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Schachet

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[54] **THORACIC DRAINAGE UNIT WITH OVERFLOW PREVENTING VALVE**

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[52] **U.S. Cl.** **128/276**

[51] **Int. Cl.** **A61m 1/00**

[58] **Field of Search** ..... 128/DIG. 24, 275–278, 128/2 F

[56] **References Cited**

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[57] **ABSTRACT**

A thoracic suction drainage device having a valve which permits restricted liquid flow in one direction between the columns of a secondary liquid seal to prevent liquid from flowing from the secondary seal into the drainage collector chamber upon the occurrence of negative pressure surges in the pleural cavity of the patient, the valve permitting relatively unrestricted liquid flow in the opposite direction to allow gas to escape through the secondary seal to atmosphere upon the occurrence of positive pressure surges from the cavity. Another valve is disposed in the control manometer and permits restricted liquid flow in one direction between the columns thereof to prevent the escape of liquid out of the device upon the occurence of excessive positive pressure surges from the pleural cavity.

12 Claims, 4 Drawing Figures

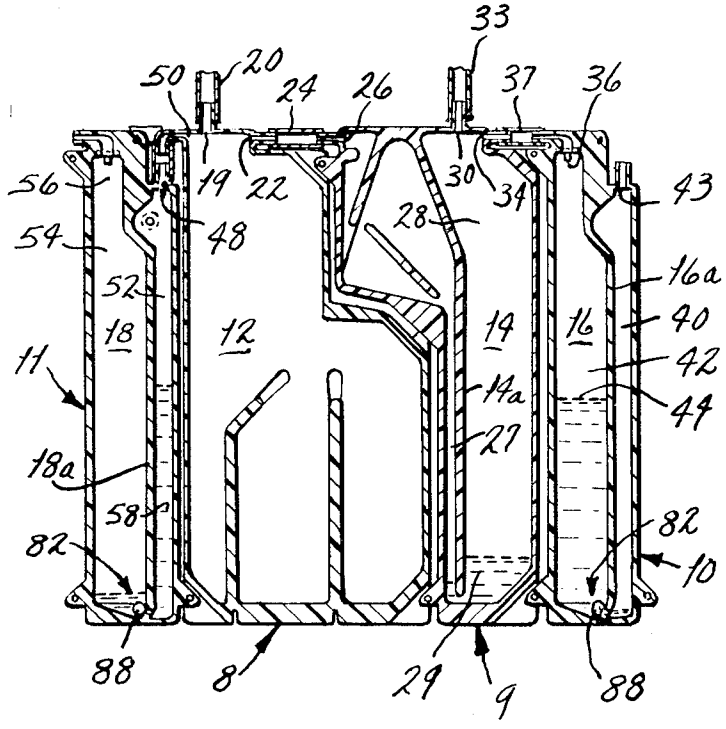


FIG. 1

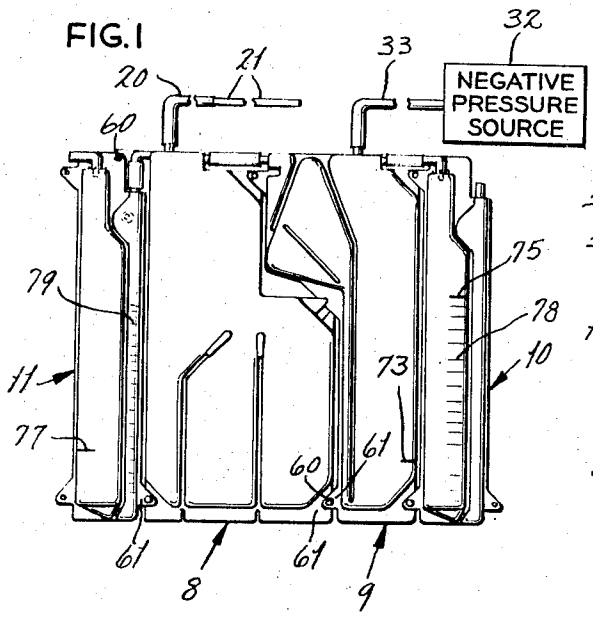


FIG. 2

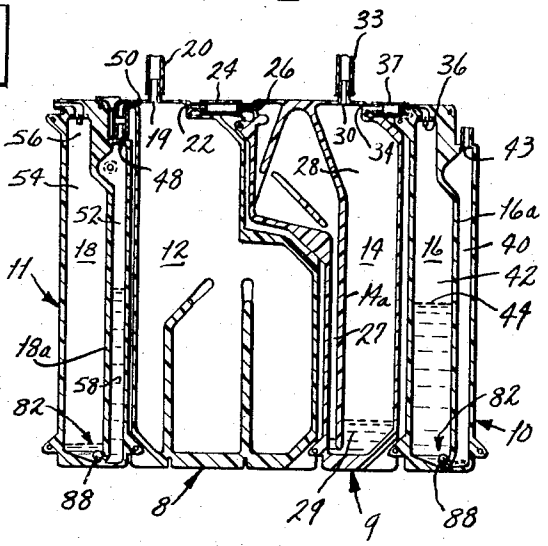


FIG. 3

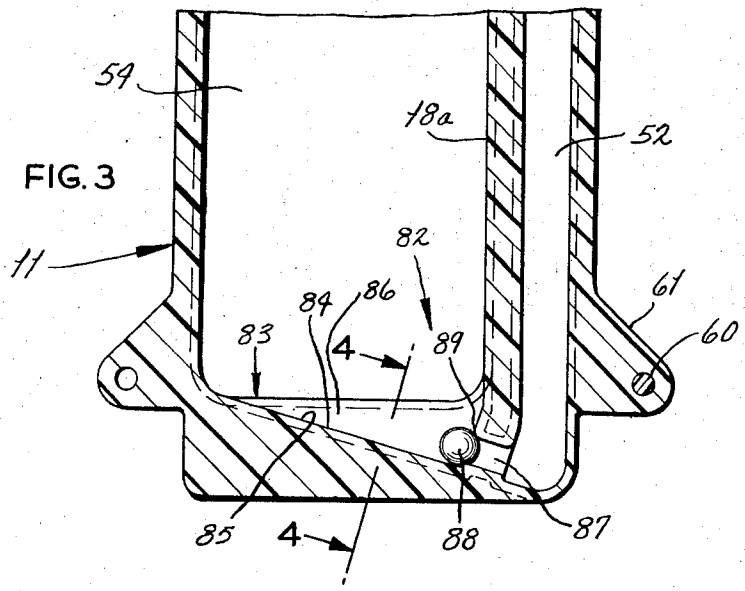
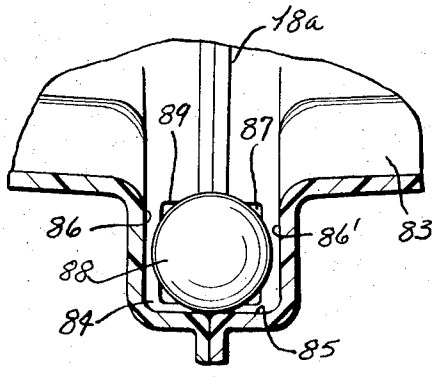


FIG. 4



THORACIC DRAINAGE UNIT WITH OVERFLOW PREVENTING VALVE

BACKGROUND OF THE INVENTION

This invention relates to thoracic drainage devices and more particularly to thoracic drainage devices of the type which are connectable to a source of negative pressure for draining fluid from a cavity of a patient.

Suction drainage devices for removing fluids from the pleural cavity of a patient generally include a drainage collector chamber, an underwater or series liquid seal chamber, and a liquid pressure control or regulating manometer which limits the negative pressure applied to the collector chamber. Drainage liquid from the patient's cavity is drawn into and accumulated in the collector chamber, and gas and air from the cavity are drawn through the liquid seal to the source of negative pressure, the liquid seal preventing airborne matter for entering the cavity. In applicant's copending application, Ser. No. 212,075, filed Dec. 27, 1971, now U.S. Pat. No. 2,783,870 issued Jan. 8, 1974, and in applicant's copending application entitled "Modular Thoracic Drainage Device" and filed concurrently herewith, a second liquid manometer connected to a collector chamber is provided in order to obtain a direct and more accurate reading of the negative pressure at the collector chamber, as well as to provide a secondary liquid seal permitting the escape of air, upon the occurrence of a surge of positive pressure in the pleural cavity, to atmosphere through the secondary seal without requiring it to pass through the series seal and control manometer.

Because of the desirability of providing compact and relatively economical suction drainage devices, it has, in the past, been necessary to provide expansion chambers and tortuous fluid flow paths between chambers in order to prevent liquid from flowing from one chamber to another upon surge conditions occurring during operation of the device. Such tortuous fluid flow paths and expansion chambers generally increase the size of the apparatus, tending to make it more difficult to handle, as well as increasing the cost. Also, even when tortuous paths and expansion chambers are used, the danger of fluid flowing from one chamber to another still exists, especially, where excessive pressure surges occur in the pleural cavity.

SUMMARY OF THE PRESENT INVENTION

It is therefore an object of the present invention to provide an improved thoracic drainage device wherein the above-mentioned disadvantages are substantially obviated.

Another object is to provide an improved thoracic drainage device having simple and effective means for preventing liquid from flowing from one chamber to another and undesirably affect the operating characteristics of the device, without interferring with the normal functions of the device.

In accordance with one form of the present invention, a thoracic drainage device is provided which includes valve means disposed in a liquid containing chamber of the device to restrict the flow of liquid from one channel to another channel of the chamber during predetermined pressure surge conditions to prevent the flow of liquid out of the chamber, while providing substantially unrestricted liquid flow in both directions through the valve under normal operating conditions of the device. These and other objects and advantages of the present invention will become apparent from the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of a drainage device in accordance with a preferred embodiment of the present invention;

FIG. 2 is a vertical sectional view of the device of FIG. 1;

FIG. 3 is a fragmentary sectional view of the lower left-hand portion of the device of FIGS. 1 and 2 but on an enlarged scale; and

FIG. 4 is a cross-sectional view taken along the line 4—4 of FIG. 3 but on an enlarged scale.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, there is shown in FIGS. 1 and 2, a thoracic suction drainage device 7 which includes four "bottles" or chamber members 8, 9, 10 and 11 having internal chambers 12, 14, 16, and 18, respectively, that are shown interconnected to form a "four-bottle" or four-chamber thoracic drainage device. Chamber 12 is a drainage collector chamber for receiving and collecting drainage from a patient; chamber 14 is an underwater seal or series liquid seal which passes gas from the patient; chamber 16 is a liquid pressure control or regulating manometer; and chamber 18 is a liquid direct reading manometer and secondary liquid seal chamber.

Drainage collector chamber 12 is preformed with a drainage inlet port 19 at the top which is connected by tubing 20 to a catheter 21. The distal end of the catheter is adapted to be connected within the pleural cavity of a patient for draining fluids. Chamber 12 is partitioned into three channels or columns which fill successively with drainage liquids from the patient. Adjacent the upper end of chamber 12 is a gas outlet port 22 connected by tubing 24 to an inlet port 26 of chamber 14.

Series liquid seal chamber 14 is preformed with an integral partition 14a dividing the chamber into a relatively narrow vertically extending column or channel 27 of relatively small volume and a relatively wide column or channel 28 of relatively large volume. The upper end of channel 27 is connected in fluid communication with the inlet port 26 by means of a liquid trap, and the lower end is connected to the channel 28. A predetermined amount of liquid, such as water 29, is disposed in the channels 27 and 28, as indicated in FIG. 2, so that the lower end of the partition 14a extends into the water. Channel 28 is provided with an outlet port 30 connected in fluid communication with a negative pressure pump or vacuum source 32 means of a tube 33. The liquid seal chamber 14 is also provided with a fluid pressure relief gas inlet port 34 connected to a port 36 of the chamber 16 by a tube 37.

The regulating manometer chamber 16 is provided with an integral partition 16a which divides the chamber into a relatively narrow vertically extending column or channel 40 of relatively small volume and a relatively wide column or channel 42 of relatively large volume. The channel 42 is connected in fluid communication with the negative pressure outlet port 30 in the upper end of the liquid seal chamber 14, and the pump

32. The relatively narrow column 40 is connected to a vent or air inlet port 43 open to the atmosphere. The lower ends of columns 40 and 42 define a liquid reservoir for water 44. Water 44 is disposed in the chamber 16 to provide a predetermined negative pressure at the inlet 19.

As is well known, the height of water in the pressure control liquid manometer chamber 16 determines the maximum suction or negative pressure available to the inlet 19 regardless of vacuum pump suction in excess of a predetermined amount. In other words, for any negative pressure exceeding a desired predetermined amount, as determined by the amount of water introduced into the liquid manometer, air will enter from vent port 43 at the top of the channel 40 and move downwardly around the lower end of partition 16*a* and up through the liquid 44 in chamber 42 and into the pump to thereby limit the pressure in the upper portion of the channel 28 of chamber 14. As negative pressure increases above the desired amount, an increased amount of air enters and bubbles through the manometer to compensate for the excess suction.

The direct pressure reading manometer and secondary seal chamber 18 is shown identical to the chamber 16. It is provided with an upper port 48 which is connected by means of tubing to port 50 in the upper portion of the drainage collector chamber 12. The chamber 18 is divided by a partition wall 18*a* into a relatively narrow vertical column or channel 52 which is connected in fluid communication with the port 48 at the top of the channel and a vertically extending relatively large column or channel 54 at the bottom of the channel. The lower ends of channels 52 and 54 serve as a liquid reservoir for liquid such as water 58. Channel 54 is open at the top to atmosphere by means of a vent port 56. The chamber 18 is connected at one end directly in fluid communication with the collector chamber 12 and therefore the pleural cavity of the patient, and at the other end to atmosphere so as to provide a continuous precise reading or indication of the pressure in the cavity of the patient. The chamber 18 also serves as a secondary liquid seal which is connected to atmosphere in by-pass relation with the liquid seal chamber 14, whereby a patient can under certain conditions, expel gas from the pleural cavity without the necessity of moving gas through the series liquid seal chamber 14 and the liquid regulating manometer chamber 16 upon the occurrence of a pump failure and the closing of the outlet port 30. The function and advantages of the liquid seal feature of chamber 18 are described in greater detail in applicant's copending application Ser. No. 183,332, filed Sept. 24, 1971, and the function of the chamber 18 as a direct reading liquid manometer is given in greater detail in applicant's copending application Ser. No. 212,075, filed Dec. 27, 1971.

The chamber members 7, 8, 9 and 10 which are illustrated as being separate, can be selectively connected to provide one, two, three, or four "bottle" thoracic drainage devices while using only the necessary member or members. In the "four-bottle" embodiment shown in the drawing, a plurality of pins 60 extend through overlapping extensions 61 of adjacent chamber members to provide a rigid assembly.

In operation, the negative pressure applied at the outlet port 30 produces a negative pressure in the collector chamber 12 which draws in and collects liquid from the patient, while gas from the patient's cavity flows into the inlet 26 of the liquid seal 14 and passes downwardly through the column 27, around the partition 14*a*, through the liquid seal 29, and then upwardly in the column 28 to the outlet port 30 and pump 32.

The liquid manometers 16 and 18 are provided with indicia or calibration marks 78 and 79, respectively, whereby the liquid level in the column may be read so as to provide and maintain a desired negative pressure acting in the pleural cavity of the patient. The calibration marks indicated at 79 on liquid manometer chamber 18 will provide a direct reading of the liquid level in channel 52 and the actual negative pressure in the collecting chamber 12 and pleural cavity of the patient. The negative pressure of the regulating manometer will be somewhat different from that of the direct reading liquid manometer 18 because of the pressure drop across the liquid seal, which may vary. Also, the chambers 14, 16, and 18 are respectively provided with marks 73, 75, and 77 which represent desired liquid fill levels prior to placing the drainage device in operation.

Each of the chamber members 8, 9, 10 and 11 is formed of a plastic material such as polypropylene, Each may be formed individually as a separate unitary member, for example, by a blow molding process. Each member is preferably of transparent or translucent plastic in order to see the liquid. Alternatively, each may be formed from a pair of mirror image plastic elements molded separately and then sealed together, such as by heat sealing or other suitable adhesive means.

As previously mentioned herein, each of the liquid manometer chambers 16 and 18 are identical in construction and, as seen in FIG. 2, each is further provided with a fluid control valve, indicated generally at 82. Since the liquid manometer chambers are identical, only the lower portion of liquid manometer chamber 18, including its valve 82, is shown enlarged in FIGS. 3 and 4.

The bottom wall of channel 54 is indicated generally at 83 and is provided with a descending, inclined channel or groove 84. Groove 84 has a bottom wall or ramp 85 which is inclined downwardly from the left-hand wall of channel 54 toward the channel 52, and a pair of opposed side walls 86 and 86'. The lower end of the groove 84 is connected in fluid communication with a passage or aperture 87 connecting the channel 54 and groove 84 with the lower end portion of channel 52. Disposed in the groove 84 and movable lengthwise of the groove is a valve ball 88. In the vertical position of the drainage device, which is its normal operating position, the ball 88 rests against the mouth or opening 89 of the passage 87. As seen in FIG. 4, the mouth 89 is of a configuration relative to the spherical surface of the valve ball 88 such that when the ball is against the mouth 89, the mouth is only partially closed so that there is provided a smaller or restricted liquid flow path for liquid flowing from channel 54 around ball 88 and into passage 87 to the column 52.

In the illustrated embodiment, the ball 88 is made of a material such that it has a greater density than the liquid or water used in the chamber. For example, the ball 88 may be made of stainless steel or other suitable metal. Thus, the ball, because of its weight, is normally urged toward and against the mouth or opening 89, which mouth forms a valve seat. While the periphery of the opening or valve seat 89 is shown generally rectan-

gular in FIG. 4, it may, of course, be of various shapes in order to permit restricted or a reduced rate of liquid flow from the channel **54** to channel **52** upon a surge of negative pressure in the collection chamber **12.** It will be apparent that upon the occurrence of a force tending to move liquid in the opposite direction from channel **52** through passage **87** around the ball and into the channel **54,** such flow will tend to move the ball away from the valve seat **89** to provide a substantially nonrestricted fluid flow.

During normal opertions, the ball valve **82** will allow normal liquid flow between channels **52** and **54** in both directions as the pressure at the inlet **19** changes. There is very little restriction of liquid flow through the valve in either direction when the patient is breathing normally because of the relatively small pressure changes across the series connected channels and the liquid flow rate through the valve is therefore relatively low. The partially closed passage **87,** in other words, is large enough so that it does not interfere with the normal operation of chamber **18** to provide a direct pressure reading and to serve as a secondary seal.

The control valve **82** in the control manometer chamber **16** during normal operation of the drainage device, will permit unrestricted liquid as well as air flow from the vent opening **43** down column **40** and into column **42** to the outlet **30** for proper pressure limiting operations. The valve will also permit substantially unrestricted liquid flow from channel **42** through the series connected valve **82** to the column **40** under normal operating conditions. Thus, valve **82** will not interfere with the normal function of the control chamber **16** to regulate or control the negative pressure available at the outlet **19** for obtaining desired operating pressures.

Positive pressure surges from the patient, for example, due to exhaling during a coughing spell, will normally cause gas to bubble through the series seal chamber **14** to the outlet **30.** However, should the outlet port **30** be closed, for example, if the pump is inadvertently stopped in a closed condition, or if the rate of flow of air exceeds the capacity of the pump or capacity of the air passages, then air due to such positive pressures can readily flow through the manometer chamber **18** which serves as a secondary seal to relieve these positive pressures. Should such positive pressures be excessively great, for example, due to severe exhaling, such as due to very heavy coughing, such positive pressures would tend to be relieved by the secondary seal function of the chamber member **18,** however, this requires a certain length of time to move the water from the channel **52** to the channel **54,** for example, due to the inertia of the water. Because of the time delay in relieving such excessive positive pressure surges, such positive pressures will also act on the relatively large area of the column of water in the channel **42** of the control manometer chamber **16.** If not quickly relieved or otherwise prevented, such surges would force water into the narrow channel **40** and upwardly and out of the vent port **43** causing water to stream out of the drainage device. In other words, upon an excessive positive pressure surge, water could escape from the device before the secondary liquid seal function of chamber **18** is operative unless otherwise prevented from doing so. The valve in the control manometer chamber **16** is effective to prevent such an occurrence. The ball **88,** upon the occurrence of a positive pressure surge, restricts the flow or reduces the rate of flow of liquid from channel **42** to channel **40** of the control manometer to allow sufficient time to permit the liquid secondary seal function mentioned above to relieve such positive pressures.

Upon the occurrence of an excessively large negative surge of pressure from the patient's cavity, for example, due to rapid inhaling caused by heavy gasping, the water in column **52** of the direct reading manometer chamber **18** would tend to rapidly rise above the outlet **48** and enter the drainage chamber **12,** and possibly flow into the inlet port **19** and tubing **20** to the cavity of the patient. This expelling of water from the channel **52** is prevented, however, by valve **82.** The valve ball **88,** upon the occurrence of such negative surge pressures will be urged against the valve seat **89** to restrict the flow or reduce the rate of liquid flow from channel **54** to channel **52.** As the liquid pressure increases, the fluid restriction caused by the valve **82,** of course, also increases.

By providing an inclined ramp at the bottom of the relatively large channel of each of the liquid manometer chambers, and using balls of a density greater than water, the balls will normally be urged by gravity toward their respective valve seats. The valves **82** remain disposed in the liquid or water used in the liquid manometers during operation.

Each of the illustrated valves **82** when closed (ball against valve seat) provides a smaller or restricted flow passage between the channels associated therewith, such smaller flow passage including the space between the periphery of the ball and the mouth or seat **89** of the valve in the construction shown for illustration. Where desired, the valve seat may be designed to be completely closed by the ball, and a continuously open second smaller passage between channels can be provided to allow the desired substantially nonrestricted liquid flow in both directions through the valve when the patient is breathing normally. The restricted flow or resistance to liquid flow through the valve under pressure surge conditions prevents the undesirable liquid flow out a chamber without the necessity of long tortuous liquid paths between chambers.

In some cases, a passage may be provided in the narrower channel of smaller volume, for example, by providing an additional valve seat in the lower end of channel **52** within the liquid. A valve ball of less density than that of the liquid would be placed below the valve seat. In such case, the valve ball would be urged upwardly in the liquid toward the valve seat by the buoyancy to partially close the liquid path through the valve.

While a preferred form of the invention has been described herein, it will be apparent that various changes and modifications thereto may be made without departing from the true spirit of the invention and the scope of the invention as defined in the claims which follow.

What is claimed is:

1. A thoracic drainage device comprising a drainage collector chamber having an inlet for connection with a body cavity to be drained, means for producing negative pressure in said collector chamber for drawing fluid from the cavity into said collector chamber, a second chamber including first and second channels interconnected at the lower ends thereof in fluid communication, said second chamber being coupled in fluid communication with said collector chamber and adapted to receive a liquid which flows in opposite di-

rections between said channels in response to normal pressure changes occurring in said collector chamber during normal operation of the device, and valve means in said second chamber within the path of liquid flow for providing substantially unrestricted flow of liquid through said valve means and between said channels in both directions during normal operation, said valve means being responsive to a pressure surge in said collector chamber to restrict the flow of liquid through said valve means in one direction to allow restricted liquid flow between said channels to prevent discharge of liquid from said second chamber.

2. The device of claim **1** wherein said valve means is disposed below the level of liquid in said second chamber during normal operation of the device and includes a valve seat through which liquid flows, and a valve member normally urged toward and movable into engagement with said valve seat to allow restricted flow of liquid in said one direction through said valve means when said valve member engages said valve seat during a pressure surge in said collector chamber.

3. The device of claim **2** wherein said valve member comprises a ball normally urged by gravity in a direction toward said valve seat and movable in the reverse direction by liquid flow in said reverse direction.

4. The device of claim **3** wherein said valve seat is shaped to provide fluid flow in said one direction around said ball and through said valve seat when said ball is engaging said valve seat, said ball being movable away from said valve seat to allow substantially unrestriced fluid flow through said valve seat in the opposite direction.

5. The device of claim **2** wherein said first channel is of greater volume than said second channel, said valve member being disposed in said first channel, the upper end of said first channel is connected to atmosphere, and the upper end of said second channel is connected to said collector chamber.

6. The device of claim **2** further including a liquid seal chamber having a pair of channels interconnected in fluid communication at the lower ends thereof and adapted to have a liquid disposed therein, the upper end of one of said liquid seal channels being connected in fluid communication with said collector chamber, the upper end of the other of said liquid seal channels being connected in fluid communication with said negative pressure producing means and the upper end of said first channel of said second chamber, the upper end of said second channel of said second chamber being connected to atmosphere, and wherein said valve member is disposed in said first channel of said second member.

7. A thoracic drainage device comprising a drainage collector chamber having an inlet for connection with a body cavity to be drained, means for producing negative pressure in said collector chamber for drawing fluid from the cavity into said collector chamber, a second chamber including first and second channels, passage means interconnecting the lower ends of said channels in fluid communication, said second chamber being coupled in fluid communication with said collector chamber and adapted to receive a liquid which flows in opposite directions in said passage means between said channels in response to normal pressure changes occurring in said collector chamber during operation of the device, said first channel having an inclined ramp at the lower end thereof extending downwardly toward the lower end of said second channel to one end of said passage means, and valve means in said second chamber within the path of liquid flow including a valve seat at said one end of said passage means, and a valve member including a ball disposed on said ramp and movable into engagment with said valve seat for providing substantially unrestricted flow of fluid between said channels during normal operation and allowing restricted flow of fluid through said valve means in one direction upon the occurrence of a pressure surge in said collector chamber to prevent discharge of liquid from said second chamber, said ball having a density greater than the liquid whereby the ball is normally urged by gravity downwardly in the liquid and toward engagement with said valve seat.

8. The device of claim **7** wherein said first channel is of greater volume than said second channel and is open to atmosphere at the upper end portion thereof, said second channel is connected at the upper end portion thereof with said collection chamber to couple said second chamber in fluid communication with said collector chamber.

9. The device of claim **8** wherein said second chamber defines a direct reading liquid manometer having indicia thereon for indicating the level of liquid in said second channel and the pressure in said collector chamber.

10. The device of claim **8** further including a liquid seal chamber having first and second channels interconnected in fluid communication at the lower ends thereof and adapted to have a liquid disposed therein, the upper end of said first liquid seal channel being connectable in fluid communication with said negative pressure producing means, and the upper end of said second liquid seal channel being connected in fluid communication with said collector chamber.

11. The device of claim **10** further including a pressure control liquid manometer chamber having first and second channels interconnected by a passageway at the lower ends thereof and adapted to receive a liquid, said first pressure control liquid manometer channel having a smaller volume than that of said second pressure control liquid manometer channel and having the upper end portion thereof open to atmosphere, said second pressure control liquid manometer channel being connected in fluid communication with said means for producing a negative pressure for limiting the negative pressure applied to said collector chamber, and second valve means in said pressure control liquid manometer chamber to provide substantially unrestricted flow of liquid between said first and second pressure control liquid manometer channels under normal patient breathing conditions, and restricted liquid flow from said second pressure control liquid manometer channel to said first control liquid manometer channel upon the occurrence of a predetermined positive pressure surge in said collection chamber.

12. The device of claim **11** wherein said second valve means includes an integral channel in the bottom wall of said second pressure control liquid manometer channel which is inclined downwardly toward one end of said passageway and the bottom wall of said first pressure control liquid manometer channel, and a ball in said integral channel having a mass greater than that of the liquid in said pressure control liquid manometer so that it is urged by gravity toward engagement with said one end of said passageway to only partially close said passageway.

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