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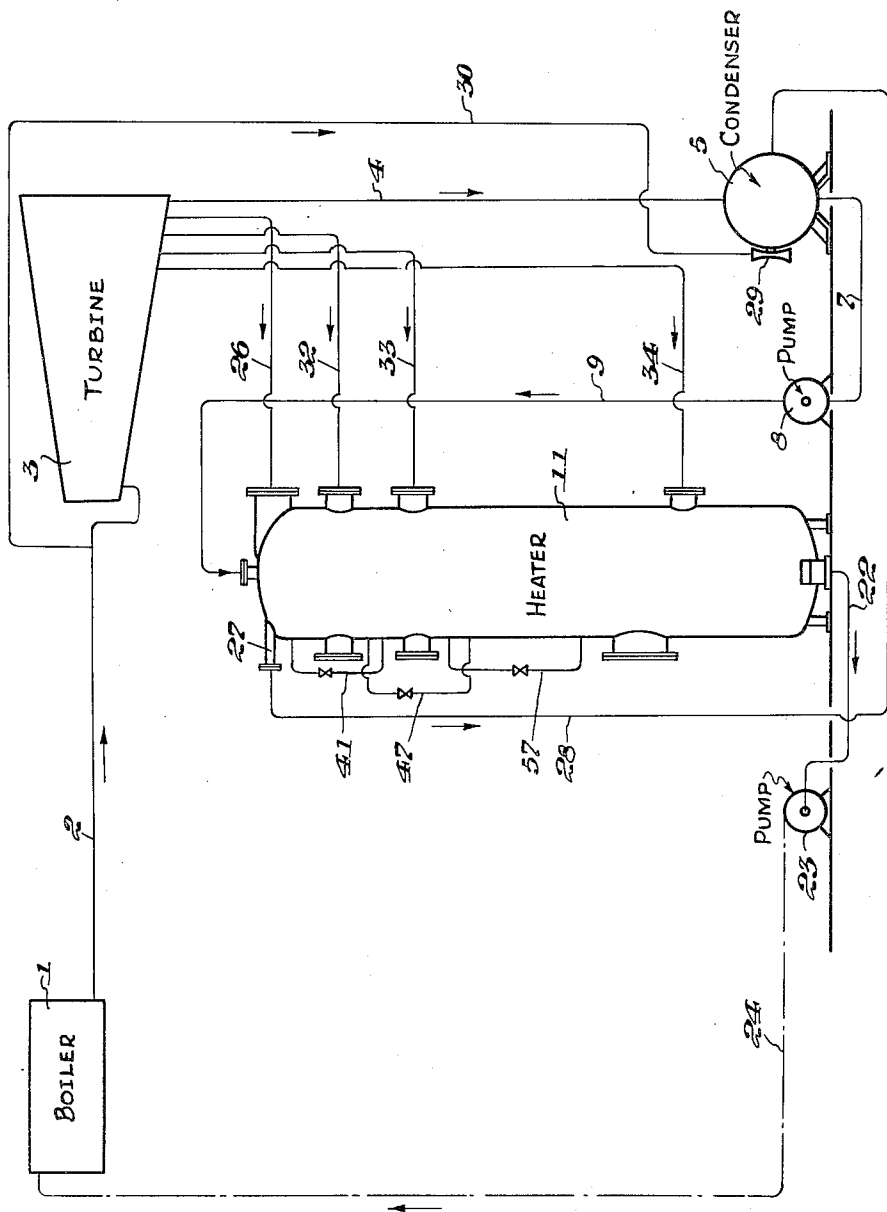
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MULTIPLE STAGE BLEED HEATER

Filed April 6, 1949

2 Sheets-Sheet 1



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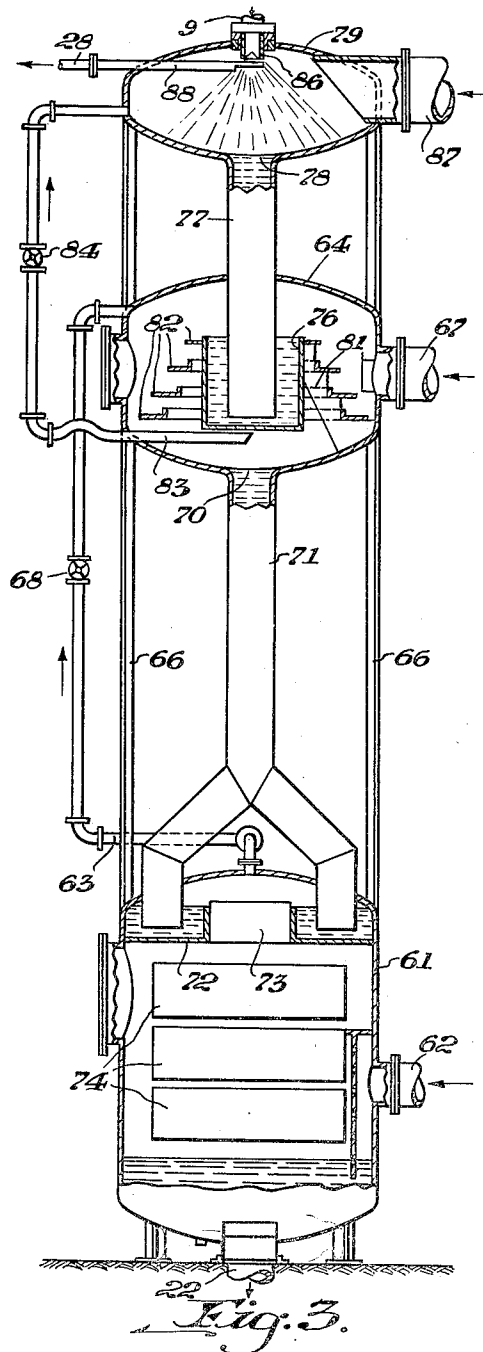
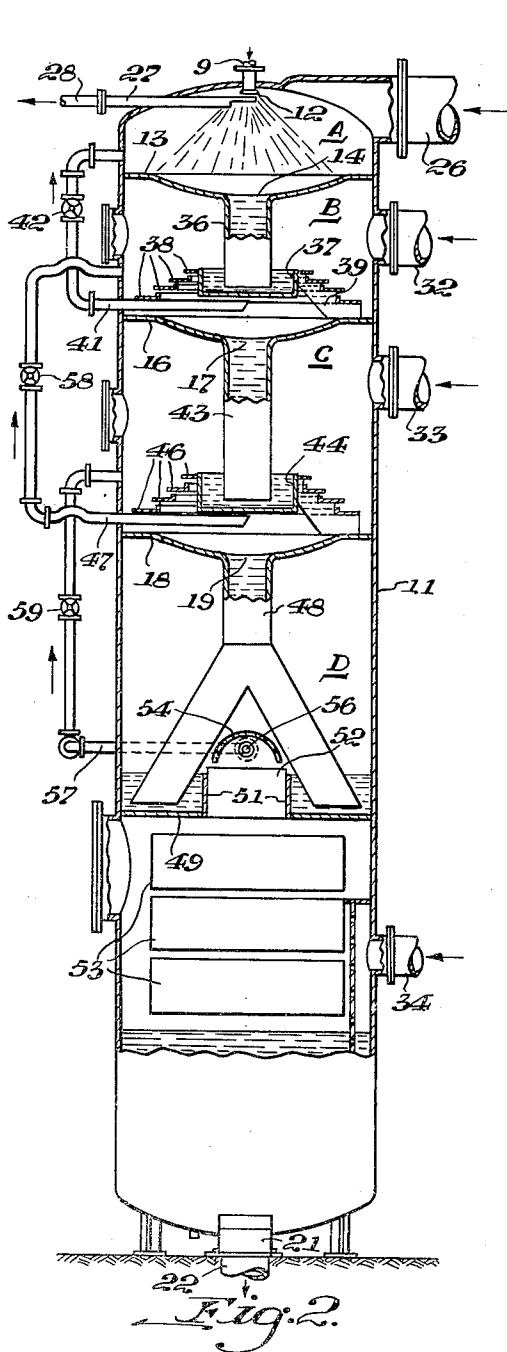
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UNITED STATES PATENT OFFICE

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MULTIPLE STAGE BLEED HEATER

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1 Claim. (Cl. 261-108)

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This invention relates to steam turbine power plants, and more particularly to apparatus for heating the condensate from the turbine as it is being returned to the boiler.

In the operation of such plants, it is common practice to bleed steam from the turbine to heat and deaerate the boiler feedwater. For this purpose closed heaters and open direct contact heaters have been used. Drip pumps are required in the case of closed heaters, while the condensate pumps and controls necessary for pumping the condensate from one direct contact heater to another have made it uneconomical to use direct contact heaters even when they are connected to the low-pressure stages of the turbine. When the direct contact heaters operate with steam from the high-pressure stages of the turbine, the condensate must be pumped at high pressure through the heaters and to the boiler. Any sudden decrease in the pressure on the condensate will permit it to flash into steam which may cause cavitation in the pumps and allow them to burn up. To prevent this, the heaters have had to be mounted at a high level in order to put a sufficient head of pressure on the pumps to prevent the water from flashing. Of course, this requires supports and piping and, in some cases, an auxiliary bay attached to the powerhouse.

It is among the objects of this invention to provide in a steam turbine plant, boiler feedwater heating apparatus which utilizes direct contact water heaters, which is economical, which requires no condensate pumps between the different heaters, which can be mounted at a low level without danger to boiler feed pumps, which permits the most efficient use of the turbine, and which requires a minimum of space.

In accordance with this invention, a condenser is connected to the lowest pressure stage of a multiple stage steam turbine. Condensate from the condenser is delivered to the upper one of a series of direct contact water heating chambers which are disposed at different levels, preferably directly above one another, such as separate compartments in a single shell, or separate superimposed tanks. Steam is delivered to the upper chamber by a conduit connected to a low-pressure stage of the turbine, by which is meant a stage that operates at a pressure below atmospheric. Other conduits bleed steam from successively higher low-pressure stages to successively lower heating chambers in the series. Thus, the lowest pressure chamber is at the top of the series and the highest pressure chamber is at the bottom where it also may serve as a deaerator. Each

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of the chambers above the lowest one has a condensate outlet in its bottom communicating with the chamber below it. The bottom chamber has an outlet from which heated water is pumped back to the boiler. Each chamber is provided with means to bring the steam and condensate within it into intimate contact with each other in order to heat the condensate. In order to permit the condensate to flow from one chamber to another by gravity, so that pumps become unnecessary, each of the condensate outlets is water-sealed against the higher pressure in the next lower chamber. This sealing can be accomplished by means of a water leg extending from each of the condensate outlets above the lowest one downward, with its lower end terminating in a water seal pan in the underlying chamber. These legs are long enough to form water heads sufficient to balance the pressures in the different chambers. Each chamber has a vent for noncondensable gases connected with the condenser, preferably by connecting vent conduits from each chamber to the chamber above, and connecting a vent conduit from the top chamber to the condenser.

The invention is illustrated in the accompanying drawings, in which Fig. 1 is a diagrammatic layout of the elements necessary for an understanding of my steam turbine power plant; Fig. 2 is an enlarged vertical section through my multiple stage bleed heater; and Fig. 3 is a similar view through a modified heater.

Referring to Fig. 1 of the drawings, steam is produced in a boiler 1 and is led through a pipe 2 to a multiple stage steam turbine 3. The last stage of the turbine, which is considerably below atmospheric pressure, is connected by a pipe 4 to a condenser 5. The outlet of the condenser hot well is connected by a pipe 7 to a pump 8 which pumps the condensate through a pipe 9 to the top of the tall cylindrical shell 11 of a feedwater heater which may be mounted on the same floor as the condenser. As shown in Fig. 2, the condensate may enter the shell through a conical spray nozzle 12. The shell is divided into several water heating chambers or zones, four being a suitable number, which are disposed one above another. The top chamber A extends from the top of the shell down to a partition 13 which has a concave central portion provided with a central outlet 14 for water. The next lower chamber B is formed between this partition and another partition 16, which likewise has a central outlet 17. This last partition serves as the upper wall of a third chamber C whose bottom is formed by a

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concave partition 18 provided with a water outlet 19. The lowest chamber D of the series has partition 18 as its upper wall and has the bottom of the shell as its lower wall. The bottom of the shell is provided with an outlet connection 21 connected by a pipe 22 to a pump 23 that pumps heated water from the heater through a conduit 24 to the boiler 1. This conduit may conduct the water through one or more closed heaters (not shown) on its way to the boiler, as may be found necessary or desirable.

The cone of water sprayed into the top chamber A is heated by steam bled from a low-pressure stage of the turbine through a pipe 26. Preferably, the steam is bled from the next to the last stage, unless the bleed piping would have to be too large. In such a case the steam can be bled from the second to the last stage. Of course, this steam is at subatmospheric pressure, as all of the last several stages operate under vacuum. Noncondensable gases separated from the steam in the top chamber are drawn out of it through a vent conduit 27 that is connected by a pipe 28 to the condenser. Suction is put on the vent conduit by an ejector 29 connected to the condenser and operated by steam pressure delivered to it from a pipe 30 branching off steam line 2. Condensate in the second chamber B is heated by steam bled from a higher pressure stage of the turbine, preferably the one next to the stage that feeds the upper chamber, through a pipe 32. The next higher stage of the turbine is connected by a pipe 33 to the third chamber C, while the next turbine stage is connected by a pipe 34 to the lowest chamber D. All four of these turbine stages are below atmospheric pressure, but are at progressively higher pressures as the inlet end of the turbine is approached. For example, in one particular installation the absolute pressures in the chambers are, from top to bottom, 1.50, 2.52, 4.33, and 7.45 pounds per square inch. Therefore, the heating chamber at the top of the shell is under the lowest pressure and the chamber at the bottom is under the highest pressure in the series.

Because of these progressively increasing pressures in the different chambers, the normal tendency would be for the steam to flow upward through the condensate outlets of the different chambers and prevent the condensate from flowing downward through them. However, by reason of this invention the condensate is caused to flow by gravity down through the heater, so that pumps are unnecessary. This is accomplished by water-sealing each of the condensate outlets against the higher pressure in the next lower chamber. The preferred way of doing this is by vertical water legs entirely within the heater shell, which extend from the condensate outlets down into water seal pans in the underlying chambers. Thus, a short straight conduit or water leg 36 extends from outlet 14 of the upper chamber down into a pan which receives and surrounds its lower end in the second chamber. The leg is of such length that a column of water filling it will have enough weight to balance the higher pressure in chamber B. The condensate being sprayed into the upper chamber will drain down to the water leg and cause the water in the pan below it to overflow onto any suitable means for bringing the water and steam in chamber B into intimate contact with each other so that the steam will give up as much heat as possible to the water. For example, such means may consist of a plurality of vertically spaced annu-

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lar trays 38 of different diameters arranged to form steps that will produce a waterfall around the pan. The trays are supported at intervals by inclined stepped plates 39 mounted on partition 16 and also supporting pan 37.

The steam is condensed in heating the water flowing over the trays, but the noncondensable gases are driven through the curtain of water and are drawn into the lower end of a vent conduit 41 that extends out of the side of the shell and then up and back to a vent inlet into the upper chamber where the pressure is less. The rate of flow through this conduit can be controlled by a valve 42. It will be seen that the noncondensable gases entering the upper chamber, as well as the noncondensibles liberated therein, will escape through the vent 27 at the top of the shell.

The outlet 17 from the second chamber B is provided with a water leg 43 that extends down into a pan 44 in the third chamber C. This pan likewise is encircled by water-distributing trays 46, and the noncondensable gases are drawn off through a vent conduit 47 that delivers them to the chamber above, which they leave through vent 41. As in the example given hereinbefore the difference in pounds pressure between the second and third chambers is greater than between the first and second chambers, the water leg in the third chamber C must be longer than leg 36 so that a greater head of water can be formed for balancing the relatively greater pressure in the third chamber.

A water leg 48 extends from the outlet 19 of the third chamber C down into the lowest chamber D. The lower portion of this leg preferably is divided into two downwardly diverging branches which terminate in a pan formed by a plate 49 extending across the shell. The center of the pan has a rectangular opening in it, from which parallel side walls 51 and parallel end walls 52 extend upward. The end walls are a little taller than the side walls so that the water in the pan will flow over the upper edges of only the side walls and down through the central opening into a series of superimposed deaerating trays 53 of any conventional construction. As the water flows through these trays and falls from one to another, it is heated by the steam entering the chamber from pipe 34, and the noncondensable gases rise through the central opening in the pan. Directly above this opening there is a curved hood 54 that extends across the shell. At one end of the hood the shell is provided with a vent outlet 56 from which a conduit 57 extends for conducting the noncondensable gases up to the next higher chamber, which is at a lower pressure. The vent conduits 47 and 57 are provided with valves 58 and 59, respectively, for controlling the upward flow of noncondensable gases. The water leg 48 in the lowest chamber is longer than the one above, because there is a bigger difference in pressure between the third and fourth chambers than there is between the second and third, whereby a greater head of water is required to permit the water to flow by gravity into chamber D. This multiple stage bleed heater is not so high as to be impractical, because it is connected to the lowest pressure stages of the turbine where the pressure differentials between stages are so small that short water legs can be used for producing the heads of water necessary to permit gravity flow of the water. Another advantage of connecting the heater to the lowest pressure stages of the turbine is that it reduces the water

drag on the turbine blades by drawing off some of the water, and thereby also reduces erosion of the low-pressure blading. Furthermore, this arrangement greatly increases the amount of power developed per pound of steam supplied to the turbine, because the steam is expanded in the turbine from the highest down to the lowest possible point before some of it is bled off. A superheat section in the lowest chamber of the shell could take advantage of the very hot turbine gland steam leak-off. All the heating chambers being in one shell, they require only one foundation and a minimum of space. The large amount of condensate which may be stored in this heater at low pressure makes it possible to absorb fluctuations in the amount of condensate required in the power plant cycle. The low pressure storage of condensate minimizes the danger of flashing, and thus reduces the hazard to boiler feed pumps.

In the embodiment of the invention shown in Fig. 3 the water heating chambers of the heater are formed in separate tanks which are mounted one above another. Three such tanks are shown, but more can be used if desired. The lowest tank 61, which forms the deaerating chamber, is connected by a pipe 62 to the highest of the group of low-pressure stages of the turbine from which steam is bled to this heater. The bottom of this tank is provided with an outlet for the heated water that is drawn out through pipe 22 by pump 23 (Fig. 1) which pumps it back to the boiler. The top of the tank is connected by a vent conduit 63 to an intermediate tank 64 supported above the bottom tank by means of struts 66. The steam inlet of the intermediate tank is connected by a bleed pipe 67 to a stage of the turbine that is at a lower pressure than the one to which pipe 62 is connected. Therefore, as the pressure in intermediate tank 64 is less than in the bottom tank, the pressure drop through vent conduit 63 will cause the noncondensable gases to flow upward through it. Their flow can be controlled by a valve 68.

The bottom of the intermediate tank is provided with a condensate outlet 70, from which a water leg 71 extends downward and has a bifurcated lower portion extending through the top of the bottom tank and into a water pan. This pan is formed from a plate 72 extending across the tank and having a walled central rectangular opening 73 down through which the overflow from the pan falls into a series of superimposed deaerating trays 74. The middle tank contains a water seal pan 76 that surrounds the lower end of a water leg 77 extending down from the condensate outlet 78 in the bottom of the top tank 79. The pan is supported by inclined plates 81 that are stepped for supporting vertically spaced annular trays 82, over which the water overflowing the pan cascades. The noncondensable gases from vent conduit 63, as well as those liberated from the steam in the middle tank, escape through a vent conduit 83, controlled by a valve 84, to the top tank. Condensate from the condenser is delivered to the upper tank through pipe 9 and a spray nozzle 86. The spray of water within the tank is heated by steam conducted to it through a bleed pipe 87 connected to a stage of the turbine that preferably is only one or two stages from the stage connected to the condenser. The noncondensable gases in this tank leave it through vent conduit 88 connected to pipe 28.

As in this particular heater the tanks are connected to turbine stages between which there are greater pressure differences than the stages to which the different chambers in Fig. 2 are connected, the water legs have to be longer. Of course, if the tanks were connected to the same turbine stages as the chambers in Fig. 2, the water legs would compare in length with those shown in that figure.

According to the provisions of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claim, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

A multiple stage bleed heater for heating the condensate from a steam turbine by means of steam bled from low-pressure stages of the turbine, comprising a series of direct contact water heating chambers disposed one above another, the top chamber having a top inlet for said condensate and a vent for noncondensable gases, the bottom chamber having a water outlet, each of the chambers having a side inlet for steam bled from a different one of said turbine stages, the lowest pressure chamber being at the top of the series and the highest pressure chamber at the bottom, each of the chambers below the highest one being vented to the chamber above it, each of the chambers above the lowest one having a condensate outlet in its bottom communicating with the chamber below it, means in the bottom chamber for deaerating by direct contact the condensate passing therethrough, a condensate pan extending across the bottom chamber above said deaerating means and provided centrally with an overflow opening having walls extending upward from the bottom of the pan, means for water sealing each of said condensate outlets against the higher pressure in the next lower chamber and including a water leg extending from the lowest of said condensate outlets downward into said pan to a point between the bottom of the pan and the top of its overflow opening, and means in the chambers above the bottom chamber for bringing the steam and condensate into intimate contact with each other to heat the condensate, the vent from the bottom chamber being above the overflow opening in said pan.

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