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3,147,743

VERTICAL RECIRCULATING TYPE VAPOR GENERATOR

Filed May 8, 1962

2 Sheets-Sheet 1

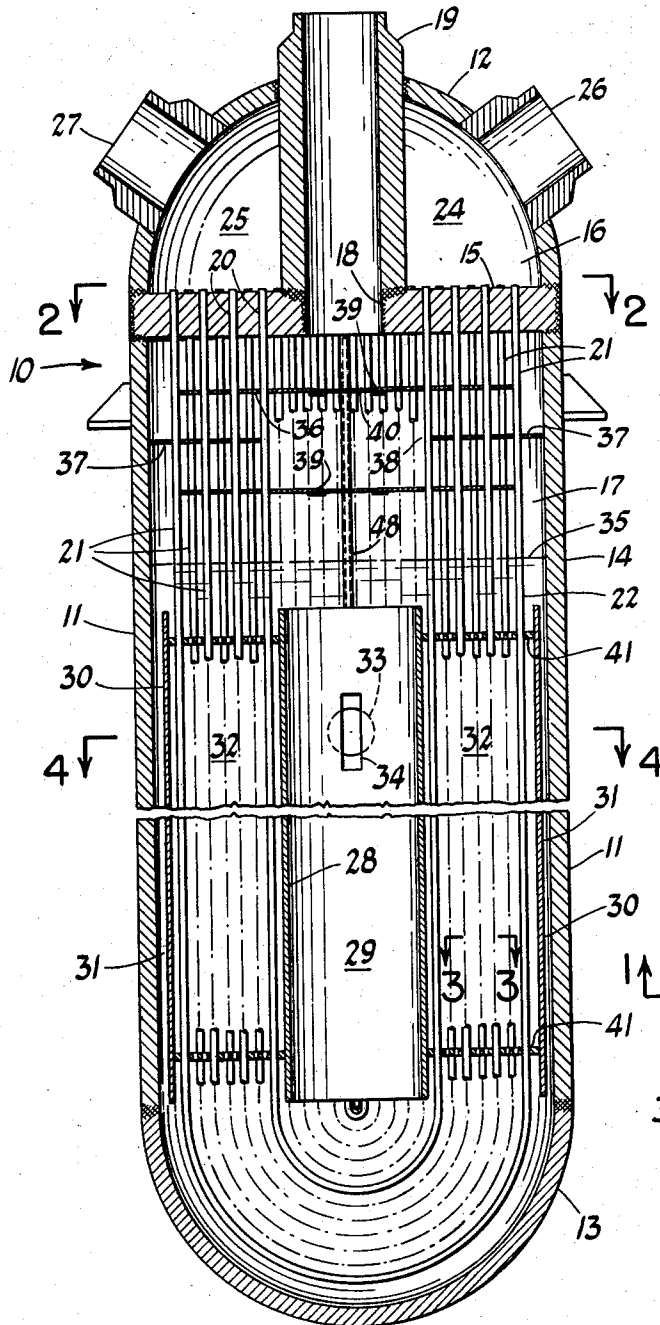


FIG. 1

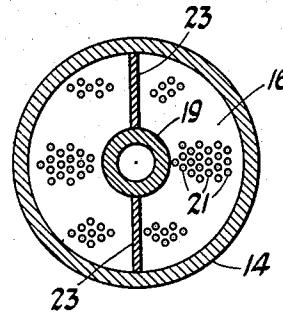


FIG. 2

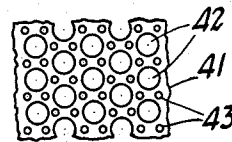


FIG. 3

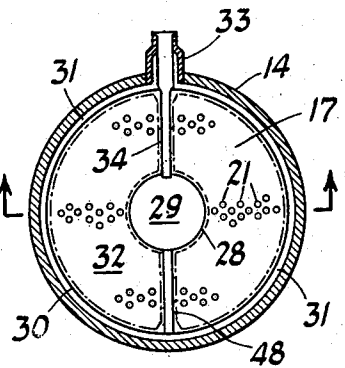


FIG. 4

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VERTICAL RECIRCULATING TYPE VAPOR GENERATOR

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2 Sheets-Sheet 2

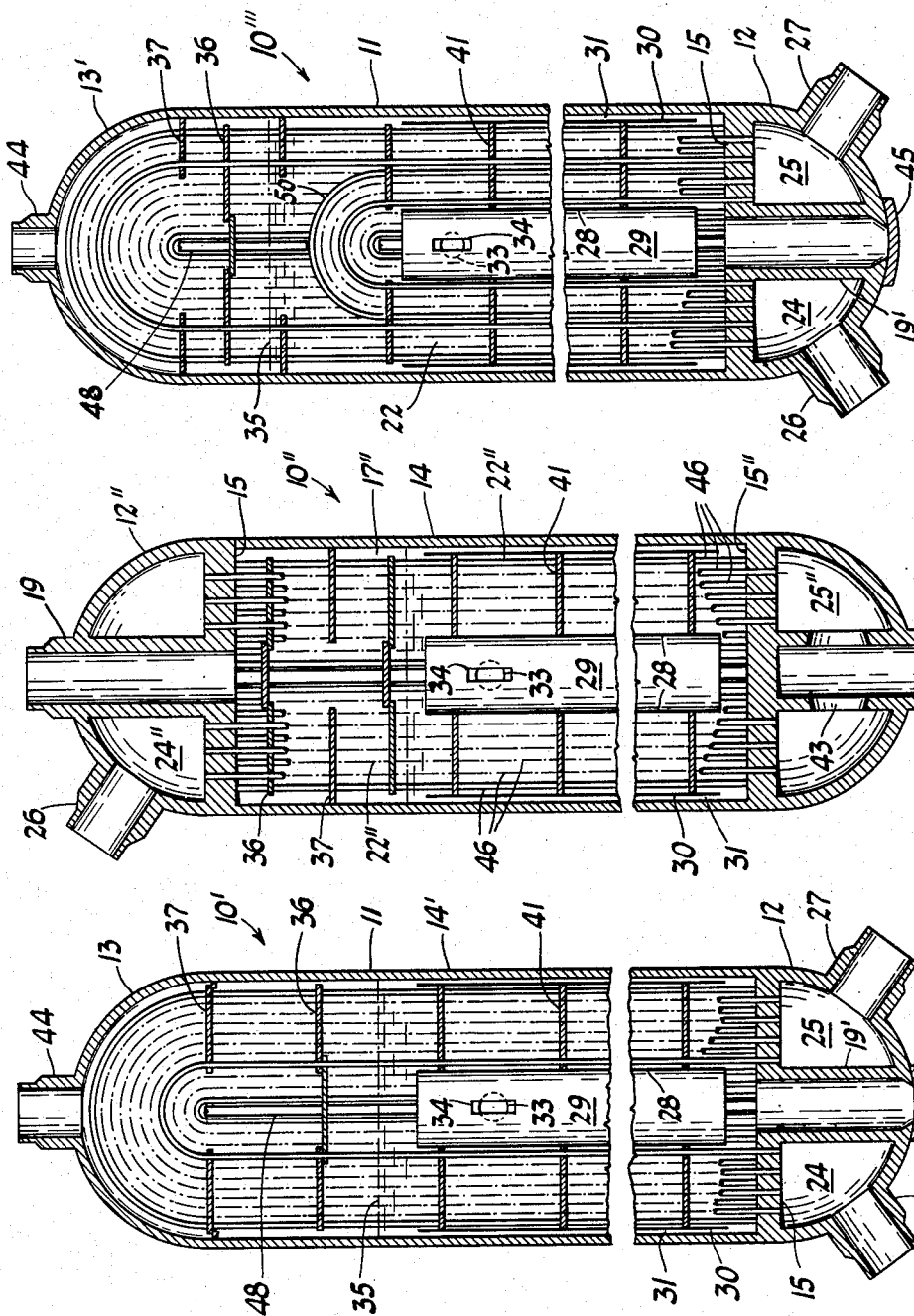


FIG. 7

FIG. 6

FIG. 5

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3,147,743 VERTICAL RECIRCULATING TYPE VAPOR GENERATOR

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The invention relates to a vapor generator wherein a hot fluid is employed as a heating medium to generate vapor. More particularly, it relates to a shell and tube type vapor generator wherein means are provided to establish continuous fluid circulation through the generator by defining distinct fluid paths therethrough.

These generator is arranged to occupy a minimum amount of space while transferring large quantities of heat. It comprises a vertically oriented body defining a vapor generator chamber in which is located a tube bundle consisting of a plurality of heat exchanger tubes. Through the tubes is passed a heating medium comprising a hot liquid, such as pressurized water, liquid metal, petroleum or gas which gives up heat to a vaporizable liquid, such as water, whereby vapor is created. The so-created vapor leaves the unit through an outlet nozzle where it may be directed to a vapor drum for further processing or to a prime mover wherein work may be done.

With in the vapor generating chamber, baffle means are provided which define downcomer and riser paths for the vaporizable liquid through the unit. The liquid which enters the generator is directed to the lowermost portion of the tube bundle by means of the downcomer paths and is transformed into vapor while flowing up the riser path around the hot liquid bearing heat exchanger tubes from which heat is extracted. The chamber is divided into an evaporator zone and a superheater zone, the limits of which are defined by the level of the liquid in the chamber. Additional baffle means are provided in the superheater zone to direct the vapor created in the evaporator zone across the heat exchanger tubes so as to impart a slight amount of superheat thereto thus superheating the vapor and eliminating any liquid that may be entrained in the vapor leaving the generator.

It is therefore a general object of the invention to provide a vapor generator characterized by compactness of form and efficiency of operation.

A further object of the invention is to provide a vapor generator wherein means are provided to accomplish vapor separation by means of heat extraction from the heating liquid.

A still further object is to provide a natural circulation vapor generator of the recirculating type wherein vapor separation is accomplished within the space occupied by the heat exchanger tubes.

Other objects and advantages will become apparent from the following description when read in conjunction with the appended drawings wherein:

FIG. 1 is a vertical section of the novel vapor generator; FIG. 2 is a section taken along line 2—2 of FIG. 1; FIG. 3 is a section taken along line 3—3 of FIG. 1; FIG. 4 is a section taken along line 4—4 of FIG. 1; and FIGS. 5-7 are modified forms of vapor generators employing the instant invention.

Referring now to FIG. 1, there is shown a vapor generator 10 comprising a vertically elongated, cylindrical body 11 having both of its ends closed by means of substantially hemispherically shaped heads 12 and 13 thereby defining a closed pressure vessel 14. Adjacent the upper end of the vessel 14 a tube sheet 15 is weldedly united to the wall thereof thus dividing the vessel 14 into two fluidly

distinct portions, the upper portion being designated the hot fluid chamber 16 and the lower portion, the vapor generating chamber 17. The tube sheet 15 has disposed therein an enlarged, centrally located aperture 18. Superposed upon the tube sheet 15, in axial alignment with the aperture 18, is a vapor outlet nozzle 19, the upper end of which extends through the upper head 12. The nozzle 19 comprises a cylindrical member which is weldedly attached to both the tube sheet 15 and the upper head 12 and permits withdrawal of the vapor created in the vapor generating chamber.

Tube seats 20 are formed in the tube sheet 15 and receive the ends of a plurality of heat exchanger tubes 21. These tubes are U-shaped and comprise a tube bundle 22 which extends into the vapor generating chamber 17 substantially filling the same. Partitions in the form of a pair of plates 23 which conform to the walls of the hot fluid chamber 16 are attached to the tube sheet 15, head 12 and nozzle 19 in a fluid impervious manner so as to divide the hot fluid chamber 16 into inlet and outlet portions 24 and 25. Inlet and outlet nozzles 26 and 27 communicate with the respective portions and permit continuous flow of a heating medium to the generator 10 from a source (not shown).

The arrangement of the tubes 21 forming the tube bundle 22 is such that an axially disposed void extends throughout the length of the bundle. Within this void is located an annular baffle plate in the form of an enlarged conduit 28 which is mounted in concentric relation with the tube bundle along the longitudinal axis of the vessel 14. The conduit 28 is open at both its upper and lower ends and extends from a point removed from the upper end of the vapor generating chamber 17 to a point spaced from the lower end of the vessel 14 so as to establish a downcomer path 29 to the lower end of the vessel. A second annular baffle plate 30, which is substantially coextensive with the first, is mounted in concentric relation therewith. It surrounds the tube bundle 22 and is spaced from the inner wall of the vessel 14 so as to establish a second, outer downcomer path 31. Between the two baffles there is thus formed a riser path 32 through which the tubes 21 of the tube bundle 22 extend.

Annular support plates 41 are attached to the baffles 28 and 30 at spaced points therealong. These plates extend between the baffles and are provided with a plurality of apertures 42 to receive and align the tubes 21. Smaller apertures 43 are provided in the plates to permit the passage of fluid therethrough.

Feedwater is admitted to the generator by means of a feedwater inlet nozzle 33 which communicates with the central downcomer path by means of a feedwater duct 34. During normal operation of the generator, a body of liquid occupies the lower portion of the vapor generating chamber 17 and has a level 35 spaced a considerable distance from the tube sheet 15 thereby dividing the chamber 17 into an evaporator zone and a superheat zone. A hollow partition 48 extends the length of chamber 17 and fills an empty portion of the tube bundle to compel the flow of fluid across the tubes 21. Within the superheat zone a plurality of baffle plates are provided which define a path over which the vapor flows across the heat exchanger tubes. Some of these plates, such as those designated as 36, are attached to the tube bundle with their peripheral edges spaced from the wall of the vessel so as to permit passage of the vapor between the plates 36 and the wall of the vessel 14. Another, designated as 37, is mounted directly to the wall of the vessel 14 and has an opening 38 provided in the center thereof to permit vapor flow therethrough.

Any number of baffles may be employed, the number being dictated by the amount of superheat to be imparted

to the vapor. Baffle plates 36 may be provided with central openings 39 which are closed during operation of the generator by means of cover plates 40. Removal of the cover plates 40 establishes a convenient means for obtaining access to the lower portion of the vapor generating chamber 17 in order to inspect or service the generator internals.

The operation of the herein disclosed vapor generator is as follows. A hot fluid, such as pressurized water, liquid metal, petroleum or gas is admitted to the inlet portion 24 of the hot fluid chamber 16 by means of the nozzle 26. It flows through the tubes 21 of the tube bundle 22 where it gives up heat before leaving the generator through the outlet nozzle 27. A vaporizable liquid, such as water, is admitted to the vapor generating portion 17 of the generator through the feedwater inlet nozzle 33 from whence it flows through the feedwater duct 34 into the central downcomer conduit 28 and thence to the lower portion of the vapor generating chamber 17. As shown in FIG. 1, the liquid level 35 in the vapor generating chamber 17 is normally above the upper ends of the annular baffle plates 28 and 30 therefore a portion of the liquid is caused to flow to the bottom of the generator 10 through the outer downcomer path 31 thereby creating recirculation of the fluid.

Due to the thermal siphonic effect of the heat given off by the hot fluid flowing through the heat exchanger tubes 21, the vaporizable liquid is caused to flow upwardly around the tubes through the riser path 32 whereby some of the fluid is transformed into vapor. Upon reaching the superheater zone of the chamber 17 the vapor is caused to flow along the tortuous path formed by the baffle plates 36 and 37 around the exposed surfaces of heat exchanger tubes 21 which thus impart an amount of superheat to the vapor thereby removing any water which may be entrained in the vapor before it leaves the generator 10 through the outlet nozzle 19.

In FIGS. 5, 6 and 7 there are shown various modified arrangements of the present invention. In FIG. 5 there is shown a vapor generator arrangement wherein the generator 10' is inverted from the arrangement shown in FIG. 1. In this arrangement the nozzle 44 permits withdrawal of the vapor from the upper end of the generator while the cylinder 19' which extends between the tube sheet 15 and the head 12 is capped by means of a cover plate 45, the latter serving as a drain or as a means of obtaining access into the generating portion of the vessel in order to inspect or service the interior thereof. In the FIG. 6 arrangement the vessel 14 is provided with a pair of tube sheets 15 and 15'', each being positioned at either end of the vessel, thereby providing hot fluid chambers at each end thereof with the vapor generating chamber 17 being positioned therebetween. Tube sheet 15'' is similar to the tube sheet 15 of FIG. 1 but the aperture 18 is omitted from tube sheet 15'' so as to close the bottom of the vapor generating chamber. In this arrangement the tube bundle 22'' consists of a plurality of straight tubes 46 which extend through the vapor generating chamber 17''. The upper hot fluid chamber 24'' receives fluid from a source, not shown, by means of the inlet nozzle 26. This fluid flows through the tube bundle 22'' to the lower chamber 25'' from whence it passes through the central outlet nozzle 27'' by means of apertures 43 formed therein. A vapor outlet means is provided in the upper portion of the generator by means of the cylindrical nozzle 19 which extends from the tube sheet through the upper head 12''. The FIG. 7 arrangement is substantially the same as that shown in FIG. 5 with the exception that a portion 50 of the tube bundle 22 is formed so as to be maintained below the liquid level 35 in the vapor generating chamber. This expedient provides a means of controlling the amount of superheat imparted to the vapor by limiting the amount of heating surface to which the vapor is exposed. It also permits the use of a lower grade material in forming the tubes which are maintained

below the liquid level since these tubes are continuously submerged in water and thus not exposed to the danger of sealing as are the tubes which extend above the water level.

By means of the present invention there is provided a vapor generating unit which is characterized by compactness of form and efficiency of operation. The unit is disposed in a vertical attitude thereby reducing the amount of floor space occupied thereby while the shell and tube arrangement permits the exposure of a large amount of heating surface for the transforming of liquid into vapor. The efficiency of the unit is enhanced by the provision of a downcomer means which permits the recirculation of liquid within the vapor generating chamber.

While there has been disclosed several particular embodiments of the invention, this disclosure is intended to merely illustrate and not to limit the inventive concept. It is understood that changes may be made in the form of the apparatus disclosed without departing from the spirit of the appended claims.

What is claimed is:

1. A vapor generator comprising a vertically elongated body forming a substantially closed vapor generating chamber; a plurality of fluid conducting tubes extending into said chamber; means for effecting a flow of heating fluid through said tubes; conduit means open at both ends extending longitudinally of said chamber and terminating short of the ends thereof for conducting vaporizable liquid to the bottom of said chamber, said conduit means being spaced from the wall of said chamber to form downcomer and riser passages therein; means communicating with said downcomer passage for admitting vaporizable liquid thereto, said vaporizable liquid filling said chamber to a level above the top of said conduit means but spaced from the top of said chamber to divide said chamber into an evaporating space and a superheating space immediately thereabove; all of said tubes being immersed at least to a substantial degree in said vaporizable liquid to provide heating surface for said evaporating space; at least some of said tubes extending above the level of said vaporizable liquid to provide heating surface for said superheating space; vapor outlet means communicating with said superheating space; and baffle means positioned in said superheating space between said liquid level and said vapor outlet means for directing vapor generated in said evaporating space cross the tube surface located in said superheating space prior to its passing through said vapor outlet means.

2. A vapor generator comprising a vertically elongated body forming a substantially closed vapor generating chamber; a plurality of fluid conducting tubes forming a tube bundle extending into said chamber, said tube bundle having a length and width to be substantially co-extensive with said chamber; means for effecting a flow of heating fluid through said tubes; conduit means open at both ends extending longitudinally of said chamber and terminating short of the ends thereof for conducting vaporizable liquid to the bottom of said chamber, said conduit means being spaced from the wall of said chamber to form downcomer and riser passages therein; means communicating with said downcomer passage for admitting vaporizable liquid thereto, said vaporizable liquid filling said chamber to a level above the top of said conduit means but spaced from the top of said chamber to divide said chamber into an evaporating space and a superheating space immediately thereabove; all of said tubes being immersed at least to a substantial degree in said vaporizable liquid defining said evaporating space to provide heating surface therefor; at least some of the tubes of said tube bundle extending above the level of said vaporizable liquid into said superheating space to provide heating surface therefor; vapor outlet means communicating with said superheating space; and baffle means positioned in said superheating space between said liquid level and said vapor outlet means for directing vapor generated in said evaporating

space across the tube surface located in said superheating space prior to its passing through said vapor outlet means.

3. A vapor generator comprising a vertically elongated cylindrical body; arcuate heads attached to the ends of said body to form a substantially closed vessel; tube sheet means within said vessel dividing the same into a hot fluid section and a vapor generating chamber; a plurality of fluid conducting tubes attached to said tube sheet means in fluid communication with said hot fluid section forming a tube bundle, said tube bundle extending into said chamber and having a length and width to be substantially co-extensive therewith; means communicating with said hot fluid section for effecting the flow of hot fluid through said tubes; elongated conduit means positioned within said vapor generating chamber and terminating short of the ends thereof for conducting vaporizable liquid to the bottom of said chamber, said conduit means being concentrically related to the wall of said chamber and spaced therefrom to form downcomer and riser passages within said chamber; means communicating with said downcomer passage for admitting vaporizable liquid thereto, said vaporizable liquid filling said chamber to a level above the top of said conduit means but spaced from the top of said chamber to form an evaporating space and a superheating space immediately thereabove; all of the tubes of said tube bundle being immersed at least to a substantial degree in the vaporizable liquid defining said evaporating space to provide heating surface therefor; at least some of said tubes extending above said level of vaporizable liquid into said superheating space to provide heating surface therefor; vapor outlet means communicating with said superheating space; and baffle means including a plurality of axially spaced plates extending laterally of said tube bundle defining radially spaced openings for directing the vapor generated in said

evaporating space along a tortuous path across the tube surface located in said superheating space prior to its passing through said vapor outlet means.

4. A vapor generator organization as recited in claim 3 wherein said tube sheet means comprises a single tube sheet located in the upper portion of said vessel dividing the same into an upper hot fluid section and a lower vapor generating chamber and said tube bundle comprises a plurality of U-shaped tubes attached to said tube sheet and depending therefrom.

5. A vapor generator organization as recited in claim 3 wherein said tube sheet means comprises a single tube sheet located in the lower portion of said vessel dividing the same into a lower hot fluid section and an upper vapor generating chamber and said tube bundle comprise a plurality of U-shaped tubes attached to said tube sheet and vertically extending therefrom.

6. A vapor generator organization as recited in claim 3 wherein said tube sheet means comprises a first tube sheet located in the upper portion of said vessel and a second tube sheet located in the lower portion of said vessel spaced from said first tube sheet thereby defining an upper hot fluid inlet section, a lower hot fluid outlet section and a vapor generating chamber therebetween and said tube bundle comprises a plurality of straight tubes extending between said tube sheets and having their ends attached to said tube sheets.

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