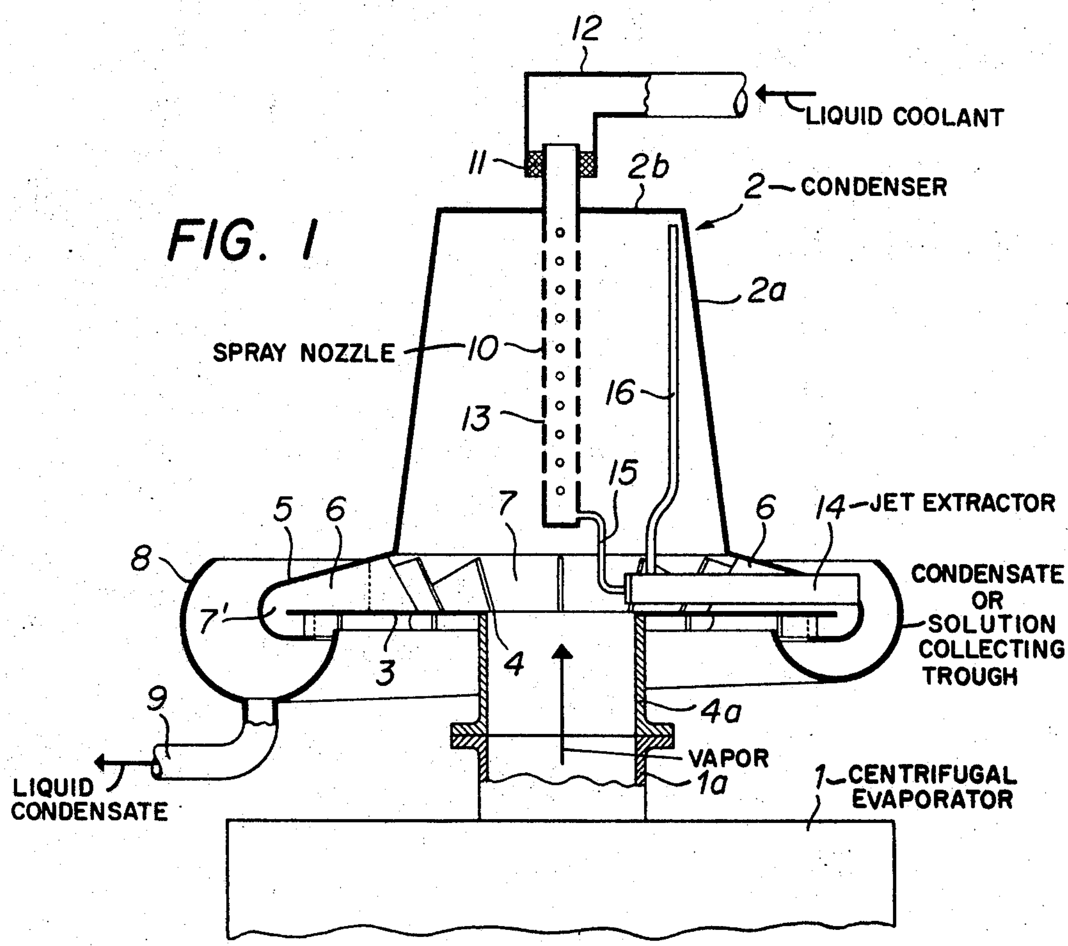
CENTRIFUGAL CONDENSING APPARATUS

Filed July 5, 1968 2 Sheets-Sheet 1

FIG. 1



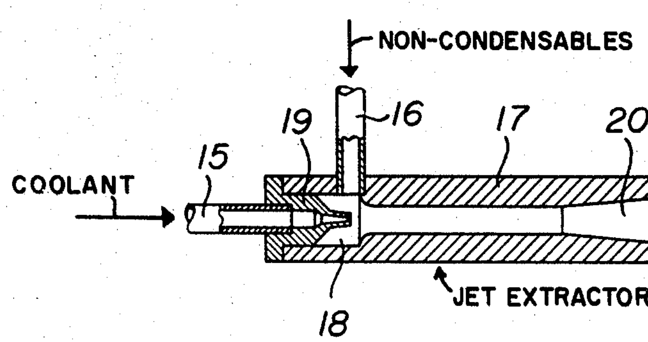


FIG. 2

FIG. 3

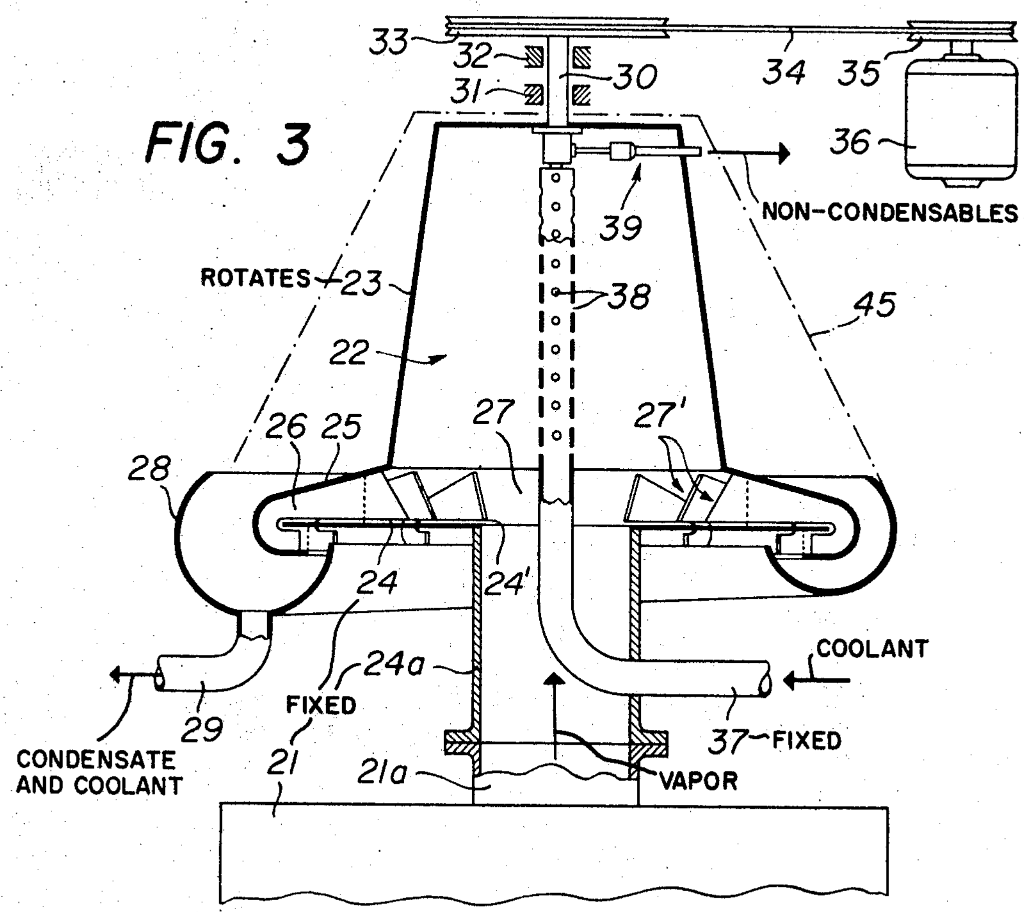
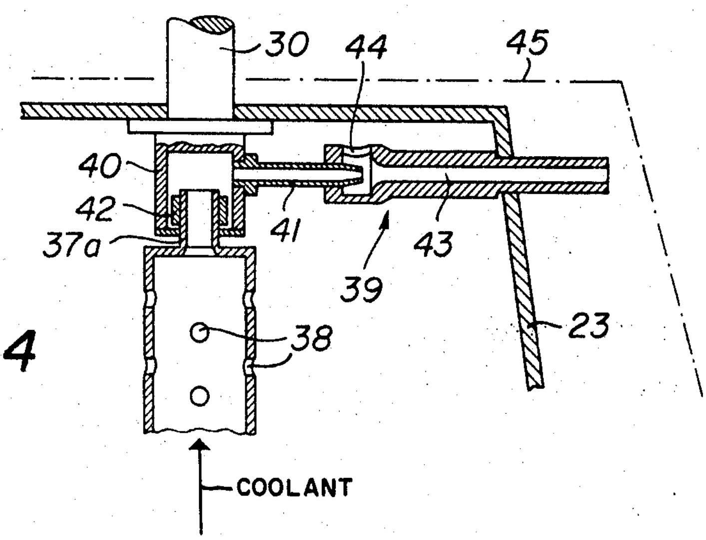

33
32
31
30
34
35
36
NON-CONDENSABLES
39
ROTATES
23
38
45
22
27
27'
26
25
28
24
24'
COOLANT
24a
FIXED
29
37
FIXED
CONDENSATE
AND COOLANT
21
21a
VAPOR

FIG. 4


30
44
45
40
42
37a
41
43
39
23
38
COOLANT

United States Patent Office 3,567,589
Patented Mar. 2, 1971

1

3,567,589
CENTRIFUGAL CONDENSING APPARATUS

Alain Javet, Grange-Canal, Geneva, Switzerland, assignor to The Battelle Development Corporation, Columbus, Ohio

Filed July 5, 1968, Ser. No. 742,589
Claims priority, application Switzerland, July 4, 1967, 9,474/67
Int. Cl. B01d *3/08*
U.S. Cl. 202—189 10 Claims

ABSTRACT OF THE DISCLOSURE

A device for enabling a liquid to be discharged from a rotating chamber through an end opening formed in a casing portion thereof and for preventing a gaseous fluid from flowing through said opening in either direction, which comprises the outer semitoric half of a toric channel with one opening of the channel directly and sealingly connected to said casing end opening and with the convex surface of the channel in a position radially more remote from the rotational axis of the chamber than said opening, a disc transverse to the axis extends radially into the channel so that, upon liquid being discharged from said casing end opening, said liquid first fills said channel to form a liquid plug before issuing at the other end of the channel. In a preferred embodiment the casing end opening and the channel extend, widthwise, circumferentially around the entire chamber.

The present invention provides improved apparatus for condensing vaporized substances, which is designed to do away with the pumping means that are normally used for removing the resulting condensate and non condensable gaseous substances.

The apparatus provided by the present invention for condensing vaporized substances comprises a rotatable condensation chamber having an inlet for the intake of said vaporized substances and a part for the discharge of the condensed solution, means for atomizing within said chamber a liquid for cooling said products, a fluid jet extractor for clearing said chamber of non condensable gases and a fluid flow control channel which communicates with said port on the outside of said chamber and which has an outline such that its flow axis forms substantially a U of which one limb begins at the end of the channel adjacent said port and the other limb ends at the opposite, discharge, end of the channel, whereas the bottom of said U is positioned on the side opposite the axis of rotation in relation to said channel ends.

In the accompanying diagrammatic drawings:

FIG. 1 is vertical section of a first embodiment of the condensing apparatus provided by the invention;

FIG. 2 is an axial section, on an enlarged scale, of a constructional detail visible in FIG. 1;

FIG. 3 is a vertical section of a second embodiment of the condensing apparatus provided by the invention; and

FIG. 4 shows in axial section and on an enlarged scale a constructional detail of FIG. 3.

The condensing apparatus shown in FIG. 1 is intended to be secured, for instance, to the rotary casing of a centrifugal evaporator **1** which is only partly visible, so as to be rotatably driven thereby.

It comprises a casing **2** having a frusto-conical side-wall **2***a* and a bottom **3** which is open at **4** to provide a passage for vaporized substances which are to be condensed and which rise up from the evaporator through a first duct section **1***a*, secured to the evaporator, and through a second duct section **4***a* which is secured to the underside of the condenser bottom **3**.

2

The frusto-conical side-wall **2***a* is connected to the bottom **3** by a circumferential flange **5** which, in cross-section, has the shape of a slightly opened out U formed with limbs of unequal length, and by twelve radial webs **6** of which only seven are visible.

The space lying between the flange **5** and the bottom **3** of the condensing apparatus forms a U-shaped channel **7** whose function will be described further on.

The condensed solution which is produced by the apparatus flows through the channel **7** and is discharged into a stationary collecting trough **8** which has a spirally inclined bottom and which entirely surrounds flange **5**, whence it may be conveyed through a drain pipe **9** to, for instance, a storage tank, not shown.

At the centre of the top wall **2***b* of casing **2** is formed a circular opening in which is rigidly mounted a tube **10** extending axially downwardly into the condensation chamber over the greater part of its axial length and upwardly into a rotary seal coupling **11** arranged in the orifice of a conduit **12** connected to a source, not shown, of cooling liquid.

The portion of the tube **10** which extneds into the condensation chamber is closed off at its lower end and is formed with a plurality of micro apertures **13** adapted to spray the cooling liquid into the condensation chamber in vaporized form.

The condensing apparatus is further provided with means to enable the non condensable gases to be cleared from the condensation chamber. These means include a fluid jet extractor **14** which is supplied with liquid by a hose **15** connected to tube **10** and to which is fitted a suction tube **16** extending upwardly into the uppermost region of the condensation chamber, where the gases generally congregate.

The fluid jet extractor **14** is positioned radially in the region of the apparatus delimited by the flange **5** and the bottom **3** and extends into the upper limb of channel **7** and its radially outer, outlet, end projects fluid-tightly through flange **5** into collecting trough **8**.

Extractor **14** is of conventional construction as is apparent from FIG. 2. It consists of a cylindrical body **17** formed with an enlarged recess **18** at its radially inner end for receiving a nozzle **19**, and with an axial passage **20** communicating with recess **18** for discharging the gases sucked in through tube **16** and the liquid ejected by nozzle **19**.

The above described condensing apparatus operates as follows:

When the evaporator **1** is operating, it rotates about its vertical axis, driving therewith the condenser, and it yields a certain amount of evaporated substances which are to be condensed by the condenser.

These evaporated substances rise up through duct sections **1***a* and **4***a* into the condensation chamber and in particular into the portion thereof lying between the casing **2** and the tube **10**, into which portion tube **10** sprays as described a cooling liquid, the nature of the latter being determined from case to case in dependence on the kind of substances having to be condensed. Thus, if these substances consist of solvents having well defined characteristics, such as for instance benzene and acetone, the cooling liquid will preferably also consist of benzene or acetone.

The condensation of the vaporized substances rising up from the evaporator **1** thus takes place by the encounter and intimate contact of the cooling liquid particles with the molecules of the substances within the chamber portion lying between the tube **10** and the side wall **2***a*. A liquid solution consisting of a mixture of the cooling liquid and of the condensate of the vaporized substances thus comes to flow along the inner surface of side wall **2***a*. This solution is subject to the action of centrifugal force which compels it to flow downwards along the side wall *2a*, in view of its flared shape, towards the channel **7**.

When the solution reaches the edge of this channel it is forced into the latter under the action of the centrifugal force and progressively first comes to fill its rounded portion **7'** then to "rise" radially on opposite sides of the peripheral portion of the bottom **3**.

The presence of the fluid jet extractor **14** and the pressure drop caused by any form of condensation in an enclosed space cause the pressure in the condensation chamber to be very much less than the atmospheric pressure which prevails, for instance, in the collecting trough **8**. Consequently the radial depth of the liquid which will have accumulated in channel **7** on opposite sides of disc **3** will be different as shown by the broken lines, this depth being considerably greater on the top side of disc **3** since the low static pressure which prevails in the condensation chamber will have to be compensated by a relatively substantial column of liquid subjected to centrifugal force.

Once channel **7** has filled with liquid solution and if there is no further inflow of solution, the channel remains filled and the solution contained therein forms an annular gastight plug preventing air from entering into the condensation chamber.

But if there is a further inflow of solution into the upper limb of channel **7**, this additional mass of liquid, which is subjected to centrifugal force, will exert on this limb a radial thrust, which will set the liquid plug closing off the channel in motion towards the outlet thereof and a corresponding amount of solution will be discharged into the collecting trough **8**. This discharge will of course cease as soon as the inflow of liquid solution into the upper limb of channel **7** stops, and such inflow will clearly only be interrupted if the supply of cooling liquid into tube **10** is cut off. The same also applies to the operation of the fluid jet extractor **14** whose nozzle **19** is directly connected to the tube **10**.

The condensing apparatus shown in FIGS. 3 and 4 is more particularly intended to be mounted on a non-rotating evaporator **21**, and comprises a condensation chamber **22** formed by a rotary bell-shaped casing **23** and a stationary disk-like base **24** formed at its centre with an opening **24'** for the inflow of vaporized substances issuing from the evaporator and rising up through a first duct section *21a* fixed to the evaporator and through a second duct section *24a* extending downwardly from the base **24** and secured around the opening **24'**.

The frusto-conical side-wall of the casing **23** is provided along its lower edge with a peripheral flange **25** which is bent so as to have, in cross-section, the shape of a slightly opened out U with limbs of unequal length and which circumferentially envelops the edge portion of the disk-like base **24**.

The space which lies between the flange **25** and the disk-like base **24** and which is identified as **27** is divided by twelve vertically positioned radial webs **26** into a corresponding number of radial U-shaped channels **27'**, whose function will be explained further on.

A stationary circular trough **28** having a spirally inclined bottom is mounted around flange **25** and co-axially therewith for collecting the condensed solution produced by the apparatus and issuing through channels **27'**, a drain pipe **29** being connected to the lowermost point of the trough **28** for conveying the collected solution to a storage tank not shown.

The bell-shaped casing **23** is rigidly secured at its top to a shaft **30** rotatably mounted in two very diagrammatically represented bearings **31** and **32**. The shaft **30** and hence the bell-shaped casing **23** are rotatably driven by an electric motor **36** through the intermediary of a grooved wheel **33** carried by shaft **30**, a grooved pulley **35** carried by the motor drive shaft and a tensioned transmission belt **34** passing round wheel **33** and pulley **35**.

Through a side opening in the duct section *24a* extends a conduit **37** which is connected at its lower end to a source

(not shown) of cooling liquid and which is bent to project vertically upwards through duct section *24a* and into chamber **22**, in co-axial alignment therewith and with the upper end thereof lying in close proximity to the top of the bell-shaped casing **23**. Above the level of channels **27'** the duct **37** is formed with a plurality of apertures **38** and, as with duct **10** and apertures **13** in the previous embodiment, duct **37** and apertures **38** serve to introduce, in atomized form, the refrigerating liquid into the condensation chamber **22**.

The function of the trough **28** and of the disk-like base **24** of chamber **22** is also similar to the corresponding parts in the previous embodiment even though base **24** is here stationary. Since base **24** is stationary the webs **26** are not secured, as in the previous embodiment, to the base **24** and a slight clearance has to be left between each web and the base to allow relative movement thereof. In the presence of these clearances, a slight amount of liquid solution will tend to pass from one radial channel **27'** to another through the clearances during operation of the apparatus.

The present embodiment is also provided with a liquid jet extractor **39** for clearing non-condensable gases from the chamber **22** but as is apparent from FIG. 3 its location is quite different from that of the extractor used in the previous embodiment. Another basic difference is that extractor **39**, which rotates with the casing **23**, is here required to cooperate with a stationary tube **37** instead of a rotating tube.

Referring to FIG. 4 it will be observed that tube **37** is formed at its upper end with a reduced diameter portion *37a* which extends, over the greater part of its length, into a distribution chamber **40** formed on the underside of shaft **30** and rotating therewith. Fluid tightness between the tube portion *37a* and the chamber **40** is ensured by a labyrinthal rotary seal device **42**.

Into an opening formed in the side-wall of chamber **40** is fitted a nozzle **41** through which liquid flowing into chamber **40** from tube **37** via portion *37a* is ejected through an axial passage **43** formed in the body of extractor **39**, which body is secured to and extends fluid-tightly through the side wall of casing **23**. As shown, the nozzle **41** opens at the head of passage **43** into a recess which has a diameter greater than this passage and which communicates with chamber **22** via a lateral port **44** through which are sucked the non condensable gaseous substances within chamber **22**, generally accumulating in the upper region thereof. These gaseous substances are discharged into a space lying between a hood **45**, indicated in chain-dotted lines in FIG. 3, and the casing **23**, this hood being preferably fluid-tight and in communication with the trough **28**.

Although in both of the illustrated embodiments the castings are shown to have frusto-conical side walls, it is clear that the casing side walls could by way of alternative, be cylindrical or have a polygonal cross-section.

It is also clear that the described condensing apparatuses could operate just as well rotating about an axis having a position other than vertical, since gravity normally plays practically no part at all on the liquids compared to the action of the centrifugal force.

Further, the webs which are mounted in the circumferential folded-over flanges could extend along nonradial planes so chosen as to facilitate the flow of the liquid solution, for instance along a spiral course, so as keep highly homogeneous the liquid fluidtightness plug which the solution is required to form at all times in the U-shaped channel between the flange and the disk-like base of the condensing apparatus.

What is claimed is:

1. Apparatus for condensing vaporized substances comprising:

(a) a rotatably mounted enclosed chamber formed with an intake for receiving vapors and an annular exit port that extends circumferentially around the vertical axis of rotation of said chamber so that, upon rotation of said chamber, liquids are centrifugally urged through said port;

(b) means for rotating said chamber;

(c) means for spraying a cooling liquid within said chamber so that condensable vapors therein may be cooled to condense and flow to said exit port;

(d) means for removing uncondensable gases or vapors from said chamber;

(e) a liquid flow channel comprising the outer portions of a torus extending around said chamber directly and sealingly connected at one end to said exit port, a disc extending transversely to the rotational axis into the channel, the channel liquid flow axis being semitoric in shape extending from said port outwardly and then turning inwardly around the disc periphery, said channel being open at its outflow end to the atmosphere exterior to said chamber so that liquid, flowing through said exit port will collect within said semitoric channel to a limited extent due to the difference between the pressure of said atmosphere and the lower pressure within said chamber caused by condensation of said vapors therein and by the removal of said uncondensable gases, thus sealing said exit port from said atmosphere but permitting liquid flow through said channel when the effect of the centrifugal force overcomes said pressure difference.

2. Apparatus as set forth in claim **1**, wherein said means for removing uncondensable gases or vapors consists of a fluid jet extractor that is supplied with liquid by said cooling liquid spraying means.

3. Apparatus as set forth in claim **1**, wherein said chamber is cylindrical in shape.

4. Apparatus as set forth in claim **1**, wherein said chamber is bell-shaped having side walls that flare outwardly from said axis of rotation to said circumferential exit port.

5. Apparatus as claimed in claim **4** wherein said spraying means are fixed to the top of said bell-shaped chamber and extend into said chamber over at least a portion of its axial length, and wherein the fluid jet extractor having a jet nozzle therein is positioned radially in the volume delimited by said annular chamber through which its ejecting end projects, a conduit connecting the jet nozzle of said extractor to said spraying means and a tube rising from the ejection passage to the upper portion of said chamber to draw away non condensable gases that have accumulated in said portion.

6. Apparatus as claimed in claim **4** wherein said spraying means is independent of said bell-shaped chamber, is stationary and extends axially into said bell-shaped chamber to near the top thereof, and wherein said spraying means is provided at its upper end with a reduced diameter portion projecting into a distribution chamber rigid with the top of said chamber to rotate therewith, a non-condensable gas-vapor extractor having a jet nozzle therein, said distribution chamber feeding cooling liquid to the jet nozzle of said extractor, the axial passage of said extractor being positioned radially near the top of said casing through being secured in a sealed through passage formed in the side wall of said chamber coaxially with said nozzle.

7. Apparatus as set forth in claim **1** wherein said disc is formed as an end closure plate that is spaced from the exit port of the chamber, said circumferential exit port constituting the space between said closure plate and the sidewall of said chamber, the radius of said plate from said axis being greater than the maximum distance of said sidewall from said axis so that said plate extends beyond said sidewall, said liquid flow channel being formed by an annular wall extending laterally outwardly from said sidewall and curving inwardly around the end of said plate while being spaced therefrom leaving a semitoric space therebetween.

8. Apparatus as claimed in claim **7**, wherein said plate forms the bottom of said chamber and is adapted to rotate with said chamber.

9. Apparatus as claimed in claim **7**, wherein said plate forms the bottom of said chamber and is stationary.

10. Apparatus as claimed in claim **7**, wherein an annular collecting trough having a semitoric bottom surrounds at least the annular outlet opening of the channel.

References Cited

UNITED STATES PATENTS

552,456	12/1895	Theisen	196—112
585,365	6/1897	Skiffington	165—108
2,884,050	4/1959	Brownell	159—6
2,999,796	9/1961	Bromley	202—236
3,214,352	10/1965	Wells	202—187

WILBUR L. BASCOMB, Jr., Primary Examiner

J. SOFER, Assistant Examiner

U.S. Cl. X.R.

55—468; 165—86, 111; 202—238; 203—99