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A. J. GRAM, JR
VAPOR GENERATING UNIT

2,845,906

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2 Sheets-Sheet 1

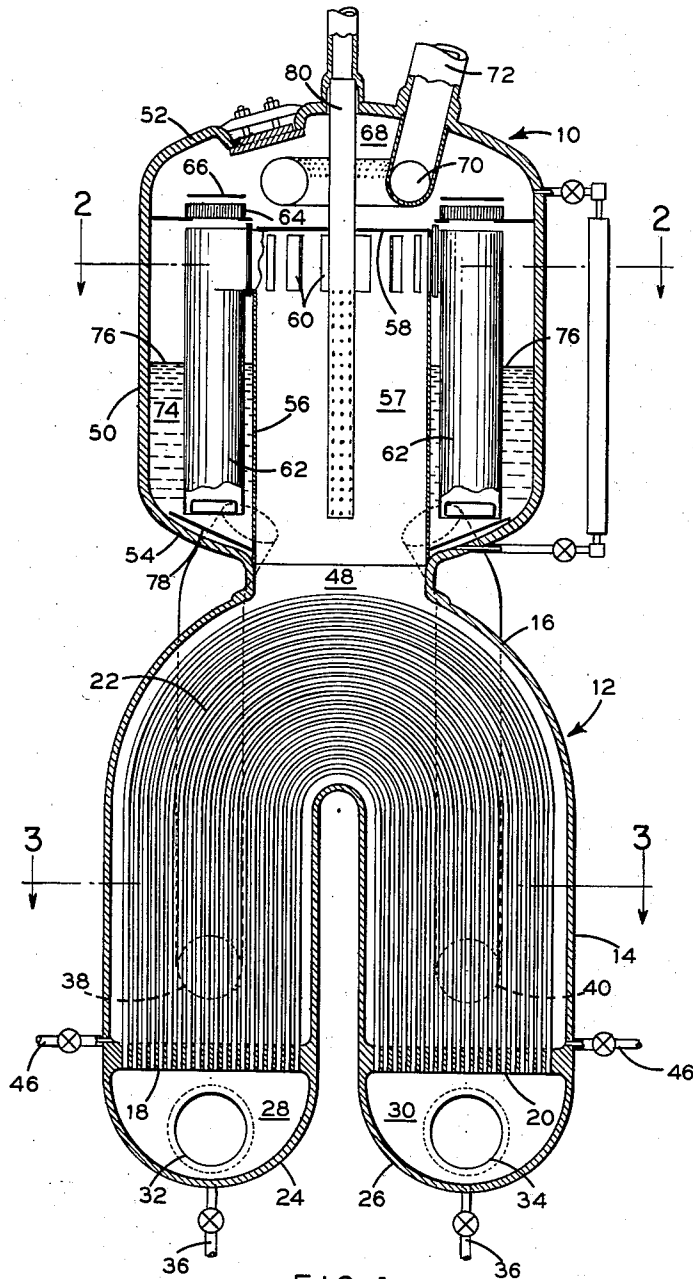


FIG. 1

INVENTOR.
Arthur J. Gram, Jr.
BY  J. P. Moran
ATTORNEY

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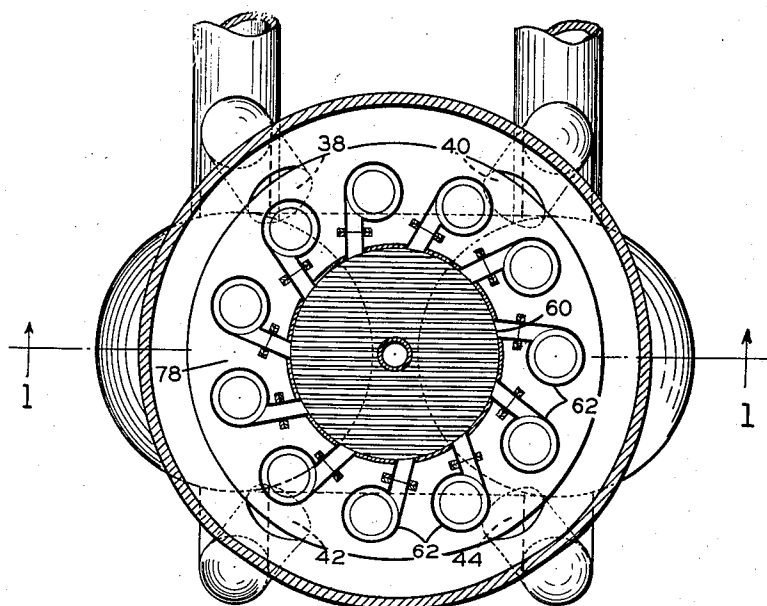


FIG. 2

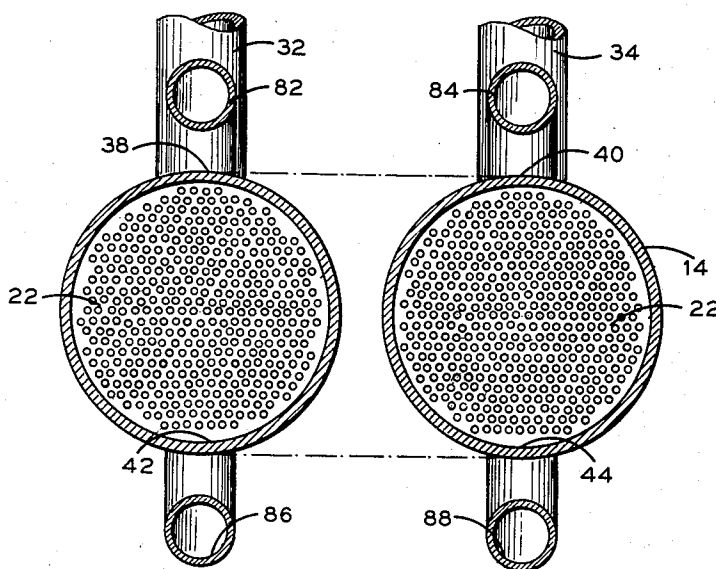


FIG. 3

INVENTOR.

Arthur J. Gram, Jr.

BY

J. P. Moran

ATTORNEY

1

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VAPOR GENERATING UNIT

Arthur J. Gram, Jr., Alliance, Ohio, assignor to The Babcock & Wilcox Company, New York, N. Y., a corporation of New Jersey

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5 Claims. (Cl. 122—32)

This invention relates in general to a vapor generating apparatus and, more particularly, to a fluid heated natural circulation vapor generating apparatus.

Vapor generating units are required in many modern-day thermodynamic systems to recover heat or convert energy. Often in these systems the heating source is in the form of a fluid either a liquid, or a high pressure gas or comminuted particles carried by a gaseous medium commonly referred to as fluidized. It is a characteristic of these fluids that they transfer heat at a high rate. Accordingly, vapor generating units utilizing such fluids must be capable of withstanding large temperature gradients and therefore must be as free as possible of stresses induced by restrained differential thermal expansion.

In some of these processes it is advantageous to have a compact vapor generator because the space available in the system into which it must go is limited. However, such a compact vapor generating unit must be fully capable of adequate circulation of the vaporizable medium to assure proper operation.

The present invention directly joins a vapor-liquid separating drum with a vertically arranged U-shaped shell and tube heat exchanger whereby there is a unitary pressure vessel. This vessel incorporates a heat exchanger and is substantially free of differential thermal stresses, compact in size and is arranged for definite circulation of the vaporizable medium.

For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of my invention.

Of the drawings:

Fig. 1 is a vertical side section of the invention;

Fig. 2 is a transverse section through the separating drum portion along the lines 2—2 of Fig. 1;

Fig. 3 is a transverse section through the heat exchanger portion along the lines 3—3 of Fig. 1.

The vapor generator consists of an upper vapor-liquid separating drum 10 directly joined to a lower U-shaped shell and tube heat exchanger 12. The heat exchanger has a pressure vessel shell 14 of circular cross section throughout its length and is arranged in a vertical plane with the bend portion 16 of the vessel uppermost. At the end of each leg of the heat exchanger there are flat tube seats 18, 20 arranged with a plurality of tube seats. Within the vessel 14 there are a multiplicity of small diameter U-shaped tubes formed in a U-shaped tube bundle 22 which substantially fills the interior of the heat exchanger vessel. Also, as can be seen with reference to Fig. 3, the cross section of the heat exchanger throughout its entire length is substantially uniform. The ends of the tubes of the tube bundle are secured into tube seats of the tube sheets 18 and 20. Hemispherical heads 24, 26 are attached to the tube sheets 18 and 20 respectively to form the fluid chambers 28 and 30. Pipes 32 and 34 are arranged to open into the fluid chambers 28 and 30. These pipes are connected to a source of the hot

2

fluid so that it may be caused to flow from one chamber through the tubes into the other chamber during which time it would give up heat. Each chamber 28, 30 has a drain connection 36.

There are four openings 38, 40, 42 and 44 to the lowermost portion of the shell sides through which the vaporizable fluid is introduced to the shell side for the generation of vapor therein. Blow-off fittings 46 are above each of the tube sheets to provide a means for removing sediment resulting from the vapor generation. At the uppermost portion of the heat exchanger pressure vessel at the top of the bend 16 there is an opening 48 at which position the vapor-liquid separating drum 10 is directly joined to the shell 14.

The separating drum 10 consists of a vertically elongated pressure vessel 50 of circular cross section having an upper dished head 52 and a lower dished head 54 in which there is an opening coinciding with the opening 48 of the lower heat exchanger pressure vessel. The upper vessel 10 is integrally joined to the heat exchanger 12 by welding to result in a unitary pressure vessel consisting of the upper drum and the lower heat exchanger vessel with free communication between the interior of the two vessels. The interior of the upper drum 10 is divided by the upright circular baffle 56, which is joined to the vapor generator at the opening 48, and extends upwardly parallel to the vertical central axis to the upper part of the drum. A circular cover plate 58 is attached to the baffle 56 to form a vapor-liquid mixture collection chamber 57, having a plurality of vertically elongated slot openings 60. The vapor-liquid collection chamber 57 receives all of the vapor-liquid from the vapor-liquid mixture rising from the two legs of the heat exchanger 12 and passing through the opening 48 as indicated by the arrows.

A plurality of upright generally cylindrically shaped whirl chamber separators 62 are disposed so that each separator is attached to the baffle 56 at a slot 60 to receive a stream of vapor-liquid mixture. The separators centrifugally separates the vapor from the liquid with the vapor passing up through corrugated type scrubber elements 64 and past a distributing plate 66 into the upper vapor space 68 of the drum. There it passes through a dry pan 70 to a vapor outlet 72. The separated liquid from the separators is passed into the lowermost portion of the drum from the bottom of the separators and into an annular liquid space 74. Due to the arrangement the liquid forms a liquid level 76 separating the vapor from the liquid space. There is an inverted generally conical shaped baffle 78 disposed at the lowermost portion of the drum spaced from the wall thereof to prevent the discharged separated liquid from thermally shocking the thick pressure vessel wall. A feed water pipe 80 enters the drum through the upper head 52 and extends downwardly along the central axis into the vapor-liquid collection chamber. By this arrangement the incoming feed liquid is heated up by the condensation of some of the generated vapor before it passes through the vapor-liquid separators.

There are four downcomer pipes 82, 84, 86, 88 which take the separated liquid from the lowermost portion of the separating drum and pass it downwardly into the lowermost portion of the U-shaped heat exchanger on the shell side. Each of these downcomers are attached at the openings 38, 40, 42 and 44 in the lower vessel 14.

The vapor generator as described herein provides a distinct circulation path for the vapor-liquid mixture to rise to an upper position where it is mechanically separated and the separated liquid to pass downwardly directly in the steam generation area. This provides a maximum circulation and allows the circulating head to be reduced. The utilization of a low circulation head is further enhanced by the use of the whirl chamber type

3

separators which are able to produce relatively moisture-free steam while utilizing small pressure drops.

By directly joining a separating drum to a U-shaped heat exchanger, there results a vapor generator substantially free of restrained differential expansion while the shell of the U-shaped heat exchanger is thinner than would have to be utilized with more conventional type heat exchangers.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form of the invention known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. A vapor generator comprising a vapor-liquid separating drum having baffle means dividing its interior into a vapor space above a liquid space and a vapor-liquid collection chamber communicating with said spaces, vapor-liquid separating means arranged in said drum to receive a vapor-liquid mixture from said collection chamber and to deliver separated vapor to the vapor space and separated liquid to the liquid space, said separating means including a ring of hollow upright whirl chamber separators circumferentially spaced to receive individual streams of vapor-liquid mixture from said chamber, and a U-shaped shell and tube type heat exchanger vertically arranged for steam generation on the shell side and with its bend uppermost, said heat exchanger directly and dependently joined to said separating drum for the delivery of the vapor-liquid mixture from both legs of said heat exchanger to the vapor-liquid collection chamber in said separating drum.

2. A vapor generator comprising a vapor-liquid separating drum having baffle means dividing its interior into a vapor space above a liquid space and a vapor-liquid collection chamber communicating with said spaces, vapor-liquid separating means arranged in said drum to receive a vapor-liquid mixture from said collection chamber and to deliver separated vapor to the vapor space and separated liquid to the liquid space, said separating means including a ring of hollow upright whirl chamber separators circumferentially spaced to receive individual streams of vapor-liquid mixture from said chamber, a U-shaped shell and tube type heat exchanger vertically arranged for steam generation on the shell side and with its bend uppermost, said heat exchanger directly and dependently joined to said separating drum for the delivery of the vapor-liquid mixture from both legs of said heat exchanger to the vapor-liquid collection chamber in said separating drum, and downcomer means connecting said liquid space of said drum to the lowermost portion of the shell side of said heat exchanger.

3. A vapor generator comprising a vapor-liquid separating drum having baffle means dividing its interior into a vapor space above a liquid space and a vapor-liquid collection chamber communicating with said spaces, vapor-liquid separating means arranged in said drum to receive a vapor-liquid mixture from said collection chamber and to deliver separated vapor to the vapor space and separated liquid to the liquid space, said separating means including a ring of hollow upright whirl chamber separators circumferentially spaced to receive individual streams of vapor-liquid mixture from said chamber, and a U-shaped shell and tube heat exchanger vertically arranged for steam generation on the shell side and with

4

its bend uppermost, said heat exchanger directly and dependently joined at its uppermost portion to the lowermost portion of said separating drum for the delivery of the vapor-liquid mixture from both legs of said heat exchanger into the vapor-liquid collection chamber in said separating drum.

4. In a vapor generator, a vertically arranged U-shaped pressure vessel of circular cross-section with its bend uppermost, an upper upright elongated pressure vessel of circular cross section superjacent and joined at its lowermost portion to said U-shaped vessel at the bend for the free communication of the interiors of said vessel, a vapor outlet from said upper vessel, a plurality of tubes constituting a U-shaped bundle disposed within and substantially filling said U-shaped vessel, means including a tube sheet forming fluid collection chambers at the end of each leg of the U-shaped vessel, means connecting the tube ends to the tube sheets for the flow of a heating fluid from one chamber through the tubes and into the other chamber, means forming a vertically elongated vapor-liquid collection chamber in the lower center portion of the upper vessel arranged to collect all of the vapor-liquid mixture generated in said U-shaped vessel, vapor separating means in said upper vessel arranged to receive and separate a vapor-liquid mixture from said vapor-liquid collection chamber including a ring of hollow upright whirl chamber separators circumferentially spaced, each separator arranged to deliver vapor to the uppermost portion of the interior of the upper vessel and separated liquid to the lowermost portion thereof, and downcomer means for delivering said separated liquid to the lowermost portion of each leg of the shell side of said U-shaped vessel.

5. In a vapor generator, a vertically arranged U-shaped pressure vessel of circular cross-section with its bend uppermost, an upper upright elongated pressure vessel of circular cross section superjacent and joined at its lowermost portion to said U-shaped vessel at the bend for the free communication of the interiors of said vessel, a vapor outlet from said upper vessel, a plurality of tubes constituting a U-shaped bundle disposed within and substantially filling said U-shaped vessel, means including a tube sheet forming fluid collection chambers at the end of each leg of the U-shaped vessel, means connecting the tube ends to the tube sheets for the flow of a heating fluid from one chamber through the tubes and into the other chamber, means introducing a vaporizable fluid into the lowermost portion of the shell side of the U-shaped vessel for the generation of vapor therein, means forming a vapor-liquid collection chamber in the upper shell arranged to collect the vapor-liquid mixture generated in said U-shaped vessel, vapor separating means in said upper vessel arranged to receive and separate a vapor-liquid mixture from said vapor-liquid collection chamber including a ring of hollow upright whirl chamber separators circumferentially spaced, each separator arranged to deliver vapor to the uppermost portion of the interior of the upper vessel and separated liquid to the lowermost portion thereof, and downcomer means for delivering said separated liquid to the lowermost portion of each leg of the shell side of said U-shaped vessel.

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