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(54) SYSTEMS FOR SMALL BORE ASPIRATION

SYSTEME ZUR ABSAUGUNG KLEINER BOHRLÖCHER

SYSTÈMES POUR L'ASPIRATION DANS UN TUYAU DE PETIT CALIBRE

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(56) References cited:

WO-A1-2009/076717 DE-A1-102007 031 722
US-A1- 2006 100 570 US-A1- 2006 100 570
US-A1- 2007 106 211 US-A1- 2008 167 595
US-A1- 2008 188 792 US-A1- 2008 188 792
US-A1- 2008 312 594 US-A1- 2010 130 944

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to aspiration systems used in phacoemulsification procedures, and more particularly, to aspirations systems employing small bore elements to improve operation.

[0002] Typical surgical instruments suitable for phacoemulsification procedures on cataractous lenses include an ultrasonically driven phacoemulsification hand piece with a cutting needle and an irrigation sleeve, and a control console. The hand piece is attached to the control console by an electric cable and flexible tubing. The flexible tubing supplies irrigation fluid to the surgical site and carries aspiration fluid from the surgical site to a waste or discard reservoir.

[0003] During a phacoemulsification procedure, the tip of the cutting needle and the end of the irrigation sleeve are inserted into the anterior segment of the eye through a small incision in the eye's outer tissue. The surgeon brings the tip of the cutting needle into contact with the lens of the eye, so that the vibrating tip fragments the lens. The resulting fragments are aspirated out of the eye through the interior bore of the cutting needle, along with irrigation fluid provided to the eye during the procedure.

[0004] Throughout the procedure, irrigating fluid is infused into the eye, passing between the irrigation sleeve and the cutting needle and exiting into the eye at the tip of the irrigation sleeve and/or from one or more ports or openings formed into the irrigation sleeve near its end. This irrigating fluid is critical, as it prevents the collapse of the eye during the removal of the emulsified lens, protects the eye tissue from the heat generated by the vibrating of the ultrasonic cutting needle, and suspends the fragments of the emulsified lens for aspiration from the eye.

[0005] During the surgical procedure, the console controls irrigation flow rates and aspiration flow rates to maintain a proper intra-ocular chamber balance in an effort to maintain a relatively consistent fluid pressure at the surgical site in the eye.

[0006] Aspiration flow rates of fluid from the eye are typically regulated by an aspiration pump that creates a vacuum in the aspiration line. The aspiration flow and/or vacuum are set to achieve the desired working effect for the lens removal. While a consistent fluid pressure in the eye is desirable during the phacoemulsification procedure, common occurrences or complications create fluctuations or abrupt changes in fluid flow and pressure at the eye. One known cause for these is occlusions or flow obstructions that block the needle tip. This common, and sometimes desirable occurrence, results in a sharp increase in vacuum in the aspirating line. When the occlusion is removed, the resulting high demand for fluid from the eye to relieve the vacuum can cause a sudden shallowing of the anterior chamber, as the aspiration flow momentarily sharply increases over the irrigation flow.

[0007] The degree of shallowing in the eye is a function of vacuum level within the aspiration path when the occlusion breaks, as well as resistive and compliance characteristics of the fluid path. Increased resistance in the aspiration path reduces the flow rate associated with occlusion break and thereby lessens the pressure drop from the irrigating source to the eye and the resulting shallowing of the anterior chamber.

[0008] The problem of occlusion surge has been addressed in the past in a number of ways. One method includes adding a reduced cross-sectional orifice to create a barrier reducing flow. While such a reduced area reduces the effects of occlusion surge, reduction of aspiration path cross-section can also increase the potential for clogging during the procedure. Other methods have been used or proposed that involve torturous paths, with corners, angles, and fluid restrictors that are also subject to clogging. Some prior solutions involve a resistive element at or near the pump. However, the effectiveness of these solutions is limited due to the relatively large tubing compliance between the resistive element and the eye. Another attempted solution has been the use of increased lengths of flexible aspiration tubing in an attempt to increase overall tubing resistance. This solution of adding flexible tubing length has the undesirable effect of adding additional compliance to the aspiration path. The additional compliance increases the demand for fluid from the eye during occlusion break, sometimes entirely offsetting the benefits obtained by the longer tubing length.

[0009] Methods with small bore aspiration lines, such as lines with a diameter of 1.27 mm (.050 inches) or less, have generally been avoided because small bore lines may become easily clogged, potentially creating inconsistent flow rates, resulting in high levels of occlusion surge, and possibly resulting in undesirable levels of trauma during the surgical procedure. In addition, methods with small bore aspiration lines have generally been avoided because, as a result of the small bore with increased wall resistance, pumping that achieves a desirable flow rate can be difficult.

[0010] DE102007031722 (A1) discloses a device for reducing pressure variations in a fluid flowing in an aspiration branch of a surgical system, which pressure variations are generated by a pump that delivers in a non-continuous manner in the active operating state, with a diffuser arrangement which is arranged, in the aspiration branch, upstream of the pump in the direction of flow of the fluid. It further discloses a surgical system, in particular an ophthalmic microsurgical system for lens surgery.

[0011] US2008188792 (A1) discloses a phacoemulsification needle having a rod member arranged for transmission of ultrasonic energy to an ocular substrate to effect emulsification thereof, and a hollow tube member having an inner surface defining a lumen arranged for aspiration of emulsified ocular material, the hollow tube member being disposed about the rod member, the rod member having a distal end and a proximal end and the

hollow tube member having a distal end and a proximal end.

[0012] An ophthalmic aspiration system that can be used with a handpiece and a vacuum source is disclosed in US2006100570 (A1). The aspiration system includes a first tube that is connected to the handpiece and a second tube that is connected to a vacuum source. A filter assembly is connected to both tubes to filter out particles aspirated into the system. The second tube has an inner diameter smaller than an inner diameter of the first tube. The smaller second tube limits the amount of flow through the system to minimize vacuum surges caused by occlusions.

[0013] WO2009076717 (A1) discloses systems, methods, and devices for controlling flows and/or pressures, wherein certain devices comprises a body having at least one chamber formed therein; at least one inlet in communication with the at least one chamber; and at least one outlet in communication with the at least one chamber; wherein the at least one chamber has at least a first portion and at least a second portion and at least one member where the at least one member has at least one restricted flow passage, and wherein the at least one member is adapted to adjust a flow rate through the body by adjusting a flow resistance through the body responsive to the flow rate through the at least one restricted flow passage within the devices.

SUMMARY OF THE INVENTION

[0014] The present invention is defined in claim 1. Preferred embodiments are defined by the claims dependent thereon.

[0015] In one exemplary aspect, the present disclosure is directed to an assembly for a phacoemulsification surgical system. The assembly includes a phacoemulsification hand piece configured to deliver irrigating fluid to a surgical site. The phacoemulsification hand piece includes an ultrasonic tip having a lumen sized and configured to aspirate aspirating fluid from the surgical site. The assembly also includes an irrigation system arranged to provide the irrigating fluid to the phacoemulsification hand piece to irrigate the surgical site and includes an aspiration system arranged to aspirate the aspirating fluid from the surgical site. The aspiration system includes an aspiration path within the phacoemulsification hand piece. The aspiration path extends from the ultrasonic tip and is arranged and configured to permit flow of the aspirating fluid through the hand piece. The aspiration system also includes a flexible small bore aspiration tubing in fluid communication with the aspiration path. The small bore aspiration tubing has a nominal inner diameter smaller than about 1.27 mm (.050 inch, other diameters are also contemplated) to reduce levels of occlusion surge within the surgical system. The inner diameter is substantially consistent through the length of the small bore aspiration tubing. A high-output, peristaltic pump communicates with the small bore aspiration tub-

ing and is operable to create a flow of about 60cc/min. through the small bore aspiration tubing.

[0016] In some aspects, the small bore aspiration tubing includes a flared portion on the inner diameter of at least one end, wherein when in an unloaded condition, the flared portion has an inner diameter larger than the nominal inner diameter of the small bore aspiration tubing. In additional aspects, the assembly includes a connector configured to receive at least a portion of the flared portion of the small bore aspiration tubing. The connector may be sized to apply radial compression on the flared portion when the flared portion is inserted in the connector such that when the small bore aspiration tubing is disposed within the connector, the inner diameter of the flared portion is about the same diameter as the neck and the nominal diameter of the small bore aspiration tubing.

[0017] In another exemplary aspect, the present disclosure is directed to a small bore aspiration system arranged to receive aspiration fluid from an ultrasonic tip used in a phacoemulsification surgical assembly. The system includes an aspiration path within the phacoemulsification hand piece that extends from the ultrasonic tip and is arranged and configured to permit flow of the aspirating fluid through the hand piece. It also includes a flexible small bore aspiration tubing in fluid communication with the aspiration path. The small bore aspiration tubing has a nominal inner diameter smaller than about 1.27 mm (.050 inch, other diameters are also contemplated) to reduce levels of occlusion surge within the surgical system, and the inner diameter being substantially consistent through the length of the small bore aspiration tubing. The system also includes a high-output, peristaltic pump in communication with the small bore aspiration tubing.

[0018] In yet another exemplary aspect, the present disclosure is directed to a method for aspirating a surgical site with an aspiration system of a phacoemulsification surgical system. The method includes the steps of creating a vacuum in an aspiration system of a phacoemulsification system, directing fluid through a needle of the phacoemulsification hand piece, and directing fluid through an aspiration passage within the hand piece having a size ratio of less than about 10 difference between the needle bore and the aspiration passage bore. The method also includes directing fluid through a small bore flexible aspiration tubing extending from the hand piece to a fluid cassette. The small bore flexible aspiration tubing has a substantially consistent nominal diameter across its length that is less than about 1.27 mm (.050 inch, other diameters are also contemplated). The method also includes directing fluid into a cassette and a pump configured to create a vacuum in the aspiration system.

[0019] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are intended to provide further explanation of the invention as claimed. The following description, as well as the practice of the

invention, sets forth and suggests additional advantages and purposes of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments.

Fig. 1 is an illustration of an exemplary phacoemulsification surgical console according to an embodiment implementing the teachings and principles described herein.

Fig. 2 is a block diagram of the phacoemulsification console of Fig. 1 showing various subsystems including a fluidics subsystem that drives aspiration according to the principles of the present disclosure.

Fig. 3 is a schematic of an exemplary fluidics subsystem usable with the phacoemulsification surgical console of Figs. 1 and 2, according to an embodiment.

Fig. 4 is an illustration of a cross-sectional view of flexible tubing usable with the fluidics subsystem in Fig. 3, according to an embodiment.

Fig. 5 is an illustration of a cross-sectional view of an end portion of the flexible tubing of Fig. 4, according to an embodiment.

Fig. 6 is an illustration of a cross-sectional view of a connector usable to connect the flexible tubing in Figs. 4 and 5 to additional aspiration components of the fluidics system in Fig. 3 according to one aspect of the present disclosure.

Fig. 7 is an illustration of a cross-sectional view of the connector of Fig. 6 with the end portion of Fig. 5 of the flexible tubing according to one aspect of the present disclosure.

Fig. 8 is an illustration of a cross-sectional view of another connector usable to connect the flexible tubing in Figs. 4 and 5 to additional aspiration components of the fluidics system in Fig. 3 according to one aspect of the present disclosure.

Fig. 9 is an illustration of a cross-sectional view of the connector of Fig. 8 with the end portion of Fig. 5 of the flexible tubing according to one aspect of the present disclosure.

DETAILED DESCRIPTION OF SEVERAL EMBODIMENTS

[0021] Reference is now made in detail to several ex-

emplary embodiments, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or like parts.

[0022] This disclosure is directed to an aspiration system that may achieve lower levels of occlusion surge than currently known systems under similar conditions. These lower levels derive from a novel, small bore aspiration line that provides increased fluid resistance when compared to known systems. This increased fluid resistance dampens or reduces the levels of occlusion surge in the aspiration line, potentially resulting in more stable and predictable surgical processes.

[0023] The small bore aspiration tubing decreases occlusion surge levels in at least two ways. First, the smaller diameter of the small bore fluid path introduces a greater level of wall resistance than larger bore fluid paths. This wall resistance decreases the amount of flow variation over short periods of time, rendering the flow more consistent, with lower levels and more controlled surge when surges occur. Second, the small bore aspiration tubing, due to its smaller surface area than larger bore aspiration tubes, is subject to less compliant deformation (radial collapse) as a result of high vacuum levels within the tube, as may occur when aspiration flow is limited or blocked by an occlusion.

[0024] As indicated above, however, small bore aspiration tubing has generally been considered easily clogged. Therefore, small bore aspiration tubing having a diameter of less than about 1.27 mm (.050 inch) have not typically been used in aspiration lines. However, the small bore aspiration tubing disclosed herein may achieve suitable, consistent flow rates with reduced clogging by using consistent-flow junction components and suitable relative dimensions between components. Thus, small bore aspiration tubing can be used, with acceptable flow tendencies, to decrease the level of occlusion surges and provide more control during surgical procedures.

[0025] Fig. 1 illustrates an exemplary emulsification surgical console, generally designated 100. Fig. 2 is a block diagram of the console 100 showing various subsystems that operate to perform a phacoemulsification procedure. The console 100 includes a base housing 102 with a computer unit 103 and an associated display screen 104 showing data relating to system operation and performance during an emulsification surgical procedure. The console 100 also includes a number of subsystems that are used together to perform an emulsification surgical procedure. For example, the subsystems include a foot pedal subsystem 106 including, for example, a foot pedal 108, a fluidics subsystem 110 including an irrigation system and an aspiration system that deliver fluid to and aspirate fluid from the eye through flexible tubing 112, an ultrasonic generator subsystem 116 including an ultrasonic oscillation hand piece 118 with a cutting needle, and a pneumatic vitrectomy cutter subsystem 120 including a vitrectomy hand piece 122. These subsystems overlap and cooperate to perform various

aspects of the procedure.

[0026] Fig. 3 illustrates a schematic showing the fluidics subsystem 110 and the hand piece 118. The fluidics subsystem 110 includes an irrigation system 300 and an aspiration system 302, each in communication with the hand piece 118. The irrigation system 300 includes an irrigation source 304 as a sterile solution reservoir, an irrigation valve 306 that regulates flow from the reservoir to the surgical site, a flexible irrigation tubing 308, an irrigation path 310 in the hand piece 118, and a sleeve 312 that may be considered a component of the hand piece 118.

[0027] The irrigation system 300 extends between the sterile solution reservoir 304 and the hand piece 118, and carries fluid to the surgical site (labeled in Fig. 3 as an eye). In one example, the sterile fluid is a saline fluid, however, other fluids may be used. The flexible irrigation tubing 308 may be formed in part of the flexible tubing 112 in Fig. 2. In some embodiments, the irrigation tubing 308 is formed of multiple segments, with some segments being rigid and others being flexible. Also, in some embodiments, at least a portion of the irrigation system 300 is formed in a cassette 314 that cooperates with the console 100 in Fig. 1 to provide fluid communication between the sterile solution reservoir 304 and the patient's eye. As indicated above, in some embodiments, the irrigation sleeve 312 is disposed about the cutting needle to provide irrigating fluid flow to the eye during the surgical procedure.

[0028] The aspiration system 302 includes an aspiration path 316 in the hand piece 118, a small bore flexible aspiration tubing 318, a pressure sensor 320, a pump 322, a vent valve 324, a drain line reservoir 326, and a drain reservoir 328. A hand piece connector 330 connects the aspiration path 316 in the hand piece 118 to the small bore flexible aspiration tubing 318. A cassette connector 332 connects the flexible aspiration tubing 318 to the cassette aspiration line in the cassette 314. As can be seen, the aspiration system 302 extends from the surgical site (eye) to the drain reservoir 328. It carries away fluid used to flush the eye as well as any emulsified particles. As described above with reference to the flexible irrigation tubing 308, at least a portion of the small bore flexible aspiration tubing 318 may be formed of the flexible tubing 112. In some embodiments, the aspiration system 302 is formed of multiple segments, with some segments being rigid and others being flexible. Also, in some embodiments, at least a portion of the aspiration system 302 is formed in the cassette 314 that cooperates with the console 100 in Fig. 1 to provide fluid communication between the hand piece 118 and the drain reservoir 328. It should be apparent that the drain reservoir 328 may in fact be a drain instead of a self-contained reservoir. As indicated above, in some embodiments, the aspiration system 302, including the aspiration fluid path 316, is in fluid communication with the bore of the cutting tip (labeled 334 in Fig. 3) of the hand piece 118 and is used to aspirate fluid and emulsified particles through

the needle bore and into the aspiration system 302 during the surgical procedure.

[0029] For ease of explanation, the flexible tubing 112 will be described first, followed by a description of additional components of the aspiration system 302.

[0030] Fig. 4 shows an exemplary embodiment of the flexible tubing 112 in cross-section, comprised of the irrigation flexible tubing 308 and the small bore aspiration flexible tubing 318. As indicated above and in Fig. 3, the irrigation flexible tubing 308 connects the hand piece 118 to the irrigation line in the cassette 314, and the small bore aspiration flexible tubing 318 connects the hand piece 118 to the aspiration line in the cassette 314.

[0031] The flexible tubing 112 extends from a proximal end 400 configured to connect to the cassette 314 to a distal end 402 configured to connect to the hand piece 118 through the hand piece connector 330. In this embodiment, the irrigation and aspiration flexible tubings 308, 318 are connected at the distal end 402, forming a dual lumen distal end. This facilitates connection to the hand piece 118, simplifying assembly of the surgical components prior to a surgery. In other embodiments however, the irrigation and aspiration tubing 308, 318 are independent tubes entirely, and in yet other embodiments, the irrigation and aspiration tubing 308, 318 are entirely connected as dual lumen systems. Other arrangements are contemplated, including arrangements where the flexible tubing 112 is formed as dual lumen system between the distal and proximal ends, but the proximal and distal ends are each split into two independent lines.

[0032] As is apparent in Fig. 4, the irrigation flexible tubing 308 has an inner diameter of a larger, first size, and the small bore aspiration flexible tubing 318 has an inner diameter of a smaller, second size. In some examples, the inner diameter of the irrigation flexible tubing 308 is around 6.35 mm (.25 inches), although both smaller and larger dimensions are contemplated.

[0033] The inner diameter of the small bore aspiration flexible tubing 318 is about 1.27 mm (.050 inches or less, other diameters are also contemplated). In the example shown, the small bore flexible tubing 318 has an average inner diameter in the range of about 1.016 - 1.27 mm (.040-.050 inch), and in some embodiments, about 1.143 mm (.045 inch, other diameters are also contemplated). Accordingly, the inner diameter is about 27% $\left(\frac{1.143}{1.5748}\right)$ $\left(\frac{.062-.045}{.062}\right)$ smaller than the aspiration tubes used in conventional systems. In other examples, the average inner diameter is in the range of 0.889 - 1.143 mm (.035-.045 inch, other diameters are also contemplated). The inner diameter is substantially consistent across the axial length of the aspiration flexible tubing 318, without orifices or bottlenecks that would increase the tubing resistance. Further, the walls are substantially smooth, such that the flow through the tubing is substantially laminar, without disrupting barriers.

[0034] The inner diameter of the aspiration flexible tub-

ing 318 is considerably smaller than the inner diameter of conventional aspiration tubes used in phacoemulsification systems. Because of the challenges surrounding the use of smaller aspiration tubing, conventional systems use tubing with an inner diameter within the range of, for example, about 1.524 (.060) or larger, typically about 1.5748 mm (.062 inches). Here however, small bore tubing, that is, tubing with an inner diameter of about 1.27 mm (.050 inch) or less, is used to control the levels of occlusion surge to a degree that is not obtainable using the conventional flexible larger tubing.

[0035] The smaller diameter of the small bore aspiration tubing 318 provides a higher tube resistance than that of aspiration systems using larger diameter aspiration lines. As discussed above, this higher tube resistance decreases the levels of occlusion surge occurring when the tip 334 becomes occluded during a surgical procedure, providing more control to a surgeon. In addition, because the small bore aspiration flexible tubing 318 has a smaller surface area on the inner diameter, and has substantially the same outer diameter as the irrigation line, the small bore aspiration flexible tubing 318 is less compliant to radial compression from vacuum surges than larger bore aspiration tubes. This reduced compliance results in smaller levels of occlusion surge as explained above.

[0036] The aspiration system 302 is also configured to reduce the propensity for clogging at the junction of the small bore aspiration flexible tubing 318 and the aspiration path 316 and at the junction of the small bore aspiration flexible tubing 318 and the cassette 314. It does this by cooperating with the connectors 330, 332 to provide a smooth transition from the hand piece 118 and to the cassette 314. For example, the small bore aspiration flexible tubing 318 has a flared inner diameter at the regions of the distal end 402 and the proximal end 400. For ease of discussion, this flared inner diameter will be discussed only with reference to a proximal end portion 404 at the small bore tubing's proximal end 400. It is understood that the distal end 402 may include the same or similar structure. This proximal end portion 404 will be described with reference to Fig. 5.

[0037] Turning to Fig. 5, the proximal end portion 404 includes a flared inner diameter surface 406 increasing from the nominal diameter n of the small bore aspiration tubing 318 to a flared diameter n_r at the proximal end 400. In some examples, the nominal diameter n is within the range of about 1.016 - 1.27 mm (.040-.050 inch), and the flared diameter n_r is within the range of about 1.524 - 1.778 mm (.060-.070 inch, other diameters are also contemplated). In one example, the nominal diameter is about 1.143 mm (.045 inch). In other examples, the nominal diameter is in the range of 0.889 - 1.143 mm (.035-.045 inch). This flared inner diameter enables the small bore aspiration tubing 318 to connect with female connectors while maintaining a low propensity for clogging. In the example shown, the flared diameter increases linearly from the nominal diameter n for a distance L

along the aspiration tubing 318 to the end 400, to the nominal flared diameter n_r . Although not readily apparent from Fig. 5, the outer diameter of the aspiration tubing 318 also decreases over the length L . In one example, the nominal outer diameter of the tubing 318 is about 3.937 mm (.155 inch), and the outer diameter decreases over the length L to a diameter of 3.8608 (.152) at the end 400 (other diameters are also contemplated). These features result in a wall thickness t at the end 400 that is narrower than the wall thickness away from the tubing ends. The purpose of these diameter changes is explained further below with reference to Figs. 6-9.

[0038] Figs. 6 and 7 show the connector 330 that connects the small bore aspiration tubing 318 to the aspiration path 316 in the hand piece 118. Figs. 8 and 9 show the connector 332 that connects the small bore aspiration tubing 318 to the fluid path in the cassette 314. The aspiration fluid path 316 (Fig. 3) within the hand piece 118 typically comprises a rigid tube configured to convey the aspiration fluid and emulsified tissue from the ultrasonic tip 334 in the surgical site to the small bore flexible aspiration tubing 318. In this embodiment, the aspiration fluid path 316 is a substantially straight-line pathway from the tip 334 to the small bore flexible aspiration tubing 318. In a conventional system, the aspiration path of the hand piece terminates in a connector such as a male luer and the aspiration tubing terminates in a mating connector such as a female luer. This typically results in an expanded fluid path diameter where the two connectors come together. This expanded diameter can be an area where clogging occurs because particulates may reorient themselves in this expanded area. The connector 330 however, helps overcome these disadvantages.

[0039] As can be seen in Fig. 6, the connector 330 includes a first end 400 and a second end 402. A first bore 404 and a second bore 406 are respectively formed in the first and second ends 400, 402. The first bore 404 includes an open receiving bore end 410, a conical inner bore surface 412, a bore end 414, and a neck 416. In this embodiment, the neck 416 has a diameter substantially matching that of the nominal diameter n of the small bore aspiration tubing 318. The open receiving bore end 410 has an inner diameter substantially matching the nominal outer diameter of the small bore aspiration tubing 318. The depth of the first bore 404 may substantially match that of the distance L of the aspiration tubing in Fig. 5. Likewise, at the bore end 414, the distance between the inner bore surface 412 and the neck 416 may be substantially equal to the wall thickness t of the aspiration tubing 118 at its tapered end.

[0040] The second bore 406 includes an open receiving bore end 420, an inner bore surface 422, and a bell-shaped curving bore surface 424 leading to the neck 416. The second bore 406 is sized to receive an end of the aspiration path 316 through the hand piece 118. Accordingly, the bore 406 has a diameter sized to receive the end of the aspiration path 316.

[0041] Since in some embodiments, the aspiration

path 316 is sized in the range of about 1.5748 mm (.062 inch) or larger, the flow from the aspiration path 316 is funneled as a nozzle into the neck 416. The bore 406 is particularly shaped with the bell-shaped curve to avoid clogging, while still carrying the fluid and emulsified particles through the neck 416. Accordingly, to minimize the propensity for clogging, the length of the bore 406 at its largest diameter is minimized to facilitate particles remaining oriented along the flow lines. In addition, instead of having a stepped or squared end as conventional connectors do, the connector 330 has a bell-shaped, curved surface 424 that provides an uninterrupted smooth transition from a larger diameter of the bore end 420 down to the diameter of the neck 416, which, as explained above, substantially matches the nominal diameter n of the small bore aspiration tubing 318. The bell-shape helps by narrowing the length required for the transition from the large diameter to the neck while still providing a smooth flow path. This may provide a better flow than a long linearly tapering path. Thus, the tubing connector 330 helps the small bore aspiration system operate effectively to control occlusion surge.

[0042] Fig. 7 shows the connector 330 attached to the aspiration path 316 in the hand piece 118 and to a distal end 402 of the small bore aspiration tubing 318. The conical inner bore surface 412 of the connector 330 is particularly designed to cooperate with the flared end of the small bore aspiration tubing 318 as shown in Fig. 7 in order to maintain the nominal diameter n , even when the end 402 is compressively deformed to fit within the female connector 330. As indicated above, the distal end 402 of the tubing 318 also includes a flared end. Conventional, non-flared tubes have an inner diameter that may radially deform or collapse to a diameter less than the nominal diameter n if used in female connectors, potentially creating a bottle-neck with increased propensity for clogging. However the connector 330 is particularly designed to receive the flexible tubing end 402, and deform the end portion in a manner not overly restricting flow. In this embodiment, it may deform the end portion only to the extent that either maintains the nominal diameter n or still results in a diameter greater than the diameter n . The taper on the outer diameter discussed with reference to Fig. 5 enables easier insertion into the connector 330.

[0043] Fig. 8 shows the connector 332 that connects the small bore aspiration tubing 318 to the fluid path in the cassette 314. As can be seen, the connector 332 includes a first end 446 and a second end 448. The first end 446 is substantially equivalent to the first end 400 in the connector 330, and the first end 446 is particularly structured to cooperate with the small bore flexible aspiration tubing 318 in order to maintain the nominal diameter n , even when the end is deformed to fit within the female connector 332. Since the first end 446 is structurally similar to the first end 400 of the connector 330 in Fig. 6, it is labeled with similar reference numerals. The first end 446 includes a first bore 404a with an open receiving bore end 410a, a conical inner bore surface 412a,

a bore end 414a, and a neck 416a. The neck 416a has a diameter matching that of the nominal diameter n of the small bore aspiration tubing 318. The description above of the first end 400 in Fig. 6 is equally applicable to the first end 446, and is not repeated here.

[0044] The second end 448 of the connector 332 is configured to interface with the cassette 314. In the embodiment shown, the cassette 314 is a conventional cassette and includes a fluid pathway connectable with the connector 332. The pathway 332 has an inner diameter sized greater than the inner diameter of the small bore aspiration tubing 318. Accordingly, the connector 332 is particularly configured to receive the fluid passage from the cassette 314. The second end includes an open receiving end 440, a conical surface 442, and a bore end 444 leading to the neck 416a.

[0045] Fig. 9 shows the connector 332 connected to the proximal end 400 of the small bore aspiration tubing 318 and the fluid path 340 from the cassette 314. Similar to the bore 404 in the connector 330, the open receiving bore end 410a has an inner diameter substantially matching the nominal outer diameter of the flexible aspiration tubing 318. The depth of the first bore 404a may substantially match that of the distance L of the aspiration tubing 318 in Fig 5. Likewise, at the bore end 414a, the distance between the inner bore surface 412 and the neck may be substantially equal to the wall thickness t of the aspiration tubing 318 at its tapered end.

[0046] Because the connector 332 is particularly designed to receive the aspiration tubing end, and deform the end portion in a manner not overly restricting flow, the propensity for clogs is reduced, resulting in a smoother, more laminar transition through the connector than conventional aspiration systems. This helps make the use of a small bore aspiration tubing to control occlusion surge more effective, without the drawbacks of clogging. Further, as described above, the taper on the outer diameter of the small bore aspiration tubing 318 discussed with reference to Fig. 5 enables easier insertion into the connector 332.

[0047] The pump 322 of the aspiration system 302 is associated with the cassette 314 and is configured to create a vacuum in the aspiration system 302 to draw fluid and emulsified particles from the surgical site. The high fluid resistance associated with the small bore aspiration tubing 118 results in greatly reduced efficiency for most peristaltic pumps. This fluid resistance, while beneficial for reducing the levels of occlusion surge, can also result in the inability to generate desired levels of aspiration flow rate (typically up to 60 cc/min) or can require a need to run the pump at a very high rate of speed resulting in objectionable acoustic noise. Accordingly, because of the small bore of the aspiration tubing 318, a conventional pump may not achieve the vacuum required for suitable flow at the surgical tip. The pump 322, therefore, is a high-output pump capable of creating the vacuum necessary to achieve suitable flow rates through the small bore aspiration tubing 318. In some examples, the

pump 322 is a bidirectional peristaltic pump. In some embodiments, the pump 322 represents multiple pumps that operate in parallel. In some aspects, the pump is as described in U.S. Patent Application 12/755,539, filed April 7, 2010, which is incorporated herein by reference.

[0048] Accordingly, the aspiration system 302 employs small bore aspiration lines, with a diameter of 1.27 mm (.050 inches or less, other diameters are also contemplated) to achieve lower levels of occlusion surge than currently known systems under similar conditions. The small bore lines provide increased fluid resistance that dampens or reduces the levels of occlusion surge in the aspiration line. These lines accomplish this by introducing a greater level of wall resistance than larger bore fluid paths and by being less compliant when subjected to high vacuum levels within the tubing. At the same time, the aspiration system maintains suitable flow rates with reduced clogging. This decreases the level of occlusion surges and provides more control during surgical procedures.

[0049] In one embodiment of the aspiration system 302, the aspiration fluid path 316 in the hand piece 118 has a small bore inner diameter, less than about 1.27 mm (.050 inches, other diameters are also contemplated), and in some embodiments, matching one or both of the inner diameter of the small bore aspiration tubing 318 and the inner diameter of the ultrasonic tip 334.

[0050] Aspiration fluid paths within a conventional hand piece are larger bore tubes having an inner diameter typically sized greater than 1.524 mm (.060 inches). This is considerably larger than a conventional lumen size of the ultrasonic tip (typically 1.143 mm (.045 inches) or less). As such, in conventional systems, emulsified particles passing through the tip may have a non-symmetrical shape and may be oriented longitudinally to the direction of flow. As the particles pass from the tip into the aspiration path in a conventional hand piece, the particles have an opportunity to reorient. These reoriented particles have a greater propensity to clog the aspiration system further down line.

[0051] In this embodiment, however, the aspiration fluid path 316 has a small bore inner diameter, less than about 1.27 mm (.050 inches), sized to cooperate with the lumen diameter of the ultrasonic tip and the small bore aspiration tubing 318. In some embodiments, the inner diameter is within the range of 1.016 - 1.27 mm (.040-.050), and in some examples, around a nominal diameter of about 1.143 mm (.045 inch). In other examples, the average inner diameter is in the range of 0.889 - 1.143 mm (.035-.045 inch, other diameters are also contemplated). In other embodiments, the lumen is sized to match that of the ultrasonic tip lumen. Accordingly, the size ratio between the inner diameter of the ultrasonic tip and the aspiration fluid path 316 is minimized.

[0052] Because its inner diameter size is less than that of conventional systems, the aspiration path 316 in the aspiration system 302 creates a higher tube resistance. As discussed above, this higher tube resistance decreases

the levels of occlusion surge occurring when the tip 334 becomes occluded during a surgical procedure.

[0053] In some embodiments, the inner diameter of the small bore aspiration tubing 318 matches the inner diameter of the aspiration fluid path 316 in the hand piece. If the inner diameter of the aspiration fluid path 316 of the hand piece is the same as or less than that of the flexible aspiration tubing 318, then propensity for clogging can be further reduced. In this way, particles aligned longitudinally with the pathway stay longitudinally aligned, with less opportunity to reorient in a position that may result in clogging or occlusion of the aspiration system 302. In such embodiments, the tapering that occurs in the connector 330 may be replaced with a flat end that abuts the end of the aspiration path 316 and has a neck with a diameter substantially matching the nominal diameter of the aspiration path 316 and the small bore aspiration tubing 318.

[0054] In use, the flexible tubing 112 is attached to the hand piece 118 prior to conducting the surgery. Irrigation fluid is directed to the surgical site through the irrigation system 300. The aspiration system 302 conveys fluid from the surgical site to the waste reservoir or drain 328. This is accomplished by vacuuming fluid and emulsified tissue from the surgical site with the phacoemulsification needle tip 334. The fluid passes to the aspiration path 316 in the hand piece 118. The fluid then flows through the connector 330 into the small bore flexible aspiration tubing 318. The connector 330 is configured to minimize clogging by creating minimal turbulence and by minimizing transitions from diameters larger than the diameter of the small bore flexible aspiration tubing 318. The fluid flows through the small bore flexible aspiration tubing 318 to the cassette 314, and through the connector 332 at the cassette. As described above, the diameter of the inner flexible tubing is substantially maintained at its nominal size, even through the female connector 334 due to its flared configuration. The flow continues to the pump 322, which may be a high-output, bidirectional peristaltic pump.

[0055] Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope of the invention being indicated by the following claims.

Claims

1. An assembly for a phacoemulsification surgical system, comprising:

a phacoemulsification hand piece;
 an irrigation system (300) configured to provide irrigating fluid to the phacoemulsification hand piece (118) to irrigate a surgical site; and
 an aspiration system (302) arranged to aspirate

aspirating fluid from the surgical site, the aspiration system comprising:

- an aspiration path within the phacoemulsification hand piece;
- a flexible small bore aspiration tubing (318) configured to be in fluid communication with the aspiration path (316) of the phacoemulsification hand piece (118), the small bore aspiration tubing (318) having a nominal inner diameter smaller than about 1.27 mm (.050 inch) to reduce levels of occlusion surge within the surgical system, the inner diameter being substantially consistent through the length of the small bore aspiration tubing (318); and
- a peristaltic pump (322) in communication with the small bore aspiration tubing (318) operable to create a flow through the small bore aspiration tubing (318);
- wherein the small bore aspiration tubing (318) comprises a flared portion on the inner diameter of at least one end, wherein when in an unloaded condition, the flared portion has an inner diameter larger than the nominal inner diameter of the small bore aspiration tubing (318);
- a connector (330, 332) is configured to receive at least a portion of the flared portion of the small bore aspiration tubing, the connector (330, 332) being sized to apply radial compression on the flared portion when the flared portion is inserted in the connector (330, 332) such that when the small bore aspiration tubing (318) is disposed within the connector (330, 332), the inner diameter of the flared portion is about the same diameter as the nominal diameter of the small bore aspiration tubing (318).
2. The assembly of claim 1, the connector (330) being disposed between the aspiration path (316) in the hand piece (118) and the small bore aspiration tubing (318), the connector (330) comprising a neck for passage of the aspiration fluid, the neck having a diameter substantially matching the nominal inner diameter of the small bore aspiration tubing (318).
 3. The assembly of claim 2, wherein the connector (330) comprises two female ends sized respectively to receive the aspiration path (316) and the small bore aspiration tubing (318), the connector (330) having a smooth transition from the largest inner diameter of the connector (330) down to the neck diameter.
 4. The assembly of claim 3, the assembly further comprising:

a cassette (314) associated with the pump (322); and

a second connector (332) disposed between the small bore aspiration tubing (318) and the cassette (314), the second connector (332) configured to receive at least a portion of the flared portion of the small bore aspiration tubing (318) and to apply radial compression on the flared portion when the flared portion is inserted in the second connector (332) such that when the small bore aspiration tubing is disposed within the second connector, the inner diameter of the flared portion is about the same diameter as the nominal diameter of the small bore aspiration tubing.

5. The assembly of claim 1, wherein the pump (322) comprises a high output parallel operating pump operable to create a flow of about 60cc/min. through the small bore aspiration tubing.
6. The assembly of claim 1, wherein the small bore aspiration tubing (318) has an inner diameter within a range of about 0.889 - 1.27 mm (.035-.050 inch).
7. The assembly of claim 6, wherein the small bore aspiration tubing (318) has an inner diameter sized about 1.143 mm (.045 inch).
8. The assembly of claim 1, the phacoemulsification hand piece comprising an ultrasonic tip (334) having a lumen sized and configured to aspirate the aspirating fluid from the surgical site; wherein the aspiration path extends from the ultrasonic tip (334) and is arranged and configured to permit flow of the aspirating fluid through the hand piece; wherein the aspiration path within the hand piece comprises an inner diameter matching the inner diameter of the lumen of the ultrasonic tip.
9. A small bore aspiration system (302) arranged to receive aspiration fluid from an ultrasonic tip (334) used in a phacoemulsification surgical assembly, with a phacoemulsification hand piece comprising:

an aspiration path (316) within the phacoemulsification hand piece (118), the aspiration path extending from the ultrasonic tip and being arranged and configured to permit flow of the aspirating fluid through the hand piece;

a flexible small bore aspiration tubing (318) in fluid communication with the aspiration path (316), the small bore aspiration tubing having a nominal inner diameter smaller than about 1.27 mm (.050 inch) to reduce levels of occlusion surge within the surgical system, the inner di-

ameter being substantially consistent through the length of the small bore aspiration tubing; a high-output, peristaltic pump (322) in communication with the small bore aspiration tubing; wherein the small bore aspiration tubing (318) comprises a flared portion on the inner diameter of at least one end, wherein when in an unloaded condition, the flared portion has an inner diameter larger than the nominal inner diameter of the small bore aspiration tubing; further comprising a connector (330,332) configured to receive at least a portion of the flared portion of the small bore aspiration tubing (318), the connector comprising a neck for passage of the aspiration fluid, the connector being sized to apply radial compression on the flared portion when the flared portion is inserted in the connector such that when the small bore aspiration tubing (318) is disposed within the connector, the inner diameter of the flared portion is about the same diameter as the neck and the nominal diameter of the small bore aspiration tubing.

10. The system of claim 9, the connector (330) being disposed between the aspiration path (316) in the hand piece and the small bore aspiration tubing (318), the neck having a diameter substantially matching the nominal inner diameter of the small bore aspiration tubing (318).

11. The system of claim 10, further comprising:

a cassette (314) associated with the pump; and a second connector (332) disposed between the small bore aspiration tubing (318) and the cassette (314), the second connector configured to receive at least a portion of the flared portion of the small bore aspiration tubing and to apply radial compression on the flared portion when the flared portion is inserted in the connector such that when the small bore aspiration tubing (318) is disposed within the connector, the inner diameter of the flared portion is about the same diameter as the nominal diameter of the small bore aspiration tubing.

12. The system of claim 9, wherein the small bore aspiration tubing (318) has an inner diameter within a range of about 0.889 - 1.27 mm (.035-.050 inch).

13. The system of claim 12, wherein the small bore aspiration tubing (318) has an inner diameter sized about 1.143 mm (.045 inch).

Patentansprüche

1. Anordnung für ein chirurgisches System zur Phako-

emulsifikation, umfassend:

ein Handstück (118) zur Phakoemulsifikation; ein Spülungssystem (300), das dazu konfiguriert ist, dem Handstück (118) zur Phakoemulsifikation eine Spülungsflüssigkeit zur Verfügung zu stellen, um den Operationsbereich zu spülen; und

ein Aspirationssystem (302), das dazu ausgerichtet ist, Aspirationsflüssigkeit von dem Operationsbereich abzusaugen, wobei das Aspirationssystem umfasst:

einen Aspirationsweg innerhalb des Handstücks zur Phakoemulsifikation;

einen flexiblen Aspirationsschlauch (318) mit kleiner Bohrung, der dazu konfiguriert ist, in flüssiger Verbindung mit dem Aspirationsweg (316) des Handstücks (118) zur Phakoemulsifikation zu sein, wobei der Aspirationsschlauch (318) mit kleiner Bohrung einen nominellen Innendurchmesser von weniger als etwa 1,27 mm (0,050 Zoll) aufweist, um den Level an Okklusionsschüben innerhalb des chirurgischen Systems zu reduzieren, wobei der Innendurchmesser im Wesentlichen auf der gesamten Länge des Aspirationsschlauchs (318) mit kleiner Bohrung gleichbleibend ist; und

eine Peristaltikpumpe (332), die in Verbindung mit dem Aspirationsschlauch (318) mit kleiner Bohrung ist und betriebsfähig ist, um einen Durchfluss durch den Aspirationsschlauch (318) mit kleiner Bohrung zu erzeugen;

wobei der Aspirationsschlauch (318) mit kleiner Bohrung einen kegelförmigen Abschnitt am Innendurchmesser wenigstens eines Endes aufweist, wobei der Innendurchmesser des kegelförmigen Abschnitts in ungeladenem Zustand größer ist als der nominelle Innendurchmesser des Aspirations-schlauchs (318) mit kleiner Bohrung;

ein Verbindungsstück (330, 332), das dazu konfiguriert ist, wenigstens einen Teil des kegelförmigen Abschnitts des Aspirations-schlauchs mit kleiner Bohrung aufzunehmen, wobei die Größe des Verbindungs-stücks (330, 332) dazu ausgelegt ist, eine radiale Kompression auf den kegelförmigen Abschnitt auszuüben, wenn der kegelförmige Abschnitt in das Verbindungsstück (330, 332) eingeführt wird, so dass der kegelförmige Abschnitt etwa den gleichen Innendurchmesser aufweist wie der nominelle Innendurchmesser des Aspirationsschlauchs (318) mit kleiner Bohrung, wenn der Aspirationsschlauch (318) mit kleiner Bohrung

- sich in dem Verbindungsstück (330, 332) befindet.
2. Anordnung gemäß Anspruch 1, wobei das Verbindungsstück (330) sich zwischen dem Aspirationsweg (316) in dem Handstück (118) und dem Aspirationsschlauch (318) mit kleiner Bohrung befindet, und das Verbindungsstück (330) einen Hals zum Durchlass der Aspirationsflüssigkeit umfasst, wobei der Hals einen Durchmesser aufweist, der im Wesentlichen mit dem nominellen Innendurchmesser des Aspirationsschlauchs (318) mit kleiner Bohrung übereinstimmt.
 3. Anordnung gemäß Anspruch 2, wobei das Verbindungsstück (330) zwei Buchsenenden aufweist, deren Größe jeweils dazu ausgelegt ist, den Aspirationsweg (316) und den Aspirationsschlauch (318) mit kleiner Bohrung aufzunehmen, und das Verbindungsstück (330) fließend vom größten Innendurchmesser des Verbindungsstücks (330) zum geringeren Halsdurchmesser übergeht.
 4. Anordnung gemäß Anspruch 3, die Anordnung weiterhin umfassend:
 - eine Kassette (314), die mit der Pumpe (332) verknüpft ist; und
 - ein zweites Verbindungsstück (332), das sich zwischen dem Aspirationsschlauch (318) mit kleiner Bohrung und der Kassette (314) befindet, wobei das zweite Verbindungsstück (332) dazu konfiguriert ist, wenigstens einen Teil des kegelförmigen Abschnitts des Aspirationschlauchs (318) mit kleiner Bohrung aufzunehmen und eine radiale Kompression auf den kegelförmigen Abschnitt auszuüben, wenn der kegelförmige Abschnitt in das zweite Verbindungsstück (332) eingeführt wird, so dass der kegelförmige Abschnitt etwa den gleichen Innendurchmesser aufweist wie der nominelle Innendurchmesser des Aspirationsschlauchs mit kleiner Bohrung, wenn der Aspirationsschlauch mit kleiner Bohrung sich in dem zweiten Verbindungsstück befindet.
 5. Anordnung gemäß Anspruch 1, wobei die Pumpe (332) eine parallel arbeitende Pumpe mit hoher Ausgangsleistung umfasst, die dazu ausgelegt ist, eine Durchflussrate durch den Aspirationsschlauch mit kleiner Bohrung von etwa 60 cm³/min. zu erzeugen.
 6. Anordnung gemäß Anspruch 1, wobei der Aspirationsschlauch (318) mit kleiner Bohrung einen Innendurchmesser aufweist, der in einem Bereich von etwa 0,889 - 1,27 mm (0,035-0,050 Zoll) liegt.
 7. Anordnung gemäß Anspruch 6, wobei der Aspirati-
- onsschlauch (318) mit kleiner Bohrung einen Innendurchmesser von etwa 1,143 mm (0,045 Zoll) aufweist.
8. Anordnung gemäß Anspruch 1, wobei das Handstück zur Phakoemulsifikation eine Ultraschallspitze (334) mit einem Lumen umfasst, dessen Größe dazu ausgelegt ist und das dazu konfiguriert ist, die Aspirationsflüssigkeit von dem Operationsbereich abzusaugen; wobei der Aspirationsweg sich von der Ultraschallspitze (334) erstreckt und dazu ausgerichtet und konfiguriert ist, den Durchfluss der Aspirationsflüssigkeit durch das Handstück zu ermöglichen; wobei der Aspirationsweg innerhalb des Handstücks einen Innendurchmesser umfasst, der mit dem Innendurchmesser des Lumens der Ultraschallspitze übereinstimmt.
 9. Aspirationssystem (302) mit kleiner Bohrung, dazu ausgerichtet, Aspirationsflüssigkeit von einer Ultraschallspitze (334), die bei einer chirurgischen Anordnung zur Phakoemulsifikation mit einem Handstück zur Phakoemulsifikation verwendet wird, aufzunehmen, umfassend:
 - einen Aspirationsweg (316) innerhalb des Handstücks (118) zur Phakoemulsifikation, wobei der Aspirationsweg sich von der Ultraschallspitze erstreckt und dazu ausgerichtet und konfiguriert ist, den Durchfluss der Aspirationsflüssigkeit durch das Handstück zu ermöglichen;
 - einen flexiblen Aspirationsschlauch (318) mit kleiner Bohrung, der in flüssiger Verbindung mit dem Aspirationsweg (316) steht, wobei der Aspirationsschlauch einen nominellen Innendurchmesser von weniger als etwa 1,27 mm (0,050 Zoll) aufweist, um den Level an Okklusionsschüben innerhalb des chirurgischen Systems zu reduzieren, wobei der Innendurchmesser im Wesentlichen auf der gesamten Länge des Aspirationsschlauchs mit kleiner Bohrung gleichbleibend ist;
 - eine Peristaltikpumpe (332) mit hoher Ausgangsleistung, die in Verbindung mit dem Aspirationsschlauch mit kleiner Bohrung steht;
 - wobei der Aspirationsschlauch (318) mit kleiner Bohrung einen kegelförmigen Abschnitt am Innendurchmesser wenigstens eines Endes aufweist, wobei der Innendurchmesser des kegelförmigen Abschnitts in ungeladenem Zustand größer ist als der nominelle Innendurchmesser des Aspirationsschlauchs mit kleiner Bohrung;
 - weiterhin umfassend ein Verbindungsstück (330, 332), das dazu konfiguriert ist, wenigstens einen Teil des kegelförmigen Abschnitts des Aspirationsschlauchs (318) mit kleiner Bohrung aufzunehmen, wobei das Verbindungsstück ei-

nen Hals zum Durchlass der Aspirationsflüssigkeit aufweist und die Größe des Verbindungsstücks dazu ausgelegt ist, eine radiale Kompression auf den kegelförmigen Abschnitt auszuüben, wenn der kegelförmige Abschnitt in das Verbindungsstück eingeführt wird, so dass der kegelförmige Abschnitt etwa den gleichen Innendurchmesser aufweist wie der nominelle Innendurchmesser des Halses und des Aspirationssschlauchs mit kleiner Bohrung, wenn der Aspirationssschlauch (318) mit kleiner Bohrung sich in dem Verbindungsstück befindet.

10. System gemäß Anspruch 9, wobei das Verbindungsstück (330) sich zwischen dem Aspirationsweg (316) in dem Handstück und dem Aspirationssschlauch (318) mit kleiner Bohrung befindet, wobei der Hals einen Durchmesser aufweist, der im Wesentlichen mit dem nominellen Innendurchmesser des Aspirationssschlauchs (318) mit kleiner Bohrung übereinstimmt.

11. System gemäß Anspruch 10, weiterhin umfassend:

eine Kassette (314), die mit der Pumpe verknüpft ist; und
ein zweites Verbindungsstück (332), das sich zwischen dem Aspirationssschlauch (318) mit kleiner Bohrung und der Kassette (314) befindet, wobei das zweite Verbindungsstück dazu konfiguriert ist, wenigstens einen Teil des kegelförmigen Abschnitts des Aspirationssschlauchs mit kleiner Bohrung aufzunehmen und eine radiale Kompression auf den kegelförmigen Abschnitt auszuüben, wenn der kegelförmige Abschnitt in das Verbindungsstück eingeführt wird, so dass der kegelförmige Abschnitt etwa den gleichen Innendurchmesser aufweist wie der nominelle Innendurchmesser des Aspirationssschlauchs (318) mit kleiner Bohrung, wenn der Aspirationssschlauch mit kleiner Bohrung sich in dem Verbindungsstück befindet.

12. System gemäß Anspruch 9, wobei der Aspirationssschlauch (318) mit kleiner Bohrung einen Innendurchmesser aufweist, der in einem Bereich von etwa 0,889-1,27 mm (0,035-0,050 Zoll) liegt.

13. System gemäß Anspruch 12, wobei der Aspirationssschlauch (318) mit kleiner Bohrung einen Innendurchmesser von etwa 1,143 mm (0,045 Zoll) aufweist.

Revendications

1. Ensemble pour un système chirurgical de phacoémulsification comprenant :

une pièce à main de phacoémulsification ;
un système d'irrigation (300) configuré pour amener le fluide d'irrigation à la pièce à main de phacoémulsification (118) afin d'irriguer un site chirurgical ; et
un système d'aspiration (302) agencé pour aspirer le fluide d'aspiration du site chirurgical, le système d'aspiration comprenant :

une trajectoire d'aspiration à l'intérieur de la pièce à main de phacoémulsification ;
un tube d'aspiration flexible de petit diamètre (318) configuré pour être en communication de fluide avec la trajectoire d'aspiration (316) de la pièce à main de phacoémulsification (118), le tube d'aspiration de petit diamètre (318) ayant un diamètre interne nominal inférieur à environ 1,27 mm (0,050 pouce) afin de réduire les niveaux d'augmentation d'occlusion à l'intérieur du système chirurgical, le diamètre interne étant sensiblement constant sur la longueur du tube d'aspiration de petit diamètre (318) ; et
une pompe péristaltique (322) en communication avec le tube d'aspiration de petit diamètre (318) pouvant fonctionner afin de créer un écoulement dans le tube d'aspiration de petit diamètre (318) ;
dans lequel le tube d'aspiration de petit diamètre (318) comprend une partie évasée sur le diamètre interne d'au moins une extrémité, dans lequel, lorsqu'elle est dans une condition non chargée, la partie évasée a un diamètre interne supérieur au diamètre interne nominal du tube d'aspiration de petit diamètre (318) ;
un connecteur (330, 332) est configuré pour recevoir au moins une partie de la partie évasée du tube d'aspiration de petit diamètre, le connecteur (330, 332) étant dimensionné pour appliquer une compression radiale sur la partie évasée, lorsque la partie évasée est insérée dans le connecteur (330, 332) de sorte que lorsque le tube d'aspiration de petit diamètre (318) est disposé à l'intérieur du connecteur (330, 332), le diamètre interne de la partie évasée représente environ le même diamètre que le diamètre nominal du tube d'aspiration de petit diamètre (318).

2. Ensemble selon la revendication 1, le connecteur (330) étant disposé entre la trajectoire d'aspiration (316) dans la pièce à main (118) et le tube d'aspiration de petit diamètre (318), le connecteur (330) comprenant un col pour le passage du fluide d'aspiration, le col ayant un diamètre correspondant sensiblement au diamètre interne nominal du tube d'aspiration

- tion de petit diamètre (318).
3. Ensemble selon la revendication 2, dans lequel le connecteur (330) comprend deux extrémités femelles dimensionnées respectivement pour recevoir la trajectoire d'aspiration (316) et le tube d'aspiration de petit diamètre (318), le connecteur (330) ayant une transition en douceur du plus grand diamètre interne du connecteur (330) jusqu'au diamètre du col. 5
 4. Ensemble selon la revendication 3, l'ensemble comprenant en outre :
 - une cassette (314) associée à la pompe (322) ; 15
 - et
 - un second connecteur (332) disposé entre le tube d'aspiration de petit diamètre (318) et la cassette (314), le second connecteur (332) étant configuré pour recevoir au moins une partie de la partie évasée du tube d'aspiration de petit diamètre (318) et pour appliquer la compression radiale sur la partie évasée lorsque la partie évasée est insérée dans le second connecteur (332) de sorte que lorsque le tube d'aspiration de petit diamètre est disposé à l'intérieur du second connecteur, le diamètre interne de la partie évasée représente environ le même diamètre que le diamètre nominal du tube d'aspiration de petit diamètre. 20
 5. Ensemble selon la revendication 1, dans lequel la pompe (322) comprend une pompe à fonctionnement en parallèle à haut rendement, pouvant fonctionner pour créer un débit d'environ 60 cc/min, dans le tube d'aspiration de petit diamètre. 25
 6. Ensemble selon la revendication 1, dans lequel le tube d'aspiration de petit diamètre (318) a un diamètre interne dans une plage d'environ 0,889 - 1,27 mm (0,035 - 0,050 pouce). 30
 7. Ensemble selon la revendication 6, dans lequel le tube d'aspiration de petit diamètre (318) a un diamètre interne d'environ 1,143 mm (0,045 pouce). 35
 8. Ensemble selon la revendication 1, la pièce à main de phacoémulsification comprenant un embout ultrasonore (334) ayant une lumière dimensionnée et configurée pour aspirer le fluide d'aspiration du site chirurgical ;
 - dans lequel la trajectoire d'aspiration s'étend à partir de l'embout ultrasonore (334) et est agencée et configurée pour permettre l'écoulement du fluide d'aspiration par la pièce à main ; 40
 - dans lequel la trajectoire d'aspiration à l'intérieur de la pièce à main comprend un diamètre interne correspondant au diamètre interne de la lumière de 45
 9. Système d'aspiration de petit diamètre (302) agencé pour recevoir le fluide d'aspiration d'un embout ultrasonore (334) utilisé dans un ensemble chirurgical de phacoémulsification avec une pièce à main de phacoémulsification, comprenant :
 - une trajectoire d'aspiration (316) à l'intérieur de la pièce à main de phacoémulsification (118), la trajectoire d'aspiration s'étendant à partir de l'embout ultrasonore et étant agencée et configurée pour permettre l'écoulement du fluide d'aspiration à travers la pièce à main ;
 - un tube d'aspiration flexible de petit diamètre (318) en communication de fluide avec la trajectoire d'aspiration (316), le tube d'aspiration de petit diamètre ayant un diamètre interne nominal inférieur à environ 1,27 mm (0,050 pouce) pour réduire le niveau d'augmentation d'occlusion à l'intérieur du système chirurgical, le diamètre interne étant sensiblement constant sur la longueur du tube d'aspiration de petit diamètre ;
 - une pompe péristaltique à haut rendement (322) en communication avec le tube d'aspiration de petit diamètre ;
 - dans lequel le tube d'aspiration de petit diamètre (318) comprend une partie évasée sur le diamètre interne d'au moins une extrémité, dans lequel lorsqu'elle est dans un condition non chargée, la partie évasée a un diamètre interne supérieur au diamètre interne nominal du tube d'aspiration de petit diamètre ;
 - comprenant en outre un connecteur (330, 332) configuré pour recevoir au moins une partie de la partie évasée du tube d'aspiration de petit diamètre (318), le connecteur comprenant un col pour le passage du fluide d'aspiration, le connecteur étant dimensionné pour appliquer une compression radiale sur la partie évasée lorsque la partie évasée est insérée dans le connecteur de sorte que, lorsque le tube d'aspiration de petit diamètre (318) est disposé à l'intérieur du connecteur, le diamètre interne de la partie évasée représente environ le même diamètre que le col et le diamètre nominal du tube d'aspiration de petit diamètre. 50
 10. Système selon la revendication 9, le connecteur (330) étant disposé entre la trajectoire d'aspiration (316) dans la pièce à main et le tube d'aspiration de petit diamètre (318), le col ayant un diamètre correspondant sensiblement au diamètre interne nominal du tube d'aspiration de petit diamètre (318). 55
 11. Système selon la revendication 10, comprenant en outre :

une cassette (314) associée à la pompe ; et un second connecteur (332) disposé entre le tube d'aspiration de petit diamètre (318) et la cassette (314), le second connecteur étant configuré pour recevoir au moins une partie de la partie évasée du tube d'aspiration de petit diamètre et pour appliquer la compression radiale sur la partie évasée lorsque la partie évasée est insérée dans le connecteur de sorte que, lorsque le tube d'aspiration de petit diamètre (318) est disposé à l'intérieur du connecteur, le diamètre interne de la partie évasée représente environ le même diamètre que le diamètre nominal du tube d'aspiration de petit diamètre.

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12. Système selon la revendication 9, dans lequel le tube d'aspiration de petit diamètre (318) a un diamètre interne dans une plage d'environ 0,889 - 1,27 mm (0,035 - 0,050 pouce).

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13. Système selon la revendication 12, dans lequel le tube d'aspiration de petit diamètre (318) a un diamètre interne d'environ 1,143 mm (0,045 pouce).

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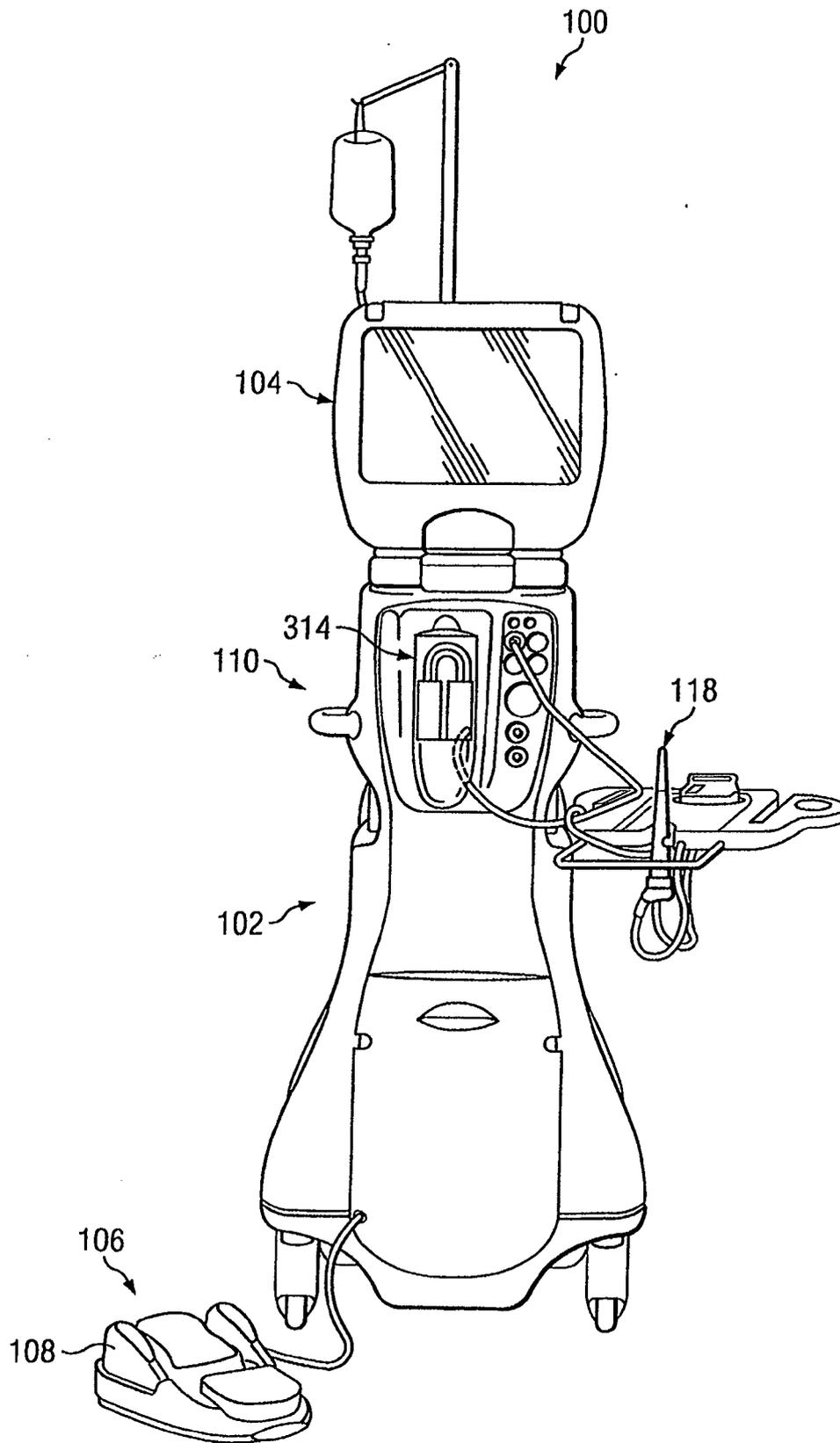


Fig. 1

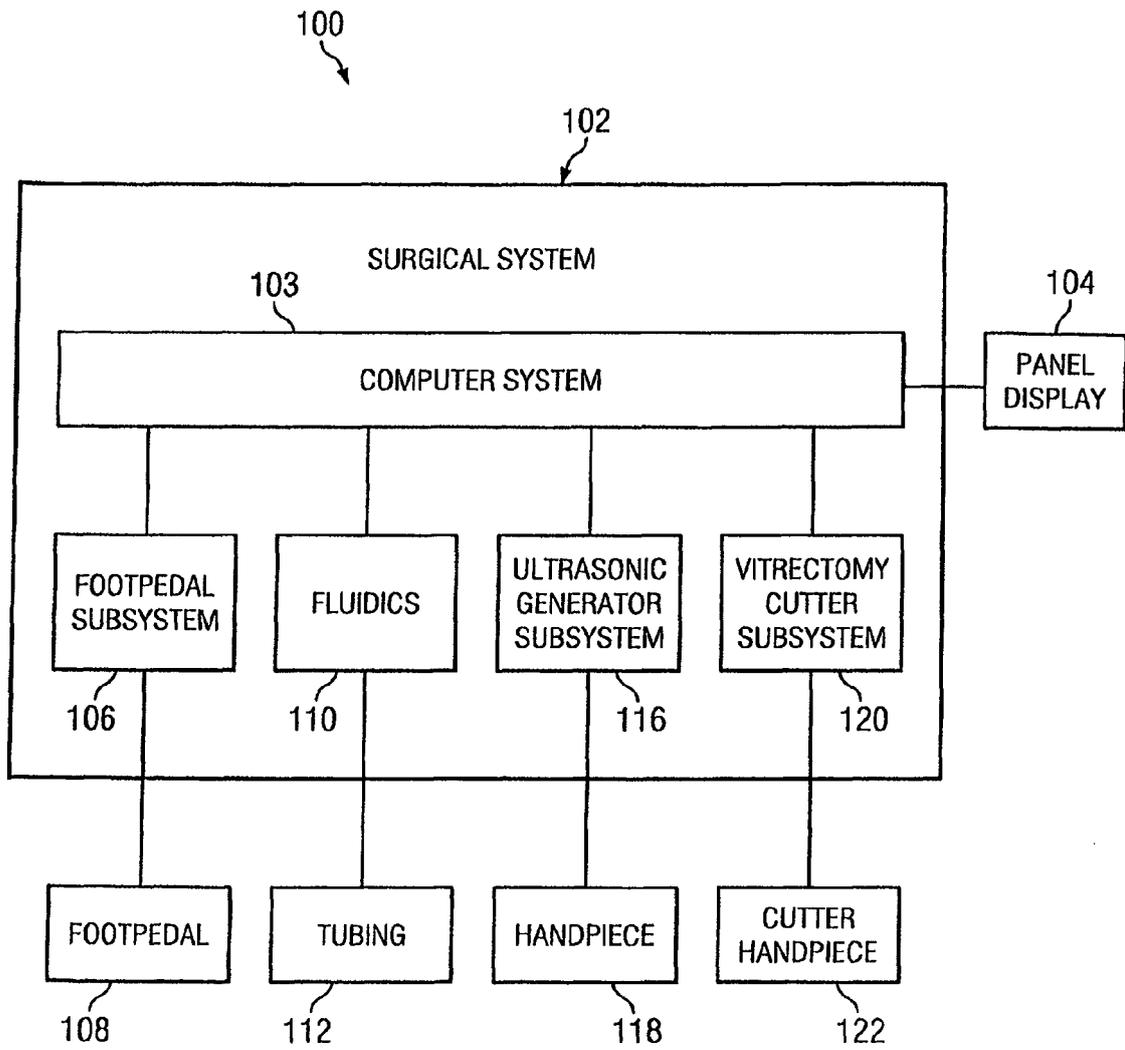


Fig. 2

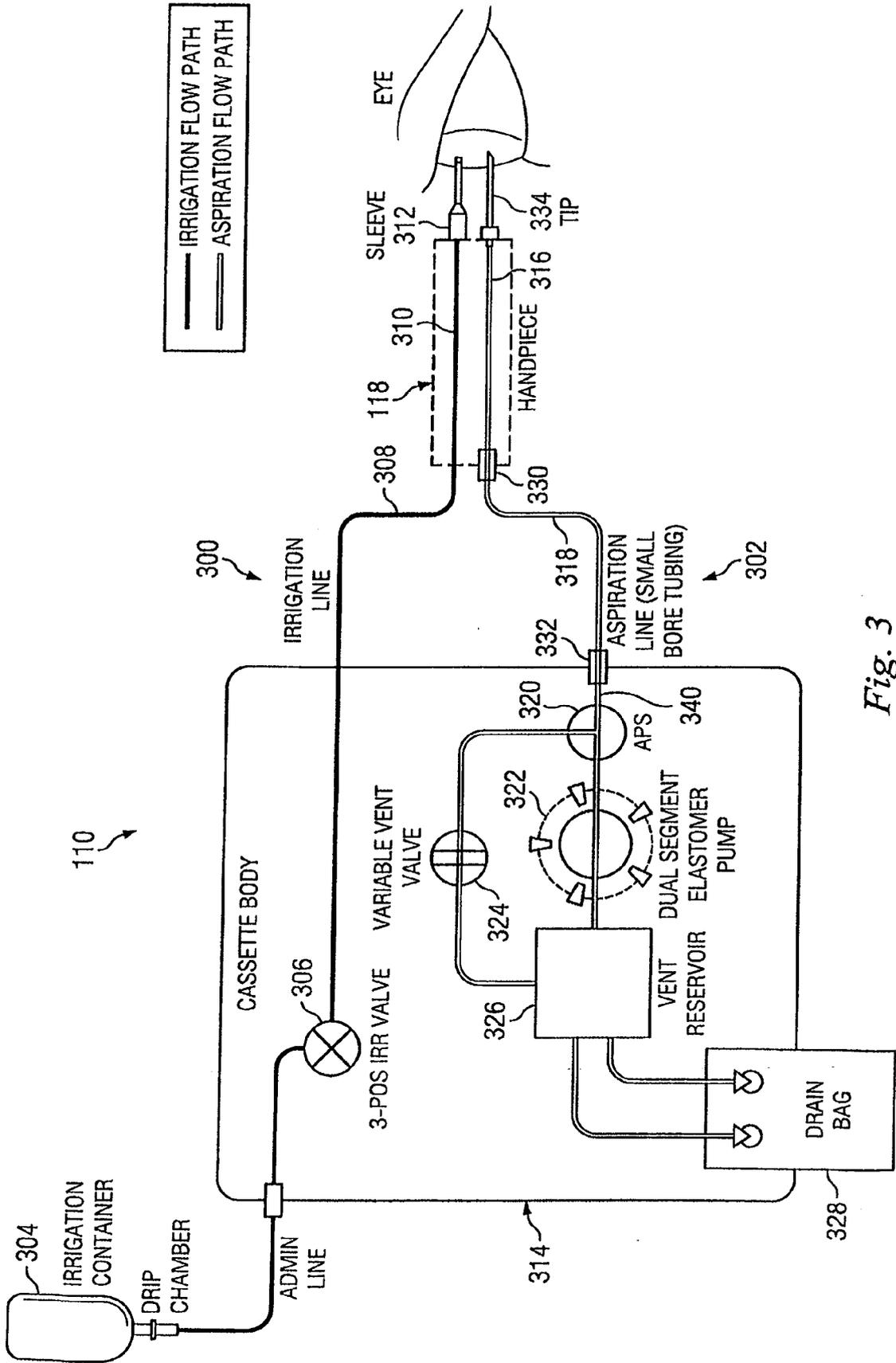


Fig. 3

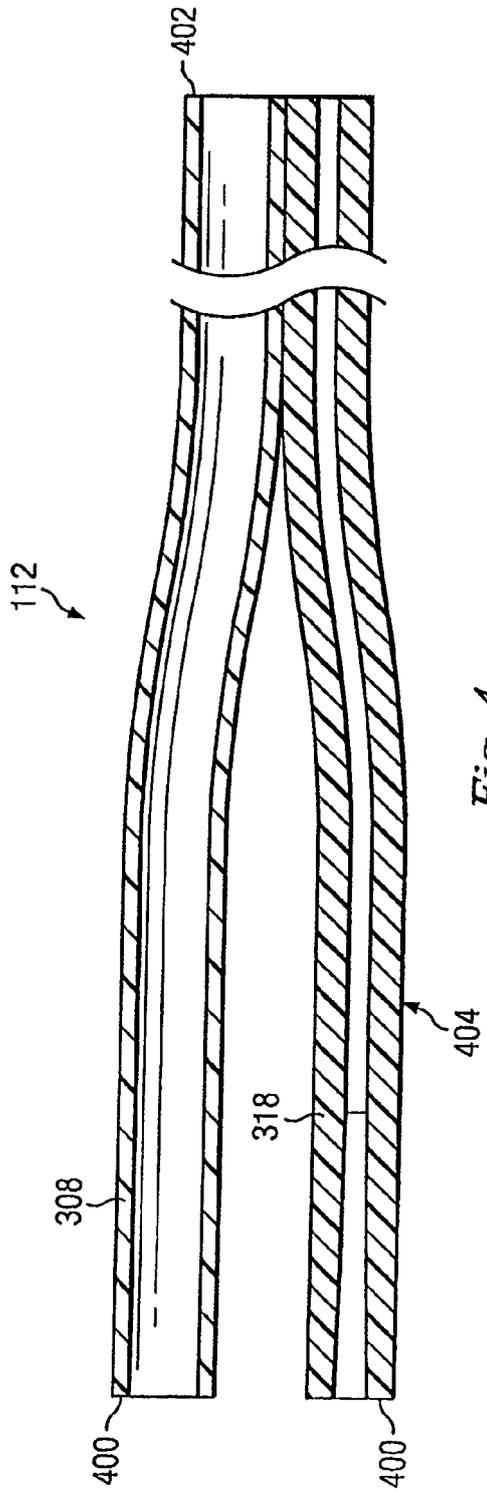


Fig. 4

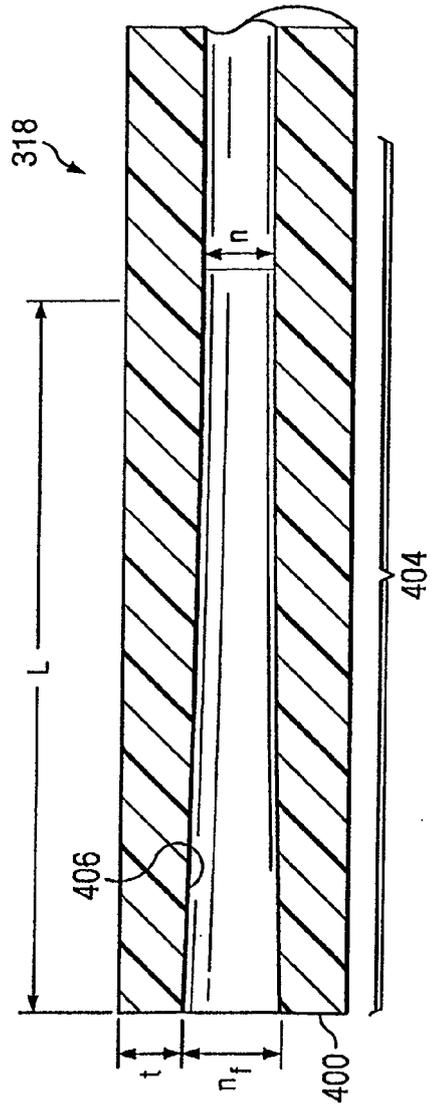


Fig. 5

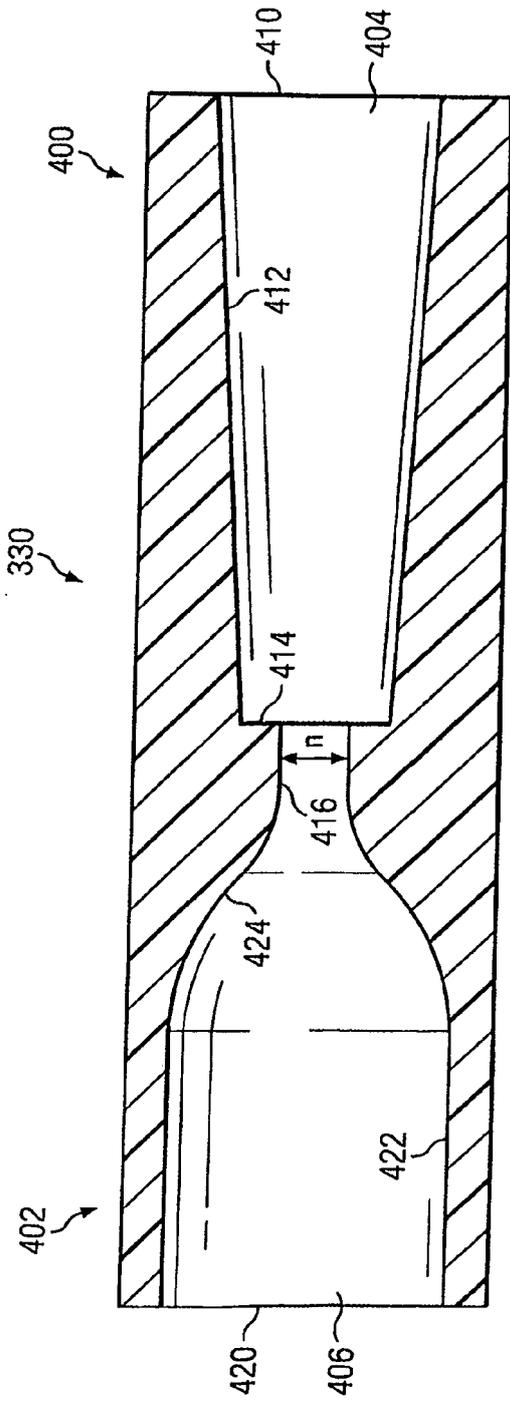


Fig. 6

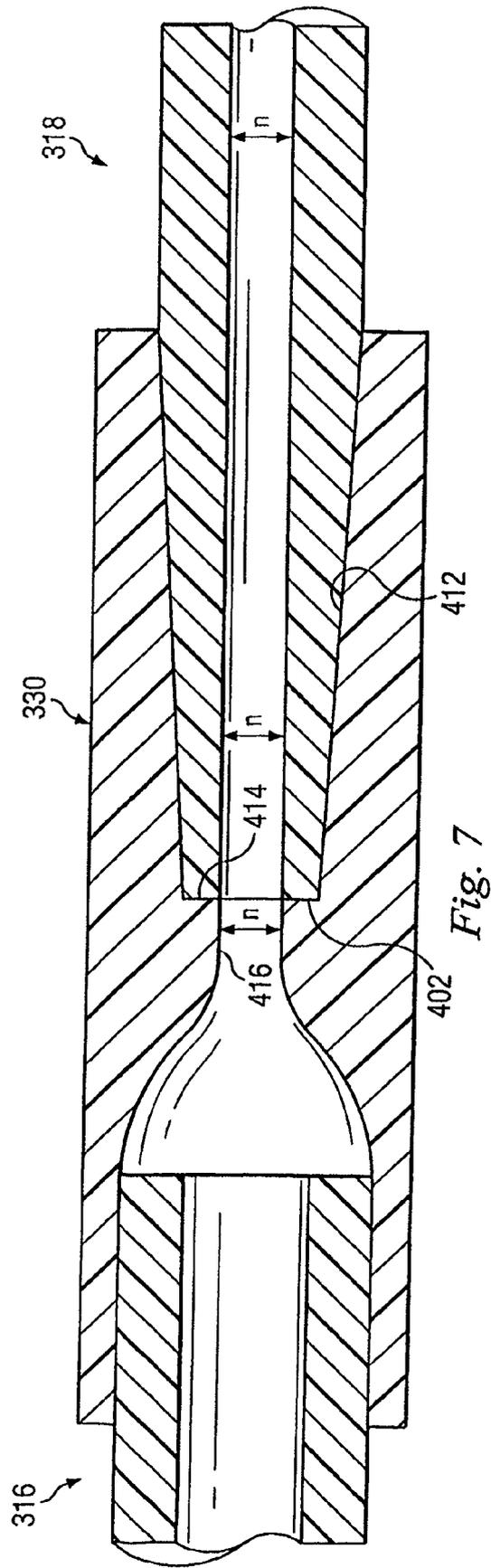


Fig. 7

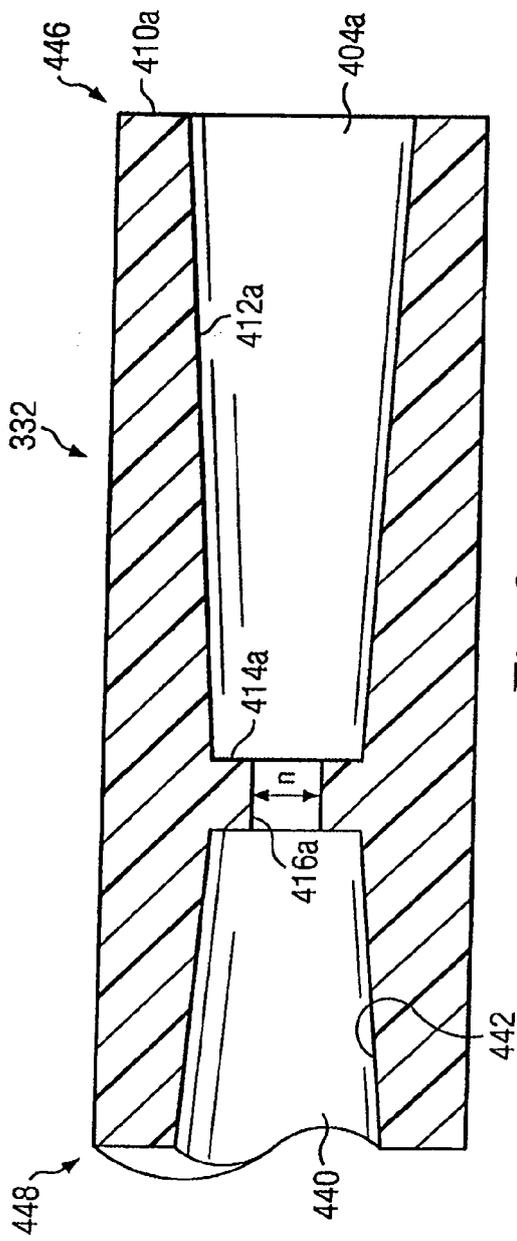


Fig. 8

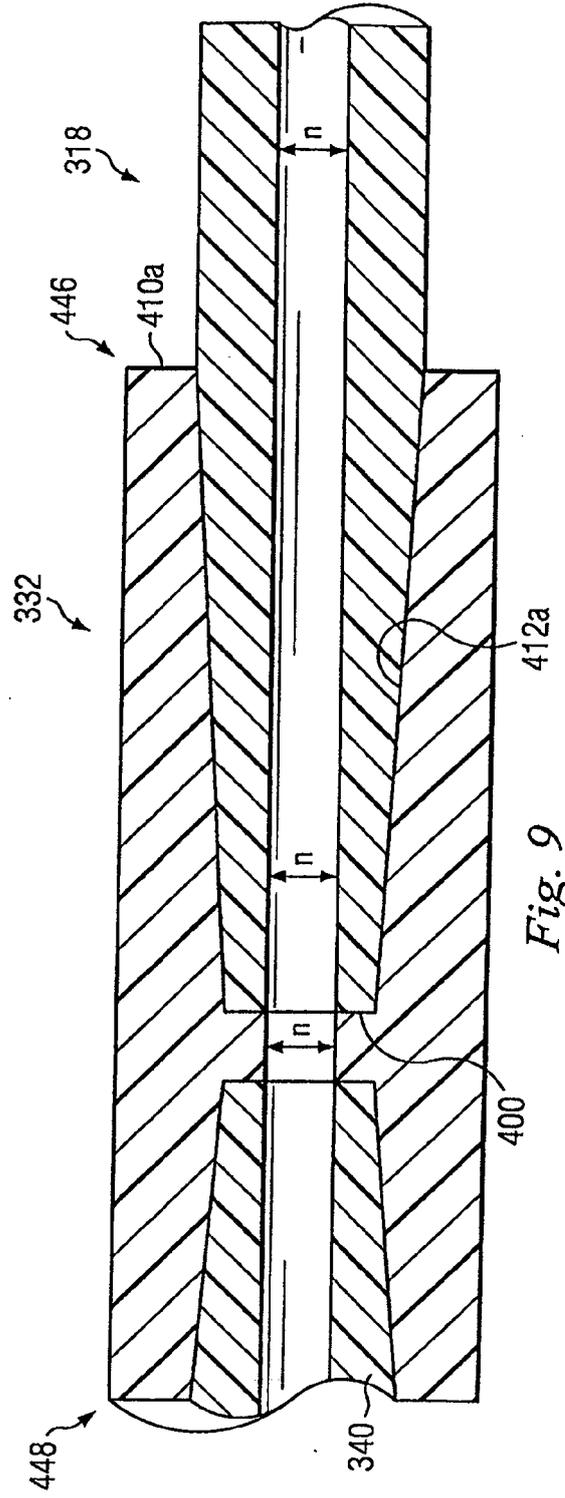


Fig. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 102007031722 A1 **[0010]**
- US 2008188792 A1 **[0011]**
- US 2006100570 A1 **[0012]**
- WO 2009076717 A1 **[0013]**
- US 75553910 A **[0047]**