United States Patent [19]

Andrieu et al.

[11] **3,906,905**

[45] **Sept. 23, 1975**

[54] **STEAM GENERATOR**

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[22] Filed: **Aug. 20, 1974**

[21] Appl. No.: **498,924**

[52] **U.S. Cl.** **122/32;** 122/34; 165/146; 165/163

[51] **Int. Cl.²** **F22B 1/06**

[58] **Field of Search** 165/74, 82, 146, 158, 163; 122/32, 34

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[57] **ABSTRACT**

In a steam generator provided with a tube plate pierced by holes to which are connected the ends of a bank of U-tubes adapted to carry a circulation of primary fluid and surrounded externally by a secondary fluid, the ends of the U-tubes are disposed in spaced relation in the tube plate with a pitch of decreasing value in the direction of flow of the secondary fluid, the tube arms through which the hot primary fluid circulates being disposed with a pitch of higher value than that of the tube arms through which the cold primary fluid circulates.

6 Claims, 5 Drawing Figures

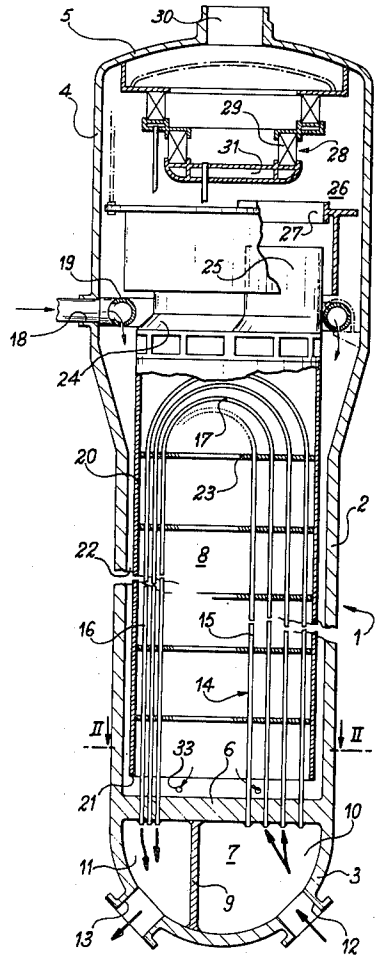


FIG. 1

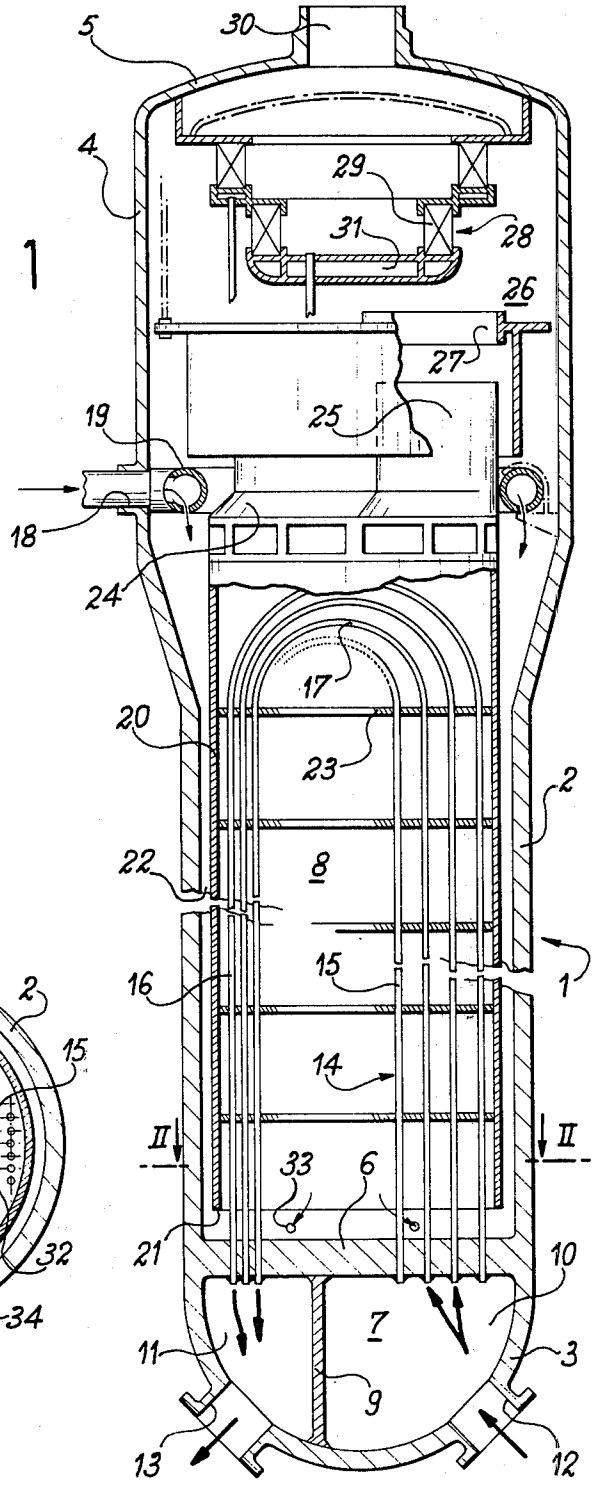
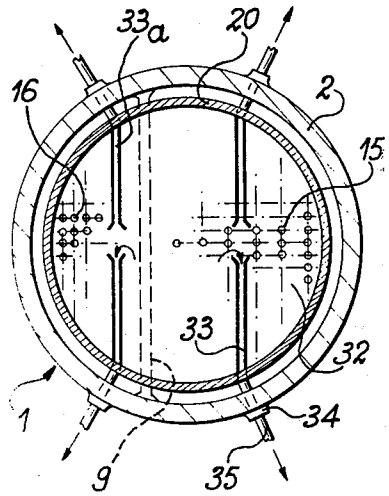

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FIG. 2


33a
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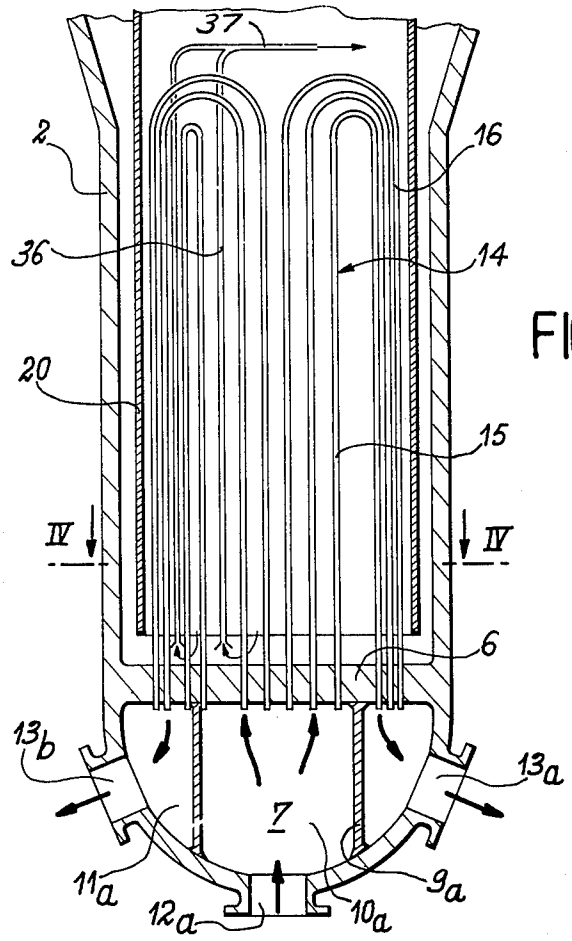


FIG. 3

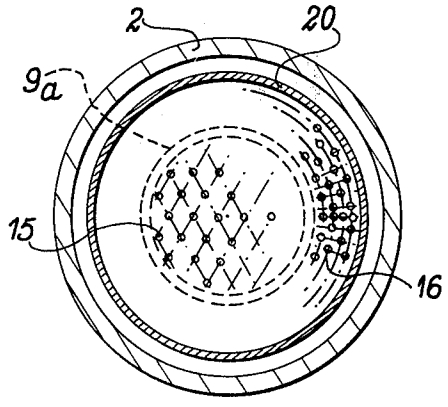


FIG. 4

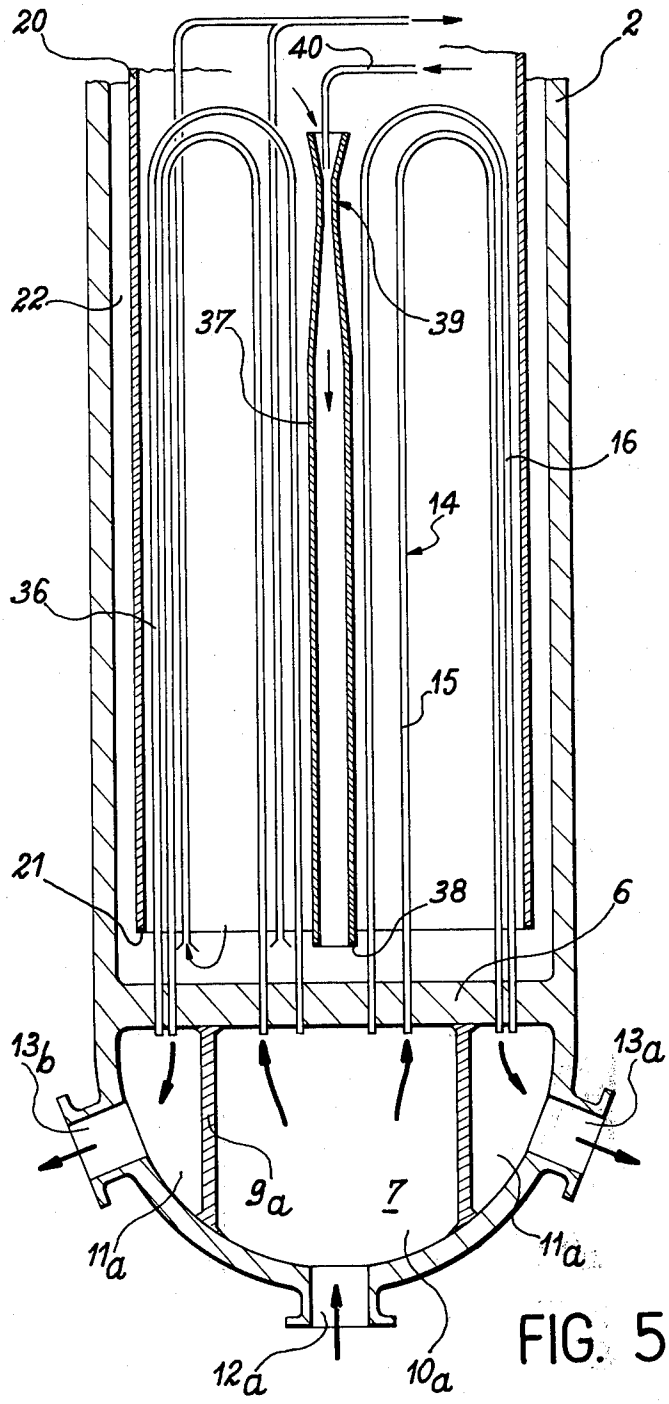


FIG. 5

STEAM GENERATOR

This invention relates to a steam generator, especially of the type comprising a tube plate pierced by holes to which are connected the ends of a bank of U-tubes, said tubes being intended to carry a circulation of primary fluid and being surrounded externally by a secondary fluid usually consisting of water and vaporized under the conditions of operation of the generator by the primary fluid which exchanges heat through the tube walls.

In more exact terms, the invention applies to a U-tube steam generator comprising an outer casing or shell having a vertical axis and divided into two sections by a tube plate which is disposed horizontally. The first section which is located beneath the tube plate and into which the U-tubes open through this latter is divided by means of an internal partition into a zone for the admission of primary fluid and a zone for the discharge of primary fluid which has passed through the tubes. The second section of the steam generator shell comprises an annular header-pipe for the admission of secondary fluid and an internal cylindrical skirt surrounding the bank of U-tubes and extended at the top portion located above the tube bank by a separating assembly connected to a duct for the discharge of the vapor produced. The secondary fluid passes between the tubes of the bank after penetrating through the lower end of the skirt between the tube plate and said skirt, then circulates between the tubes in the direction of the vertical axis of the outer shell.

In generators of this type which are supplied with secondary fluid through the peripheral portion of the U-tube bank and in which said tube bank has a constant pitch, especially in the lattice of holes through which the tubes are joined to the tube plate, experience has shown that the secondary fluid does not penetrate between the tube arms in an identical manner, depending in particular on whether the circulation within said tube arms consists either of the hot primary fluid derived from the zone of admission beneath the tube plate or on the contrary of the primary fluid which is cooled by exchange with the secondary fluid and which returns to the tube plate and the discharge zone.

It appears in particular that cooling of the U-tubes located in the central and hottest portion of the tube bank is often insufficient since the secondary fluid reaches these tubes with much greater difficulty than at the periphery. Moreover, despite all the precautions which are taken, different impurities are always carried along with the secondary fluid, especially mineral salts and iron oxide which form sludges at the time of vaporization by heat exchange; these sludges also have a tendency to accumulate in the central portion of the tube bank against the tube plate.

The sludges just mentioned have the effect of reducing the coefficient of cooling of the tubes and are liable as a result of decomposition in the steam to cause the formation of compounds which have a corrosive action on the metal of the tubes; in particular, this local vaporization of the secondary fluid is liable to cause drying of the sodium phosphate which is usually incorporated in the secondary fluid for the purpose of reducing corrosion. As a consequence, said sodium phosphate is converted to sodium hydroxide which is liable to damage the tube bank of the generator in a very short time. Finally, sludges derived from the secondary fluid and deposited against the tube plate can be removed from the generator only with difficulty as a result of the presence of the tube bank, which also constitutes a major disadvantage.

This invention is directed to a steam generator in which the particular structure and arrangement of the bank of U-tubes carried by the tube plate circumvent the disadvantages of conventional designs. The arrangement proposed permits the possibility of improving the circulation of the secondary fluid within the tube-bank section through which the hot primary fluid circulates, especially within the section located at the greatest distance from the peripheral region of admission of said secondary fluid, by making provision in addition for simple and effective devices which serve to draw-off sludges and which can be mounted within these sections.

To this end, the generator under consideration is characterized in that the ends of the U-tubes of the bank are disposed in spaced relation in the tube plate with a pitch of decreasing value in the direction of flow of the secondary fluid, the tube arms through which the hot primary fluid circulates being disposed with a pitch of higher value than that of the tube arms through which the cold primary fluid circulates.

Depending on requirements, the U-tubes of the bank are disposed in parallel planes, the tube arms through which the hot primary fluid circulates being disposed in spaced relation in a lateral direction contained in the plane of said tubes. Alternatively, the tubes are disposed in approximately radial planes, the tube arms through which the hot primary fluid circulates being disposed in spaced relation in a central zone of the tube plate surrounded by a peripheral zone containing the arms through which the cold primary fluid circulates.

In accordance with a particular feature of the invention, the tube arms through which the hot primary fluid circulates delimit transverse passageways occupied by ducts having their openings in the vicinity of the tube plate for the suction of sludges formed in the secondary fluid.

In accordance with yet another characteristic feature, the transverse passageways are supplied with an additional flow of secondary fluid circulated through plunger tubes disposed vertically between at least a certain number of the U-tubes, said plunger tubes being each associated at the end remote from the tube plate with a venturi for mixing with the reheated secondary fluid which is withdrawn from the upper section of the tube bank.

Further characteristic features of a steam generator as constructed in accordance with the invention will become apparent from the following description of a number of examples of construction which are given by way of indication without any limitation being implied, reference being made to the accompanying drawings, wherein:

FIG. 1 is a diagrammatic longitudinal sectional view of a first embodiment of the steam generator under consideration;

FIG. 2 is a transverse sectional view taken along line II—II of FIG. 1;

FIG. 3 is a partial longitudinal sectional view of an alternative embodiment of the generator;

FIG. 4 is a sectional view taken along line IV—IV of FIG. 3;

FIG. 5 is a partial sectional view of another alternative embodiment, this view being drawn to a larger scale.

In the different figures listed above, the same reference numerals serve to designate identical components.

The generator which is illustrated in FIG. 1 and generally designated by the reference numeral 1 is mainly composed of a cylindrical shell 2 which has a vertical axis and defines the outer casing of the generator, said shell being closed at the lower end by a hemispherical end 3. The shell 2 has an extension at the opposite end in the form of a second shell 4 which is in turn closed by a top domical end 5. The generator casing thus defined is separated internally by a horizontal tube plate 6 which delimits two regions 7 and 8 located respectively beneath and above the tube plate 6. Said regions are reserved for the circulation on the one hand of a primary fluid and on the other hand of a secondary fluid which are separate from each other, the secondary fluid which usually consists of water being intended to be vaporized within the generator by heat exchange with the primary fluid in the manner which will be explained hereinafter.

The region 7 located beneath the tube plate 6 is separated by a transverse partition 9 which, in the example of construction shown, extends at right angles to the tube plate 6 and at right angles also to the plane of the figure so as to delimit within said region 7 two zones 10 and 11 respectively, into which open nozzle-ducts 12 and 13 for the admission and discharge of the primary fluid. Said fluid is fed into the generator at a given temperature and pressure and flows through the tube plate 6 into the upper section 8 of the shell through a bank of U-tubes which are carried by the tube plate and the ends of which pass through bores formed in this latter in suitably spaced relation. Each U-tube 14 has two arms 15 and 16 respectively which are joined together at the top end by bends 17. In the drawings, the arm 15 through which the primary fluid circulates after passing into the tube considered constitutes the "hot leg" of said tube whilst the portion 16 through which the same fluid is discharged from the tube and then returns into the region 11 constitutes the "cold leg" of said tube.

The secondary fluid penetrates into the interior of the outer generator casing through a duct 18 which opens into the shell 4 and has an extension in the form of an annular header-pipe 19 which serves to distribute the secondary fluid within the upper section 8, said secondary fluid being usually water. A cylindrical skirt 20 is placed around the bank of U-tubes 14 within said upper section 8 and in coaxial relation with the shell 2. The lower end 21 of said skirt is located at a short distance above the tube plate 6 without being in contact with this latter so that the secondary fluid derived from the header 19 and flowing within the annular space delimited between the skirt 20 and the shell 2 is permitted to pass beneath said skirt so as to circulate outside the U-tubes 14 in contact with the arms 15 and 16 of these latter. It is advantageous to ensure that the tube bank 14 is suitably maintained in position and protected in particular from vibrations by mounting within the skirt 20 a series of spacer plates 23 which are provided with open portions or preferably mounted as a baffle system so as to maintain the different tubes at a predetermined spacing without interfering with the upward flow of secondary fluid. The baffles have the advantage of producing a stirring action on the secondary emulsion and consequently better homogenization of the secondary temperatures around either the hot leg or the cold leg of the tube bank.

The secondary fluid is vaporized in contact with the tubes 14 by heat exchange with the primary fluid as this latter circulates within said tubes, then passes through an upper shell 24 forming an extension of the skirt 20 and is collected by cyclone devices 25, the steam produced being forced towards the top portion of the generator through passages 27 towards an end zone 26. Said zone contains an assembly 28 comprising drying units 29 of a type which is known per se, in which the steam is freed from any droplets of liquid which it may have entrained. The dry steam finally escapes from the generator through an outlet 30 provided in the domical end 5 whilst the separated liquid portion is collected if necessary in a bottom collector 31.

As shown more clearly in FIG. 2 which is a transverse sectional view of the lower section of the steam generator under consideration, the U-tube bank 14 is so arranged that the pitch of the hot legs 15 of said tubes at the points of penetration of these latter into the tube plate 6 is substantially greater than the pitch of the ends of the cold legs 16 in the same tube plate. In this case, by reason of this dissymmetry of the pitch, the partition 9 formed in the region 7 beneath the tube plate is displaced to the left of the drawing, the hot legs 15 of the U-tubes being intended to occupy a region which is substantially larger in total volume than that which corresponds to the cold legs 16.

Under these conditions, the secondary fluid which comes from the space 22 between the skirt 20 and the shell 2, passes beneath the lower end 21 of said skirt and penetrates into the tube-bank 14 is distributed among the hot legs 15 of said tubes 14 in a more effective manner. In particular, said secondary fluid is permitted to reach any of the tubes and especially those located in the central portion of the tube bank without any attendant danger of excessively abrupt local evaporation. This results in better general cooling of the tube bank and especially in elimination of any risk of inhomogeneous vaporization of the water, which accordingly prevents drying of the incorporated products, in particular the sodium phosphate which is usually added to reduce corrosion of the tubes. Moreover, the impurities contained in the secondary fluid and transformed into solid sludges during operation collect under the action of gravity against the top surface of the tube plate 6 and can be readily removed. In fact, by virtue of the substantial pitch of the tube bank within the hot legs 15, there are thus delimited transverse spaces or passageways which are sufficient to permit fitting of draw-off tubes or ducts 33 for the suction of sludges. Said sludges thus pass through a leak-tight penetration 34 within the shell 2 and are then directed through a pipe 35 to a purge unit which is not shown in the drawings. It should be noted that other sludge draw-off tubes such as the tube 33a can also be disposed within passageways formed between the cold legs 16 of the U-tubes although the presence of sludges in these regions is less serious than between the hot legs.

In the example shown in FIGS. 1 and 2, the U-tube bank is so arranged that the whole assembly of tubes is located in a series of parallel vertical planes extending in particular at right angles to the direction of the partition 9. In the alternative embodiment illustrated in

FIGS. 3 and 4, the U-tubes 14 are distributed in the bank in radial planes, the hot legs 15 of said tubes 14 being grouped together with a sufficient pitch in the central region of the tube plate whilst the cold legs 16 are disposed in an annular region surrounding the central portion aforesaid with a smaller pitch. In this case, the partition 9a provided beneath the tube plate so as to delimit the admission and discharge zones for the primary fluid is cylindrical, the primary fluid being admitted into the central region 10*a* through a nozzle duct 12*a* whilst the same fluid is withdrawn from the peripheral region 11*a* through nozzle ducts 13*a* and 13*b*. In this alternative embodiment, there have also been shown at 36 tubes for drawing-off the sludges formed in the secondary fluid and collected on the top face of the tube plate, the draw-off tubes 36 in this alternative form being more horizontal but adapted to extend vertically between the tubes both in the hot-leg region and in the cold-leg region.

Finally, in the alternative embodiment illustrated in FIG. 5 which is deduced directly from the embodiment shown in FIG. 3, provision is made among the bank of hot legs 15 of the U-tubes 14 for an ejector system comprising a plunger tube 37 which is open at the lower end 38 thereof in the vicinity of the tube plate 6, the upper portion of said plunger tube 37 being provided with a venturi 39 into which opens the extremity of a supply pipe 40. Said pipe carries into the venturi the secondary emulsion which is drawn-off in the vicinity of the upper end of the tube bank.

It must be clearly understood that the invention is not limited to the examples of construction which have been more especially described with reference to the accompanying drawings but extends on the contrary to all alternative forms.

What we claim is:

1. A steam generator comprising a tube plate, holes in said plate, a bank of U-tubes having ends connected in the holes, said U-tubes, receiving a circulation of a primary fluid and a secondary fluid externally surrounding said U-tubes, wherein the ends of the U-tubes of the bank are disposed in spaced relation in the tube plate with a pitch of decreasing value in the direction of flow of the secondary fluid, the tube arms through which the hot primary fluid circulates being disposed with a pitch of higher value than that of the tube arms through which the cold primary fluid circulates.

2. A steam generator according to claim 1, wherein the U-tubes of the bank are disposed in parallel planes, the tube arms through which the hot primary fluid circulates being disposed in spaced relation in a lateral direction contained in the plane of said tubes.

3. A steam generator according to claim 1, wherein the tubes are disposed in radial planes, the tube arms through which the hot primary fluid circulates being disposed in spaced relation in a central zone of the tube plate surrounded by a peripheral zone containing the arms through which the cold primary fluid circulates.

4. A steam generator according to claim 1, wherein the tube arms through which the hot primary fluid circulates delimit transverse passageways occupied by ducts having their openings in the vicinity of the tube plate for the suction of sludges formed in the secondary fluid.

5. A steam generator according to claim 4, wherein the transverse passageways are supplied with an additional flow of secondary fluid circulated through plunger tubes disposed vertically between at least a certain number of the U-tubes, said plunger tubes being each associated at the end remote from the tube plate with a venturi for mixing with the reheated secondary fluid which is withdrawn from the upper section of the tube bank.

6. A steam generator according to claim 1 including spacer plates to hold the tubes of the bank in position each of said spacer plates covering a small portion of the tube bank and forming a baffle system which promotes stirring of the emulsion around the two legs of said tube bank.

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