Aug. 23, 1966 W. E. GLAUSSER ET AL 3,267,907

STEAM GENERATOR

Original Filed Dec. 5, 1960 4 Sheets-Sheet 1

FIG. 2.

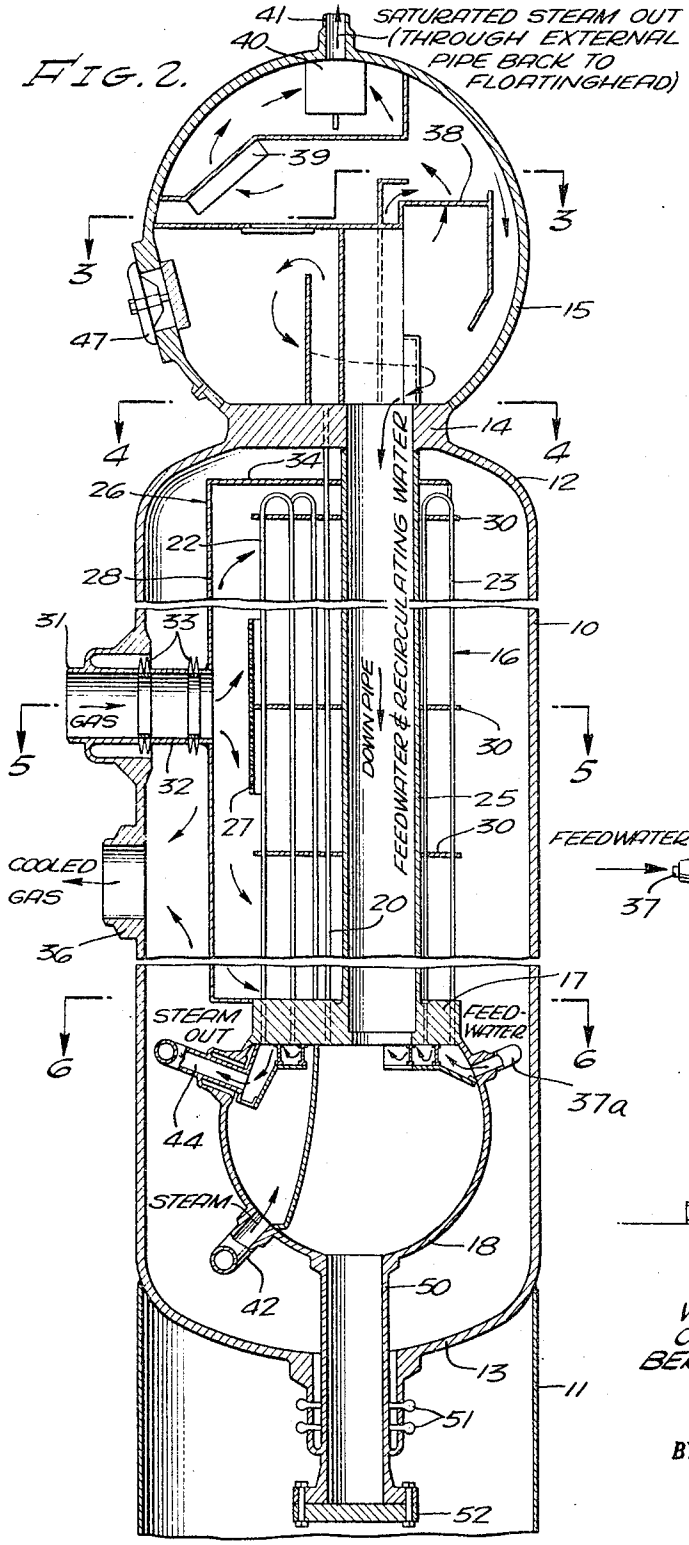
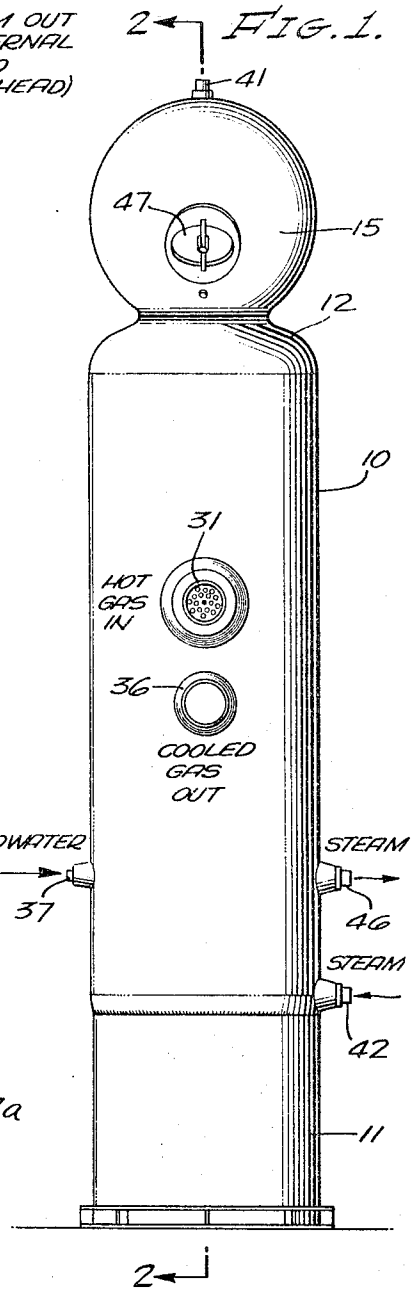


FIG. 1.



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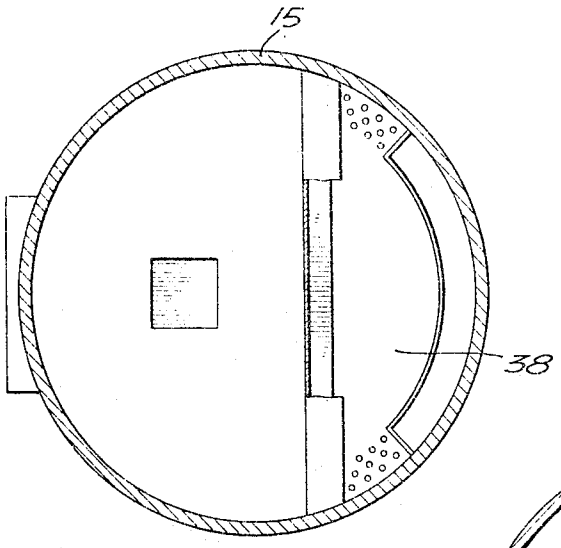
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STEAM GENERATOR

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FIG. 3.



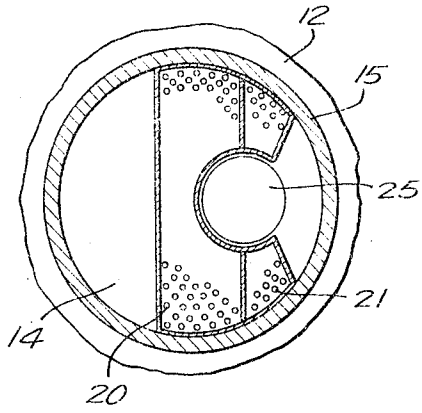


FIG. 4.

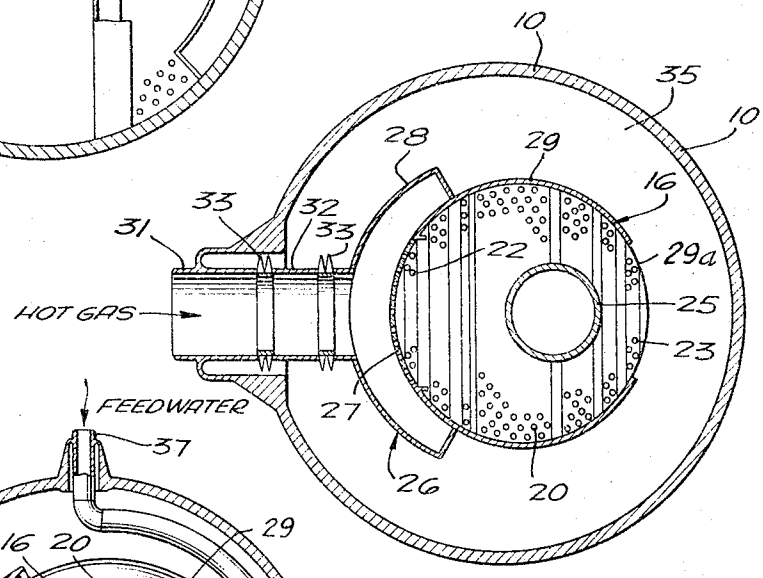
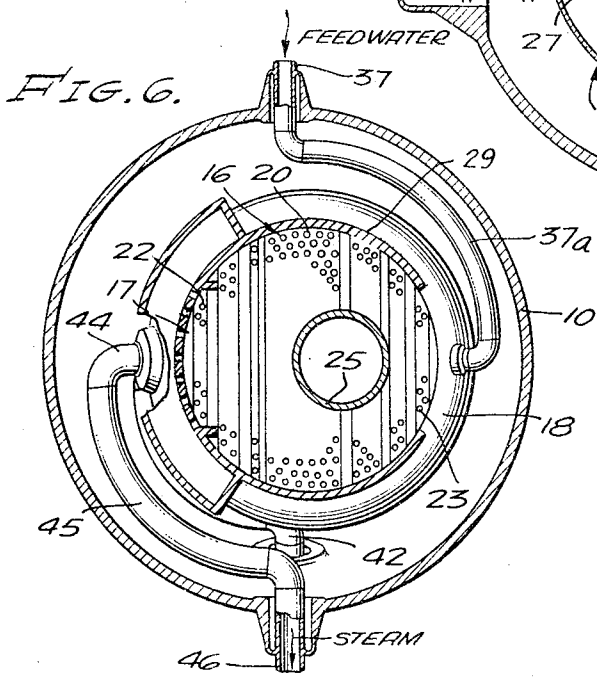


FIG. 5.

FIG. 6.



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STEAM GENERATOR

Original Filed Dec. 5, 1960 4 Sheets-Sheet 3

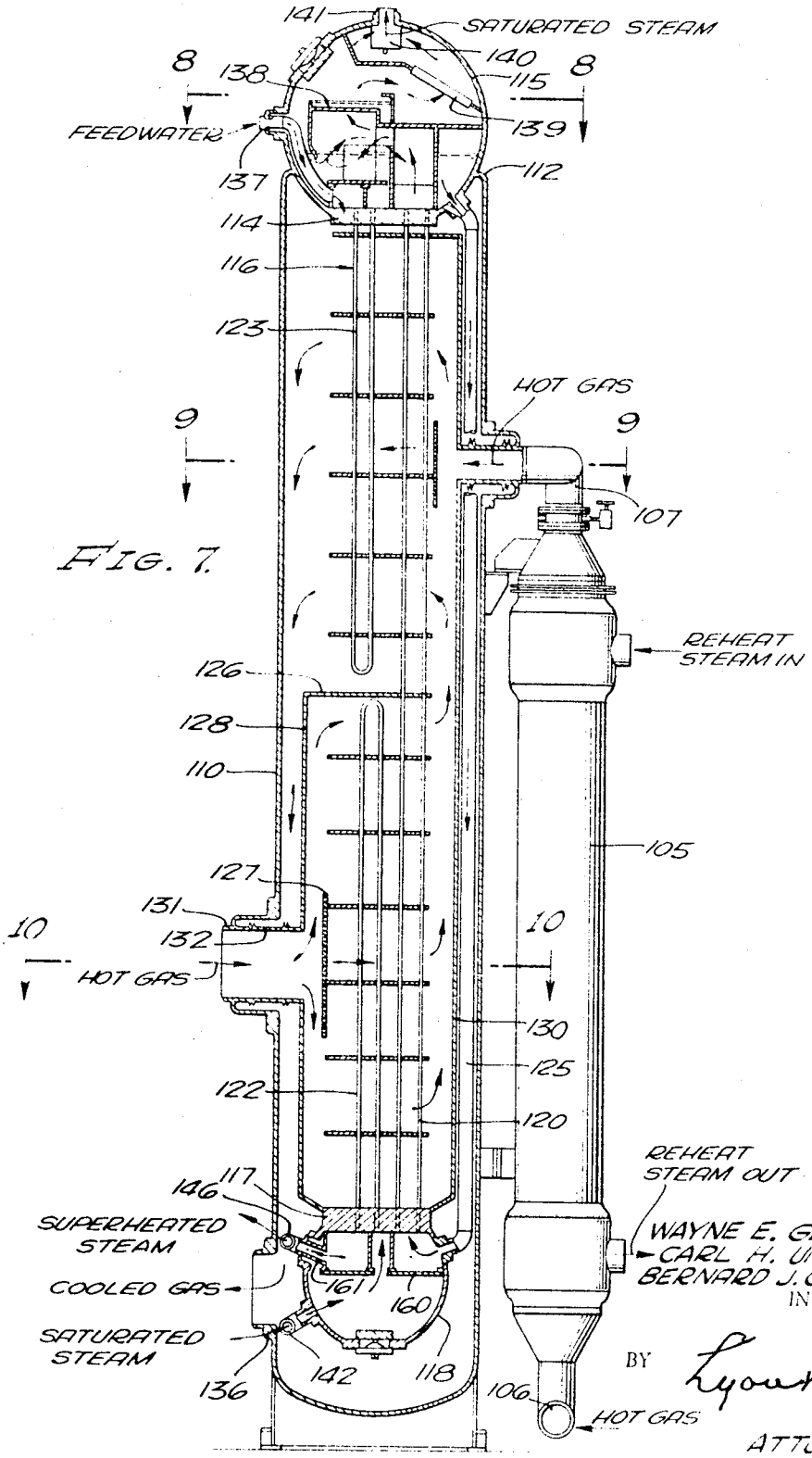


FIG. 7.

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STEAM GENERATOR

Original Filed Dec. 5, 1960 4 Sheets-Sheet 4

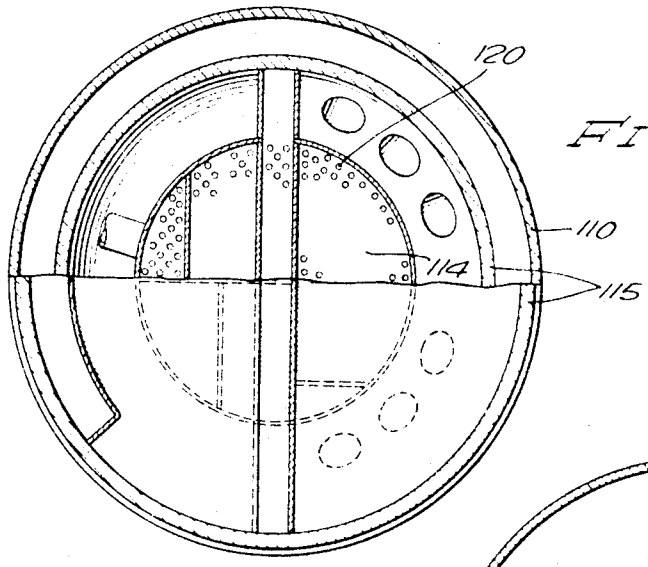


FIG. 8.

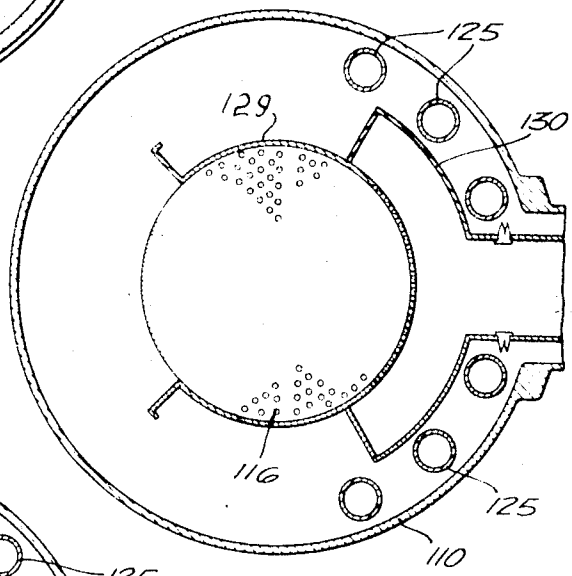


FIG. 9.

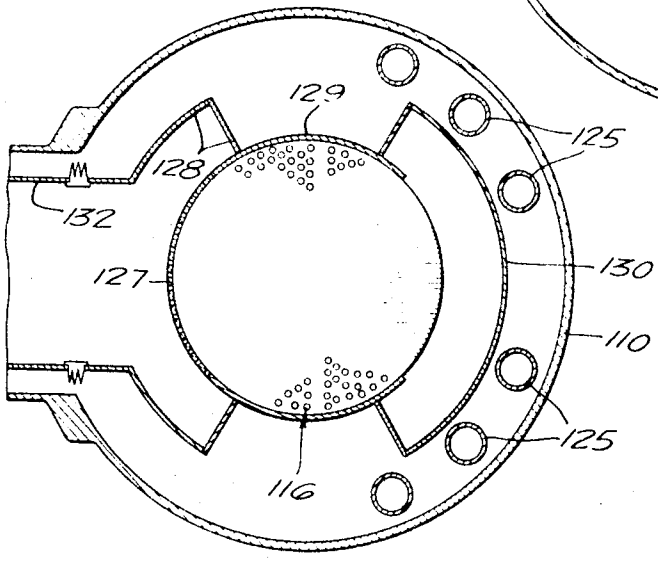


FIG. 10.

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United States Patent Office 3,267,907 Patented August 23, 1966

3,267,907

STEAM GENERATOR

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Continuation of application Ser. No. 73,615, Dec. 5, 1960. This application Aug. 27, 1963, Ser. No. 304,939
19 Claims. (Cl. 122—34)

This application is a continuation of our application Serial No. 73,615, filed December 5, 1960 and now abandoned.

This invention relates to heat exchange apparatus and is particularly directed to improvements in steam generators which are constructed to use hot gases in large volume as a source of heat. Steam generators embodying this invention have been found especially useful for producing steam by utilizing a flow of hot gas issuing from a nuclear reactor.

An object of this invention is to provide a steam generator comprising a heat exchanger of the shell-and-tube type wherein a single bundle of tubes includes both straight tubes and U-bend tubes, or all U-bend tubes. Hollow spheres with integral tube sheets serve as the steam drum and the floating head. The hot gases at inlet temperature do not impinge directly on the outer shell. Instead, internal metallic shrouds direct the hot gases across the straight tubes and U-tubes in either single pass or multiple pass. Not until the gases have given up a large part of their heat to the tube bundle are the gases discharged into the outer shell.

Another object is to provide a steam generator in which the superheater tubes, evaporator tubes and economizer tubes are all contained in a common vertical tube bundle enclosed within a shroud, and wherein the hot gases pass horizontally across the tube field. This construction is superior to the conventional horizontal tube construction wherein undesirable high superheater tube metal temperatures and steam temperatures are produced during periods of very low gas flow. With the vertical tube bundle construction embodying this invention, thermal recirculation currents are set up at very low gas flow rates and these currents serve to cool the superheater steam and lower the hot gas temperature, thereby preventing excessive tube metal and steam temperatures.

Another object is to provide a steam generator of this general type having a single downcomer tube extending between the steam drum sphere and the floatinghead sphere for conducting recirculating water therebetween. The downcomer tube reduces the area for flow of the hot gases, thereby producing higher velocity and maintaining higher heat density as the gases cool. The downcomer tube also serves as an access tube between the two spherical vessels.

Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

FIGURE 1 is a side elevation showing one embodiment of this invention.

FIGURE 2 is a sectional side view taken substantially on the lines 2—2 as shown in FIGURE 1.

FIGURES 3, 4, 5, and 6 are sectional plan views taken substantially on lines 3—3, 4—4, 5—5, and 6—6, respectively, as shown in FIGURE 2.

FIGURE 7 is a sectional side elevation showing a modified form of this invention.

FIGURES 8, 9, and 10 are sectional plan views taken substantially on lines 8—8, 9—9, and 10—10, respectively, as viewed in FIGURE 7.

Referring to the drawings, the upright shell or pressure vessel **10** is carried by a suitable support **11**. The shell

10 is generally cylindrical in shape, having rounded ends or domes **12** and **13**. The dome **12** is integrally joined with the tubesheet **14**. Also integrally joined with tubesheet **14** is the hollow sphere **15** which serves as the steam drum. This construction is similar to that shown in the Haight Patent No. 2,919,906.

The tube bundle generally designated **16** extends from the tubesheet **14** to the floatinghead tubesheet **17**, which is integrally joined with and forms a part of the hollow spherical floatinghead **18**. All of the evaporator tubes **20** and some of the economizer tubes, designated **21**, are straight tubes and are attached to both the steam drum tubesheet **14** and to the floatinghead tubesheet **17**. The superheater tubes **22** and some of the economizer tubes, designated **23**, which comprise the first passes, are U-bend tubes extending upward from the floatinghead tubesheet **17**. A single large diameter downcomer pipe **25** is located within the tube bundle and is connected to both tubesheets **14** and **17**.

Internal shrouds direct the flow of hot gases across and through the tube bundle **16** in a single pass. The skeleton structure of the tube bundle **16** is supported on the floatinghead tubesheet **17** and is free to expand in relation to the shell **10** and tube bundle **16**. The bundle skeleton **26** includes the curved perforated plate **27**, the flow directing shrouds **28** and **29**, and the horizontal tube support plates **30**. The inlet pipe **31** for hot gases connects to the distribution shroud **28** through a duct **32** provided with expansion joints **33**. The straight evaporator tubes **20** and the downcomer **25** pass through a horizontal plate **34** at the top of the skeleton **26** and the U-bend tubes **22** and **23** are contained within the skeleton **26**. The evaporator tubes **20** and the downcomer **25** operate at about the same temperature and have very little tendency for differential expansion.

It will be noted that the tube bundle **16** is not concentrically mounted within the shell **10**, but is displaced laterally away from the inlet pipe **31**. Similarly, the vertical downcomer **25** is displaced laterally in the same direction from the central axis of the shell **10** and also from the central axis of the tube bundle **16**.

The hot gases entering the inlet pipe **31** strike the perforated plate **27**, thereby preventing direct impingement on the tubes **22**, and the shroud **28** provides good distribution of the hot gases along the length of the tube bundle **16**. The shroud **29** directs the flow of hot gases across and through the tube bundle **16**. The gases then flow through the longitudinal opening **29***a* in the shroud **29** and into the annular space **35** (see FIGURE 5) between the shroud **29** and the shell **10**, and to the outlet duct **36** mounted on the shell **10**.

Feedwater enters the inlet pipe **37** (see FIGURE 6) and passes through curved pipe **37***a* to the floatinghead **18**. The feedwater makes several passes through the U-bend economizer tubes **23** and then one pass through the straight economizer tubes **21** up to the steam drum **15**. In the steam drum, feedwater is directed across a contact tray **38** to wash entrained solids from the steam. The feedwater mixes with recirculating water and flows through the downcomer **25** back into the floatinghead **18**. Water enters the evaporator tubes **20** in the floatinghead **18**, and the water boils as it rises to the steam drum **15**. Water recirculates through the downcomer **25**. The steam passes through the perforated wash tray **38** and through mechanical separators **39** and **40** to the steam outlet **41** at the top of the steam drum sphere **15**. The dry and saturated steam issuing through outlet **41** flows through an external pipe (not shown) to the inlet **42** connected to the floatinghead **18**. The steam makes two or more passes through the U-bend superheater tubes **22** and leaves at the bottom of the unit through outlet

duct **44**, curved pipe **45** (see FIGURE 6), and through the steam outlet pipe **46**.

It will be observed that the downcomer **25** has several important functions. It provides a channel for the recirculating water to flow from the steam drum **15** to the floatinghead **18**. Its position in the tube field serves to accomplish flow rate acceleration for the hot gases as their temperature drops while passing through the tube bundle **16**. The downcomer **25** also provides access to the interior of the floatinghead **18**, since it is made large enough to permit a man to pass through the interior thereof from the upper sphere **15** to the lower sphere **18**. The upper sphere **15** has a removable closure **47**, which is large enough to permit a man to enter the interior of the steam drum **15**.

In some cases it may not be desirable to use the downcomer **25** as a means for access to the interior of the floatinghead **18**. In such case, a special access tube **50** is provided at the bottom of the floatinghead **18** and extends through the bottom dome **13** of the shell **10** by means of an expansion joint **51**. The access tube **50** is provided with a flanged and bolted coverplate **52**.

The use of the hollow spherical vessels **15** and **18** with integral tubesheets **14** and **17**, respectively, provides important advantages. Among these are that space is provided for interpass chambers in the economizer and superheater sections. The superheater interpass chamber can be thermally isolated from the walls of the pressure sphere. Tubesheet terminals are provided for the steam generating tubes. Space is provided for water storage and for steam and water separation. The lower spherical vessel **18** is a floating header. It is not directly attached to the pressure vessel **10** containing the hot gases, and it is free to expand with relation thereto. The metal shrouds **28, 29** act as a floating thermal sleeve to permit operation of the pressure vessel **10** at a lower temperature than the temperature of the hot gases entering the inlet pipe **31**. The shrouds contain the hot gases and distribute them to obtain uniform flow to all parts of the tube bundle **16**.

The combination of U-bend tubes and straight tubes in the same tube bundle have the following advantages:

The U-bend tubes prevent high stresses caused by differential expansion in the tubes and in the tube-end joints in the economizer and superheater sections. The straight tubes in the evaporator section interconnect the spherical vessels **15** and **18** and provide support for the vessel **18**. The U-bend tubes and the straight tubes are arranged so that the hot gases flow counter-current thermally to the flow of water and steam.

In the modified form of the invention shown in FIGURES 7–10, the construction is such that two gas-flow passes are provided through the tube bundle, rather than the single pass as shown in the construction of FIGURES 1–6. Many construction features are similar in both forms of the invention.

The vertical steam generator shown in FIGURE 7 includes an upright cylindrical shell **110** integrally joined at its upper end **112** to the hollow spherical steam drum **115**. The tubesheet **114** is integrally connected to the steam drum **115** and the tube bundle **116** extends downward from the tubesheet **114** to the tubesheet **117** of the floatinghead **118**. The floatinghead **118** is also formed as a hollow spherical member and is integrally joined to the tubesheet **117**.

Hot gas coming from a source such as a nuclear reactor enters the inlet **131** and passes through the duct **132** and against the perforated impingement plate **127**. This prevents the high velocity gases from impinging directly on the tubes of the tube bundle **116**, and it helps provide for uniform distribution of gas along the length of the tube bundle. The hot gases are directed by the internal shrouds **128** and flow first across the superheater tubes **122** and then across the lower half of the evaporator tubes **120**. Shrouds **129** confine a lateral flow of gas through the tube bundle **116**. The gases then rise through the space within the shroud **130** and pass above the horizontal plate **126** which is fixed to the upper limits of the shroud **128**. The gases then flow laterally from right to left, as viewed in FIGURE 7, across and through the tube bundle **116** and into the interior of the shell **110**. The cooled gas flows down the annular space between the shell **110** and the shroud **128** to the outlet duct **136** near the lower end of the shell **110**.

The external steam reheater **105** may be used for the reheat cycle. Hot gas is delivered to the inlet pipe **106** and emerges from the outlet **107** after giving up some of its heat passing through tubes, not shown, contained within the reheater. The gases passing through the outlet **107** join with the gases leaving the lower half of the evaporator tubes **120** within the shell **110**. The combined streams of hot gases flow across the upper half of the evaporator and then across the economizer tubes **123**.

The feedwater enters the inlet **137** at the steamdrum **115** and enters the economizer tubes **123**. The feedwater flows up and down through the U-bend tubes **123** in the general direction counter-current to the flow of the hot gases. After the feedwater is heated to a boiling temperature, it flows across as vapor-liquid contact tray **138** and then mixes with the recirculating feedwater. The recirculating feedwater flows through a plurality of upright downcomer pipes **125** to the floatinghead sphere **118** where it enters the evaporator tubes **120**. The evaporator tubes **120** are straight and extend between the tubesheets **114** and **117**. The steaming mixture rises in the evaporator tubes **120** to the steam drum **115**. The liquid recycles to the downcomers **125**, and the steam goes to the wash tray **138** to contact incoming feedwater and reduce the entrained solids in the steam. The steam then flows through two mechanical steam separation units **139** and **140** to remove entrained water. Dry and saturated steam leaving the steam drum at the outlet **141** flows through an external pipe (not shown) and enters the floatinghead **118** through the steam inlet **142**. Steam flows up and down through the U-bend superheater tubes **122** countercurrent to the hot gases and leaves at the bottom of the unit through outlet **146**.

The shrouds **128** and **130** direct flow of hot gases across and through the tube bundle **116** and prevent the hot gases from coming into direct contact with the shell **110**. All of the shrouds are supported on the floatinghead **118** and are free to expand in relation to the shell **110** and the tube bundle **116**. The portions of the shroud **128** in contact with the hottest of gases may be constructed of double-thickness plate to reduce heat loss and to limit transfer of radiant heat to the shell **110**.

The superheater tubes **122** and the economizer tubes **123** are U-bends to provide for differential expansion.

The superheater channel **160** is enclosed within the floatinghead **118** and is entirely surrounded by saturated steam. With this design, the hot superheater channel **160** can be designed for differential pressure. Also, the high-pressure floatinghead sphere **118** can be designed for relatively low temperature. The superheater outlet **161** leaves the sphere **118** through a thermal sleeve to protect the sphere from high temperature.

Having fully described our invention, it is to be understood that we do not wish to be limited to the details set forth above, but our invention is of the full scope of the appended claims.

We claim:

1. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, an upright bundle of generally parallel fluid-carrying tubes positioned within said shell, at least some of the tubes having ends fixed to said tubesheet, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing at least a portion of said tube bundle to direct hot gas from

said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle at least once before contacting the interior of said shell, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

2. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, an upright bundle of generally parallel fluid-carrying tubes positioned within said shell, said bundle including evaporator tubes and superheater tubes, means connecting said evaporator tubes to said superheater tubes for serial flow therethrough, at least some of the tubes having ends fixed to said tubesheet, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing at least a portion of said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle at least once before contacting the interior of said shell, said hot gas first contacting the superheater tubes and then contacting the evaporator tubes, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

3. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, an upright bundle of generally parallel fluid-carrying tubes positioned within said shell, said bundle including economizer tubes and evaporator tubes, means connecting said economizer tubes to said evaporator tubes for serial flow therethrough, at least some of the tubes having ends fixed to said tubesheet, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing at least a portion of said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle at least once before contacting the interior of said shell, said hot gas first contacting the evaporator tubes and then contacting the economizer tubes, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

4. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, an upright bundle of generally parallel fluid-carrying tubes positioned within said shell, said bundle including economizer tubes, evaporator tubes and superheater tubes, means connecting said tubes for serial flow therethrough in the order named, at least some of the tubes having ends fixed to said tubesheet, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing at least a portion of said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle at least once before contacting the interior of said shell, said hot gas first contacting the superheater tubes, next the evaporator tubes and then the economizer tubes in that order, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

5. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, an upright bundle of generally parallel fluid carrying tubes positioned within said shell, at least some of the tubes having ends fixed to said tubesheet, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell having a distributor connected to said inlet pipe and having a shroud element enclosing said tube bundle and provided with a longitudinal discharge opening, said shroud means acting to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle at least once before contacting the interior of said shell, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

6. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, an upright bundle of generally parallel fluid-carrying tubes positioned within said shell, at least some of the tubes having ends fixed to said tubesheet, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, and an outlet pipe for discharging cooled gas from said shell, shroud means within said shell to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle at least once before contacting the interior of said shell and to direct gas, which has passed across said tubes to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes, said shroud means including a shroud element enclosing the tube bundle and having a longitudinal discharge opening, said shroud means also having a curved distributor diametrically opposed from said longitudinal discharge opening, said distributor being fixed to said inlet pipe and positioned to direct hot gas into said shroud element.

7. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, a second tubesheet mounted within the shell, an upright bundle of generally parallel tubes positioned within said shell, some of said tubes being connected to both of said tubesheets, a downcomer pipe extending between the said tubesheets within said tube bundle, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing said tube bundle and said downcomer pipe to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle before contacting said shell, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

8. In a steam generator, the combination of: an upright shell, a steam drum supported on the upper end of said shell and comprising a hollow member having a tubesheet connected integrally therewith, an upright bundle of generally parallel tubes positioned within said shell, a hollow floatinghead positioned within the lower portion of said shell and having a floatinghead tubesheet connected integrally therewith, some of said tubes being connected to both of said tubesheets, a downcomer pipe within said tube bundle, said tubes and said downcomer pipe communicating between the interior of the steam drum and the interior of the floatinghead, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing said tube bundle

and said downcomer pipe to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle before contacting said shell, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

9. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, a second tubesheet positioned within the shell, an upright bundle of generally parallel tubes positioned within said shell, a downcomer pipe extending between the tubesheets within said tube bundle, said tube bundle including straight evaporator tubes having opposite ends fixed to said tubesheets, said bundle also including U-bend superheater tubes each having both ends fixed to only one of said tubesheets, means connecting said evaporator tubes and said superheater tubes for serial flow therethrough, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing said tube bundle and downcomer pipe to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle before contacting the interior of said shell, said hot gas first contacting the superheater tubes and then contacting the evaporator tubes, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

10. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, a second tubesheet positioned within the shell, an upright bundle of generally parallel fluid carrying tubes positioned within said shell, a downcomer pipe extending between the tubesheets within the tube bundle, said tube bundle including straight evaporator tubes having opposite ends fixed to said tubesheets, said bundle also including U-bend economizer tubes each having both ends fixed to only one of said tubesheets, means connecting said economizer tubes and said evaporator tubes for serial flow therethrough, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing said tube bundle and downcomer pipe to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle before contacting the interior of said shell, said hot gas first contacting the evaporator tubes and then contacting the economizer tubes, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

11. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, a second tubesheet positioned within the shell, an upright bundle of generally parallel fluid-carrying tubes positioned within said shell, a downcomer pipe extending between the tubesheets within the tube bundle, said tube bundle having straight evaporator tubes having opposite ends fixed to said tubesheets, said bundle also including U-bend superheater tubes and U-bend economizer tubes having both ends fixed to said second tubesheet, means connecting said economizer tubes, evaporator tubes and superheater tubes for serial flow therethrough in the order named, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within said shell connected to said inlet pipe and enclosing said tube bundle and downcomer pipe to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means across and through said tube bundle before contacting the interior of said shell, said hot gas contacting the superheater tubes, the evaporator tubes and the economizer tubes in the order named, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

12. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, an upright bundle of generally parallel tubes positioned within said shell, at least some of said tubes being connected to said tubesheet, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within the shell connected to said inlet pipe and enclosing said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means in a first pass across and through said tube bundle, then longitudinally within the shroud means, and then substantially in a lateral direction within said shroud means in a second pass across and through the tube bundle, all before the hot gas contacts said shell, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

13. In a steam generator, the combination of: an upright shell, means including a tubesheet closing the upper end of said shell, a second tubesheet mounted within the shell, an upright bundle of generally parallel tubes positioned within said shell, at least some of said tubes being connected to both of said tubesheets, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within the shell connected to said inlet pipe and enclosing said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means in a first pass across and through said tube bundle near one of said tubesheets, then longitudinally within the shroud means, and then substantially in a lateral direction within said shroud means in a second pass across and through the tube bundle near the other of said tubesheets, all before the hot gas contacts said shell, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

14. In a steam generator, the combination of: an upright shell, a steam drum supported on the upper end of said shell and comprising a hollow member having a tubesheet connected integrally therewith, an upright bundle of tubes positioned within said shell, a hollow floatinghead positioned within the lower portion of said shell and having a floatinghead tubesheet connected integrally therewith, some of said tubes being connected to both of said tubesheets downcomer pipes positioned within the shell and outside said bundle of tubes and connected to the steam drum and floatinghead, the later said tubes and said downcomer pipes communicating between the interior of the steam drum and the interior of the floatinghead, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within the shell connected to said inlet pipe and enclosing said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means in a first pass across and through said tube bundle, then longitudinally within the shroud means, and then substantially in a lateral direction within said shroud means in a second pass across and through the tube bundle, all before the hot gas contacts said shell, and an outlet pipe for discharging cooled

gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

15. In a steam generator, the combination of: an upright cylindrical shell, a steam drum supported on the upper end of said shell and comprising a hollow spherical member having a circular tubesheet connected integrally therewith, an upright bundle of tubes positioned within said shell, a hollow spherical floatinghead positioned within the lower portion of said shell and having a circular floatinghead tubesheet connected integrally therewith, some of said tubes being connected to both of said tubesheets, downcomer pipes positioned within the shell and outside said bundle of tubes and communicating between the interior of the steam drum and the interior of the floatinghead, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within the shell connected to said inlet pipe and enclosing said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means; in a first pass across and through said tube bundle near one of said tubesheets, then longitudinally within the shroud means, and then substantially in a lateral direction within said shroud means; in a second pass across and through the tube bundle near the other of said tubesheets, all before the hot gas contacts said shell, and an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

16. In a steam generator, the combination of: an upright cylindrical shell, a steam drum supported on the upper end of said shell and comprising a hollow spherical member having a circular tubesheet connected integrally therewith, an upright bundle of tubes positioned within said shell, a hollow spherical floatinghead positioned within the lower portion of said shell and having a circular floating head tubesheet connected integrally therewith, said bundle of tubes including evaporator tubes connected to both of said tubesheets, economizer tubes comprising U-bends connected to the first said tubesheet, and superheater tubes comprising U-bends connected to the floatinghead tubesheet, downcomer pipes positioned within the shell and outside said bundle of tubes, said tubes and said downcomer pipes communicating between the interior the steam drum and the interior of the floatinghead, means connecting the enonomizer tubes, evaporator tubes and superheater tubes for serial flow therethrough, the shell having a lateral inlet pipe for hot gas located adjacent one side of said tube bundle, shroud means within the shell connected to said inlet pipe and enclosing said tube bundle to direct hot gas from said inlet pipe to flow substantially in a lateral direction within said shroud means in a first pass across and through said tube bundle near one of said tubesheets, then longitudinally within the shroud means, and then substantially in a lateral direction within said shroud means in a second pass across and through the tube bundle near the other of said tubesheets, and all before the hot gas contacts said shell, an outlet pipe for discharging cooled gas from said shell, said shroud means being positioned to direct gas, which has passed across said tubes, to said outlet pipe from the interior of the shell while preventing further contact between said gas and said tubes.

17. A steam generator as defined in claim **7**, wherein the shroud means and tube bundle are non-concentrically disposed in the shell.

18. A steam generator as defined in claim **7**, wherein the downcomer pipe is non-concentrically disposed in both the shroud means and the shell.

19. A steam generator as defined in claim **7**, wherein the shroud means and tube bundle are non-concentrically disposed in the shell, and wherein the downcomer pipe is non-concentrically disposed in both the shroud means and the shell, and wherein the non-concentric disposition of the shroud means and tube bundle, and the non-concentric disposition of the downcomer pipe are effected by lateral displacement thereof in a direction away from the inlet pipe.

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