# United States Patent [19]

**Ris**

[11] **3,731,735**

[45] **May 8, 1973**


[54] **SELECTIVE ORIFICING STEAM CONDENSER**


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[73] Assignee: **Ecodyne Corporation,** Chicago, Ill.



[22] Filed: **Mar. 19, 1971**

[21] Appl. No.: **126,174**

[52] **U.S. Cl.** .....**165/110,** 165/146, 165/174

[51] **Int. Cl.**.....**F28f 13/00,** F28b 1/06

[58] **Field of Search**.....165/174, 111, 146, 165/110, 147



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 3,073,575 | 1/1963 | Schulenberg | 165/174 X |
| 3,582,599 | 6/1971 | Yohn | 219/60 R |

FOREIGN PATENTS OR APPLICATIONS

| | | | |
|---|---|---|---|
| 1,291,617 | 3/1962 | France | 165/174 |
| 908,806 | 10/1962 | Great Britain | 165/174 |



*Primary Examiner*—Albert W. Davis, Jr.

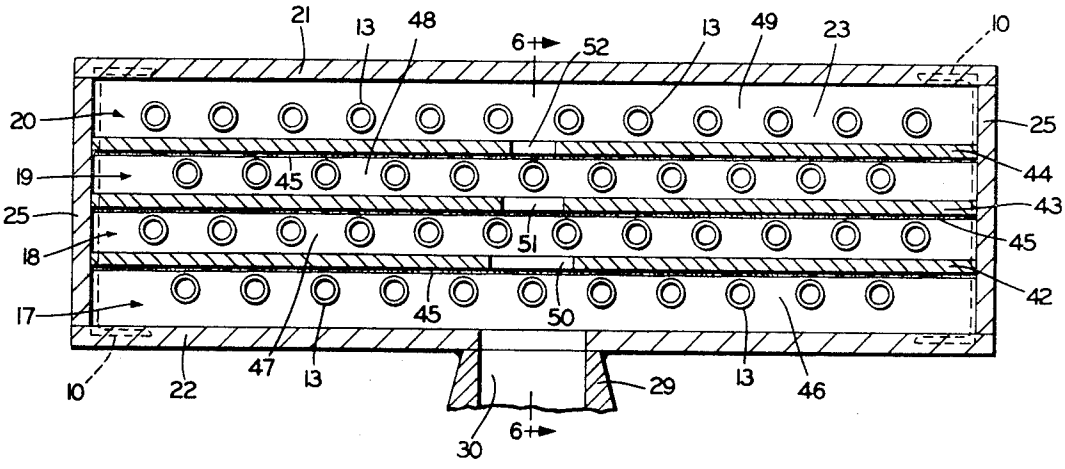
*Attorney*—Charles M. Koplan and Joel E. Siegel



[57] **ABSTRACT**

An air cooled steam condenser having plate means or a series of plates mounted within the steam intake header compartment. The plate means in effect form a series of interconnected subchambers, each of which communicates with a row of cooling tubes in which steam is condensed by a stream of cooling air flowing over, around and past the tubes. The rows of tubes extend transversely of the direction of airflow and the rows extend perpendicular to the direction of airflow at spaced intervals. An opening is formed in each plate through which steam flows between sub-chambers. The openings are smaller in area in successive plates in the header through which the steam flows so that only that amount of steam that can be condensed effectively within the tubes in any row, enters such row, having regard to the tube length and the temperature difference at the particular row which determines the cooling effect of the airflow over the successive rows of tubes.


**2 Claims, 10 Drawing Figures**



3 Sheets-Sheet 1

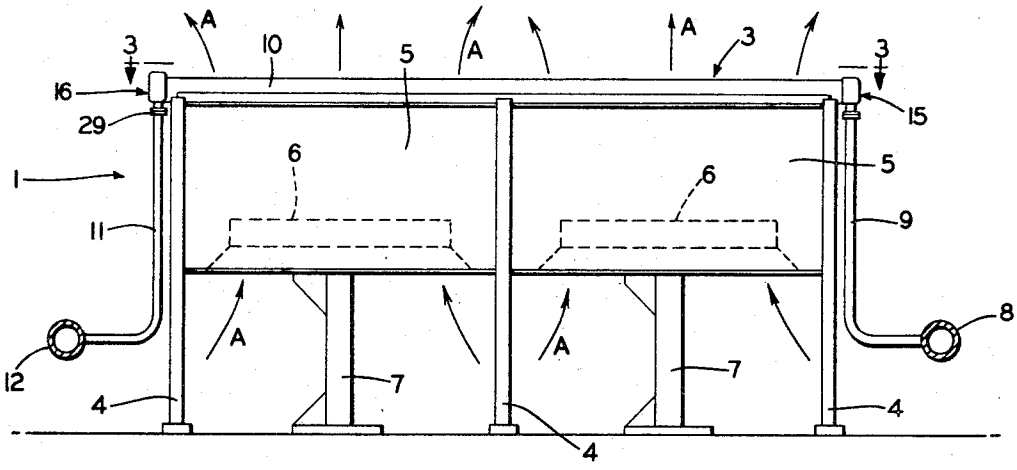



FIG. 2

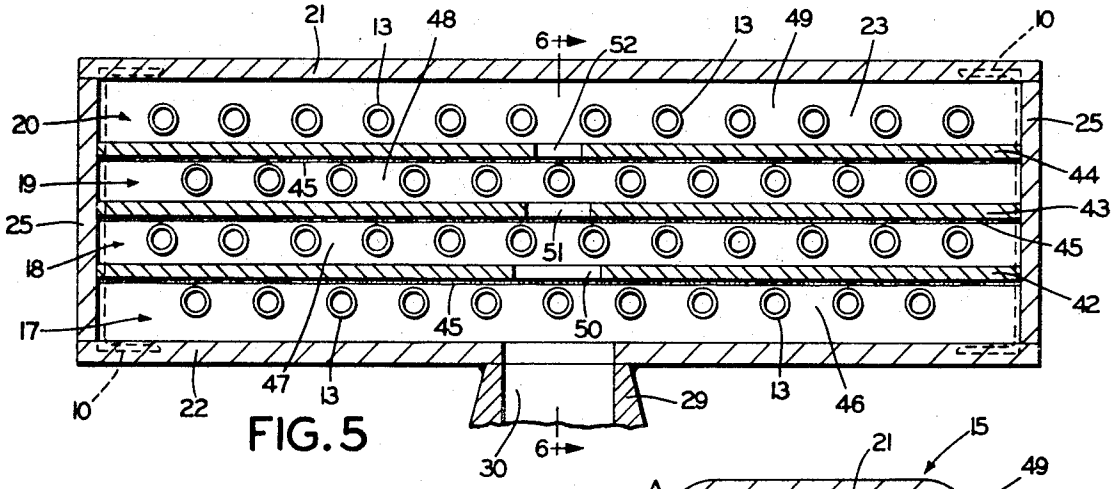



FIG. 5

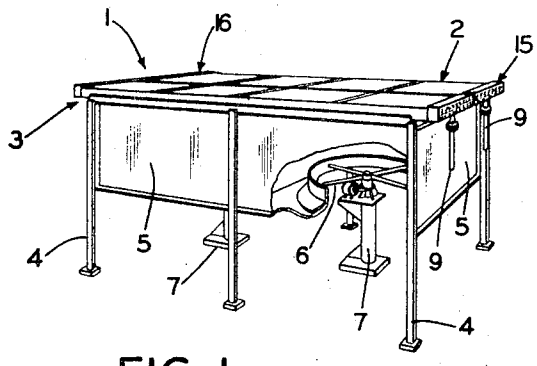



FIG. 1

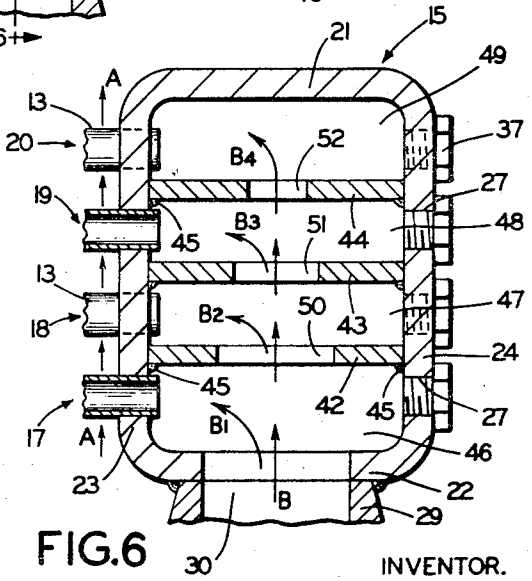



FIG. 6

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3 Sheets-Sheet 2

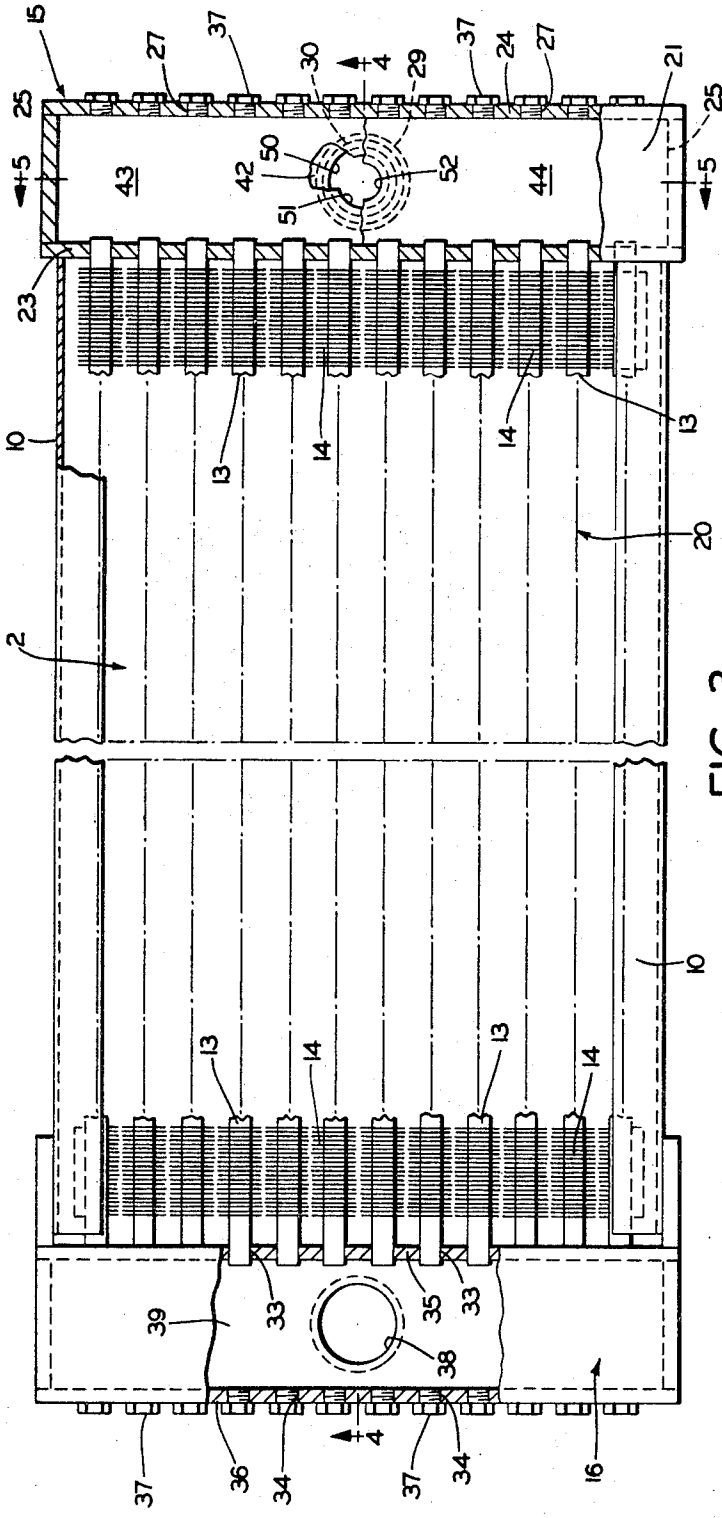


FIG. 3

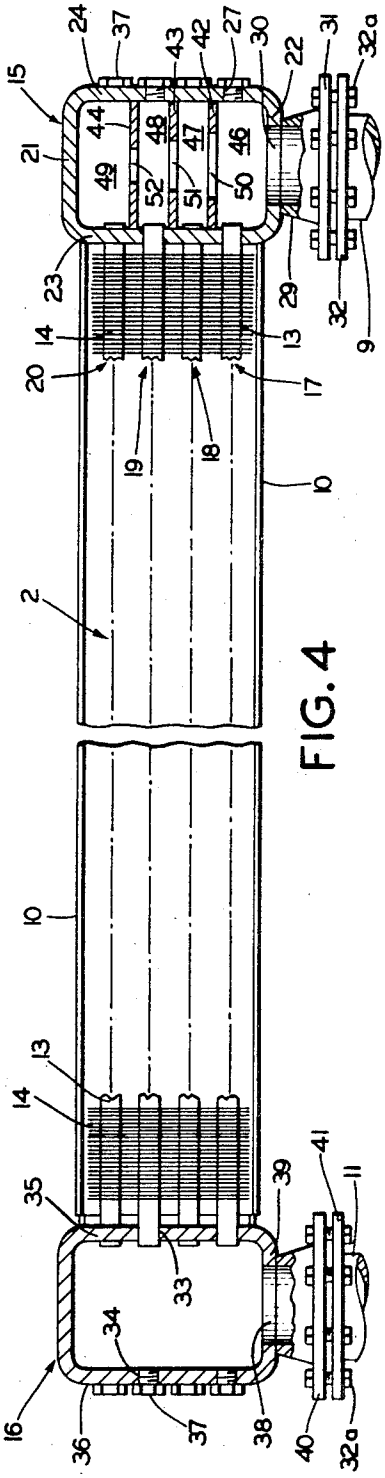


FIG. 4

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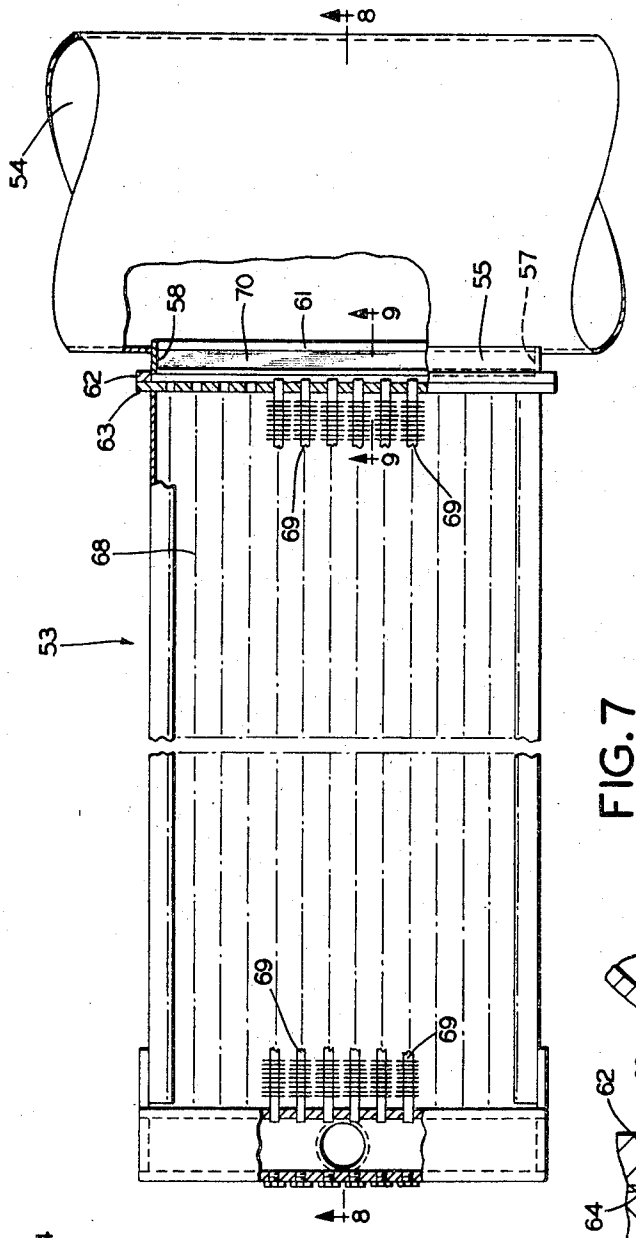



FIG. 7

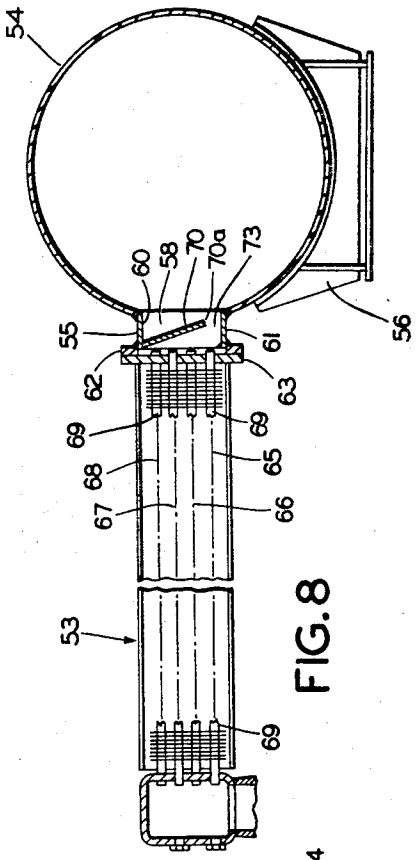



FIG. 8

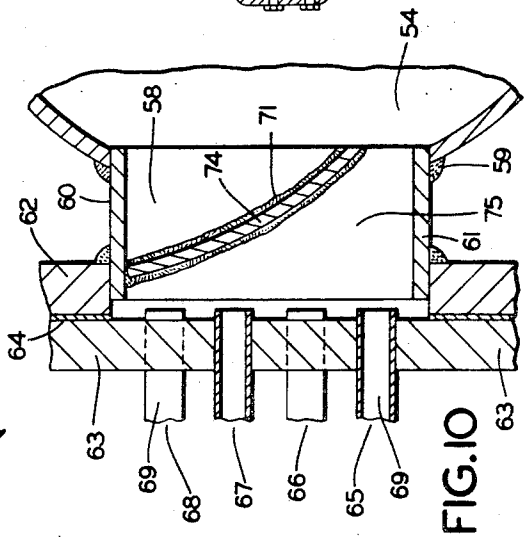



FIG. 10

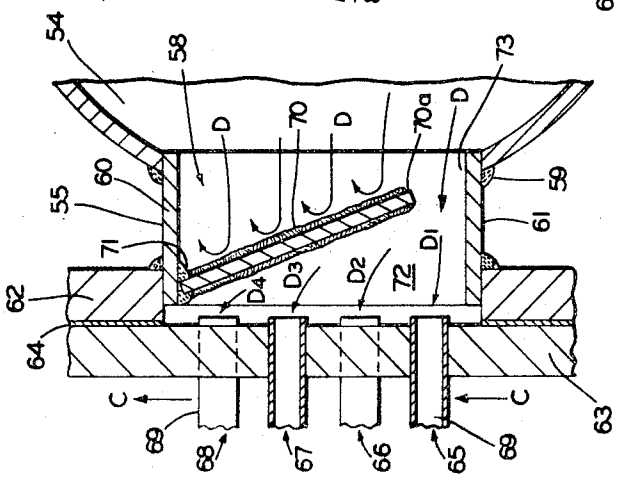



FIG. 9

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# SELECTIVE ORIFICING STEAM CONDENSER

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to heat exchangers and in particular to air cooled steam condensers. More particularly the invention relates to orificing means mounted within the condenser header whereby the amounts of steam entering various rows of condensing tubes are metered or reduced proportionally to the reduced cooling effect of the cooling air due to increased cooling air temperature resulting from heat extracted from tubes previously cooled, so that only that amount of steam that can be cooled efficiently is supplied to the tubes of a particular row.

2. Description of the Prior Art

Air cooled steam condensers usually include a plurality of condenser tubes arranged in rows one behind the other in the direction of airflow of the cooling air. Steam enters the condenser inlet header which communicates with the inlet ends of the tubes and then flows through the tubes wherein it is condensed. Fan blow cooling air across the tubes in an airflow direction generally perpendicular to the rows of tubes. The steam is condensed by the cooling air to form condensate as it travels through the tubes, and the condensate is collected at the outlet ends of the tubes in any suitable manner. Condensation should take place throughout the length of the tubes for most efficient condenser operation.

Problems have arisen in the construction and operation of air cooled steam condensers as described in U.S. Pat. No. 3,073,575 relating to inefficient steam feed distribution to the cooling tubes, temperature differential changes due to changing weather conditions, etc. The various solutions to such problems suggested in said U.S. Pat. No. 3,073,575, however, are complicated in structure and expensive in execution.

No air cooled steam condenser constructions of which I am aware have eliminated the problems of uneven steam distribution by efficiently metering or distributing the steam within the condenser inlet header by simple partition means using simple finned condenser tubes in all rows of the condenser having the same structure and characteristics as to diameter, length and cooling fin surface.

## SUMMARY OF THE INVENTION

Objectives of the invention include providing selective orificing for steam condensers which meters the amounts of steam flowing to and through the cooling tubes in tube rows of the condenser, proportional to the condensing ability of the tubes in any particular tube row; providing selective orificing for steam condensers having condenser tubes all of which are the same in length, passage cross section, number of fins, and total heat exchange surface area; providing selective orificing for steam condensers in which plates having openings of varying sizes are mounted within the condenser inlet header for selective distribution of steam; providing selective orificing for steam condensers permitting existing condenser designs to be converted easily and inexpensively to establish predetermined metered distribution of steam to the several rows of cooling tubes in the condenser; and providing selective orificing for steam condensers which eliminate difficulties heretofore encountered, achieve the stated objectives simply and effectively, and solve problems and satisfy existing needs.



These objectives and advantages are obtained by the selective orificing construction for steam condensers, the general nature of which may be stated as including in a steam condenser for condensing steam in a plurality of tubes arranged in a plurality of generally parallel rows, extending between and communicating with a steam inlet header and a condensate outlet header; the rows of tubes extending transversely of and at spaced intervals perpendicular to the direction of airflow of cooling air that passes over and around the rows of tubes to condense steam flowing through the tubes from the inlet header; the steam inlet header having a chamber and inlet means for said chamber; partition means mounted within the chamber dividing the chamber into a series of metered steam zones each communicating with at least one row of tubes; said partition means being constructed to distribute inlet steam in the chamber in successively smaller amounts to each successive zone corresponding to the reduced cooling effect of the airflow of cooling air passing successively over the spaced rows of tubes to which steam is distributed from successive zones; means preferably including a plurality of partition plates dividing the chamber into a plurality of sub-chambers forming said successive zones and communicating respectively with successive rows of tubes; an opening formed in each plate for supplying steam from one sub-chamber zone to the adjacent sub-chamber zone; and the openings in successive plates between adjacent sub-chamber zones being successively smaller.

In the alternative the partition means may include a partition plate located in the inlet header angularly with respect to the tubesheet at the inlet ends of the rows of tubes; and said angular plate defining in said header a passage and a series of successively smaller tube inlet zones communicating respectively with successive rows of tubes.

## BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention — illustrative of the best modes in which applicant has contemplated applying the principles — are set forth in the following description and shown in the drawings and are particularly and distinctly pointed out and set forth in the appended claims.

FIG. 1 is a perspective view, with portions broken away, showing an air cooled steam condenser equipped with the improved selective orificing plate construction;

FIG. 2 is a diagrammatical side elevation of the steam condenser shown in FIG. 1;

FIG. 3 is an enlarged fragmentary top plan view, with portions broken away and in section, looking in the direction of arrows 3—3, FIG. 2 and showing one condenser section;

FIG. 4 is a sectional view taken on line 4—4, FIG. 3;

FIG. 5 is an enlarged sectional view taken on line 5—5, FIG. 3;

FIG. 6 is a further enlarged fragmentary sectional view taken of line 6—6, FIG. 5;

FIG. 7 is a fragmentary top plan view, with portions broken away and in section, showing a modified steam

condenser construction having a cylindrical steam drum or header equipped with improved selective orificing plate means;

FIG. 8 is a sectional view taken on line 8—8, FIG. 7;

FIG. 9 is an enlarged fragmentary sectional view taken on line 9—9, FIG. 7; and

FIG. 10 is a view similar to FIG. 9 showing a modified form of construction.

Similar numerals refer to similar parts throughout the drawings.

## DESCRIPTION OF PREFERRED EMBODIMENTS

First Embodiment

A typical air cooled heat exchanger is indicated at 1, (FIG. 1 and 2) and includes two steam condenser sections 2 and 3 supported on frame members 4 and having side and end panels 5 mounted on the frame members 4. Fans 6 mounted on pedestals 7 beneath condenser sections 2 and 3 blow cooling air (indicated by arrows A, FIG. 2) upward through sections 2 and 3.

A steam supply manifold 8 communicates with a source of steam, such as the exhaust of a steam turbine, to be condensed, and pipes 9 form steam inlets for the individual sections 2 and 3 from manifold 8. Condensate outlet lines 11 are connected to the opposite ends of sections 2 and 3 and deliver condensate into a main condensate line 12.

Different heat exchanger installations may have a different number of condenser sections 2 and 3 assembled together. The operation and function of condenser sections each having the improved selective orificing means incorporated therein are similar. Therefore only one condenser section 2 (FIGS. 3–6) is described in detail.

Condenser section 2 includes a plurality of cooling tubes 13 preferably having helical fins 14 extending outward therefrom. Tubes 13 are mounted within a frame having side channels 10, an inlet header 15 and an outlet header 16.

Tubes 13 are mounted parallel to each other within the frame in a plurality of rows 17, 18, 19 and 20 spaced one above the other (FIGS. 4, 5 and 6) arranged in that order along the direction of flow indicated by the arrow A. Tubes 13 in a particular row may be spaced intermediate the tubes in the adjacent rows, above and below, as shown in FIG. 5. Likewise, tubes 13 are assembled within the frame so as to have a slight incline from inlet header 15 to outlet header 16 so that condensate flows or drains into header 16.

Inlet header 15 may have a welded construction as shown in U.S. Pat. No. 3,582,599 (Ser. No. 748,311) of Melvin G. Yohn. Such construction may include a generally rectangular cross section formed by top and bottom walls 21 and 22, tubesheet 23, plug sheet 24, and end walls 25. The inlet ends of tubes 13 are connected in a usual manner by expending or welding in tubesheet 23; and holes 27 in plug sheet 24 aligned with tubes 13 permit access into header 15 and tubes 13 for expending or welding tubes 13 into the header and for cleaning and for removing any obstructions that may form in tubes 13.

A flanged coupling connected to header bottom wall 22 forms a steam inlet opening 30 for header 15. Coupling 29 has a flange 31 for connection with steam inlet pipe coupling 32 of pipe 9 by bolts 32*a*.

Condensate outlet header 16 may be constructed similar to header 15 having aligned holes 33 and 34 formed in tubesheet 35 and plug sheet 36 for expanding or welding the outlet ends of tubes 13 in holes 33 and for removable plugs 37 for access holes 34. Outlet opening 38 in bottom wall 39 of header 16 is connected by flanged coupling 40 with coupling 41 on condensate outlet line 11.

In accordance with the invention a plurality of partition plates 42, 43 and 44 are mounted within header 15 extending between tubesheet 23 and plug sheet 24 and attached by welds 45. The plates 42, 43 and 44 are parallel to each other and to bottom wall 22, and are mounted between tube rows 17 and 18, 18 and 19, and 19 and 20, respectively. Thus sub-chambers 46, 47, 48 and 49 are formed within header 15. Openings 50, 51 and 52 are formed in plates 42 and 43 and 44, respectively, with opening 50 being larger in area than opening 51, and opening 51 being larger in area than opening 52. The openings 50, 51 and 52 are shown as being circular. However, they may have any desired shape to obtain the required area and may be square, rectangular or elliptical.

Steam flow, indicated by arrow B (FIG. 6), enters header 15 through distribution pipe 9 and inlet opening 30. The amount of steam that passes through subchambers 46–49 and subsequently rows 17–20 of tubes 13, respectively, becomes decreasingly smaller due to the decreasing size of openings 50–52.

Therefore, a larger amount of steam $B_1$ enters the tubes in row 17 for condensation therein than the reduced amount of steam $B_2$ entering tube row 18, and likewise the further reduced amounts of steam $B_3$ and $B_4$ entering tube rows 19 and 20. This continual reduction in amounts of steam entering succeeding tube rows of similar tubes spaced along the direction of flow A of the cooling air, is a characteristic of the concept of the invention. This compensates for the continual increase in temperature of the air and the decreasing mean effective temperature difference as the air passes from row 17 over the subsequent rows 18–20 picking up heat from the previously cooled rows of tubes.

The areas of openings 50–52 are determined in designing any particular installation by taking into consideration factors including the average pressure and temperature of the steam entering header 15, the velocity and average temperature of cooling air flowing at A past the tubes 13, and the total finned heat exchange cooling surface of tubes 13. Ideally, the areas of openings 50–52 will be such that the amounts of steam $B_1$–$B_4$ entering the respective rows 17, 18, 19 and 20 of tubes 13 will be completely condensed as steam flow in any tube 13 reaches the outlet header 16.

Second Embodiment

A modified selective orificing steam condenser construction indicated at 53 is shown in FIGS. 7–9 having a cylindrical steam manifold or header 54 provided with a header inlet section 55 communicating with the inlet tubesheet 63 of the condenser. Header 54 is mounted in a cradle support structure 56, and header section 55 may be formed by plates 57, 58, 60 and 61 secured by welds 59 to header 54.

Header section 55 is provided with a flange 62 which is connected in a suitable manner with tubesheet 63, as shown in FIG. 9. The connection may be sealed by a gasket 64.

Rows of tubes **65–68** each having a plurality of tubes **69**, have their inlet ends connected to tubesheet **63** and communicate with header inlet section **55**. Tubes **69** otherwise are arranged like tubes **13** in condenser **1** and cooling air flows past tubes **69** as indicated at C.

A partition plate **70** is mounted within the header inlet section **55** of the header compartment of header **54**, preferably by welding the plate **70** at **71** to header inlet section plates **60**, **57** and **58** (FIG. **9**). Plate **70** extends outwardly downwardly at an angle away from tubesheet **63**, and the lower or free edge **70***a* of plate **70** is spaced above plate **61** of header section **55** to form a passage **73** communicating between the header compartment and header sub-chamber **72** located between partition plate **70** and the inlet ends of tubes **69**.

The angular arrangement of partition plate **70** with respect to tubesheet **63** forms a series of zones in sub-chamber **72** of decreasing size from bottom to top (FIG. **9**) opposite the inlet ends of the rows **65**, **66**, **67** and **68** of tubes **69**. This series of zones of decreasing size meters the amounts of steam flowing into tube rows **65–68** in decreasing amounts, as indicated at D-**1**, D-**2**, D-**3** and D-**4**, and distributed from the main steam flow indicated at D entering the sub-chamber **72** from the inlet header **54**.

Partition plate **70** thus forms partition means defining in the header **54** and header section **55** a passage **73** and a series of successively smaller tube inlet zones communicating respectively with the successive rows of tubes **65–68**.

The amounts of steam entering the various rows can be changed by changing the angle of projection of plate **70**, thereby changing the capacity of sub-chamber **72**. The flow C of cooling air is in a direction across the rows **65–68** of tubes **69** such that row **65**, which receives the greatest amount of steam, is cooled by the coolest air. If for some reason the direction of airflow C is from top to bottom in FIG. **9**, plate **70** would project upwardly outwardly with respect to tubesheet **63** from plate **61**.

Third Embodiment

The construction shown in FIG. **10** is similar to that shown in FIG. **9** excepting that the partition plate **74** may be curved, as shown, rather than a flat plate **70** as illustrated in FIG. **9**. The curved shape may be designed so that the respective series of zones of decreasing size in sub-chamber **75** will have the required size or volume to obtain the steam distribution pattern to be achieved in the design of the sub-chamber **75**.

## IN GENERAL

In each of the embodiments of the invention illustrated in the drawings and described above, partition means is provided within the inlet header to distribute the incoming steam in decreasing amounts of successive rows of cooling tubes so that the row of tubes first cooled by the coolest airflow receives the greatest amount of steam and subsequent tube rows along the path of airflow receive proportionally decreasing amounts of steam. Any individual row of tubes therefore receives only that amount of steam that can be condensed throughout its length, eliminating premature or insufficient condensation within the tubes, while using tubes all identically the same in the construction of the condenser.

Accordingly, the selective orificing steam condenser construction provides for progressively reducing the amount of steam passing through header zones so as to correspond to the location of the rows of tubes in the path of flow of cooling air; enables condenser tubes having the same length, the same passage cross section, the same number of fins and the same total heat exchange surface to be used in fabricating the condenser; enables many designs of steam condensers to be easily and inexpensively converted to include the improved selective orificing construction; enables maximum efficiency to be achieved in the operation of the condenser; prevents premature condensation which may result in frozen conditions during cold weather; and provides such a construction which is effective, safe, inexpensive, and efficient in assembly, operation and use, and which achieves all the enumerated objectives, provides for eliminating difficulties encountered with prior devices, and solves problems and obtains new results in the art.

In the foregoing description, certain terms have been used for brevity, clearness and understanding but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such terms are used for descriptive purposes and are intended to be broadly construed.

Moreover, the description and illustration of the invention is by way of example, and the scope of the invention is not limited to the exact details of the construction shown or described.

Having now described the features, discoveries and principles of the invention, the manner in which the improved selective orificing steam condenser is constructed, assembled and operated, the characteristics of the new construction, and the advantageous, new and useful results obtained; the new and useful structures, devices, elements, arrangements, parts, and combinations are set forth in the appended claims.

I claim:

**1**. In a steam condenser of a type in which a plurality of tubes are arranged in a plurality of generally parallel rows, extending between and communicating with a steam inlet header and a condensate outlet header; and in which the rows of tubes extend transversely of and at spaced intervals perpendicular to the direction of airflow of cooling air that passes over and around the rows of tubes to condense steam flowing through the tubes from the inlet to the outlet header; the steam inlet header having a chamber and inlet means for said chamber; partition means mounted within said chamber dividing the chamber into a series of metered steam zones each communicating with at least one row of tubes; said partition means including a plurality of partition plates which divide said chamber into a plurality of sub-chambers which form said series of metered zones; said partition plates having openings formed therein in facing relationship to said inlet means; said openings in successive plates being successively smaller and concentric with one another so as to distribute inlet steam in said chamber in successively smaller amounts to each successive zone corresponding to the reduced cooling effect of the airflow of cooling air passing successively over the spaced rows of tubes to which steam is distributed from successive zones.

2. The construction defined in claim 1 in which the inlet header includes a tubesheet and a plug sheet; in which the plates are mounted on and extend between said tubesheet and plug sheet; and in which each plate is mounted between a pair of adjacent tube rows.

* * * * *