July 6, 1965 H. H. L. RITZ ETAL 3,193,002

FEED WATER HEATERS FOR STEAM TURBINE PLANT

Filed April 10, 1961 7 Sheets-Sheet 1

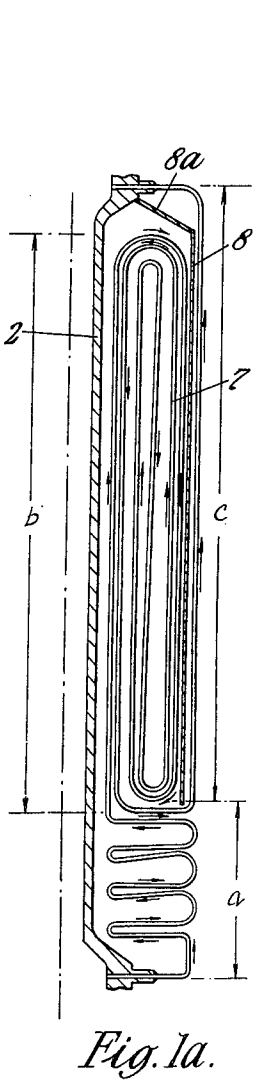


Fig. 1a.

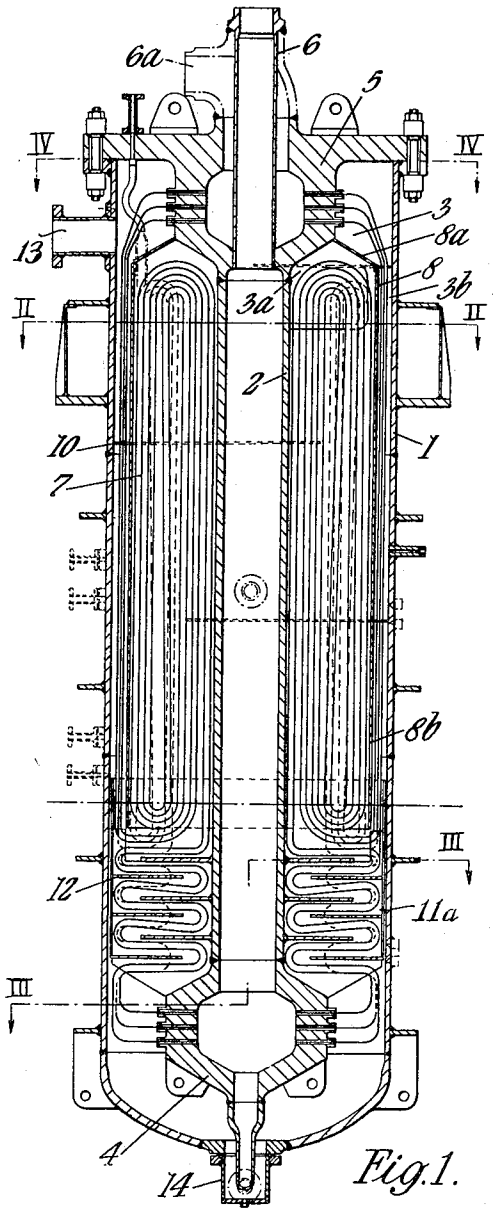


Fig. 1.

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FEED WATER HEATERS FOR STEAM TURBINE PLANT

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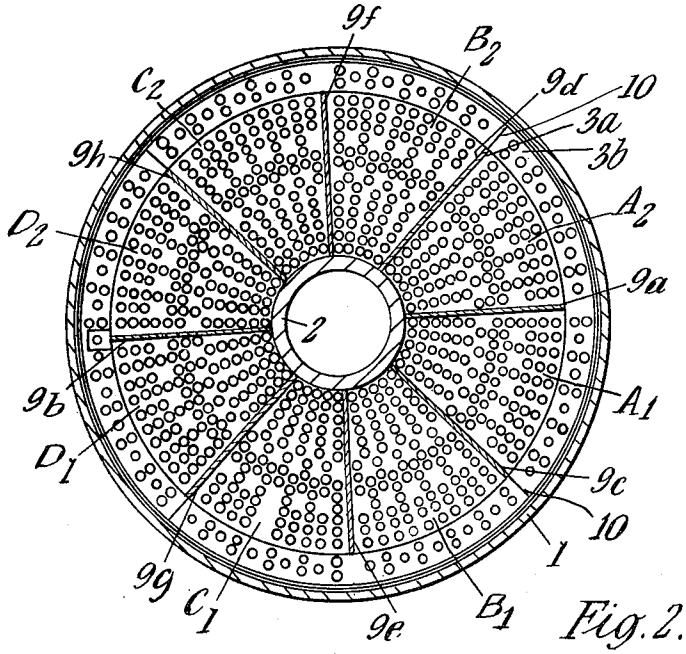


Fig. 2.

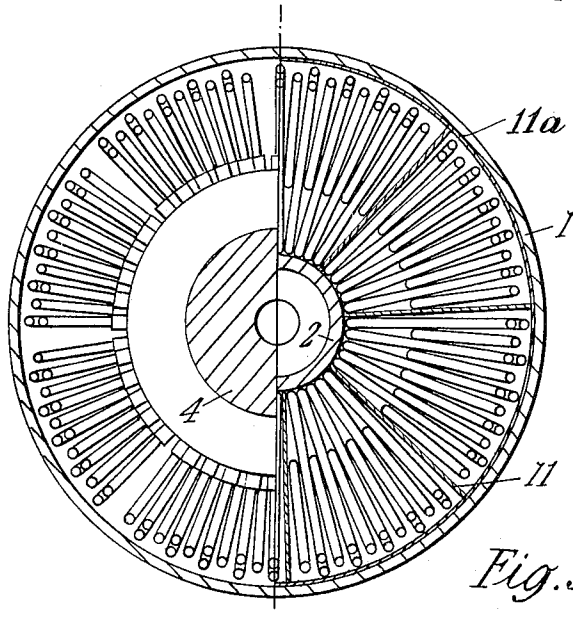


Fig. 3.

FEED WATER HEATERS FOR STEAM TURBINE PLANT

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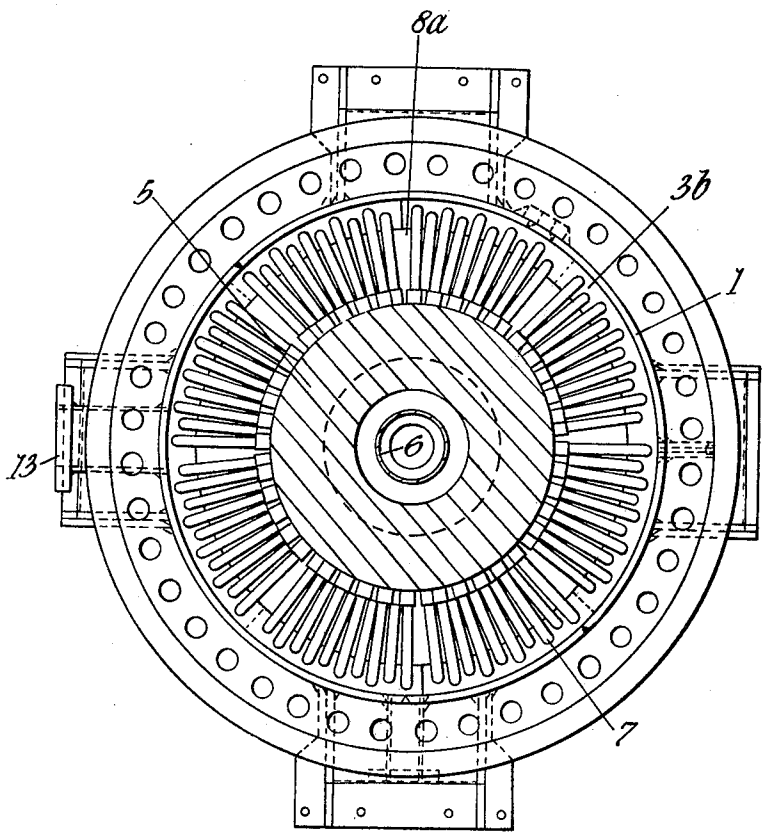


Fig. 4.

FEED WATER HEATERS FOR STEAM TURBINE PLANT

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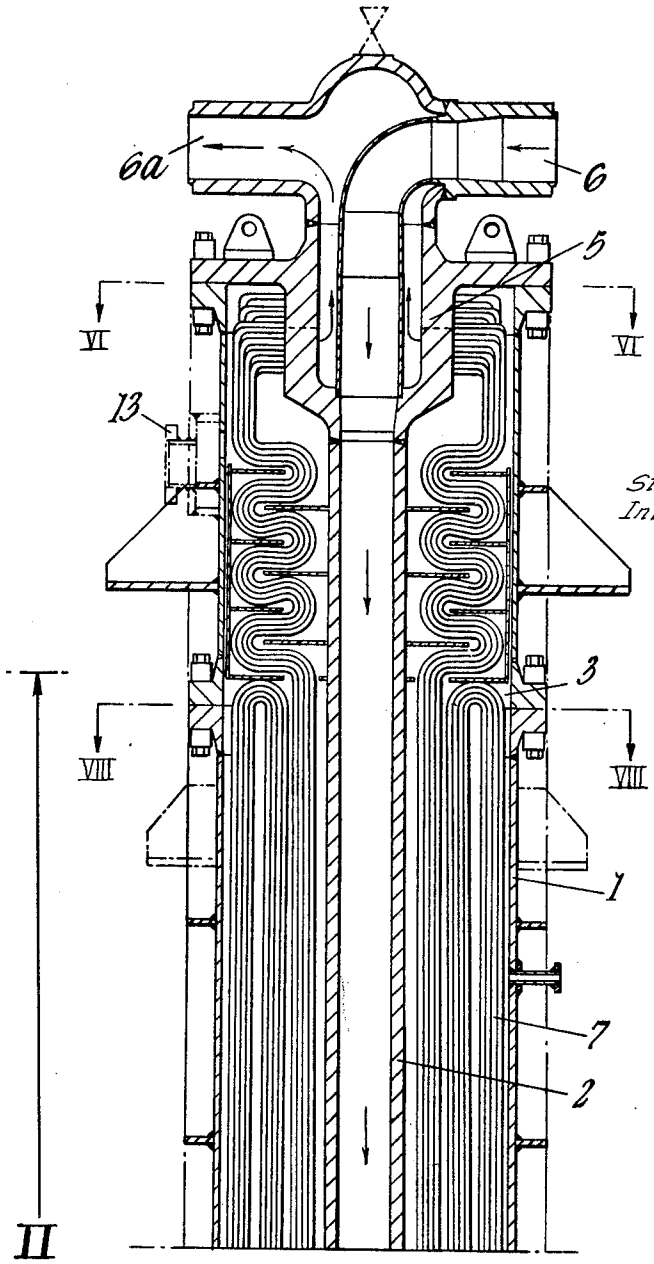


Fig. 5a

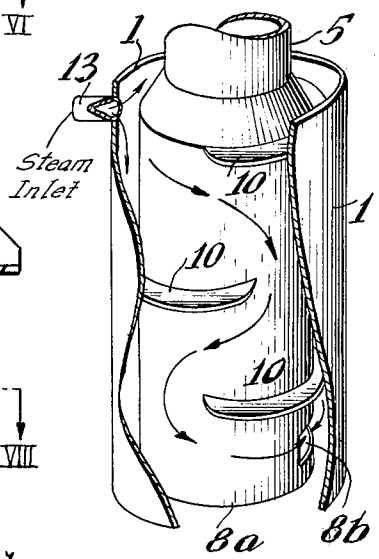


Fig. 8

FEED WATER HEATERS FOR STEAM TURBINE PLANT

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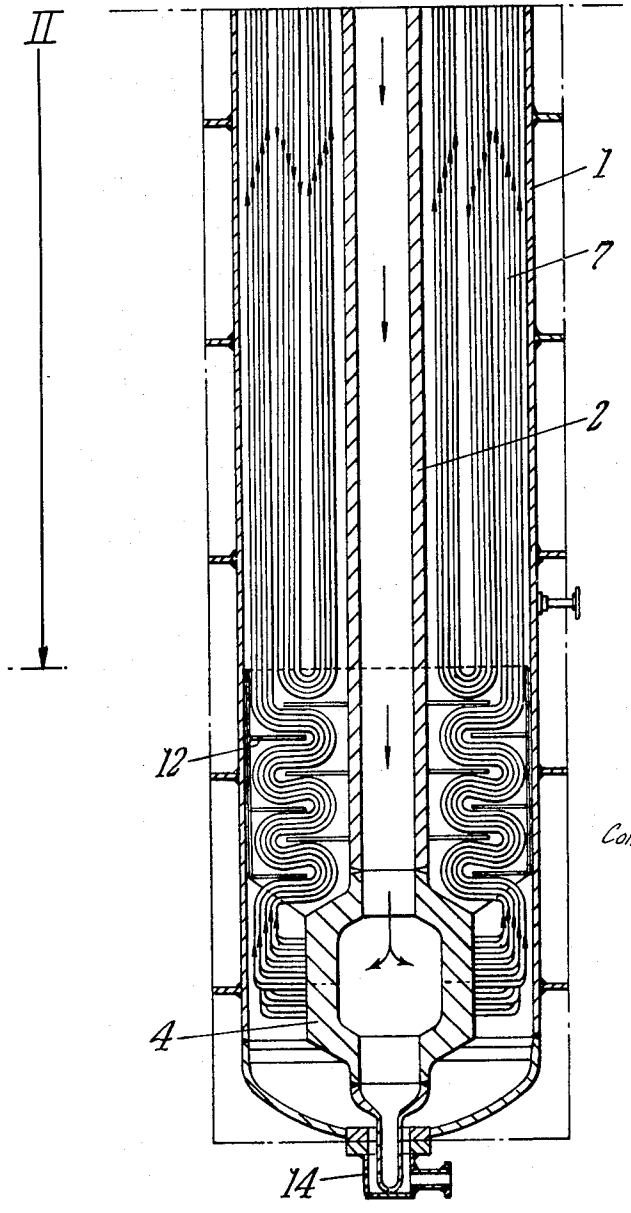


Fig. 5b

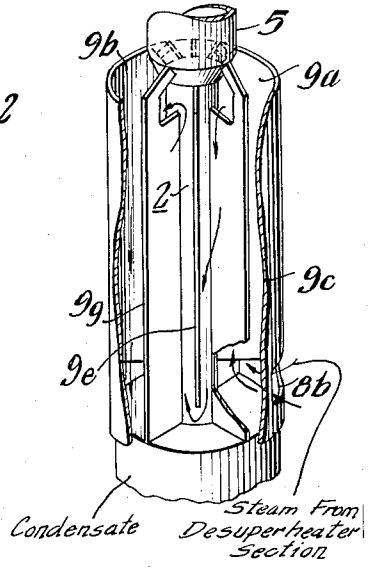


Fig. 9

FEED WATER HEATERS FOR STEAM TURBINE PLANT

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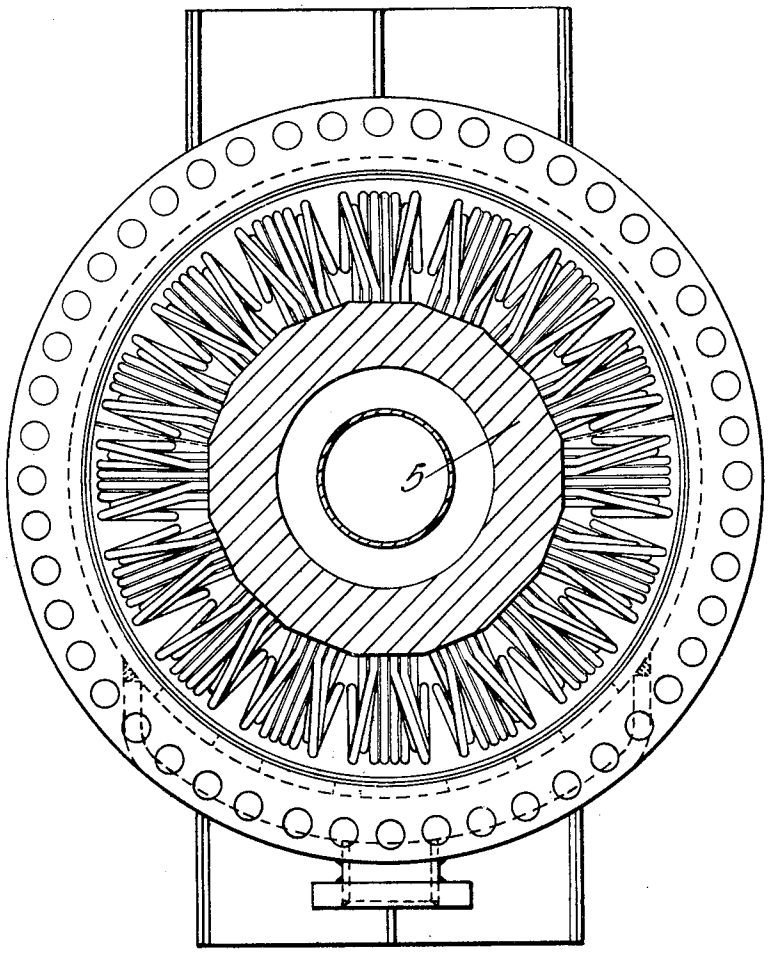


Fig. 6.

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FEED WATER HEATERS FOR STEAM TURBINE PLANT

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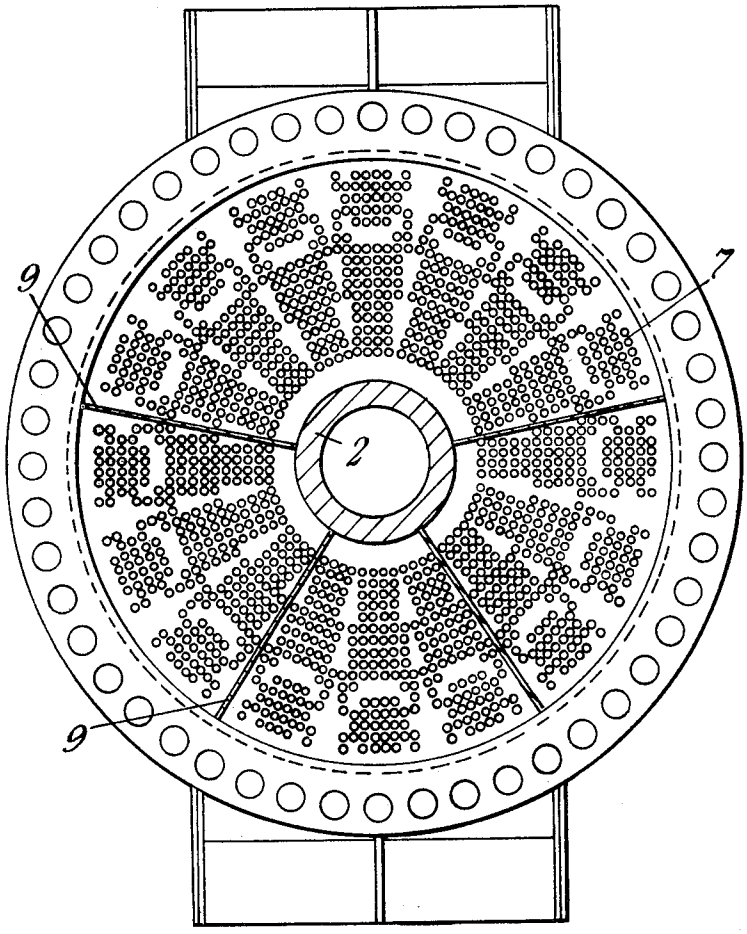


Fig. 7.

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3,193,002

FEED WATER HEATERS FOR STEAM TURBINE PLANT

Hugo Heinrich Ludolf Ritz and Vincent Power, Newcastle-upon-Tyne, England, assignors to C. A. Parsons & Company Limited, Newcastle-upon-Tyne, England

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Claims priority, application Great Britain, Mar. 10, 1961, 8,923/61
4 Claims. (Cl. 165—139)

This invention relates to feed water heaters for steam turbine plant.

It is common practice in steam turbine plants to construct feed heaters in the form of one or more banks of U-shaped tubes located in a casing the tubes having their ends secured in a common flat tube plate. The feed water is circulated through the tubes and steam is circulated over the outside of the tube bank to raise the temperature of the feed water prior to its recirculation by means of a boiler feed pump to a steam boiler.

In some instances it is desirable to have the boiler feed pump on the inlet side of the feed heater or heaters in which case the pressure of the feed water entering the feed heaters is higher than in the more normal case when the pump is placed between the feed heaters and the boiler. The higher pressures involved require tube plates of increased thickness and this leads to practical difficulties in the spacing of the tubes and the joining of the tubes to the tube plate.

A further disadvantage with the type of feed heater using U-shaped tubes is that the condensed steam drains from the lower end of the vessel containing the tube nest which is normally the end remote from the inlet for feed water to the tubes. From a heat transfer viewpoint it is desirable that the condensate should be giving up heat to the incoming feed water and this is not possible unless the condensate is raised up the casing to flow over the inlet ends of the tubes.

The object of the present invention is to provide an improved construction of feed heater which substantially overcomes the above disadvantages.

The invention in brief consists in a feed water heater for steam turbine plant comprising a casing, an internal duct located within the casing to form an annular space between the outer surface of the duct and the inner surface of the casing, a header at each end of the duct each header comprising curved walls, a plurality of tubes arranged in said annular space, inlet ends of the tubes passing through the curved walls of one header and outlet ends passing through the curved walls of the other header, inlet and outlet pipes for feed water attached to one of the headers, one pipe passing through said header and communicating with the internal duct, to provide a flow path for feed water through the headers, tubes and internal duct inlet means for steam adjacent the header connected to the outlet ends of the tubes and outlet means for condensed steam adjacent the other header; the flow path for steam through the casing being divided into three sections, a desuperheater section, a condensing section and a condensate section, the condensing section being formed by dividing the annular space into a number of sector shaped compartments, steam from the desuperheating section entering at least one of the compartments flowing in an axial direction towards the condensate section then

flowing in the reverse direction in an adjacent compartment until finally it enters the condensate section.

The invention includes a feed heater substantially as described below with reference to the accompanying drawings in which:

FIGURE 1 is a longitudinal section through a feed water heater in accordance with one form of the invention;

FIGURE 1*a* is a reproduction of part of FIGURE 1 showing only one tube for explanation purposes;

FIGURE 2 is an enlarged section on line II—II of FIGURE 1;

FIGURE 3 is an enlarged section on line III—III of FIGURE 1;

FIGURE 4 is an enlarged section on line IV—IV of FIGURE 1;

FIGURES 5*a* and 5*b* are respectively top and bottom halves of a longitudinal section through a feed water heater in accordance with an alternative form of the invention;

FIGURE 6 is a section on line VI—VI of FIGURE 5*a*;

FIGURE 7 is a section on line VII—VII of FIGURE 5*a*;

FIGURE 8 is a view in perspective with parts broken away and sectioned and showing by means of arrows through the desuperheated section of the heater of FIG. 1; and

FIGURE 9 is a view in perspective with parts broken away and sectioned and showing by means of arrows the steam flow path through the condensing section of the heater of FIG. 1.

In carrying the invention into effect in the forms illustrated by way of example and referring to FIGURE 1 a feed water heater for steam turbine plant comprises a casing 1, an internal duct 2 located within the casing such that an annular space 3 is formed between the outer surface of duct 2 and the inner surface of casing 1. At each end of the duct 2 is a header; a header 4 is in communication with the duct 2 whilst header 5 is sealed off from duct 2 by an inlet duct 6 passing through header 5 and communicating with duct 2.

In space 3 is arranged a plurality of tubes 7 indicated by their centre lines in FIGURE 1. The inlet ends of the tubes are in communication with header 4 and the outlet ends communicate with header 5 surrounding inlet duct 6. Each tube as can best be seen in FIGURE 1*a* comprises three main sections, a first section *a* in which the tube follows a sinuous path in a substantially single plane, a second section *b* in which the tube forms a coil lying in a substantially single plane the tube forming successive turns of the coil one within the other and then being reversed to form successive turns of the coil one outside the other, and a third and substantially straight section *c* lying in substantially the same plane as the coil which third section communicates with header 5.

The annular space 3 is divided into two concentric annular spaces 3*a*, 3*b* by a cylinder 8 one end of which 8*a* is closed and surrounds duct 2 whilst the other end adjacent tube sections *a* is open. The cylinder 8 separates the second and third sections of the tubes, the coiled second sections lying enclosed by cylinder 8 in space 3*a* and the straight third sections in space 3*b*.

The space 3*a* is subdivided into a number of sector shaped compartments by radially extending walls or baffles 9*a*–9*h* as can best be seen from FIGURE 2. In the space

3*b* are circumferentially disposed baffles **10**. These baffles are placed at intervals along the axis of the heat exchanger as can be seen in FIGURE 1. They do not extend for the full circumferential extent of the heat exchanger. The edges of the uppermost baffle **10** can be seen in FIGURE 2, being represented by the full lines extending radially across space 3*b*. The edges of the lower baffle **10** are shown dotted in space 3*b*.

In the part of the heater containing the first sections of the tubes the annular space **3** is likewise divided into sections by radially extending walls or baffles **11** as can be seen in FIGURE 3. The walls **11** extend from the walls of an open ended cylinder **11***a* which encloses the tubes in this section. The baffles **11** also support further baffles **12** (FIGURE 1) in a plane at right angles thereto and these baffles **12** interleave the tubes, as shown.

Boiler feed water from the condenser enters inlet duct **6** passes through internal duct **2** and enters header **4**. From header **4** it enters tubes **7**. The water then flows through each main section of the tubes and finally enters header **5** from which it is conducted from the feed heater through outlet **6***a*.

Steam enters through inlet **13** and flows over the third section of the tubes in space 3*b*. Steam flows in a generally longitudinal direction over the tubes in the third section and is deflected at intervals by baffles **10**. In this part of the feed heater, in which the steam is in contact with the third sections of the tubes in space 3*b*, the steam has its superheat removed by the feed water in the tubes.

When the desuperheated steam reaches the lower end of said third sections of the tubes it passes through an opening 8*b* in the cylindrical wall **8** which opening extends on either side of baffle 9*a*. It then flows upwards in the two sectors A_1, A_2 (see FIGURE 2) on either side of baffle 9*a*, over the second sections of the tubes. On reaching the upper region of the said second sections its passes over the top of radial baffles 9*c*, 9*d* and flows through sectors B_1, B_2 in a downward direction. It then passes beneath baffles 9*e*, 9*f* and then flows upwards in sectors C_1, C_2. On reaching the upper region of sectors C_1 and C_2 its passes over the top of baffles 9*g*, 9*h* and flows downwardly in sectors D_1 and D_2. During its flow upwards and downwards in the various sectors the steam is condensing and the condensate collects in the lower portion of the feed heater surrounding the first sections of the tubes.

The condensate level is controlled at a level below the aforementioned inlets for steam from the desuperheater section that is to say below the second section of the tubes. The condensate leaves the feed heater via drain **14** and in its passage to the drain it follows a path which is governed by the baffles **12** which direct it in a direction substantially parallel to the tube axes for most of its passage.

The steam therefore passes through three separate stages, a desuperheater stage in space 3*b* when it is in contact with the third sections of the tubes, a condensing stage in space 3*a* when it is in contact with the second sections of the tubes and a water or condensate stage where it is in contact with the first sections of the tubes and from which stage it is conducted from the feed heater. FIGURE 4 shows the arrangement of the tubes where they enter header **5**.

The construction described allows substantially full utilisation of the available space by virtue of the tube arrangement particularly in the second or condensing section, and the condensate is in heat transfer relationship with the feed water entering the tubes without the need for forced circulation of the condensate.

Further by virtue of the fact that the headers comprise curved surfaces and the ends of the tubes pass through these curved surfaces a flat tube plate is dispensed with and consequently reduced wall thicknesses are permissible with consequent lessening of leakage problems.

In the form shown in the drawing the header **5** is formed integrally with an end cover for the feed heater casing but this is not essential to the functioning of the heater.

In some instances where the length of height of the heater is not important the desuperheater, condensing and condensate sections can be arranged successively one after the other in the direction of the axis of the casing and in the direction of steam flow. This form is shown in FIGURES 5–7.

In this arrangement the condensate and condensing section remain substantially the same. For convenience of assembly the shape of the tubes in the desuperheater section is made the same as those in the condensate section so that the tubes are reversible.

With the arrangements of FIGURES 5–7 a smaller diameter of heater is achieved and therefore the casing thickness is reduced. A further advantage of this type is that the superheater steam is in the upper part of the casing only and does not extend over a considerable portion of its length as in the case of the other arrangement shown in FIGURES 1–4. This leads to reduced expansion of the casing.

In both arrangements, however, the tube bank is fixed only at one end the other end of the tube bank and associated header can expand relative to the casing.

In the forms illustrated the feed water inlet and outlet pipes are in the header adjacent the steam inlet but this is not essential. For example the feed water inlet and outlet pipes could be in the header **4** in which case the inlet pipe **6** for the feed water would be the pipe conveying water into the header **4** and into the inlet ends of the tubes and the outlet pipe **6***a* would communicate with the internal duct **2** and seal of the header **4** from this duct.

The condensing section *b* of the feed heater shown in FIGURES 5–7 is divided by radial walls **9** in similar fashion to the heater shown in FIGURES 1–4.

We claim:

1. A feed water heater for steam turbine plant comprising a casing, an internal duct located within the casing and extending through the major portion of the length of said casing to form an annular space between the outer surface of the duct and the inner surface of the casing, a header at each end of the duct each header comprising curved walls, a plurality of tubes arranged in radial planes within said annular space, inlet ends of all the tubes passing through the curved walls of one header and outlet ends of all the tubes passing through the curved walls of the other header, inlet and outlet pipes for feed water attached to one of the headers, one pipe passing through said header and communicating with the internal duct, to provide a flow path for feed water through the headers, tubes and through the full length of the internal duct, inlet means for steam adjacent the header connected to the outlet ends of the tubes and outlet means for condensed steam adjacent the other header; the flow path for steam through the casing comprising a desuperheater section, a condensing section and a condensate section, the condensing section being located immediately above the condensate section and having radial walls therein dividing the annular space into a number of sector-shaped compartments extending from the surface of condensate in the condensate section, there being a passage at one axial end of each radial wall, the passage at the end of one radial wall being at the opposite end to that of the adjacent radial wall whereby steam can flow from the desuperheating section into a sector-shaped compartment and then successively via said passages through a series of such compartments in opposite axial directions in adjacent compartments until finally it enters the condensate section.

2. A feed water heater as claimed in claim **1** in which the annular space is divided into two separate annular spaces, an inner space and outer space, by a cylindrical

wall the tubes in the inner space forming the condensing section and the tubes in the outer space the desuperheating section, the inner space being sealed off from the outer space at the end of the cylinder adjacent the steam inlet by a wall joining the said cylindrical wall and the header receiving the outlet ends of the pipes.

3. A feed water heater as claimed in claim 1 in which the desuperheating, condensing and condensate sections are arranged successively one after the other in the direction of the casing axis and in the main direction of steam flow.

4. A feed water heater as claimed in claim 3 in which the tubes in the condensate section are of sinous form and the tube bends are interleaved by baffles extending in a circumferential direction from radial walls.

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CHARLES SUKALO, *Primary Examiner.*

FREDERICK L. MATTESON, JR., *Examiner.*