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APPARATUS FOR CONDENSING STEAM

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This invention relates to apparatus for effecting a substantially equal longitudinal distribution of steam within the condenser casing.

5 In a steam condenser, wherein the cooling medium makes a single pass through the tubes from inlet to outlet, and the steam flows transversely across the tubes, the temperature of the tubes at the inlet is lower than at the
10 outlet, for the reason that the cooling medium is heated by the heat absorbed from the steam, and the temperature increases progressively along the length of the tubes.

The steam at the warmer end of the condenser penetrates the tube bank to a greater
15 depth than at the colder end, because at the warmer end the condensing capacity is less. As a result of this condition, the steam at the cooler end of the condenser does not reach
20 and contact with the lowest tubes in the bank. Also, the vapors leaving the warmer end contain a larger amount of uncondensed steam than at the cooler end and as the evacuating
25 apparatus is a limiting factor, the amount of air withdrawn from the condenser is not at a maximum, although at the cooler end the air is efficiently cooled. These conditions result in inefficient operation of the condenser.

Various schemes have been suggested for
30 securing longitudinal distribution of and substantially equal depth of penetration of the steam such as baffle plates at the steam inlet, valves at the steam inlet and at the outlets, the use of an orifice plate in the branch of the
35 air line attached to the compartment of the condenser in which the depth of steam penetration is greater. All of these expedients impose an artificial resistance and somewhat reduce the advantage gained by better steam
40 distribution.

It is the object of this invention to secure proper steam distribution without imposing any appreciable artificial resistance. The invention contemplates the use of an air cooler or auxiliary condenser in which the cooling
45 capacity is adjusted to the requirements of the various compartments of the main condenser; for example, from that compartment in which the depth of steam penetration
50 is greatest and from which steam laden air

will be drawn to the evacuator, a connection is made to a section of the air cooler having the greater cooling capacity.

The invention will be clearly understood by reference to the accompanying drawing
55 forming a part of the specification, in which,

Fig. 1 is a view, in elevation and partly in section, of a single pass condenser and one form of auxiliary cooler, and

Fig. 2 is another form of auxiliary cooler
60 arrangement with a single pass condenser.

The condenser proper, shown in Fig. 1, consists of an outer shell 1 provided with a bundle or nest of water tubes 2, supplied with cooling water from the inlet 3 and discharging
65 through the outlet 4. Substantially midway of the two ends of the condenser, there is a partition plate 5, substantially tight and serving also to support the tubes, which are of considerable length. The steam inlet 6 is
70 located so that the partition 5 will divide the flow of steam into two paths, one directed into the compartment toward the water inlet 3 and the other into the compartment toward the outlet 4. By this arrangement there are
75 established two condensing zones or sections and two paths for the flow of steam transverse to the flow of the cooling medium. When desirable the condenser may be divided
80 into more than two sections or zones and by proper means more than two paths for the flow of steam may be established.

In Fig. 1 there is shown an auxiliary condenser or air cooler 11, provided with a water or other cooling medium inlet 8 and outlet 9
85 and tubes 10 for the passage of the cooling medium through the cooler 11, from end to end in one pass. A partition 12 is provided and so located as to provide a space to the right of said partition of greater area and
90 volume than that to the left of said partition. The tubes 10 in the space or section to the right of the partition 12 have not only a greater exposed surface but a longer path for water flow, and hence greater condensing capacity, than do the tubes 10 in the
95 space or section to the left of said partition 12.

Without provision of any sort for longitudinal distribution of the steam, in a single pass condenser of the type shown, in the com-
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partment or zone to the left of the partition plate 5, nearest the cooler end of the condenser, the steam will be completely condensed in the upper portion of the bundle of tubes and the lower tubes will do substantially no work. The tubes 2 in the section or zone to the right of the partition 5, nearer the outlet, have become warm because of the absorption of heat from the steam, and hence the depth of steam penetration is greater, covering substantially the lowermost tubes, and likewise the condensing capacity is less. These conditions result in inefficiency of operation. To remedy this defect and secure proper longitudinal distribution of the steam, and substantially equal depth of penetration from end to end of the condenser (which may be determined by the relative proportions of steam and air at the exits of the different zones or compartments, the steam penetration being equal if the proportions of steam to air at the exits are substantially equal), the zone or section of the condenser to the right of partition 5 is connected by the pipe 13 with the section of the cooler 7, having the greater cooling capacity, to the right of its partition 12 and the section of the condenser to the left of the partition 5, which is cooler, is connected by pipe 14 to the section of the cooler to the left of its partition 12, which is of lesser cooling capacity.

As an example of the described control of the temperatures at the air outlets of the compartments of the condenser, it may be assumed that the steam which enters inlet 6 of the condenser contains about ten cubic feet of air per minute measured at atmospheric pressure and at ordinary temperatures. If the division of the steam into the two paths is substantially equal between the two compartments, an equivalent of five cubic feet of air per minute would be flowing through each compartment and upon leaving the condenser at the two air outlets 13 and 14, would be saturated with water vapor at the temperatures existing at these exits and at the absolute pressure within the condenser. Assuming this absolute pressure to be two inches of mercury and that the air of the warmer end of the condenser leaves the exit 13 at a temperature of 95 degrees, the volume of the mixture of vapor and air at this end of the condenser will be approximately 440 cubic feet per minute. At the cooler end of the condenser, assuming that the temperature of the vapors at the exit is 90 degrees, the volume of the vapors at this end will be approximately 260 cubic feet per minute, making a total volume of vapors to be abstracted by the evacuating apparatus (not shown but connected to the air outlet 15) from the condenser of approximately 700 cubic feet per minute.

If, assuming the steam, air distribution, air quantity and vacuum, as set forth, the

temperature of vapors leaving the warmer end of the condenser is reduced to 92.5 degrees by passing through the air cooler section, the volume of vapors abstracted and entering the evacuating apparatus from the warmer zone of the condenser, will be 320 cubic feet per minute instead of 440 cubic feet per minute. This reduction in the quantity of vapor to be removed from the warmer end will make it possible for the evacuating apparatus to abstract a greater quantity of vapor from the colder end with the result that the depth of steam penetration in the cooler end will be greater than it would be had there been no reduction of temperature at the warmer end due to the cooling effect of the air cooler in communication with this end of the condenser.

Substantially an ideal condition is obtained when the temperature of the air leaving the two compartments is substantially the same. Upon the assumptions made these temperatures would be approximately 92.5 degrees. The total volume of vapors leaving the condenser as stated, at 92.5 degrees, and two inches absolute pressure of mercury, would be approximately 640 cubic feet per minute. As an evacuating apparatus capable of operating under the original assumption will have a capacity of 700 cubic feet per minute it will be capable of maintaining a higher vacuum within the condenser because of a decrease in the quantity of vapor which is handled. This improvement in vacuum will also be enhanced by reason of the fact that the active steam is brought into contact with more surface by reason of the greater depth of penetration at the cooler end of the condenser.

In Fig. 2 there is illustrated an alternative arrangement wherein two air coolers or auxiliary condensers 7^a and 7^b are shown, each in communication, through the respective connections 13^a and 14^a, with the compartments or zones of the condenser. Each of these coolers may be of the same size or the cooler 7^b in communication with the warmer end of the condenser may be of larger cooling capacity. The coolers are provided with water supply piping having the inlet 16 and outlet 17, the path for the flow dividing; one branch 18 extending to the cooler 7^b and the other branch 19 extending to the cooler 7^a, each branch controlled by the valves 20 and 21 respectively. By means of such arrangement the cooling surface may be adjusted, either manually or automatically by thermostatic control, to pass a larger amount of water through the cooler 7^b than through the other cooler and thus provide for greater cooling capacity in that cooler connected with the warmer end of the condenser.

The specification illustrates and describes a single pass condenser to which has been

applied the described cooling arrangement, but it is to be understood that the apparatus and method for cooling is equally adaptable to a multi-pass condenser. The condenser and air cooler shown are each provided with two compartments. The air cooling arrangement is equally adapted to any number of condenser compartments or zones.

What I claim is:

1. In condensing apparatus comprising a main condenser having a plurality of compartments in each of which the condensing capacity is different, the combination therewith of means for equalizing the depth of steam penetration in said condenser compartments comprising an auxiliary condenser and air cooler provided with a plurality of cooling sections, each of such cooling sections having a different cooling capacity, means for connecting the cooling section having the greatest cooling capacity with that condenser compartment in which the steam penetration is deepest, means for connecting the cooling section having lesser cooling capacity with a condenser compartment in which the steam penetration is not so deep, and an evacuating apparatus connected to said cooler.

2. In combination with a condenser having tubes with unequal condensing capacities in zones along their length, means for equalizing depth of steam penetration in such zones comprising a plurality of cooling members of different cooling capacities, that cooling member of greatest capacity being connected to that condenser zone in which the depth of steam penetration is greatest, and a cooling member of lesser cooling capacity being connected to a condenser zone in which the depth of steam penetration is not so great.

3. In combination with a condenser having two condensing compartments, evacuating apparatus for said condenser, an auxiliary condenser and air cooler located between the condenser and the evacuating apparatus, said cooler being divided into two sections of different cooling capacities, means for connecting the cooler section of the greater capacity with the condenser compartment the tubes of which are hotter, and means for connecting the cooler section of lesser capacity with the condenser compartment the tubes of which are cooler.

4. Apparatus of the character described comprising a relatively large shell having a vapor inlet, means for dividing said shell into a plurality of vapor compartments, a relatively small shell, means for dividing said small shell into a corresponding plurality of compartments, conduits connecting the compartments of said large shell individually with the compartments of said small shell to form pairs of connected compartments,

means for passing cooling fluid through the compartments of said large shell in series and through the compartments of said small shell in series and in inverse order with respect to the respective compartments of said pairs, and means to withdraw fluid from the compartments of said small shell.

5. Condensing apparatus comprising a main condensing member divided into a plurality of relatively large compartments of different cooling capacities, auxiliary condensing means comprising a corresponding plurality of relatively small auxiliary cooling sections of different cooling capacities and conduits connecting each of a plurality of the compartments of the main condensing member with each of a plurality of the auxiliary cooling sections to form pairs of connected compartments, said compartments being connected to said cooling sections in inverse order with respect to cooling capacities.

6. In combination with a condenser having tubes with unequal condensing capacities in zones along their length, a plurality of cooling members for equalizing depth of steam penetration in said zones, said cooling members having different cooling capacities and being of smaller size than the zones of the condenser, a conduit connecting that cooling member of greatest cooling capacity with that condenser zone in which the depth of steam penetration is greatest, and a conduit connecting a cooling member of lesser cooling capacity with a condenser zone in which the depth of steam penetration is not so great.

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