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Wolfgarten

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[54] **STEAM GENERATOR**

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[52] **U.S. Cl.** **122/32;** 122/34

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

[58] **Field of Search** 122/32, 33, 34

[56] **References Cited**

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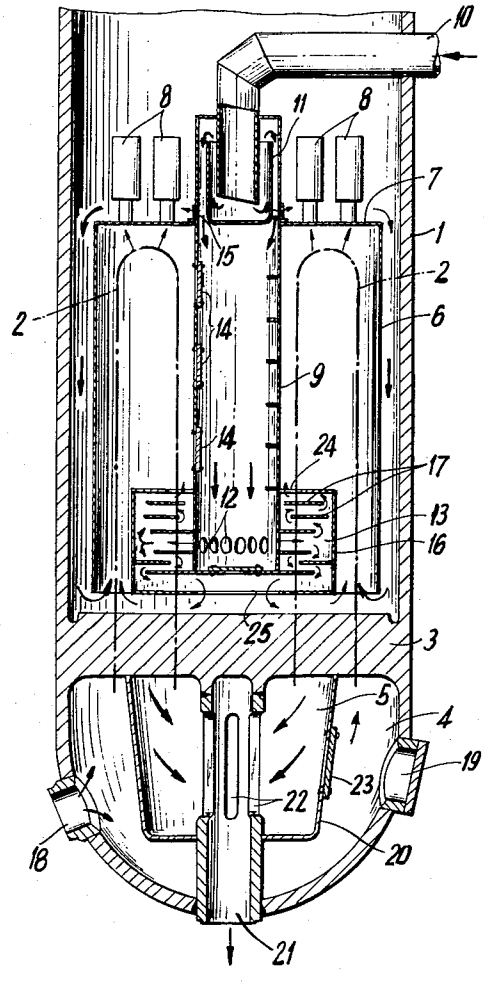
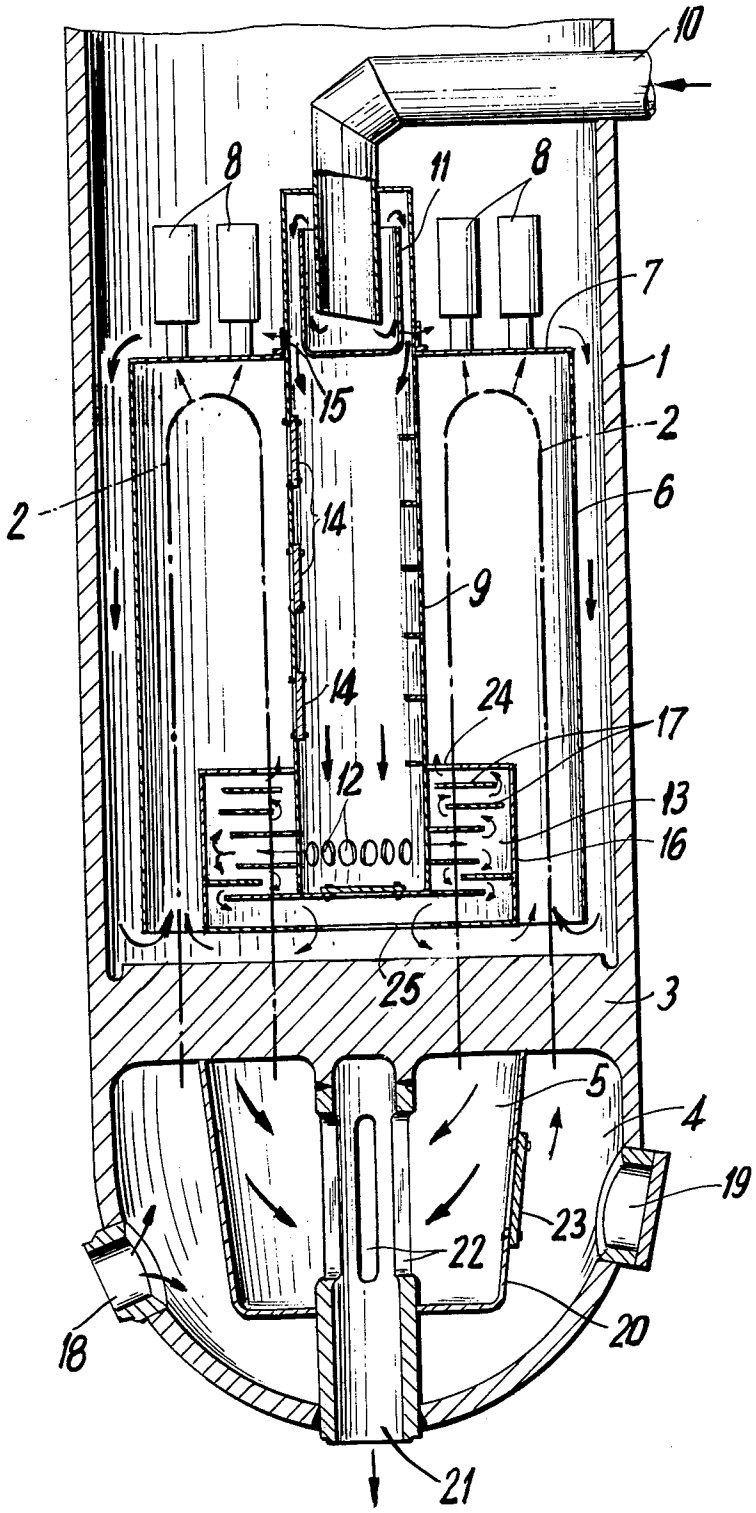
[57] **ABSTRACT**

A steam generator having a bundle of U-shaped tubes fixed to a tube sheet within the casing. A feed-water pipe extends between the tubes and extends into a pre-heating chamber surrounding the outlet legs of the tubes. The pipe has openings at its bottom end to allow the water to enter the pre-heating chamber, and openings at the top end above the top cover plate of the shell encasing the tube bundle for supplying feed-water to the steam separators on the cover-plate.

2 Claims, 1 Drawing Figure

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STEAM GENERATOR

The present invention concerns a steam generator in the casing of which U-shaped tubes are installed through which a heating agent flows and which are fixed in a tube sheet.

In steam generators preference is generally given to U-shaped tubes, this permitting a better control of different thermal expansion of tubes relative to the casing shell. With the steam generators previously known, feed water is supplied from a ring main arranged above the shell into which the tube bundle is installed. On top of the shell cover plate steam separators are arranged. The feed water supplied through the ring main is mixed with the water flowing out of the separators at saturation temperature. This mixing process offers the advantage of immediate condensation of any steam possibly present in the return water.

However, mixing the feed water with the return water on the other hand entails as a disadvantage that the average differential temperature between the tube-side and shell-side media, which is crucial for the determination of the preheating area, is only about 80 – 85% of the level that could be achieved if the two media concerned were conducted in an optimum way. A similarly adverse effect is produced by this way of flow conduct on the average differential temperature crucial for the determination of the vaporization area. The heat transfer area required is inversely proportional to the average differential temperature. At the same thermal output and same overall heat-transfer coefficient it would thus be possible under the above conditions to save 15 – 20% of area in designing the steam generator. Considering that depending on the tube material used the cost of the heat transfer area amounts to about 30% of the total cost of a steam generator, the said in area offers an obvious advantage.

One of the features of the previously known steam generators is a strong variation in the heat flow density — or heating-area loading — along the flow path in the tubes, as a function of the design of the tube bundle and the temperature characteristics. The heating-area loading and as a consequence the steam generation rate per unit of area are proportional to the differential temperature between the tube-side and shell-side media. This leads to more steam being generated by the heating area located on the tube-inlet side than by the area on the tube-outlet side. Expressed in figures, the one vertical heating-area half will generate about 65% and the other only about 35% of the total steam quantity produced. In operation, this results in inadequate water admission rate to the higher loaded heating-area half closely above the tube sheet in the outer space therefor, leading to deposition of material and tube damage by corrosion.

Further, an unequal steam generation rate over the cross-section of the generator is accompanied by an unequal distribution of the specific density of the steam/-water mixture, causing unilateral mechanical stresses in the tube bundle on account of cross flow.

The temperature of the tube-side heating medium changes along the flow path as a function of the heat transfer rate, with saturation temperature of the mixture prevailing on the outer tube side. This means that the tube-wall temperature is subject to change over the tube length, approximating the average value of the respective tube outside and inside temperatures. As a consequence, the U-tube leg through which the medium flows first has a higher average temperature than a lower one. In operation, this difference in the average temperatures will lead to a different elongation of the tube legs, causing unilateral mechanical stresses in the tubes, particularly in the curved area.

The task of the present invention was to eliminate the above disadvantages inherent in steam generators previously known, by a different way of supplying and preheating the feed water.

In the steam generator specified at the beginning and incorporating the features of the present invention this task is accomplished by an symmetrical arrangement of the U-tubes and by a pre-heating chamber encircling the outlet legs of the tubes along the longitudinal axis near the tube sheet and the side walls of which extend in axial direction, further by the provision of supply openings for the admission of feed water to the preheating chamber. A particularly favourable effect can be achieved by designing the steam generator so that the outlet legs of the tubes are arranged around the central longitudinal axis of the generator, and by further installing along this axis an inner feed-water supply pipe extending close to the tube sheet.

A steam generator designed in accordance with the present invention offers the advantage of direct contact being established between the feed water and the heating areas, with the feed-water temperature not being increased through mixing with the return water.

Consequently, a higher differential temperature is available between the tube-side and shell-side media, both in the pre-heating and vaporization areas, which means that the heating area required can be reduced for the same thermal output.

Admission of an adequate quantity of water to the hot tube areas above the tube sheet is ensured by preheated feed water flowing in from the one side and return water from the other. Therefore, deposition of material on account of an inadequate water admission rate cannot occur.

By the symmetrical arrangement of the U-tubes and by the provision of a pre-heating chamber, all heating areas are fully utilized for steam generation, which means that the disadvantages inherent in an unequal steam generation rate need not be feared.

Further, the special way of feed-water supply described above ensures even mechanical stresses in both legs of each individual U-tube. Finally, even thermal loading of the tube sheet is guaranteed by the symmetrical arrangement of the tubes, making calculation work much easier.

Although the symmetrical arrangement of the U-tubes is already known from the German first notice of disclosure No. 1,932,322, it is not this arrangement alone which yields the favourable results characteristic of steam generators designed according to the present invention. Steam generators previously known do not incorporate the special way of arranging the preheating chamber with the consequential possibility of feed-water supply as above.

From the German first notice of disclosure No. 2,054,578 there is further known the provision of a preheating chamber encircling the outlet ends of straight tubes in a steam generator. However, this design requires two expensive tube sheets, and further the different thermal expansion of the tubes relative to the casing shell is difficult to control. In steam generators de-

signed according to the present invention these disadvantages are eliminated by the use of U-tubes arranged symmetrically.

The above-described steam-generator design in accordance with the present invention further permits the incorporation of the following useful elements.

A central collection chamber is arranged within the distribution chamber, with the outlet nozzle of the former running across the latter. This nozzle can be designed to be supported by the outer shell, in this way carrying the tube sheet, the thickness of which can thus be reduced.

The inner feed-water supply pipe further serves as a water storage reservoir. The space available for this inner pipe comprises the entire inner chamber between the tubes assuming that it is not filled with tubes. The pipe can be designed to be accessible, including the provision of inspection doors.

Further, outlet openings incorporating a flow throttling device to permit the proportioned admission of a flow of feed water can be arranged in the inner pipe at the level of the top cover plate on which the steam separators are mounted. The feed water admitted at this point at a rate of about 10% of the entire feed-water quantity is to ensure condensation of any steam possibly present in the return water.

The present invention will be exemplified below by reference to the drawing enclosed, which is a longitudinal section of a steam generator incorporating the features of the invention:

The steam generator comprises a casing **1** into which U-tubes **2** are installed which are fixed in a tube sheet **3.** The heating agent is supplied through a distribution chamber **4** arranged below the tube sheet **3.** After passing through the tubes **2,** the heating agent enters a collection chamber **5** from which it is led off.

Within the casing **1** the tubes **2** are encased in a shell **6** extending down to near the tube sheet **3,** with an annular clearance provided beween the shell **6** and the casing **1.** At the top, the shell **6** is sealed off by a cover plate **7** on which the steam separators **8** are mounted.

The U-tubes **2** are arranged symmetrically along the longitudinal axis leaving a free inner space in the longitudinal axis of the steam generator, through which an inner pipe **9** runs and which is sealed off from the shell **6.** The feed-water supply main **10** extends into this inner pipe **9,** with a siphon-type steam trap **11** arranged at the inlet. The inner pipe **9** extends down to near the tube sheet **3** and is closed at the bottom. Openings **12** provided in the inner pipe ensure the supply of feed water to a pre-heating chamber **13** described below. The pipe **9** fills the entire free inner chamber of the steam generator where no tubes **2** are installed. Therefore, it can be dimensioned to serve as a water storage reservoir. In such a case, the annular clearance between casing **1** and shell **6** can be correspondingly smaller. The inner pipe **9** is accessible and provided with lock-up inspection doors **14,** permitting the inspection of at least part of the tubes **2** which was not possible at all with the steam generators previously known.

Above the top cover plate **7** the inner pipe **9** has further outlets **15** the cross-section of which can be adjusted. These outlets **15** permit a part of the feed-water flow to pass through, with the main flow being admitted to the steam generator through the supply openings **12.** The feed water admitted through outlets **15** is mainly intended to condense any steam present in the return water from the steam separators.

The pre-heating chamber **13** encircling the outlet legs of tubes **2** has closed side walls **16** extending in axial direction along the central axis of the symmetrically arranged tube bundles. The pre-heating chamber is divided by radial baffle plates **17.** The feed water admitted to the pre-heating chamber through openings **12** arranged at half the chamber height flows around the baffle plates **17** as shown by arrows in the drawing enclosed, and leaves the pre-heating chamber **13** at the top and bottom through outlets **24** and **25.** Another flow of water consisting of return water and the smaller feed-water supply and coming from the annular clearance between the casing wall and the shell flows into the space between the tubes of the bundle. In this way, water will flow around the tubes from all sides thus avoiding the deposition of material in the lower tube-bundle area.

The distribution chamber **4** has the form of a ring and incorporates an inlet nozzle **18** for the admission of the heating agent. The chamber is accessible to permit the plugging of individual tubes **2** from the tube sheet should the need arise. For this purpose, the distribution chamber includes a manway **19.**

The collection chamber **5** is separated from the distribution chamber **4** by a cup-shaped plate **20.** The outlet nozzle **21** of the collection chamber **5** extends across the ring-shaped distribution chamber **4.** In the case under consideration the outlet nozzle is arranged centrally and provided with slots **22** through which the heating agent flows from the collection chamber **5** into the outlet nozzle **21.** The nozzle **21** further has the function of an intermediate carrying element for support of the tube sheet **3** via a dished head of the casing **1.** As a consequence, the thickness of the tube sheet can be reduced. The collection chamber is likewise accessible. To minimize the time of sojourn of the maintenance personnel in the collection chamber **5,** the manway **23** of this chamber is arranged opposite the manway **19** of the distribution chamber **4.** Due to this, the manway **23** can be opened from the outside. It would also be possible to enter the collection chamber through a nozzle extending across the distribution chamber **4** and closed at the outside.

What I claim is:

1. A steam generator comprising a casing, a tube sheet, a bundle of U-shaped tubes having inlet and outlet legs mounted within said casing directing the flow of the heating agent, a shell encasing said bundle having a top cover plate, steam separators on said top plate, said bundle of tubes fixedly secured to said tube sheet and arranged symmetrically about the longitudinal axis of the steam generator, a pre-heating chamber encircling said outlet legs near said tube sheet for pre-heating the feed-water, the sides of said chamber extending axially, the supply means lying between the tubes of the tube bundle and extending into said chamber for admitting feed-water into said pre-heating chamber, said supply means comprises a pipe extending near said tube sheet, said pipe comprises outlet openings above said top cover plate, and said outlet openings having a flow throttling means for permitting a specified portion of the feedwater to flow around said steam separators.

2. A steam separator comprising a casing, a tube sheet, a bundle of U-shaped tubes having inlet and out-

let legs mounted within said casing for directing the flow of a heating agent, a shall encasing said bundle having a top cover plate, steam separators on said plate, said bundle of tubes fixedly secured to said tube sheet and arranged symmetrically about the longitudinal axis of the steam generator, a pre-heating chamber encircling said outlet legs near said tube sheet for pre-heating the feed-water, the sides of said chamber extending axially, supply means lying between tubes of tube bundle, and extending into said chamber for admitting feed-water to said pre-heating chamber, said supply means comprises a pipe extending near said tube sheet, and said pipe comprises a siphon-type trap at the upper end of said pipe to prevent steam from entering said pipe.

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