Aug. 18, 1925. 1,550,332

P. A. BANCEL

SURFACE CONDENSER

Filed Oct. 15, 1924 4 Sheets-Sheet 1

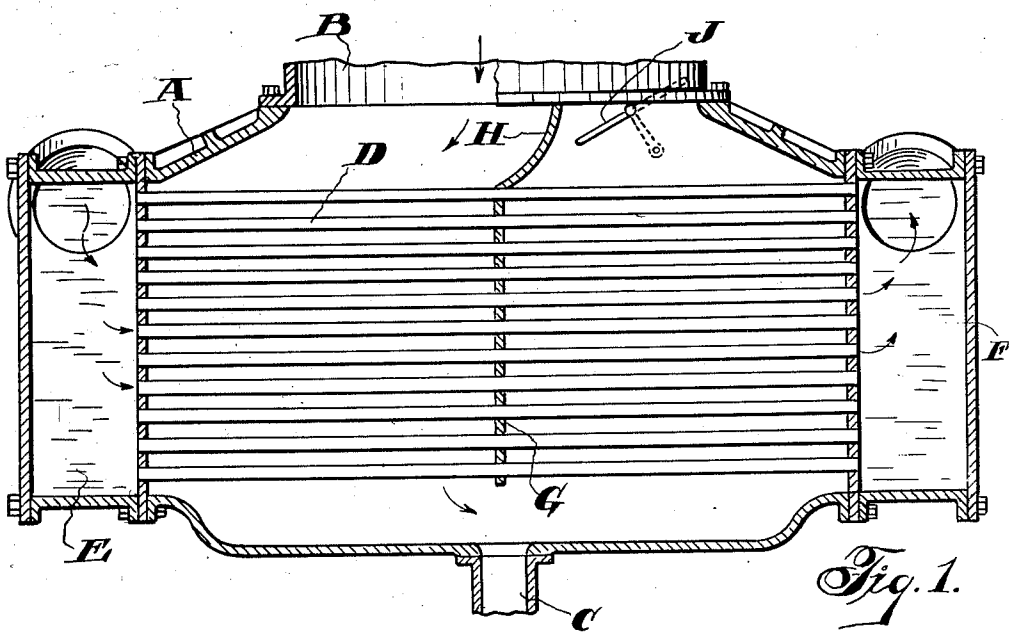


Fig. 1.

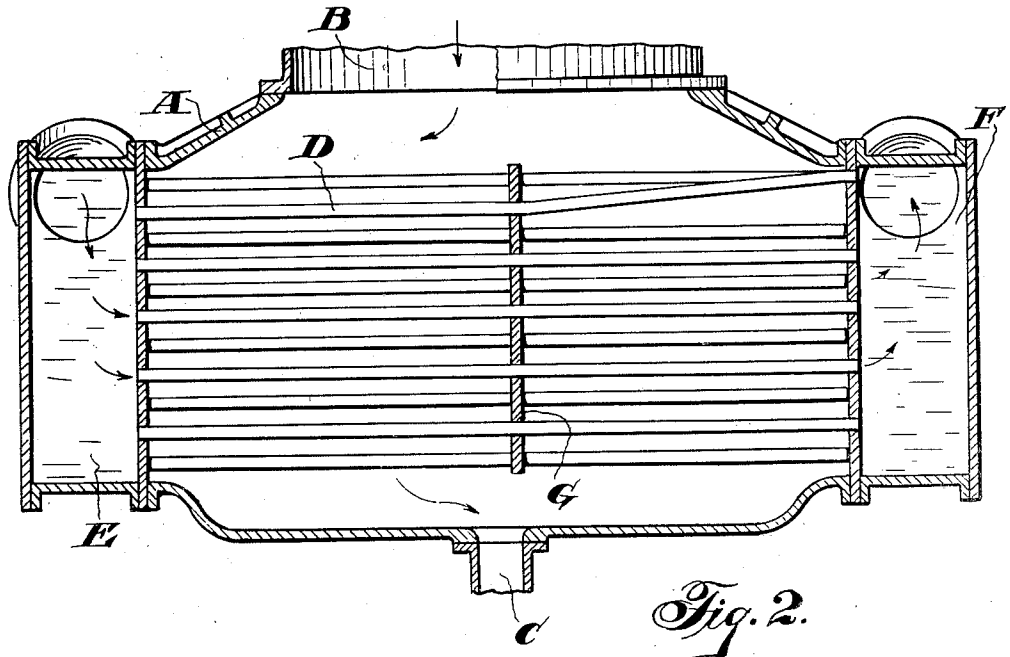


Fig. 2.

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Filed Oct. 15, 1924 4 Sheets-Sheet 2

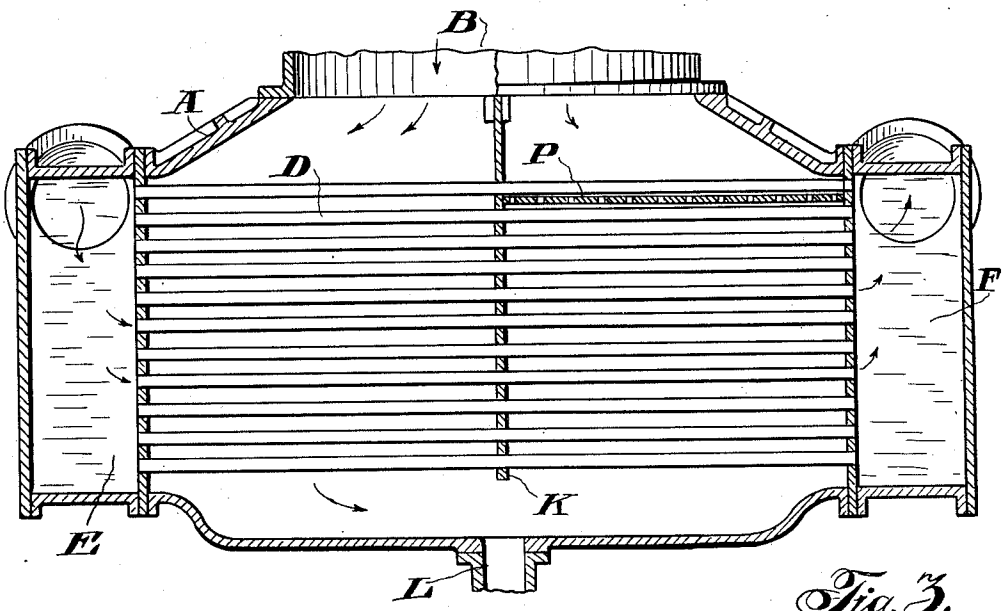


Fig. 3.

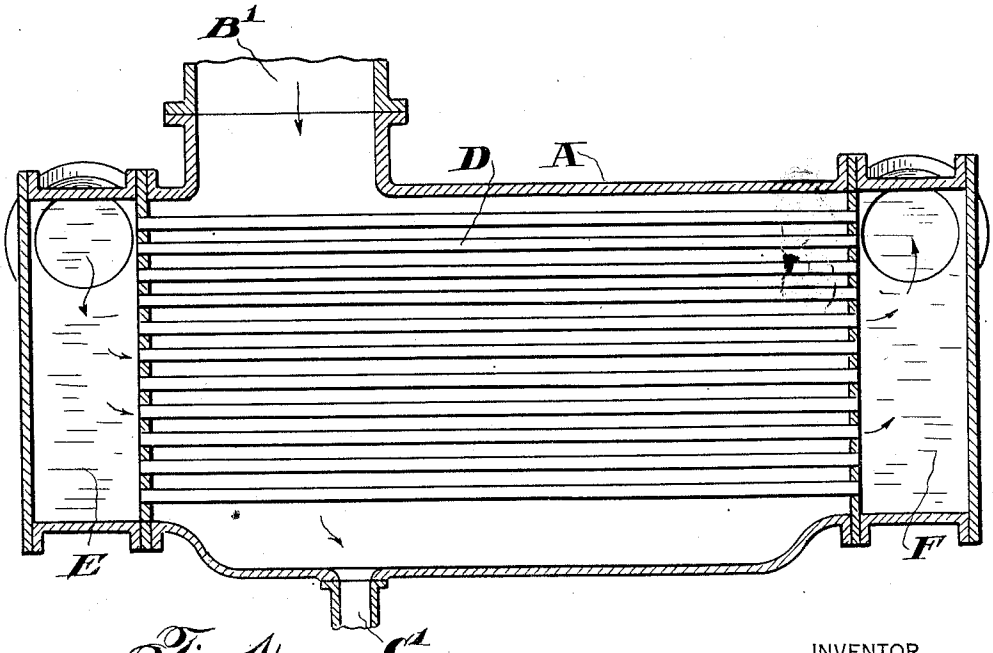


Fig. 4

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SURFACE CONDENSER

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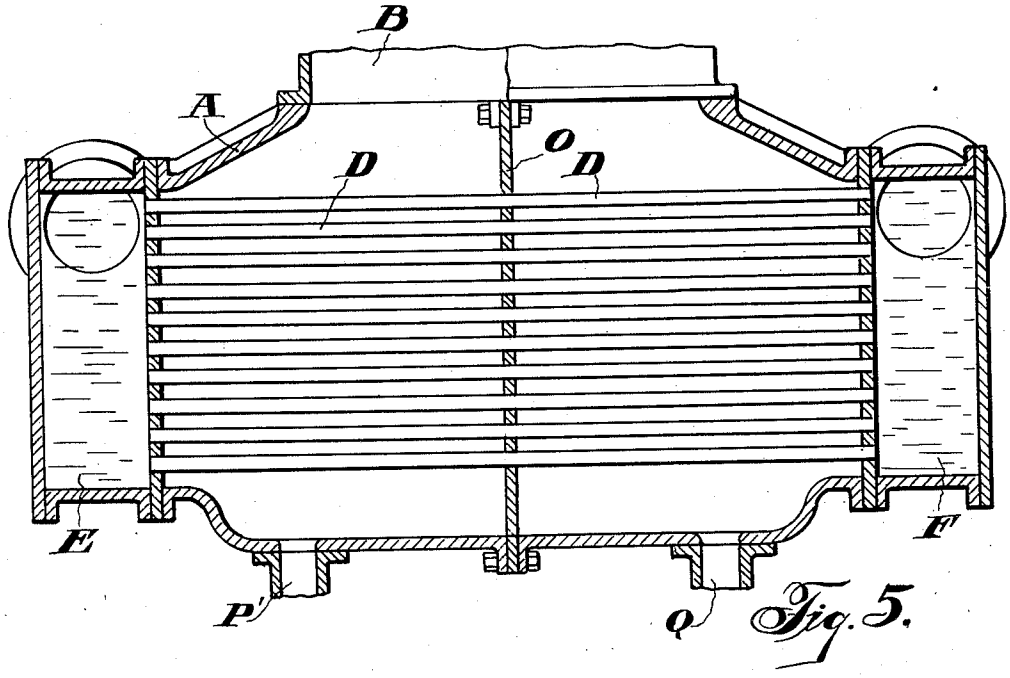


Fig. 5.

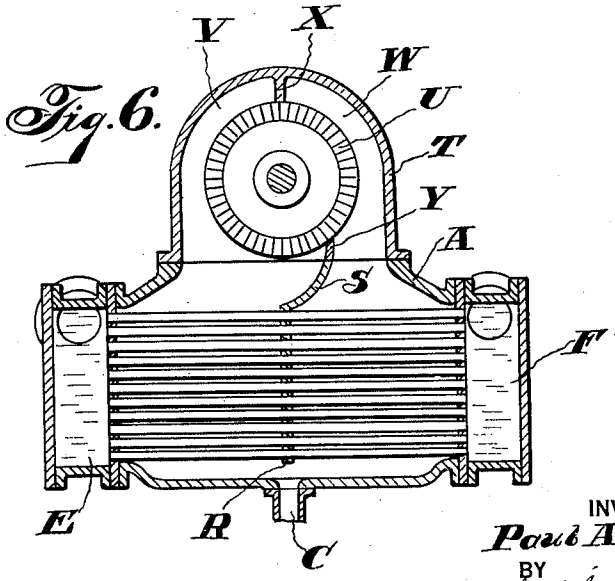


Fig. 6.

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Filed Oct. 15, 1924 4 Sheets-Sheet 4

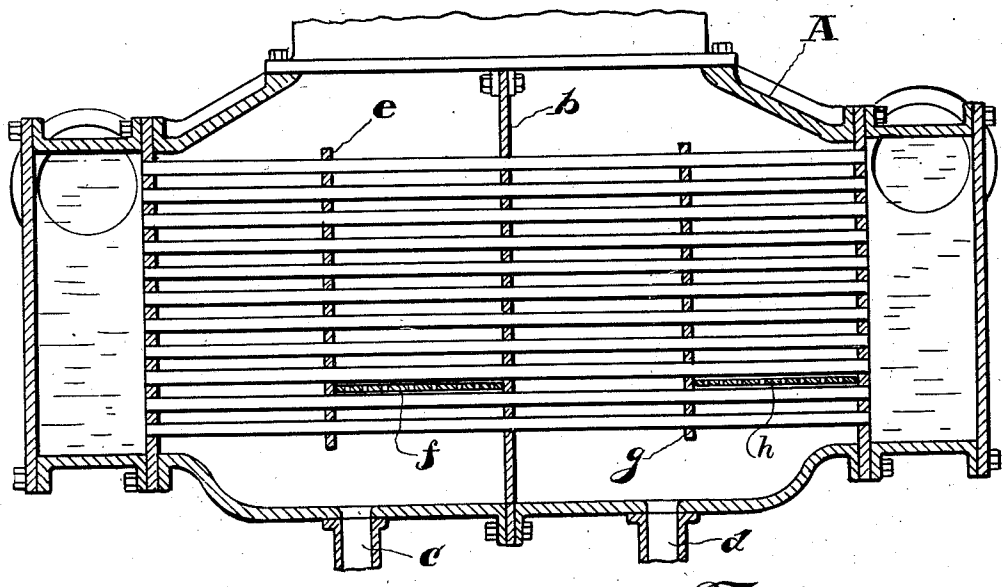


Fig. 7.

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Patented Aug. 18, 1925. 1,550,332

UNITED STATES PATENT OFFICE.

PAUL A. BANCEL, OF NUTLEY, NEW JERSEY, ASSIGNOR TO INGERSOLL-RAND COMPANY, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

SURFACE CONDENSER.

Application filed October 15, 1924. Serial No. 743,695.

To all whom it may concern:

Be it known that I, PAUL A. BANCEL, a citizen of the United States, and a resident of Nutley, county of Essex, and State of New Jersey, have invented a certain Surface Condenser, of which the following is a specification accompanied by drawings.

This invention relates to surface condensers and more particularly to that type of surface condenser comprising surface cooler tubes extending longitudinally through a chamber across the path of the steam flow.

In single pass condensers having water tubes over which steam to be condensed passes or condensers so designed that all of the tubes passed over by the steam between the point of entrance of steam and the point of exit of non-condensable vapor and air have water flowing the same direction, the tubes are cooler at the inlet portions than at their outlet because in passing through the tubes, the water is warmed from the heat absorbed, and in condensing the steam the water temperature rises progressively along the length of the tubes in the direction of water flow. The effect of this temperature condition is to decrease the capacity of the water to condense steam in sections of the condenser relatively remote from the water inlet. In condensers having two or more passes the conditions are identical if the flow is toward a central air outlet, or the same general effect is observed when the air outlet is at the end of the lower pass, for the reason that a greater part of the condensation takes place in the upper tubes and the lower tubes condense a relatively small quantity of steam, their purpose being rather to cool the mixture of uncondensable air and vapor.

As steam is condensed more rapidly in the cool end of a single pass condenser than at the warm end, there must be a larger flow through that end than at the warm end in order to supply sufficient steam to the lowermost tubes. This would call for a greater loss of pressure at one end of the condenser than at the other, which is ordinarily impossible since the whole lowermost section is in free communication with the vacuum pump withdrawing the uncondensable gases. The result in an ordinary single pass condenser or any condenser to a greater or less extent is that steam does not come into contact with the lowermost tubes at the cold end and thus condensers of this type heretofore have been inefficient to a certain extent in that there is provided a certain amount of cooling surface which does not condense steam. If the vacuum pump is operated to draw steam down into the condenser into contact with all portions of the tubes, uncondensed steam will pass through the warm end and be drawn from the outlet. This is undesirable since additional means must be provided to condense the steam which has passed through the condenser.

It is an object of this invention to apportion the steam in the various parts of the condenser so as to produce substantially the same depth of penetration throughout and to utilize the entire available cooling surface of the condenser. This object may be accomplished in a variety of ways, some of which are hereinafter described. In some cases it is desirable to divide the condenser into sections, utilizing for this purpose partitions for the usual tube supporting plates and in a suitable manner to direct the steam in accordance with the flow or passage of steam toward the cooler section as by means of a baffle, by gathering or bunching the tubes to resist the flow in the warmer section, or to maintain different degrees of vacuum at the outlets of the various sections. The apportionment of the steam flowing to the various sections of the condenser may also be accomplished at the source from which the steam is drawn as, for instance in the turbine casing.

The invention will be more clearly understood by reference to the accompanying drawings forming part of the specification, in which,

Figure 1 is a diagrammatic representation of a single pass condenser divided vertically into two sections and provided with a valve or baffle to direct the flow of steam from the section which has the greatest steam condensing capacity,

Figure 2 is a diagrammatic representation of an embodiment of the invention in which the greater part of steam is directed to the cooler section of the condenser by bunching tubes in the warmer section,

Figure 3 is a diagrammatic representation of an embodiment of the invention in which the increased flow of steam to the cooler section and the reduction of the quan-

tity of steam flowing to the warmer section is secured by a baffle in the warmer section of the condenser,

Figure 4 is a diagrammatic representation of an embodiment of the invention in which equal depth of penetration of the steam throughout the condenser is obtained by arrangement of the steam inlet and outlet,

Figure 5 is a diagrammatic representation of a modified form of the invention in which equal depth of penetration is secured in the various sections or compartments by separate withdrawal outlets for each compartment by means of which the proper degree of vacuum in each is maintained,

Figure 6 shows diagrammatically a modified arrangement in which the discharge chamber of the associated turbine is arranged to deliver to the compartments of the condenser quantities of steam proportionate to their steam condensing capacities, and,

Figure 7 shows diagrammatically an arrangement in which two main compartments are subdivided into other compartments and each is provided with means arranged to secure equal steam penetration depth. Such an arrangement as this is more particularly suitable where the condenser tubes are relatively long.

Referring to the drawings and more particularly to Figure 1 the condenser consists of an outer shell A of the usual form having a steam inlet B and outlet C for the withdrawal of condensate and uncondensable gases. The shell A is preferably long and is traversed by a plurality of tubes D supplied with water from the water head E discharging into a head F at the opposite end of the condenser. A tube support in the form of a drilled plate G divides the space within the shell A into two compartments, one being comparatively cool as it includes that portion of the water tubes nearer the water head E, and a warmer compartment nearer the discharge head F containing water which has already absorbed heat in condensing steam.

The steam pressure is uniform everywhere in the inlet B. This pressure which is a partial vacuum is maintained by a suitable evacuating apparatus (not shown) which withdraws the condensate and uncondensable gases from the outlet C and produces also a uniform degree of vacuum in the casing A below the tubes D. In other words, it may be said that the same pressure drop exists across both compartments and therefore more steam cannot flow down to the same depth in the left hand as compared to the right hand as desired on account of the cooler water because this would necessitate unequal pressure drops. What happens therefore is a condition of equilibrium in which the steam penetrates only partly as far on the cool end, a greater steam velocity through fewer rows, balancing lesser velocity through more rows. This results in a loss of efficiency because in that case some of the tubes in the cooler section will not function, the steam having been condensed before reaching them. To avoid this loss in efficiency, means is provided for directing an increased flow or passage of steam to that section in which the tendency of steam is to penetrate to a less depth on account of the greater heat absorbing capacity. To this end there is provided a plate H extending upwardly toward the warm end of the condenser, which is arranged to direct the greater part of the steam from the inlet B toward the cooler end of the condenser. Additionally, a valve J may be provided to reduce the amount of steam entering the warm section. By a proper adjustment of the valve J the flow of steam may be apportioned to the various sections of the condenser in proportion to the thermal capacity of each.

In Figure 2 the flow of steam from the inlet B is directed through the relatively cool and warm sections of the condenser in proportions corresponding to their relative steam condensing capacity by providing a passageway through the cool section of less resistance to the flow of steam than in the warm section. This is accomplished in this embodiment by bending up the second row of tubes to project into the plane of the first bank of tubes. Bunching of the tubes D in this manner produces less restriction to the flow of steam in the cool section and results in greater depth of penetration resulting in the desired increase in efficiency. The increased flow and velocity of the steam resulting in a slight increase of friction loss is offset by the larger and less restricted path as compared with that of the warmer section.

In Figure 3 the tube support K divides the condenser into two sections and a single outlet L is employed for the withdrawal of the uncondensed air from both sections. The operation of this form of condenser is similar to that shown in Figure 2. Instead of bunching the tubes D a baffle P interposed between two layers of tubes directs the greater part of the steam to be condensed toward the cooler section of the condenser.

Figure 4 illustrates an embodiment in which the desired result may be accomplished by arranging the inlet B′ and the outlet C′ so that the warmer part of the condenser is further away from the inlet than the cooler part and the velocity of the steam on entering causes it to tend to flow toward the cooler part. This produces an increased flow or passage of steam to those vertical sections in which the tendency of the steam

is to penetrate less deeply on account of the greater heat absorbing capacity in those sections. The flow or passage of steam in those vertical sections in which the heat absorbing capacity is less on account of the high temperature of the cooling water is reduced correspondingly to prevent penetration beyond the last bank of cooling tubes.

In the embodiment shown diagrammatically in Figure 5 the shell or casing A is divided from top to bottom by means of a partition O forming two compartments, both communicating with the inlet B at the top and therefore being supplied with steam at equal absolute pressures. Separate outlets P′ and Q are provided for the cooler and warmer compartments respectively to withdraw the condensate and uncondensable gases. At each of these outlets a degree of vacuum is maintained sufficient to draw steam to equal depths of penetration in the respective compartments.

In the forms of the invention above described, the various sections or compartments of the condenser are supplied from a common inlet with steam at a uniform pressure throughout the inlet end of the condenser. Equal depths of steam penetration are secured either by obstructing the flow in the warmer compartments in those arrangements in which there is provided a common air outlet for the various compartments, or by maintaining different degrees of vacuum at the outlets of those embodiments in which each compartment is provided with its separate outlet. Substantially the same result may be obtained without obstructing the flow of steam and at the same time maintaining uniform pressure throughout the lower part of the condenser. Such an arrangement is shown diagrammatically in Figure 6 in which the apportionment of the steam is effected in the discharge portion of the turbine while the uncondensable gases are withdrawn through an outlet common to both the cooler and warmer parts. The casing A is divided into two compartments by the tube sheet R which is provided with an extension S curving upwardly to the casing T of the turbine runner U. The steam discharged from the runner U is passed into two chambers V and W separated above by a partition X and below by a partition Y adjoining the extension S. The partition Y is positioned so that the chamber V communicates with a larger portion of the turbine runner U than does the chamber W and therefore receives the greater part of the steam discharged. The chamber V connects with the cooler section of the condenser and the chamber W is associated with the warmer section. By the proper positioning of the partition Y steam may be delivered to the two sections of the condenser in proportions corresponding to their steam condensing capacities, and at sufficiently different pressures or vacuums, thus securing equal depth of steam penetration throughout the length of the condenser.

If a condenser is relatively long and of large capacity it may be desirable to divide the steam condensing space into more than two sections or to divide such spaces into two main sections and further subdivide the main sections into other sections to secure equal depth of steam penetration. Two or more of the arrangements above described may be combined to produce the desired equal depth of steam penetration. Figure 7 illustrates diagrammatically a practical arrangement for a very long condenser. The space within the casing A is divided vertically into two main sections by a partition *b* similar to the partition O shown in Figure 5. The cooler section is provided with an outlet *c* for the uncondensable gases, and an outlet *d* is provided for uncondensable gases from the warmer section. The cooler section is subdivided vertically into smaller sections by a tube support *e*, the warmer of the two subsections being provided with a baffle *f* to direct a greater quantity of steam toward the cooler subsection. Likewise, a tube support sheet *g* divides the warm section into two subsections, the warmer of which is provided with a baffle *h* which directs the greater part of the steam in the warm section to the cooler subsection thereof. A somewhat higher degree of vacuum is maintained at the outlet *c* in order to draw more steam into the cooler section than into the warm section. The function of the baffles *f* and *h* is similar to the operation of the baffle P described in connection with Figure 3. Equal depth of steam penetration is thus secured in all parts of each main section as well as with respect to the two main sections.

I claim:

1. A condenser having tubes with different temperatures along their length resulting in unequal capacities for condensing steam in vertical sections along their length, and means for obtaining substantially equal depth of penetration of steam in said sections along the length of the condenser.

2. A condenser having tubes with different temperatures along their length resulting in unequal capacities for condensing steam in vertical sections along their length, and means for increasing the depth of penetration in the vertical sections in which the cooler water has more heat absorbing capacity.

3. A condenser having tubes with different temperatures along their length resulting in unequal capacities for condensing steam in vertical sections along their length, and means for directing an increased flow

or passage of steam to those vertical sections in which the tendency of the steam is to penetrate to a less depth on account of the greater heat absorbing capacity in the section.

4. A condenser having tubes with different temperatures along their length resulting in unequal capacities for condensing steam in vertical sections along their length and means for directing an increased flow or passage of steam to those vertical sections in which the tendency of the steam is to penetrate to a less depth on account of the greater heat absorbing capacity in the sections, including means for reducing the flow or passage of steam in those vertical sections in which the tendency of the steam is to penetrate to a greater depth on account of the less heat absorbing capacity therein.

5. A condenser having tubes with different temperatures along their length resulting in unequal capacities for steam in vertical sections along their length and means to apportion the flow of steam to the various sections in proportion to their thermal capacity.

In testimony whereof I have signed this specification.

PAUL A. BANCEL.