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(54) LIQUID VENTING SURGICAL CASSETTE

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Said application No. 10/407,388 is a continuation-in-part of application No. 10/153,371, filed on May 28, 2002, and which is a continuation-in-part of application No. 09/925,989, filed on Aug. 9, 2001, now Pat. No. 6,740,074, which is a continuation-in-part of application No. 09/771,945, filed on Jan. 29, 2001, now Pat. No. 6,632,214, which is a division of application No. 09/387,357, filed on Aug. 31, 1999, now Pat. No. 6,261,283.

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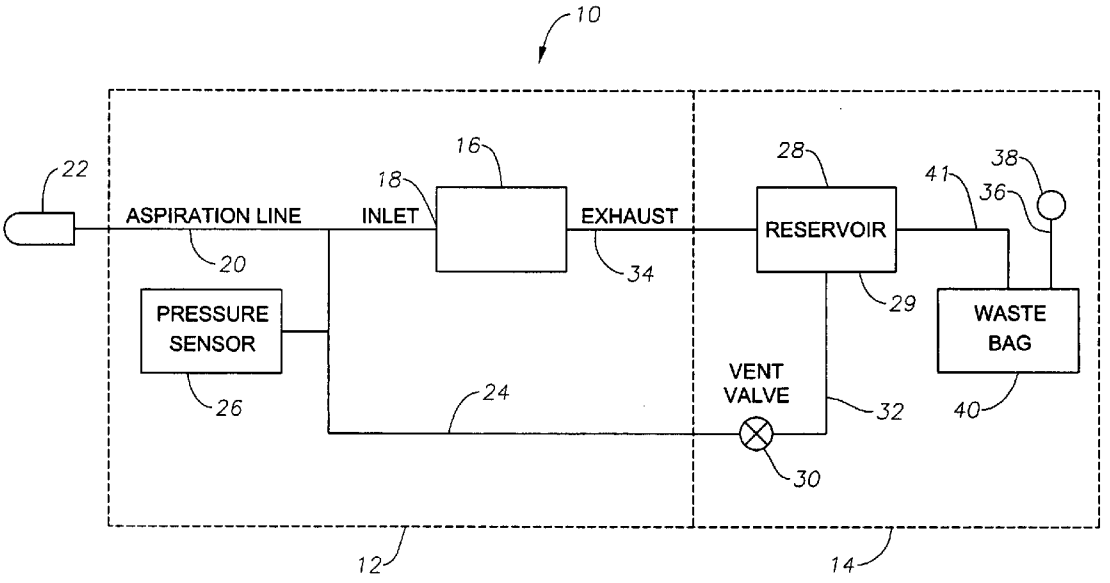
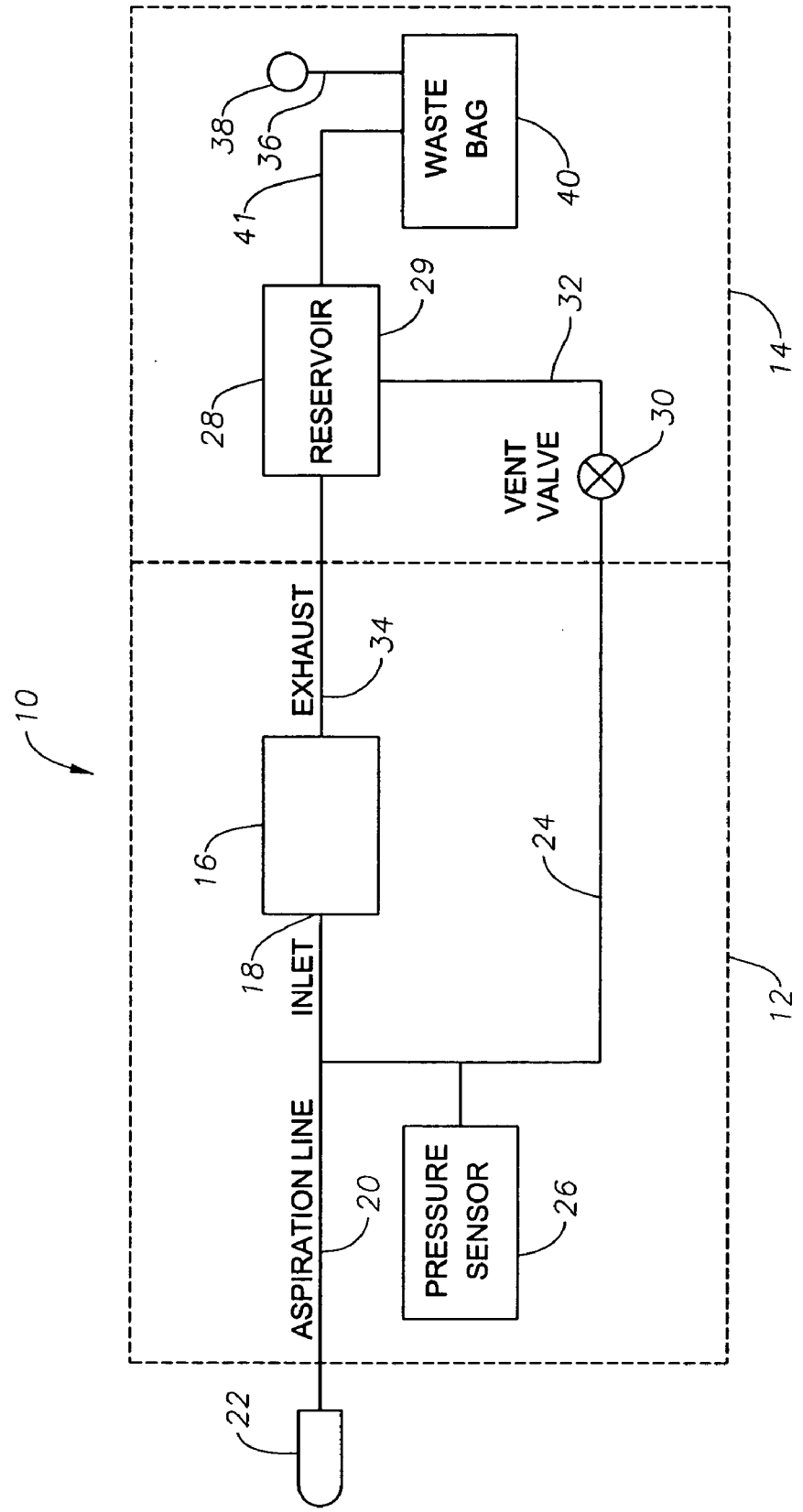
(57) ABSTRACT

A surgical system having a cassette with an aspirant vent line that permits a fluidic connection between the inlet to a aspirant pump and the outlet of the aspirant pump through a vent valve. When the aspiration vent valve is open, fluid flows from the pump outlet into the pump inlet, thereby releasing any pressure within the pump inlet. Such a system does not require a second source of irrigation fluid, minimizes pressure surges into the irrigation fluid line and does not affect the fluidic performance of the aspiration system.

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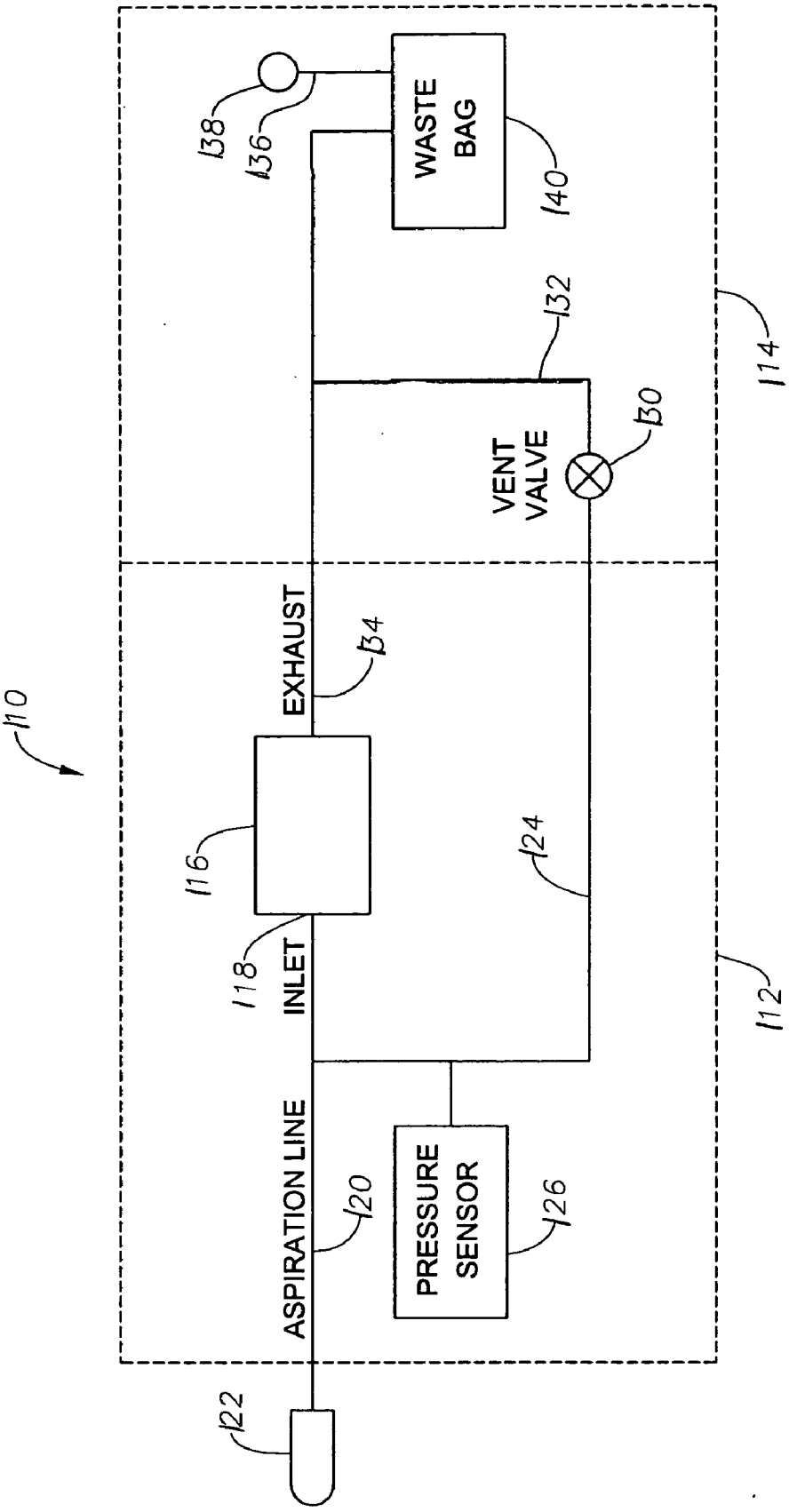
WASTE BAG
RESERVOIR
VENT VALVE
EXHAUST
INLET
ASPIRATION LINE
PRESSURE SENSOR

FIG. 1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WASTE BAG
VENT VALVE
EXHAUST
INLET
ASPIRATION LINE
PRESSURE SENSOR

FIG. 2

LIQUID VENTING SURGICAL CASSETTE

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 10/430,974, filed May 7, 2003, currently co-pending which is a continuation-in-part of U.S. patent application Ser. No. 10/407,388, filed Apr. 4, 2003, which is a continuation-in-part application of U.S. patent application Ser. No. 09/846,724, filed May 1, 2001, now U.S. Pat. No. 6,572,349 B2, which is a continuation of U.S. patent application Ser. No. 09/437,392, filed Nov. 10, 1999, now U.S. Pat. No. 6,293,926 B1, and a continuation-in-part of U.S. patent application Ser. No. 10/153,371, filed May 28, 2002, and is a continuation-in-part application of U.S. patent application Ser. No. 09/925,989, filed Aug. 9, 2001, now U.S. Pat. No. 6,740,074 B1, which is a continuation-in-part of U.S. patent application Ser. No. 09/771,945, filed Jan. 29, 2001, now U.S. Pat. No. 6,632,214 B1, which is a divisional of U.S. patent application No. 09/387,357, filed Aug. 31, 1999, now U.S. Pat. No. 6,261,283 B1.

BACKGROUND OF THE INVENTION

[0002] This invention relates generally to the field of cataract surgery and more particularly to an aspiration system for a handpiece for practicing the phacoemulsification technique of cataract removal.

[0003] The human eye in its simplest terms functions to provide vision by transmitting light through a clear outer portion called the cornea, and focusing the image by way of the lens onto the retina. The quality of the focused image depends on many factors including the size and shape of the eye, and the transparency of the cornea and lens.

[0004] When age or disease causes the lens to become less transparent, vision deteriorates because of the diminished light which can be transmitted to the retina. This deficiency in the lens of the eye is medically known as a cataract. An accepted treatment for this condition is surgical removal of the lens and replacement of the lens function by an artificial intraocular lens (IOL).

[0005] In the United States, the majority of cataractous lenses are removed by a surgical technique called phacoemulsification. During this procedure, a thin phacoemulsification cutting tip is inserted into the diseased lens and vibrated ultrasonically. The vibrating cutting tip liquifies or emulsifies the lens so that the lens may be aspirated out of the eye. The diseased lens, once removed, is replaced by an artificial lens.

[0006] A typical ultrasonic surgical device suitable for ophthalmic procedures consists of an ultrasonically driven handpiece, an attached cutting tip, and irrigating sleeve and an electronic control console. The handpiece assembly is attached to the control console by an electric cable and flexible tubings. Through the electric cable, the console varies the power level transmitted by the handpiece to the attached cutting tip and the flexible tubings supply irrigation fluid to and draw aspiration fluid from the eye through the handpiece assembly.

[0007] The operative part of the handpiece is a centrally located, hollow resonating bar or horn directly attached to a set of piezoelectric crystals. The crystals supply the required ultrasonic vibration needed to drive both the horn and the attached cutting tip during phacoemulsification and are controlled by the console. The crystal/horn assembly is suspended within the hollow body or shell of the handpiece by flexible mountings. The handpiece body terminates in a reduced diameter portion or nosecone at the body's distal end. The nosecone is externally threaded to accept the irrigation sleeve. Likewise, the horn bore is internally threaded at its distal end to receive the external threads of the cutting tip. The irrigation sleeve also has an internally threaded bore that is screwed onto the external threads of the nosecone. The cutting tip is adjusted so that the tip projects only a predetermined amount past the open end of the irrigating sleeve. Ultrasonic handpieces and cutting tips are more fully described in U.S. Pat. Nos. 3,589,363; 4,223,676; 4,246,902; 4,493,694; 4,515,583; 4,589,415; 4,609,368; 4,869,715; 4,922,902; 4,989,583; 5,154,694 and 5,359,996, the entire contents of which are incorporated herein by reference.

[0008] In use, the ends of the cutting tip and irrigating sleeve are inserted into a small incision of predetermined width in the cornea, sclera, or other location. The cutting tip is ultrasonically vibrated along its longitudinal axis within the irrigating sleeve by the crystal-driven ultrasonic horn, thereby emulsifying the selected tissue in situ. The hollow bore of the cutting tip communicates with the bore in the horn that in turn communicates with the aspiration line from the handpiece to the console. A reduced pressure or vacuum source in the console draws or aspirates the emulsified tissue from the eye through the open end of the cutting tip, the cutting tip and horn bores and the aspiration line and into a collection device. The aspiration of emulsified tissue is aided by a saline flushing solution or irrigant that is injected into the surgical site through the small annular gap between the inside surface of the irrigating sleeve and the cutting tip.

[0009] During surgery, the hollow, resonating tip can become occluded. During occlusion, vacuum can build in the aspiration line downstream of the occlusion. When the occlusion eventually breaks apart, this pent up vacuum is released into the eye which can, depending upon the amount of vacuum, draw a significant amount of fluid from the eye, thereby increasing the risk of anterior chamber collapse. To address this concern, modem surgical console can detect increases in aspiration line vacuum beyond normal operating parameters and therefore predict occlusions. These consoles can then either stop or slow the aspiration pump, or sound an alarm so that the surgeon can take appropriate precautions.

[0010] The cassettes used in modem consoles also allow the aspiration line to be vented, either to atmosphere or to a liquid so as to reduce or eliminate vacuum surge upon occlusion break. Prior art air vented cassettes allow ambient air to enter the aspiration line, however, venting air into the aspiration line changes the fluidic performance of the aspiration system. Liquid venting systems allow irrigation fluid to bleed into the aspiration line, thereby reducing any impact on the fluidic performance of the aspiration system. Liquid venting cassettes are more fully described in U.S. Pat. Nos. 4,832,685 and 4,935,005 (Haines) and U.S. Pat. No. 4,713,051 (Steppe, et al.), the entire contents of which being incorporated herein by reference. When higher aspiration vacuums are used, cassettes that vent the aspiration line to the irrigation line can cause high pressure surges in the irrigation line. Other systems provide a separate source of

irrigation fluid to vent the aspiration line, requiring the use of two irrigation fluid sources and increasing the cost and complexity of the system.

[0011] Therefore, a need continues to exist for a simple surgical system that allows rapid venting of excess aspiration vacuum without introducing pressure variations in the irrigation line or the downstream aspiration line.

BRIEF SUMMARY OF THE INVENTION

[0012] The present invention improves upon the prior art by providing a surgical system having a cassette with an aspirant vent line that permits a fluidic connection between the inlet to a aspirant pump and the outlet of the aspirant pump through a vent valve. When the aspiration vent valve is open, fluid flows from the pump outlet into the pump inlet, thereby releasing any pressure within the pump inlet. Such a system does not require a second source of irrigation fluid, minimizes pressure surges into the irrigation fluid line and does not affect the fluidic performance of the aspiration system.

[0013] Accordingly, one objective of the present invention is to provide a surgical system having a aspiration line vent.

[0014] Another objective of the present invention is to provide a surgical system having a cassette that allows the aspiration line to be vented of excess vacuum.

[0015] Another objective of the present invention is to provide a surgical system having a cassette that vents the aspiration line to an aspirant collection chamber.

[0016] Another objective of the present invention is to provide a surgical system that vents the aspiration line without introducing pressure surges in the irrigation line.

[0017] Another objective of the present invention is to provide a surgical system that vents the aspiration line without affecting the fluidic performance of the aspiration system.

[0018] These and other advantages and objectives of the present invention will become apparent from the detailed description and claims that follow.

BRIEF DESCRIPTION OF THE DRAWING

[0019] **FIG. 1** is a schematic illustration of a first embodiment of the system and cassette of the present invention.

[0020] **FIG. 2** is a schematic illustration of a second embodiment of the system and cassette of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] As best seen in **FIG. 1**, first embodiment of system **10** of the present invention generally includes surgical console **12** and cassette **14**. Console **12** may be any suitably modified commercially available surgical console, such as the SERIES TWENTY THOUSAND® LEGACY®V, INFINITI® or ACCURUS® surgical systems available from Alcon Laboratories, Fort Worth, Tex. Cassette **14** may be any suitably modified commercially available surgical cassettes, such as those described in U.S. Pat. Nos. 5,267,956, 5,364,342 and 5,499,969 (Beuchat, et al.) and U.S. Pat. No. 5,899,674 (Jung, et al.), the entire contents of which being incorporated herein by reference. Cassette **14** is held in operative association with console **12** by means well-known in art.

[0022] As seen in the **FIG. 1**, console **12** generally contains aspiration pump mechanism **16**, which may be any suitable flow or vacuum based pump, such pumps being widely known in the art. For example, pump mechanism **16** may be a peristaltic pump roller head that interacts with a peristaltic pump tube formed by aspiration line **20** and aspiration exhaust line **34**. Aspiration line **20** is connected to surgical handpiece **22** on one end and end **18** of aspiration line **20** opposite handpiece **22** interacts with pump mechanism **16** so as to draw fluid through handpiece **22**. Aspiration line **20** is intersected between handpiece **22** and **18** by aspiration vent line **24**. In fluid communication with aspiration vent line **24** is pressure sensor **26**, which may be one of a variety of invasive or non-invasive pressure sensors well-known in the art.

[0023] Cassette **14** generally contains fluid reservoir **28**. Extending from reservoir **28** at or near bottom **29** is aspiration vent line **32**, which fluidly connects to aspiration vent line **24** through vent valve **30**. Aspirant or exhaust from pump mechanism **16** is directed into reservoir **28** through aspiration exhaust line **34**. Reservoir **28** may also vent to ambient through fluid line **41**, waste bag **40** and vent line **36**, which may contain antimicrobial filter **38**.

[0024] As discussed above, while it is preferred that pump mechanism **16** be a peristaltic roller head and aspiration line **20** and aspiration exhaust line **34** be formed in one continuous length so as to form a peristaltic pump tube that interacts with pump mechanism **16**, one skilled in the art will recognize that aspiration line **20** and aspiration exhaust line may be formed as a separate piece or pieces or may be formed integrally with cassette **14** and that pump mechanisms **16** other that peristaltic pump roller heads may be used, such as linear peristaltic pumps.

[0025] In addition, pressure sensor **26** is depicted as being contained within console **12**. One skilled in the art will recognize that portions of pressure sensor **26**, such as a pressure diaphragm (not shown) may be contained in or on cassette **14** and interact with a force transducer or other means (not shown) contained within console **12**.

[0026] In use, cassette **14** is installed on or within console **12** and held in operative association with console **12** by means well-known in the art. System **10** is primed initially with clean surgical fluid so that a small amount of fluid fills reservoir **28**. During surgery, pump mechanism **16** draws aspirant through handpiece **22** and into reservoir **28**. If the vacuum within aspiration line **20** is too high and needs to be vented, vent valve **30** is opened allowing aspirant to be drawn off of bottom **29** of reservoir **28** (reservoir **28** being at or near ambient) and into aspiration line **20** (which contains a vacuum) through aspiration vent line **24**. One skilled in the art will recognize that by varying the vertical position of reservoir **28** relative to aspiration line **20**, various vent head pressures may be achieved. Reservoir **28** may be relatively small, and not capable of holding all of the aspirant collected during surgery. Waste bag **40** may be used to drain and hold excess fluid from reservoir **28**, through fluid line **41** above bottom **29** of reservoir **28**. Waste bag **40** may be integrally formed within cassette **14** or may be formed as a separate collapsible bag attached to cassette **14**, as is well-known in the art.

[0027] As best seen in **FIG. 2**, second embodiment of system **100** of the present invention generally includes surgical console **112** and cassette **114**. Console **112** may be any suitably modified commercially available surgical console, such as the SERIES TWENTY THOUSAND® LEGACY® or ACCURUS® surgical systems available from Alcon Laboratories, Fort Worth, Tex. Cassette **114** may be any suitably modified commercially available surgical cassettes, such as those described in U.S. Pat. Nos. 5,267,956, 5,364,342 and 5,499,969 (Beuchat, et al.) and U.S. Pat. No. 5,899,674 (Jung, et al.), the entire contents of which being incorporated herein by reference. Cassette **114** is held in operative association with console **112** by means well-known in art.

[0028] As seen in **FIG. 2**, console **112** generally contains aspiration pump mechanism **116**, which may be any suitable flow or vacuum based pump, such pumps being widely known in the art. For example, pump mechanism **116** may be a peristaltic pump roller head that interacts with a peristaltic pump tube formed by aspiration line **120** and aspiration exhaust line **134**. Aspiration line **120** is connected to surgical handpiece **122** on one end and end **118** of aspiration line **120** opposite handpiece **122** interacts with pump mechanism **116** so as to draw fluid through handpiece **122**. Aspiration line **120** is intersected between handpiece **122** and **118** by aspiration vent line **124**. In fluid communication with aspiration vent line **124** is pressure sensor **126**, which may be one of a variety of invasive or non-invasive pressure sensors well-known in the art.

[0029] Extending from vent line **134** is aspiration vent line **132**, which fluidly connects to aspiration vent line **124** through vent valve **130**. Aspirant or exhaust from pump mechanism **116** is directed into vent line **132** through aspiration exhaust line **134** but is prevented from entering line **124** by valve **130**. Exhaust line **134** empties into waste bag **40**, which may vent waste bag **140** to atmosphere through vent line **136**, which may contain antimicrobial filter **38**.

[0030] As discussed above, while it is preferred that pump mechanism **116** be a peristaltic roller head and aspiration line **120** and aspiration exhaust line **134** be formed in one continuous length so as to form a peristaltic pump tube that interacts with pump mechanism **116**, one skilled in the art will recognize that aspiration line **120** and aspiration exhaust line **134** may be formed as a separate piece or pieces or may be formed integrally with cassette **114** and that pump mechanisms **116** other that peristaltic pump roller heads may be used, such as linear peristaltic pumps.

[0031] In addition, pressure sensor **126** is depicted as being contained within console **112**. One skilled in the art will recognize that portions of pressure sensor **126**, such as a pressure diaphragm (not shown) may be contained in or on cassette **114** and interact with a force transducer or other means (not shown) contained within console **112**.

[0032] In use, cassette **114** is installed on or within console **112** and held in operative association with console **112** by means well-known in the art. System **100** is primed initially with clean surgical fluid so that a small amount of fluid fills exhaust line **134** and waste bag **140**. During surgery, pump mechanism **116** draws aspirant through handpiece **122** and into exhaust line **134**. If the vacuum within aspiration line **120** is too high and needs to be vented, vent valve **130** is opened allowing aspirant to be drawn out of exhaust line **134** and into aspiration line **120** (which contains a vacuum) through aspiration vent line **124**, effectively shunting positively pressurized fluid from exhaust line **134** into negatively pressurized aspiration line **120**.

[0033] This description is given for purposes of illustration and explanation. It will be apparent to those skilled in the relevant art that changes and modifications may be made to the invention described above without departing from its scope or spirit. For example, one skilled in the art will recognize that by varying the vertical position of the distal end of exhaust line **134** relative to aspiration line **120**, various vent head pressures can be achieved.

We claim:

1. A cassette, comprising:

a) a body;

b) an aspiration line extending through the body;

c) an aspiration exhaust line extending through the body and connected to a waste bag;

d) an aspiration vent line extending through the body, the aspiration vent line connected on one end to the aspiration exhaust line and to the aspiration line on the other end; and

e) a vent valve located in the body in the aspiration vent line.

* * * * *