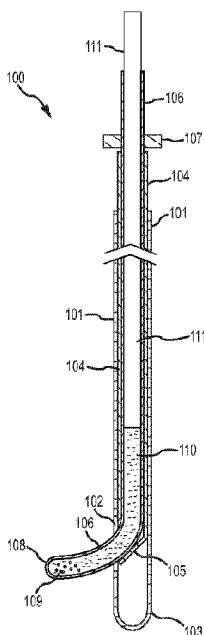




(86) Date de dépôt PCT/PCT Filing Date: 2013/07/26
(87) Date publication PCT/PCT Publication Date: 2014/01/30
(45) Date de délivrance/Issue Date: 2021/06/08
(85) Entrée phase nationale/National Entry: 2015/01/06
(86) N° demande PCT/PCT Application No.: US 2013/052301
(87) N° publication PCT/PCT Publication No.: 2014/018871
(30) Priorité/Priority: 2012/07/27 (US61/676,767)

(51) Cl.Int./Int.Cl. *A61M 25/088* (2006.01),
A61M 25/09 (2006.01)
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(54) Titre : CATHETER DE MICRO-INJECTION
(54) Title: MICROINJECTION CATHETER



(57) **Abrégé/Abstract:**

An insertion device for delivering media inside a patient includes an outer guide tube having a side port. An inner guide tube is nested within the outer guide tube and movable axially within the outer guide tube. The inner guide tube includes a deflector at an end within the outer guide tube. The device also includes a catheter nested within the inner guide tube and movable axially within the inner guide tube. The deflector of the inner guide tube is positionable such that it deflects the dispensing end of the catheter outward through the opening in the outer guide tube when the catheter is advanced axially within the inner guide tube. A therapeutic delivery cannula may be nested within the catheter, such that the deflected end of the catheter determines the direction of travel of the therapeutic delivery cannula into patient tissue when the cannula emerges from the catheter.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
30 January 2014 (30.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/018871 A1

- (51) **International Patent Classification:**
A61M 25/088 (2006.01) *A61M 25/09* (2006.01)
- (21) **International Application Number:**
PCT/US2013/052301
- (22) **International Filing Date:**
26 July 2013 (26.07.2013)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/676,767 27 July 2012 (27.07.2012) US
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- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).
- Published:** — with international search report (Art. 21(3))

(54) **Title:** MICROINJECTION CATHETER

(57) **Abstract:** An insertion device for delivering media inside a patient includes an outer guide tube having a side port. An inner guide tube is nested within the outer guide tube and movable axially within the outer guide tube. The inner guide tube includes a deflector at an end within the outer guide tube. The device also includes a catheter nested within the inner guide tube and movable axially within the inner guide tube. The deflector of the inner guide tube is positionable such that it deflects the dispensing end of the catheter outward through the opening in the outer guide tube when the catheter is advanced axially within the inner guide tube. A therapeutic delivery cannula may be nested within the catheter, such that the deflected end of the catheter determines the direction of travel of the therapeutic delivery cannula into patient tissue when the cannula emerges from the catheter.



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MICROINJECTION CATHETER

BACKGROUND OF THE INVENTION

5 Cell therapy has shown great promise in the treatment of a wide range of neurological diseases, including Parkinson's disease (PD), Huntington's disease, and stroke.

To date, cell therapies have been delivered to the human brain with a stereotactically inserted straight cannula. While effective for small animal experimental models, straight cannula transplantation strategies present significant challenges when scaled-up for human therapy. The
10 human brain is 800 to 2300 times larger than that of rodents used for preclinical research. With a straight cannula, cell delivery to the larger target volumes of human brain requires several independent brain penetrations. Some patients with PD have received up to 16 separate penetrations for transplantation to the putamen. Every transcortical brain penetration injures normal brain tissue and threatens hemorrhagic stroke.

15 In one approach to translational scale-up, very large numbers of cells can be delivered to a single location or along a short segment of the cannula tract. Unfortunately, the implantation of a large mass of cells within a confined location can severely impair graft viability, resulting in necrosis at the center of the transplant.

Another approach has been to insert a large host catheter, which is comprised of a number of
20 internal passages, or lumens for the advancement of micro-catheters. These internal passages within the host catheter exit at specified distal orifice locations around the distal end to allow the delivery of a media to a desired target area. Using this approach, the host catheter is inserted into the center of the desired target, or delivery area in the patient. Then, the micro-catheters are inserted into the various lumens, where multiple doses can be delivered to each of the distal
25 orifice locations along the elongate member. This method allows a larger target area to be covered without the need for multiple cranial penetrations. The introduction of a relatively large host catheter displaces a larger amount of tissue and the use of multiple micro catheters makes the ability to deliver a metered injection more difficult due to their variable lengths.

A problem with at least some prior systems is that the delivered media may not stay at the desired delivery site. In a phenomenon called reflux, a portion of the media may flow back up the penetration shaft, significantly reducing the amount of media that remains at the treatment site. Larger injection volumes worsen the reflux of infused materials along the penetration tract making cell dosing unpredictable in terms of numbers as well as final graft location.

In most clinical trials, a syringe is used to deliver cells through the inserted cannula. Unless the syringe is kept in constant motion, the cells naturally sediment to the most dependent location, usually the end attached to cannula. Thus, the first partial injection volume from a syringe may contain far more cells than those dispensed later, further contributing to unpredictable variability of cell dosing. The use of a syringe having a larger diameter than the catheter main lumen may make it difficult to control the volume of each dose, and may subject the cells to shear and other mechanical forces that result in the decrease of cell viability for cell transplantation.

BRIEF SUMMARY OF THE INVENTION

An insertion device for delivering media inside a patient includes an outer guide tube having a closed end configured for insertion into patient tissue. The outer guide tube defines a side port in a wall of the guide tube near the closed end. The insertion device also includes an inner guide tube nested within the outer guide tube and movable axially within the outer guide tube. The inner guide tube includes a deflector at an end within the outer guide tube. The device also includes a catheter nested within the inner guide tube and movable axially within the inner guide tube. The catheter has a dispensing end that defines one or more dispensing holes for dispensing the media. The deflector of the inner guide tube is positionable in relation to the opening of the outer guide tube such that it deflects the dispensing end of the catheter outward through the opening in the outer guide tube when the catheter is advanced axially within the inner guide tube.

According to one aspect of the present invention, there is provided an insertion device for delivering media inside a patient, the insertion device comprising: an outer guide tube having a closed end configured for insertion into patient tissue, the outer guide tube defining a side port in a wall of the outer guide tube near the closed end; an inner guide tube nested within the outer guide tube and movable axially within the outer guide tube, the inner guide

tube including a deflector at an end within the outer guide tube, the inner guide tube configured to be disposed within the outer guide tube in a first position or a second position, wherein when the inner guide tube is disposed in the first position, the side port is covered by the inner guide tube, and wherein when the inner guide tube is disposed in the second position, the side port is uncovered; and a catheter nested within the inner guide tube and movable axially within the inner guide tube and including an insertion end; wherein when the inner guide tube is disposed in the second position, the deflector of the inner guide tube is aligned with the side port of the outer guide tube, and wherein the deflector alignment with the side port deflects the insertion end of the catheter outward through the side port in the outer guide tube when the catheter is advanced axially within the inner guide tube.

According to another aspect of the present invention, there is provided an insertion device for delivering media inside a patient, the insertion device comprising: an outer guide tube having a closed end configured for insertion into patient tissue, the outer guide tube defining a side port in a wall of the outer guide tube near the closed end; an inner guide tube nested within the outer guide tube and movable axially within the outer guide tube, the inner guide tube including a deflector at an end within the outer guide tube, the inner guide tube configured to be disposed within the outer guide tube in a first position or a second position, wherein when the inner guide tube is disposed in the first position, the side port is covered by the inner guide tube, and wherein when the inner guide tube is disposed in the second position, the side port is uncovered; a catheter nested within the inner guide tube and movable axially within the inner guide tube and including an insertion end; and a therapeutic delivery cannula nested within the catheter and having a distal end for insertion into patient tissue; wherein when the inner guide tube is disposed in the second position, the deflector of the inner guide tube is aligned with the side port of the outer guide tube, and wherein the deflector alignment with the side port deflects the insertion end of the catheter outward through the side port in the outer guide tube when the catheter is advanced axially within the inner guide tube; and wherein the therapeutic delivery cannula has sufficient flexibility that when the distal end of the therapeutic delivery cannula is advanced beyond the insertion end of the catheter, the direction of travel of the distal end of the therapeutic delivery cannula is set by the catheter, and wherein the therapeutic delivery cannula has sufficient rigidity that the distal end of the

therapeutic delivery cannula travels in a substantially straight path through the patient tissue after emerging from the insertion end of the catheter.

According to still another aspect of the present invention, there is provided an insertion device for delivering media inside a patient, the insertion device comprising: a guide tube configured for insertion into patient tissue and having a longitudinal axis, the guide tube comprising an inner guide tube and an outer guide tube, the outer guide tube having a closed end configured for insertion into patient tissue, the outer guide tube defining a side port in a wall of the outer guide tube proximate to the closed end; a catheter nested within the guide tube and movable axially within the inner guide tube and including an insertion end, wherein the inner guide tube includes a mechanism for deflecting the insertion end of the catheter away from the longitudinal axis of the guide tube and into patient tissue, the inner guide tube configured to be disposed within the outer guide tube in a first position or a second position, wherein when the inner guide tube is disposed in the first position, the side port is covered by the inner guide tube, and wherein when the inner guide tube is disposed in the second position, the side port is uncovered; and a therapeutic delivery cannula nested within the catheter and having a distal end for insertion into patient tissue; wherein when the inner guide tube is disposed in the second position, the mechanism of the inner guide tube is aligned with the side port of the outer guide tube, and wherein the mechanism alignment with the side port deflects the insertion end of the catheter outward through the side port in the outer guide tube when the catheter is advanced axially within the inner guide tube, and wherein the therapeutic delivery cannula has sufficient flexibility that when the distal end of the therapeutic delivery cannula is advanced beyond the insertion end of the catheter, the direction of travel of the distal end of the therapeutic delivery cannula is set by the catheter, and wherein the therapeutic delivery cannula has sufficient rigidity that the distal end of the therapeutic delivery cannula travels in a substantially straight path through the patient tissue after emerging from the insertion end of the catheter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an insertion device in accordance with an embodiment of the invention.

FIG. 2 shows an embodiment of the insertion device of FIG. 1 incorporated with a stereotactic frame for animal surgery.

FIG. 3 illustrates additional components that may be used in accordance with embodiments.

FIG. 4 illustrates the protrusion of a catheter from an outer guide tube through a side port, in
5 an experimental embodiment.

FIG. 5 also shows the protrusion of a catheter from an outer guide tube through a side port, in accordance with embodiments.

FIGS. 6A-6D illustrate the operation of the insertion device of FIG. 1 in more detail.

FIG. 7 illustrates the dispensing of media from a catheter into brain tissue, in accordance with embodiments.

FIGS. 8A and 8B illustrate dispensing of media to a second treatment site, according to
5 embodiments.

FIG. 9 illustrates the use of a single penetration of a skull to reach the putamen of a brain, in accordance with embodiments.

FIG. 10 illustrates a “tree-like” pattern of treatment sites that may be reached through a single penetration into patient tissue, in accordance with embodiments.

10 FIGS. 11A and 11B illustrate an example embodiment of reloading a catheter, and dispensing media from the reloaded catheter.

FIG. 12 illustrates an insertion device in accordance with another embodiment of the invention.

FIG. 13 is a rendering of an actual insertion of a delivery device similar to the delivery device of FIG. 12 into an Agarose gel, simulating insertion into patient tissue.

15 FIG. 14 illustrates a delivery device according to another embodiment of the invention.

FIG. 15 shows an embodiment in which a therapeutic delivery cannula includes openings.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates an insertion device **100** in accordance with an embodiment of the invention.

Example insertion device **100** includes a set of three tubes that assemble in a nested manner. An
20 outer guide tube **101** may be rigid or semi-rigid, and may be made for example of stainless steel, polyetheretherketone (PEEK), or another suitable material. It should be noted that FIG. 1 is not necessarily to scale. The diameters of the components are exaggerated for clarity of illustration. Outer guide tube **101** may have an outer diameter suitable for the intended use of insertion device **100**. In one example embodiment intended for placement of media into the human brain,
25 outer guide tube **101** has an outer diameter of about 2.4 mm and an inner diameter of about 1.8 mm, although it is to be understood that other sizes may be used for treatment of the human brain, and may be especially helpful in the treatment of other human organs, or in the treatment of animals which may be larger or smaller than humans. In another example embodiment, outer guide tube **101** has an outer diameter of about 2.11 mm, an inner diameter of about 1.6 mm, and
30 a length of about 38 cm or more.

Outer guide tube **101** includes a side port **102** placed a distance from distal end **103** of outer guide tube **101**. In one example embodiment, side port **102** is placed about 4 mm from closed distal end **103**, but other suitable dimensions may be used.

5 An inner guide tube **104** nests within outer guide tube **101**. Inner guide tube **104** may also be rigid or semi-rigid, and may be made for example of stainless steel, nylon-12, or another suitable material. In one example embodiment, inner guide tube **104** has an outer diameter of about 1.65 mm and an inner diameter of about 1.19 mm, although other suitable dimension may be used. In another example embodiment, inner guide tube **104** has an outer diameter of about 1.47 mm, an inner diameter of about 1.07 mm, and a length of about 43 cm or more. Inner guide tube **104** is
10 movable at least axially within outer guide tube **101**, so that inner guide tube can cover or uncover (close or open) side port **102**. Inner guide tube **104** may be lockable in the open and closed positions with respect to outer guide tube **101**, for example using a Tuohy Borst adapter or other device (not shown). Inner guide tube **104** also includes a deflector **105**, the purpose of which is explained in more detail below.

15 A flexible delivery catheter **106** translates within inner guide tube **104**. Catheter **106** may be made, for example, of nylon-12, nylon-11, or another suitable material. In one example embodiment, catheter **106** has an outer diameter of about 1.0 mm and an inner diameter of about 0.4 mm, but other suitable dimensions may be used. Catheter **106** may be lockable with respect to inner guide tube **104**, for example using another Tuohy Borst adapter or other device (not
20 shown). A depth stop **107** may be provided to prevent inadvertent deployment of catheter **106** beyond its intended range.

At an insertion end **108** of catheter **106**, one or more dispensing holes are provided for dispensing media **110**. Any suitable number and arrangement of dispensing holes may be used. In the vicinity of insertion end **108**, catheter **106** is preferably pre-formed into a curved shape. A
25 heat set or other procedure may be used to pre-form insertion end **108**. For example, in one example embodiment having a catheter made of nylon-12, the catheter was heat set using a lab oven for approximately 15 minutes after the glass transition temperature (170°F) was achieved. This process provided the necessary environment to shape the catheter to the desired specifications. The catheter was both straightened and bent at the insertion end. A metal rod
30 mandrel was placed in the inner lumen of the catheter excluding the last 1.5cm from the distal end. This distal portion was then fixated to the desired radius of curvature (0.5cm). After the allotted time, the catheter was removed from the oven yielding a cell delivery catheter with various radii of curvatures near the distal end.

During use, inner guide tube **104** may be positioned to align deflector **105** with side port **102**. The combination of deflector **105** and the preset bend in catheter **106** causes catheter **106** to emerge from outer guide tube **101** approximately perpendicularly. In other embodiments, different deflector shapes and different preset bends may be used to achieve other angles of emergence. The system may be configured for any suitable maximum deployment of catheter **106**. In one example embodiment, catheter **106** can protrude from outer guide tube **101** by up to 2.0 cm. Deflector **105** may be an angled, radiused, or have another suitable shape to accomplish the deflection of catheter **106**.

A plunger **111** fits within catheter **106**. Plunger **111** may be made from any suitable material, for example a Ti6Al4V (Grade 5 Titanium) wire. In one example embodiment, plunger **111** has an outer diameter of 0.4 mm and a flattened end, but other suitable sizes and shapes may be used. For example, the end of plunger **111** may be rounded, tapered, pointed, or have any other workable shape. A close fit between the walls of the catheter and the plunger wire may provide a nearly gas-tight seal to allow both aspiration and dispensing of fluids. Dip coating of the distal end of the plunger wire may further enhance this seal. For safety, a torquer (not shown) at the catheter proximal end prevents inadvertent movement of the plunger wire. To allow translational movement of the plunger wire, the user must open this plunger lock. Preferably, catheter **106** can be fixed at any deployed distance by closing the catheter lock while still allowing the user to manipulate the plunger wire by opening the plunger lock. Thus, advancement of the plunger wire does not result in movement of the catheter.

To use insertion device **100**, the user preferably plans an insertion trajectory into the tissue of the patient. Where feasible, the insertion may be planned and accomplished using stereotactic surgery techniques. For example, **FIG. 2** shows an embodiment of insertion device **100** incorporated with a stereotactic frame **201** for animal surgery.

Whatever means are used to guide the insertion, at least outer guide tube **101** and inner guide tube **104** are inserted into the patient tissue to the desired insertion depth. Preferably, inner guide tube **104** is positioned so that side port **102** is closed during the insertion. Once the desired insertion depth is reached, the position of outer guide tube **101** may be locked. Catheter **106** and plunger **111** may be present within inner guide tube **104** during the insertion or may be inserted later.

Catheter **106** is loaded at any convenient time with media **110** to be dispensed to the patient tissue. For example media **110** may be a suspension of cells to be used for cell therapy. Side port **102** is opened by withdrawing inner guide tube **104**, and inner guide tube **104** is preferably

locked with respect to outer guide tube **101**. Catheter **106** (along with plunger **111**) is advanced so that insertion end **108** emerges through side port **102**. When the desired protrusion distance is reached, catheter **106** is preferably locked in relation to inner guide tube **104**. Plunger **111** may then be unlocked and advanced through inner guide tube **104** to force media **110** out through
5 dispensing holes **109**.

Once the desired dose has been delivered to the first treatment site, the process may be reversed to withdraw catheter **106** back into inner guide tube **104**, and to close side port **102**. Outer guide tube **101** may then be repositioned for delivery of media to a second treatment site. During the repositioning, outer guide tube **101** may be translated along its longitudinal axis (either advanced
10 or retracted), rotated about its longitudinal axis, or moved in a combination of translation and rotation. When outer guide tube is in the desired position for dispensing media to a second treatment site, inner guide tube **104** is retracted to open side port **102**, catheter **106** is advanced, and plunger **111** is advanced to dispense media **110** to the second treatment site.

This process may be repeated, so that a number of different treatment sites are accessed through
15 a single original penetration of outer guide tube **101** into the patient tissue. In some embodiments, this process may be called radially branched deployment, and can result in delivery of media in a precise “tree-like” pattern within the patient tissue.

It will be recognized that variations on this basic procedure are possible. For example, while outer guide tube **101** is held in a single orientation, catheter **106** may be deployed to multiple
20 distances with media **110** being dispensed at each of the multiple distances. In another variation, catheter **106** may be withdrawn and re-loaded with media **110**, and re-inserted into inner guide tube **104** during the procedure. In another variation, catheter **106** may be replaced with a second pre-loaded catheter, so that some treatment sites receive media from a first catheter and some receive media from a second catheter, while still requiring only one penetration of patient tissue
25 by outer guide tube **101**. This technique may be especially useful for complex treatment volumes. A variety of catheters may be provided having different preset bends, and different catheters may be used as needed to reach different parts of the treatment volume.

FIG. 3 illustrates additional components that may be used in accordance with embodiments. In this example, a first Tuohy Borst adapter **301** is positioned to lock and unlock inner guide tube
30 **104** in relation to outer guide tube **101**, and a second Tuohy Borst adapter **302** is positioned to lock and unlock catheter **106** in relation to inner guide tube **104**.

FIG. 4 illustrates the protrusion of catheter **106** from outer guide tube **101** through side port **102**, in an experimental embodiment. **FIG. 5** also shows the protrusion of catheter **106** from outer guide tube **101** through side port **102**, in another view.

FIGS. 6A-6D illustrate the operation of insertion device **100** in more detail. A deployed position is shown in **FIG. 6A** and **FIG. 6B**, in which catheter **106** protrudes from outer guide tube **101** and inner guide tube **104** through side port **102**. A retracted position is also shown in **FIG. 6C**, where side port **102** is open, but catheter **106** has been retracted within inner guide tube **104**. Finally, **FIG. 6D** shows a closed position, where inner guide tube **104** has been advanced so that side port **102** is closed.

FIG. 7 illustrates the dispensing of media **110** from catheter **106** into brain tissue, in accordance with embodiments.

FIGS. 8A and 8B illustrate dispensing of media **110** to a second treatment site, according to embodiments. In **FIG. 8A**, catheter **106** has been retracted after dispensing media **110** to a first treatment site, and outer guide tube **101** is rotated. In some embodiments, inner guide tube **104** may also be advanced to close side port **102** during the rotation. In **FIG. 8B**, outer guide tube **101** has been rotated about its longitudinal axis, for dispensing a second dose of media **110** to a second treatment site. Inner guide tube **104** has been retracted to open side port **102**, and catheter **106** has been extended, and additional media **801** is dispensed to a second treatment site.

FIG. 9 illustrates the use of a single penetration **901** of the skull **902** to reach the putamen **903** of a brain **904**. **FIG. 10** illustrates a “tree-like” pattern of treatment sites that may be reached through a single penetration of outer guide tube **101** into patient tissue. Catheter **106** may be placed in several different rotational positions and several depths, resulting in a relatively large number of treatment sites accessible through the single penetration. The treatment volume may have a radius or up to 2 cm or more.

As was mentioned above, a close fit between the walls of catheter **106** and plunger **111** may provide a nearly gas-tight seal to allow aspiration of media **110**. Accordingly, one method of loading catheter **106** is to insert plunger **111** into catheter **106**, and advance plunger **111** until it has reached closed insertion end **108**. This system can then be placed into a media or solution, and plunger **111** withdrawn to any location along the catheters long axis, creating a suction force (negative pressure) that will drive, or load, the media from the one or more dispensing holes **109** into the main lumen of catheter **106**. This process is illustrated in **FIG. 11A**. Once the operator has loaded the appropriate dose, depending on how far plunger **111** has been withdrawn from the

long axes of the main lumen of catheter **106**, the media **110** can then be placed into the appropriate target location in the patient as previously described and shown in **FIG. 11B**.

- One advantage of an insertion device according to embodiments, as compared with previous systems, may be that reflux of the dispensed media is significantly reduced. In an experimental evaluation, an insertion device embodying the invention was used to inject 10 μ l of Allura Red AC dye into an agarose gel that mimics the gross structural characteristics of brain. The catheter was deployed 7 cm below the gel surface, and dye was infused using a plunger advancement rate of 2 μ l/min. No dye was observed to reflux up the tract created by the outer guide tube. Reflux was arrested at the transition point between the deployed catheter and the outer guide tube side port. This surprising resistance to reflux may be a consequence of the directional change of the tract and the larger caliber of the outer guide tube. By contrast, delivery of 10 μ l of dye through a 20G cannula-syringe system inserted to the same depth resulted in significant reflux of dye. This difference in reflux was also observed when MRI was used to track the delivery of a suspension of paramagnetic beads to an agarose gel contained within a model skull.
- An insertion device according to embodiments of the invention may promote cell viability when the device is used to deliver cells to a treatment site. The system has a comparatively short and uniform flow path for cells, so that few opportunities arise for shear forces induced by the flow of media **110** to injure cells in the media. Additionally, the small diameter of plunger **111** enables the precise dispensing of very small quantities of media **110** to a large number of sites. For example, in one experimental embodiment, the volume of media **110** delivered by 1 cm of plunger travel was only 1.36 μ l. Thus comparatively few cells compete for the available oxygen at any particular treatment site.

- FIG. 12** illustrates an insertion device **1200** in accordance with another embodiment of the invention. Insertion device **1200** has several components similar to components of insertion device **100** discussed above, and these components are designated with the same reference numerals. For example, outer guide tube **101** may be rigid or semi-rigid, and may be made for of stainless steel, polyetheretherketone (PEEK), or another suitable material. Outer guide tube **101** includes a side port **102**, and a closed distal end **103** for insertion into tissue such as brain tissue. In one example embodiment, outer guide tube has an outer diameter of about 2.0 mm, an inner diameter of about 1.5 mm, and a length of about 38 cm, although different sizes may be used for different applications.

Inner guide tube **104** nests within outer guide tube **101**. Inner guide tube **104** may also be rigid or semi-rigid, and may be made for example of stainless steel, nylon-12, or another suitable

material. In one example embodiment, inner guide tube **104** has an outer diameter of about 1.47 mm, an inner diameter of about 1.07 mm, and a length of about 43 cm or more, although other suitable dimensions may be used. Inner guide tube **104** is movable at least axially within outer guide tube **101**, so that inner guide tube can cover or uncover (close or open) side port **102**.

- 5 Inner guide tube **104** may be lockable in the open and closed positions with respect to outer guide tube **101**, for example using a Tuohy Borst adapter or other device (not shown). Inner guide tube **104** also includes a deflector **105**.

A flexible delivery catheter **1201** translates within inner guide tube **104**. Catheter **1201** may be made, for example, of nylon-12, nylon-11, or another suitable material. In one example

- 10 embodiment, catheter **106** has an outer diameter of about 0.40 mm and an inner diameter of about 0.38 mm, but other suitable dimensions may be used. Catheter **1201** may be lockable with respect to inner guide tube **104**, for example using another Tuohy Borst adapter or other device (not shown). A depth stop may be provided to prevent inadvertent deployment of catheter **1201** beyond its intended range. Similar to catheter **106** described above, delivery catheter **1201**
15 preferably is formed into a curved shape near insertion end **1202**, using a heat set or other operation.

In contrast to catheter **106**, delivery catheter **1201** is open at insertion end **1202**, and serves as a conduit for a therapeutic delivery cannula **1203**. Therapeutic delivery cannula **1203** may be, for example a step cannula as shown in FIG. 12, having a step **1204** in its diameter near distal end
20 **1205**, and suitable for delivering biologics to a brain or other tissue via convection enhanced delivery. However, it will be recognized that a wide variety of other cannula types and delivery methods may be used. Therapeutic delivery cannula **1203** is preferably made of a semi-rigid material such as Nitinol, and is flexible enough that it can be guided by catheter **1201**. However, therapeutic delivery cannula **1203** preferably does not include a pre-formed curved shape, so that
25 therapeutic delivery cannula **1203** tends to maintain a straight configuration unless acted on by another element such as catheter **1201**. In one example embodiment, therapeutic delivery cannula is a step cannula made of Nitinol having an outside diameter of 0.375 mm over much of its length, an outside diameter of 0.150 mm below step **1204** at distal end **1205**, and an inner diameter of 0.0625 mm.

- 30 To use insertion device **1200**, the user preferably plans an insertion trajectory into the tissue of the patient. Where feasible, the insertion may be planned and accomplished using stereotactic surgery techniques as described above.

Whatever means are used to guide the insertion, at least outer guide tube **101** and inner guide tube **104** are inserted into the patient tissue to the desired insertion depth. Preferably, inner guide tube **104** is positioned so that side port **102** is closed during the insertion. Once the desired insertion depth is reached, the position of outer guide tube **101** may be locked. Catheter **1201** and therapeutic delivery cannula **1203** may be present within inner guide tube **104** during the insertion or may be inserted later.

Therapeutic delivery cannula **1203** is loaded at any convenient time with media to be dispensed to the patient tissue. Side port **102** is opened by withdrawing inner guide tube **104**, and inner guide tube **104** is preferably locked with respect to outer guide tube **101**. Catheter **1201** (possibly along with therapeutic delivery cannula **1203**) is advanced so that dispensing end **1202** emerges through side port **102**. In contrast to the use of delivery device **100** described above, catheter **1201** may be advanced only a relatively small distance from inner guide tube **104**. The distance is sufficient to establish a desired delivery angle Θ of delivery end **1202** with respect to outer guide tube **101**, but the distance is small enough to avoid any appreciable “sweep” of catheter **1201** through the tissue. Sweep may occur, for example, when a curved catheter is advanced into tissue and, due to its curvature and stiffness, tends to sweep through the tissue transverse to the longitudinal axis of the catheter, rather than following the longitudinal axis narrowly through the tissue. Because catheter **1201** is advanced only a small distance, it has little or no opportunity to sweep through the tissue.

Once the desired protrusion distance is reached, catheter **1201** is preferably locked in relation to inner guide tube **104**. Therapeutic delivery cannula **1203** is then advanced through catheter **1201** to reach the relatively distant treatment site. The curve of catheter **1201** directs therapeutic delivery cannula **1203** in the direction of angle Θ , but once therapeutic delivery cannula **1203** emerges from catheter **1201**, catheter **1201** no longer influences the direction of travel of therapeutic delivery cannula **1203**. Because therapeutic delivery cannula **1203** is semi-rigid and is straight in its natural condition, it tends to proceed through the tissue along a straight line, without a tendency to sweep. A therapeutic agent may then be delivered through therapeutic delivery cannula **1203** by any suitable means, for example by convection enhanced delivery.

Once the desired dose has been delivered to a first treatment site, the process may be reversed to withdraw therapeutic delivery cannula **1203** and catheter **1201** back into inner guide tube **104**, and to close side port **102**. Outer guide tube may then be repositioned for delivery of media to a second treatment site. During the repositioning, outer guide tube **101** may be translated along its longitudinal axis (either advanced or retracted), rotated about its longitudinal axis, or moved in a

combination of translation and rotation. When outer guide tube **104** is in the desired position for dispensing media to a second treatment site, inner guide tube **104** is retracted to open side port **102**, catheter **1201** is advanced, and therapeutic delivery cannula **1203** is advanced to another treatment site where a therapeutic agent is delivered.

- 5 This process may be repeated, so that a number of different treatment sites are accessed through a single original penetration of outer guide tube **101** into the patient tissue. **FIG. 13** is a rendering of an actual insertion of a delivery device similar to insertion device **1200** into an Agarose gel, simulating insertion into patient tissue.

- While delivery of a therapeutic agent through therapeutic delivery cannula **1203** may be
10 accomplished by any suitable method, in some embodiments a plunger similar to plunger **111** discussed above may be used. **FIG. 14** illustrates a delivery device **1400** according to this embodiment. Delivery device **1400** is similar to insertion device **1200** in construction and use, with the addition of plunger **1401** within therapeutic delivery cannula **1203**. Thus, delivery device **1400** includes five nested elements: outer guide tube **101**, inner guide tube **104**, delivery
15 catheter **1201**, therapeutic delivery cannula **1203**, and finally plunger **1401**. As before, the use of plunger **1401** enables very accurate dosing of a therapeutic agent, because the plunger is of a relatively small diameter and moves a relatively large distance during dispensing, allowing very fine control of the amount of agent dispensed.

- It will also be recognized that steps in the operation of the delivery device described above may
20 be performed in any suitable order. For example, catheter **1201** may be inserted into inner guide tube **104** and advanced through side port **102** before therapeutic delivery cannula **1203** (and plunger **1401** if present) is inserted into catheter **1201**. Alternatively, catheter **1201**, therapeutic delivery cannula **1203**, and plunger **1401** (if present) could be advanced together to the extent of the advancement of catheter **1201**. Catheter **1201** may then be fixed, and therapeutic delivery
25 cannula **1203** and plunger **1401** advanced beyond the insertion end of catheter **1201** to reach the treatment site. Many other sequences are possible.

Therapeutic delivery cannula **1203** may be withdrawn and re-loaded in a manner similar to catheter **106** described above, or in any other suitable manner.

- While therapeutic delivery cannula **1203** is shown as open ended, this is not a requirement. For
30 example, therapeutic delivery cannula could have a closed end similar to catheter **106** discussed above, including side openings similar openings **109**. This arrangement may be especially suitable for delivering a suspension of cells for cell therapy as discussed above. **FIG. 15** shows such an embodiment, in which therapeutic delivery cannula **1501** includes openings **1502**.

In addition to the delivery of therapeutic agents described in the above embodiments, other embodiments may enable delivery of other kinds of therapy. For example, an electric therapeutic such as an electrode may be delivered in place of or through therapeutic delivery cannula **1203**.

5 Embodiments of the invention have now been described in detail for the purposes of clarity and understanding. However, those skilled in the art will appreciate that certain changes and modifications may be practiced within the scope of the appended claims. It is to be understood that all workable combination of the components and features described herein are considered to be disclosed.

CLAIMS:

1. An insertion device for delivering media inside a patient, the insertion device comprising:

an outer guide tube having a closed end configured for insertion into patient tissue,
 5 the outer guide tube defining a side port in a wall of the outer guide tube near the closed end;

an inner guide tube nested within the outer guide tube and movable axially within the outer guide tube, the inner guide tube including a deflector at an end within the outer guide tube, the inner guide tube configured to be disposed within the outer guide tube in a first position or a second position, wherein when the inner guide tube is disposed in the
 10 first position, the side port is covered by the inner guide tube, and wherein when the inner guide tube is disposed in the second position, the side port is uncovered; and

a catheter nested within the inner guide tube and movable axially within the inner guide tube and including an insertion end;

wherein when the inner guide tube is disposed in the second position, the deflector
 15 of the inner guide tube is aligned with the side port of the outer guide tube, and wherein the deflector alignment with the side port deflects the insertion end of the catheter outward through the side port in the outer guide tube when the catheter is advanced axially within the inner guide tube.

2. The insertion device of claim 1, wherein the catheter includes a preset bend at the
 20 insertion end.

3. The insertion device of claim 2, further comprising a set of catheters having a variety of preset bends.

4. The insertion device of claim 1, wherein the insertion end of the catheter is a dispensing end defining one or more dispensing holes for dispensing the media.

25 5. The insertion device of claim 4, further comprising a plunger within the catheter and axially movable within the catheter to force the media out of the catheter through the one or more dispensing holes.

6. The insertion device of claim 5, wherein the outer guide tube, the inner guide tube, the catheter, and the plunger are made of a material or materials compatible with magnetic resonance imaging.

7. The insertion device of claim 1, wherein the inner guide tube is positionable within
5 the outer guide tube to cover the side port.

8. The insertion device of claim 1, further comprising a therapeutic delivery cannula nested within the catheter and moveable axially within the catheter, the therapeutic delivery cannula having a distal end through which a therapeutic is delivered.

9. The insertion device of claim 8, further comprising a plunger within the therapeutic
10 delivery cannula and axially movable within the therapeutic delivery cannula to force the therapeutic out of the therapeutic delivery cannula.

10. The insertion device of claim 8, further comprising an electrode within the therapeutic delivery cannula.

11. The insertion device of claim 9, wherein the distal end of the therapeutic delivery
15 cannula defines one or more dispensing holes for dispensing the therapeutic.

12. An insertion device for delivering media inside a patient, the insertion device comprising:

an outer guide tube having a closed end configured for insertion into patient tissue, the
outer guide tube defining a side port in a wall of the outer guide tube near the closed end;

20 an inner guide tube nested within the outer guide tube and movable axially within the outer guide tube, the inner guide tube including a deflector at an end within the outer guide tube, the inner guide tube configured to be disposed within the outer guide tube in a first position or a second position, wherein when the inner guide tube is disposed in the first position, the side port is covered by the inner guide tube, and wherein when the inner guide
25 tube is disposed in the second position, the side port is uncovered;

a catheter nested within the inner guide tube and movable axially within the inner guide tube and including an insertion end; and

a therapeutic delivery cannula nested within the catheter and having a distal end for insertion into patient tissue;

wherein when the inner guide tube is disposed in the second position, the deflector of the inner guide tube is aligned with the side port of the outer guide tube, and wherein the deflector alignment with the side port deflects the insertion end of the catheter outward through the side port in the outer guide tube when the catheter is advanced axially within the inner guide tube;

and wherein the therapeutic delivery cannula has sufficient flexibility that when the distal end of the therapeutic delivery cannula is advanced beyond the insertion end of the catheter, the direction of travel of the distal end of the therapeutic delivery cannula is set by the catheter, and wherein the therapeutic delivery cannula has sufficient rigidity that the distal end of the therapeutic delivery cannula travels in a substantially straight path through the patient tissue after emerging from the insertion end of the catheter.

13. The insertion device of claim 12, wherein the catheter includes a preset bend at the insertion end.

14. The insertion device of claim 12, further comprising a plunger within the therapeutic delivery cannula and axially movable within the therapeutic delivery cannula to force the therapeutic out of the therapeutic delivery cannula.

15. The insertion device of claim 12, further comprising an electrode within the therapeutic delivery cannula.

16. An insertion device for delivering media inside a patient, the insertion device comprising:

a guide tube configured for insertion into patient tissue and having a longitudinal axis, the guide tube comprising an inner guide tube and an outer guide tube, the outer guide tube having a closed end configured for insertion into patient tissue, the outer guide tube defining a side port in a wall of the outer guide tube proximate to the closed end;

a catheter nested within the guide tube and movable axially within the inner guide tube and including an insertion end, wherein the inner guide tube includes a mechanism for deflecting the insertion end of the catheter away from the longitudinal axis of the guide tube

and into patient tissue, the inner guide tube configured to be disposed within the outer guide tube in a first position or a second position, wherein when the inner guide tube is disposed in the first position, the side port is covered by the inner guide tube, and wherein when the inner guide tube is disposed in the second position, the side port is uncovered; and

- 5 a therapeutic delivery cannula nested within the catheter and having a distal end for insertion into patient tissue;

 wherein when the inner guide tube is disposed in the second position, the mechanism of the inner guide tube is aligned with the side port of the outer guide tube, and wherein the mechanism alignment with the side port deflects the insertion end of the catheter outward
10 through the side port in the outer guide tube when the catheter is advanced axially within the inner guide tube,

 and wherein the therapeutic delivery cannula has sufficient flexibility that when the distal end of the therapeutic delivery cannula is advanced beyond the insertion end of the catheter, the direction of travel of the distal end of the therapeutic delivery cannula is set by
15 the catheter, and wherein the therapeutic delivery cannula has sufficient rigidity that the distal end of the therapeutic delivery cannula travels in a substantially straight path through the patient tissue after emerging from the insertion end of the catheter.

17. The insertion device of claim 16, wherein the catheter includes a preset bend at the insertion end.

- 20 18. The insertion device of claim 16, further comprising a plunger within the therapeutic delivery cannula and axially movable within the therapeutic delivery cannula to force the therapeutic out of the therapeutic delivery cannula.

19. The insertion device of claim 16, further comprising an electrode within the therapeutic delivery cannula.

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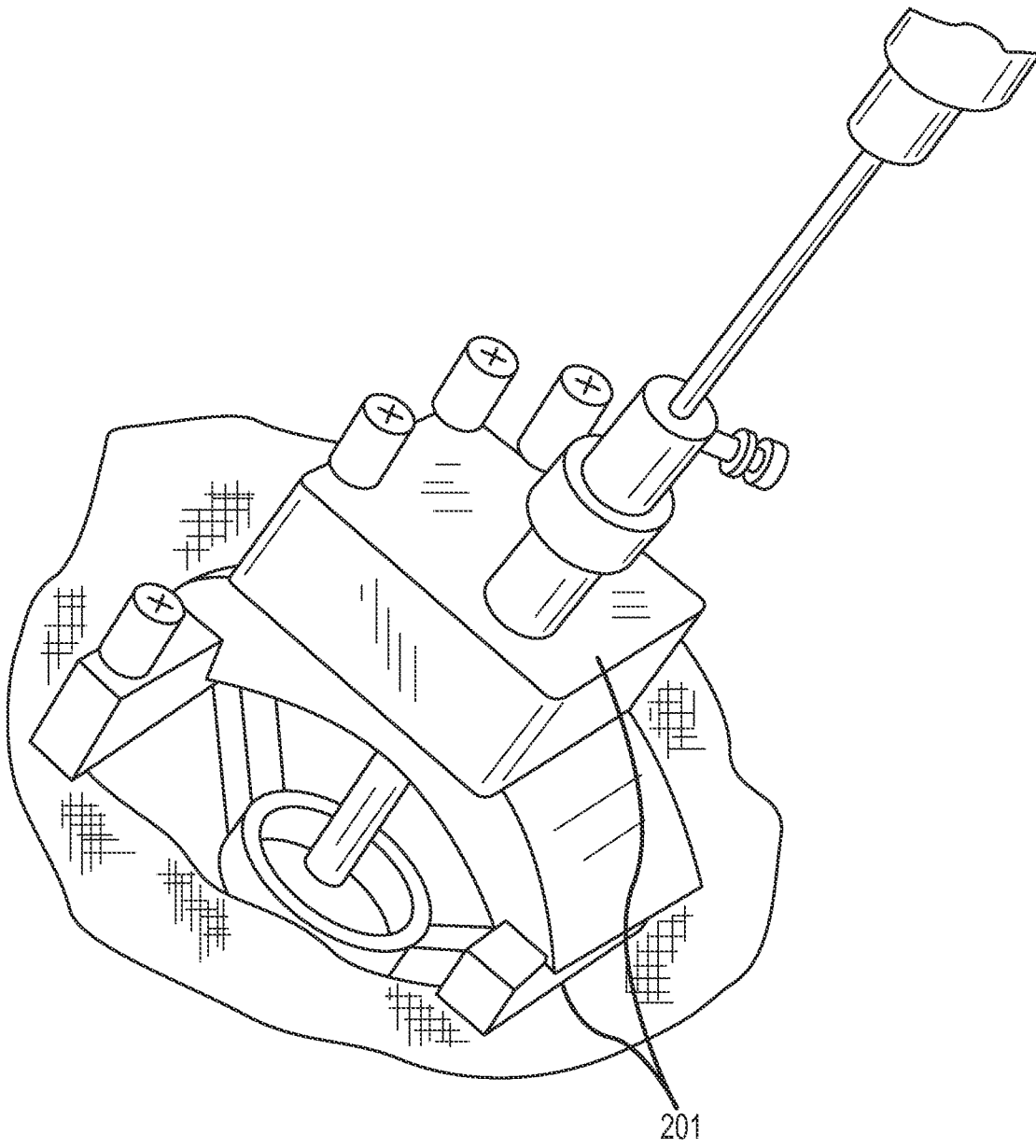


FIG. 2

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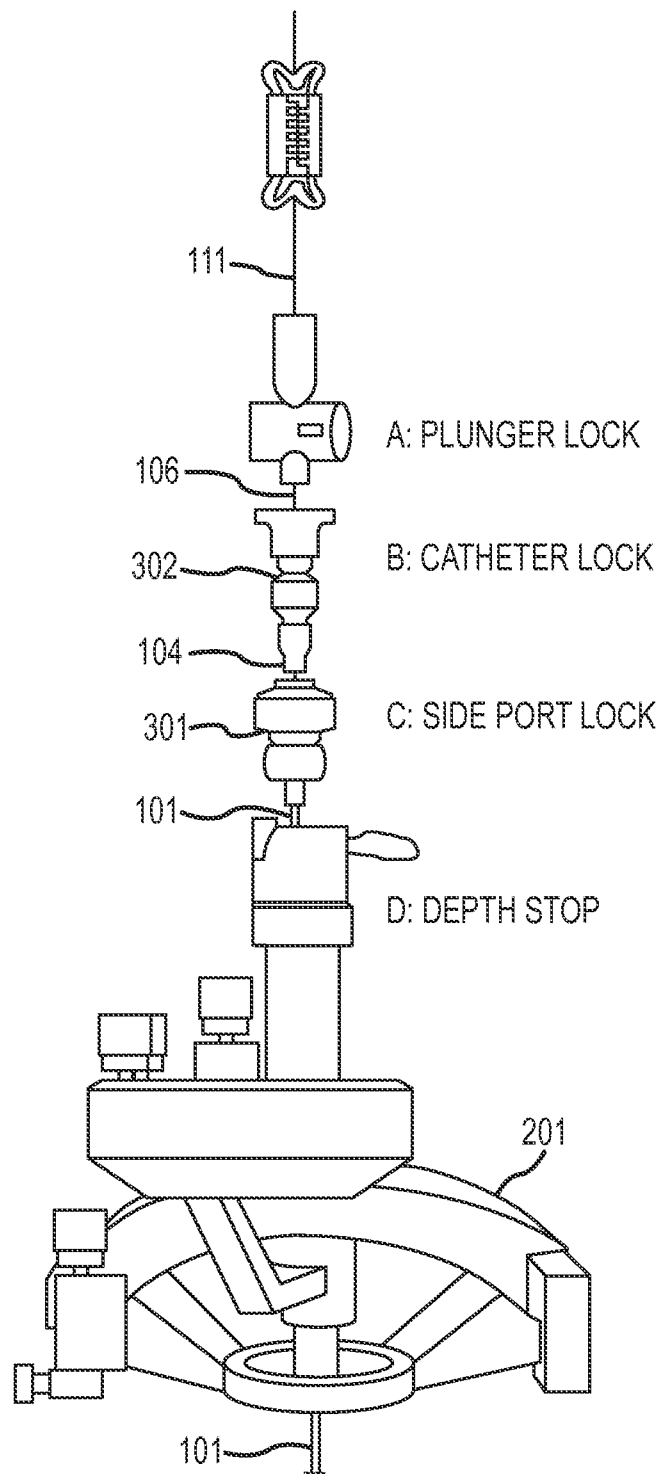


FIG.3

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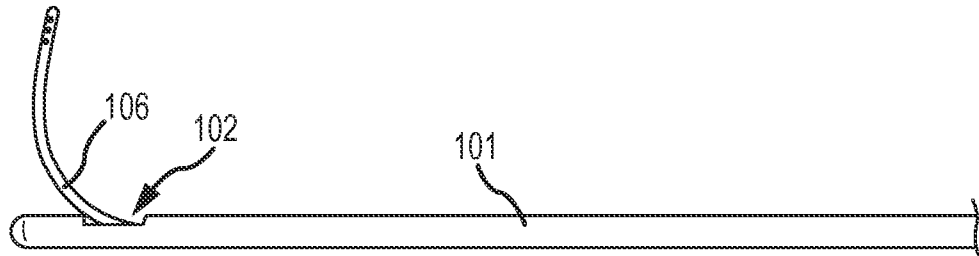


FIG. 4

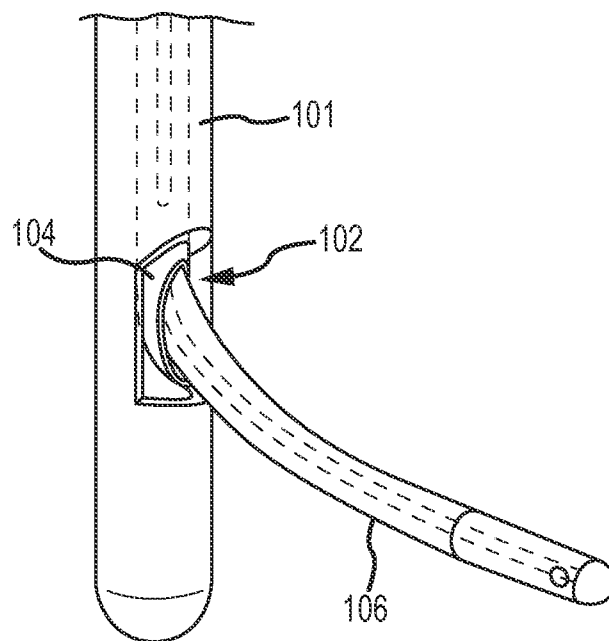
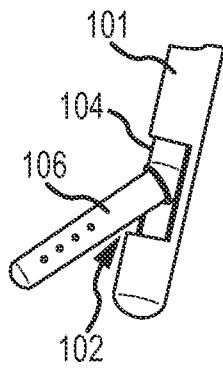


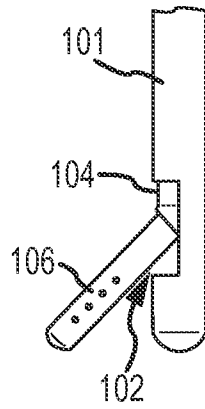
FIG. 5

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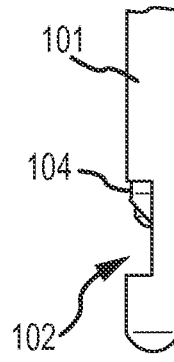
DEPLOYED

FIG. 6A



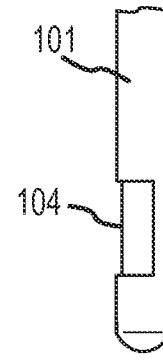
DEPLOYED

FIG. 6B



RETRACTED

FIG. 6C



CLOSED

FIG. 6D

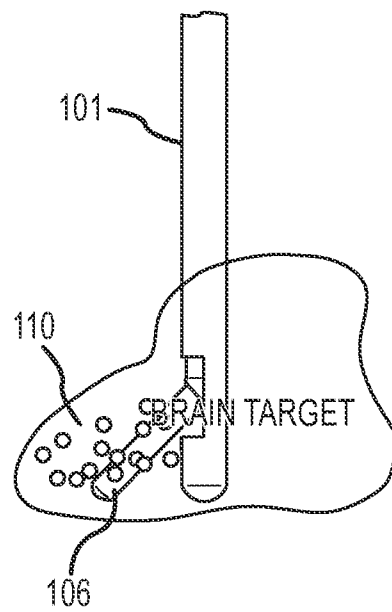


FIG. 7

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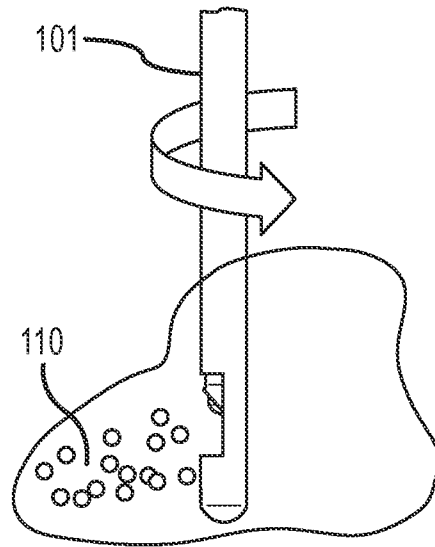


FIG. 8A

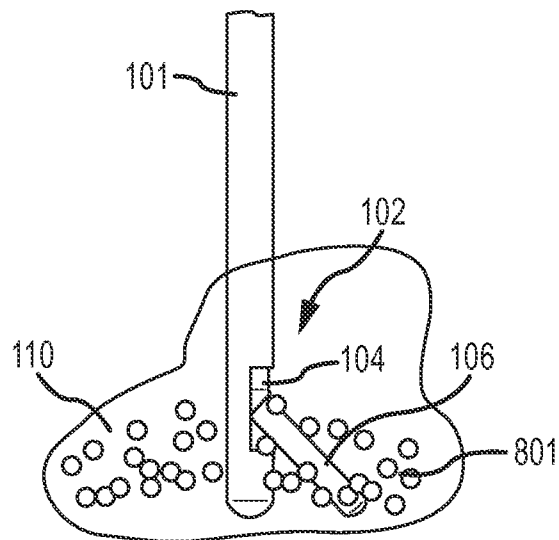


FIG. 8B

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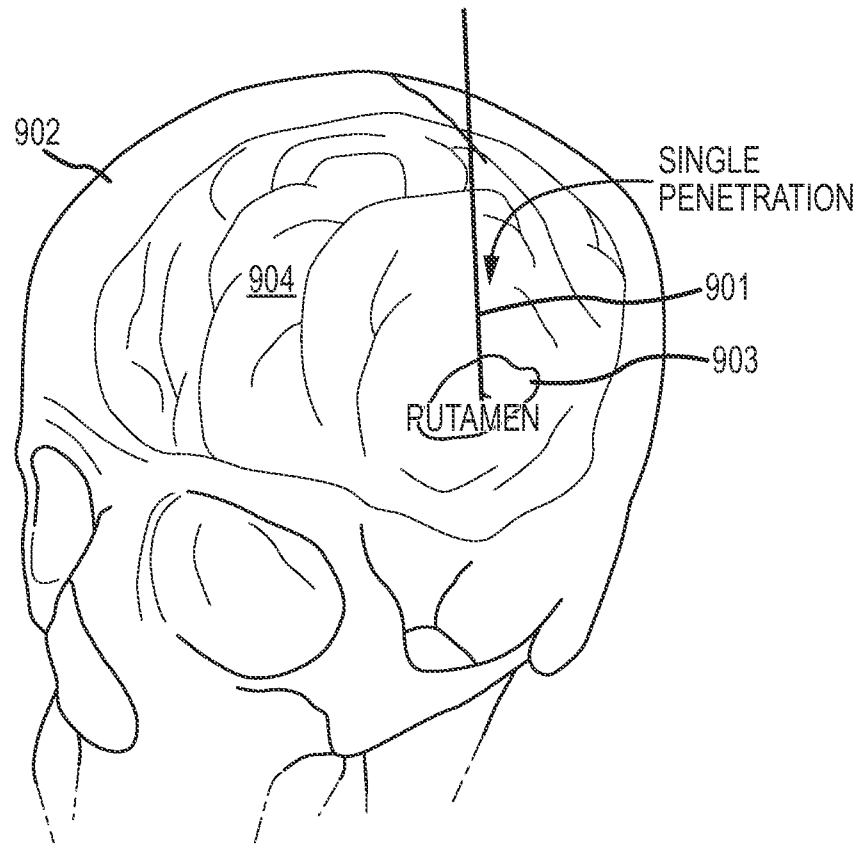


FIG. 9

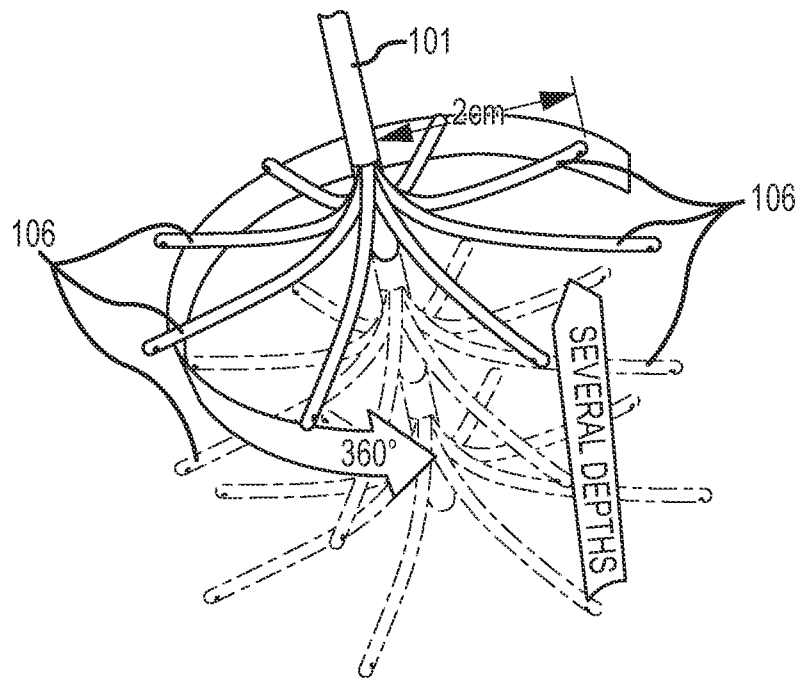
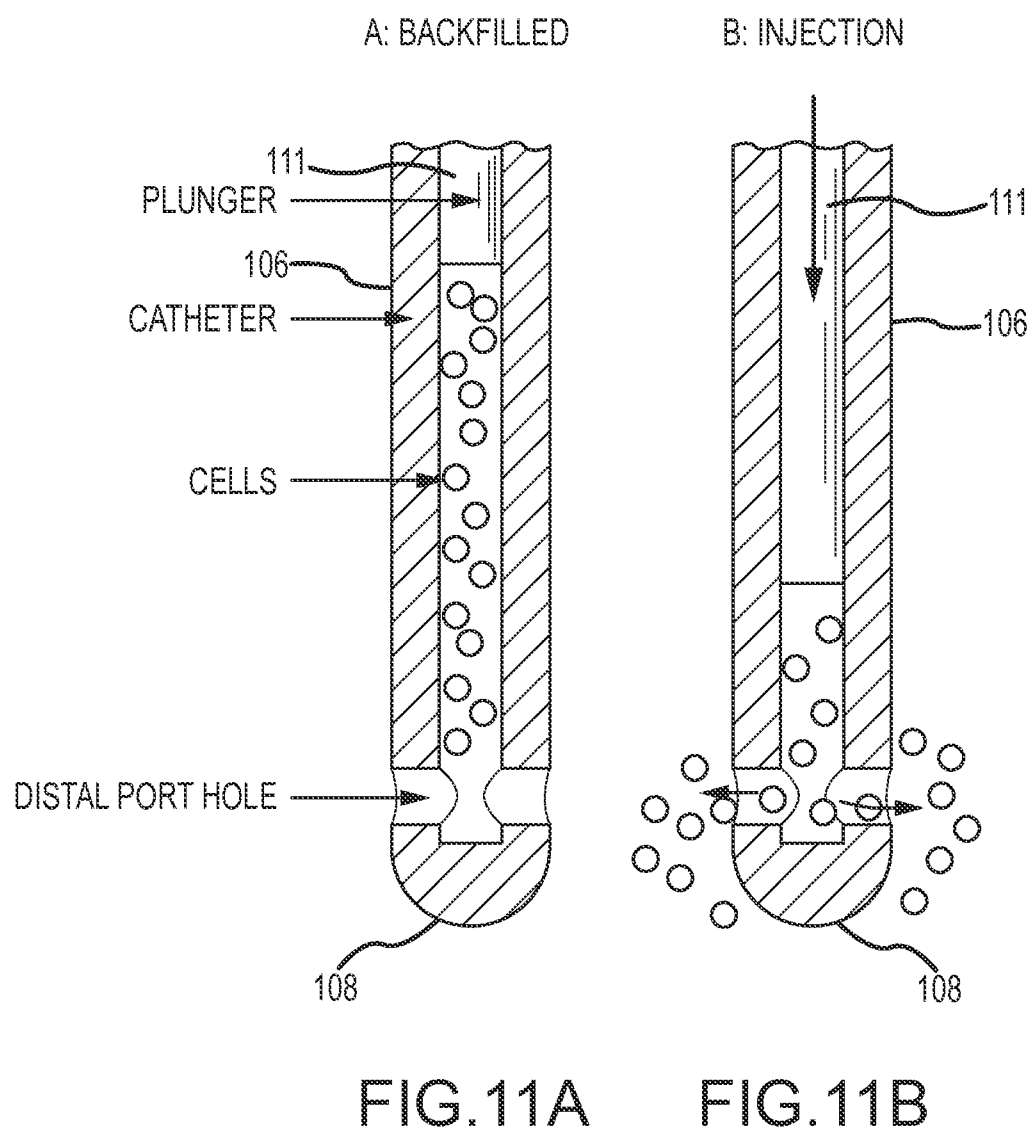


FIG. 10

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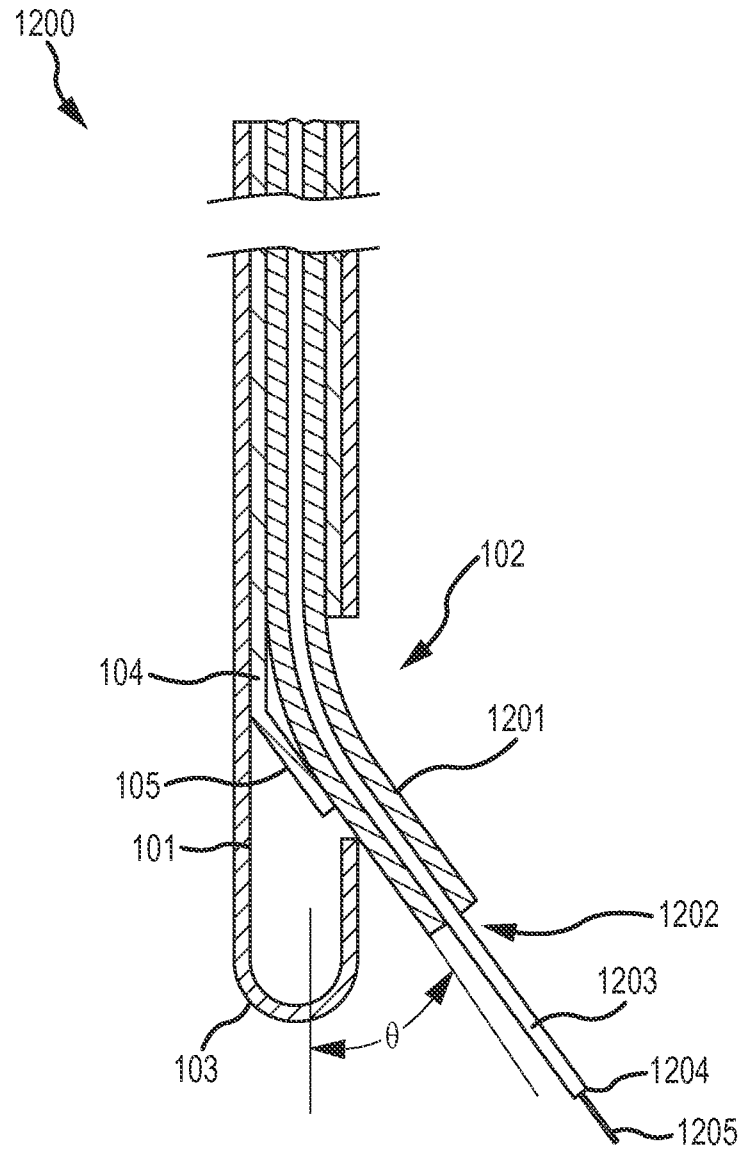


FIG. 12

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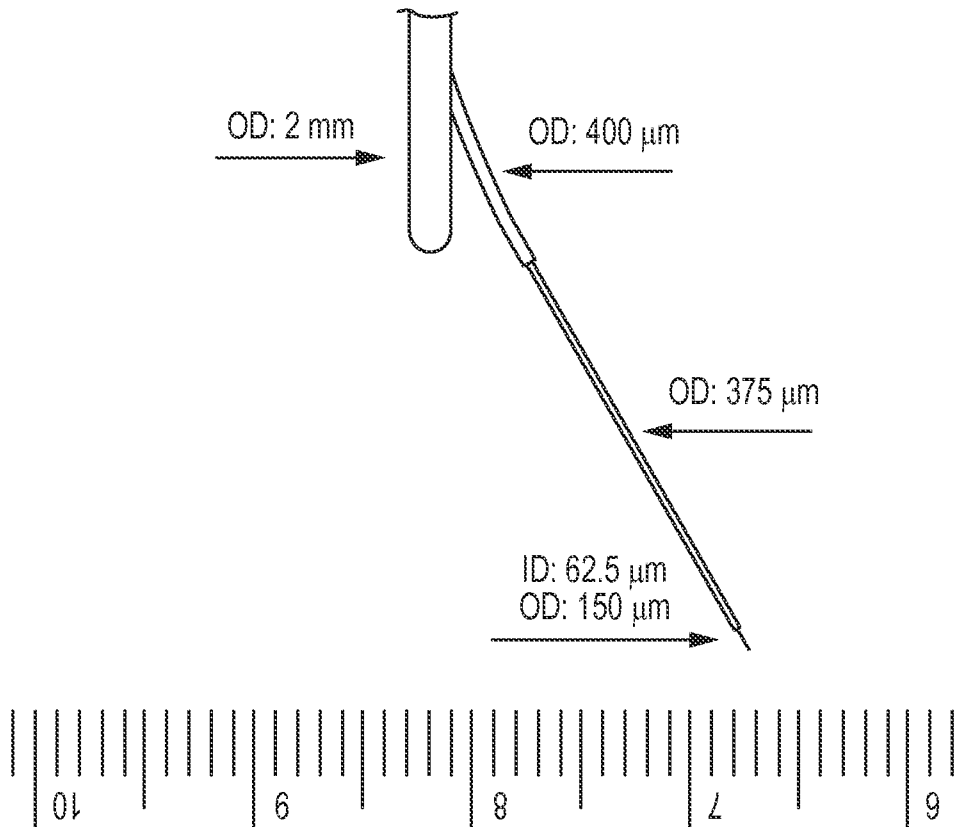


FIG.13

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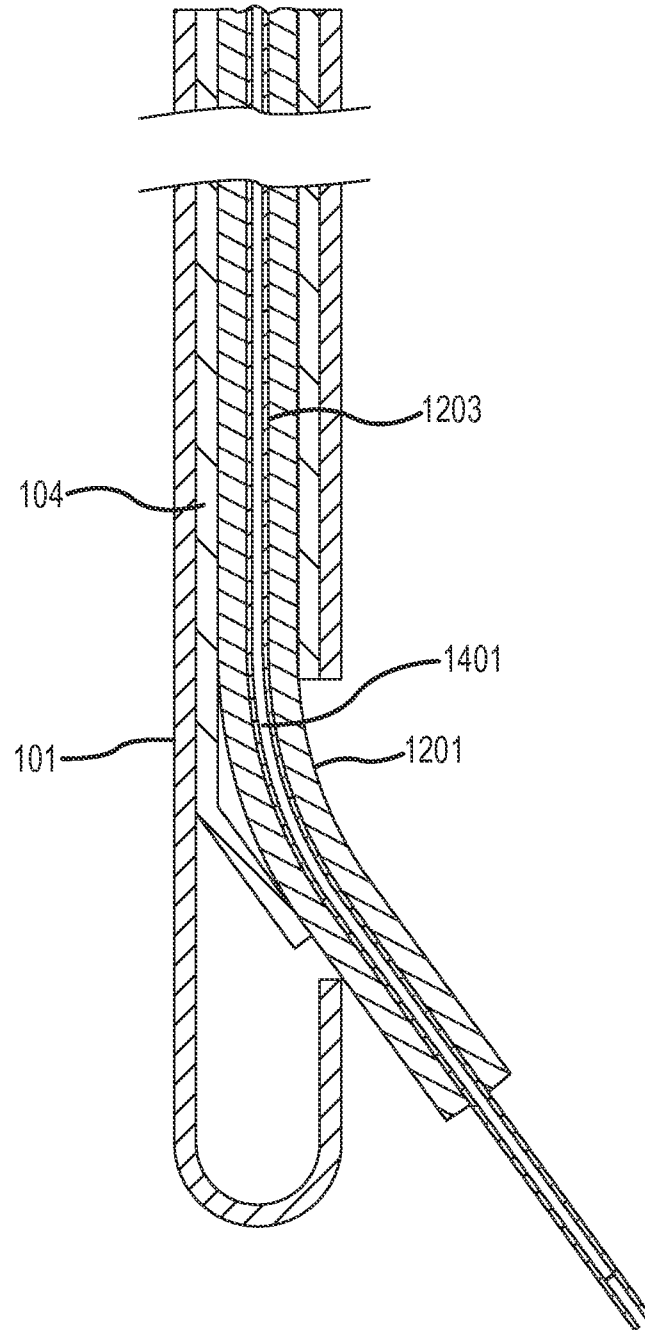


FIG.14

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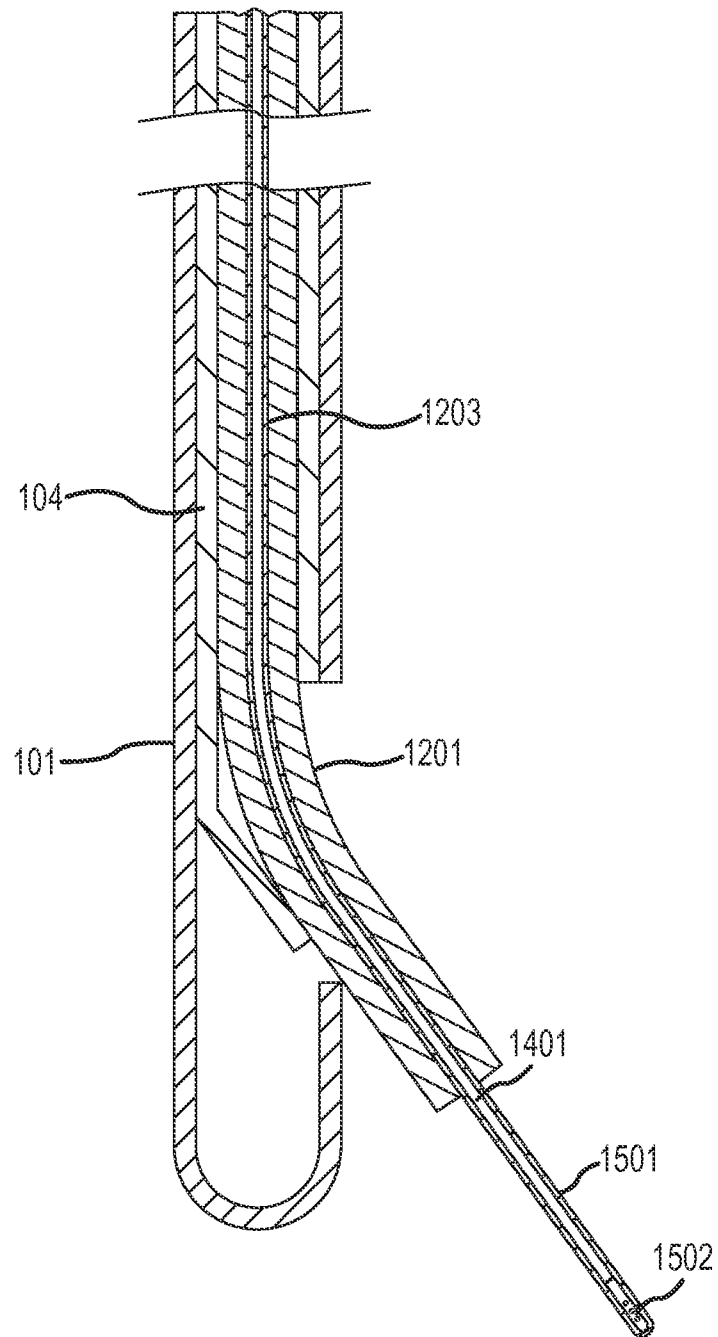


FIG.15

