

# US Patent & Trademark Office

## Patent Public Search | Text View

---

United States Patent	12383665
Kind Code	B2
Date of Patent	August 12, 2025
Inventor(s)	Nazarifar; Nader et al.

---

### Systems and methods for proportional pressure and vacuum control in surgical system

---

#### Abstract

A pneumatic cross-connect proportional valve provides the capability to calibrate pressure and vacuum sensors in a surgical cassette associated with a surgical console. Calibration of non-invasive pressure and vacuum sensors in a cassette by utilizing a proportional cross-connect to pressurize the lines with set pressure or vacuum the lines with set vacuum and measure the response of respective sensors in the cassette. The use of proportional pressure may be used along with other clearing methods to clear material clogging the aspiration channel pathways and tubing of the surgical system. Utilize the cross-connect functionality to more rapidly pressurize the aspiration line upon detection or prediction of a post occlusion surge, thereby reducing the pressure difference between the surgical field, the eye chamber, and aspiration line which may prevent, for example, a surge of fluid out of the anterior chamber of the eye.

---

**Inventors:** Nazarifar; Nader (Laguna Niguel, CA), Mehta; Deep (Irvine, CA), Hickey; Lauren (Los Angeles, CA)

**Applicant:** Johnson & Johnson Surgical Vision, Inc. (Irvine, CA)

**Family ID:** 1000008749630

**Assignee:** Johnson & Johnson Surgical Vision, Inc. (Irvine, CA)

**Appl. No.:** 18/482908

**Filed:** October 08, 2023

#### Prior Publication Data

<b>Document Identifier</b>	<b>Publication Date</b>
US 20240033416 A1	Feb. 01, 2024

#### Related U.S. Application Data

## Publication Classification

**Int. Cl.:** **A61M3/02** (20060101); **A61B17/32** (20060101); **A61F9/007** (20060101); **A61M1/00** (20060101); A61B17/00 (20060101)

**U.S. Cl.:**

**CPC** **A61M3/0216** (20140204); **A61B17/320068** (20130101); **A61F9/00745** (20130101); **A61M1/74** (20210501); **A61M1/742** (20210501); **A61M1/774** (20210501); A61B2017/00199 (20130101); A61B2017/00973 (20130101); A61B2017/32007 (20170801); A61B2017/320084 (20130101); A61F9/00754 (20130101); A61M2210/0612 (20130101)

## Field of Classification Search

**CPC:** A61M (3/0216); A61M (1/74); A61M (1/742); A61M (1/774); A61M (2210/0612); A61M (1/72); A61M (3/0201); A61M (2205/128); A61B (17/320068); A61B (2017/00199); A61B (2017/00973); A61B (2017/32007); A61B (2017/320084); A61F (9/00745); A61F (9/00754); A61F (2009/0087)

---

## References Cited

### U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
6290690	12/2000	Huculak et al.	N/A	N/A
2010/0030134	12/2009	Fitzgerald	604/35	A61M 1/77
2010/0280439	12/2009	Kuebler	N/A	N/A
2013/0150782	12/2012	Sorensen et al.	N/A	N/A
2016/0166742	12/2015	Layser et al.	N/A	N/A
2018/0338861	12/2017	Hallen	N/A	N/A
2019/0099529	12/2018	Mehta et al.	N/A	N/A

### FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
1302185	12/2003	EP	N/A
3295906	12/2017	EP	N/A
2004108189	12/2003	WO	N/A

---

*Primary Examiner:* Stigell; Theodore J

---

## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a divisional of and claims priority to U.S. patent application Ser. No. 16/393,856, filed Apr. 24, 2019, all of which is incorporated herein by reference in its entirety.

## FIELD OF THE INVENTION

(1) The present invention relates to phacoemulsification surgical systems, and, more particularly, a phacoemulsification surgical system comprising a pneumatic cross-connect proportional valve between pressure and vacuum systems.

## BACKGROUND OF THE INVENTION

(2) Cataracts affect more than 22 million Americans age 40 and older. And as the U.S. population ages, more than 30 million Americans are expected to have cataracts by the year 2020. Cataract surgery entails the removal of a lens of an eye that has developed clouding of the eye's natural lens, or opacification. As a result of opacification, light is unable to travel to the retina, thereby causing vision loss. Once vision becomes seriously impaired, cataract surgery is a viable option with a high level of success. During cataract surgery, a surgeon replaces the clouded lens with an intraocular lens (IOL).

(3) Certain surgical procedures, such as phacoemulsification surgery, have been successfully employed in the treatment of certain ocular problems, such as cataracts. Phacoemulsification surgery utilizes a small corneal incision to insert the tip of at least one phacoemulsification handheld surgical implement, or handpiece, through the corneal incision. The handpiece includes a needle which is ultrasonically driven once placed within the incision to emulsify the eye lens, or to break the cataract into small pieces. The broken cataract pieces or emulsified eye lens may subsequently be removed using the same handpiece, or another handpiece, in a controlled manner. The surgeon may then insert a lens implant into the eye through the incision. The incision is allowed to heal, and the result for the patient is typically significantly improved eyesight.

(4) Currently during cataract surgery, a majority of phacoemulsification platforms provide three primary states for fluidics and phaco control: irrigation, aspiration and ultrasound with respective operative foot pedal activation zones. The foot pedal treadle position 1, which correlates to irrigation only mode of the fluidics control and in which irrigation valve, is opened to allow either gravity or pressurized irrigation flow to reach the chamber via a sleeve at distal end. Foot pedal treadle position 2, which correlates to irrigation/aspiration mode of the fluidics control, in which both irrigation and aspiration valves are opened to allow both fluid and Cataract particles to be aspirated out of the chamber while chamber pressure is maintained using the irrigation flow. Foot pedal treadle position 3, which correlates to irrigation/aspiration/ultrasound mode of fluidics and phaco control, in which ultrasound energy is applied to emulsify the cataract particle whilst emulsified particles are being aspirated out of the chamber to a waste bag in the cassette.

(5) In flow mode aspiration, the fluidics control provides a capability to gradually increase or decrease aspiration flow by traversing the foot pedal treadle in zone 2. In vacuum mode aspiration, the fluidics control provides a capability to gradually increase or decrease aspiration vacuum by traversing the foot pedal in zone 2. In both aspiration modes, the fluidics control can relieve vacuum in the aspiration line when the foot pedal is traversed from zone 2 to zone 1; in other words, when the fluidics controls is switched from irrigation/aspiration to irrigation only. When the foot pedal treadle is traversed from zone 1 (irrigation only) to zone 0 (idle), the fluidics control pressurizes the aspiration line to a set point. By relieving vacuum and applying pressure in the aspiration line, the fluidics control pushes fluid out of the aspiration line into the chamber thus clearing any obstructing particles or eye tissue occluding the tip of the surgical instrument. Current phacoemulsification systems generate pressure in the aspiration line by using a peristaltic pump or column height of the fluid to allow irrigation head height to pressurize the aspiration line.

## BRIEF SUMMARY OF THE INVENTION

(6) In an embodiment of the present invention, the use of a cross-connect valve may provide the capability to calibrate pressure and vacuum sensors in a surgical cassette associated with a surgical console, for example. The present invention may support calibration of non-invasive pressure and vacuum sensor in the cassette by utilizing the proportional cross-connect to pressurize the lines

with set pressure or vacuum the lines with set vacuum and measure the response of respective sensors in the cassette. This may require, for example, that irrigation and aspiration lines are at least partially connected, for example.

(7) The present invention may also provide for the clearing of obstructions in the aspiration channel fluid pathways by applying proportional pressure. The use of proportional pressure may be used along with other clearing methods to clear material clogging the aspiration channel pathways and tubing of the surgical system.

(8) In an embodiment of the present invention, the system may also mitigate post occlusion surge by applying just in time proportional pressure. The present invention may utilize the cross-connect functionality to more rapidly pressurize the aspiration line upon detection or prediction of a post occlusion surge, thereby reducing the pressure difference between the surgical field, the eye chamber for example, and aspiration line which may prevent, for example, a surge of fluid out of the anterior chamber of the eye.

(9) The present invention may provide a phacoemulsification surgical system, comprising at least one pressure system comprising at least one irrigation line communicatively coupled to a first valve, at least one vacuum system comprising at least one aspiration line coupled to a second valve, at least one cassette removably attached to a surgical console and in communicatively coupled to the at least one irrigation line and the at least one aspiration line, and at least one cross-connection between the at least one pressure system and the at least one vacuum system, the at least one cross-connection configured to build proportional pressure between the at least one irrigation line and the at least one aspiration line.

(10) The present invention may provide a surgical system including a surgical cassette, the surgical system comprising an aspiration line, an irrigation line, a pneumatic cross-connect proportional valve communicatively coupled between the aspiration line and irrigation line, the pneumatic cross-connect valve configured to vent and reflux the aspiration line, calibrate pressure and vacuum sensors of the surgical cassette, build proportional pressure or vacuum of the aspiration line and the irrigation line, and applying proportional pressure to clear obstructions of the aspiration line. The surgical system may further comprise at least one surgical console configured to house the pneumatic cross-connect proportional valve.

---

## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

(1) This disclosure is illustrated by way of example and not by way of limitation in the accompanying figure(s). The figure(s) may, alone or in combination, illustrate one or more embodiments of the disclosure. Elements illustrated in the figure(s) are not necessarily drawn to scale. Reference labels may be repeated among the figures to indicate corresponding or analogous elements.

(2) The detailed description makes reference to the accompanying figures in which:

(3) FIG. 1 schematically illustrates an eye treatment system in which a cassette couples an eye treatment probe with an eye treatment console;

(4) FIGS. 2A and 2B provide an exemplary diagram that illustrates a pneumatics connection of pressure and vacuum system with a key feature of cross-connection between two systems; and

(5) FIG. 3 is an exemplary diagram illustrates a design of a fluidics manifold assembly with cross-connect.

### DETAILED DESCRIPTION

(6) It is to be understood that the figures and descriptions of the present invention have been simplified to illustrate elements that are relevant for a clear understanding of the present invention, while eliminating, for the purpose of clarity, many other elements found in typical surgical, and

particularly optical surgical, apparatuses, systems, and methods. Those of ordinary skill in the art may recognize that other elements and/or steps are desirable and/or required in implementing the present invention. However, because such elements and steps are well known in the art, and because they do not facilitate a better understanding of the present invention, a discussion of such elements and steps is not provided herein. The disclosure herein is directed to all such variations and modifications to the disclosed elements and methods known to those skilled in the art.

(7) Referring to FIG. 1, a system **10** for treating an eye **E** of a patient **P** generally includes an eye treatment probe handpiece **12** coupled to a console **14** by a cassette **100** mounted on the console via interface **200**. Handpiece **12** may include a handle for manually manipulating and supporting an insertable probe tip. The probe tip has a distal end which is insertable into the eye, with one or more lumens in the probe tip allowing irrigation fluid to flow from the console **14** and/or cassette **100** into the eye. Aspiration fluid may also be withdrawn through a lumen of the probe tip, with the console **14** and cassette **100** generally including a vacuum aspiration source, a positive displacement aspiration pump, or both to help withdraw and control a flow of surgical fluids into and out of eye **E**. As the surgical fluids may include biological materials that should not be transferred between patients, cassette **100** will often be disposable or comprise a disposable (or alternatively, re-sterilizable) structure, with the surgical fluids being transmitted through conduits of the cassette that avoid direct contact in between those fluids and the components of console **14**.

(8) When a distal end of the probe tip of handpiece **12** is inserted into an eye **E**, for example, for removal of a lens of a patient with cataracts, an electrical conductor and/or pneumatic line (not shown) may supply energy from console **14** to an ultrasound transmitter of the handpiece, a cutter mechanism, or the like. Alternatively, the handpiece **12** may be configured as an irrigation/aspiration (I/A) or vitrectomy handpiece. Also, the ultrasonic transmitter may be replaced by other means for emulsifying a lens, such as a high energy laser beam. The ultrasound energy from handpiece **12** helps to fragment the tissue of the lens, which can then be drawn into a port of the tip by aspiration flow. So as to balance the volume of material removed by the aspiration flow, an irrigation flow through handpiece **12** (or a separate probe structure) may also be provided, with both the aspiration and irrigations flows being controlled by console **14**.

(9) So as to avoid cross-contamination between patients and/or to avoid incurring excessive expenditures for each procedure, cassette **100** and its conduit **18** may be disposable. Alternatively, the conduit or tubing may be disposable, with the cassette body and/or other structures of the cassette being sterilizable. Regardless, the disposable components of the cassette are typically configured for use with a single patient and may not be suitable for sterilization. The cassette will interface with reusable (and often quite expensive) components of console **14**, which may include one or more peristaltic pump rollers, a Venturi or other vacuum source, a controller **40**, and the like.

(10) Controller **40** may include an embedded microcontroller and/or many of the components common to a personal computer, such as a processor, data bus, a memory, input and/or output devices (including a touch screen user interface **42**), and the like. Controller **40** will often include both hardware and software, with the software typically comprising machine readable code or programming instructions for implementing one, some, or all of the methods described herein. The code may be embodied by a tangible media such as a memory, a magnetic recording media, an optical recording media, or the like. Controller **40** may have (or be coupled to) a recording media reader, or the code may be transmitted to controller **40** by a network connection such as an internet, an intranet, an Ethernet, a wireless network, or the like. Along with programming code, controller **40** may include stored data for implementing the methods described herein and may generate and/or store data that records parameters corresponding to the treatment of one or more patients. Many components of console **14** may be found in or modified from known commercial phacoemulsification systems.

(11) In a first embodiment, the use of a cross-connect valve, which may be a pneumatic cross-connect proportional valve, for example, may allow for the connecting of an irrigation channel to

aspiration and vice versa to provide either pressurization or vacuum to the channel(s) as desired. The invention may provide the capability to build proportional pressure in an aspiration line to support fluidics features such as venting and reflux, for example. The present invention may provide an alternative method to vent and reflux an aspiration line. By way of non-limiting example, in vacuum mode, a proportional vacuum regulator may relieve vacuum in the aspiration line followed by allowing a proportional cross-connect valve to build desired pressure in the aspiration line thus pushing fluid out from the aspiration line at the distal end. In the flow mode, an aspiration line may be opened to a vacuum mode tank on the pneumatic side; the vacuum mode tank being at or near atmosphere pressure, thereby at least partially relieving any vacuum in the aspiration line. Similarly, a pneumatic proportional cross-connect valve may be engaged to build desired pressure in the aspiration line. Reflux may be achieved in an equivalent manner by allowing the proportional cross-connect pathway to further pressurize the aspiration line.

(12) The use of an air-pneumatic system may provide a capability to build and relieve vacuum in an aspiration line as needed in vacuum mode aspiration. In one non-limiting example, a proportional vent valve may proportionally relieve vacuum in a vacuum tank and in turn the aspiration line as a function of a foot pedal treadle position. The foot pedal treadle position may for example, include at least a first position and second position. A similar functionality may apply when building vacuum in a vacuum tank as a function of foot pedal treadle travel from position 1 to position 2 in a linear mode.

(13) To achieve venting, a fluidics subsystem may be utilized. The fluidics subsystem relieves vacuum in an aspiration line and gradually builds positive pressure based on a user-defined set point of venting strength. The proportional cross-connect valve provides capability to proportionally build pressure in the aspiration line up to set irrigation pressure to vent the aspiration channel. In one non-limiting example, in vacuum mode aspiration, when venting is activated, the fluidics subsystem may gradually relieve vacuum in the aspiration tank using a proportional vent valve and in turn vacuum is reduced at the distal end of the aspiration channel. Once the vacuum is relieved from the aspiration line, a cross-connect valve may be used to gradually pressurize the aspiration tank and in turn the distal end of the aspiration channel based on a desired venting strength.

(14) In reflux, the fluidics subsystem, in one non-limiting example, refluxes contents of the aspiration line into an anterior chamber. The aforementioned proportional cross-connect valve may be utilized to gradually build positive pressure in the aspiration line up to the irrigation pressure. Contents of the aspiration line may then reflux to the anterior chamber as positive pressure is applied to the vacuum tank in the cassette. In this mode, the proportional cross-connect valve may pressurize the aspiration line up to a set irrigation pressure.

(15) In a second embodiment, the use of a cross-connect valve, which may be a pneumatic cross-connect proportional valve, for example, may provide a capability to calibrate pressure/vacuum sensor in a surgical cassette. An eddy current probe may be mounted in the console and a communication compatible interface disc may be located in the cassette. The eddy current pressure/vacuum sensor may be calibrated for zero offset and gain parameters by applying a known pressure and vacuum measurement points using the air-pneumatic system. In one non-limiting example, when a cassette is captured in a system console, the system may begin a sensor calibration process through the interface disc. The irrigation and aspiration luers may also be connected.

(16) The air-pneumatic system may create a series of known pressure set points using proportional main and vent valves. Such associated pressure may be applied to the pressurized irrigation tank in the cassette while the valve (e.g. rotary valve) is engaged to pressurize the irrigation tank so that it may be measured using the irrigation pressure sensor. A proportional cross-connect valve may be engaged such that regulated irrigation pressure from the air-pneumatic system is applied to the aspiration channel and the vacuum tank and measured using the aspiration pressure sensor in the

cassette. Similarly, the aspiration valve (e.g. rotary valve) may be engaged to the vacuum tank. As a result, both pressure transducers in the cassette may measure a series of pressure set points being applied by the air-pneumatic system.

(17) For vacuum, the air-pneumatic system may create a series of known vacuum set points using proportional main and vent valves. Such a vacuum may be applied to the vacuum tank in the cassette while the valve (e.g. rotary valve) may be engaged to the vacuum tank. This allows the known vacuum to be measured using the aspiration pressure sensor in the cassette. A proportional cross-connect valve may be engaged such that regulated vacuum from the air-pneumatic system is applied to the irrigation channel and irrigation tank and measured using the irrigation pressure sensor in the cassette while irrigation the valve (e.g. rotary valve) is engaged to the irrigation tank.

(18) This method may allow the system to simultaneously calibrate irrigation and aspiration pressure sensors in the cassette for a series of known pressure and vacuum set points. This series of known pressure set points include measurement points between maximum and minimum allowed pressure in the system. Similar set points may be applied for the vacuum.

(19) In a third embodiment, the use of a cross-connect valve, which may be a pneumatic cross-connect proportional valve, for example, may allow for the capability to build proportional pressure or vacuum in both the irrigation and aspiration lines to support the priming of the fluidics. Cassette calibration may be performed prior to priming. The primary objective of fluidics prime, in at least one instance, is to evacuate air pockets from irrigation and aspiration fluid pathways including respective tanks and bladders in the cassette.

(20) In a first implementation example, a gravity irrigation and peristaltic aspiration fluid path is described. In this example, the air-pneumatic valves for irrigation and aspiration may be in a default off position. The irrigation and aspiration luers may be connected together. An IV pole may be raised to a predetermined position and the irrigation valve in the cassette may be opened to gravity. Fluid from the irrigation source may start flowing through the irrigation inlet, valve (e.g. rotary), irrigation pressure sensor and to an irrigation distal end. This may allow the system to confirm head height pressure as measured by the irrigation pressure sensor. On the aspiration circuit, the peristaltic pump may be rotated at predetermined rotations per minute thereby generating a certain flow rate which causes the fluid to travel through the aspiration tubing, aspiration pressure sensor, aspiration bladders and to the waste bag.

(21) In a second implementation example, a pressurized irrigation and peristaltic aspiration fluid path is described. In this example, a proportional main valve and a vent valve may be engaged to maintain certain predetermined pressure(s) in the irrigation tank. The fluid may be drawn from the irrigation source using a peristaltic pump which is rotating at a predetermined rotation per unit of time, generally minutes. Fluid may then travel through the irrigation inlet, peristaltic bladders, and to the irrigation tank in the cassette. Once the fluid reaches a certain level in the tank, the irrigation valve (e.g. rotary valve) may be engaged to the tank so that fluid then flows through the valve and irrigation pressure sensor to the irrigation distal end. On the aspiration circuit, the peristaltic pump may be rotating at predetermined rotations per minute generating a certain flow rate which causes the fluid to travel through the aspiration tubing, aspiration pressure sensor, aspiration bladders, and to the waste bag. The air-pneumatic system may apply a series of pressure set points up to a maximum allowed.

(22) In a third implementation example, a pressurized irrigation and vacuum aspiration fluid path is described. In this case, a proportional main valve and a vent valve may be engaged to maintain a certain predetermined pressure in the irrigation tank. The fluid may be drawn from the irrigation source using a peristaltic pump which is rotating at a predetermined rotation per minute. Fluid may travel through the irrigation inlet, peristaltic bladders, and to the irrigation tank in the cassette. Once the fluid reaches a certain level in the tank, the irrigation valve (e.g. rotary valve) may be engaged to the tank so that fluid flows through the valve and irrigation pressure sensor and to the irrigation distal end.

(23) A proportional main valve and a vent valve may be engaged to maintain a certain predetermined vacuum in the aspiration tank. The aspiration valve (e.g. rotary valve) may be engaged to the tank so that fluid travels through the aspiration tubing, aspiration pressure sensor, and to the tank. Once the fluid reaches a certain level in the tank, the peristaltic pump may be rotated to evacuate fluid from the tank to a waste bag. The air-pneumatic system may apply a series of vacuum set points up to a maximum allowed amount of set points. The proposed solution is therefore enabled to support fluidics prime by utilizing the proportional cross-connect to build pressure or vacuum in both irrigation and aspiration lines when the lines are connected.

(24) In a fourth embodiment, the use of a cross-connect valve, which may be a pneumatic cross-connect proportional valve, for example, may allow for the capability to clear clogging of an aspiration channel fluid pathways by applying proportional pressure.

(25) In a fifth embodiment, the use of a cross-connect valve, which may be a pneumatic cross-connect proportional valve, for example, may allow for the capability to mitigate post occlusion surge by applying just in time proportional pressure. In one non-limiting example, in vacuum mode aspiration while the tip is occluded, the proportional vent valve can be used to gradually reduce vacuum in the aspiration line up to predetermined set point. Upon occlusion break, the vent valve relieves the remaining vacuum in the aspiration line followed by the cross-connect valve instantly applying an effective amount of positive pressure in the vacuum tank and in turn the aspiration line to mitigate the surge. Post occlusion surge occurs when a hand piece tip is blocked by a fragment or particulate of the cataractic lens. A blocked tip may cause a vacuum to build in the aspiration tubing. When the occlusion breaks, the stored energy in the tubing pulls fluid from the anterior chamber. The amount of volume that the aspiration tubing pulls depends on how much it had collapsed during the occlusion. By allowing the cross-connect valve to just-in-time apply a small effective amount of positive pressure in the aspiration line, the fluid movement from anterior chamber to aspiration tubing during the surge break may be reduced.

(26) The diagram shown in FIGS. 2A and 2B illustrates pneumatics connection of a pressure and vacuum system having a cross-connection between the two systems. FIG. 2A includes an irrigation system **202** and a vacuum system **206** which are in communication with each other through at least one cross connect valve **214**. The at least one cross connect valve **214** may be a proportional valve which may, for example, connect the irrigation system **202** to the vacuum system **206**.

(27) As illustrated in FIG. 2A, irrigation system **202** may include at least one irrigation line **210** communicatively coupled to at least one valve for the regulation of flow through the irrigation line **210**. At least one of the valves may include vent valve **218** which may further be a proportional valve. Similarly, at least one of the valves may include a regulator valve **216**, which may also be a proportional valve. Irrigation system **202** may also include air regulator **211** and at least one safety check valve **213**. In addition, a sensor, such as sensor **215**, may be in communication with irrigation line **210** to monitor pressure and/or fluid flow in line **210**. The irrigation system **202** is preferably pressurized and may provide up to 120 mmHg of pressure for vent and reflux operations.

(28) Aspiration system **206** may include at least one aspiration line **212** communicatively coupled to at least one valve for the regulation of flow through the aspiration line **212**. At least one of the valves may include vent valve **221** which may further be a proportional valve. Similarly, at least one of the valves may include a regulator valve **220**, which may also be a proportional and/or vent valve. An additional regulator valve **222** may be used and may be situated in-line with aspiration line **212**. Aspiration system **206** may also a sensor, such as sensor **223**, may be in communication with aspiration line **212** to monitor pressure and/or fluid flow in line **21**.

(29) As illustrated in FIG. 2B, a cassette **290** may be removably attached to a portion of surgical console **280** and may be in communication with aspiration line **212** and irrigation line **210**. Cassette **290** may be in communication with pump **246** and associated drain bag **260**, wherein the pump **246** may be a peristaltic pump, for example. Similarly, cassette **290** may be in communication with



pump **262** and associated irrigation source **204**, wherein the pump **262** may be a peristaltic pump, for example. Aspiration line **212** may be in communication with fluid level sensor **248** and at least one valve **266** proximate to cassette **290**. The irrigation line **210** may be in communication with fluid level sensor **249** and at least on valve **251** proximate to cassette **290**. Each fluid level sensor may be at least in part optical and may be of any suitable technology common to those skilled in the art.

(30) Certain aspects of cassette **290** may at least partially control various aspects of the surgical console **280**. For example, motor control **244** may control pump **246**, motor control **242** may control valve **266**, and sensor control **240** may control and/or read sensor **241**. Similarly, motor control **250** may control pump **262**, motor control **252** may control valve **251**, and sensor control **254** may control and/or read sensor **255**.

(31) Aspiration line **212** and irrigation line **210** may be communicatively coupled through at least one proportional valve **214**. Fluid communication between each of the lines and proportional valve **214** may occur at any position along each line and may, for example, occur prior to the distal end of each line. In an embodiment of the present invention, the at least one proportional valve **214** is located in the surgical console prior to either the aspiration line **212** or the irrigation line **210** enters cassette **210**. In an embodiment of the present invention, the at least one proportional valve **214** is located outside the surgical console prior to either the aspiration line **212** or the irrigation line **210** terminating at the surgical site **208**. The cross-connect provided by the at least one proportional valve **214** is normally closed, thereby isolating the pressure and vacuum pneumatic circuits.

(32) The diagram shown in FIG. 3 illustrates the present design of a fluidics manifold assembly **300** with cross-connect as described herein. The diagram shows an isometric view of the fluidics manifold assembly.

(33) Those of skill in the art will appreciate that the herein described apparatuses, engines, devices, systems and methods are susceptible to various modifications and alternative constructions. There is no intention to limit the scope of the invention to the specific constructions described herein. Rather, the herein described systems and methods are intended to cover all modifications, alternative constructions, and equivalents falling within the scope and spirit of the disclosure, any appended claims and any equivalents thereto.

(34) In the foregoing detailed description, it may be that various features are grouped together in individual embodiments for the purpose of brevity in the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that any subsequently claimed embodiments require more features than are expressly recited.

(35) Further, the descriptions of the disclosure are provided to enable any person skilled in the art to make or use the disclosed embodiments. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the spirit or scope of the disclosure. Thus, the disclosure is not intended to be limited to the examples and designs described herein, but rather is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

## Claims

1. A surgical system including a surgical cassette, the surgical system comprising: an aspiration line; an irrigation line; a pneumatic cross-connect proportional valve communicatively coupled between the aspiration line and irrigation line, the pneumatic cross-connect valve configured to: vent and reflux the aspiration line; calibrate pressure and vacuum sensors of the surgical cassette; build proportional pressure or vacuum of the aspiration line and the irrigation line; and apply proportional pressure to clear obstructions of the aspiration line.

2. The surgical system of claim 1, further comprising: at least one surgical console configured to house the pneumatic cross-connect proportional valve.

---