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Bennett

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[54] **STEAM GENERATOR**

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[52] **U.S. Cl.** **122/34**

[51] **Int. Cl.** **F22b 1/06**

[58] **Field of Search** 122/32, 34

[56] **References Cited**

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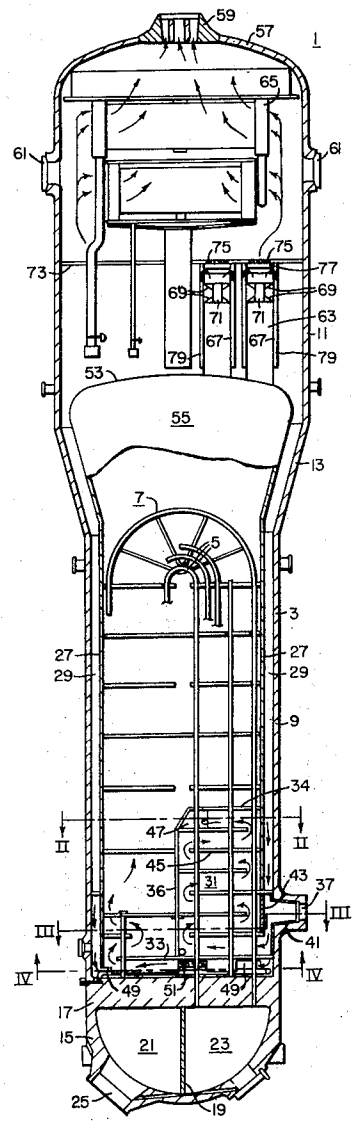
[57] **ABSTRACT**

A shell and tube steam generator having a U-shaped tube bundle and a preheater. The preheater is disposed on the cold leg portion of the tube bundle and is cooperatively associated with an annular chamber formed by a tube bundle wrapper and the shell to direct inlet water upwardly through the preheater portion and downwardly through the annular chamber, across the tube sheet and upwardly along the outside surfaces of the tubes to optimize the temperature and pressure of the steam produced.

6 Claims, 4 Drawing Figures



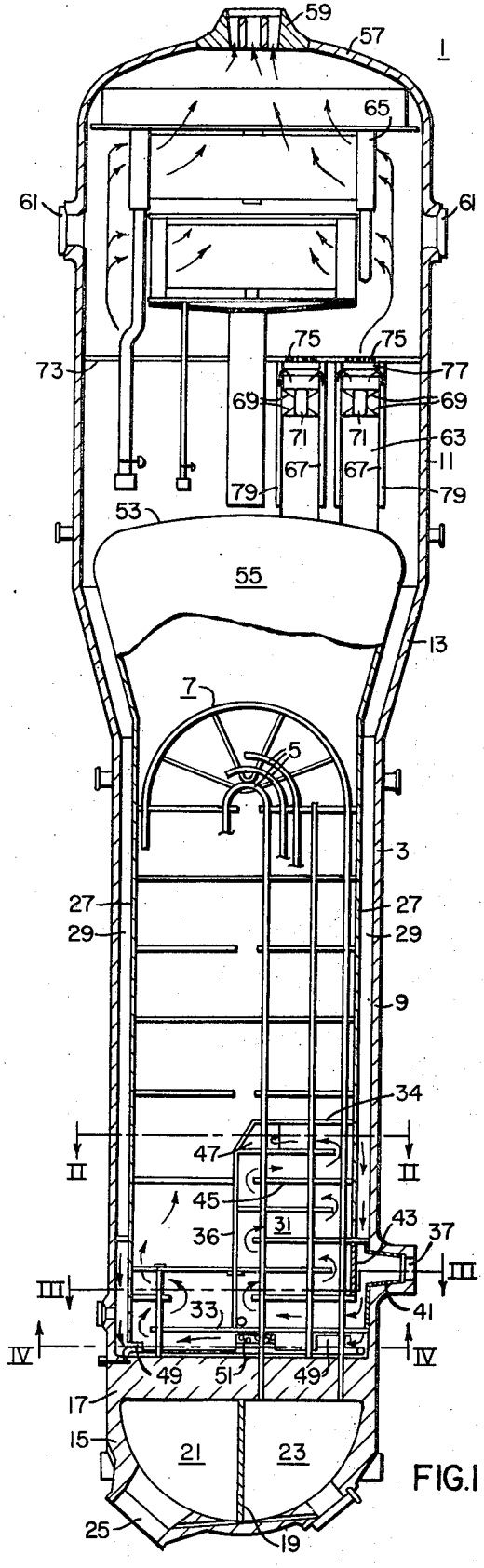


FIG.1

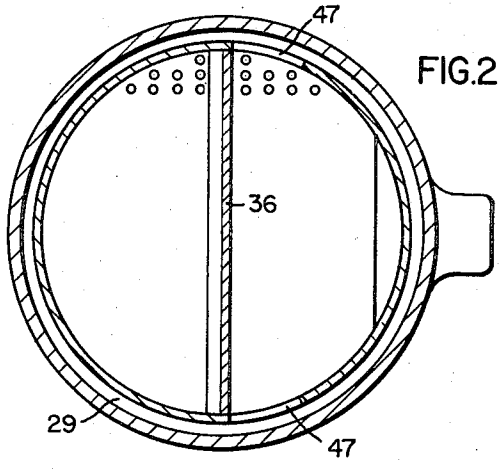


FIG.2

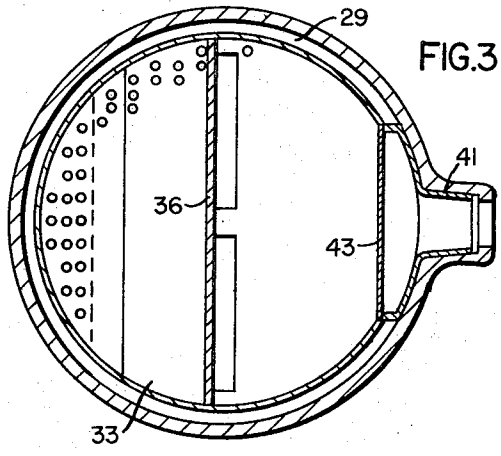


FIG.3

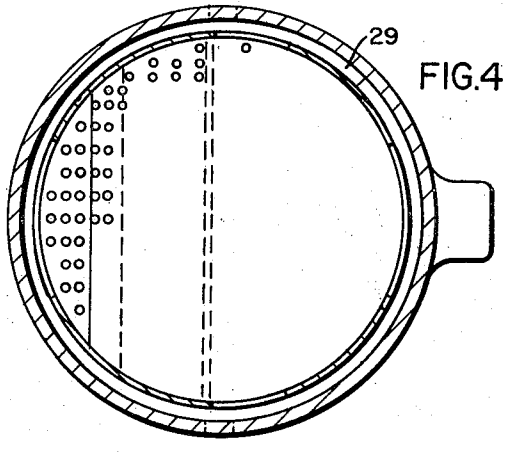


FIG.4

STEAM GENERATOR

BACKGROUND OF THE INVENTION

This invention relates to steam generators for nuclear power plants and more particularly to such steam generators having a preheater portion disposed therein.

In a steam generator utilizing a heated fluid to produce steam the pressure of the steam is a function of the log means temperature difference (LMTD) of the two fluids. Thus, by increasing the LMTD the pressure of the steam can be increased.

An obvious way to increase the LMTD is to raise the temperature of the primary fluid, however in nuclear steam generating systems the temperaure of the primary fluid is a limiting factor in the design of the system and is normally set at the maximum allowable safe value.

Increasing the LMTD may also be accomplished within the steam generator by providing a preheater chamber in which inlet water is heated to a temperature lower than the boiling point.

SUMMARY OF THE INVENTION

In general a steam generator utilizing a primary heated fluid to vaporize a secondary liquid, when made in accordance with this invention, has a vertical shell portion, a tube sheet disposed adjacent one end thereof, a tube bundle having a plurality of U-shaped tubes through which the primary fluid flows, a wrapper encircling the tubes and forming an annular chamber between the tube bundle and the shell, and a preheated portion disposed adjacent the tube sheet. A fluid inlet nozzle is disposed to feed secondary fluid into the preheater portion and the preheater has an outlet disposed to discharge the secondary fluid into the annular chamber. The wrapper cooperates with the shell and outlet to cause preheated secondary fluid to flow generally upwardly over all of the outer tube surface disposed outside of the preheater.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of this invention will become more apparent from reading the following detailed description in connection with the accompanying drawings, in which:

FIG. 1 is a vertical sectional view of a steam generator made in accordance with this invention;

FIG. 2 is an enlarged sectional view taken on line II—II of FIG. 1;

FIG. 3 is an enlarged sectional view taken on line III—III OF FIG. 1; and

FIG. 4 is an enlarged sectional view taken on line IV—IV of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail, FIG. 1 shows a steam or vapor generator 1 having a vertical shell portion 3 and a plurality of U-shaped tubes 5 forming a tube bundle 7 which is disposed within the shell 3. The shell has a lower portion 9 having one diameter, an upper portion 11 having a larger diameter and a frustoconical portion 13 serving as a transition member between the upper and lower portions 11 and 9, respectively. The lower portion of the shell 9 is enclosed by a spherical head portion 15. The head portion 15 has

an integral tube sheet 17 which receives the ends of the U-shaped tubes 5. A dividing plate 19 separates the head 15 into two generally equal compartments 21 and 23. The inlet compartment 21, the one on the left, has an inlet nozzle 25 for primary fluid and the outlet compartment, 23, the one on the right, has an outlet nozzle disposed therein, however, the outlet nozzle is not shown. A sleeve or wrapper portion 27 enwraps the tube bundle and forms an annular chamber 29 between the wrapper 27 and the shell 3. A preheater portion 31 is disposed adjacent the tube sheet 17 on the cold leg portion of the tube bundle 7, the portion shown on the right. The preheater 31 is an enclosed chamber formed by a portion of the wrapper 27, a bottom circular closure plate 33 disposed adjacent and parallel to the tube sheet 17, an upper closure plate 34 disposed parallel to the bottom closure plate 33 and a vertical closure plate 36 extending between the bottom and upper closure plates 33 and 34, respectively, and parallel to the tubes 5. A secondary fluid or water inlet nozzle 37 is disposed in the shell 3 adjacent the preheater 31 and has a liner 41 which directs the inlet water to the preheater and an impact plate 43 which directs the inlet flow downwardly and prevents the high velocity inlet fluid from impinging upon the tubes. A plurality of horizontal baffles 45 are so disposed within the preheater 31 to cause the inlet secondary fluid to follow a sinuous path as it flows upwardly to outlet portion 47, which discharge the preheated secondary fluid into the annular chamber 29. The end of the wrapper 27 adjacent the tube sheet 17 has a plurality of notches 49 so disposed to direct the preheated fluid so that it sweeps across the tube sheet 17 prior to flowing upwardly along the outer surface of the tubes not contained within the preheater. Some of the notches 49 are provided with adjustable flow gates 51 which are adapted to change the opened area of the notches to adjust the flow of the preheated secondary fluid across the tube sheet.

The wrapper 27 generally parallels the shell and flares outwardly along with the transition portion 13 and has a domed end closure 53 disposed in the lower portion of the upper portion 11 of the shell 3. The domed end closure 53 and wrapper 27 thus form a chamber 55 above the tubes for collecting the steam or vapor produced by the steam generator. The upper portion 11 of the shell is closed by an elliptical head portion 57. A steam or vapor outlet nozzle 59 is centrally disposed in the elliptical head and provides a discharge port for vapor produced in the steam generator. Two diametrically opposed manways 61 provide access to the interior of the upper portion of the shell which houses two separate moisture or liquid separators 63 and 65. The first separator 63 is a centrifugal-type separator and comprises a plurality of riser tubes 67 in communication with the chamber 55 and extending upwardly from the domed end portion 53 of the wrapper 27. The riser tubes 67 have swirl vanes 69 disposed therein. The swirl vanes 69 extend radially from a centrally disposed hub portion 71 which is disposed adjacent the upper end of the riser tube 67. A closure plate 73 generally extends horizontally across the shell 3 dividing the upper portion 11 into two chambers. The closure plate 73 is disposed slightly above the upper end of the riser tubes 67 and has orifices 75 which register with the riser tubes 67. Collars 77 extend through the orifices 75 and extend downwardly therefrom. Sleeves 79 encircle the riser tubes and depend from the

closure plate **73.** The lower end of the sleeve **79** are disposed above the domed end closure **53** providing a lower discharge port. The upper end of the sleeves have tangential discharge ports **81** disposed adjacent the closure plate **73.**

The second moisture separator **65** comprises two groups of hook and pocket vane-type or chevron separators disposed in parallel, one group being disposed above the other. The hook and pocket vane-type separators **65** have drip legs **83** depending therefrom, the lower end of the drip legs **83** have a seal cup **85** connected thereto.

The operation of the steam generator is as follows: primary heated fluid from a nuclear reactor (not shown) flows through the primary fluid inlet nozzle **25** to the inlet chamber **21,** which acts as a header for the U-shaped tubes. The primary fluid then flows through the U-shaped tubes and is discharged into the outlet chamber **23** and returns to the nuclear reactor through the discharge nozzle (not shown). Secondary fluid or water enters through the secondary fluid inlet nozzle **37** and flows to the preheater section **31** wherein it flows upwardly across the cold leg portion of the tube bundle following a sinuous path defined by the baffles **45** to the outlet ports **47** disposed in the upper end of the preheater. The preheated secondary fluid or water then flows downwardly in the annular chamber **29** and is directed to sweep across the tube sheet **17** by the notches **49.** The open area of the notches **49** is adjusted by the flow gates **51** to provide the proper distribution of secondary fluid sweeping across the tube sheet to prevent chemical hideout and premature boiling. The secondary fluid then flows upwardly over the outer surface of the tubes not disposed within the preheater removing heat from the primary fluid thus increasing its temperature to the boiling point. Boiling takes place as the secondary fluid moves upwardly, thus forming steam or vapor which separates from the liquid and collects in the chamber **55.** The steam which collects in the chamber **55** flows upwardly through the riser tubes **67** and as it passes over the swirl vane **69** it begins to swirl and form a vortex as it leaves the riser tubes. The moisture or liquid flows to the outside of the vortex and is discharged downwardly through the annular chamber formed between the sleeve and the riser tube or is discharged through the tangential discharge nozzles **81** disposed adjacent the closure plate **73.** Steam with a large portion of the moisture removed then flows upwardly through the collar **77** and through the hook and pocket vane-type separator **65** which removes additional moisture or fluid droplets from the vapor or steam and then essentially moisture-free vapor or steam flows through the outlet nozzle **59.** The water or liquid droplets separated from the steam are discharged into the lower portion of the upper portion of the shell and flow across the upper side of the domed enclosure **53** and down the annular chamber **29** and mixes with the discharge from the preheater. The mixture flows downwardly due to natural circulation and sweeps across the tube sheet prior to beginning its upward flow along the outside of the tubes not included in the preheater.

The steam generator **1** with a preheater **31** as hereinbefore described advantageously raises the temperature of the secondary fluid to a temperature below the boiling point and then directs the preheated fluid upwardly along the outer surfaces of the tubes not included within the preheater to optimize the pressure and temperature of the steam produced therein.

What is claimed is:

1. A vapor generator utilizing a primary heated fluid to vaporize a secondary fluid, said vapor generator having a vertical shell portion, a tube sheet disposed adjacent one end thereof, a tube bundle formed by a plurality of U-shaped tubes through which said primary fluid flows, a wrapper generally encircling the entire length of said tube bundle to form an annular chamber between said wrapper and said shell which generally extends the entire length of said tube bundle, a preheated portion disposed adjacent said tube sheet, and a secondary fluid inlet nozzle disposed to feed secondary fluid into said preheater portion, said preheater portion having outlet means for discharging secondary fluid into said annular chamber, said wrapper being cooperatively associated with said shell and said outlet whereby preheated secondary fluid flows generally upwardly over all the outside surface of the tubes disposed outside the preheater.

2. A vapor generator as set forth in claim **1,** wherein the secondary fluid nozzle is in fluid communication with a portion of the preheater disposed adjacent the tube sheet, whereby the secondary fluid flows upwardly in the preheater portion.

3. A vapor generator as set forth in claim **1,** wherein the tube sheet and preheater are disposed adjacent the lower end of the shell.

4. A vapor generator as set forth in claim **3,** wherein the lower end of the wrapper has a plurality of openings disposed therein, whereby preheated secondary fluid sweeps the tube sheet preventing chemical hideout and premature boiling adjacent the tube sheet.

5. A vapor generator as set forth in claim **3,** wherein the shell has separating means disposed therein, said separating means being disposed in the upper portion of the shell and being adapted to remove entrained secondary fluid droplets from the vapor produced therein, said separating means having drain means connected thereto, for returning the secondary fluid collected in liquid form to the chamber formed between the wrapper and the shell whereby said liquid mixes with the preheated secondary fluid as they are moved downwardly toward the tube sheet by natural circulation.

6. A vapor generator as set forth in claim **5,** wherein the upper end of the wrapper is closed forming a chamber above the upper end of the tubes and the separating means are in communication with said chamber.

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