United States Patent

[11] 3,578,004

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[21] Appl. No. **832,710**
[22] Filed **June 12, 1969**
[45] Patented **May 11, 1971**
[73] Assignee **The Regents of the University of California**
Continuation-in-part of application Ser. No. 534,012, Mar. 14, 1966, now abandoned.

[54] **METHOD AND DEVICE FOR FLOW CONTROL OF LIQUOR BY VORTEX MOVEMENT OF THE LIQUOR**
18 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **137/1,** 137/590, 159/14
[51] **Int. Cl.** **B01d 1/22**
[50] **Field of Search** ..... 137/1.2, 81.5, 590; 138/44; 159/13, 13 (A), 14

[56] **References Cited**

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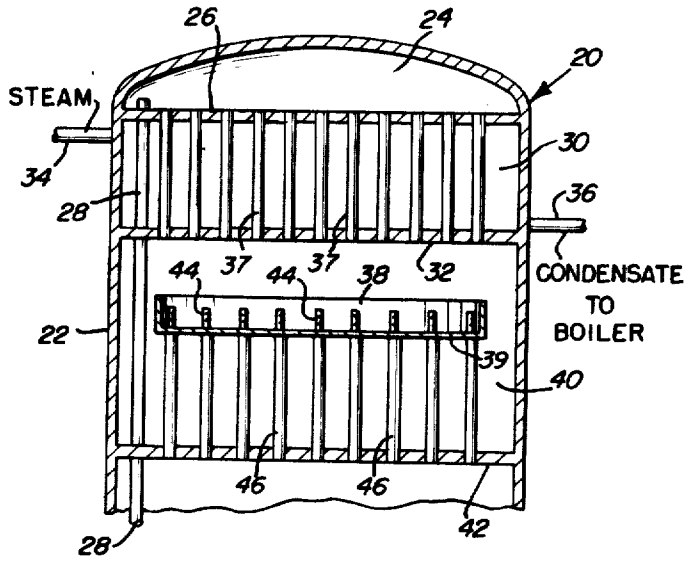
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Primary Examiner—William R. Cline
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ABSTRACT: A method of controlling the flow of volatile liquor from a container in a manner to (1) maximize the ratio of liquor flow relative to vapor flow, (2) distribute the flow of liquor evenly to a series of parallelly disposed tubes although the inlets thereto are not in the same horizontal plane, (3) distribute the flow evenly against the interior walls of the tubes, and (4) accelerate the flow along the interior walls of the tubes to increase heat exchange with the environment about the tubes. The controller for carrying out the method includes a tubular element having (1) a portion provided with an inlet in the upper part thereof for the flow of fluid thereto from the container, (2) a portion having a passage leading from the container downstream of the inlet and disposed for causing vortical movement to be imparted to the liquor entering the second mentioned portion through the passage, and (3) a throat downstream of the second mentioned portion.



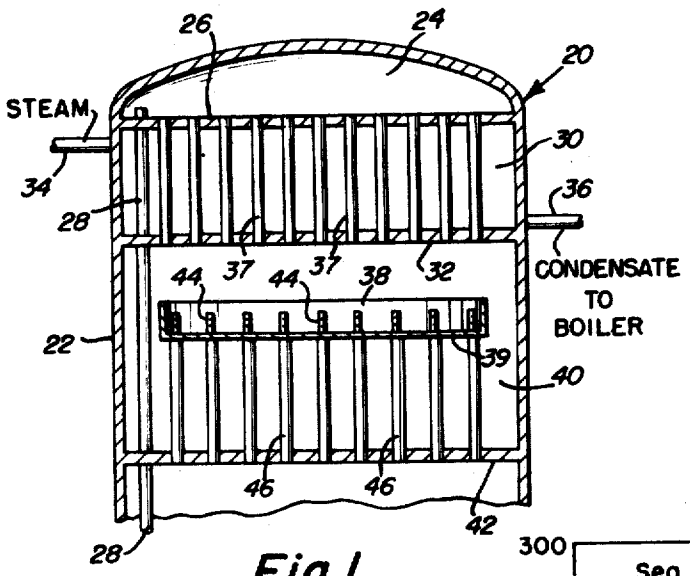


Fig.1

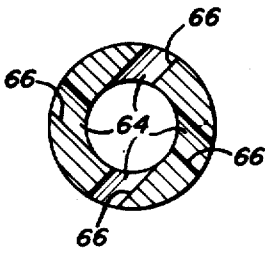


Fig.3

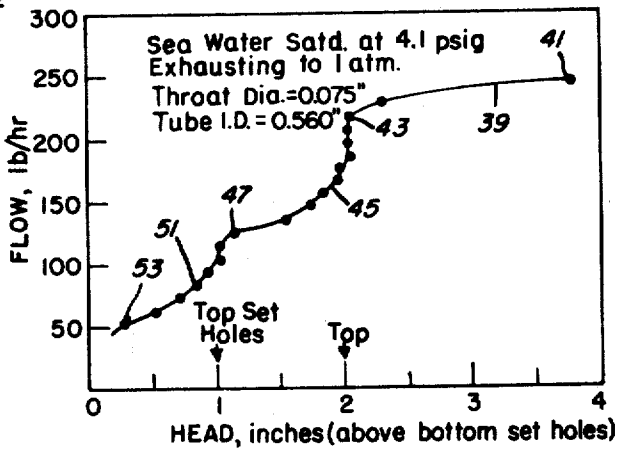


Fig.5

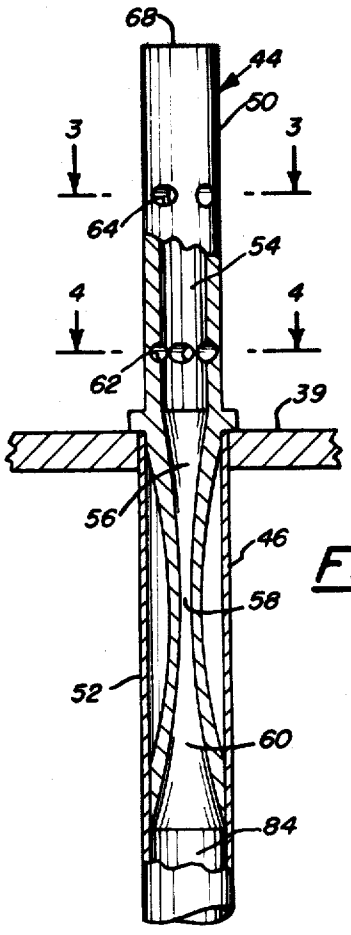


Fig.2

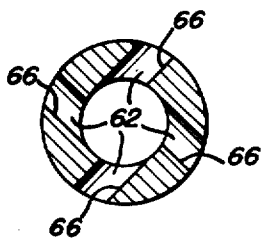


Fig.4

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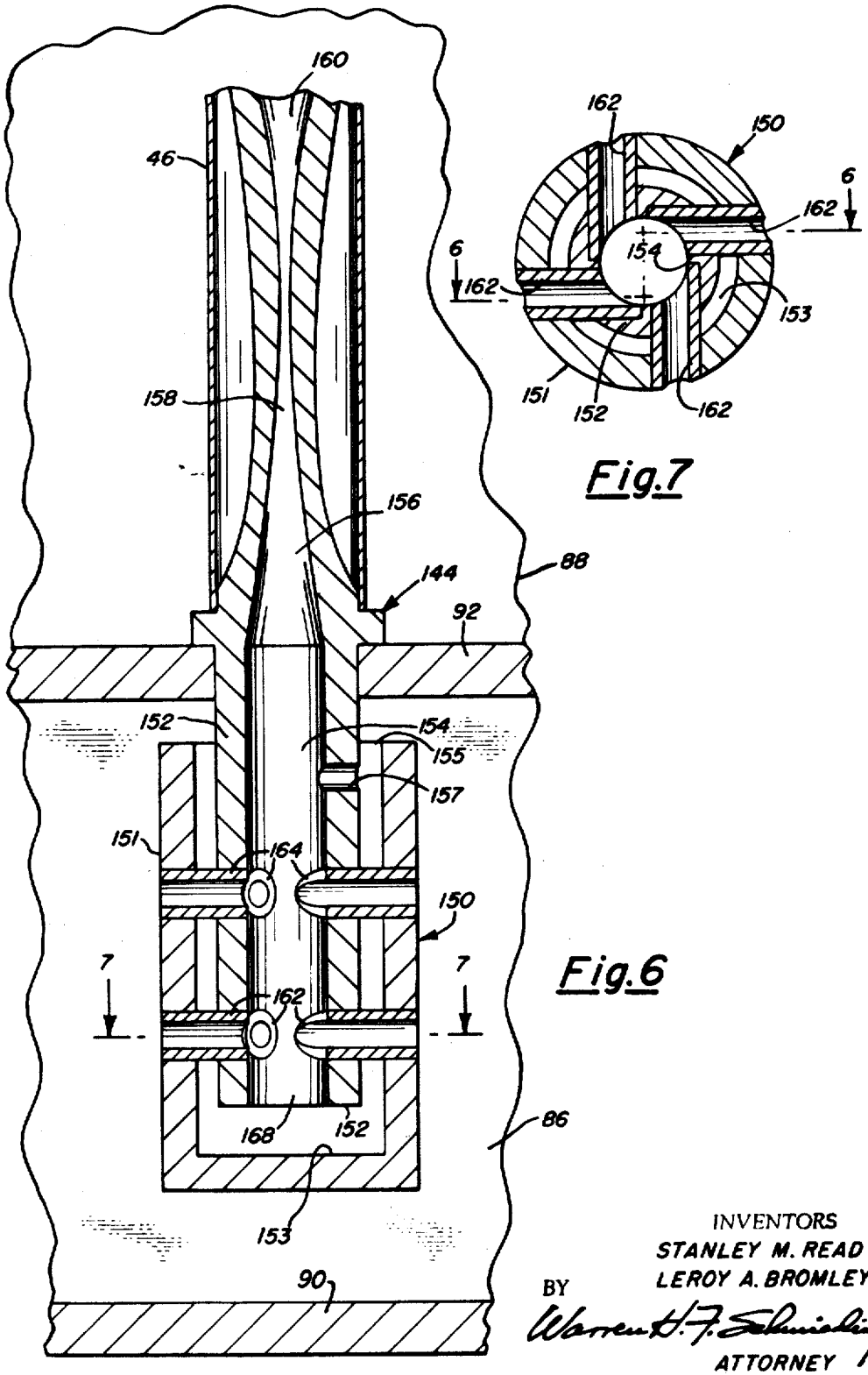


Fig.7

Fig.6

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METHOD AND DEVICE FOR FLOW CONTROL OF LIQUOR BY VORTEX MOVEMENT OF THE LIQUOR

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in-part of the copending application Ser. No. 534,012, filed Mar. 14, 1966, now abandoned, and one application of the disclosure is to control the flow of liquor from one container to another, such as the containers disclosed in the now abandoned application of Bromley, et al. Ser. No. 348,550, filed Mar. 2, 1964. and the continuation-in-part thereof, Ser. No. 629,843, filed Feb. 15, 1967, now Pat. No. 3,487,873.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Broadly, the invention is directed to the control of the flow of liquor from a container.

2. Description of the Prior Art

The most pertinent art known to the applicants is the disclosure in the aforementioned application Ser. No. 629,843.

SUMMARY OF THE INVENTION

The present invention is directed to a method employing a controller having characteristics of a steam trap which provides for the flow of liquor and minimizes, or if desirable, prevents the passage of vapor from one container to another. In carrying out the method, the liquor flowing from the one container to the other passes through a portion of the controller in which vortical movement is imparted to the liquor and this liquor, while in a vortex, flows to a throat before entering the downstream container.

The method and the controller is useful particularly in multiple effect flash evaporators such as that disclosed in the aforementioned application, Ser. No. 348,550, and the continuation-in-part thereof, Ser. No. 629,843, which latter matured into U.S. Letters Pat. No. 3,487,873 on Jan. 6, 1970. The Letters Patent is hereby incorporated by reference into this present disclosure. In those applications, the floors such as the floors for pans or receivers such as receiver **128**, have tubes depending therefrom, such as tubes **132** which depend from the floor of receiver **128**. The inlet to those tubes are restricted as by orifices **126** which are more clearly shown in FIG. 3 of those applications. Should, for example, the floor of receiver **128** slant somewhat from horizontal, relatively less liquor and in some cases only vapor would pass through the tube having the higher inlet thereto resulting in an uneven flow of liquor through the tubes. Unless the floor is substantially level, uneven flow takes place resulting in uneven flow around the inside circumference of the tube. Such uneven flow could lead to drying in areas and scale formations.

The method and the controller of the present invention assures a constant flow of liquor through all of a multiplicity of parallel depending tubes, the flow being such that no drying takes place within any of the tubes although the inlets thereto are not in the same horizontal plane.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a cross-sectional view of the upper part of a multiple effect flash evaporator similar to that shown in the aforementioned Letters Patent, but showing a series of controllers of the present invention;

FIG. **2** is a longitudinal sectional view of one of the controls shown in FIG. **1**, but on a larger scale;

FIGS. **3** and **4** are cross-sectional views taken along lines **3–3** and **4–4**, respectively of FIG. **2**;

FIG. **5** is a graphical illustration of the flow characteristics, with varying head, in the controller;

FIG. **6** is a longitudinal sectional view showing the controller employed for conveying liquid from a lower container to an upper container; and

FIG. **7** is a sectional view taken along line **7–7** of FIG. **6**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The upper part of a multiple effect flash evaporator **20** includes a tank **22**, having an upper container **24** which is formed by the upper part of the tank and a floor **26**. This compartment receives liquor, for example sea water, through a pipe **28**. A lower container **30** is formed by the sidewalls of the tank, the floor **26** of container **24** and a floor **32**. It receives steam through a pipe **34** and the condensate is drained through a pipe **36**. A series of tubes **37** have their upper ends hermetically joined with the floor **26** and extend through container **30** and through the floor **32** of the latter container. Each of these tubes **37** is provided with a restrictor as shown in FIG. **3** of the aforementioned Patent. The liquor is heated in the tubes and the pressure is consequently increased by the steam within container **30**. The liquor falls into a third container in the form of a pan **38** having floor **39**, which container is disposed below container **30** and in a compartment **40** which is formed by the sidewalls of the tank and a floor **42**.

A series of the improved controllers **44** extend through the floor **39** of container **38** and each extends into a separate tube **46**. The upper ends of tubes **46** are hermetically joined with floor **39**.

Referring now to FIGS. **2**, **3** and **4**, the controller **44** is in the form of an elongated tubular element which is circular in cross section. The upper portions **50** of a series of these controllers extend through the floor **39** of the pan **38**. The lower portions **52** extend into tubes **46** in compartment **40**. The upper portion of each controller forms an elongated passage **54**. The lower part of passage **54** of portion **50** reduces regularly and progressively longitudinally in circular cross section downstream as shown at **56** and merges into a throat **58** below floor **39**. A longitudinal passage **60** increases regularly and progressively in circular cross section downstream from the throat. The tube **46** extends downstream, i.e. below the outlet end of the controller and when used in a multiple effect flash evaporator as disclosed in the aforesaid patent, the area below the throat forms an expansion chamber. Passages **54** and **56**, throat **58**, passage **60** and tube **46** are in longitudinal alignment.

The upper portion **50** of controller **44** is provided with a lower set **62** and an upper set **64** of transversely extending inlets for the flow of liquid into passage **54**. The inlets are preferably circular in cross section and the axis of each is spaced laterally from the axis of the passage **54**. As shown, these inlets are tangent with the inner surface of the passage **54**. Thus, the transversely extending walls **66** forming the inlets provide for directing the incoming fluid tangentially into the passage **54** and not into the longitudinal center of mass of the fluid passing through the passage **54**. Thus, the momentum of the incoming fluid will urge the fluid, passing longitudinally through the passage **54**, to circulate about the axis of the passage **54** and to vortex as it passes through the passage portion **56** and toward the throat **58**. It will be clear that when the passage **54** is not full of liquid, i.e. vapor has entered through the open top **68** of the upper portion **50**, this vortical movement of the fluid will cause an elongated funnel, that is devoid of liquid, to be formed about the axis of the vortex, which axis extends longitudinally of the passage **54**.

When the controller **44** is employed to control the flow from a container that contains volatile liquor, or liquor at the saturation temperature, and when the passage **54** is not full of liquid, the liquid forming the surface of the funnel, will cause increased liquor surface area, whereupon, increased vaporization or flashing will be induced. This vaporizing will increase the volume of vapor contained in the passage portion **54**, approaching the throat **58**, thereby proportionately decreasing the volume of liquid, resulting in a decreased mass flow rate. The decreased flow rate will reduce the vortical action causing the funnel to recede in the passage portion **56** which, in turn, will tend to increase the flow rate, resulting in increased vortical action and the above described process will be repeated.

The inlet **68** at the top of the passage **54** is sufficiently large to insure that fluid will be introduced into the passage **54** at as

rapid a rate as it will pass through the throat **58**, when the liquid level is above the top of the controller.

Due to the venturi effect of throat **58**, the flow of liquid therethrough is accelerated, and, due to the continuing vortical movement of the liquid as it passes through the passage **60** and into the tube **46**, a film of liquid is assured throughout the inner surface of the tube **46**. This film provides maximum heat exchange between the liquor and the tube throughout the length thereof and maximum heat exchange with the environment surrounding the tube.

It will be understood that higher pressure prevails in chamber **38** than in tube **46**, and it will be further understood that due to the design of the apparatus to which the control is applied, the level of liquid will always be above the inlet passage **62**.

When such controllers are in parallel for a multiple effect, flash evaporator, they assure maximum flow of liquor relative to the vapor flow through the parallelly disposed tubes **46**. They assure even flow to the parallelly disposed tubes and like flow of liquor throughout all tubes.

Too, when the controllers are employed in a multiple effect, flash evaporator, the throat **58** functions as a restrictor resulting in vaporization in the passages **60** and in the tubes **46**. Since the swirling continues in passage **60** and tube **46**, the cooled liquor on the interior of the tubes effects condensation of vapor thereabout, which vapor is emanating from the upstreamlike tubes.

The flow control characteristics of this controller **44** can be understood also by referring to FIG. **5**, which graphically depicts the mass flow rate change at constant pressure as the liquid level is lowered below the top inlet **37** and also below the upper set of inlets **64**. The upper portion **39** of the flow characteristics curve **41** depicts the flow rate through the controller as the liquid level is lowered to the same level as the inlet **68**. When the liquid level is lowered below the level of the inlet **68**, the incoming liquid will pass only through the sets **62** and **64** of inlets thereby inducing the above-described vortexing, funneling, vaporization and consequent flow rate reduction. This transition from somewhat steady flow to substantially decreased flow with only a small change in head is depicted at **43**. It will be noted that the flow rate decreases rather slowly to **45** where the curve recedes slowly to **47**. Thus, a desirable characteristic is provided in that the liquid level in the container from which the controller **44** is controlling the flow can fluctuate between the levels represented by the points **45** and **47** without significant flow rate changes.

Point **47** represents the level of the upper set of inlets **64** and it will be apparent that when the liquid level is lowered below that set of inlets, the entire fluid being controlled must pass through the lower set of inlets **62**. Consequently, the above-described vortexing, funneling and vaporization takes place closer to the throat **58** than when the vortex is induced by inlets **62**, thus causing the flow rate to decrease rapidly with decreasing head until the liquid level reaches the level represented by the point **51**. Again the curve **41** recedes slowly through point **53**, thus providing a second desirable liquid level operating range.

When this device is used as a steam trap only, where tube **46** is not heated, the device could be cut off at any point below about outlet **60** and exhaust into almost any sized pipe or chamber. Since the tube **44** is flared gradually and progressively, outwardly, from the throat **58** to the outlet **84**, the exiting fluid will be urged to flow adjacent the walls forming the passage **60** rather than directly down the center of that passage and will continue to flow down the inner surface of the tube **46**.

From the foregoing, it will be apparent that the controller **44** of this invention is of simple, sturdy construction and that it is inexpensive to produce. In addition, the controller provides reliable flow control and desirable flow characteristics. It will be readily apparent to those skilled in the art that this controller satisfies also the following criteria:

1. It operates over a wide range of flow rates, with or without level trays, and without an excessive passage of steam or the need of a large liquid head above the device. This minimizes liquor holdup, yet assures adequate feed to each tube. 2. It is the major pressure reducing device between effects in an evaporator (80 to 90 percent) and it utilizes this pressure drop to accelerate the fluid, thereby increasing the heat transfer rate to the fluid. 3. It maintains an even distribution of liquor over the entire inside surface of the evaporator tube to prevent drying and scale formation.

It will be readily apparent to those skilled in the art that another purpose is for transmitting fluid in equilibrium with its vapor from one container to another in such a manner as to maximize the ratio of liquid flow to vapor flow. Too, it will be readily understood by those skilled in the art that there is substantial freedom in the vertical positioning of the controller in that each will function satisfactorily any time the liquid level is above the inlet **62**, although the inlet heights of the tube vary considerably. This feature renders it unnecessary to accurately level the surface, such as floors **39**, from which the plurality of controllers are controlling flow. The controller of this invention is especially adaptable to be utilized in steam lines as a steam trap and also for controlling the flow from sequential stages of sea water conversion devices.

Referring now to the embodiment shown in FIGS. **6** and **7**, superimposed containers are shown at **86** and **88**, container **88** being disposed above container **86**. Containers **86** and **88** are provided with bottoms **90** and **92**, respectively. A controller **144** has a lower portion **150** including section **151** and portion **152**, which are disposed in lower container **86**. Portion **152** is downstream of section **151**. The section **151** is open at the bottom as at **168** and is provided with a longitudinally extending passage **154** which merges downstream with passage **156** in the upper portion which is disposed in container **88**. This passage **156** merges with a throat **158**, the latter being downstream of passage **156**. The upper portion includes also a passage **160** downstream of the throat **158**. The passage **160** leads to a tubelike tube **46**.

In the embodiment shown in FIGS. **6** and **7**, the lower portion **150** includes a section **151** which surrounds the lower part of that portion and is provided with a closed bottom wall **153**. As shown more clearly in FIG. **7**, the section **151** is provided with a lower set **162** and an upper set **164** of passages for conducting liquor from the container **86** to the passage **154**. These passages are disposed for directing liquor tangentially into passage **154** as explained with respect to passages **62** and **64** in the embodiment shown in FIGS. **2**, **3** and **4**.

The open top **155** of section **151** is disposed below the bottom **90** of container **86**. A vapor inlet **157** is provided in the upper portion **150** below the top **155** of section **151** and above the upper passages **164** for supplying vapor from the upper part of container **86** to the passage **154** when the level of liquid in the container falls below the open top of the section **151**.

When the liquor level in container **86** is above the top of section **151** of portion **150**, the passages have substantially no effect. However, when the liquor level in container **86** falls to below the top of section **151**, but above tangentially disposed passages **164**, all liquor passing to passage **154** from container **86** is through tangentially disposed passages **164** and **162**, and, when the level in container **86** falls below passages **164**, then all liquor will flow from the container **86** through tangentially disposed passages **162**. The vortical movement imparted to the liquor in the passages **154** and **156**, throat **158**, passage **160** and tube **46**, functions the same and achieves the results as explained heretofore with respect to the controller **44**. Vapor is supplied to support the vortex through inlet **157**. Also, the acceleration to the liquor, induced in the throat **158**, has the same characteristic as explained heretofore with respect to throat **58**, i.e. swirling of the liquor continues through passage **160** and against the interior of tube **46** providing intimate heat exchange between the liquor and the tube and between the tube and the surrounding environment.

We claim:

1. The method of minimizing the flow of vaporizable liquor from a container, which method consists in:

A. introducing, into a tubular element having an inlet in the upper part thereof in open communication with the container, liquor from the container in a manner to effect vortical movement of the liquor in the element below the inlet;

B. passing the liquor, while in the vortical movement state, from the element toward and thereafter through a confining throat;

C. conducting the liquor downstream from the throat.

2. The method of controlling the flow of vaporizable liquor from a container as defined in claim 1, characterized in that the container is above the throat.

3. The method of controlling the flow of vaporizable liquor from a container as defined in claim 1, characterized in that the container is below the throat.

4. The method of controlling the flow of vaporizable liquor from a container as defined in claim 1, characterized in that the introducing force creating the vortical movement is sufficient to maintain vortical movement throughout and downstream of the throat.

5. The method of controlling the flow of vaporizable liquor from a container as defined in claim 1, characterized in that the conducting of the liquor downstream from the throat is through a progressively increasing area.

6. A combination comprising:

A. a container for volatile liquor;

B. a controller for minimizing the flow of vaporizable liquor from the container, said controller including:

1. a tube having:

a. a tubular portion extending into the container, said portion having an inlet in the upper part thereof in open communication with the container,

b. a tubular portion in the container downstream of the inlet, said latter portion having at least one passage leading to the interior thereof from the container, said passage having a surface for directing liquor tangentially into the latter portion for effecting vortical movement of the liquor in the latter portion,

c. a portion forming a throat disposed downstream from said passage for receiving liquor from the second mentioned portion

C. means downstream of the throat for receiving liquor passing through the throat.

7. A combination as defined in claim 6, characterized in that the container lies above the throat.

8. A combination as defined in claim 6, characterized in that the container lies below the throat.

9. A combination as defined in claim 6, characterized in that the throat increases in cross section progressively downstream.

10. A combination as defined in claim 6, characterized in that the second mentioned tubular portion has a second passage disposed below the first mentioned passage, said second mentioned passage having a surface for directing the liquor tangentially to augment the effect of the first mentioned passage.

11. A combination as defined in claim 6, characterized in that the means (C) downstream of the throat is a tube.

12. A fluid flow controller for minimizing the flow of volatile liquor from a container, said controller comprising:

A. a tube having:

1. a tubular portion extending into the container, said portion having an inlet in the upper part thereof in open communication with the container;

2. a tubular portion extending into the container downstream of the inlet in the first mentioned portion, said second mentioned portion having at least one inlet leading thereto from the container, said latter inlet having a surface for directing liquor tangentially into the second mentioned portion for effecting vortical movement of the liquor in the second mentioned portion;

3. a portion forming a throat disposed downstream from the second mentioned portion for receiving liquor therefrom

4. means downstream of the throat for receiving liquor passing through the throat.

13. A fluid flow controller as defined in claim 12, characterized in that the container is above the throat.

14. A fluid flow controller as defined in claim 12, characterized in that the container is below the throat.

15. A fluid flow controller as defined in claim 12, characterized in that the means downstream of the throat is a tube.

16. A fluid flow controller as defined in claim 12, characterized in that the second mentioned tubular portion has a second passage disposed below the first mentioned passage, said second mentioned passage having a surface for directing the liquor tangentially to augment the effect of the first mentioned passage.

17. A fluid flow controller for minimizing the flow of vaporizable liquor from a container to a tube with vortical movement of the liquor in the tube, said controller comprising:

A. a tube having:

1. a tubular portion extending into the container, said portion having an inlet in the upper part thereof in open communication with the container;

2. a tubular portion extending into the container downstream of the inlet in the first mentioned portion, said second mentioned portion having at least one inlet leading thereto from the container, said latter inlet having a surface for directing liquor tangentially into the second mentioned portion for effecting vortical movement in the second mentioned portion;

3. a portion forming a throat disposed downstream from the second mentioned portion for receiving liquor therefrom, the downstream portion of the throat being connected with the tube.

18. A fluid flow controller as defined in claim 17, characterized in that the throat increases in cross section progressively downstream.