Oct. 18, 1966 J. H. AMMON 3,279,439

VAPOR GENERATING SUPERHEATING AND REHEATING UNIT

Filed June 5, 1964 4 Sheets-Sheet 1

FIG. 1

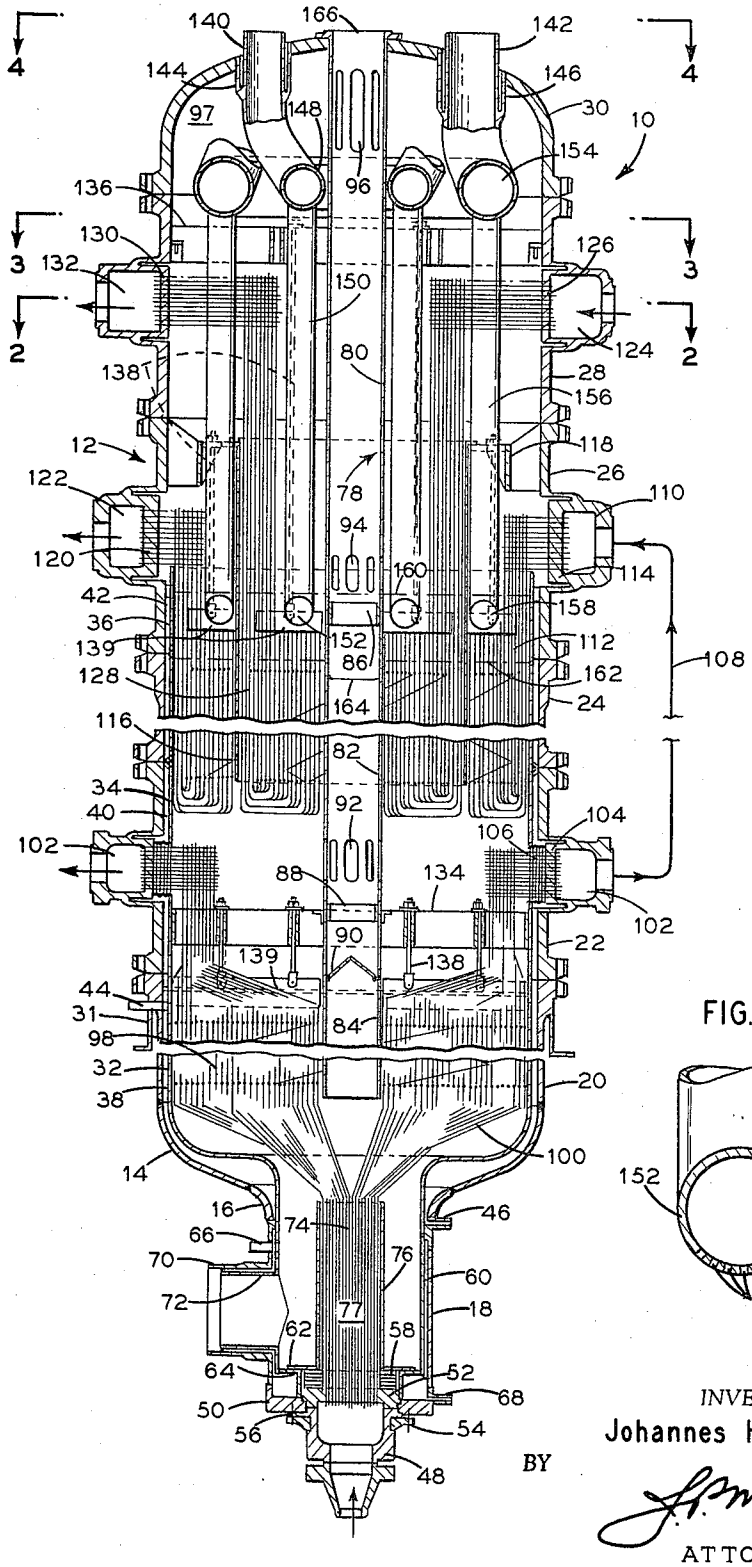


FIG. 5

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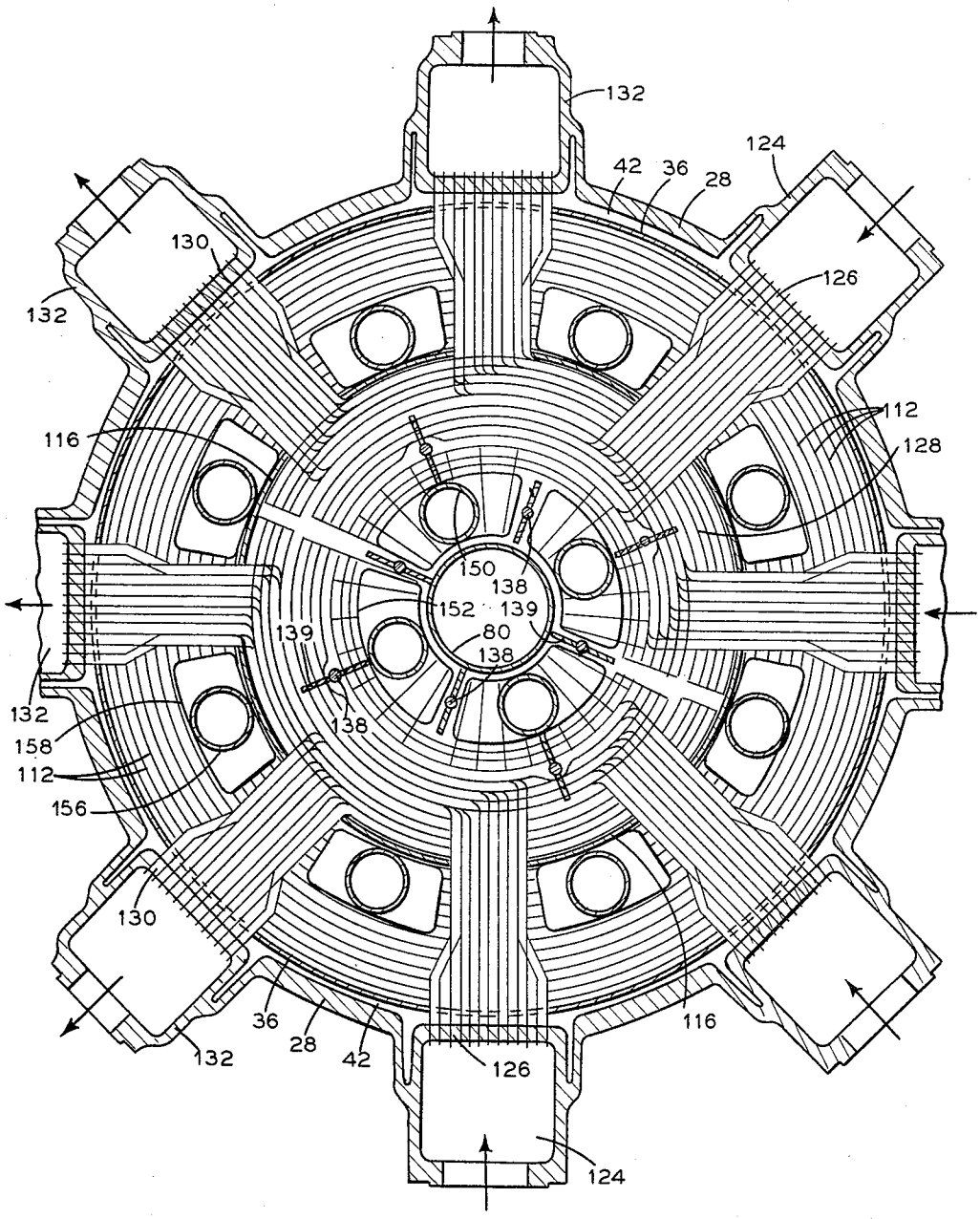
BY

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VAPOR GENERATING SUPERHEATING AND REHEATING UNIT

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FIG. 2

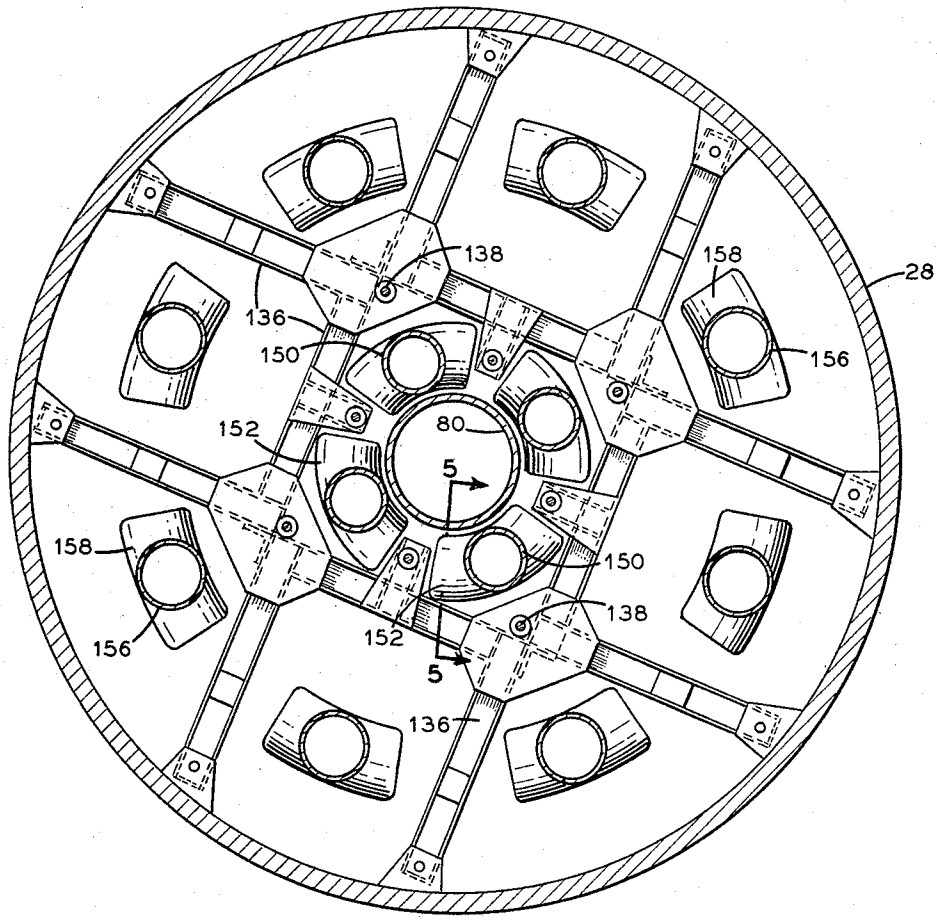


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VAPOR GENERATING SUPERHEATING AND REHEATING UNIT

Filed June 5, 1964 4 Sheets-Sheet 3

FIG. 3

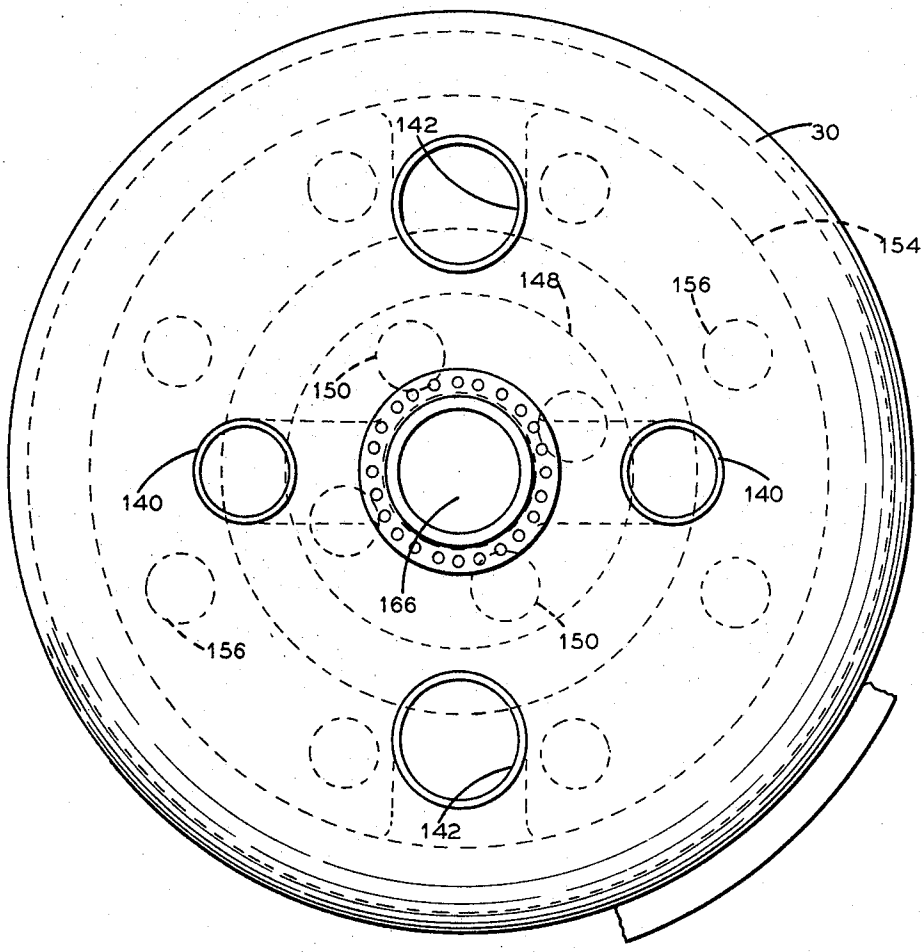


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VAPOR GENERATING SUPERHEATING AND REHEATING UNIT

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FIG. 4



United States Patent Office

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VAPOR GENERATING SUPERHEATING AND REHEATING UNIT

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17 Claims. (Cl. 122—34)

This invention relates to a fluid heated vapor generating unit and, more particularly, to a heat exchanger incorporating vapor generating, superheating and reheating tubular heat exchange surfaces all within a single shell.

One of the difficulties in combining a vapor generator, superheater and reheater into a single unit is in devising a tube arrangement which, while providing the required heat exchange surfaces, will afford minimum containment vessel diameter and height. Another problem in such a unit is in providing a construction which will facilitate assembly, disassembly and maintenance of the component parts. Additionally such a unit, particularly one employing liquid metal as the heating medium, must provide adequate structural features to withstand any accidents resulting from the interaction of the heating and heated fluids.

It is a primary object of the present invention to include the reheater surfaces with the vapor generator and superheater surfaces within a single vessel without thereby disadvantageously increasing the height or diameter of the vessel.

Another object of the invention is to provide a heat exchanger in which the vapor generator tubes are completely drainable to facilitate properly controlling the chemistry of the vaporizable fluid.

Still another object is to construct a unit structurally capable of withstanding any violent reaction resulting from the interaction of the heating and the heated fluids.

Yet another important object of the invention is to provide a heat exchanger construction such that even when utilizing a high temperature heating fluid, the walls of the vessel will not be subjected to the extremes of thermal stresses induced by high temperature differentials.

A further object of the invention is to provide a unit arrangement which will facilitate both assembly and disassembly.

Accordingly, the present invention comprises an integral vapor generating, superheating and reheating unit wherein the heating fluid passes in indirect heat transfer relationship over the tubular surfaces which contain the vaporizable fluid. The arrangement of heating surface comprises a bank of vertically extending vapor generator tubes positioned in the lower end of a pressure vessel with banks of superheater and reheater tubes superjacent thereto. To minimize the height of the pressure vessel, the superheater tubes are arranged in annular array concentrically about and coextensive with the reheater tubes. Positioned between the banks of superheater and reheater tubes is a baffle which provides separate flow paths for the heating fluid passing over each of the banks.

The fluid to be heated passes initially through the generator tube bank which is drainable. To accomplish this, the inlets for supplying fluid to the bank of vapor generator tubes are subjacently located in the lower end of the pressure vessel, while the vapor generator tube outlets are located above the bank. Both the inlet and outlet connections for the banks of superheater and reheater tubes are located above the tubes and are also formed integrally with the pressure vessel.

To permit removal of the individual bank of tubes, the pressure vessel is composed of a number of separately removable, circumferentially extending wall sections. The several banks, together with the inlet and outlet chambers are each connected to the appropriate wall section so that they can be removed as individual units. Heating fluid inlet means extend downwardly into the vessel from the upper head and are disposed so that the superheater and reheater tubes each receive separate streams of heating fluid.

Further, individual liner sections within and closely spaced from the pressure vessel wall cooperate to form suitably disposed annular spaces. Inlet and outlet means are arranged in the pressure vessel for fluid supply to and drainage of each of these annular spaces. In addition, an axially extending pipe is arranged within the pressure vessel which, by passing through the several banks of tubes, permits the escape of any gases resulting from the reaction between the heating and heated fluids.

The various objects, features and advantages of the invention will appear more fully from the detailed description which follows, taken in connection with the accompanying drawing.

Of the drawings:

FIG. 1 is a vertical sectional view of a vapor generating, superheating and reheating unit embodying the present invention;

FIG. 2 is a sectional view taken along line 2—2 in FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 in FIG. 1;

FIG. 4 is a top view of the unit shown in FIG. 1 with a portion of the heating fluid inlet system within the vessel shown in dashed lines; and

FIG. 5 is an enlarged sectional view taken along line 5—5 in FIG. 3.

The unit disclosed herein is a further development of the vapor generating and superheating unit set forth in the copending application Serial No. 261,636, dated February 28, 1963, filed in the names of Johannes H. Ammon and Theodore S. Sprague, which application is also owned by the assignee of this application.

In the arrangement shown in FIG. 1 a vapor generating, superheating and reheating unit **10** is disposed within a vertically extending cylindrically shaped pressure vessel **12**. The vessel **12** comprises a lower head **14** contoured for connection to a throat forging **16** which, at its lower end connects to a combined feedwater inlet-sodium outlet member **18**. Serially disposed above the lower head are first, second, third, fourth and fifth wall sections **20**, **22**, **24**, **26** and **28**, respectively, topped by upper closure head **30**. Wall section **20** is welded about its lower edge to the lower head **14** and has a flanged upper edge. In addition, the vessel is supported by means of the skirt **31** integrally attached to and extending downwardly from wall section **20**. The remaining wall sections **22**, **24**, **26** and **28** have flanges about both their lower and upper edges for securing adjacent sections. Additionally, the closure head **30** is flanged for connection to the adjacent wall section **28**. These various wall sections and the upper head are bolt-connected together to facilitate disassembly of the vessel and removal of its internals.

Closely spaced from, and in combination with, the interior of the pressure vessel a number of liner sections **32**, **34** and **36** form annular flow spaces **38**, **40**, **42**, respectively. As indicated by inlet **44** and outlet **46**, connections are provided for delivering a fluid to flow space **38** and for draining the fluid and any accumulations from this space. Though not shown, similar connections are provided for the annular flow spaces **40**, **42** whereby a gas or other fluid may be introduced into the space between the liner and the shell for limiting the effect of

thermal stresses on the pressure vessel wall sections due to the high temperature heating fluid passing through the heat exchange sections.

A flange **50** at the lower end of the member **18** is connected to feedwater inlet member **48**. The flange **50** is machined to form a tight contact surface joint with tube sheet **52** of the feedwater inlet member. Rocker clamps **54** secure the feedwater inlet member **48** and the flange **50** in tightly fitting engagement while flexible membrane **56** seals the joint between the flange **50** and the member **48** against leakage from within the vessel.

Tightly packed annular shaped stainless steel plates **58** are stacked on the upper face of the tube sheet **52** to prevent any of the heating fluid from reaching the uncooled portion of the tube sheet. Within member **18** liner plates **60**, **62** and **64** form a shield for keeping the heating fluid from contacting the walls of the member **18**. Inlet and outlet connections **66**, **68** pass through the wall of the member **18** for circulating a fluid in the annular space between the liner plates **60**, **62**, **64** and the adjacent cooperating walls of the member **18**.

Extending from the wall of the vessel and located above the feedwater inlet member **48** is a heating fluid outlet connection **70**. A sleeve **72** extends outwardly from an extension of liner plate **60** within the outlet **70** forming an annular thermal shield or sleeve within this connection.

Extending upwardly from tube sheet **52** is a plurality of feedwater inlet capillary tubes **74**. These tubes are back welded to the tube sheet, that is the tube sheet **52** is machined to provide projecting stubs on its inner surface, the capillary tubes are butted against the stubs, and the tube and stub are welded together from inside of the tube. Arranged about the capillary tubes and extending upwardly from liner plates **62** is a circular shield **76** which forms a space **77** closed at its base and open at its top.

Centrally located within the vessel **12** is an escape tube assembly **78** connected at its upper end to the head member **30** and extending vertically downward to terminate open ended in a transverse plane located a short distance above the top of the capillary tubes **74**. Assembly **78** is made up of an upper tube section **80**, a center tube section **82** and a lower tube section **84**. These tube sections are joined together to form an integral tubular conduit with slip joints **86** and **88** to permit the removal of the individual sections. Just below slip joint **88** in the lower tube section **84** is a segmented hatch **90** biased to a normally closed position. If gases accumulate in the lower end of the vessel, and there reach a predetermined pressure, the hatch will automatically open, and they will pass upwardly through the escape tube assembly **78**. After the gases have been relieved the hatch will return to its closed position as shown in FIG. 1. For a more complete description of a similar construction refer to the previously mentioned application No. 261,636.

Immediately above slip joints **88**, **86** openings **92** and **94** in tube sections **82** and **80**, respectively, provide venting means for the heating fluid. Near the upper end of the tube assembly **78**, in tube section **80**, additional openings **96** provide communication between the escape tube and the space **97** in the top of the vessel above the heat exchange banks.

Coiled about the lower tube section **84** is a bank of vapor generator tubes **98**. Connecting tubes **100** extend from the upper end of the capillary tubes **74** to the lower end of the vapor generator tubes **98**. The capillary tubes are about one-half the inside diameter of the vapor generator tubes to assure proper distribution of the feedwater from the inlet member **48** into the multiple vapor generator tubes. The bank of vapor generator tubes **98** are helically coiled in closely spaced relationship within the annular space between the concentrically disposed escape tube assembly **78** and the liner section **32**. The upper portion of the upwardly extending tube bank **98** terminates in four tube groupings which open into equally spaced outlet chambers **102**. These chambers, projecting radially from the vessel wall are integrally connected to the wall section **22** with a suitable thermal sleeve-like arrangement provided for protecting the chambers **102** from thermal shock. Within each of the outlet chambers **102** the tubes comprising the vapor generating bank are secured in a vertically positioned tube sheet **104**. The tube sheet is protected from the harmful effects of the high temperature heating fluid which passes over the tubes by tightly fitting stainless steel plates **106** disposed adjacent the inside face of the tube sheet.

From each of the four outlet chambers **102** the vapor flows through lines **108** into four superheater inlet chambers **110** spaced 45° apart and located within the wall section **26** superjacent the outlet chambers **102**.

Spaced superheater tubes **112**, connected to tube sheets **114** and opening into the inlet chambers **110**, proceed first inwardly and then downwardly adjacent the inner face of the liner section **36**. Closely above the vapor outlet chambers **102**, the superheater tubes **112** are bent through 180° and then coil helically upward concentric with and spaced about a vertically depending baffle **116** positioned intermediate the liner section **36** and the escape tube assembly **78**. This baffle extends to a point somewhat above the inlet chamber **110** and is supported by means of a suspension bracket assembly **118**, which is secured to the upper end of the wall section **26**. At the top or outlet end of the helically coiled bank, the superheater tubes, secured in tube sheets **120**, open into four superheated vapor outlet chambers **122** which are spaced 45° apart. From the outlet chambers **122** the superheated steam flows to a point of use, not illustrated.

After releasing some of its heat as useful work, the steam is returned for reheating, entering four reheater steam inlet chambers **124** located in the wall sections **28** of the vessel. Tube sheets **126** secure the inlet ends of reheater tubes **128** which extend inwardly into the vessel and pass downwardly adjacent the inner face of the baffle **116** to the same lower level as the superheater tubes **112**. As with the superheater tubes, the reheater tubes **128** similarly form a number of helically coiled rows winding upwardly, concentrically spaced about the center escape tube section **82** to a point closely spaced below the slip joint **86**. Next, the reheater tubes extend upwardly terminating in a tube sheet **130** associated with reheater outlet chamber **132**. There are four such chambers, and the reheated vapor leaving there is conveyed by suitable piping to a point of use, not shown.

The three helically coiled banks of tubes are dependently supported within the vessel. The tubes of the vapor generator **98** and reheater tubes **128** are supported from structural steel grids **134** and **136**, respectively, while the superheater tubes are supported by the brackets **118** which also support the baffle **116**. In each case hanger rods **138** extend downwardly from the structural supports and in turn carry frame members **139** which provide the actual support for the tubes.

Heating fluid is supplied for flow over the reheater and superheater surfaces by two inlet conduits **140** and two superheater inlet conduits **142** passing through the upper head of the vessel. The conduits are secured to the vessel head by thermal sleeve-like connections **144** and **146** to reduce the thermal stresses which would be induced by the high temperature heating fluid entering the vessel. First inlet conduits **140** are connected into a ring header **148** which is aligned above the bank of reheater tubes **128**. Four distribution tubes **150** depend from the ring header **148** to a plane immediately above the upper end of the helically coiled reheater tubes. The lower ends of the distribution tubes **150** are fitted with short horizontal distributor header sections **152** containing a plurality of spaced openings **153** for uniformly distributing the heating fluid over the bank of reheater tubes.

The second conduits **142** are connected into a ring

header **154** which is aligned above the annular bank of superheater tubes **112**. Eight distributor tubes **156**, see FIGS. 2 and 3, extend downwardly from the ring header **154** terminating in the same plane as the distributor tubes **150** and having similar horizontal distributor header sections **158** at their lower ends, see FIG. 5.

Within the confines of the superheater and reheater tubes, the heating fluid is maintained within limits of an upper level **160** and a lower level **162**. Additionally, a heating fluid level **164** is also maintained within the escape pipe section **82** which fluid enters the pipe by way of the relief openings **92**.

A rupture disk **166** is located at the juncture of the upper end of the escape tube assembly **78**, and the upper closure head **30** of the vessel, as a protection for the pressure parts, in the event gas pressure within the vessel exceeds a predetermined limit.

Preferably, a liquid metal such as sodium would be used as the heating fluid in the unit **10**. As indicated, separate heating fluid sources supply the reheater and superheater banks to facilitate close temperature control in each of these heat exchange sections. The heating fluid is distributed over the superheater tubes by the header section **158** and flows downwardly over the tubes in the annulus formed by the baffle **116** and the liner section **36**. Concurrently, fluid also flows over the reheater tubes from the distributor header **152** passing downwardly over the tubes in the annulus formed by the baffle **116** and the center section **82** of the escape tube assembly **78**. At the lower end of the baffle **116**, the separate streams of heating fluid combine and flow, as a single stream, downwardly over the vapor generator tubes. Below the vapor generator tubes the heating fluid passes into the annular space between liner plate **60** and the shield **76** within the member **16** and then is discharged from the vessel through the fluid heating outlet **70**. In addition the space **77** is filled with a stagnant body of heating fluid maintaining the capillary tubes out of contact with the heating fluid continuously flowing out of the vessel.

In this forced-flow once-through vapor generating and superheating unit, as mentioned previously, feedwater enters through the inlet member **48** passing serially upward through the capillary tubes **74**, the connecting tubes **100** and then through the vapor generating tubes **98** wherein it is vaporized, from whence the fluid discharged enters the chambers **102**. It then flows through lines **108**, outside of the vessel, into the superheater inlet chambers **110** for passage through the tubes **112** of the superheater bank, discharging into the superheater outlet chambers **122**, from whence the superheated steam flows to a point of use and subsequent return to the reheater inlet chambers **124** for reheating in the tubes **128** of the reheater bank. After reheating the steam again flows to a point of use, not illustrated.

Because of the potentially dangerous nature of chemical interaction between water and liquid metal heating fluids, such as sodium, provision is made to relieve gases which might be generated thereby. In the present construction gases generated in the vessel can be relieved by passing upwardly through the escape tube assembly **78** and into the gas space **97** above the heating fluid in the upper end of the vessel. As previously noted, gas generated in the lower end of the vessel may pass upwardly through hatch **90** to the upper end of the vessel. The pressure surge evolved by gas generation may be absorbed within the gas space **97** in the vessel or with higher attendant gas pressures by breaking the rupture disk **166**.

While the annular space **42** and space **97** are continuous, the other annular spaces **38** and **40** are sealed off by integrally attaching the liner sections **32** and **34** at their upper extremities to the associated juxtaposed wall sections **20** and **22** of the pressure vessel. Preferably, an inert gas, such as argon, would be utilized in these spaces. However, in the flow space between the liner plate section **60**, **62** and **64** and member **18** a stagnant layer of the heating fluid would be employed.

One of the principal features of the unit **10** is the manner in which it can be readily assembled or dissassembled for inspection and maintenance with a minimum of effort. By disconnecting the exterior piping to the vessel and removing the bolts connecting the flanges of wall section **28** and head **30**, the head, the attached heating fluid distribution piping system and the upper section **80** of tube assembly **78** may be removed as a unit. The arrangement of elements in FIG. 3 clearly shows how the entire assembly may be removed through the structural steel grid **136** without encountering interference with the other vessel internals. With the head removed, access may be had to the tops of the reheater and superheater tube banks and to their structural steel supports without removing any other portions of the vessel.

After breaking the connections between the reheater inlet and outlet chambers **124**, **132** and the point of use and disconnecting the lower flange of the wall section **28** from the upper flange of the wall section **26**, the bank of reheater tubes **128** may be removed as a unit from the vessel. Since the reheater tube support grid **136** is attached to wall section **28**, and the reheater inlet chambers **124** and **132** and outlet, respectively, are also connected to it, the reheater assembly may be removed from within the vessel without interfering with any of the other vessel internals.

Next, after breaking line **108**, the wall section **26** can be separated from the wall section **24** and removed from the remainder of the vessel taking with it the bank of superheater tubes **112**, the tube support structure **118** and the baffle **116** which provides the partition between the superheater and reheater tubes. All that remains within the vessel at this stage in the disassembly is the center and lower tube sections **82** and **84** and the bank of vapor generator tubes **98**.

In order to remove the bank of vapor generator tubes it is first necessary to disconnect the wall section **24** from wall section **22** and lift it from the vessel. The liner section **36** will also be removed with the wall section **24**. Next the center tube **82** may be removed from the lower tube **84**, the break coming at the slip joint **88**. In order to remove the bank of vapor generator tubes **98**, the wall section **22** must be disconnected from wall section **20** and the rocker clamps **54** disconnected from the tube sheet **52** so that the tube sheet and the capillary tubes **74** may be slid upwardly through the member **18**. With the wall section **22** the bank of vapor generator tubes **98**, the connecting tubes **100**, the capillary tubes **74** and the tube sheet **52** with the liner plate **62** and the shield **76** will be removed as a unit. In addition, the lower tube section **84** also will be removed with the vapor generator tubes since it is carried by the structural steel support **134** which supports the vapor generator tubes. With the tubes removed from the vessel, all that remains is wall section **20**, throat forging **16** and the integrally connected liner section **32**, plus the member **18** from which the inlet member **48** and tube sheet **52** have been disconnected.

As compared with the unit disclosed in the earlier mentioned patent application No. 261,638, this unit is particularly advantageous since it provides a vapor generator tube bank which is drainable and a combined reheater, superheater arrangement which permits disposing the optimum quantity of tube surface within the minimum diameter and height of vessel. Further, by providing separate, controllable admission of heating fluid flow to the superheater and reheater tubes, control of the degree of superheating and reheating may be readily achieved.

Because of the inherently dangerous nature of interactions between water and certain heating fluids, the construction of the liner shell provides for maximum safety with a minimum of possible damage. The top of the liner section **36** is arranged so that it is always above the upper level of the heating fluid and, therefore, the heating fluid

does not contact the pressure vessel walls. If there is any upsurge of heating fluid, rather than overflowing the top of the liner section, it will pass inwardly from the openings **94** into the upper tube section **80**.

Specifically, this unit is directed to the use of liquid sodium as the heating fluid, however, it is also readily adaptable to other types of heating fluids which may require protecting the vessel from the high temperature heating fluid, even though the other fluids may not be as likely to cause as violent reaction due to the interaction of the heating and heated fluids.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now 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.

What is claimed is:

1. A vapor generating superheating and reheating unit wherein a heating fluid passes in indirect heat transfer relationship with a vaporizable fluid comprising:

A. a vertically arranged pressure vessel comprising at least three separately removable circumferentially extending wall sections and a removable closure head forming the upper portion of the vessel,

B. a bank of vertically extending vapor generator tubes positioned within the lower end of the pressure vessel,

C. a vertically extending bank of superheater tubes disposed within said vessel above said bank of vapor generating tubes,

D. a vertically extending bank of reheater tubes disposed within said vessel coextensive with said bank of superheater tubes,

E. vertically extending baffle means located within said vessel between said banks of superheater and reheater tubes for forming separate heating fluid flow paths over said banks of tubes,

F. inlet means for said bank of vapor generator tubes detachably connected to said pressure vessel and positioned below said bank of tubes,

G. outlet means for said vapor generator tubes positioned above said bank of tubes and attached to a first one of said wall sections,

H. inlet means and outlet means connected to and located above said bank of superheater tubes and attached to a second one of said wall sections,

I. inlet means and outlet means connected to and located above reheater tubes and attached to a third one of said wall sections, and

J. heating fluid inlet means arranged to supply a separate stream of heating fluid to each of said banks of superheater and reheater tubes.

2. A vapor generating superheating and reheating unit as set forth in claim **1** wherein connecting tubes having a smaller inside diameter than said vapor generator tubes extend between the inlet means for said vapor generator tubes to the lower ends of said vapor generator tubes.

3. A vapor generating superheating and reheating unit as set forth in claim **2** wherein a sleeve encircles said connecting tubes extending upwardly from the inlet means for said vapor generator tubes forming a chamber about said connecting tubes.

4. A vapor generating superheating and reheating unit as set forth in claim **1** wherein a plurality of open ended vertically positioned circular liner sections are disposed closely inward from said pressure vessel and form in combination therewith annular spaces therebetween, the top of said liner sections spaced below the upper end of said pressure vessel.

5. A vapor generating superheating and reheating unit as set forth in claim **4** wherein said wall sections are circular serially arranged and mechanically connected together to facilitate assembly and disassembly.

6. A vapor generating superheating and reheating unit as set forth in claim **5** wherein said bank of superheater tubes is disposed concentrically about said bank of reheater tubes and both of said banks are vertically aligned above said bank of vapor generator tubes.

7. A vapor generating superheating and reheating unit as set forth in claim **6** wherein the wall section to which the bank of superheater tubes is attached is located between the wall sections to which bank the vapor generator and reheater tubes are attached.

8. A vapor generating superheating and reheating unit as set forth in claim **7** wherein a first distributor assembly comprising a plurality of uniformly circumferentially spaced vertical tubes each having a distributor header section at its lower end for supplying heating fluid to said bank of reheater tubes and a second distributor assembly comprising a plurality of uniformly circumferentially spaced vertical tubes each having a distribution header section at its lower end for supplying heating fluid to said bank of superheater tubes.

9. A vapor generating superheating and reheating unit as set forth in claim **8** wherein a heating fluid outlet is located at the lower end of said pressure vessel below said bank of vapor generating tubes.

10. A vapor generating superheating and reheating unit as set forth in claim **9** wherein an axially extending conduit is positioned within said pressure vessel passing through said banks of vapor generator and reheater tubes from the closure head of said vessel downwardly to at least the lower end of said vapor generator tubes for relieving gas generated within said vessel.

11. A vapor generating superheating and reheating unit as set forth in claim **10** wherein said conduit has openings therein along its length and contains a hatch near its lower end biased to a normally closed position for preventing any by-pass flow of heating fluid downwardly through the conduit and opening at a selected pressure for relieving gases generated in the lower end of said vessel.

12. A vapor generating superheating and reheating unit as set forth in claim **11** wherein each of said banks of tubes are helically coiled around said conduit substantially filling the spaces in which they are located.

13. A vapor generating superheating and reheating unit as set forth in claim **12** wherein a vertically extending cylindrically shaped baffle is arranged laterally extensive with and between said banks of superheater and reheater tubes.

14. A vapor generating superheating and reheating unit as set forth in claim **13** wherein the upper end of said baffle is disposed above the distribution header sections of said first and second distribution assemblies.

15. A vapor generating superheating and reheating unit as set forth in claim **14** wherein support means provide individual pendant support for each of said banks of tubes.

16. A vapor generating superheating and reheating unit as set forth in claim **14** wherein thermal barrier means are disposed between the heating fluid and the portion of the pressure vessel to which the outlet ends of the vapor generator tubes are attached.

17. A vapor generating superheating and reheating unit wherein a heating fluid passes in indirect heat transfer relationship with a vaporizable fluid comprising:

A. a vertically arranged cylindrically shaped pressure vessel comprising at least three serially arranged mechanically connected separately removable circular wall sections and a removable head member forming the upper portion of the vessel,

B. a number of upwardly positioned serially arranged cylindrically shaped open ended liner sections disposed inwardly from said pressure vessel and forming annular spaces therewith, the top of said liner

sections being spaced below the upper end of said vessel,

C. a vertically extending bank of helically coiled vapor generator tubes positioned within said liner sections in the lower end of said pressure vessel,

D. a vertically extending bank of helically coiled reheater tubes disposed within and below the upper end of said liner sections and above said bank of vapor generator tubes,

E. a vertically extending annular shaped bank of helically coiled superheater tubes disposed within said liner sections coextensive with and concentrically arranged about said reheater tubes,

F. a vertically extending cylindrically shaped baffle located within said liner sections and disposed between said banks of superheater and reheater tubes for forming separate heating fluid flow paths over said banks of tubes,

G. an inlet chamber for said vapor generator tubes positioned below the bank of said tubes and detachably connected to said pressure vessel, a plurality of capillary tubes within said vessel interconnecting said inlet chamber and vapor generator tubes, said capillary tubes having a smaller interior diameter than the vapor generator tubes to which they are connected for uniform distribution of feedwater to said vapor generator tubes,

H. an outlet chamber disposed above and in communication with said vapor generator tubes and connected to and extending outwardly from a lower one of said pressure vessel wall sections located above said tubes,

I. a separate inlet chamber and outlet chamber in communication with said superheater tubes connected to and extending outwardly from one of said pressure vessel wall sections disposed above said wall section incorporating the vapor generating tubes outlet chamber and located above the said bank of superheater tubes,

J. a separate inlet chamber and outlet chamber in communication with said reheater tubes and connected to and extending outwardly from one of said pressure vessel wall sections and disposed above said wall section incorporating the superheater tubes inlet and outlet chambers,

K. separate heating fluid inlet means for each of said banks of superheater and reheater tubes comprising a

first ring header located in the upper end of said pressure vessel and aligned above said bank of reheater tubes, a second ring header located in the upper end of said pressure vessel aligned above said bank of superheater tubes and concentrically disposed about said first ring header, a plurality of downwardly extending first distribution conduits connected at their upper ends to said first ring header, a first short horizontally extending member connected to the lower end of each of said first conduits for uniformly distributing heating fluid to said banks of reheater tubes, a plurality of downwardly extending second distribution conduits connected at their upper ends to said second ring header, a second short horizontally extending member connected to the lower end of each of said second conduits for uniformly distributing heating fluid to said bank of superheater tubes,

L. top mounted tube hanger supports for each of said banks of tubes,

M. a vertically arranged pipe centrally located within said pressure vessel and passing through said banks of tubes, said pipe connected at its upper end to the head member of said pressure vessel and having its lower end open and positioned at the lower end of the bank of vapor generator tubes, a normally closed hatch in said pipe arranged to open and permit high pressure gases to escape from the lower end of the pressure vessel,

N. inlet and outlet connections in said pressure vessel communicating with the annular spaces formed between the pressure vessel wall sections and liner sections for supplying fluid to and for draining these spaces, and

O. walls forming a heating fluit outlet located at the lower end of the vessel, and plate means spaced inwardly from said walls forming an annular flow space therebetween.

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KENNETH W. SPRAGUE, *Primary Examiner.*