water of condensation and the non-condensible gases are not illustrated as they form no part of my present invention.

According to the present invention, as illustrated in Fig. 1, the tubes are arranged within a zone limited at its upper part by a line in saw toothed formation and designated by the letters A B C D E F G H I and in the lower part by an inverse line designated by the characters A′ B′ C′ D′ E′ F′ G′. In Fig. 2 the upper line is designated by the letters A B C D E F G H I and the lower line by the characters A′ B′ C′ D′ E′ F′ G′ H′ I′.

Such an outline according to Fig. 1 produces in the upper part of the condenser spaces S′, S^2, S^3 and S^4 without tubes, which spaces converge from the top to the bottom, and in the lower part spaces S'^1, S'^2, and S'^3 which diverge from the top towards the bottom. The central part of the condenser may be occupied by a projecting tooth, as illustrated in Fig. 1, or by an empty space like S^2 as illustrated in Fig. 2. The outline according to Fig. 2 produces spaces S′, S^2, and S^3 in the upper part and spaces S′, S'^2, S'^3 and S'^4 in the lower part of the condenser.

The tubes 12 may be arranged in the nests or groups illustrated in Figs. 1 and 2 as shown in either Figs. 3 or 4. In Fig. 3 the tubes are shown arranged in quincunx, forming a series of vertical rows. In Fig. 4, the tubes 12 are arranged in oblique rows inclined toward the lower spaces.

The operation is as follows: The steam arrives in the condenser 10 through the inlet 11 in the direction of the arrow 13. It enters the open spaces S′ S^2 S^3 S^4 of Fig. 1 and the spaces S′, S^2 or S^3 of Fig. 2 as the case may be, and flows in a generally downward direction through the nests of tubes and is condensed in the elements or groups of the nest of tubes which define these spaces. The form of the section of these open spaces, which narrows down to a point, is therefore, logical, since the volume delivered diminishes from the top to the bottom.

The water of condensation formed on the tubes 12 of each element or group, follows the line 14—15 (Fig. 3) by dripping on each vertical row of tubes and, arriving at 15, it drops directly to the bottom of condenser 10 and across open spaces S'^1, S'^2 and S'^3 of Fig. 1 and across the open spaces S'^1, S'^2, S'^3 and S'^4 of Fig. 2. The effect of the accumulation of the water of condensation by its dripping is therefore produced only on a number of tubes equal to that of a row such as 14—15 and may therefore be increased or reduced at will. Moreover, if the total surface is judiciously chosen, the steam is completely condensed after having passed the elements or groups such as E F E′ D′ (Fig. 1), and in the open spaces S'^1, S'^2, and S'^3 only the non-condensible gases remain.

But in the lower spaces, the water of condensation freely drops directly from all the tubes in the broken end-line of the nest A′ B′ C′ D′ F′ G′ H′. In the open spaces S'^1, S'^2, S'^3 of Fig. 1 and the spaces S'^1, S'^2, S'^3 and S'^4 of Fig. 2 there is produced an intensive downfall and it is known that under such conditions the gases are carried along. The momentum of the water of condensation falling freely from the lower tubes through the spaces S'^1, S'^2, S'^3, etc. formed by the nest of tubes brings about the desired entrainment of the gases and collects them in the lower part where they are extracted by suitable means.

I have illustrated in Fig. 3 an arrangement of the tubes in such a way that the water of condensation from an upper tube falls vertically upon a lower tube. The invention may also be carried out in practice by staggering the tubes in such manner that an oblique travel of the condensation water from the upper trenches to the lower trenches is produced, as illustrated in Fig. 4. The function is the same in either case but the realization of the oblique travel of the water of condensation presents the following advantage:

In the case of this slanting travel, all lines except those at the right of line 14—15 parallel to the travel of the water of condensation, strike the rim E′ D′ of trench S'^2 at a point 15 situated higher than the point of intersection 15^a of the perpendicular 14—15^a drawn from 14. The result thereof is that the condensate falling in the trenches S'^1, S'^2, etc. from each tube situated within the broken lines A′ B′ C′ D′ E′ F′ G′ H′, drops from a greater height in the case of oblique dripping than in case of vertical dripping. In consequence thereof, the momentum for the entrainment of the non-condensible gases is much greater in the former than in the latter case.

It is understood that the construction is not limited to the above described details and that a number of modifications may be made without deviating from the principle of the invention. In particular, the outlines A B C D etc. and A′ B′ C′ D′ etc. may have a different form from those represented in Figures 1 and 2, provided that the upper line produces trenches or spaces converging downwardly and the lower line provides trenches as spaces where the water of condensation may freely drop from the lower tube towards the lower part of the apparatus.

What I claim and desire to secure by Letters Patent is:

1. A condenser comprising a nest of cooling tubes distributed therein to form downwardly converging trenches above the same and downwardly diverging trenches below the same, said nest comprising a series of

rows of tubes inclined towards said lower trenches and so arranged that the condensed water falling from the bottom of an upper tube of a row will fall on one side of the tube just below it in the same row to provide parallel paths for the steam, water and air.

2. A condenser comprising a nest of cooling tubes distributed therein to form downwardly converging trenches above the same into which the steam is admitted and downwardly diverging trenches below the same from which the air is withdrawn, said nest comprising a series of rows of tubes inclined toward said lower trenches and so arranged that the condensed water falling from the bottom of an upper tube of a row will fall practically tangentially on one side of the tube just below it in the same row.

3. A condenser comprising a nest of cooling tubes distributed therein to form downwardly converging trenches above the same into which the steam is admitted and downwardly diverging trenches below the same from which the air is withdrawn, said nest comprising a series of rows of tubes inclined toward the lower trenches and so arranged that the condensed water falling from the bottom of an upper tube of a row will fall on that side of the tube just below it in the same row which is remote from the lower trench toward which steam flows.

4. A condenser comprising a nest of cooling tubes distributed therein to form downwardly converging trenches above the same into which the steam is admitted and downwardly diverging trenches below the same from which the air and water is withdrawn, the marginal tubes of the nest defining said downwardly diverging trenches being so disposed that a vertical plane including the axis of any marginal tube will pass outside of the tube immediately therebelow.

5. A condenser comprising a nest of cooling tubes distributed therein to form downwardly diverging trenches below the same, the marginal tubes of the nest being so disposed that a vertical plane including the axis of any marginal tube will pass outside of the tube immediately therebelow.

6. A condenser comprising a nest of cooling tubes distributed therein to form a space for the admission of steam and a space for the withdrawal of air, said nest comprising a series of rows of tubes inclined toward said last named space and so arranged that the condensed water falling from the bottom of an upper tube of a row will fall on one side of the tube just below it in the same row to provide parallel paths for the steam, water and air.

In testimony whereof, I have hereunto set my hand this 13th day of June, 1925.

ALBERT DELAS.