United States Patent

Henkin

[15] **3,661,143**

[45] **May 9, 1972**

[54] MEDICAL APPARATUS FOR DRAINAGE, COLLECTION AND MONITORING OF BODY FLUIDS

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[22] Filed: **June 23, 1969**

[21] Appl. No.: **835,619**

[52] **U.S. Cl.** **128/2,** 128/275

[51] **Int. Cl.** **A61b 5/10**

[58] **Field of Search** 128/2, 275–276, 128/294–295

[56] **References Cited**

UNITED STATES PATENTS

3,583,401	6/1971	Valliancourt	12 B/275
2,749,913	6/1956	Wallace	128/295
2,840,079	6/1958	Conway et al.	128/295
2,936,757	5/1960	Trace	128/276
3,345,980	10/1967	Coanda	128/2
3,363,626	1/1968	Bidwell et al.	128/276
3,503,401	3/1970	Andersen et al.	128/275

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[57] **ABSTRACT**

A sealed fluid drainage system, particularly well adapted for urine drainage, collection and monitoring, including parallel drainage tubes in fluid communication via a venting passage, the tubes and associated drip chambers being physically arranged to provide a difference in hydrostatic pressure for initiating liquid flow and completely draining liquid from the tubes and chambers. Highly reliable valving and flexible drip chamber configurations enable further enhancement of unidirectional flow and system line clearing capabilities. An effective gas gap is also provided to minimize the possibility of ascending infections in the system. Fluid collection is accomplished in a sealed, multi-chamber, flexible, calibrated container, with fluid being first directed into the smallest chamber and overflowing successively or being deliberately emptied into larger capacity chambers. Suitably located drain tubes permit selective sampling of liquid from the smallest chamber or complete emptying of the container from the largest chamber.

59 Claims, 15 Drawing Figures

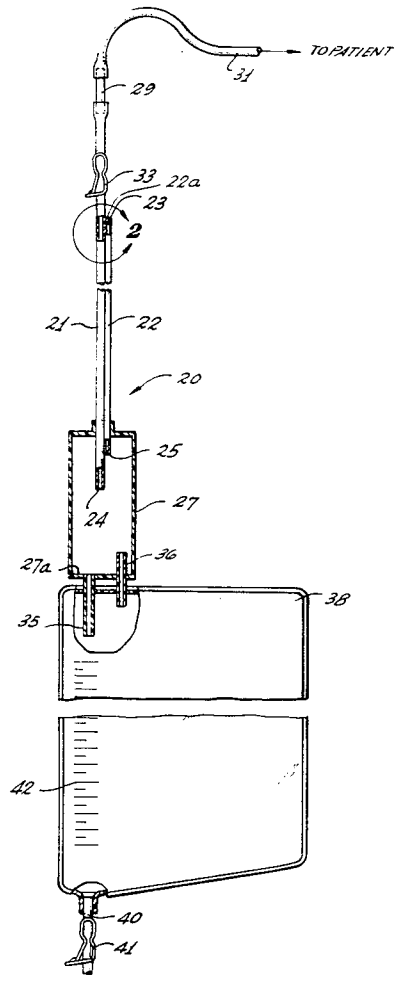


Fig. 1

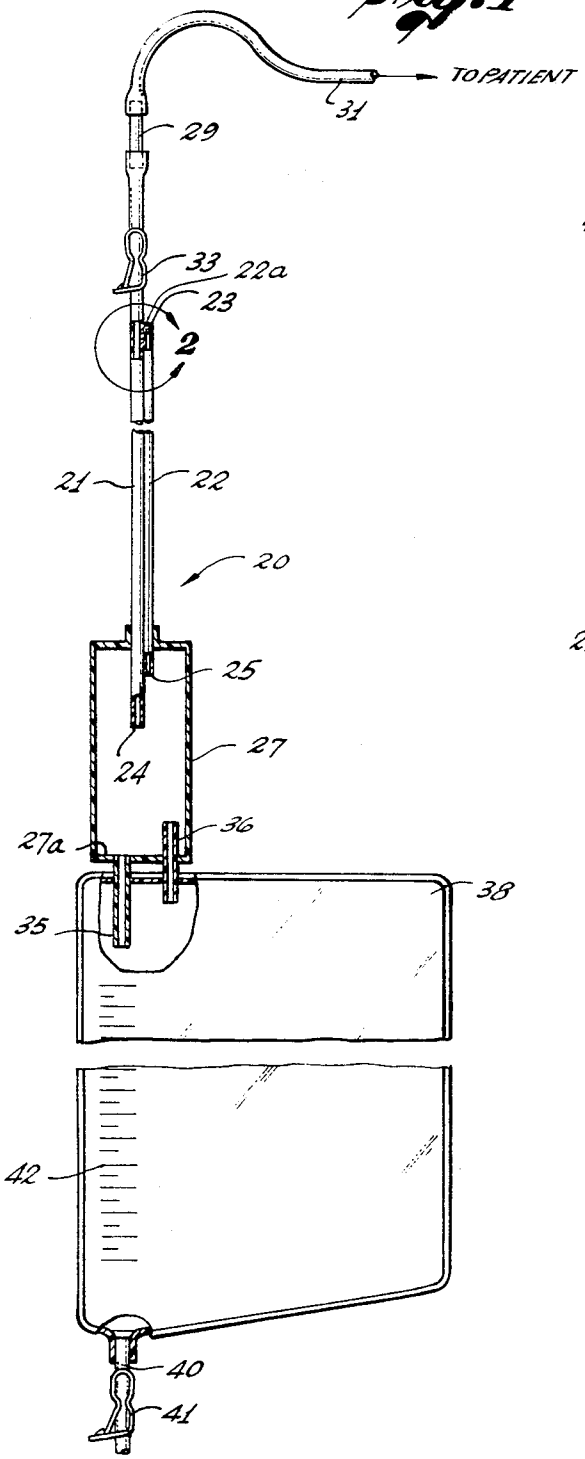


Fig. 3

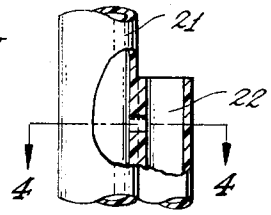


Fig. 4

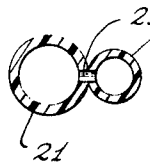
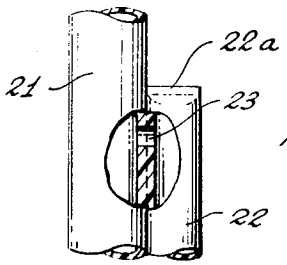


Fig. 2



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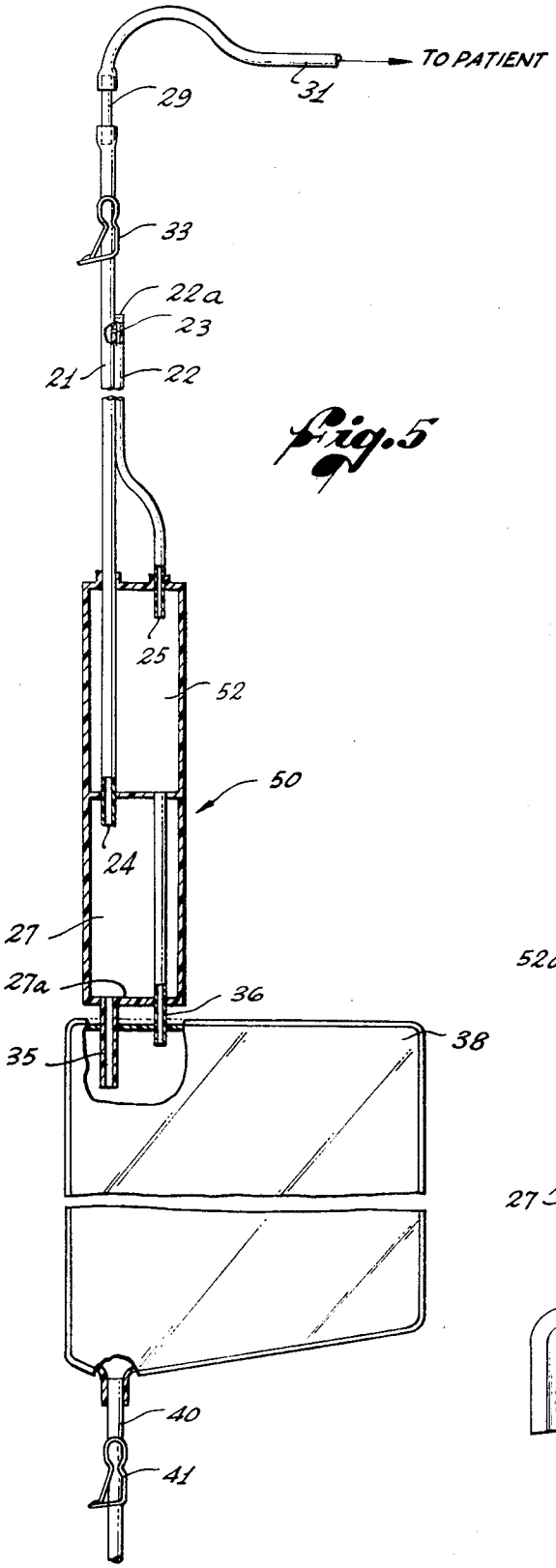


Fig. 5

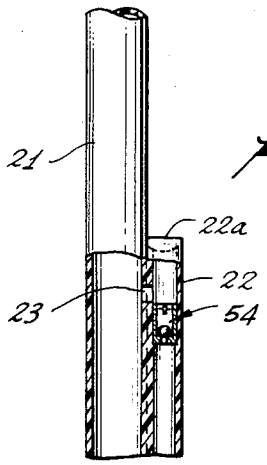
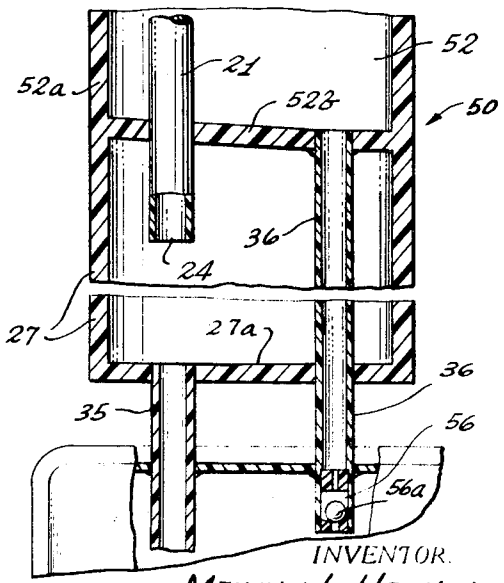


Fig. 6

Fig. 7



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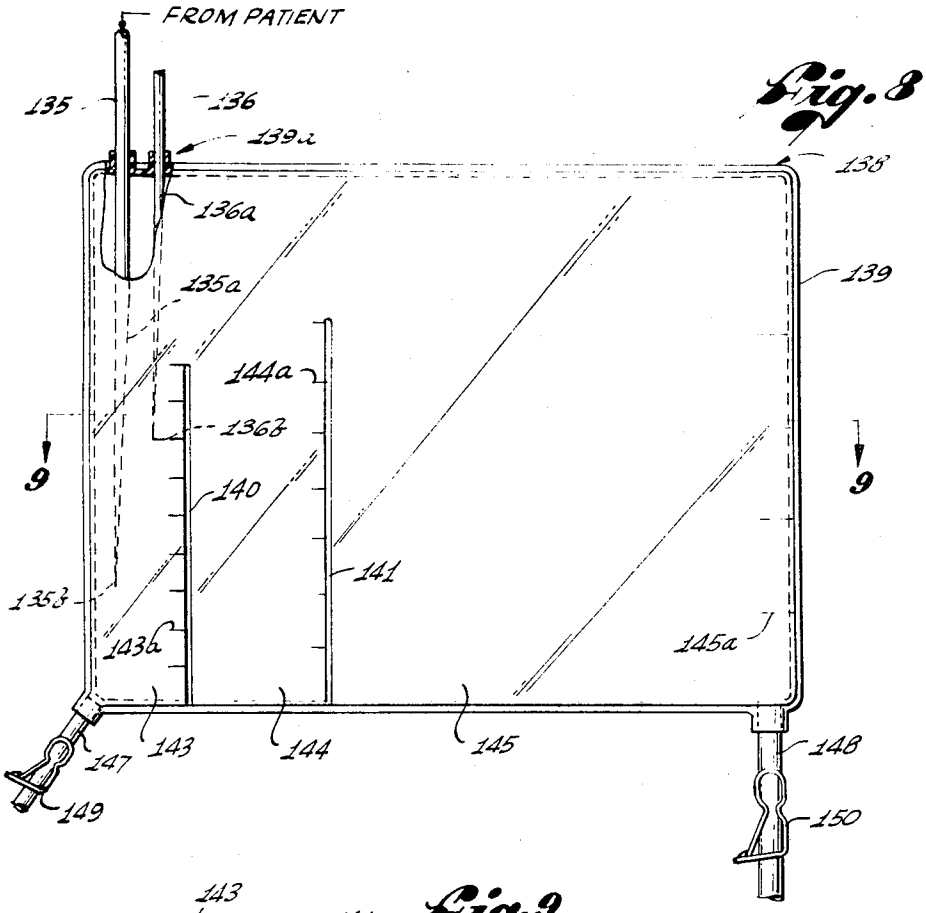


Fig. 8



Fig. 9

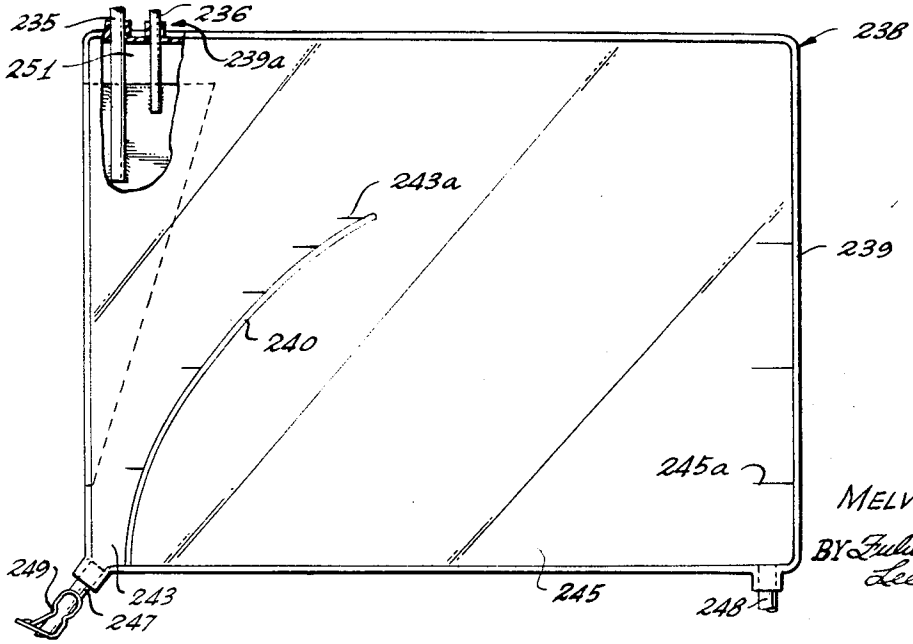


Fig. 10

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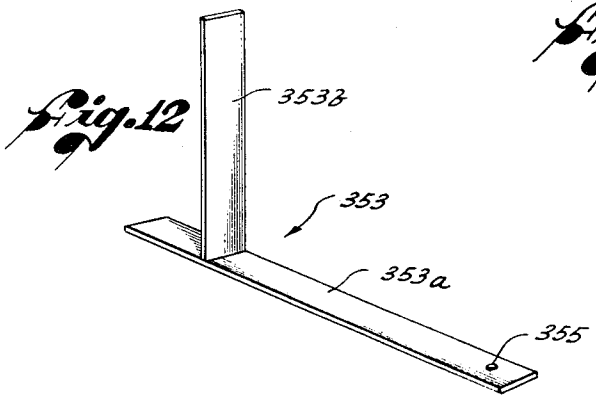


Fig. 12

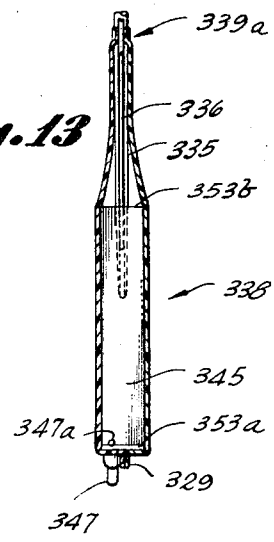


Fig. 13

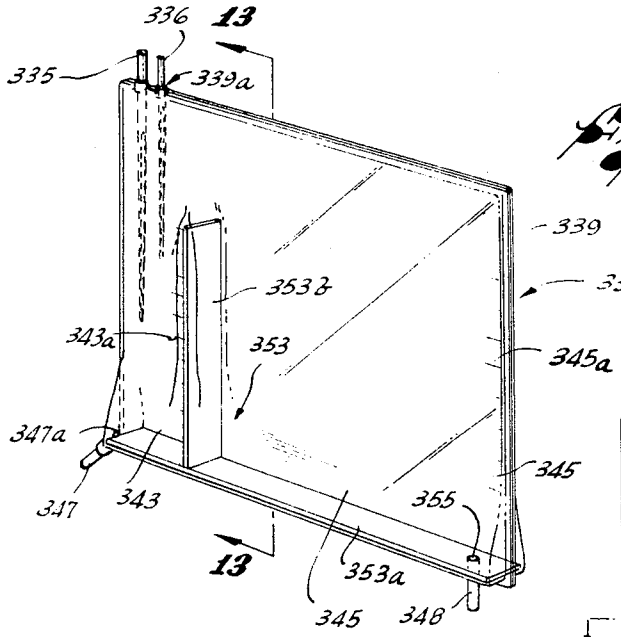


Fig. 11

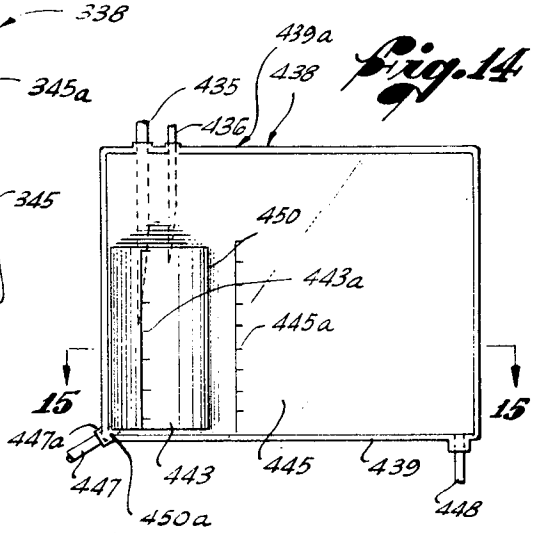


Fig. 14

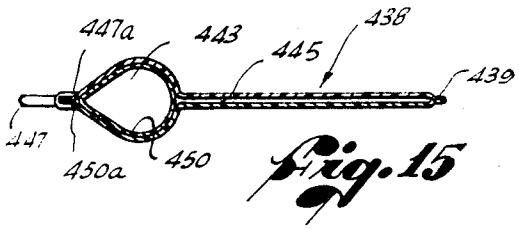


Fig. 15

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MEDICAL APPARATUS FOR DRAINAGE, COLLECTION AND MONITORING OF BODY FLUIDS

BACKGROUND OF THE INVENTION

This invention relates generally to improvements in medical apparatus for drainage, collection and monitoring of body fluids and, more particularly, to a new and improved urine drainage, collection and monitoring system characterized by relatively simple and economical construction, higher reliability, versatility and accuracy, substantially reduced possibilities of spillage, contamination or infection and enhanced physical tolerance by the patient.

Those concerned with the design, development and clinical use of various types of medical apparatus for drainage, collection and monitoring of body fluids, and particularly urinary drainage systems and the like, have long been concerned with the problems of providing reliable and accurate devices free from the commonly encountered difficulties of delayed flow, gross fluid retention, fluid contamination, patient infection, poor patient tolerance, and the lack of simple, economical means for obtaining short term, low volume fluid samples.

Typical of the various approaches for accomplishing urinary drainage, collection and monitoring in hospitalized patients on medical or surgical wards and the like is the use of a single, vertically oriented drainage tube, communicating at its upper end with an implanted patient catheter and terminating at its lower end in a drip chamber. The lower end of the drip chamber communicates with a flexible, plastic urine collection bag which includes an air vent at or near the top of the bag and a drain tube at the bottom of the bag. The air vent passage usually includes a filter of cotton wadding or the like.

The aforedescribed system of the prior art is in wide use, despite the presence of a number of problems involving mechanical operation, patient safety and tolerance, thus indicating a very substantial need for improved apparatus in this area. In this regard, the systems of the prior art have been prone to delayed urine flow and gross retention of urine in the drain tube between the patient and the collection bag, frequently requiring jiggling or squeezing of various portions of the apparatus, with unreliable results. Retention of urine also makes quantitative urine output determinations extremely difficult, particularly in the case of short term, low volume measurements. The devices of the prior art have also been prone to urine spillage, urine contamination through the air vent, and clogging of the air vent. In addition, the prior art devices have posed a substantial risk of ascending infection to the patient, particularly when used over relatively long periods of time. Moreover, vented collection bags often result in unduly high negative pressures which are transmitted to the patient and frequently result in bladder lesions or system clogging due to the sucking of mucosa from the patient into the drainage system. While attempts have been made to eliminate the negative pressure phenomenon and its deleterious consequences by air venting the catheter end of the drain tube to room pressure, such approaches have generally proved cumbersome or unreliable, particularly where valving is employed.

Further difficulties encountered with the devices of the prior art include inaccuracy in the measurement of low volumes of urine in the collection bag, together with relatively high cost and complexity of separate or combined specialized devices for short term, low volume urine output measurements or for obtaining recent urine specimens for testing. Unfortunately, such specialized devices are often even more prone to trapping or retention of fluid, contamination and spillage.

It will be apparent, therefore, that there has been a long existing need in the medical art, and particularly in the area of fluid drainage, collection and monitoring, for a relatively simple, compact, low cost, yet safe, accurate and reliable drainage, collection and monitoring system, without the usual problems of spillage, contamination, poor flow, infection,

complicated sampling and poor patient tolerance which has so plagued the prior art. The present invention clearly fulfills these requirements.

SUMMARY OF THE INVENTION

Briefly, and in general terms, the present invention provides a new and improved system for draining, collecting and monitoring a selected body fluid, e.g., urine, and includes a pair of substantially vertically oriented drain tubes in fluid communication with each other via an upper venting passage, the relative elevations of the lower terminal ends of the tubes producing a hydrostatic pressure differential, whereby one of the tubes functions as a liquid drain while the other tube functions as a positive pressure air vent for initiating liquid drainage flow and insuring both complete drainage and unidirectional flow. The pair of tubes communicate with various drip chamber configurations, including drip chambers embodying flexible walls, to increase the magnitude of the hydrostatic pressure differential and facilitate hand pumping wherever necessary or desirable. Valves in the air vent tube and drip chamber further enchance the unidirectional flow and total drainage characteristics of the system. In addition, the dual tube drip chamber functions as a very effective gas barrier to ascending infection.

Fluid collection and monitoring is accomplished in a completely sealed, flexible, calibrated bag which is suitably divided into a plurality of different volumetric capacity chambers, with the tops of the chambers in direct communication. Novel flow directing means are utilized to direct fluid being collected into the smallest chamber first, thus facilitating accurate low volume measurement, with overflow occurring successively into the larger chambers or, alternatively, deliberate emptying into the larger chambers by rotation of the collection bag. Appropriately located drain tubes permit selective sampling of the collected liquid from the smallest chamber, to obtain a recent fluid specimen, or complete emptying of the collection bag from the largest chamber. The sealed collection bag usually develops a low positive pressure as it is filled, and this pressure is transmitted in use to the dual drain tube system and to the patient.

In a presently preferred embodiment of the present invention, by way of example and not necessarily by way of limitation, the dual drain tubes may be extruded as a siamese pair with a one-way check valve just below the venting passage between the tubes, to further prevent liquid from flowing down the air vent line. In addition, an air pump chamber may include a one-way check valve having an occluding member with a specific gravity less than unity, so that any liquid which may inadvertently drain into the chamber will drain from the chamber rather than being trapped.

The enhanced drainage efficiency of the present invention facilitates the use of much smaller diameter tubing than that used with prior art devices, thereby reducing the size and cost of the apparatus. In addition, the low pressure within the system of the present invention is generally well tolerated by the patient.

Hence, the fluid drainage, collection and monitoring system of the present invention is of relatively compact and economical construction, and is characterized by trouble-free, complete drainage, while substantially obviating problems of spillage, contamination, ascending infection and patient injury. The present invention also provides relatively simple, compact, reliable, low cost means for making accurate, low volume measurements and obtaining recent flow fluid specimens for testing.

The above and other objects and advantages of the invention will be better understood by reference to the following more detailed description, when considered in connection with the accompanying drawings of illustrative embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial, elevational view of a first embodiment of a drainage system constructed in accordance with the present invention, portions being shown in section;

FIG. 2 is an enlarged, fragmentary sectional view of the area "2" in FIG. 1, illustrating the venting passage between the drain tubes;

FIG. 3 is a view similar to FIG. 2, but taken at an earlier stage in the manufacture of the dual tube configuration;

FIG. 4 is a sectional view, taken substantially along the line 4—4 in FIG. 3;

FIG. 5 is a partial, elevational view of a second embodiment of a drainage system constructed in accordance with the present invention, portions being shown in section;

FIG. 6 is an enlarged, fragmentary view of portions of a third embodiment of a drainage system in accordance with the invention;

FIG. 7 is an enlarged, fragmentary view of a modified drip chamber construction in accordance with the present invention;

FIG. 8 is an elevational view, with portions broken away, of a new and improved liquid collection and measurement bag constructed in accordance with the invention;

FIG. 9 is a sectional view, taken substantially along the line 9—9 in FIG. 8;

FIG. 10 is an elevational view, similar to FIG. 8, of another embodiment of a liquid collection and measurement bag constructed in accordance with the present invention;

FIG. 11 is a perspective view of a further embodiment of a fluid collection and measurement bag constructed in accordance with the invention;

FIG. 12 is a perspective view of the chamber divider used with the bag of FIG. 11;

FIG. 13 is a sectional view, taken substantially along the line 13—13 in FIG. 11;

FIG. 14 is an elevational view of still another embodiment of a liquid collection and measurement bag constructed in accordance with the invention; and

FIG. 15 is a sectional view, taken substantially along the line 15—15 in FIG. 14.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and particularly to FIG. 1 thereof, there is shown a urinary drainage system, constructed in accordance with the present invention, and designated generally by the reference numeral **20**. Although the invention is particularly described in connection with urine drainage, collection and monitoring systems, it is to be understood that its use is not so limited, and it may also be used in other medical procedures and for draining, collecting and monitoring other body fluids.

The drainage system **20** includes a pair of parallel, vertically oriented, flexible tubes **21** and **22**, the tube **21** performing the function of liquid drainage, while the tube **22** functions as an air vent.

As best observed in FIG. 2, the air vent tube **22** is sealed at its upper end **22***a* after first providing an air vent port **23** to establish fluid communication between the vent tube and the drain tube **21**.

The upper end of the drain tube **21** is connected by a conventional tubing connector **29** to an appropriate catheter **31** (such as a Foley catheter) dwelling within the bladder of a patient (not shown). An occlusive clamp **33**, of any appropriate design, is located between the upper end of the drain tube **21** and the junction of the tubes **21**, **22**, the clamp being used to selectively seal the drain tube and prevent urine flow whenever desired. The catheter **31** and clamp **33** are preferably physically located as close as is practically feasible to the junction of the tubes **21**, **22** for best system performance.

The lower distal ends **24** and **25** of the tubes **21** and **22**, respectively, terminate in a drip chamber **27** which should be maintained in the substantially vertical position shown in FIG. **1** for proper operation of the drainage system. The open end **24** of the drain tube **21** is at a lower elevation than the open end **25** of the vent tube **22**, thus providing a hydrostatic head when both tubes are filled with liquid, the resulting pressure differential forcing urine to flow down the tube **21** and into the drip chamber **27** while air rises up the vent tube **22**, passes through the port **23** between the tubes, and then moves down the drain tube **21**.

The dual tube arrangement shown favors unidirectional flow, with substantially no retention of liquid within the tubes **21**, **22**. Thus, the drainage system of the present invention is essentially self-clearing, and the lack of liquid retention by the system makes accurate short term low volume urine output measurements feasible.

The lower end of the drip chamber **27** is provided with two openings in which a pair of tubes **35** and **36** are mounted. The upper open end of the tube **35** is flush with the bottom wall **27***a* of the chamber **27**, to enable liquid to drain therethrough, whereas the upper open end of the tube **36** is located above the bottom wall **27***a*. Similarly, the lower open end of the tube **35** is below the lower open end of the tube **36**.

Tube **35** drains the urine in the drip chamber **27** into a urine collection bag **38**, while the tube **36** allows air from the bag **38** to enter the drip chamber and replace the liquid leaving the chamber. Hence, tube **35** functions as a liquid drain tube, while tube **36** functions as a vent tube. In this regard, the relative elevations of the upper and lower ends of the tubes **35**, **36** insure substantially unidirectional flow of both gas and liquid. Moreover, the dual tube drip chamber **27** serves as a very effective gas barrier to ascending infection and is, therefore, safer to use than conventional drainage devices. It will be understood that by the term drip chamber is meant any arrangement that will provide a break in the liquid path of the drain tube, and such breaks may take numerous forms other than that illustrated herein.

The collection bag **38** is typically fabricated of any pliable material, typically a transparent or translucent flexible plastic, which is heat-sealed along its periphery to exclude entry of any contaminating gas from outside the system. The tubes **35**, **36** are sealed in position, by any appropriate conventional means, where the tubes enter at the top of the bag **38**. The bag **38** is also provided with an output drain tube **40** and an associated occlusive clamp **41**, to permit selective drainage of collected urine from the bag.

If desired, the collection bag **38** may be provided with appropriate calibrations **42**, typically in milliliters, to indicate the volume of liquid collected within the distended bag.

The drainage system **20** and collection bag **38** are typically supplied with all clamps closed and with the small residual volume of tubing and chambers filled with sterile gas. In actual use, the clamps **33** and **41** are selectively unclamped for drainage of urine through the tube **21**, drip chamber **27**, tube **35**, into the bag **38**, and for drainage of collected urine from the bag **38** via the tube **40**. At these times, substantially no additional gas enters the system since the relatively small diameter drainage tubes essentially provide their own water seal. The collected urine distends the pliable plastic urine collection bag **38**, and the small supplied volume of sterile gas is then displaced above the liquid in the bag, tubes and drip chamber.

The sealed collection bag **38** usually develops a small positive pressure as it is filled with liquid, and this latter pressure is transmitted through the dual tube drainage system and the catheter to the patient. Such small positive pressures are well tolerated by the patient and are generally desirable to minimize the occurrence of bladder lesions.

Referring now more particularly to FIGS. 3 and 4, it will be observed that the drain tube **21** and vent tube **22** can be economically manufactured by simultaneous co-extrusion as a siamese tubing pair. After punching the vent port **23** through the common wall between the tubes **21**, **22**, the upper open end of the vent tube **22** is heat-sealed at **22***a* as shown in FIG. **2**.

Referring now to FIG. 5, there is shown a second embodiment of a urinary drainage system, constructed in accordance with the present invention, and designated generally by the reference numeral 50. Like reference numerals designate like or corresponding parts in the drainage systems of FIGS. 1 and 5.

The drainage system of FIG. 1 differs from the drainage system of FIG. 5 primarily in the addition of a separate drip chamber 52 located above the urine drainage drip chamber 27. Although the chambers 27 and 52 are described as being separate, it is understood that this is meant in terms of separate compartments only, and the two chambers may preferably be provided as a single, integrally formed unit as shown in FIG. 5.

The lower open end 25 of the vent tube 22 in FIG. 5 terminates within the chamber 52 adjacent the top of the latter chamber, whereas the drain tube 21 passes through the chamber 52 and its lower open end 24 terminates within the lower chamber 27.

It will also be noted in FIG. 5 that the vent tube 36 passes through the lower chamber 27 and enters the upper chamber 52. Locating the upper end of the vent tube 36 in the chamber 52, while locating the lower end of the drain tube 21 in the chamber 27, results in complete separation of the liquid drainage system from the gas venting system, i.e., chamber 27 is confined substantially to liquid drainage while chamber 52 is essentially limited to gas venting functions, thus simplifying the fluid flow paths, further decreasing the chance of any fluid retention in the tubes or chambers, and providing a more efficient gas barrier to ascending infection.

It will be appreciated that the drain tube 21 and vent tube 36 need not pass directly through the chambers 52 and 27, respectively, as shown in the preferred embodiment of FIG. 5, but may also travel outside of the drip chambers as long as they ultimately terminate at proper elevation and in the appropriately designated chambers shown, without in any way departing from the spirit and scope of the present invention.

The embodiment of the drainage system shown in FIG. 6 essentially duplicates the systems of FIGS. 1 and 5 previously discussed, with the additional modification of providing a one-way check valve 54, typically a simple ball valve, in the vent tube 22 just below the venting port 23.

The valve 54 prevents any substantial amount of liquid from flowing into the vent tube 22 through the port 23, thus further assuring a relatively high hydrostatic pressure differential between the tube 22 and the drain tube 21. Hence, unidirectional flow is further enhanced, since liquid must always flow down the tube 21, while air must always go up the tube 22 past the valve 54.

An additional advantage of locating the valve 54 adjacent the port 23 is that the relatively close proximity to the exit of the Foley catheter assures a substantially moist state, with consequent reduced probability of valve failure due to inspissated material.

Referring now to FIG. 7, there is shown a modified drip chamber construction which is particularly well suited for application in the drainage systems of FIGS. 5 and 6. The primary differences between the embodiment of the invention snown in FIG. 7 and the embodiment shown in FIG. 5 resides in the provision of a flexible outer wall 52*a* for the upper chamber 52, and the location of a one-way check valve 56 at the lower end of the vent tube 36.

The check valve 56 includes an occlusive member 56a, e.g., a small ball, with a specific gravity (typically less than unity) below that of the liquid drained through the system. Therefore, if liquid should inadvertently enter the upper chamber 52 (a condition which is unlikely to occur with the system of the present invention), the liquid will enter the tube 36, and the member 56a will then rise to open the valve 56 and permit the liquid to exit from the vent tube. In this connection, the lower wall surface 52*b* of the chamber 52 is appropriately sloped to favor drainage of liquid within the chamber towards the side of the chamber where the tube 36 and valve 56 are located.

The flexible wall 52*a* of the chamber 52 enables the chamber 52 to be used as a hand operated air pump to assure immediate clearing of all tubes and chambers when desired. In this regard, upon squeezing the wall 52*a*, any liquid that might be present in the chamber 52 is rapidly forced through the tube 36 and the open valve 56 into the collection bag 38. When the chamber 52 is substantially empty, the valve 56 closes and the entire fluid pressure generated by the pumping action is directed through the upper vent tube 22 and port 23 to clear the remaining tubes and chambers.

In view of the very high relative humidity in the sealed system of the present invention, normally at or near 100%, the likelihood of failure of the valve 56 due to inspissated material is very remote.

Application of the modified drip chamber and valve construction of FIG. 7 to the drainage system 50 of FIG. 5, with the addition of the valve 54 in the vent tube 22 as shown in FIG. 6, results in an extremely trouble-free, consistently reliable system with an inherently high hydrostatic pressure differential and a hand pump backup. The drainage efficiency of such an arrangement is sufficiently high that it will function extremely well, even with very small diameter tubing, typically 3/32 inch I.D. and less, with obvious advantages in terms of cost and compactness.

FIGS. 8 through 15 of the drawings illustrate several embodiments of a new and improved liquid collection and measurement bag particularly well adapted for use with the drainage systems of FIGS. 1 through 7 in lieu of the simplified collection bag 38 previously described. However, while the collection and measurement bags of FIGS. 8 through 15 are well suited for use with such drainage systems, it is to be understood that the bags may also be used with other drainage systems and for collecting liquids other than urine.

Referring now to FIG. 8, there is shown a urine collection and measurement bag 138 fabricated of pliable translucent or transparent material, preferably plastic, which has been first vacuum-heat formed to define three slightly distended chambers 143, 144,145, and then heat-sealed along the bag periphery 139 and the pair of inner seams 140, 141. The result is a completely sealed bag capable of excluding contaminating gas from the external environment. In addition, as best observed in FIG. 8, the seams 140, 141 extend considerably less than the full height of the bag 138, and the seam 140 is shorter than the seam 141, thus defining the three liquid collection chambers 143, 144, 145 of progressively increasing volumetric capacity, respectively, with all three chambers communicating with each other at their upper open ends.

The collection chamber 143 is the smallest chamber and is ideally suited for accurate, short term, low volume measurements, particularly when used in conjunction with any of the previously described drainage systems of the present invention which avoid liquid retention that would otherwise introduce inaccuracies into such measurements.

The bag 138 and each of the chambers 143, 144, 145 become further distended when filled with the weight of the urine collected. In this regard, appropriate vertically spaced series of calibration marks 143*a*, 144*a*, 145*a*, typically in milliliters, are printed or otherwise appropriately defined in the bag 138 along the edge of each of the chambers 143, 144, 145, respectively, to indicate the distended volumes of liquid collected.

The bag 138 is either pierced and subsequently heat-sealed, or provided with any other appropriate gas tight mounting, at 139*a* for receiving a drain tube 135 and vent tube 136 equivalent to the tubes 35, 36, respectively, previously described in connection with the drainage systems of FIGS. 1–7.

The drain tube 135 is slashed diagonally at 135a from a point a few centimeters below its point of entry into the bag 138 to its tip 135*b* near the bottom of the bag and well within the smallest collection chamber 143. Similarly, the vent tube 136 is slashed diagonally at 136*a* from a point above the beginning of the diagonal slash for drain tube 135 to the tip of the tube 136 at point 136*b* within the chamber 143.

The slashed tube construction serves as a liquid flow director to make sure that liquid entering the bag **138** enters the smallest collection chamber **143** first. As for the tube **136**, if liquid flow should inadvertently reverse in direction, the liquid will still enter the chamber **143** first in the embodiment of the system shown in FIG. **8**. Normally, however, the tube **136** performs its primary designated function of venting gas, displaced above the liquid entering bag **138**, to the remainder of the drainage system.

When collection chamber **143** is filled with urine or the like, the liquid will overflow into the chamber **144**. When both of the chambers **143** and **144** are full, urine then overflows into the largest chamber **145**. After a prescribed interval of liquid collection, the urine from chambers **143** and **144** may be emptied into the chamber **145** by tipping the bag **138** so that it rotates clockwise **90** degrees or more.

The bag **138** is also provided with a pair of drain tubes **147**, **148** located at the bottoms of collection chambers **143**, **145**, respectively. The drain tubes **147**, **148** are typically ¼ inch I.D. in size and are provided with conventional occlusive clamps **149**, **150**, respectively, located close to the bottom of the bag **138**.

Short term, relatively low volume liquid specimens from a given collection period may be selectively drained from the small chamber **143** through the drain tube **147** for any type of subsequent testing. If desired, a relatively inexpensive, disposable urinometer (not shown), for measuring urine specific gravity, may also be incorporated into the chamber **143**. At the end of each day or nursing shift, the entire bag **138** may be emptied through the drain tube **148**.

The collection and measurement bag **138** completely avoids the problems of the prior art involving urine spillage through the air vent, urine contamination by gas entering the system through the air vent, and vent clogging. In addition, the bag **138** provides a relatively simple, low cost, accurate collection and monitoring apparatus as an ideal solution to the problem of making precise, low volume urine measurements and obtaining recent urine specimens for testing.

Referring now to FIG. **10**, there is shown another embodiment of a liquid collection and measurement bag **238**, constructed in accordance with the present invention. In this connection, reference numerals **235–249** in the embodiment of FIG. **10** designate like or corresponding parts as the reference numerals **135–149** in the embodiment of FIG. **8**.

The primary distinction between the bag **238** of FIG. **10** and the bag **138** of FIG. **8** is that, in lieu of the pair of heat-sealed seams **140**, **141**, the bag **238** is provided with a single curved seam **240** which divides the bag into two chambers **243** and **245**. Since the seam **240** curves closer to the side of the bag **238** as it approaches the bottom of the bag, smaller urine output volumes are measured more accurately, while the ability to measure relatively large hourly volumes is preserved at the wider, upper end of the chamber **243** and the much larger chamber **245** into which urine overflow occurs.

FIG. **10** also shows a different form of a liquid flow director than the diagonally slashed tubes shown in FIG. **8**. In this regard, the bag **238** includes an additional layer or flap **251** of flexible plastic material which is heat-sealed into the adjacent peripheral joint **239** of the bag. The flap **251** defines a flow directing web which is secured at its upper end to the lower ends of the tubes **235**, **236** and extends down into the chamber **243**, to assure that urine entering the bag enters the latter chamber first.

FIGS. **11–13** illustrate another embodiment of a liquid collection and measurement bag **338**, constructed in accordance with the present invention. In this connection, reference numerals **335–348** in the embodiment of FIGS. **11–13** designate like or corresponding parts as the reference numerals **135–148** in the embodiment of FIG. **8**.

The primary difference between the bag **338** of FIGS. **11–13** and the bag **138** of FIG. **8** resides in the provision of a rigid baffle **353** as a divider defining collection chambers **343**, **345**, rather than using the seams **140**, **141** shown in FIG. **8**. The baffle **353** is typically fabricated of relatively rigid plastic material and includes a base member **353*a*** secured to or integrally formed with an upwardly extending compartment dividing member **353*b***.

The vertical edges of the member **353*b*** are heat-sealed to the outer walls of the bag **338** after the baffle **353** is installed within the bag. The opening **347*a*** of the drain **347** overlaps with the upper surface of the member **353*a*** within the bag **338** to permit selective drainage from the compartment **343**. Drainage from the compartment **345** by the drain tube **348** is accomplished through a hole **355** provided in the base member **353*a*** directly above the tube **348**.

FIGS. **14** and **15** illustrate a further embodiment of a novel liquid collection and measurement bag **438**, constructed in accordance with the present invention. In this connection, reference numerals **435–448** in the embodiment of FIGS. **14**, **15** designate like or corresponding parts as the reference numerals **135–148** in the embodiment of FIG. **8**.

The primary difference between the bag **438** of FIGS. **14**, **15** and the bag **138** of FIG. **8** resides in the provision of a separate, relatively rigid walled, graduated container **450** within the bag **438** and defining the small volume collection chamber **443**. The container **450** includes a spout **450a** at the lower edge thereof adapted to enter the mouth **447*a*** of the drain tube **447** when the container is installed within the bag **438**.

It will be appreciated that, while the container **450** is shown in FIGS. **14**, **15** as defining only the single chamber **443**, it is within the ordinary skill of the art to provide a similar container defining two or more collection chambers, without in any way departing from the present invention.

Except for the structural differences noted, the intended use, operational performance and advantages of the bag embodiments shown in FIGS. **10** through **15** of the drawings substantially duplicate those for the bag **138** shown in FIGS. **8** and **9** of the drawings.

The new and improved fluid drainage, collection and monitoring systems of the present invention are characterized by relatively simple, compact and economical construction, while substantially obviating or minimizing the prior art problems of spillage, contamination, ascending infection to the patient and poor patient tolerance. In addition, the present invention satisfies a long existing need in the medical arts for a system capable of trouble-free, complete drainage and capable of making accurate, low volume urine output measurements and obtaining recently collected urine specimens.

It will be apparent from the foregoing that, while particular forms of the invention have been illustrated and described, various modifications can be made without departing from the spirit and scope of the invention.

I claim:

1. Fluid drainage apparatus, comprising:

first means defining a first conduit, adapted for use in a substantially vertical position, both upper and lower ends of said conduit being open, said upper end being adapted for connection to a liquid source to be drained;

second means defining a second conduit, adapted for use in a substantially vertical position and substantially adjacent said first conduit, said second conduit being in fluid communication with said first conduit at substantially the upper end of said first conduit;

closed collection means for receiving liquid drained from said source;

means connecting the lower ends of said first and second conduits to said collection means, said second conduit being open at its lower end and remaining open to gas flow only from said collection means in normal use, said lower end of said second conduit being located above said lower end of said first conduit in normal use to establish a hydrostatic pressure differential between said first and said second conduits, whereby said conduits will carry liquid from said source to said collection means even when said source is closed to the atmosphere.

2. Apparatus as set forth in claim **1**, and further including:

manual pump means in fluid communication with said second conduit for selectively increasing the pressure differential between said first and said second conduits so that fluid is pumped up said second conduit and liquid is pumped down said first conduit.

3. Fluid drainage apparatus, comprising:

first means defining a first conduit, adapted for use in substantially vertical position, both upper and lower ends of said conduit being open, said upper end being adapted for connection to a liquid source to be drained;

second means defining a second conduit, adapted for use in a substantially vertical position and in substantially close proximity to said first conduit;

closed collection means for receiving liquid drained from said source;

means connecting the lower ends of said first and second conduits to said collection means, said second conduit being open at its lower end and remaining open to gas flow only from said collection means in normal use; and

a fluid passage defined between said first and said second conduits remote from both of said lower ends whereby at least one of said conduits will carry liquid from said source to said collection means even when said source and said collection means are closed to the atmosphere.

4. Apparatus as set forth in claim 3, wherein said first and said second means are in abutment and said fluid passage is defined by said first and said second means.

5. Apparatus as set forth in claim 3, and further including:

selectively actuable pump means in fluid communication with said second conduit for pumping fluid up said second conduit.

6. Apparatus as set forth in claim 3, and further including:

one-way check valve means in said second conduit for limiting fluid flow therein to an upward direction.

7. Apparatus as set forth in claim 6, and further including:

selectively actuable pump means in fluid communication with said second conduit.

8. Fluid drainage apparatus, comprising:

first means defining a first conduit, adapted for use in substantially vertical position, both upper and lower ends or said conduit being open, said upper end being adapted for connection to a liquid source to be drained;

second means defining a second conduit, adapted for use in a substantially vertical position and in substantially close proximity to said first conduit, said second conduit being open at its lower end, and remaining open to gas flow in normal use;

a fluid passage defined between said first and said second conduits remote from both of said lower ends;

drip chamber means for receiving the lower ends of said first and said second conduits; and

additional means defining a plurality of conduits communicating with said chamber means for draining a first fluid therefrom and simultaneously replacing said first fluid with a second fluid.

9. Apparatus as set forth in claim 8, and further including:

one-way check valve means in said second conduit, below said fluid passage.

10. Apparatus as set forth in claim 8, and further including:

a substantially sealed collection container in fluid communication with said drip chamber means via said conduits defined by said additional means.

11. Apparatus as set forth in claim 10, and further including:

means for dividing said collection container into a plurality of different size volumetric capacity compartments.

12. Apparatus as set forth in claim 11, and further including:

drain means at the bottom of said container for selectively draining fluid from the smallest of said compartments.

13. Apparatus as set forth in claim 12, and further including:

additional drain means at the bottom of said container for selectively draining fluid from the largest of said compartments.

14. For use in a liquid drainage medical apparatus, the combination comprising:

a first, substantially vertically oriented tube, said tube being open at its upper end and at its lower end, said upper end being adapted for connection to a liquid source to be drained;

a second, substantially vertically oriented tube, said second tube being closed at its upper end and open at its lower end, said lower end remaining open to gas flow in normal use;

means defining a fluid passage between said first tube and said second tube; and

valve means in said second tube, below said fluid passage, for enabling fluid flow up said second tube while substantially preventing liquid flow down said second tube.

15. Apparatus as set forth in claim 14, and further including:

selectively actuable pump means in fluid communication with said second tube for pumping fluid up said second tube.

16. Apparatus as set forth in claim 14, wherein said second tube is in abutment with said first tube substantially along the entire length of said second tube, and said fluid passage is located adjacent the upper end of said second tube.

17. Apparatus as set forth in claim 14, wherein both of said first and said second tubes terminate at their lower ends in a drip chamber.

18. Apparatus as set forth in claim 14, and further including:

drip chamber means for receiving both lower ends of said first and said second tubes; and

conduit means communicating with said chamber means for draining liquid therefrom and simultaneously replacing said liquid with gas.

19. Apparatus as set forth in claim 16, wherein both of said first and said second tubes are co-extruded as an integral tube pair.

20. Apparatus as set forth in claim 18, wherein said conduit means comprises:

a pair of drain and vent tubes each open at both ends and passing through the bottom of said chamber means, the relative elevations of said drain and said vent tubes providing a hydrostatic pressure differential promoting substantially unidirectional fluid flow.

21. Apparatus as set forth in claim 18, and further including:

a substantially sealed liquid collection bag in fluid communication with said drip chamber means via said conduit means.

22. Apparatus as set forth in claim 21, wherein said conduit means comprises:

a pair of drain and vent tubes each open at both ends and passing through the bottom of said chamber means into said collection bag, the relative elevations of said drain and said vent tubes providing a hydrostatic pressure differential promoting substantially unidirectional fluid flow for both liquid an gas.

23. Apparatus as set forth in claim 22, wherein said second tube is in abutment with said first tube substantially along the entire length of said second tube, and said fluid passage is located closely adjacent the upper end of said second tube.

24. Apparatus as set forth in claim 23, and further including:

one-way check valve means in said second tube, below said fluid passage, for enabling gas flow up said second tube while substantially preventing liquid flow down said second tube.

25. Apparatus as set forth in claim 22, and further including:

divider means for dividing said collection bag into a plurality of different size volumetric capacity compartments.

26. Apparatus as set forth in claim 25, and further including:
flow director means for directing liquid flow from said drain tube into the smallest of said compartments.

27. Apparatus as set forth in claim 25, wherein said divider means includes at least one integral seam separating said compartments.

28. Apparatus as set forth in claim 25, wherein said divider means includes at least one substantially rigid container.

29. Apparatus as set forth in claim 25, wherein said compartments are calibrated.

30. Apparatus as set forth in claim 26, and further including:
first drain means for selectively draining liquid from the smallest of said compartments; and
second drain means for selectively draining liquid from the largest of said compartments.

31. Apparatus as set forth in claim 26, wherein said flow director means includes a tapered lower open end of said drain tube extending into said smallest compartment.

32. Apparatus as set forth in claim 26, wherein said flow director means includes a tapered lower open end of said vent tube extending into said smallest compartment, the beginning of said tapered end of said vent tube initiating at a higher elevation than said tapered end of said drain tube.

33. Apparatus as set forth in claim 26, wherein said flow director means includes a web secured to the lower open end of said drain tube and extending down into said smallest compartment.

34. Apparatus as set forth in claim 33, wherein said web is also secured to the lower open end of said vent tube.

35. For use in a liquid drainage medical apparatus, the combination comprising:
a first, substantially vertically oriented tube, said tube being open at its upper end and at its lower end, said upper end being adapted for connection to a liquid source to be drained;
a second, substantially vertically oriented tube, said second tube being closed at its upper end and open at its lower end, said lower end remaining open to gas flow in normal use;
means defining a fluid passage between said first tube and said second tube;
a first chamber receiving and locating said lower open end of said second tube above the bottom of said chamber;
a venting conduit having its upper open end in fluid communication with said first chamber, said venting conduit having a lower open end;
a second chamber, said lower open end of said first tube being received within said second chamber; and
a drainage conduit in fluid communication with said second chamber at substantially the bottom of said second chamber, the lower open end of said drainage conduit being lower than the lower open end of said venting conduit.

36. Apparatus as set forth in claim 35, wherein said second chamber is located below said first chamber.

37. Apparatus as set forth in claim 35, wherein said first chamber includes a flexible wall.

38. Apparatus as set forth in claim 36, wherein said first tube passes through said first chamber to enter said second chamber, and said venting conduit passes through said second chamber to enter said first chamber.

39. Apparatus as set forth in claim 35, wherein said upper open end of said venting conduit is located substantially no higher than the bottom of said first chamber.

40. Apparatus as set forth in claim 39, and further including:
a one-way valve means located in said venting conduit for normally allowing fluid flow only up said venting conduit, said valve having an occluding member with a specific gravity less than the specific gravity of any liquid to be drained, whereby said valve is disabled in the presence of said liquid to permit fluid flow down said venting conduit.

41. Apparatus as set forth in claim 40, wherein the bottom of said first chamber is shaped to favor liquid drainage towards said venting conduit.

42. For use in a liquid drainage medical apparatus, the combination comprising:
a first, substantially vertically oriented tube, said tube being open at its upper end and at its lower end, said upper end being adapted for connection to a liquid source to be drained;
a second, substantially vertically oriented tube, said second tube being closed at its upper end and open at its lower end, said lower end remaining open to gas flow in normal use;
means defining a fluid passage between said first tube and said second tube;
a first sealed drip chamber, at least a portion of the walls defining said drip chamber being flexible, said lower end of said second tube being received by one of said walls to space said lower end of said second tube above the bottom of said chamber;
a venting conduit entering said drip chamber through said bottom wall, the upper open end of said venting conduit being substantially no higher than the bottom of said chamber;
one-way valve means located in said venting conduit for normally allowing fluid flow only up said venting conduit, said valve means having an occluding member with a specific gravity less than the specific gravity of any liquid to be drained, whereby said valve means is disabled in the presence of said liquid to permit fluid flow down said venting conduit;
a second drip chamber below said first chamber, the lower end of said first tube being received within said second drip chamber; and
a drainage conduit in fluid communication with said second drip chamber through the bottom of said second chamber, the lower open end of said drainage conduit being lower than the lower open end of said venting conduit.

43. Apparatus as set forth in claim 42, and further including:
valve means in said second tube, below said fluid passage, for enabling gas flow up said second tube while substantially preventing liquid flow down said second tube.

44. For use in a liquid drainage medical apparatus, the combination comprising:
a substantially sealed liquid collection bag; and
divider means for dividing said collection bag into a plurality of different size volumetric capacity compartments, said divider means including a substantially rigid baffle member separating said compartments, the tops of said compartments being in open communication with each other within said bag.

45. For use in a liquid drainage medical apparatus, the combination comprising:
a substantially sealed liquid collection bag;
divider means for dividing said collection bag into a plurality of different size volumetric capacity compartments, said divider means including at least one substantially rigid container defining at least one of said compartments, the tops of said compartments being in open communication with each other within said bag;
a spout in fluid communication with said container at the bottom of said container; and
selectively operable drain means at the bottom of said bag in fluid communication with said spout.

46. For use in a closed liquid drainage system, medical apparatus comprising, in combination:
a drainage tube having an open upper end for connection to a liquid source to be drained, said liquid source being effectively closed to the atmosphere;
a vent tube adjacent and generally parallel to said drainage tube, and having its upper end closed to atmosphere and

in fluid communication with said drainage tube at substantially the upper end of the drainage tube; and

closed collection means for receiving liquid drained from said source, the lower ends of said drainage and vent tubes being connected to said collection means and in fluid communication with the interior thereof, whereby liquid from said closed source will flow down one of said tubes to said closed collection means and fluid from said closed collection means will flow up the other of said tubes.

47. The system of claim **46**, wherein the lower end of said vent tube is located above the lower end of said drainage tube within said closed collection means in normal use to establish a hydrostatic pressure differential between said vent and drainage tubes.

48. The system of claim **47**, further including pump means in fluid communication with said vent tube for selectively increasing the pressure differential therebetween so that fluid may be pumped up said vent tube and down said drainage tube when the upper end of said drainage tube is connected to said liquid source.

49. The system of claim **46**, further including one-way valve means in said vent tube for limiting fluid flow therein to a direction away from said collection means.

50. The system of claim **49**, further including selectively actuable pump means in fluid communication with said vent tube for pumping fluid from said collection means and up said vent tube, thereby pumping liquid down said drainage tube when the upper end of said drainage tube is connected to said liquid source.

51. The system of claim **50**, wherein said collection means is a drip chamber.

52. The system of claim **50**, wherein said collection means is a liquid collection bag having a flexible wall.

53. The system of claim **50**, wherein said vent and drainage tubes form an integral unit.

54. The system of claim **46**, further including selectively actuable pump means in fluid communication with at least one of said tubes for pumping fluid from said collection means up said vent tube and for pumping liquid down said drainage tube when the upper end of said drainage tube is connected to said liquid source.

55. For use in a liquid drainage medical apparatus, the combination comprising:

a first substantially vertically oriented tube, said tube being open at its upper end and at its lower end, said upper end being adapted for connection to a liquid source to be drained;

a second, substantially vertically oriented tube, said second tube being closed at its upper end and open at its lower end, said lower end remaining open to gas flow in normal use;

means defining a fluid passage between said first tube and said second tube; and

selectively actuable unidirectional pump means in fluid communication with at least one of said first and second tubes for pumping fluid up said second tube, through said fluid passage, and down said first tube.

56. The apparatus of claim **55**, further including valve means in said second tube, below said fluid passage, for enabling fluid flow up said second tube while substantially preventing liquid flow down said second tube.

57. The apparatus of claim **55**, wherein said pump means comprises a gas barrier chamber for receiving the lower open end of said second tube, said chamber having a flexible wall.

58. The apparatus of claim **57**, further including one-way check valve means in said chamber limiting the direction of fluid flow therethrough.

59. The apparatus of claim **55**, further including one-way check valve means in at least one of said tubes for limiting the direction of flow therein.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,661,143 Dated May 9, 1972

Inventor(s) MELVYN L. HENKIN

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 9, line 42, after "ends" delete "or" and insert therefor --of--.

Signed and sealed this 24th day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents