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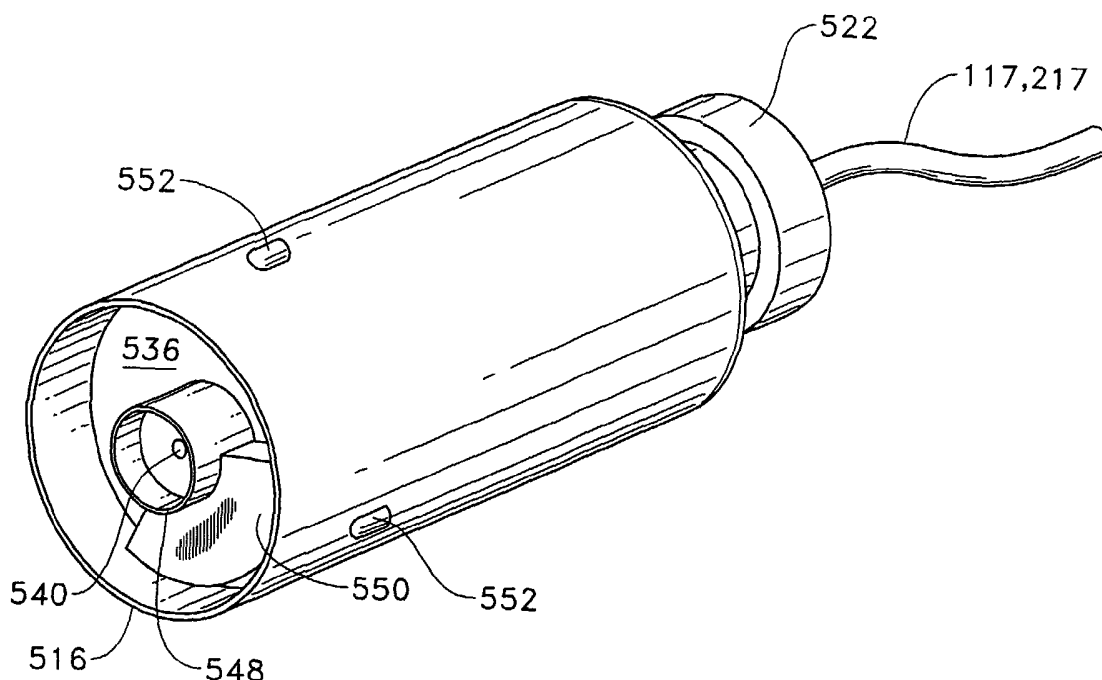
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(54) Title: CONTAINER FOR DELIVERY OF FLUID TO OPHTHALMIC SURGICAL HANDPIECE



(57) Abstract: A container (500) for delivery of a surgical fluid to a surgical handpiece is disclosed. The container includes a volume for receiving the surgical fluid to be delivered to the handpiece and an end (536) for removably engaging a receptacle in a surgical console and for fluidly coupling with a source of pressurized fluid in a surgical console.

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**CONTAINER FOR DELIVERY OF FLUID
TO OPHTHALMIC SURGICAL HANDPIECE**

Field of the Invention

This invention relates generally to ophthalmic surgery and more particularly to the liquefracture technique of cataract surgery. The invention also generally pertains to a container for the delivery of surgical fluids to ophthalmic microsurgical systems and more particularly to such containers for use with a liquefracture handpiece.

Description of the Related Art

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

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

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

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

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

In use, the ends of the cutting tip and irrigating sleeve are inserted into a small incision of predetermined width in the cornea, sclera, or other location. The cutting tip is ultrasonically vibrated along its longitudinal axis within the irrigating sleeve by the

crystal-driven ultrasonic horn, thereby emulsifying the selected tissue in situ. The hollow bore of the cutting tip communicates with the bore in the horn that in turn communicates with the aspiration line from the handpiece to the console. A reduced pressure or vacuum source in the console draws or aspirates the emulsified tissue from the eye through the open end of the cutting tip, the cutting tip and horn bores, and the aspiration line and into a collection device. The aspiration of emulsified tissue is aided by a saline flushing solution or irrigant that is injected into the surgical site through the small annular gap between the inside surface of the irrigating sleeve and the cutting tip.

Recently, a new cataract removal technique has been developed that involves the injection of hot (approximately 45°C to 105°C) water or saline to liquefy or gellate the hard lens nucleus, thereby making it possible to aspirate the liquefied lens from the eye. Aspiration is conducted concurrently with the injection of the heated solution and the injection of a relatively cool solution, thereby quickly cooling and removing the heated solution. This technique is more fully described in U.S. Patent No. 5,616,120 (Andrew, et al.), the entire content of which is incorporated herein by reference. The apparatus disclosed in the publication, however, heats the solution separately from the surgical handpiece. Temperature control of the heated solution can be difficult because the fluid tubings feeding the handpiece typically are up to two meters long, and the heated solution can cool considerably as it travels down the length of the tubing.

U.S. Patent No. 5,885,243 (Capetan, et al.) discloses a handpiece having a separate pumping mechanism and resistive heating element. Such a structure adds unnecessary complexity to the handpiece.

U.S. Patent No. 6,206,848 (Sussman et al.), which is incorporated in its entirety by this reference, discloses liquefracture handpieces. In the liquefracture technique of cataract removal, the cataractous lens is liquefied or emulsified by repetitive pulses of a

surgical fluid that are discharged from the handpiece. The liquefied lens may then be aspirated from the eye. Since the surgical fluid is actually used to liquefy the cataractous lens, a consistent, pressurized source of surgical fluid is important to the success of the liquefracture technique. In addition, different surgical fluids may be advantageous for the removal of different hardness of cataracts or for various patient conditions.

Therefore, a need exists for a simple and reliable container and method of delivering a surgical fluid used to perform the liquefracture technique.

Summary of the Invention

The present invention is directed to a container for delivery of a surgical fluid to a surgical handpiece. The container generally includes a first portion or body, and a second portion or deformable liner. The first portion is made from a deformable material and has a closed end, an open end, an outer surface, and a first volume for receiving a surgical fluid for delivery to a surgical handpiece. The second portion is made from a material more rigid than the deformable material and has a first end, a second end, an outer surface, an inner surface, a transverse wall having a first side and a second side, and a second volume receiving the first portion. The first end has an outlet for delivery of the surgical fluid. The first side of the transverse wall has an aperture for receiving a pressurized fluid between the outer surface of the first portion and the inner surface of the second portion. The second side of the transverse wall has an area for removably engaging a source of the pressurized fluid so that the source of the pressurized fluid is in fluid communication with the aperture.

Brief Description of the Drawings

For a more complete understanding of the present invention, and for further objects and advantages thereof, reference is made to the following description taken in conjunction with the accompanying drawings in which:

5 FIG. 1 is a front, upper, left perspective view of a first preferred embodiment of the handpiece of the present invention.

 FIG. 2 is a rear, upper, right perspective view of the handpiece of FIG. 1.

 FIG. 3 is a cross-sectional view of the handpiece of FIG. 1 taken along a plane passing through the irrigation channel.

10 FIG. 4 is a cross-sectional view of the handpiece of FIG. 1 taken along a plane passing through the aspiration channel.

 FIG. 5 is an enlarged partial cross-sectional view of the handpiece of FIG. 1 taken at circle 5 in FIG. 4.

15 FIG. 6 is an enlarged partial cross-sectional view of the handpiece of FIG. 1 taken at circle 6 in FIG. 3.

 FIG. 7 is an enlarged cross-sectional view of the handpiece of FIG. 1 taken at circle 7 in FIGS. 3 and 4.

 FIG. 8 is a partial cross-sectional view of a second preferred embodiment of the handpiece of the present invention.

20 FIG. 9 is an enlarged partial cross-sectional view of the handpiece of FIG. 8 taken at circle 9 in FIG. 8.

 FIG. 10 is an enlarged partial cross-sectional view of the pumping chamber used in the handpiece of FIG. 8 taken at circle 10 in FIG. 9.

25 FIG. 11 is a partial cross-sectional view of a third preferred embodiment of the handpiece of the present invention.

FIG. 12 is an enlarged partial cross-sectional view of the handpiece of FIG. 11 taken at circle 12 in FIG. 11.

FIG. 13 is an enlarged partial cross-sectional view of the pumping chamber used in the handpiece of FIG. 11.

5 FIG. 14 is a block diagram of a control system that can be used with the handpiece of the present invention.

FIG. 15 is a front, right perspective view of a container for the delivery of a surgical fluid to an ophthalmic surgical handpiece according to a preferred embodiment of the present invention.

10 FIG. 16 is a sectional, perspective view of the container of FIG. 15 along line 16-16.

FIG. 17 is longitudinal, sectional view of the container of FIG. 15 taken along a plane passing through a raised surface of a second transverse wall of the container.

FIG. 18 is a rear, right perspective view of the container of FIG. 15.

15 FIG. 19 is a front view of a preferred embodiment of a receptacle in a surgical console for receiving the container of FIG. 15.

FIG. 20 is a side, sectional view of the receptacle of FIG. 19 along line 20-20.

FIG. 21 is a longitudinal, sectional view of the container of FIG. 15 during the discharge of surgical fluid from the container.

20 FIG. 22 is a longitudinal, sectional view of a container for the delivery of a surgical fluid to an ophthalmic surgical handpiece according to a second preferred embodiment of the present invention taken along a plane passing through a raised surface of a transverse wall of the container.

Detailed Description of the Preferred Embodiments

The preferred embodiments of the present invention and their advantages are best understood by referring to FIGS. 1-22 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

5 Handpiece 10 of the present invention generally includes handpiece body 12 and operative tip 16. Body 12 generally includes external irrigation tube 18 and aspiration fitting 20. Body 12 is similar in construction to well-known in the art phacoemulsification handpieces and may be made from plastic, titanium or stainless steel. As best seen in FIG. 6, operative tip 16 includes tip/cap sleeve 26, needle 28 and tube 30. 10 Sleeve 26 may be any suitable commercially available phacoemulsification tip/cap sleeve or sleeve 26 may be incorporated into other tubes as a multi-lumen tube. Needle 28 may be any commercially available hollow phacoemulsification cutting tip, such as the TURBOSONICS tip available from Alcon Laboratories, Inc., Fort Worth, Texas. Tube 30 may be any suitably sized tube to fit within needle 28, for example 29 gauge 15 hypodermic needle tubing.

As best seen in FIG. 5, tube 30 is free on the distal end and connected to pumping chamber 42 on the proximal end. Tube 30 and pumping chamber 42 may be sealed fluid tight by any suitable means having a relatively high melting point, such as a silicone gasket, glass frit or silver solder. Fitting 44 holds tube 30 within bore 48 of aspiration 20 horn 46. Bore 48 communicates with fitting 20, which is journaled into horn 46 and sealed with O-ring seal 50 to form an aspiration pathway through horn 46 and out fitting 20. Horn 46 is held within body 12 by O-ring seal 56 to form irrigation tube 52 which communicates with irrigation tube 18 at port 54.

As best seen in FIG. 7, in a first embodiment of the present invention, pumping 25 chamber 42 contains a relatively large pumping reservoir 43 that is sealed on both ends by

electrodes 45 and 47. Electrical power is supplied to electrodes 45 and 47 by insulated wires, not shown. In use, surgical fluid (*e.g.* saline irrigating solution) enters reservoir 43 through port 55, tube 34 and check valve 53, check valves 53 being well-known in the art. Electrical current (preferably Radio Frequency Alternating Current or RFAC) is delivered to and across electrodes 45 and 47 because of the conductive nature of the surgical fluid. As the current flows through the surgical fluid, the surgical fluid boils. As the surgical fluid boils, it expands rapidly out of pumping chamber 42 through port 57 and into tube 30 (check valve 53 prevents the expanding fluid from entering tube 34). The expanding gas bubble pushes the surgical fluid in tube 30 downstream of pumping chamber 42 forward. Subsequent pulses of electrical current form sequential gas bubbles that move surgical fluid down tube 30. The size and pressure of the fluid pulse obtained by pumping chamber 42 can be varied by varying the length, timing and/or power of the electrical pulse sent to electrodes 45 and 47 and by varying the dimensions of reservoir 43. In addition, the surgical fluid may be preheated prior to entering pumping chamber 42. Preheating the surgical fluid will decrease the power required by pumping chamber 42 and/or increase the speed at which pressure pulses can be generated.

As best seen in FIGS. 8-10, in a second embodiment of the present invention, handpiece 110 generally includes body 112, having power supply cable 113, irrigation/aspiration lines 115, and pumping chamber supply line 117. Distal end 111 of handpiece 110 contains pumping chamber 142 having a reservoir 143 formed between electrodes 145 and 147. Electrodes 145 and 147 are preferably made from aluminum, titanium, carbon or other similarly conductive materials and are electrically insulated from each other and body 112 by anodized layer 159 formed on electrodes 145 and 147. Anodized layer 159 is less conductive than untreated aluminum and thus, acts as an electrical insulator. Electrodes 145 and 147 and electrical terminals 161 and 163 are not

anodized and thus, are electrically conductive. Layer 159 may be formed by any suitable anodization technique, well-known in the art, and electrodes 145 and 147 and electrical terminals 161 and 163 may be masked during anodization or machined after anodization to expose bare aluminum. Electrical power is supplied to electrodes 145 and 147 through terminals 161 and 163 and wires 149 and 151, respectively. Fluid is supplied to reservoir 143 through supply line 117 and check valve 153. Extending distally from pumping chamber 142 is outer tube 165 that coaxially surrounds aspiration tube 167. Tubes 165 and 167 may be of similar construction as tube 30. Tube 167 is of slightly smaller diameter than tube 165, thereby forming an annular passage or gap 169 between tube 165 and tube 167. Annular gap 169 fluidly communicates with reservoir 143.

In use, surgical fluid enters reservoir 143 through supply line 117 and check valve 153. Electrical current is delivered to and across electrodes 145 and 147 because of the conductive nature of the surgical fluid. As the current flows through the surgical fluid, the surgical fluid boils. As the surgical fluid boils, it expands rapidly out of pumping chamber 142 through annular gap 169. The expanding gas bubble pushes forward the surgical fluid in annular gap 169 downstream of pumping chamber 142. Subsequent pulses of electrical current form sequential gas bubbles that move or propel the surgical fluid down annular gap 169.

One skilled in the art will recognize that the numbering in FIGS. 8-10 is identical to the numbering in FIGS. 1-7 except for the addition of "100" in FIGS. 8-10.

As best seen in FIGS. 11-13, in a third embodiment of the present invention, handpiece 210 generally includes body 212, having power supply cable 213, irrigation/aspiration lines 215, and pumping chamber supply line 217. Distal end 211 of handpiece 210 contains pumping chamber 242 having a reservoir 243 formed between electrodes 245 and 247. Electrodes 245 and 247 are preferably made from aluminum and

electrically insulated from each other and body 212 by anodized layer 259 formed on electrodes 245 and 247. Anodized layer 259 is less conductive than untreated aluminum and thus, acts as an electrical insulator. Electrodes 245 and 247 and electrical terminals 261 and 263 are not anodized and thus, are electrically conductive. Layer 259 may be
5 formed by any suitable anodization technique, well-known in the art, and electrodes 245 and 247 and electrical terminals 261 and 263 may be masked during anodization or machined after anodization to expose bare aluminum. Electrical power is supplied to electrodes 245 and 247 through terminals 261 and 263 and wires 249 and 251, respectively. Fluid is supplied to reservoir 243 through supply line 217 and check valve
10 253. Extending distally from pumping chamber 242 is outer tube 265 that coaxially surrounds aspiration tube 267. Tubes 265 and 267 may be of similar construction as tube 30. Tube 267 is of slightly smaller diameter than tube 265, thereby forming an annular passage or gap 269 between tube 265 and tube 267. Annular gap 269 fluidly communicates with reservoir 243.

15 In use, surgical fluid enters reservoir 243 through supply line 217 and check valve 253. Electrical current is delivered to and across electrodes 245 and 247 because of the conductive nature of the surgical fluid. As the current flows through the surgical fluid, the surgical fluid boils. The current flow progresses from the smaller electrode gap section to the larger electrode gap section, i.e., from the region of lowest electrical
20 resistance to the region of higher electrical resistance. The boiling wavefront also progresses from the smaller to the larger end of electrode 247. As the surgical fluid boils, it expands rapidly out of pumping chamber 242 through annular gap 269. The expanding gas bubble pushes forward the surgical fluid in annular gap 269 downstream of pumping chamber 242. Subsequent pulses of electrical current form sequential gas bubbles that
25 move or propel the surgical fluid down annular gap 269.

One skilled in the art will recognize that the numbering in FIGS. 11-13 is identical to the numbering in FIGS. 1-7 except for the addition of "200" in FIGS. 11-13.

While several embodiments of the handpiece of the present invention are disclosed, any handpiece producing adequate pressure pulse force, temperature, rise time and frequency may also be used. For example, any handpiece producing a pressure pulse force of between 0.02 grams and 20.0 grams, with a rise time of between 1 gram/sec and 20,000 grams/sec and a frequency of between 1 Hz and 200 Hz may be used, with between 10 Hz and 100 Hz being most preferred. The pressure pulse force and frequency will vary with the hardness of the material being removed. For example, the inventors have found that a lower frequency with a higher pulse force is most efficient at debulking and removing the relatively hard nuclear material, with a higher frequency and lower pulse force being useful in removing softer epinuclear and cortical material. Infusion pressure, aspiration flow rate and vacuum limit are similar to current phacoemulsification techniques.

As seen in FIG. 10, one embodiment of control system 300 for use in operating handpiece 310 includes control module 347, power gain RF amplifier 312 and function generator 314. Power is supplied to RF amplifier 312 by DC power supply 316, which preferably is an isolated DC power supply operating at several hundred volts, but typically ± 200 volts. Control module 347 may be any suitable microprocessor, micro controller, computer or digital logic controller and may receive input from operator input device 318. Function generator 314 provides the electric wave form in kilohertz to amplifier 312 and typically operates at around 450 KHz or above to help minimize corrosion.

In use, control module 347 receives input from surgical console 320. Console 320 may be any commercially available surgical control console such as the LEGACY® SERIES TWENTY THOUSAND® surgical system available from Alcon Laboratories,

Inc., Fort Worth, Texas. Console 320 is connected to handpiece 310 through irrigation line 322 and aspiration line 324, and the flow through lines 322 and 324 is controlled by the user via footswitch 326. Irrigation and aspiration flow rate information in handpiece 310 is provided to control module 347 by console 320 via interface 328, which may be
5 connected to the ultrasound handpiece control port on console 320 or to any other output port. Control module 347 uses footswitch 326 information provided by console 320 and operator input from input device 318 to generate two control signals 330 and 332. Signal 332 is used to operate pinch valve 334, which controls the surgical fluid flowing from fluid source 336 to handpiece 310. Fluid from fluid source 336 is heated in the manner
10 described herein. Signal 330 is used to control function generator 314. Based on signal 330, function generator 314 provides a wave form at the operator selected frequency and amplitude determined by the position of footswitch 326 to RF amplifier 312 which is amplified to advance the powered wave form output to handpiece 310 to create heated, pressurized pulses of surgical fluid.

15 Any of a number of methods can be employed to limit the amount of heat introduced into the eye. For example, the pulse train duty cycle of the heated solution can be varied as a function of the pulse frequency so that the total amount of heated solution introduced into the eye does not vary with the pulse frequency. Alternatively, the aspiration flow rate can be varied as a function of pulse frequency so that as pulse
20 frequency increases aspiration flow rate increases proportionally.

FIGS. 15-18 show a preferred embodiment of a container 500 for delivery of a surgical fluid to an ophthalmic surgical handpiece. Container 500 is described herein as delivering a surgical fluid to a liquefracture handpiece such as liquefracture handpieces 10, 110, 210, or 310. However, container 500 may also be used with other surgical
25 handpieces, such as those used in otic or nasal surgery. Container 500 is represented by

fluid source 336 in FIG. 14. A bottom 516 of container 500 is designed to removably engage with a receptacle 508 (FIGS. 19 and 20) of surgical console 320.

Container 500 is preferably a conventional multilayer plastic bottle having a first a first portion or body 510 and a second portion or deformable liner 512 located within first
5 portion 510. Second portion 512 is preferably formed from a deformable plastic that is separable from first portion 510. By way of example, second portion 512 may be formed of nylon. As another example, second portion 512 may be formed of an inner layer of polypropylene coupled to an outer layer of ethylene vinyl oxide with an adhesive therebetween. First portion 510 is preferably formed from a more rigid plastic than used
10 to form second portion 512. By way of example, first portion 510 may be formed of high density polyethylene. As another example, first portion 510 may be formed of polypropylene. Container 500 is preferably formed using a conventional injection molding process. Alternatively, first portion 510 may be formed from stainless steel or other relatively rigid, non-plastic material, and second portion 512 may be formed from a
15 deformable material other than plastic.

First portion 510 generally includes an open mouth 514, a side wall 518, a first transverse wall 530, and a second transverse wall 536. First transverse wall 530 is formed with an aperture 520. Container 500 preferably also has a cap 522 that may be secured to mouth 514. Cap 522 is preferably made of aluminum and is crimp sealed to mouth 514.
20 Alternatively, cap 522 may be secured to mouth 514 by way of threads (not shown). Cap 522 preferably includes a rubber stopper 523 having a hole 524 therethrough designed to sealingly receive pumping chamber supply line 117 or 217. Alternatively, mouth 514 of first portion 510 may be sealed only by rubber stopper 523.

Second transverse wall 536 preferably includes an aperture 540 that is preferably
25 disposed in the center of container 500, a first side 542, and a second side 544. First side

542 also preferably includes a recessed volume 546. Second side 544 preferably includes an annular skirt 548 and at least one raised surface 550. As shown best in FIGS. 16 and 18, raised surface 550 preferably has an arc length of about 120 degrees. The second side 544 of second transverse wall 536 creates a pattern that can be used to identify the particular kind of surgical fluid held within container 500, and also whether container 500 is engaged within receptacle 508. Although not shown in the FIGS., second side 544 may be formed with no raised surface 550 or with various combinations of multiple raised surfaces 550. For example, two raised surfaces 550 may form a continuous raised surface of 240 degrees. As another example, three raised surfaces 550 may form a continuous raised surface of 360 degrees. One skilled in the art will recognize that, given the 120 degree arc length of raised surface 550 and the possible angular positions around aperture 540, second side 544 of second transverse wall 536 may be formed with seven unique patterns of raised surfaces. Each such pattern is representative of a binary signal (e.g. 001, 011, 101, 110, 010, 111, 000) where 1 indicates the presence of a raised surface and 0 indicates the absence of a raised surface. Of course, if a different arc length is used for each raised surface 550, second side 544 of second transverse wall 536 may be formed with more or less than seven unique patterns of raised surfaces. Three lugs 552 are disposed on an outer surface of side wall 518 proximate first transverse wall 530. Lugs 552 are preferably spaced at 115 degree intervals around aperture 540.

Receptacle 508 generally includes a housing 602, an interior 604, a piston 606, a piston retainer 608, a pressure spine or needle 610, and a plurality of sensors 614. Interior 604 receives bottom 516 of container 500. The inner surface of interior 604 has three slots 616 for operative engagement with lugs 552 of container 500. Each of slots 616 preferably has a "L"-shaped geometry, with one leg of the "L" extending in a clockwise direction along the circumference of the inner surface of interior 604 for a distance of less

than 90 degrees. Piston 606 has a face seal 618 on a front end thereof, and is biased outwardly from interior 604 by a spring 620 disposed in cavity 622. Piston retainer 608 secures piston 606 within interior 604 and is secured to housing 602 via bolts 624.

Pressure spine 610 has a sharp tip 626 and a lumen 612 that is fluidly coupled to a source of pressurized fluid (e.g. pressurized air) within surgical console 320. Sensors 614 are

preferably spaced at 120 degree intervals around pressure spine 610 for operative engagement with raised surfaces 550 of container 500. Each sensor 614 preferably includes a plunger 615 that is capable of movement along the longitudinal axis of housing

602 and that is biased outwardly by a spring 628 mounted on a spring seat 629; a fin 617

coupled to plunger 615; and an optical sensor 619 mounted on a printed circuit board 621.

An optical path or signal (e.g. beam of light) is formed across the width of sensor 614 via dual apertures 623 of optical sensor 619. An exemplary optical sensor 619 suitable for sensor 614 is the EESJ3G interruptive sensor available from Omron Sensors.

Alternatively, sensor 614 may be a conventional force resistive sensor that measures the

deflection or deflection force of plunger 615. Such a force resistive sensor may be formed without fin 617, optical sensor 619, and printed circuit board 621. Receptacle 508 is mounted within surgical console 320 via mounting bracket 630.

When a user aligns lugs 552 with slots 616, slides bottom 516 of container 500 into interior 604, and then twists container 500 in a clockwise direction, container 500 is removably secured within receptacle 508. At the same time, the inner surface of annular skirt 548 engages the outer surface of piston 606, and piston 606 moves inwardly through cavity 622 allowing pressure spine 610 to engage aperture 540 of second transverse wall 536. Recessed volume 546 prevents pressure spine 610 from contacting first transverse wall 530 or piercing second portion 512 holding the surgical fluid. At portions of second side 544 of second transverse wall 536 containing raised surfaces 550, the plunger 615 of

the corresponding sensor 614 is depressed. If no raised surface 550 is present, the plunger 615 of the corresponding sensor 614 is not depressed, or alternatively is depressed a smaller amount than when a raised surface 550 is present. When a plunger 615 of a sensor 614 is depressed, fin 617 moves between dual apertures 623 of optical sensor 619 to break the optical path of sensor 619. Each sensor 614 having a plunger 615 that is depressed combines to generate a binary, electrical signal representative of a unique pattern of raised surfaces 550 on second side 544 of second transverse wall 536 that is transmitted to surgical console 320 via printed circuit board 621. Control module 347 of surgical console 320 may be programmed to associate such electrical signals with a particular surgical fluid having particular properties (e.g. viscosity, surgical fluid supply pressure). In addition, control module 347 may automatically alter or adjust surgical fluid supply pressure, or other operating parameters of control system 300, surgical console 320, or liquefracture handpiece 10, 110, 210, or 310, as a function of the particular surgical fluid.

Once container 500 is engaged within receptacle 508 as described above, surgical fluid from container 500 is delivered to liquefracture handpiece 210 in the following preferred manner. Pressurized air is delivered from lumen 612 of pressure spine 610, through aperture 540 of second transverse wall 536, and through aperture 520 of first transverse wall 530. As shown best in FIG. 21, the pressurized air enters the space between the outer surface of second portion 512 and the inner surface of first portion 510, separating second portion 512 from first portion 510, and at least partially collapsing second portion 512. The pressurized air forces the surgical fluid from within second portion 512 to handpiece 210 via tubing 217.

FIG. 22 shows a second, preferred embodiment of a container 700 for delivery of a surgical fluid to an ophthalmic surgical handpiece. Container 700 is substantially similar

to container 500 of FIGS. 15-18, except that container 700 has a single transverse wall 702 having sides 704 and 706, instead of two transverse walls 530 and 536. First side 704 has a geometry substantially similar to first transverse wall 530 and also includes recessed volume 546. Second side 706 has a geometry substantially similar to second transverse wall 536 without recessed volume 546. Container 700 is preferably made, and used to deliver surgical fluid to a liquefracture handpiece, in a substantially similar manner to that described above for container 500.

From the above, it may be appreciated that the present invention provides a simple and reliable apparatus and method of delivering a surgical fluid to a surgical handpiece. The invention further provides an automated way of identifying the particular surgical fluid to be provided to the handpiece.

The present invention is illustrated herein by example, and various modifications may be made by a person of ordinary skill in the art. For example, second transverse wall 536 of container 500, or second side 706 of transverse wall 702 of container 700, may be formed without aperture 540. In this case, reference numeral 540 indicates the longitudinal axis of container 500, and sharp tip 626 of pressure spine 610 may be formed to pierce second transverse wall 536 or transverse wall 702.

It is believed that the operation and construction of the present invention will be apparent from the foregoing description. While the apparatus and methods shown or described above have been characterized as being preferred, various changes and modifications may be made therein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A container for delivery of a surgical fluid to a surgical handpiece, comprising:

5 a first portion made from a deformable material and having a closed end, an open end, an outer surface, and a first volume for receiving a surgical fluid for delivery to a surgical handpiece;

a second portion made from a material more rigid than said deformable material and having a first end, a second end, an outer surface, an inner surface, a first transverse wall, a second transverse wall, and a second volume receiving said first portion, said first
10 end having an outlet for delivery of said surgical fluid, said first transverse wall having an aperture for receiving a pressurized fluid between said outer surface of said first portion and said inner surface of said second portion, said second transverse wall having first and second sides, said second side of said second transverse wall having an area for
15 removably engaging a source of said pressurized fluid so that said source of said pressurized fluid is in fluid communication with said aperture.

2. The container of claim 1 wherein said area of said second side of said second transverse wall is capable of being engaged by a lumen for providing said pressurized fluid.

20 3. The container of claim 1 wherein said second side of said second transverse wall has a geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

4. The container of claim 3 wherein said geometry comprises at least one raised surface.

5. The container of claim 1 wherein said first portion is at least partially separable from said second portion when said surgical fluid is discharged from said first volume.

6. The container of claim 1 further comprising:
5 a stopper disposed in said outlet of said second portion; and
tubing sealingly disposed within said stopper and in fluid communication with said first volume.

7. The container of claim 1 further comprising a plurality of lugs disposed on an outer surface of said second portion for alignment and operative engagement with a
10 receptacle in a surgical console.

8. The container of claim 1 wherein said first side of said second transverse wall defines a third volume between said second transverse wall and said first transverse wall.

9. A container for delivery of a surgical fluid to a surgical handpiece,
15 comprising:
a first portion made from a deformable material and having a closed end, an open end, an outer surface, and a first volume for receiving a surgical fluid for delivery to a surgical handpiece;

a second portion made from a material more rigid than said deformable material
20 and having a first end, a second end, an outer surface, an inner surface, a transverse wall having a first side and a second side, and a second volume receiving said first portion, said first end having an outlet for delivery of said surgical fluid, said first side of said transverse wall having an aperture for receiving a pressurized fluid between said outer surface of said first portion and said inner surface of said second portion, said second side
25 of said transverse wall having an area for removably engaging a source of said pressurized

fluid so that said source of said pressurized fluid is in fluid communication with said aperture.

10. The container of claim 9 wherein said area of said second side of said transverse wall is capable of being engaged by a lumen for providing said pressurized fluid.

11. The container of claim 9 wherein said second side of said transverse wall has a geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

12. The container of claim 11 wherein said geometry comprises at least one raised surface.

13. The container of claim 9 wherein said first portion is at least partially separable from said second portion when said surgical fluid is discharged from said first volume.

14. The container of claim 9 further comprising:
a stopper disposed in said outlet of said second portion; and
tubing sealingly disposed within said stopper and in fluid communication with said first volume.

15. The container of claim 9 further comprising a plurality of lugs disposed on an outer surface of said second portion for alignment and operative engagement with a receptacle in a surgical console.

16. The container of claim 9 wherein said first side of said transverse wall defines a third volume between said transverse wall and said closed end of said first portion.

17. A container for delivery of a surgical fluid to a surgical handpiece,
comprising:

a deformable liner having a first volume for receiving a surgical fluid for delivery to a surgical handpiece;

5 a body having a second volume receiving said deformable liner, an open mouth, a first transverse wall having an aperture disposed therethrough, a second transverse wall having first and second sides, said second side of said second transverse wall having an area for removably engaging a source of pressurized fluid so that said source of said pressurized fluid is in fluid communication with said aperture and a space between said body and said liner.

18. The container of claim 17 wherein said second side of said second transverse wall has a geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

19. A container for delivery of a surgical fluid to a surgical handpiece, comprising:

15 a deformable liner having a first volume for receiving a surgical fluid for delivery to a surgical handpiece;

a body having a second volume receiving said deformable liner, an open mouth, a transverse wall having a first side, a second side, and an aperture disposed therethrough, said second side of said transverse wall having an area for removably engaging a source of pressurized fluid so that said source of said pressurized fluid is in fluid communication with said aperture and a space between said body and said liner.

20. The container of claim 19 wherein said second side of said transverse wall has a geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

21. A system for delivering a surgical fluid to a liquefracture handpiece, comprising:

25

a liquefracture handpiece having a pumping chamber;

a container having:

a first portion made from a deformable material and having a closed end, an open end, an outer surface, and a first volume for receiving a surgical fluid for delivery to a surgical handpiece;

a second portion made from a material more rigid than said deformable material and having a first end, a second end, an outer surface, an inner surface, a first transverse wall, a second transverse wall, and a second volume receiving said first portion, said first end having an outlet for delivery of said surgical fluid, said first transverse wall having an aperture for receiving a pressurized fluid between said outer surface of said first portion and said inner surface of said second portion, said second transverse wall having first and second sides, said second side of said second transverse wall having an area for removably engaging a source of said pressurized fluid so that said source of said pressurized fluid is in fluid communication with said aperture;

a surgical console containing said source of said pressurized fluid and having a receptacle for removably receiving said container, said receptacle having a lumen for fluidly coupling said source of said pressurized fluid with said area of said second side of said second transverse wall; and

tubing fluidly coupling said outlet of said second portion with said liquefracture handpiece;

whereby when said surgical console provides said pressurized fluid from said lumen, said pressurized fluid flows through said aperture and between said outer surface of said first portion and said inner surface of said second portion, and said surgical fluid is delivered to said pumping chamber by said tubing.

22. The system of claim 21 wherein said pressurized fluid is air.

23. The system of claim 21 wherein said second side of said second transverse wall has a geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

24. The system of claim 23 wherein said geometry comprises at least one raised surface.

25. The system of claim 23 wherein said receptacle comprises a plurality of sensors for operatively engaging said geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

26. The system of claim 21 further comprising a plurality of lugs disposed on an outer surface of said second portion for alignment and operative engagement with a plurality of slots in said receptacle.

27. The system of claim 26 wherein said lugs and slots cooperate to removably secure said container to said receptacle.

28. A system for delivering a surgical fluid to a liquefracture handpiece, comprising:

a liquefracture handpiece having a pumping chamber;

a container having:

a first portion made from a deformable material and having a closed end, an open end, an outer surface, and a first volume for receiving a surgical fluid for delivery to a surgical handpiece;

a second portion made from a material more rigid than said deformable material and having a first end, a second end, an outer surface, an inner surface, a transverse wall having a first side and a second side, and a second volume receiving said first portion, said first end having an outlet for delivery of said surgical fluid, said first side of said transverse wall having an aperture for receiving a pressurized fluid between

said outer surface of said first portion and said inner surface of said second portion, said second side of said transverse wall having an area for removably engaging a source of said pressurized fluid so that said source of said pressurized fluid is in fluid communication with said aperture;

5 a surgical console containing said source of said pressurized fluid and having a receptacle for removably receiving said container, said receptacle having a lumen for fluidly coupling said source of said pressurized fluid with said area of said second side of said transverse wall; and

tubing fluidly coupling said outlet of said second portion with said liquefracture
10 handpiece;

whereby when said surgical console provides said pressurized fluid from said lumen, said pressurized fluid flows through said aperture and between said outer surface of said first portion and said inner surface of said second portion, and said surgical fluid is delivered to said pumping chamber by said tubing.

15 29. The system of claim 28 wherein said pressurized fluid is air.

30. The system of claim 28 wherein said second side of said transverse wall has a geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

20 31. The system of claim 30 wherein said geometry comprises at least one raised surface.

32. The system of claim 30 wherein said receptacle comprises a plurality of sensors for operatively engaging said geometry for providing a binary signal indicative of a particular kind of said surgical fluid.

33. The system of claim 28 further comprising a plurality of lugs disposed on an outer surface of said second portion for alignment and operative engagement with a plurality of slots in said receptacle.

5 34. The system of claim 33 wherein said lugs and slots cooperate to removably secure said container to said receptacle.

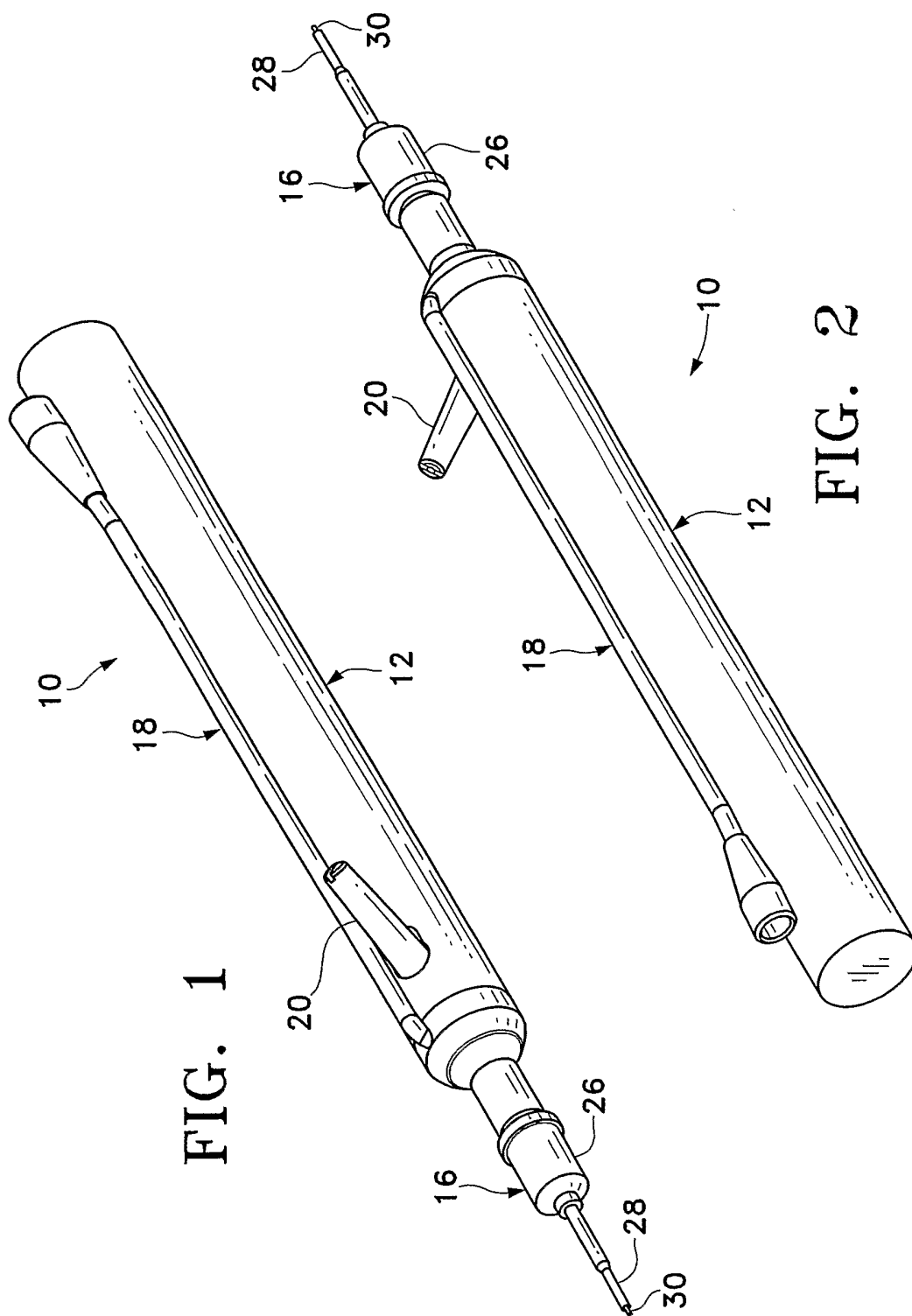
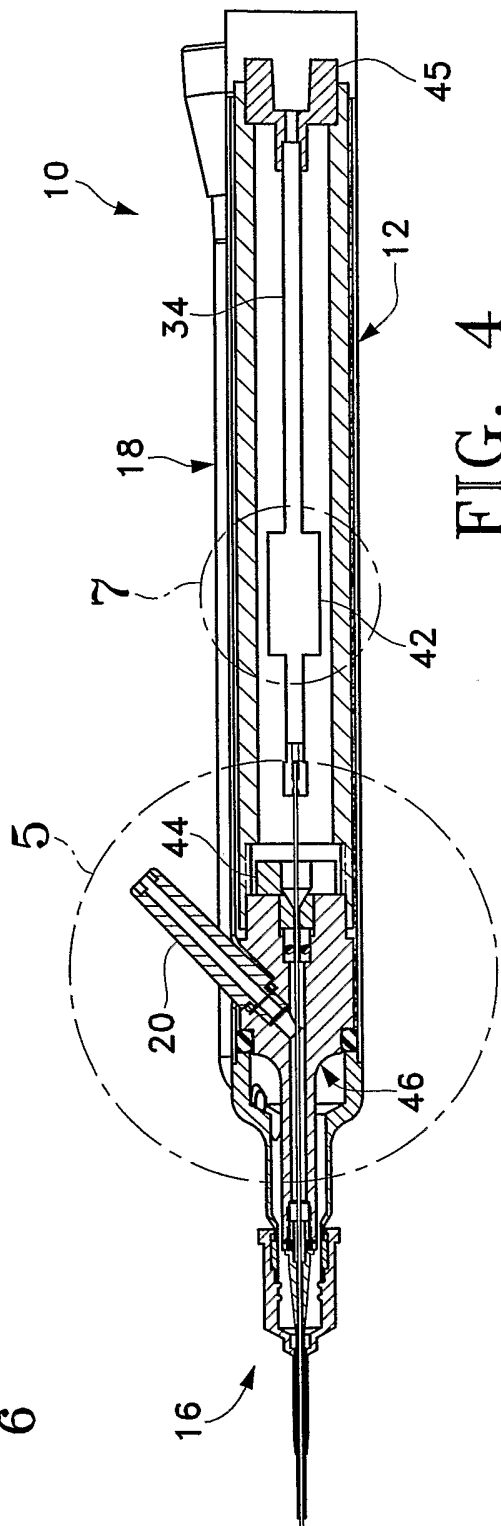
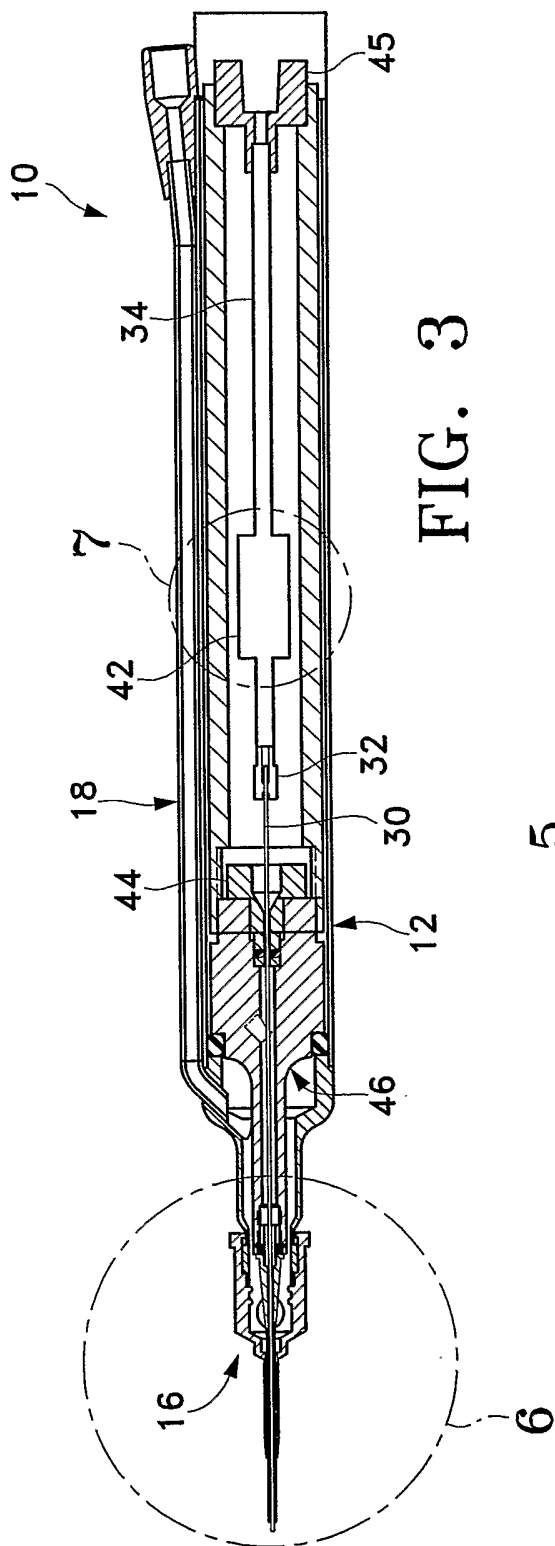


FIG. 1

FIG. 2



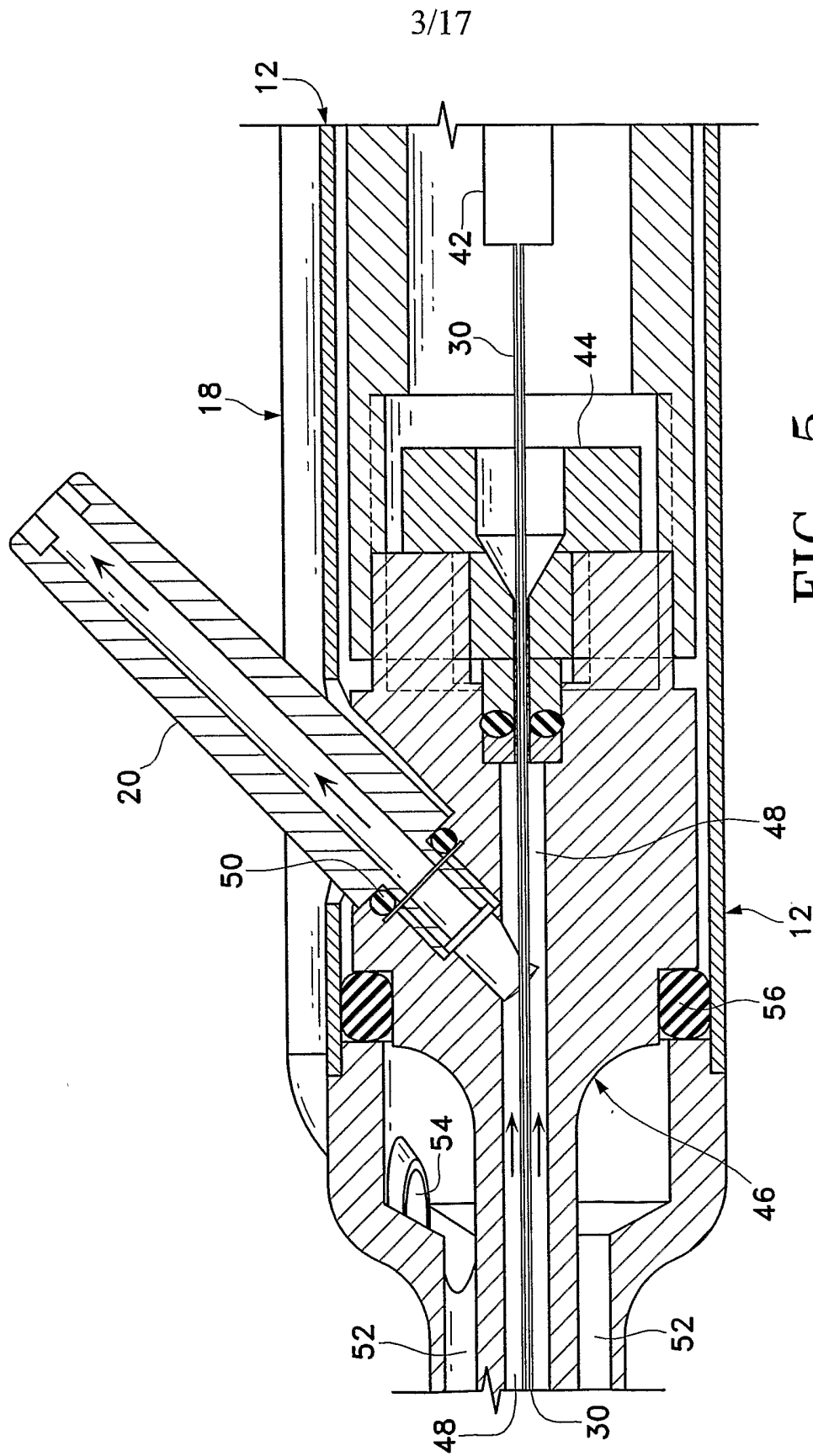


FIG. 5

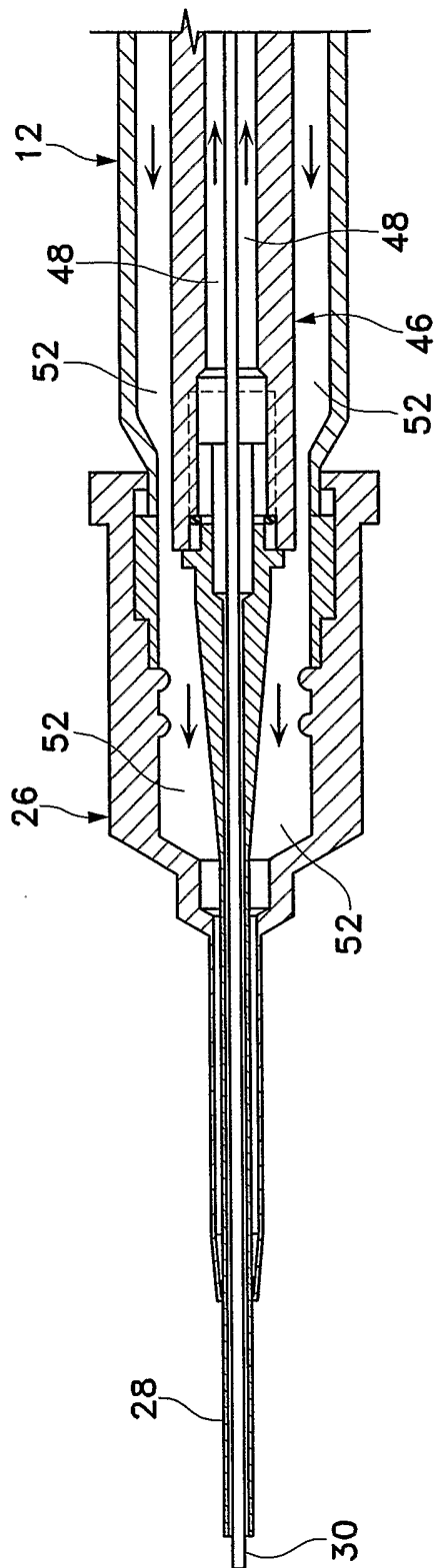


FIG. 6

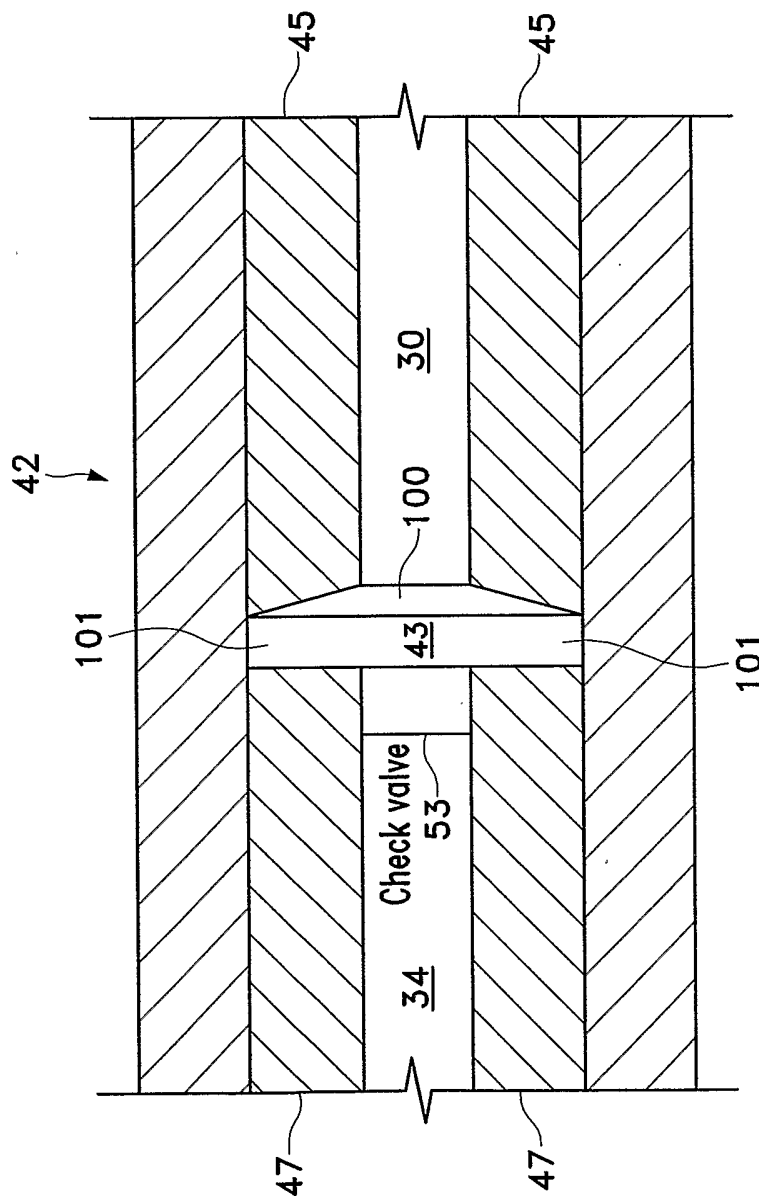


FIG. 7

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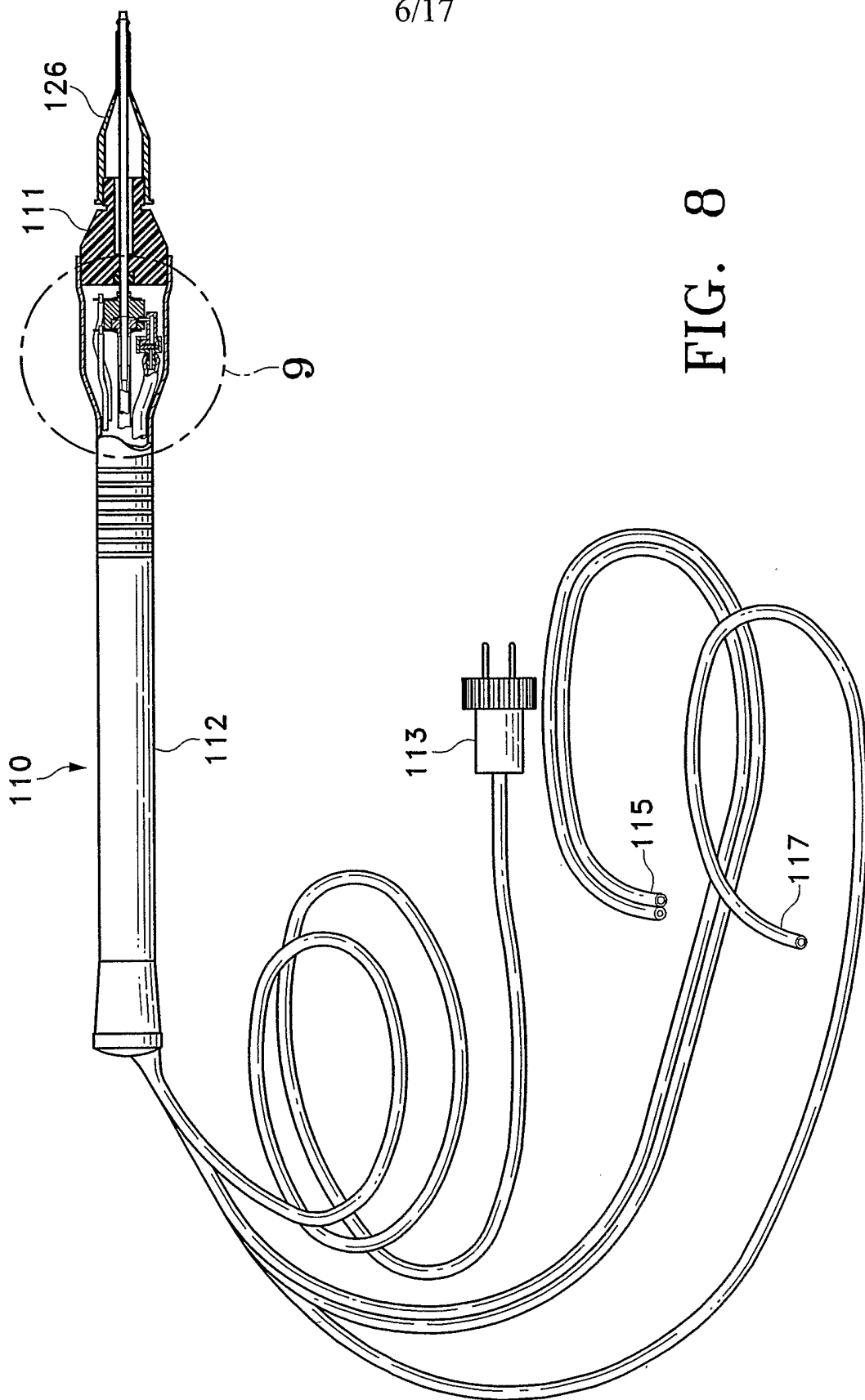


FIG. 8

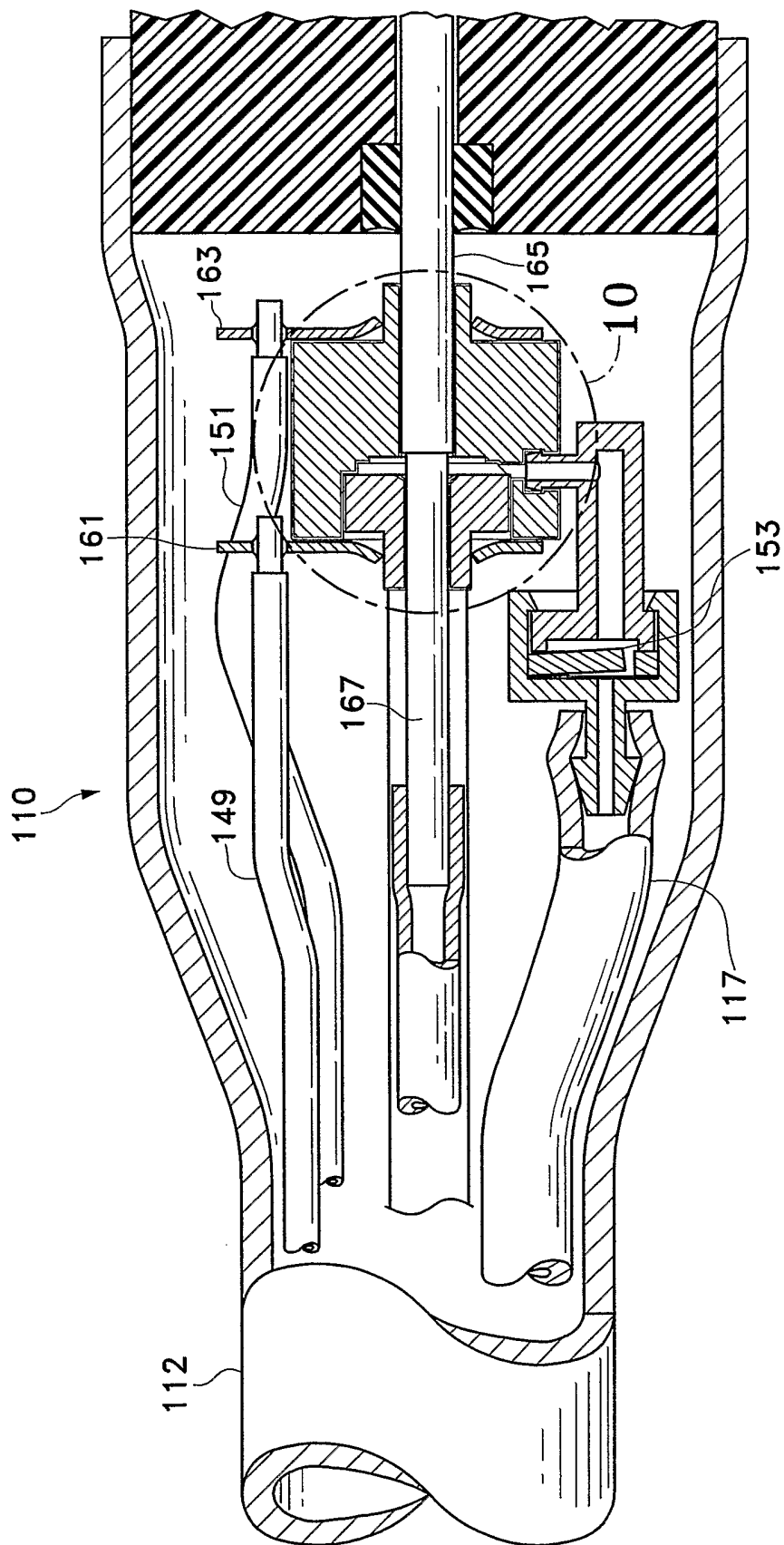


FIG. 9

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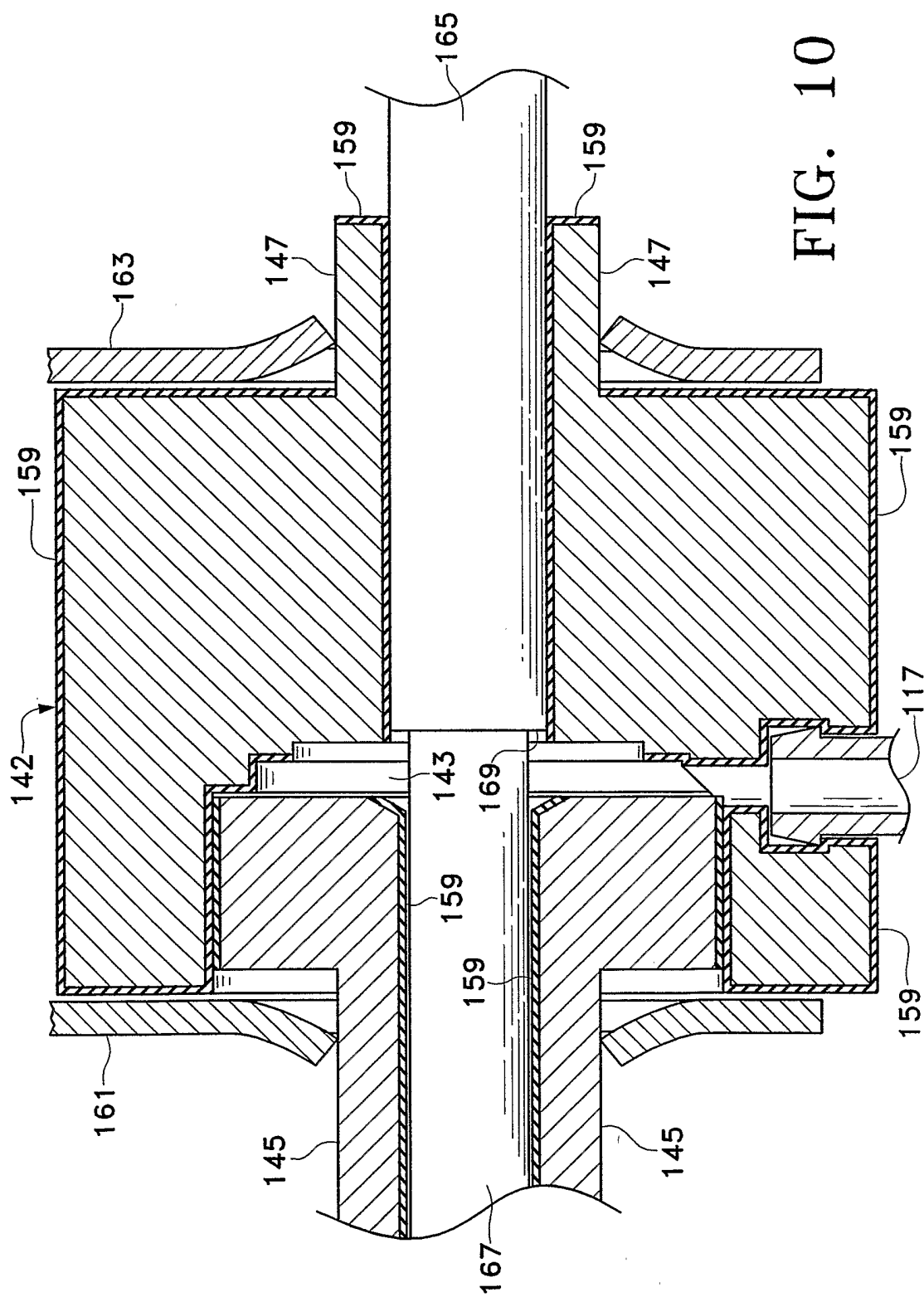


FIG. 10

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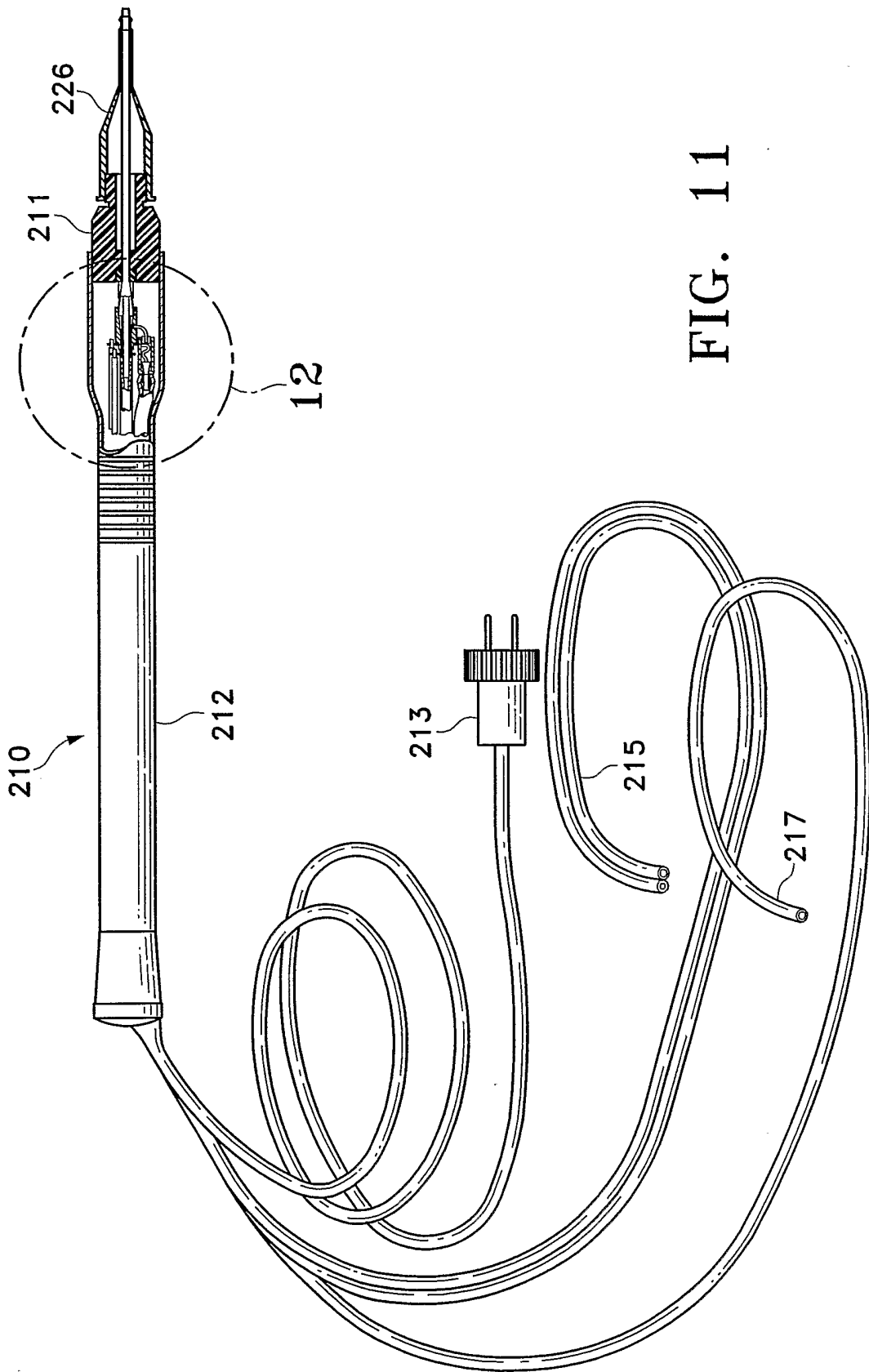


FIG. 11

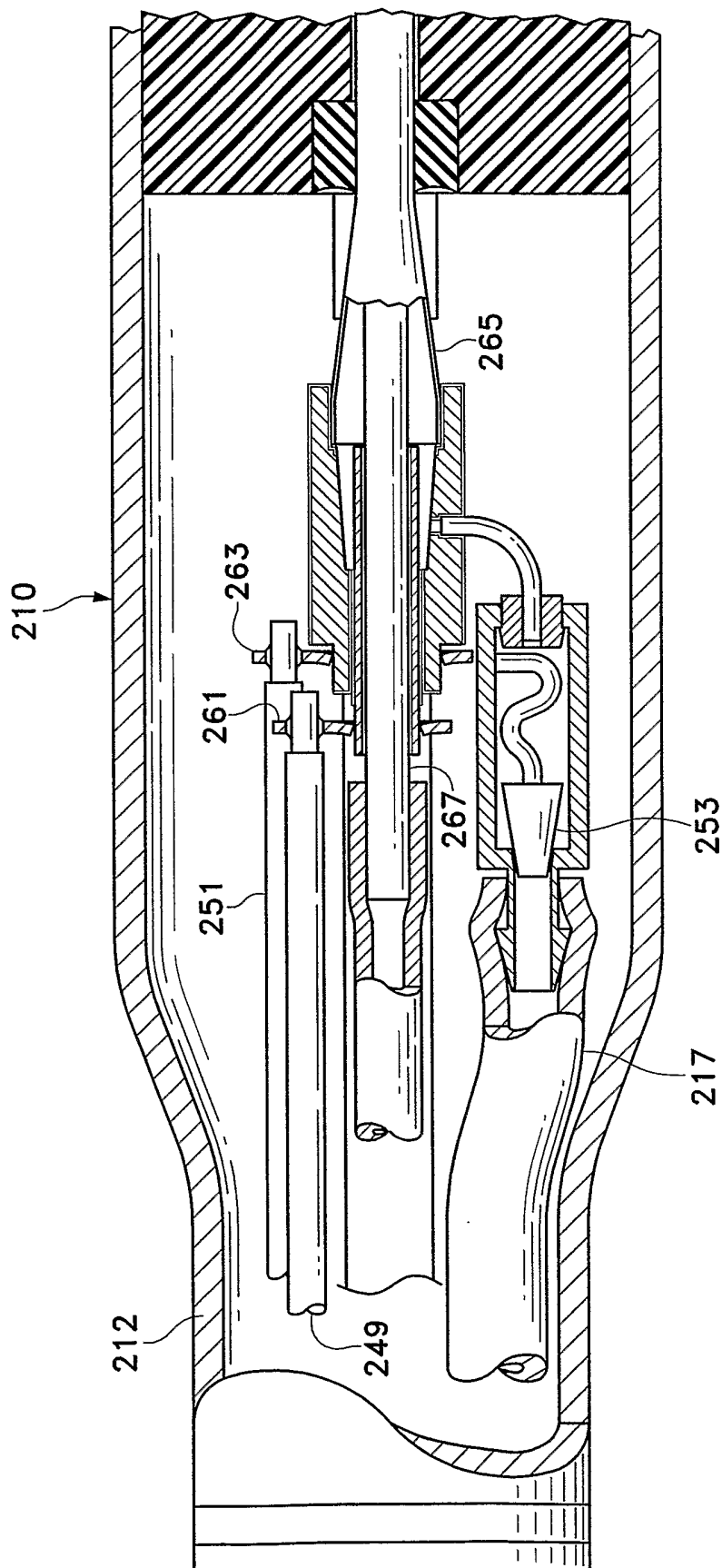


FIG. 12

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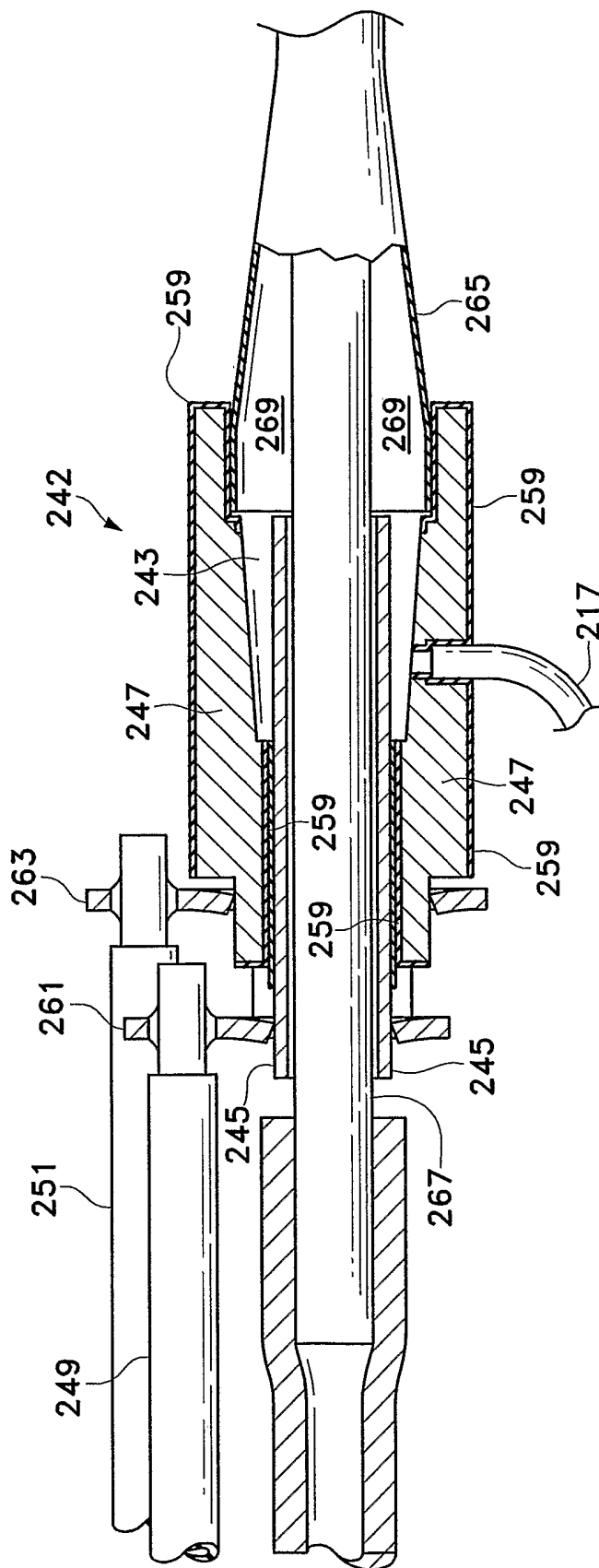


FIG. 13

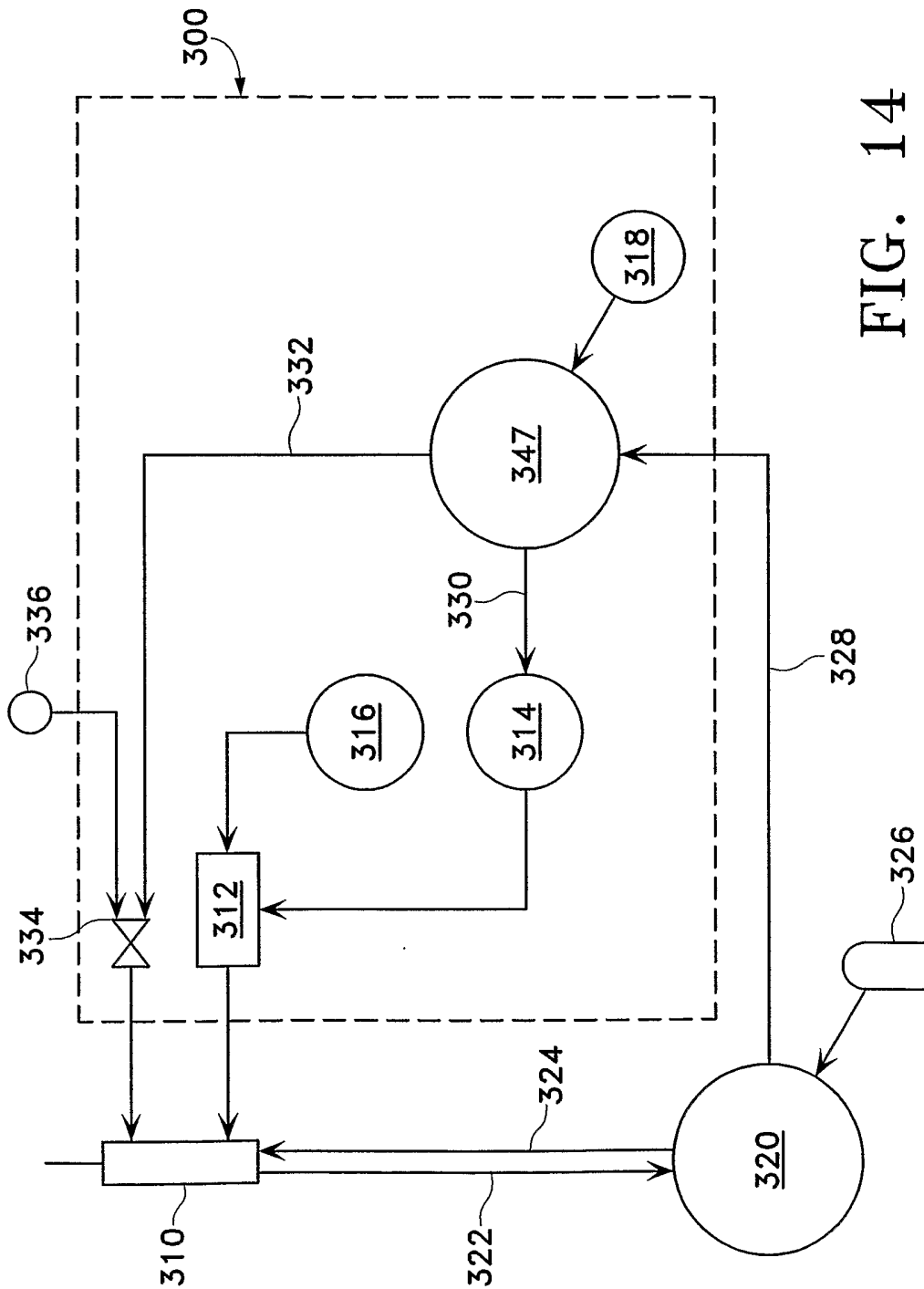


FIG. 14

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FIG. 15

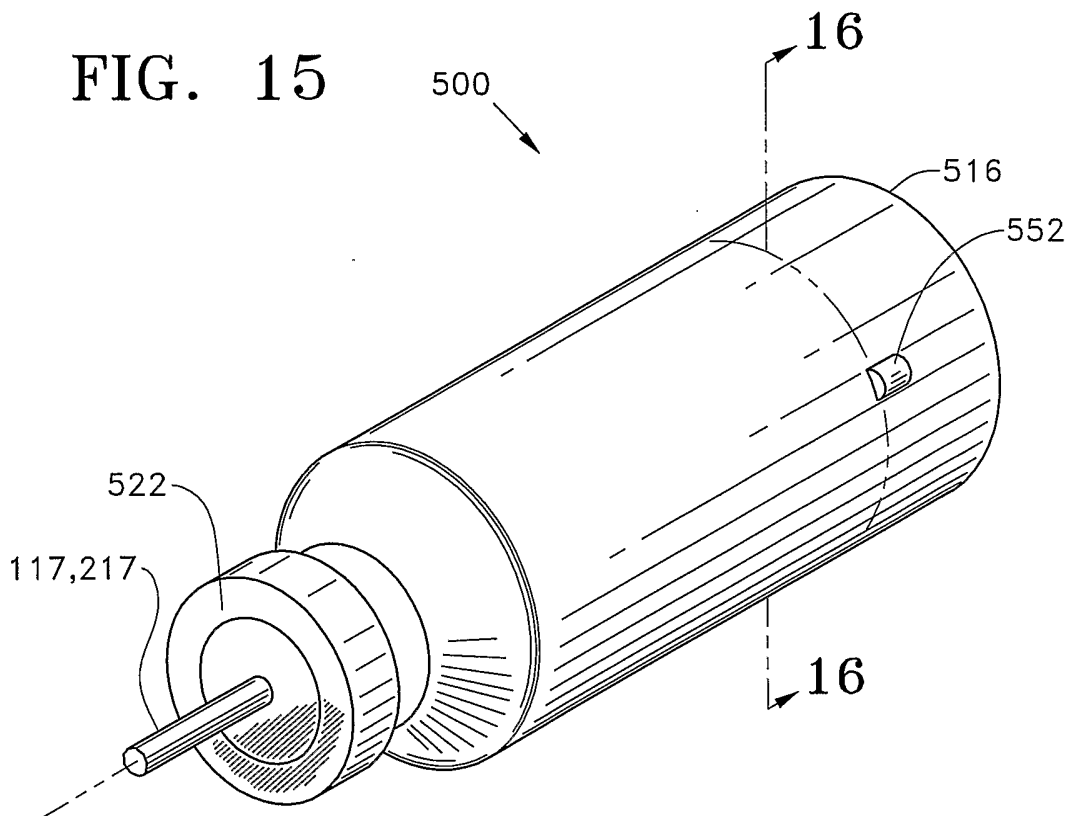


FIG. 16

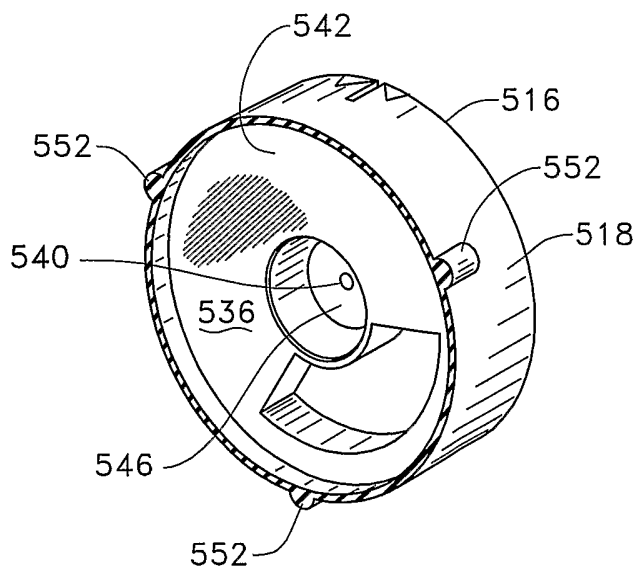


FIG. 17

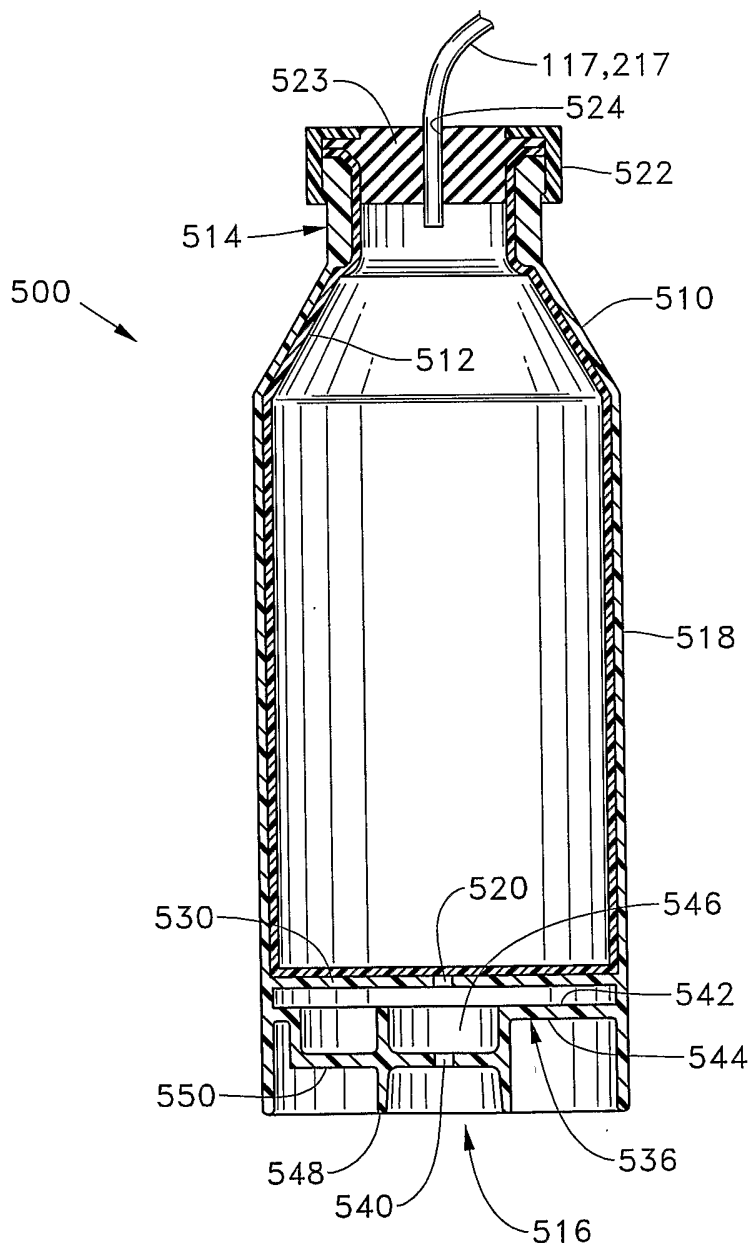


FIG. 18

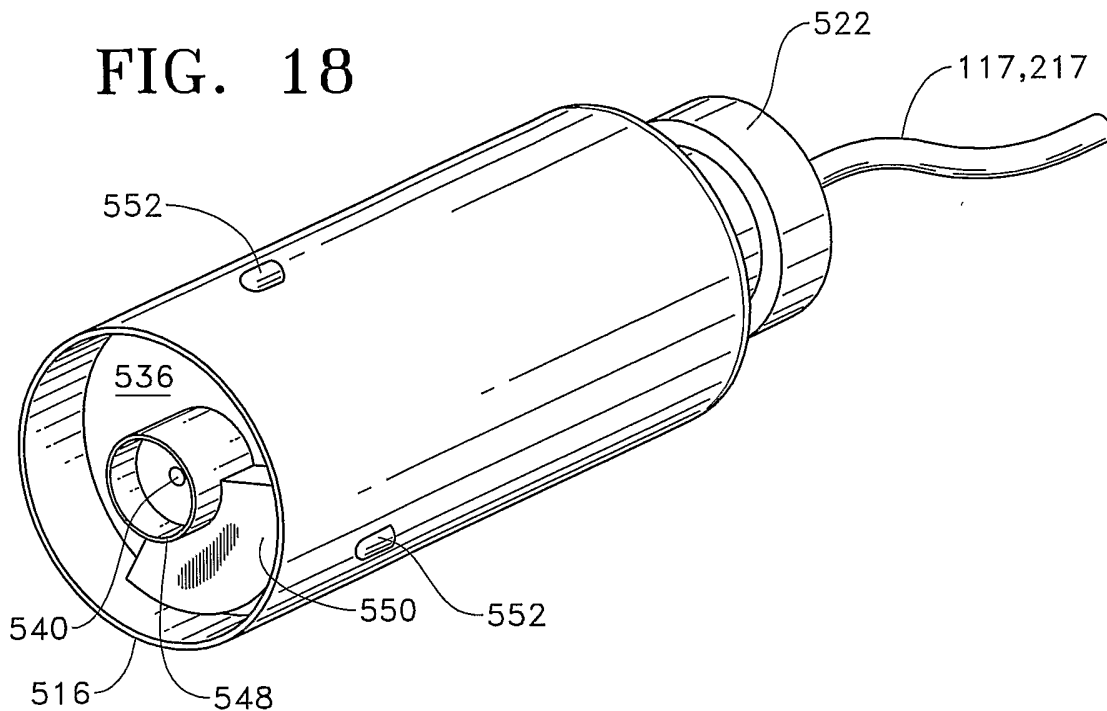
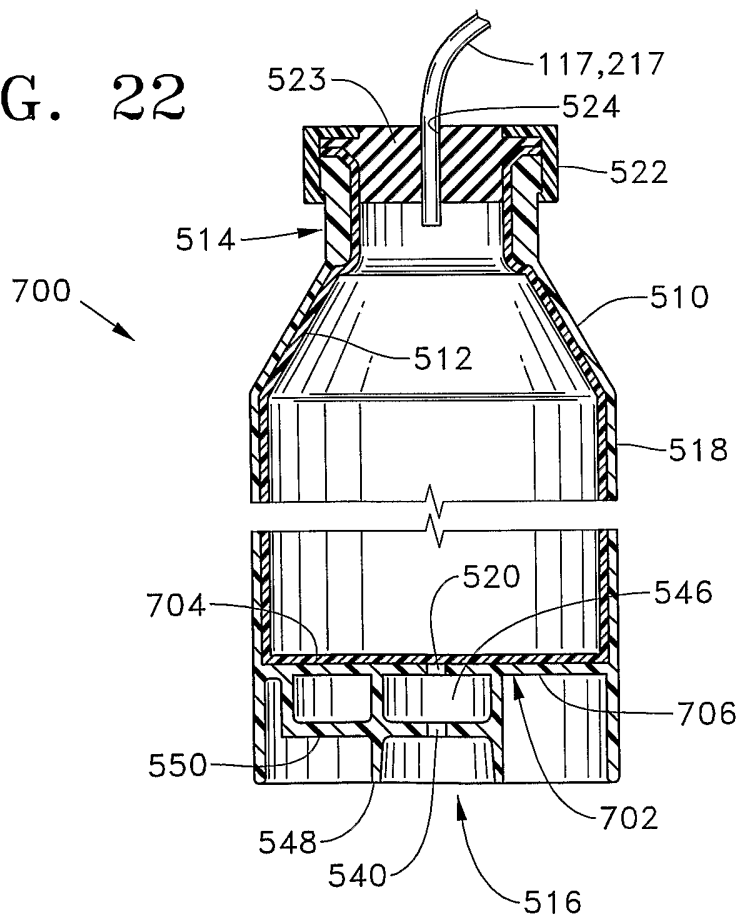


FIG. 22



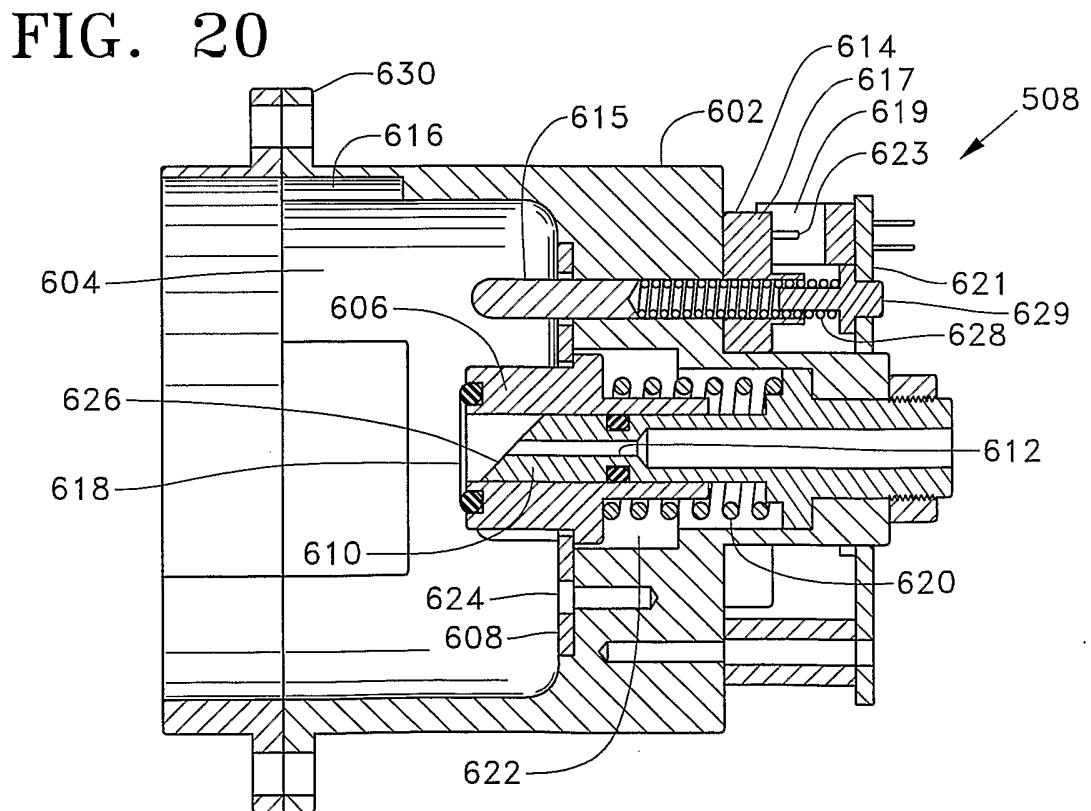
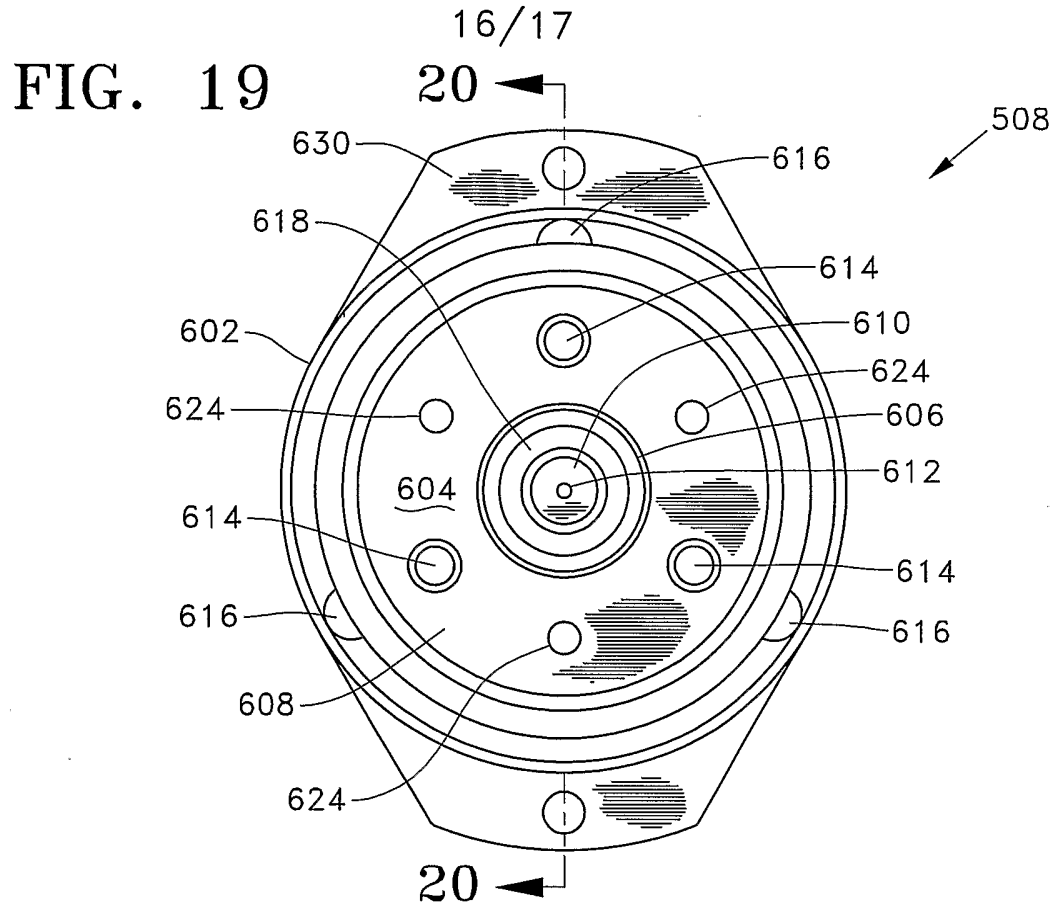
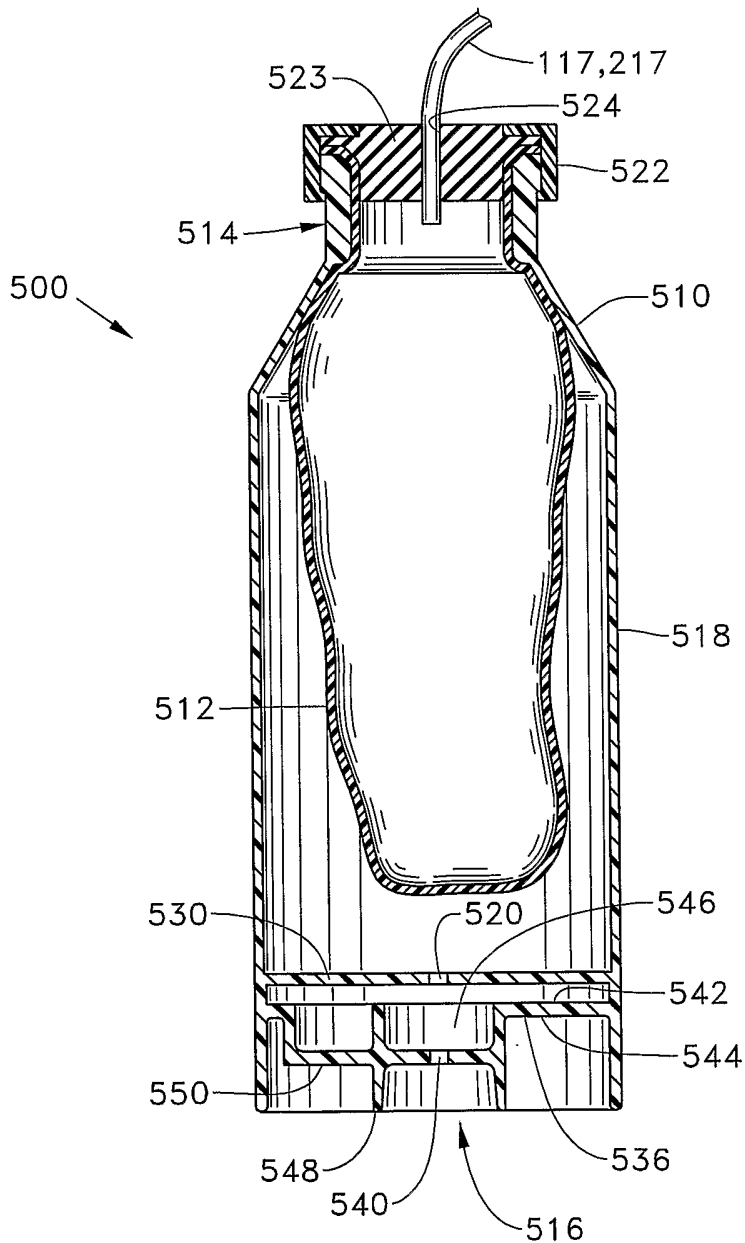


FIG. 21



INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/22909

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 A61F9/007 A61M1/00 A61M15/00 A61B17/32 A61B18/14
 A61F2/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 A61F A61M A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
 EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 363 932 B1 (JOHNSON ROBERT ET AL) 2 April 2002 (2002-04-02) column 4, line 26 -column 4, line 41 column 6, line 11 -column 6, line 19; claims 1,4,7,9; figure 1 ----	1,2,5-7
A	US 6 340 355 B1 (BARRETT GRAHAM DAVID) 22 January 2002 (2002-01-22) column 4, line 29 -column 5, line 29; claims 1,11-14,17; figures 3,8,10 ----	1,4
A	US 4 301 802 A (POLER STANLEY) 24 November 1981 (1981-11-24) column 1, line 63 -column 1, line 66; figure 5 ----- -/--	1,2

Further documents are listed in the continuation of box C. Patent family members are listed in annex.

° Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
E earlier document but published on or after the international filing date	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
O document referring to an oral disclosure, use, exhibition or other means	*G* document member of the same patent family
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 3 December 2003	Date of mailing of the international search report 11/12/2003
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Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Merté, B
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/22909

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01 30286 A (ALCON LAB INC) 3 May 2001 (2001-05-03) cited in the application figures 7,9 -----	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 03/22909

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: 9-34
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 9-34

In view of the large number of 6 independent and also the wording of the claims presently on file, which render it difficult, if not impossible, to determine the matter for which protection is sought, the present application fails to comply with the clarity and conciseness requirements of Article 6 PCT (see also Rule 6.1(a) PCT) to such an extent that a meaningful search is impossible. Consequently, the search has been carried out for those parts of the application which do appear to be clear (and concise), namely claims 1-8.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/22909

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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