Dec. 1, 1953 A. KIRKPATRICK 2,661,190

CONDENSER WITH SUBCOOLER AND VENTING MEANS

Filed Jan. 29, 1953 2 Sheets-Sheet 1

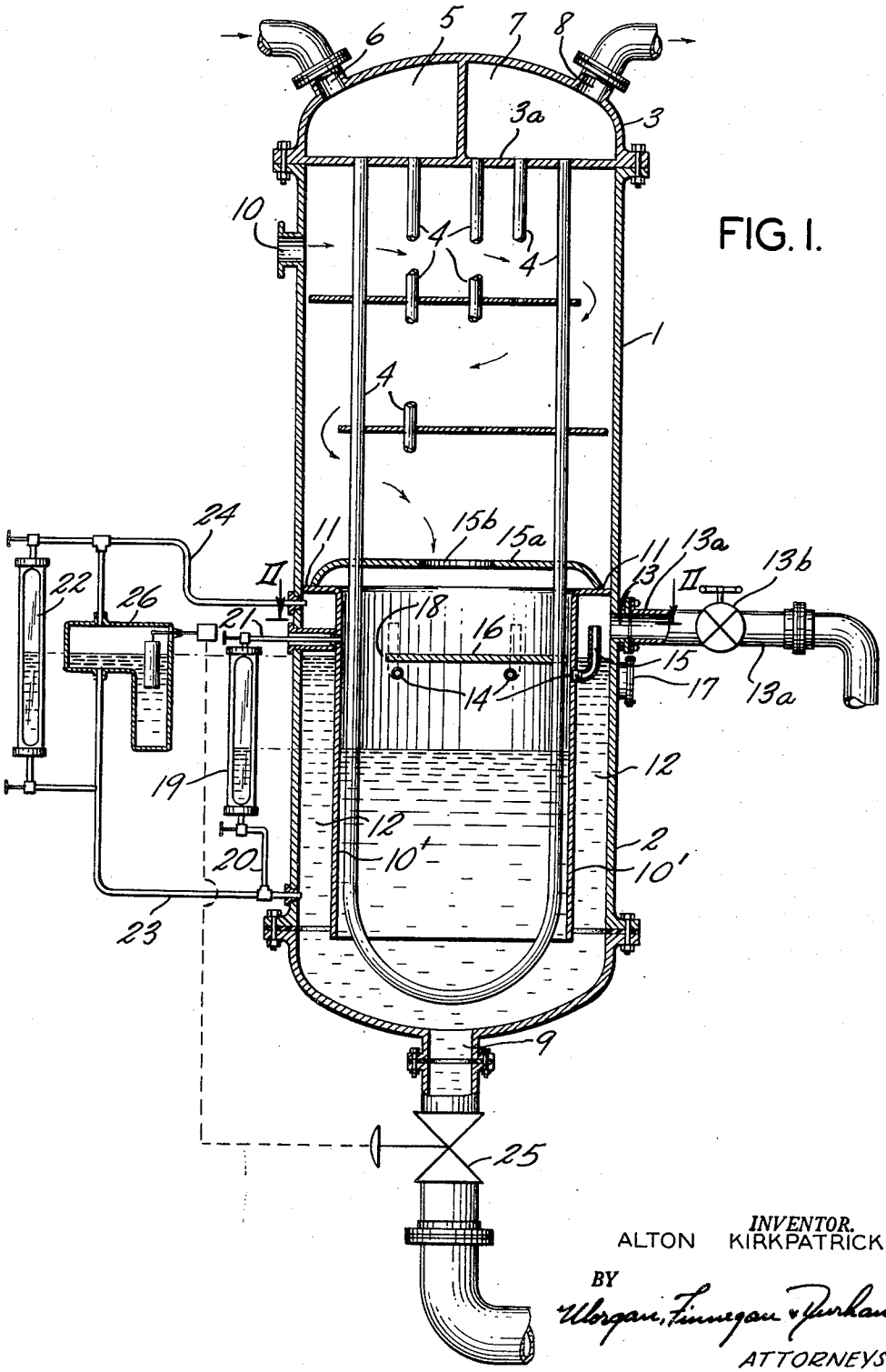


FIG. I.

INVENTOR.
ALTON KIRKPATRICK

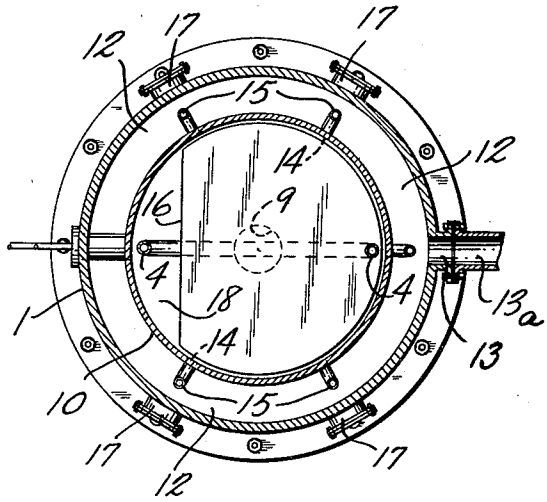
BY
Morgan, Finnegan & Durham
ATTORNEYS.

Dec. 1, 1953 A. KIRKPATRICK 2,661,190

CONDENSER WITH SUBCOOLER AND VENTING MEANS

Filed Jan. 29, 1953 2 Sheets-Sheet 2

FIG. 2.



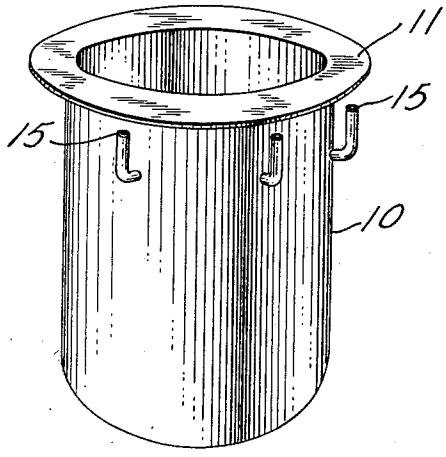


FIG. 3.

INVENTOR.
ALTON KIRKPATRICK

BY
Morgan, Finnegan & Durham

ATTORNEYS.

Patented Dec. 1, 1953 2,661,190

UNITED STATES PATENT OFFICE

2,661,190

CONDENSER WITH SUBCOOLER AND VENTING MEANS

Alton Kirkpatrick, Brighton, Mass., assignor to Stone & Webster Engineering Corporation, Boston, Mass., a corporation of Massachusetts

Application January 29, 1953, Serial No. 333,979

6 Claims. (Cl. 257—32)

1

This invention relates to vapor to liquid heat exchangers, and especially to vertical tubular vapor to liquid heaters adapted to condense the vapor by indirect heat exchange with a cooling liquid and to vent non-condensible gases, and more especially to such heaters wherein provision is made for sub-cooling the condensate.

Speaking generally, the invention ensures satisfactory condensation of the condensible vapor and/or gases in the vapor and provides a positive and continuous venting of the non-condensible gases, without also venting large quantities of condensibles. Further, positive venting of the non-condensible gases is also provided with and during sub-cooling of the condensate within the same heater wherein the condensate was formed so as to obtain high thermal efficiency in the installation, particularly where the condensate is in turn cascaded to another heat exchanger of lower pressure. Still further, the invention permits the condensate to be withdrawn and its rate of withdrawal to be controlled while the gas venting or condensate subcooling, or both, is continued. In addition, by suitable compartmentation, sub-cooling of condensate under conditions such that positive gas venting can be provided is assured and assurance of such gas venting can be had by visual observation of difference in compartment condensate levels.

Briefly, this is accomplished by providing a compartmented vertical vapor to liquid heat exchanger, having a closed-end vertically disposed shell with an outlet for condensate below the vapor inlet and having a bundle of cooling tubes within its shell with means for circulating coolant in these tubes. Two types of conventional vertical heaters in current practice are: (1) U-tube; and (2) floating head, with fixed tube sheet either at top or bottom. An open ended annular inner shell is disposed within the lower or bottom portion of the first mentioned or outer shell but spaced apart from the lower end of the outer shell. The inner shell is held fixed in this position within the outer shell by a baffle section adjacent its upper end that extends outwardly toward the inner surface of the walls of the outer shell, the outer edges of this baffle being in sealing engagement with these walls, thus forming an annular vent compartment between the outer shell and the inner shell. At least one vent in the wall of the outer shell and at least one vent in the wall of the inner shell are provided below and substantially adjacent to the baffle section, the total vent area in the outer

2

shell being the greater, provision being made, preferably, for varying the area of the inner shell vent area. The condensate outlet is positioned below the vent of the outer shell. With this arrangement the condensible gases in the entering vapor condense on the tubes and fall by gravity through the inner shell to collect in the lower end of the outer shell and lower portion of the vent compartment for removal through the outlet at a controlled rate, selected to maintain a substantially constant liquid level in the vent compartment. Non-condensible gases are positively and continuously vented from the interior of the inner shell into the upper portion of the vent compartment through the vents in the inner shell, and thence out of the heat exchanger through the vent in the outer shell with minimum or negligible venting of condensible gases.

It is preferred to have means (a valve, etc.) to regulate the rate of condensate removal through the outlet where the quantity of vapor entering the heat exchanger fluctuates during continued operation.

Preferably, the lower end of the bundle of tubes extends into the lower portion, i. e. the condensate collecting portion, of the inner shell, to sub-cool the condensate prior to its removal through the outlet, and more preferably the bundle of tubes extends downwardly through the inner shell into the lower portion. i. e. condensate collecting portion, of the outer shell to sub-cool the condensate. A maximum degree of subcooling (which is limited by the amount of cooling tube surface and the temperature of the cooling liquid within the tubes) is most advantageous.

Still more preferably, a float level control or similar control device is provided to regulate the valve means and thus the rate of flow of condensate through the outlet in accordance with changes in the rate of condensate formation within the outer shell, to maintain a liquid seal in, and to prevent flooding of, the vent compartment.

Also, more preferably, sight glasses and connecting means are provided to permit visual observation of the difference in condensate levels in the annular vent compartment and inner shell, it being apparent that such difference in level evidences a differential pressure between the two compartments being such as to ensure gas venting at all times.

The accompanying drawings, referred to herein and constituting a part hereof, illustrate a preferred embodiment of the invention, and to-

gether with the description, serve to explain the principles of the invention.

Of the drawings:

Fig. 1 is a view in sectional elevation of a vertical tubular vapor to liquid heater embodying the invention, the view being taken along the vertical medial plane of the heater.

Fig. 2 is a horizontal section of the heater at line II—II of Fig. 1.

Fig. 3 is a perspective of the inner shell and its baffle section, the inner shell having replaceable vent tubes.

Referring now in detail to the illustrative embodiment of the invention shown by way of example in the accompanying drawings, the vertically disposed outer shell of the heat exchanger is designated generally by the numeral 1. It has closed ends at its lower or condensate portion 2 and upper or head portion 3. The head 3 with fixed tube sheet 3a is removably secured to the top of outer shell 1 and carries a tube bundle 4 extending downwardly within the outer shell, so as to permit ready withdrawal of the tube bundle for purposes of cleaning, repair, etc., without disturbing internal connections. The bundle of tubes illustrated is of the U-tube type but this is not necessary to the invention, since the invention is adaptable to the use of a floating head with fixed tube sheet either at top or bottom. Means for circulating water or other suitable coolant in the bundle of tubes 4 is provided in partitioned head 3 by inlet compartment 5 with coolant inlet 6 and outlet compartment 7 with coolant outlet 8.

Outer shell 1 has a condensate outlet 9 in its lower or condensate collecting head portion 2 (at the extreme lower end of the shell, as shown in Fig. 1) and a vapor inlet 10 is provided in the upper body portion of outer shell 1 below head 3.

An inner shell 10 is disposed within the lower portion of outer shell 1. It is open at both ends and is, preferably, of cylindrical contour and has an outwardly extending annular baffle section 11 adjacent its upper end, the outer edges of which are in sealing engagement with the body walls of outer shell 1 to hold and fix inner shell 10' with its lower end spaced from the lower end of the outer shell and with the walls of the inner shell spaced apart from the body walls of outer shell 1. Baffle section 11, inner shell 10', and the inner surface of the adjacent body walls of outer shell 1, thus form an annular vent compartment 12.

A vent orifice 13 is provided in outer shell 1 below and adjacent to the baffle section 11 for the discharge of non-condensible gases from vent compartment 12. Vent orifice 13 leads into outlet pipe 13a, which has a manual control valve 13b and preferably leads into a vessel at lower pressure such as another heat exchanger or condenser (not shown) for efficient operation of the entire installation. A plurality of smaller vent orifices 14 are provided in the inner shell below and adjacent to baffle section 11. One vent orifice 14, instead of a plurality, and similarly a plurality of vent orifices 13 instead of a single vent orifice 13 and any combination thereof can be used provided that the total vent area of the inner shell vents (i. e. the total cross-sectional area of the vents) is substantially less than the total vent area of the vent or vents 13. However, a single vent orifice 13 and a plurality of small vent orifices 14 is preferred. Preferably, also, the inner shell vent orifices 14 of the preferred embodiment illustrated each has an

outwardly extending tube 15 threadedly removably received within the orifice and extending upwardly within the vent compartment 12. These tubes are adapted for removal or replacement through allied removable shell-closures 17 providing "hand-holes," so that through the use of tubes 15 of greater or less internal diameter, a desired total vent area may be created. If desired, the tubes 15 may be equipped with externally operable valves for varying their venting capacity at will.

The bundle of tubes 4 extends downwardly from head 3 into the lower portion of the outer shell 1 and, as here preferably embodied, through the open lower end of inner shell 10', with the lower end of the tubes protruding therefrom. Attached and fixed to the bundle of tubes 4 for removal as a unit therewith, are two baffle sections 15a and 16. Baffle 15a is in the form of a dished disc positioned above baffle section 11 and has a central orifice at 15b. Its outer edges are adapted to rest on baffle section 11 and fit substantially snugly thereon to channel substantially all of the vapor, and non-condensible gases through the orifice 15b only. Baffle 16 is positioned within the inner shell 10' below upper baffle 15a and above vent orifices 14 of the inner shell 10'. It extends horizontally transversely of the tubes of the tube bundle 4 within the inner shell 4 but is dimensioned to provide an opening 18 displaced horizontally from the centre of orifice 15b of upper baffle 15a, to channel downwardly moving condensate, vapor and non-condensible gases into a non-vertical path and thus effect a more efficient vapor-liquid separation.

Sight glass 19 has fluid pipe connections 20, 21 leading to the condensate portion of outer shell 2 and to the upper portion of inner shell 10', respectively, to indicate the level of condensate within inner shell 10'. Sight glass 22 has fluid pipe connections 23, 24 leading to the lower (liquid) and upper (vapor) portions, respectively, of vent compartment 12 to visually indicate the level of condensate in the annular vent compartment 12.

Condensate outlet 9 is provided with a valve 25 and suitable automatic valve regulating control means (either mechanical, electrical, etc.) to regulate the opening of valve 25 in response to the rise and fall of condensate levels within the outer shell with a pre-determined setting. As illustrated, Fig. 1, the valve regulating control is float level 26, which is suitably connected to valve 25 and fluid pipe connections 23, 24 and set to maintain a desired condensate level within the annular gas venting section or compartment 12 allowing condensate level within the circular inner shell or baffle to be at a lower level depending on the pressure difference between the vent section and the vapor (steam) space of the heater. The level in the vent section should be sufficiently low to keep condensate in vent compartment 12 below the upper end of tubes 15 and also below vent orifice 13 as the quantity of pressure differential during operation provides corresponding quantity of level differential.

Operation of the device illustrated and described is as follows: In starting the operation, float control 26 is set to maintain condensate outlet valve 25 closed until the condensate level within vent compartment 12 is slightly below vent 13 and the open end of tubes 15 leading from vent orifices 14, and to thereafter regulate the opening of valve 25 to maintain the condensate at

such a level (see Fig. 1). Gas outlet valve 13b is opened.

Vapor (steam) to be condensed enters the heater through steam inlet 10 and upon impinging on cooling tubes 4 through which coolant (water) is circulated, the vapor condenses to liquid and the liquid-vapor mixture courses downwardly, as will be understood, passes through orifices 15b and 18 of baffles 15a and 16, respectively, through inner shell 10' to the lower end and condensate collecting portion 2 of outer shell 1. Final cooling and condensation is effected within the circular baffle 10'. The level of condensate rises, with continued condensing, until the condensate rises into the lower end of inner shell baffle 10' and vent compartment 12 to provide a liquid seal at the bottom of vent compartment 12. As the condensate level continues to rise, the non-condensible gases are caused to pass from the higher pressure steam space through the small vent orifices 14 of the inner shell, and thence through tubes 15 into lower pressure vent compartment 12 wherein they are passed through vent orifice 13 to gas outlet pipe 13a. The latter may be connected cascade fashion to a vessel of lower pressure.

Since vent 13 has greater vent area than vent orifices 14, the non-condensible gases vent more rapidly from vent compartment 12 through outlet pipe 13a than from the steam space of outer shell 1 and inner shell 10' through vent orifices 14 into the vent compartment, and a greater pressure rapidly builds up and is caused to be maintained within the inner shell 10' than occurs within the vent compartment 12. Accordingly, a positive and continuous driving force is rapidly achieved which positively and continuously vents the non-condensible gas to outlet pipe 13a from within the steam space of inner shell 10'.

This pressure differential is reflected in the levels of the condensate within the inner shell and within the vent compartment. The level of condensate within the vent compartment is much higher than the condensate level of the inner shell (Fig. 1). These condensate levels continue to rise until the condensate within the vent compartment is slightly below the vent orifice 13 and the open ends of inner shell vent tubes 15, whereupon float level 26 actuates the valve 25 to open it to continuously withdraw sufficient effluent to maintain the desired level of condensate within the vent compartment as more vapor enters the heat exchanger and is condensed.

With the tubes 15 provided on vent orifices 14, the vent compartment condensate level can be allowed to rise above vent orifices 14 to a position slightly below the upper open end of the tubes. This is preferred for the most efficient operation of the heat exchanger but it will be understood that removal of tubes 15 merely requires a setting of float level 26 to maintain the vent compartment condensate level below vent orifices 14 to permit continued venting through vent orifices 14 into venting section 12.

During the initial starting operation and before the condensate level rises within inner circular baffle 10', some non-condensed vapor passes into the vent compartment 12 and is vented to gas outlet pipe 13a with the non-condensible gases. However, this period is brief and little of the vapor is thus vented.

After the condensate levels have risen, the continued operation is as follows: The entering vapor is continuously condensed on the cooling tubes as the vapor and its forming condensate courses downwardly and through the non-vertical path formed by the intermediate baffles and orifices 15b and 18 in baffles 15a and 16, respectively. The non-condensible gases are continuously vented through vent orifices 14 via tubes 15 to gas outlet pipe 13a and the condensate falls into the body of condensate within the inner shell. Since the bundle of cooling tubes extends into the collected condensate in the depicted embodiment, it further cools (i. e. sub-cools) the condensate, thus increasing the overall efficiency of the installation. The condensate thereafter is continuously withdrawn by gravity through valve 25 and outlet pipe 9 as the positive venting of non-condensible gases continues. Passage of condensible vapor into gas outlet pipe 13a is substantially negligible.

Assurance of proper operation is afforded by sight glasses 22, 19. Visual observation of the liquid levels therein reveals the condensate level difference within the heat exchanger and thus the existence of positive gas venting, and permits ready adjustment of a faulty setting of the float level if vent compartment flooding into outlet pipe 13a or through vents 14 into the inner shell has occurred or is imminent.

Although preferable for greater overall efficiency, sub-cooling may be eliminated from the condensing and venting operation by constructing the bundle of cooling tubes of such length that the lower end thereof does not extend downwardly into the inner shell condensate, e. g. the lower end of the tube is positioned above vents 14 (not shown). Operation of this form of the invention is identical with operation of the heat exchanger illustrated and described above except that the body of condensate is not further cooled appreciably beyond its temperature of condensation.

If it is desired to provide more than one vent 13 for the outer shell, a vent manifold (not shown) can be added to convey the non-condensible gases to outlet pipe 13a.

Speaking generally, the greater the difference in the total vent areas of outer shell vent or vents 13 and vent orifice or orifices 14, the greater the pressure differential between vent compartment 12 and inner circular baffle shell 10', and the greater the driving force venting the non-condensible gases.

This is illustrated but not restricted by the following examples:

Example 1

If the heater is operating with steam inside the shell 1 at atmospheric pressure and manual control valve 13b is opened until the difference in water level between vent compartment 12 and inner shell space enclosed by 10' is 6 inches and there are five vent tubes 15 each having an inside diameter of 0.402 inch, there will be vented to the vessel of lower pressure approximately 13 cubic feet per minute of saturated air or other gas or vapor which may be present. At 3 inches difference in water level approximately 9 cubic feet per minute will be vented.

It will be understood that my invention is not limited to the details described and shown in the drawings, except as appears hereafter in the claims.

What I claim is:

1. A vapor to liquid heat exchanger comprising a vertically disposed outer shell, said shell having an outlet to remove condensate and a vapor inlet, a bundle of cooling tubes disposed within

said shell, means for circulating coolant in said tubes, an open ended inner shell within the lower portion of said outer shell but spaced apart from the walls thereof, said inner shell having a baffle section adjacent its upper end extending outwardly with its outer edges in sealing engagement with the walls of said outer shell to form a vent compartment and hold said inner shell in fixed position, at least one vent from said compartment in said outer shell and at least one vent to said compartment in said inner shell, the total vent area in said outer shell being greater than the total vent area in said inner shell to positively remove non-condensible gases from within said heat exchanger, said condensate outlet being below said vents and said vapor inlet being above said baffle section.

2. The subject matter of claim 1 including a valve on the condensate outlet to vary flow therethrough and means responsive to changes in condensate levels within said outer shell to regulate the valve in accordance with a pre-determined setting of said means whereby a determined condensate level may be maintained in said vent compartment.

3. The subject matter of claim 2 characterized by the fact that said bundle of cooling tubes is of a length to extend into a body of condensate collected in the lower portion of said outer shell to sub-cool said condensate during positive and continuous venting of non-condensible gases.

4. The subject matter of claim 1 characterized by the fact that each inner shell vent orifice has a vent tube extending into said vent compartment and upwardly with its free end adjacent said baffle section.

5. The subject matter of claim 4 characterized by the fact that each such vent tube is removably secured to said inner shell and that said outer shell is provided with sealed access openings for removing and installing vent tubes in said vent orifices.

6. The subject matter of claim 1 including sight glasses and connecting means to said vent compartment and inner shell to afford visual observation of condensate levels within said vent compartment and said inner shell.

ALTON KIRKPATRICK.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,412,573	Fraser	Dec. 17, 1946
2,489,944	Worn et al.	Nov. 29, 1949