Jan. 17, 1933. E. L. CAHOON 1,894,753

CONDENSER

Filed Sept. 27, 1930 3 Sheets-Sheet 1

Fig. 2.

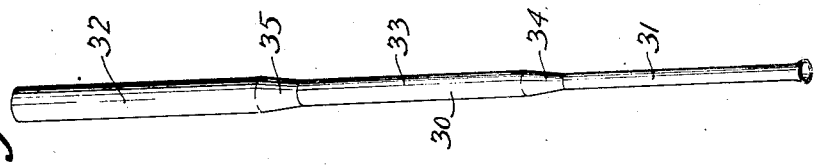



Fig. 1.

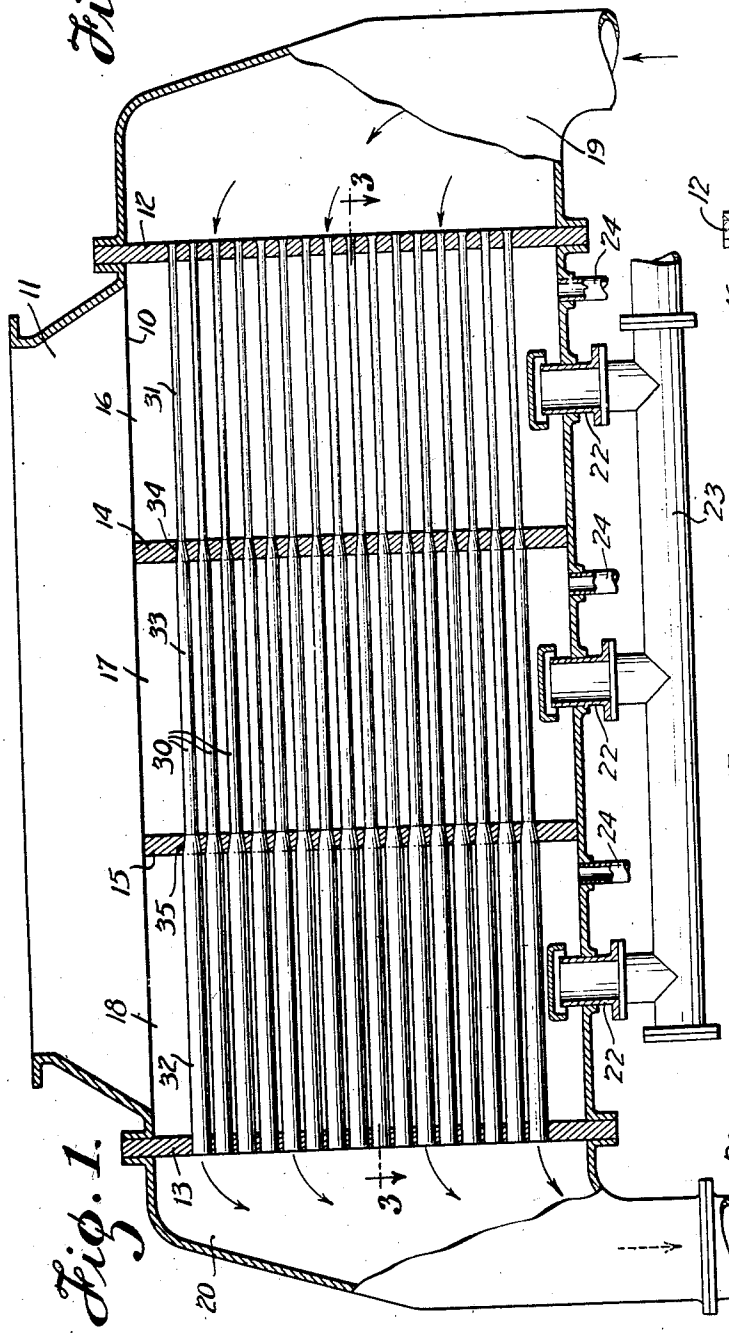
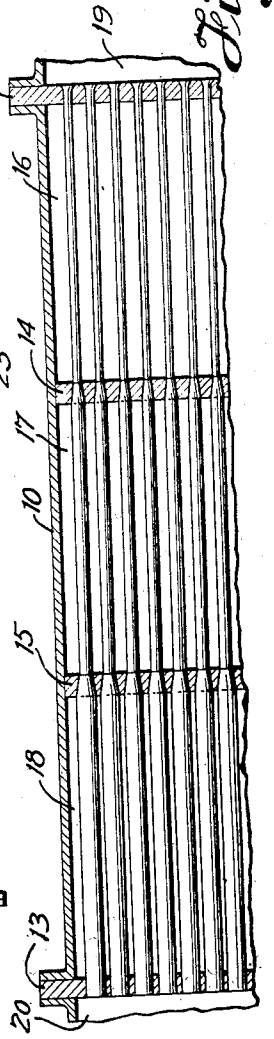



Fig. 3.



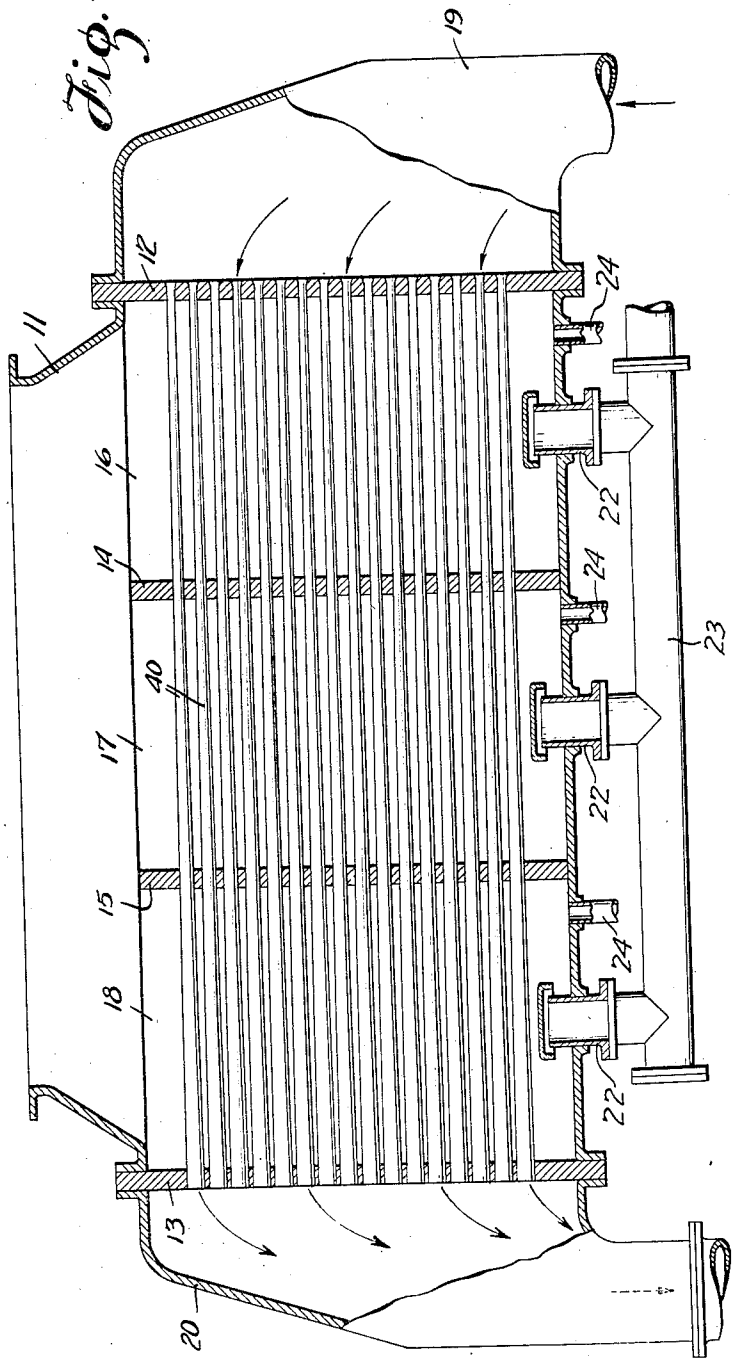

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CONDENSER

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Fig. 4.



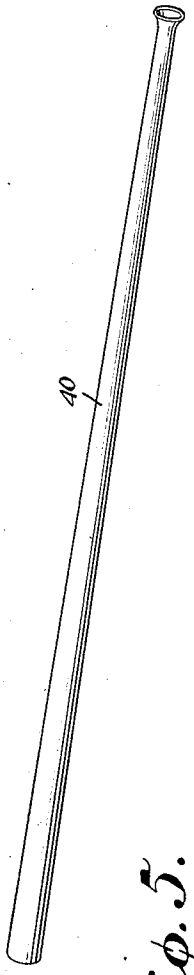




Fig. 5.

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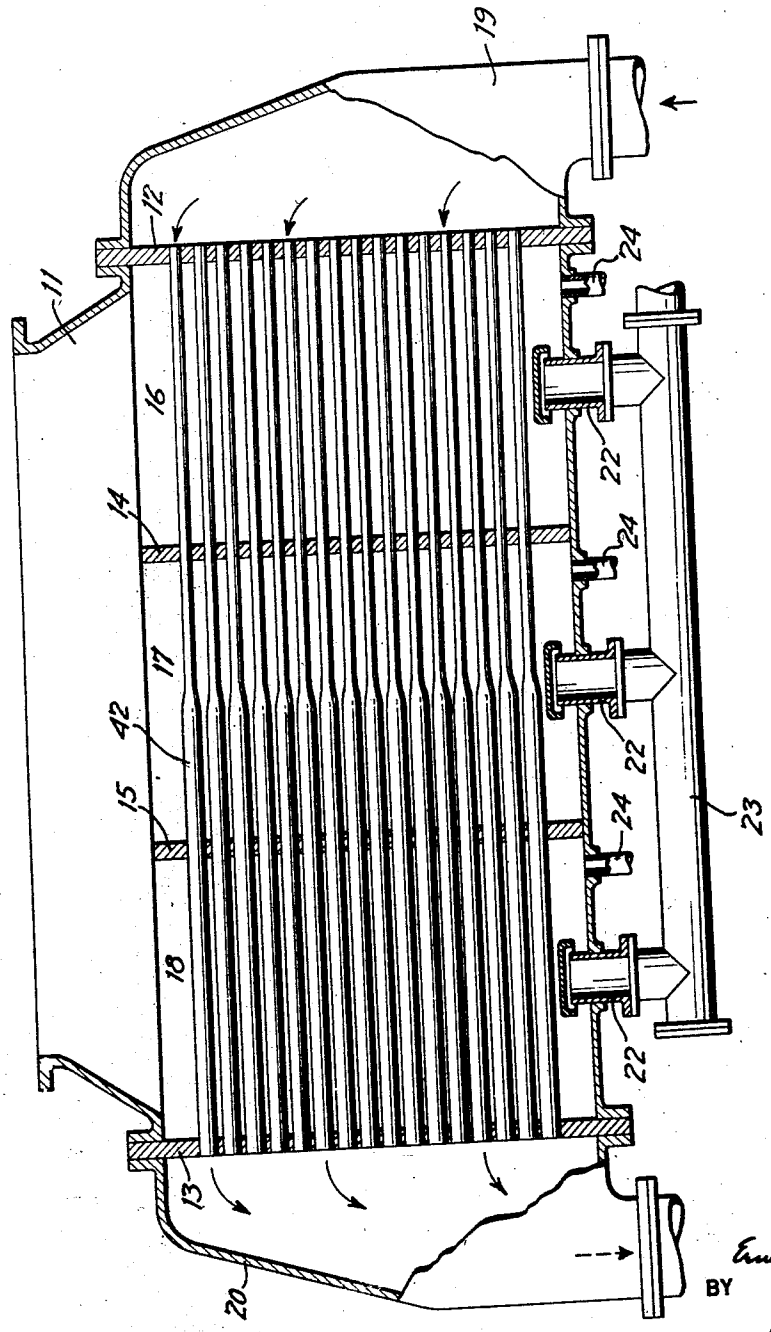



Fig. 6.

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1,894,753

# UNITED STATES PATENT OFFICE

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## CONDENSER

Application filed September 27, 1930. Serial No. 484,732.

This invention relates to condensers, and more particularly to surface condensers having a plurality of compartments of different heat absorbing capacities, such, for example, as single-pass, multi-compartment condensers with equally spaced partitions.

In condensers of the type referred to, the cooling capacities of the compartments differ because the cooling water flows in series through them, the cooling water being gradually heated as it absorbs heat from and condenses the steam or other vapor to be condensed. The compartment adjacent the cooling water inlet is the coldest and has the greatest cooling capacity; the compartment adjacent the cooling water outlet is the warmest and has the least cooling capacity.

Since the compartments have unequal cooling capacities, they should be supplied with different quantities of steam if they are to do all the work that they are respectively able to do. Several ways have been proposed to vary the flow of steam in the different compartments, all of which have involved complications of design.

I propose to vary the rate of flow of steam through the various compartments, without the use of baffles or valves and while maintaining free communication of the compartment inlets and outlets, by varying the resistance to flow in the different compartments by means of the cooling members themselves. In the preferred form of my invention I use the same number of tubes in each of the compartments, but provide different tube diameters in different compartments in order to vary the effective cross-sectional areas to the paths of flow of the vapor in the respective compartments.

Thus my improved condenser overcomes the disadvantages of the ordinary condenser having compartments of unequal cooling capacity while varying therefrom only in the shape of the tubes.

The nature of the invention will be apparent from the following description taken in conjunction with the accompanying drawings forming a part of this specification and in which:

Fig. 1 is a more or less diagrammatic view, in elevational section, of a single-pass compartment type surface condenser embodying the present invention;

Fig. 2 is an enlarged perspective view of one of the condenser tubes constructed in accordance with the present invention;

Fig. 3 is a view looking down and taken on the line 3—3 of Fig. 1;

Fig. 4 is a view similar to Fig. 1 of another form of condenser embodying the invention;

Fig. 5 is an enlarged perspective view of another form of condenser tube constructed in accordance with the present invention; and

Fig. 6 is a view similar to Fig. 1 of still another form of condenser embodying the invention.

Referring to Fig. 1, numeral 10 represents the shell of a three-compartment, single-pass surface condenser embodying the present invention. The shell is provided with an upper vapor inlet 11. Tube sheets 12 and 13 are secured to the ends of the shell. Partitions 14 and 15 divide the condenser into compartments designated 16, 17 and 18, respectively. Cooling fluid enters the condenser through an inlet water box 19 and leaves the condenser through an outlet water box 20, passing through the cooling tubes hereinafter to be described. Air, poor in steam, is withdrawn from the bottom of each compartment through connections 22 and conduit 23, the latter being connected to a suitable vacuum pump. Condensate is withdrawn from the various compartments through connections 24 in known manner.

The condenser shell 10 surrounds the longitudinally extending cooling tubes 30, which tubes are constructed in accordance with the present invention. The tubes 30 are supported at their ends and are fixed in the tube sheets 12 and 13 in known manner. The tubes are supported intermediate their ends by the partitions 14 and 15 through which they pass. As shown, each of the tubes 30 is constructed so that its end portions 31 and 32 and its intermediate portion 33 are of different diameters, the end and intermediate portions being connected by relatively short tapering portions 34 and 35. The end portion 31 is of

smaller diameter than the intermediate portion 33 and the intermediate portion is of smaller diameter than the end portion 32. In this form of the invention the tubes are of uniform diameter in any one compartment, the variations of diameter occurring at the partitions 14 and 15. It is not necessary that the variation takes place within the partitions, but they may be adjacent the partitions. The small diameter ends of the tubes are in the coldest compartment 16 adjacent the cooling water inlet. The cold ends of the tubes are preferably flared, as shown, to provide a Venturi-shaped entrance.

Each of the compartments 16, 17 and 18 constitutes a path of flow of vapor downwardly from the inlet 11 to the outlet connections 22. In each of the compartments there is a lower pressure at the outlet than at the inlet, the drop in pressure producing the flow. The pressure at the inlets of the compartments is substantially the same and the pressure at the outlets of the compartments is the same. The pressure drop through any compartment is determined by the resistance to flow. The resistance to flow is determined by the tubes. Considering the area transverse to the path of flow in any compartment, that is, the horizontal cross-sectional area, it will be seen that the flow resistance depends upon the proportion of the cross-sectional area which is taken up by tubes. The less of the area that is taken up by tubes, the less is the resistance to flow. It will be seen from consideration of Fig. 3, which constitutes a view looking in the direction of flow, that the resistance to flow is the least in compartment 16 and the greatest in compartment 18. Furthermore, the resistance to flow in compartment 17 is of a value intermediate to that of the compartments 16 and 18. This is because the percentage of the cross-sectional area transverse to the path of flow blocked off by the tubes is less in compartment 16 than in compartment 17 and less in compartment 17 than in compartment 18. I choose the diameters of the different tube sections to give a flow resistance which has a relation to the cooling capacity of the compartment. Since compartment 16 has the greatest cooling capacity I wish to pass the greatest quantity of steam through this compartment and therefore I decrease the resistance to flow in this compartment, relative to the other compartments, by decreasing the tube size in this compartment relative to the other compartments. Thus it will be seen that the compartment of greatest heat absorbing capacity has the least flow resistance and will therefore permit the passage of the greatest amount of steam. Thus I am able to provide the compartments with effective cross-sectional areas of vapor flow which are proportionate or approximately proportionate to the heat absorbing capacities of the several compartments. With this arrangement it will be seen that each compartment of the condenser is caused to absorb all the heat which it is capable of absorbing, and this result is obtained without structurally blocking the condenser with baffles, regulating throttle valves, etc.

Another form of condenser tube which will accomplish the same result is shown in Figs. 4 and 5. The tubes of the condenser shown in Fig. 4, indicated 40, are tapered longitudinally so that the diameter gradually increases from the cold end to the hot end. With the tubes 40, it will be seen that the average diameters of the end portions which are disposed in compartment 16 of the condenser are smaller than the average diameters of the portions disposed in intermediate compartment 17, and the latter in turn are smaller than the average diameters of the end portions disposed in end compartment 18.

In the arrangement shown in Fig. 6 the tubes 42 are each made with two different diameters. The change in diameter occurs in the middle part of compartment 17. It will be seen that in this case the average tube diameter in compartment 16 is less than in compartment 17, and less in compartment 17 than in compartment 18. It will be seen that this condenser operates in the same manner so that the resistance to flow in the several compartments is less for the compartment of greater cooling capacity, the transverse area of flow being greater for the greater cooling capacity.

While, in each of the embodiments shown, the gas contact surface is decreased in a colder compartment relative to the gas contact surface in a warmer compartment, this disadvantage is more than offset by the advantages resulting from variation in transverse cross-sectional area of steam flow and is even to some extent directly compensated by the better heat transfer between the cooling medium and the tubes since the velocity of the cooling medium is increased and this heat transfer increases as the square of the velocity.

It will be understood that the invention is adaptable to many different structures and I am not to be limited to the specific arrangements above described.

What I claim is:

1. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within the shell extending between the tube sheets and connecting the water boxes, said tubes being of smaller diameter at the inlet water box end than at the outlet water box end.

2. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within the shell extending between the tube sheets and connecting the water boxes, said

tubes being of increasing diameter from the inlet water box end to the outlet water box end.

3. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes and partitions in said shell transverse to said tubes forming a plurality of condensing compartments of different heat absorbing capacities, said tubes being of smaller diameter at one end than at the other.

4. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes and partitions in said shell transverse to said tubes forming a plurality of condensing compartments of different heat absorbing capacities, said tubes being of smaller diameter at the inlet water box end than at the outlet water box end.

5. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes and partitions in said shell transverse to said tubes forming a plurality of condensing compartments of different heat absorbing capacities, said tubes being of gradually increasing diameter from the inlet water box end to the outlet water box end.

6. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions in said shell transverse to said tubes forming a plurality of condensing compartments of different heat absorbing capacities, the portions of said tubes passing through the compartment of greatest heat absorbing capacity being of smaller diameter than the other portions of the tubes.

7. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions in said shell transverse to said tubes forming a plurality of condensing compartments of different heat absorbing capacities, the portions of said tubes passing through the compartment of greatest heat absorbing capacity having an average diameter smaller than the average diameter of the other portions of said tubes.

8. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions in said shell transverse to said tubes forming a plurality of condensing compartments of different heat absorbing capacities, the portions of said tubes passing through the compartment of greatest heat absorbing capacity being of a certain diameter and another portion of said tubes passing through a compartment of lower heat absorbing capacity being of larger diameter than said certain diameter.

9. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions in said shell transverse to said tubes forming a plurality of condensing compartments of different heat absorbing capacities, said tubes being arranged so as to provide a smaller condensing surface area and a larger vapor area transverse to the path of vapor flow in the compartment of greatest heat absorbing capacity than in the compartments of lower heat absorbing capacities.

10. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions therein transverse to said tubes separating the condenser into hot, intermediate and cold compartments, the portions of said tubes passing through each of said compartments having different diameters.

11. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions therein transverse to said tubes separating the condenser into hot, intermediate and cold compartments, the portions of said tubes passing through each of said compartments having different average diameters.

12. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions therein transverse to said tubes separating the condenser into hot, intermediate and cold compartments, the portions of said tubes passing through the hot compartment being of a certain diameter, the portions of said tubes passing through the intermediate compartment being of a smaller diameter and the portions passing through the cold compartment being of still smaller diameter.

13. A condenser comprising a shell, tube sheets, inlet and outlet water boxes, tubes within said shell extending between said tube sheets and connecting the water boxes, and partitions therein transverse to said tubes separating the condenser into hot, intermediate and cold compartments, the portions of said tubes passing through the hot compartment being of larger diameter than the portions of said tubes passing through the intermediate compartment and the portions of said tubes passing through the cold compartment being of smaller diameter than the portions passing through the intermediate compartment.

14. A condenser tube comprising a plurality of longitudinal portions, each portion being of uniform diameter and each portion being of different diameter than an adjacent portion.

15. A condenser tube comprising a plurality of longitudinal portions, each portion being of uniform diameter, the portion adjacent one end having a given diameter and successive portions having successively larger diameters.

16. A condenser tube comprising a plurality of longitudinal portions, each portion being of uniform diameter, the portion adjacent one end having a given diameter, the portion adjacent the other end having a different diameter and an intermediate portion having an intermediate diameter.

In testimony whereof I hereunto affix my signature.

ERNEST L. CAHOON.