

[54] **SEDIMENT BLOWDOWN ARRANGEMENT
FOR A SHELL AND TUBE VAPOR
GENERATOR**

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[51] Int. Cl.² **F22B 1/06; F22B 37/54**

[58] Field of Search 122/32, 34, 381, 382;
165/114, 158, 159, 160, 161, 163

[56] **References Cited**

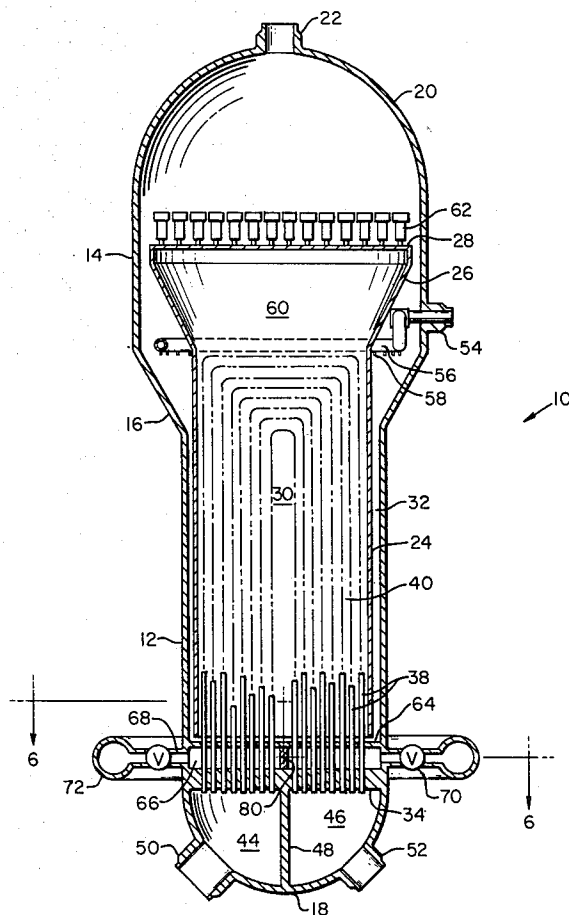
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[57] **ABSTRACT**

Removal of sediment caused by the settling of suspended particulate material in the secondary liquid circulated through a vapor generator of the shell and tube type is effected by providing a baffle plate closely spaced from the tube sheet therein to define a plenum therebetween. One or more blowdown lines extend from the plenum and the baffle plate contains a plurality of drilled holes through which a limited portion of the secondary liquid passes at a high velocity conducting sediment with it to the blowdown plenum for removal through the blowdown lines.

5 Claims, 6 Drawing Figures



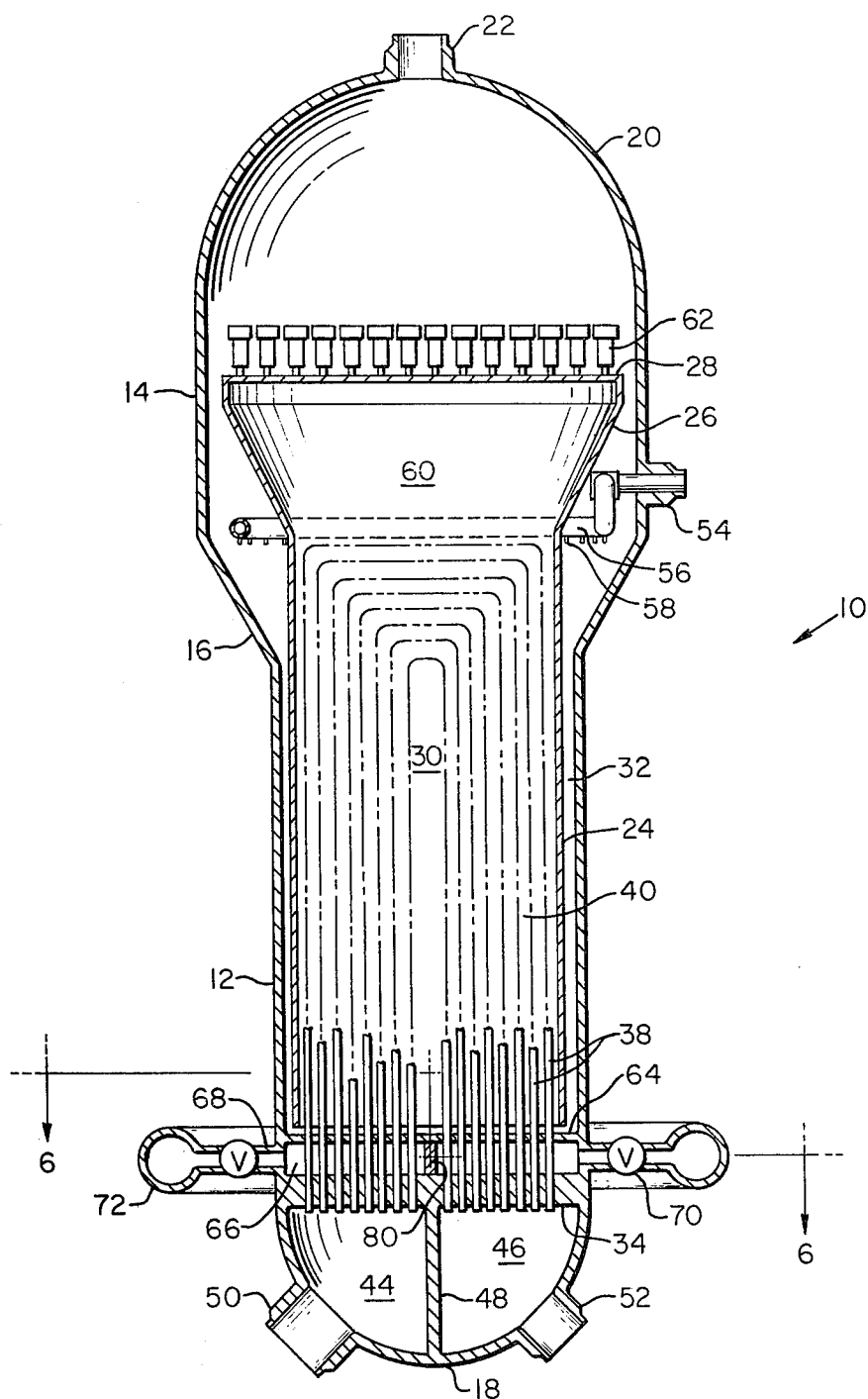


FIG. 1

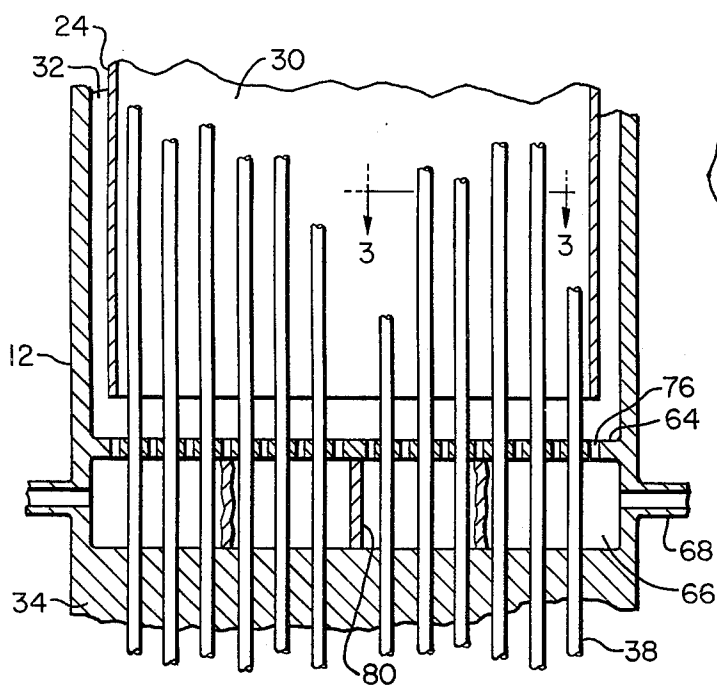


FIG. 2

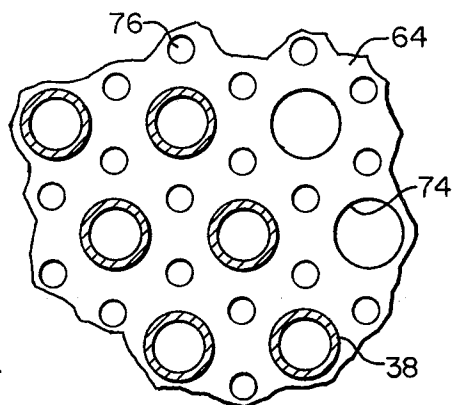


FIG. 3

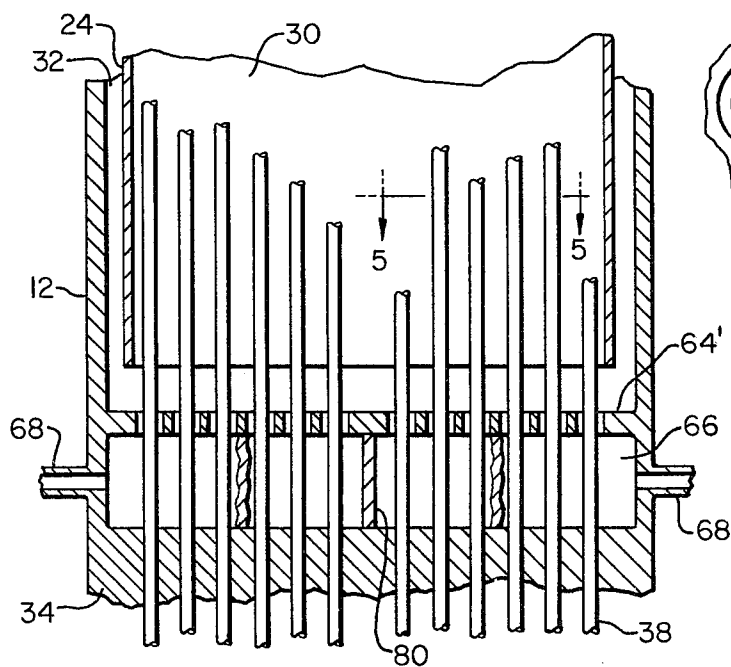


FIG. 4

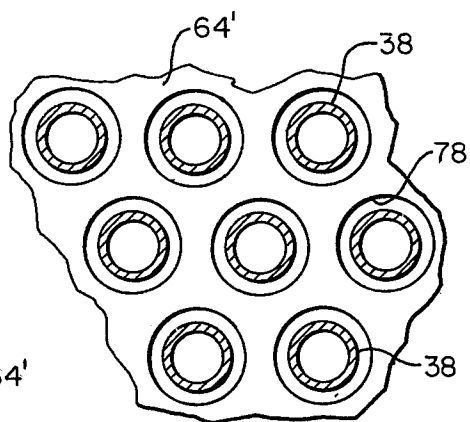


FIG. 5

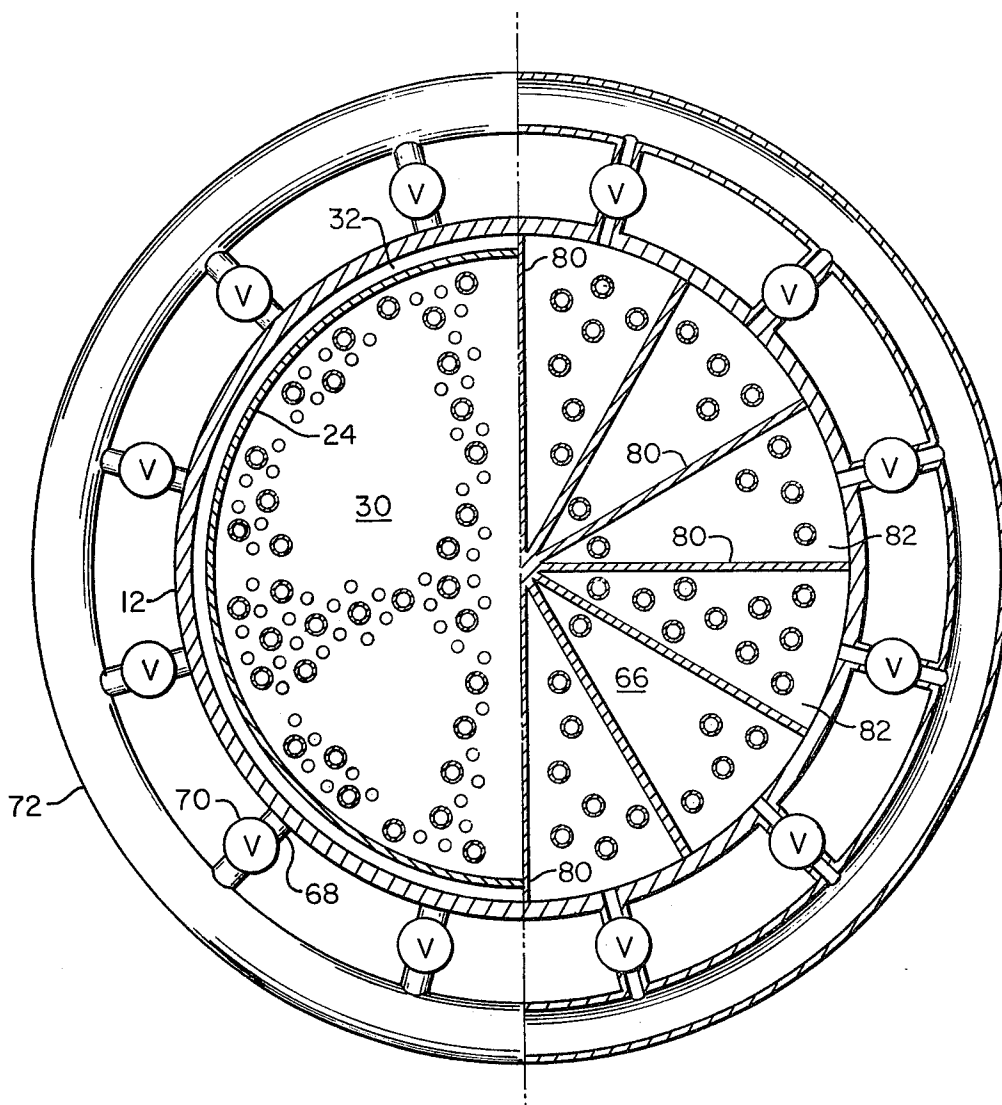


FIG. 6

SEDIMENT BLOWDOWN ARRANGEMENT FOR A SHELL AND TUBE VAPOR GENERATOR

BACKGROUND OF THE DISCLOSURE

The present invention relates in general to vapor generators of the shell and tube type wherein vaporizable liquid, termed the secondary liquid, is transformed into vapor by passing it in heat exchange relation with the high temperature primary fluid that is conducted through the tubes. Vapor generators of this type characteristically employ a bundle of tubes, either of the inverted U-type in which both ends of each tube are connected to a single tube sheet or of the straight type in which the tubes are connected at their opposite ends to a pair of axially spaced tube sheets. The units operate with a body of secondary liquid maintained at a predetermined level in the downcomer annulus and in the vapor generating region and circulation of the liquid between the two sections is maintained by the thermal syphonic action created by the difference in densities between the liquid bodies in the respective sections.

Conventionally, the secondary liquid flow through vapor generators of the described type is such that the liquid from the downcomer annulus enters the vapor generating region from its periphery and must turn and flow upwardly therethrough. This flow pattern creates a region of relatively stagnant flow in the lower part of the vapor generating region within which any suspended particles entrained in the secondary liquid, such as metal oxides or scale-forming calcium, may be permitted to settle thereby forming sediment deposits. Such deposits, if not removed, may cover the tube surfaces thereby operating to reduce the amount of heat transfer area provided thereby. Additionally, sediment deposits provide a convenient medium for the concentration of corrosive impurities, such as chloride salts, or the like, which can attack the tube material and may result in tube failure thereby requiring shutdown of the plant.

Although the removal of sediment deposits has traditionally been provided by blowdown procedures in which the affected area receives a periodic or continuous flushing with relatively high velocity fluid, such procedures have become increasingly difficult as the capacity of shell and tube type vapor generators has increased. Increased unit capacities require a greater number of tubes disposed within the shell and because of the desire to maintain the vapor generator shell as small as possible, there has been a tendency to accommodate the increased number of tubes by placing the tubes on closer spacing. Thus, blowdown is impeded since space is no longer available to accommodate the piping required to adequately flush all regions of the tube bundle. To remove rows of tubes in order to accommodate additional blowdown piping is uneconomic because of the resulting loss of heat transfer area.

It is to the solution of such problems that the present invention is directed.

SUMMARY OF THE INVENTION

According to the present invention there is provided in a vapor generator of the shell and tube type a baffle plate extending transversely of the shell axis in close parallel spacing from the tube sheet in the lower region of the unit. Normal secondary liquid flow and sediment deposition occurs on the upper surface of the baffle plate. The space between the baffle plate and the tube

sheet defines a plenum from which one or more blowdown lines extend for removing liquid from the plenum on a continuous or periodic basis. The baffle plate contains a plurality of drilled holes of limited through-area whereby fluid flow through the plate and into the plenum is at a relatively high velocity. By flowing fluid through the baffle plate in this manner the sediment deposits can be effectively flushed into the blowdown plenum from whence they can be conveniently discharged from the unit through the blowdown lines.

In one form of the invention the baffle plate is provided with one set of drilled holes through which the heat transfer tubes pass and another set of holes, of significantly smaller diameter, interposed between the tube-accommodating holes by means of which flushing of the region is effected. In another form of the invention, the baffle plate is provided with only a single set of drilled holes which are of a diameter slightly greater than the tube diameter whereby flushing is effected by the flow of liquid into the blowdown plenum through the clearance spaces provided between the tubes and the periphery of the holes.

According to another aspect of the invention, the effectiveness of blowdown is enhanced by the provision, in the blowdown plenum, of a series of radially disposed plates dividing the plenum into mutually sealed sectors which are arranged to independently pass flushing liquid. By selectively passing liquid through individual sectors higher flushing velocities can be effected using a minimum total blowdown flow rate.

For a better understanding of the invention, its operating advantages and the specific objects obtained by its use, reference should be made to the accompanying drawings and description which relate to preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of a typical shell and tube vapor generator equipped with apparatus of the present invention;

FIG. 2 is an enlarged partial vertical section of the vapor generator of FIG. 1 illustrating one embodiment of the invention;

FIG. 3 is a plan section taken along line 3—3 of FIG. 2;

FIG. 4 is an enlarged partial vertical section of the vapor generator of FIG. 1 illustrating a second embodiment of the invention;

FIG. 5 is a plan section taken along line 5—5 of FIG. 4; and

FIG. 6 is a plan section taken along line 6—6 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 of the drawings, there is shown a shell and tube type vapor generator 10 incorporating the present invention. It comprises a vertically elongated pressure vessel defined by a lower cylindrical shell 12 and a larger diameter, upper cylindrical shell 14, the latter being integrally connected with the former by means of a frustoconical transition member 16. The ends of the vessel are closed, at the bottom by means of hemispherically formed closure head 18 and at the top by a dome-shaped cover 20 containing a vapor outlet nozzle 22. The interior of the pressure vessel contains a plurality of annular baffles 24, 26 and 28, baffle 24 being cylin-

drical and extending in coaxially shaped relation from the wall of the lower shell 12 to cooperate therewith in forming an inner vapor generation region 30 and an outer, annular downcomer passage 32. The lower end of the vessel interior is closed by tube sheet 34 disposed between the lower end of shell 12 and the lower closure head 18. The tube sheet 34 extends transversely of the vessel axis and connects at its periphery between the shell 12 and closure head 18. The tube sheet 34 contains a plurality of tube openings adapted to fixedly receive the ends of inverted U-shaped heat transfer tubes 38 that form a longitudinally extending tube bundle 40 substantially filling the vapor generating region of the vessel. The tube ends are open and extend through the tube sheet to place the tubes 38 in fluid communication with a heating fluid chamber that occupies that region of the vessel enclosed between the closure head 18 and the tube sheet 34 and which is divided into inlet and outlet portions 44 and 46, respectively, by means of a diametral plate 48. The heating fluid chamber is, in turn, connected to a source of heating fluid (not shown) by means of inlet and outlet nozzles 50 and 52, respectively, that communicate with the respective chamber portions 44 and 46 and thereby effect circulation of heating fluid through the tubes 38.

Feedwater is supplied to the unit through an inlet nozzle 54 that is shown penetrating the upper shell 14. A ring header 56 connects with the nozzle 54 and serves to distribute feedwater passed through the nozzle about the circumference of the downcomer passage 32 discharging into the passage by means of downwardly-directed discharge ports 58. Flow of feedwater from the downcomer passage 32 into the vapor generation chamber 30 is effected by the spaced relationship that exists between the lower end of the cylindrical baffle plate 28 and the upper surface of tube sheet 34. Within the vapor generation region the feedwater is caused to flow in heat exchange relation with the tubes 38 where heat is extracted from the heating fluid circulated therethrough to cause some of the feedwater to be transformed into vapor. The so-created vapor-liquid mixture flows to the upper region of the vapor generation chamber formed as a mixture collection chamber indicated as 60. From the mixture collection chamber 60 the flowing mixture is passed to vapor-liquid separator apparatus, a multiplicity of such separators indicated as 62 being mounted upon baffle plate 28 and communicating with the chamber 60 by means of openings provided in the baffle. The separators 62 may be of any well known constructions, those shown being of the centrifugal type, and are arranged to discharge separated liquid downwardly upon the baffle plate 28 from whence it is returned to the downcomer passage 32 to be mixed with the incoming feedwater and recirculated through the unit. The separated vapor, on the other hand, is discharged from the separators 62 in the upward direction for discharge out of the vapor outlet nozzle 22 from whence it is conducted to a point of use.

According to the present invention, means are provided to effectively remove sediment deposits from the bottom of the vapor generating region 30 of the vessel interior. In the embodiment of the invention illustrated best in FIGS. 2 and 3 of the drawings such means include a baffle plate 64 extending transversely of the vessel axis in parallelly spaced, superposed relation to the tube sheet 34. The plate 64, about its outer periphery, is attached to the vessel, as by means of welding,

at the lower end of the shell 12. As shown in the drawings, the plate is vertically spaced above the tube sheet 34, being disposed intermediate it and the bottom end of the cylindrical baffle 24. The space defined between the plate 64 and the tube sheet 34 defines a blowdown plenum 66. A plurality of circumferentially spaced blowdown lines 68 containing actuating valves 70 communicate with the plenum 66 at spaced locations about the circumference of the unit and connect the same to a blowdown manifold here shown as ring header 72.

The baffle plate is apertured, as at 74 in FIG. 3, to accommodate passage of the tubes 38. It further contains a set of drilled holes 76 interposed in regular array between the tube holes to establish fluid communication between the blowdown plenum 66 and the vapor generating region 30 of the vessel interior that lies above the plate. The disposition of the baffle plate 64 is such that normal flow of secondary liquid and sediment deposition occurs above its upper surface; however, the diameter of the holes 76 is such as will effect the generation of a flow velocity of a secondary liquid into the blowdown plenum that is sufficient to entrain and conduct sediment from the vapor generating region to discharge the same from the unit when the valves 70 are actuated. The spacing between the baffle plate 64 and tube sheet 34 is maintained at only a slight amount, for example at one or two inches, in order to maintain sufficiently high fluid velocities through the plenum so as to prevent settling of sediment in this space.

In the alternate embodiment illustrated in FIGS. 4 and 5 of the drawing, the baffle plate, indicated as 64', contains only a single set of drilled openings 78. The openings 78 are adapted to accommodate passage of the tubes 38 and are provided with a diameter greater than the external diameter of the tubes thereby defining concentric clearance spaces about the tubes for the passage of liquid and entrained sediment into the blowdown plenums 66.

As shown best in FIG. 6, the blowdown plenum 66 may be provided with a plurality of upstanding, radially disposed plates 80 extending from the tube sheet 34 to the undersurface of the baffle plate 64 or 64' thus dividing the plenum into circumferentially spaced, mutually sealed sectors 82. The blowdown lines 68 are arranged each to communicate with one of the sectors 82 whereby the respective actuating valves 70 can be individually operated to effect blowdown only in selected sectors. In this way higher velocities can be induced in the flow of fluid through the flow holes in the baffle plate 64 thereby maximizing local blowdown velocities with a given total flow rate.

It will be appreciated that the herein described blowdown apparatus, which involves only a minimum change in vapor generator geometry, provides an effective solution to the problem of sediment removal from a shell and tube vapor generator. Because the arrangement requires no blowdown piping within the interior of the tube bundle, spaces that could only be produced by the removal of heat exchange tubes are not required, thus the loss of available heat transfer surface is minimized. Moreover, due to the fact that flow openings are provided closely adjacent all of the tubes, maximum blowdown flushing can be achieved in all regions of the tube bundle.

While the preferred embodiment of the present invention has been described herein, it should be understood that the description is merely illustrative and that

variations and modifications can be made therein without departing from the spirit and scope of the invention. What is sought to be protected herein is as recited in the appended claims.

What is claimed is:

1. In a shell and tube heat exchanger for the generation of vapor by the indirect transfer of heat from a heating fluid to a secondary liquid including a pressure shell having a transverse tube sheet defining a vapor generating region enclosing a bundle of heat exchange tubes emanating from said tube sheet, means for passing heating fluid through said tubes and means for circulating said secondary liquid through said vapor generating region exteriorly of said tubes, the improvement comprising means for the removal of sediment from said vapor generating region comprising:

- a. a baffle plate extending transversely of said shell in closely spaced, superposed, parallel relation to said tube sheet and defining therewith a blowdown plenum;
- b. means communicating with said blowdown plenum for fluid discharge therefrom;
- c. means forming through openings in said baffle plate for passing secondary liquid and entrained sediment from said vapor generating region to said blowdown plenum; and
- d. said blowdown plenum containing a plurality of

upstanding plates extending transversely thereof to divide said plenum into a plurality of independent sections, and means for passing fluid selectively from said sections.

2. The organization according to claim 1 in which said baffle plate contains a first set of through openings to accommodate passage of said tubes and a second set of through openings of smaller diameter than said first set for passage of fluid to said blowdown plenum.

3. The organization according to claim 1 in which said baffle plate contains a plurality of through openings to accommodate passage of said tubes, said openings being of greater diameter than the outside diameter of said tubes and defining clearance spaces for the passage of fluid to said blowdown plenum.

4. The organization according to claim 1 in which said upstanding plates are substantially radially extending through said plenum dividing the same into a plurality of independent sectors.

5. The organization according to claim 1 including header means surrounding said shell; blowdown lines communicating between each of said plenum sections and said header means; and valve means in said blowdown lines for passing fluid through selective ones of said blowdown lines.

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