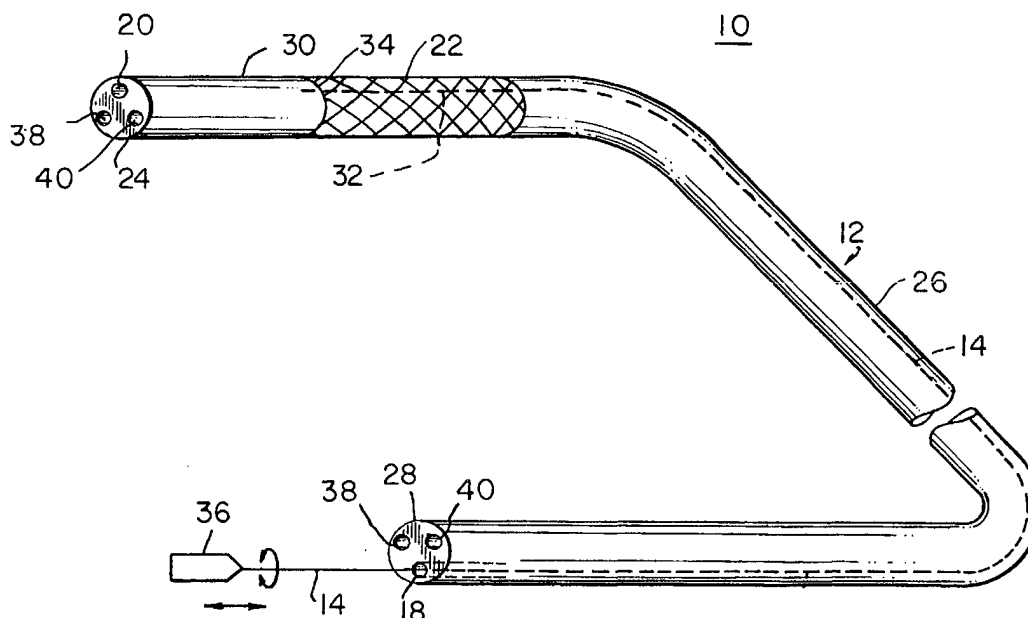




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : A61M 25/01, 25/00, A61B 1/005		A1	(11) International Publication Number: WO 98/19732
			(43) International Publication Date: 14 May 1998 (14.05.98)
(21) International Application Number: PCT/US97/20142 (22) International Filing Date: 5 November 1997 (05.11.97) (30) Priority Data: 08/745,618 7 November 1996 (07.11.96) US 08/842,391 23 April 1997 (23.04.97) US (71) Applicant: VASCULAR SCIENCE INC. [US/US]; Suite 202, 701 Decatur Avenue North, Minneapolis, MN 55427 (US). (72) Inventors: BACHINSKI, Thomas, J.; 19059 Orchard Trail, Lakeville, MN 55044 (US). SULLIVAN, Daniel, J.; 1245 Oak View Road, Medina, MN 55356 (US). GOLDSTEEN, David, S.; 4885 East Lake Harriet Parkway, Minneapolis, MN 55409 (US). (74) Agents: TREYZ, G., Victor et al.; Fish & Neave, 1251 Avenue of the Americas, New York, NY 10020 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	

(54) Title: STEERABLE INSTRUMENT FOR USE IN MEDICAL PROCEDURES



(57) Abstract

An elongated medical instrument is provided in which the angular orientation of the distal portion is controlled by adjusting the axial position in the instrument of a wire that has a curved distal portion. The instrument has a stiffened straight portion that is set back slightly from the distal end of the instrument. When the curved portion of the wire is retracted into the stiffened portion, the distal portion of the instrument is undeflected. When the curved portion of the wire is advanced beyond the distal edge of the stiffened portion, the curvature of the wire angularly deflects the distal portion of the instrument. The curvature of the wire tip can be customized by the physician. The rotational orientation of the deflected distal portion of the instrument can be controlled by rotating the wire.

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STEERABLE INSTRUMENT
FOR USE IN MEDICAL PROCEDURES

Background of the Invention

5 This invention relates to medical instruments, and more particularly, to steerable medical instruments.

 Elongated medical instruments are widely used in modern medical procedures for surgery, drug
10 delivery, imaging, and other functions at remote and/or relatively inaccessible locations in a patient's body. Some examples of such instruments are catheters, endoscopes, remote biopsy tools, laproscopic instrumentation and the like. The operative portion of
15 the instrument is typically at its distal tip or end portion. Proper use of such an instrument depends on the ability to properly orient the distal tip or end portion during the medical procedure.

 Some instruments are relatively rigid and can
20 be positioned and oriented by manipulating the proximal end of the instrument, which proximal end is not inserted into the patient's body. However, such relatively inflexible instruments generally cannot be used in procedures that require the instrument to pass
25 along complex routes such as through circulatory system vessels.

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The tips of flexible instruments can be difficult to properly position and orient by manipulating the proximal end of the instrument. Accordingly, flexible instruments are sometimes
5 provided with steering mechanisms. These steering mechanisms generally use a pair of pull wires connected to the tip of the catheter. When one of the wires is tensioned, the resulting differential force deflects the catheter tip laterally. Although widely used, pull
10 wire steering mechanisms use fairly complicated tensioning devices at the handle of the catheter, which can add complexity and expense to pull wire systems.

It is therefore an object of the present invention to provide improved structures and methods
15 for controlling steering movements of the distal portions of elongated medical instruments.

Summary of the Invention

This and other objects of the invention are
20 accomplished in accordance with the principles of the present invention by providing an elongated medical instrument which includes two elongated structures that are constrained to remain substantially parallel to one another but that are longitudinally movable relative to
25 one another. A first of these elongated structures has a relatively stiff medial portion and a relatively flexible distal portion. The second elongated structure has a resilient distal portion which is resiliently biased into an alignment different from the
30 alignment of the medial portion of the first elongated structure. When the distal portion of the second structure is adjacent the medial portion of the first structure, the stiffness of the medial portion forces the second structure to substantially conform to the

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alignment of the medial portion. But when the distal portion of the second structure is pushed distally beyond the medial portion and into adjacency with the distal portion of the first structure, the relatively
5 flexible distal portion of the first structure substantially conforms to the alignment of the distal portion of the second structure. For example, the medial portion of the first structure may be substantially straight and the distal portion of the
10 second structure may be resiliently biased to curve (e.g., into an arc of a circle). Depending on how much of the distal portion of the second structure is adjacent the distal portion of the first structure, the distal portion of the first structure can be made to
15 deflect more or less.

An illustrative embodiment of the invention is an instrument including a tubular structure (the first elongated structure mentioned above) in which the angular orientation of the distal portion of tubular
20 structure is controlled by adjusting the axial position of a wire (the second elongated structure mentioned above) within the tubular structure. The distal portion of the wire is curved. The proximal portion of the wire protrudes from the instrument and may be
25 manipulated by a physician. Near the distal end of the instrument, the tubular structure has a medial, stiffened, straight portion. When the curved portion of the wire is retracted into the stiffened portion of the tubular structure, the distal portion of the
30 instrument tends to assume a straight, undeflected orientation. When the curved distal portion of the wire is advanced beyond the distal edge of the stiffened portion, the wire can begin to resume its curvature, and it therefore begins to deflect the

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distal portion of the instrument. The physician can remove the wire from the instrument to customize the curvature of the wire. The rotational orientation of the distal portion of the instrument can be controlled
5 by rotating the wire about its longitudinal axis relative to the tubular structure.

One of the advantages of this invention is that it allows the orientation of the catheter tip to be controlled without using potentially highly stressed
10 pull wires.

Further features of the invention, its nature and various advantages will be more apparent from the accompanying drawings and the following detailed description of the preferred embodiments.

15 Brief Description of the Drawings

FIG. 1 is a simplified perspective view of an illustrative steerable medical instrument constructed in accordance with the invention in which the distal portion is in an undeflected position.

20 FIG. 2 is another simplified perspective view of the steerable instrument of FIG. 1 in which the distal portion is in a deflected position.

FIG. 3 is a simplified perspective view of just the distal portion of an illustrative steerable
25 medical instrument in accordance with the invention having fiber optics and a snare.

Detailed Description of the Preferred Embodiments

An illustrative steerable medical instrument
10 in accordance with the present invention is shown in
30 FIG. 1. Member 12 of instrument 10 is preferably an elongated member suitable for longitudinal insertion into the body of a patient during a medical procedure.

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Wire 14 reciprocates within lumen 15 (partly shown in FIG. 2) in member 12. Wire 14 is inserted into lumen 15 through proximal opening 18. Lumen 15 is preferably closed at distal end 20, but it may instead be open if
5 desired.

Stiffening member 22 may be formed using a tube, braided cage, rib-type structure, or any other suitable structure for stiffening member 12. Stiffening member 22 may be formed of metal, plastic,
10 or any other sufficiently stiff material. Preferably, stiffening member 22 is a tubular stiffening cage formed from a stainless steel braid with a polyimide covering. Stiffening member 22 is approximately two inches (5 cm) long and is preferably located a
15 comparable axial distance from distal end 24 of member 12. These structures, materials, and dimensions are only illustrative and any other suitable combination of structures, materials, and dimensions may be used.

With wire 14 inserted in member 12, the
20 portion 26 of instrument 10 between medial stiffening member 22 and proximal end 28 of instrument 10 is preferably flexible enough to allow portion 26 to flex during insertion through narrow and twisted body organ structures such as blood vessels. On the other hand,
25 portion 26 is preferably stiff enough to allow instrument 10 to be advanced into various organ structures by the physician.

If desired, portion 26 may be more inflexible than is suggested above, which may be appropriate for
30 procedures that do not require portion 26 to flex to accommodate insertion into twisting passages.

Regardless of the flexibility of proximal portion 26, the distal portion 30 of member 12 between stiffening member 22 and distal end 24 is preferably

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stiff enough to assume the straight, undeflected alignment shown in FIG. 1 when wire 14 is withdrawn from within portion 30.

Distal portion 32 of wire 14 has a predefined curved shape when not confined by stiffening member 22. The position of wire 14 within member 12 may be controlled by the physician by manipulating wire positioning member 36. When distal wire portion 32 is pushed beyond edge 34 of stiffening member 22, distal wire portion 32 begins to assume its natural curved shape and deflects distal member portion 30, as shown in FIG. 2.

The extent of the lateral or angular deflection of distal member portion 30 can be adjusted by controlling the length of distal wire portion 32 that extends beyond edge 34. The lateral or angular deflection of distal member portion 30 is greatest when all of distal wire portion 32 extends beyond edge 34. When distal wire portion 32 is fully retracted, distal wire portion 32 is confined by stiffening member 22 and there is no lateral deflection of distal member portion 30. When a fraction of distal wire portion 32 extends beyond edge 34, the lateral deflection of distal member portion 30 is less than the lateral deflection when distal wire portion 32 is fully extended but greater than the lateral deflection when distal wire portion 32 is fully retracted.

Wire 14 is preferably constructed from highly elastic nitinol or stainless steel and has a diameter approximately in the range of 0.019 to 0.040 inches. Wires 14 of this construction generally have sufficient torsional stiffness to reliably transfer torque from wire positioning member 36 to distal wire portion 32. Thus the physician can also rotate wire positioning

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member 36 and thereby wire 14 relative to member 12 to change the direction of lateral deflection of distal portion 30 produced by wire 14. The physician can therefore adjust both the amount of lateral deflection and the rotational orientation of that deflection by controlling the axial and rotational movement of wire 14.

If desired, the physician can withdraw wire 14 from member 12 entirely to customize the curvature of distal wire portion 32. For example, if the physician wishes to increase the maximum angular deflection of distal member portion 30, the physician can increase the curvature of wire 14 (e.g., by manually curling distal wire portion 32). The physician may also customize the curvature of distal wire portion 32 by selecting a replacement wire 14 with a different natural curvature at its tip. After customizing the curvature of wire 14, the physician inserts wire 14 into member 12.

The lateral and rotational control features of instrument 10 can be used in a variety of medical applications. For example, instrument 10 can be an imaging or illuminating device, a surgical instrument, a drug delivery instrument, a catheter (e.g., for balloon angioplasty and/or stent delivery), a device for irrigating and/or draining a patient, or a combination device including the features of two or more of these or any other suitable instruments. Goldsteen et al. U.S. patent application No. 08/745,618, filed November 7, 1996, and Sullivan et al. U.S. patent application No. 08/844,992, filed April 23, 1997, show intraluminal bypass procedures which can be performed in part with the aid of instruments of the type shown herein. These references are hereby

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incorporated by reference herein in their entirety.
One or more lumens such as lumens 38 and 40 may be included in member 12 to provide passageways for the performance of various functions by instrument 10. For example, lumen 38 may contain fiber optics for imaging, and lumen 40 may house an axially reciprocable snare. (Although the interior portions of lumens 38 and 40 and wire lumen 15 are only partly shown in FIG. 2 to avoid over-complicating the drawings, lumens 15, 38, and 40 extend axially though the entire length of member 12.) Other suitable instrument configurations may involve the use of angioplasty balloons, fiber optics for illumination or laser ablation, cutting and biopsy tools, anchoring wires, and irrigation or drainage ports.

An illustrative instrument tip 38 having snare 40, fiber optics port 42, fiber optics 44, and sealed wire lumen opening 46 is shown in FIG. 3. If instrument tip 38 is used for optical imaging, port 42 may have integral imaging capabilities. Snare 40 may be axially reciprocated in and out of its associated lumen 48 and may be provided within a coaxial separately reciprocable sheath 50, as described in Bachinski et al. U.S. patent application No. 08/844,910, filed April 23, 1997, which is hereby incorporated by reference herein in its entirety.

It will be understood that the foregoing is only illustrative of the principles of the invention, and that various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention.

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The Invention Claimed Is

1. An instrument comprising:
an elongated member having a distal member portion and a stiffened member portion; and
a wire disposed in the elongated member and having a curved distal wire portion, wherein the distal member portion is deflected angularly by the distal wire portion when at least some of the distal wire portion extends beyond the stiffened member portion and into the distal member portion.
2. The instrument defined in claim 1 wherein the distal member portion is undeflected when the entire distal wire portion is within the stiffened member portion.
3. The instrument defined in claim 1 wherein the wire has a proximal end extending from the elongated member.
4. The instrument defined in claim 3 wherein rotation of the proximal end of the wire rotates the distal wire portion and the distal member portion.
5. The instrument defined in claim 3 wherein when the proximal end of the wire is retracted, less of the distal wire portion extends beyond the stiffened member portion and the angular deflection of the distal member portion is reduced.
6. The instrument defined in claim 3 wherein when the proximal end of the wire is advanced

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into the elongated member more of the distal wire portion extends beyond the stiffened member portion and the angular deflection of the distal member portion is increased.

7. The instrument defined in claim 1 wherein the wire is removable by a physician to customize the curvature of the curved distal wire portion.

8. The instrument defined in claim 1 further comprising fiber optics.

9. The instrument defined in claim 1 further comprising a snare.

10. The instrument defined in claim 1 further comprising a lumen disposed in the elongated member.

11. The instrument defined in claim 1 further comprising a wire lumen in the elongated member in which the wire reciprocates.

12. The instrument defined in claim 1 wherein the stiffened member portion comprises a metal braid.

13. A method for using an instrument having an elongated member with a distal member portion and a stiffened member portion, comprising the steps of:

providing a wire in the elongated member that has a curved distal wire portion; and

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adjusting the axial position of the wire within the elongated member such that at least some of the distal wire portion extends beyond the stiffened member portion to angularly deflect the distal member portion.

14. The method defined in claim 13 further comprising the step of adjusting the axial position of the wire within the elongated member such that the distal wire portion is entirely within the stiffened member portion and the distal member portion is undeflected.

15. The method defined in claim 13 wherein the wire has a proximal end extending from the elongated member.

16. The method defined in claim 15 further comprising the step of rotating the proximal end of the wire to rotate the distal wire portion and the distal member portion.

17. The method defined in claim 15 further comprising the step of reducing the angular deflection of the distal member portion by retracting the wire so that less of the distal wire portion extends beyond the stiffened member portion.

18. The method defined in claim 15 further comprising the step of increasing the angular deflection of the distal member portion by advancing the wire so that more of the distal wire portion extends beyond the stiffened member portion.

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19. The method defined in claim 13 further comprising the step of customizing the curvature of the wire.

20. The method defined in claim 13 further comprising the step of providing fiber optics in the elongated member.

21. The method defined in claim 13 further comprising the step of providing a snare in the elongated member.

22. The method defined in claim 13 further comprising the step of providing a lumen in the elongated member.

23. The method defined in claim 13 further comprising the step of providing a wire lumen in the elongated member in which the wire reciprocates.

24. The method defined in claim 13 further comprising the step of forming the stiffened portion from a metal braid.

25. A steerable instrument comprising:
a first elongated structure having a proximal portion, a distal portion, and a medial portion between the distal and proximal portions, the medial portion being relatively stiff in a lateral direction so that it tends to maintain a first predetermined alignment along its length, and the distal portion being relatively flexible in a lateral direction; and

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a second elongated structure constrained to remain substantially parallel to the first elongated structure but being movable longitudinally relative to the first elongated structure, a distal portion of the second elongated structure being resiliently biased to assume a second predetermined alignment along its length, the first and second alignments being different from one another, the medial portion of the first elongated structure being sufficiently stiff to substantially overcome the resilient bias of the distal portion of the second elongated structure when the distal portion of the second elongated structure is adjacent the medial portion of the first elongated structure, and the resilient bias of the distal portion of the second elongated structure being strong enough to cause the distal portion of the first elongated structure to substantially conform to the second alignment when the distal portions are adjacent to one another.

26. The instrument defined in claim 25 wherein the first elongated structure has an elongated lumen in which the second elongated structure is longitudinally received.

27. The instrument defined in claim 26 wherein the second elongated structure is longitudinally movable in the lumen.

28. The instrument defined in claim 25 wherein the first and second elongated structures are rotatable relative to one another about an axis of elongation of the first and second structures.

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29. The instrument defined in claim 25 wherein the first elongated structure includes:
patient treatment instrumentation adjacent the distal portion of the first elongated structure.

30. The instrument defined in claim 29 wherein the patient treatment instrumentation comprises a light source.

31. The instrument defined in claim 29 wherein the patient treatment instrumentation comprises an image receptor.

32. The instrument defined in claim 29 wherein the patient treatment instrumentation comprises a snare for engaging another structure.

33. The instrument defined in claim 29 wherein the patient treatment instrumentation comprises a tool for taking a biopsy sample.

34. The instrument defined in claim 29 wherein the patient instrumentation comprises a medication dispenser.

35. The instrument defined in claim 29 wherein the patient treatment instrumentation comprises an irrigation fluid source.

36. The instrument defined in claim 29 wherein the patient treatment instrumentation comprises a fluid drain.

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37. The instrument defined in claim 25 wherein the second elongated structure includes a metal wire.

38. The instrument defined in claim 37 wherein the metal includes nitinol.

39. the instrument defined in claim 25 wherein the first predetermined alignment is substantially straight.

40. The instrument defined in claim 39 wherein the second predetermined alignment is curved.

41. The instrument defined in claim 40 wherein the second predetermined alignment is an arc of a circle.

42. The instrument defined in claim 25 wherein the second predetermined alignment is curved.

43. The instrument defined in claim 42 wherein the second predetermined alignment is an arc of a circle.

44. The instrument defined in claim 25 further comprising:

a control structure adjacent the proximal portion of the first elongated structure and operatively connected to the second elongated structure for controlling movement of the second elongated structure relative to the first elongated structure.

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45. The instrument defined in claim 25 wherein the proximal portion of the first elongated structure is relatively flexible in a lateral direction like the distal portion of the first elongated structure.

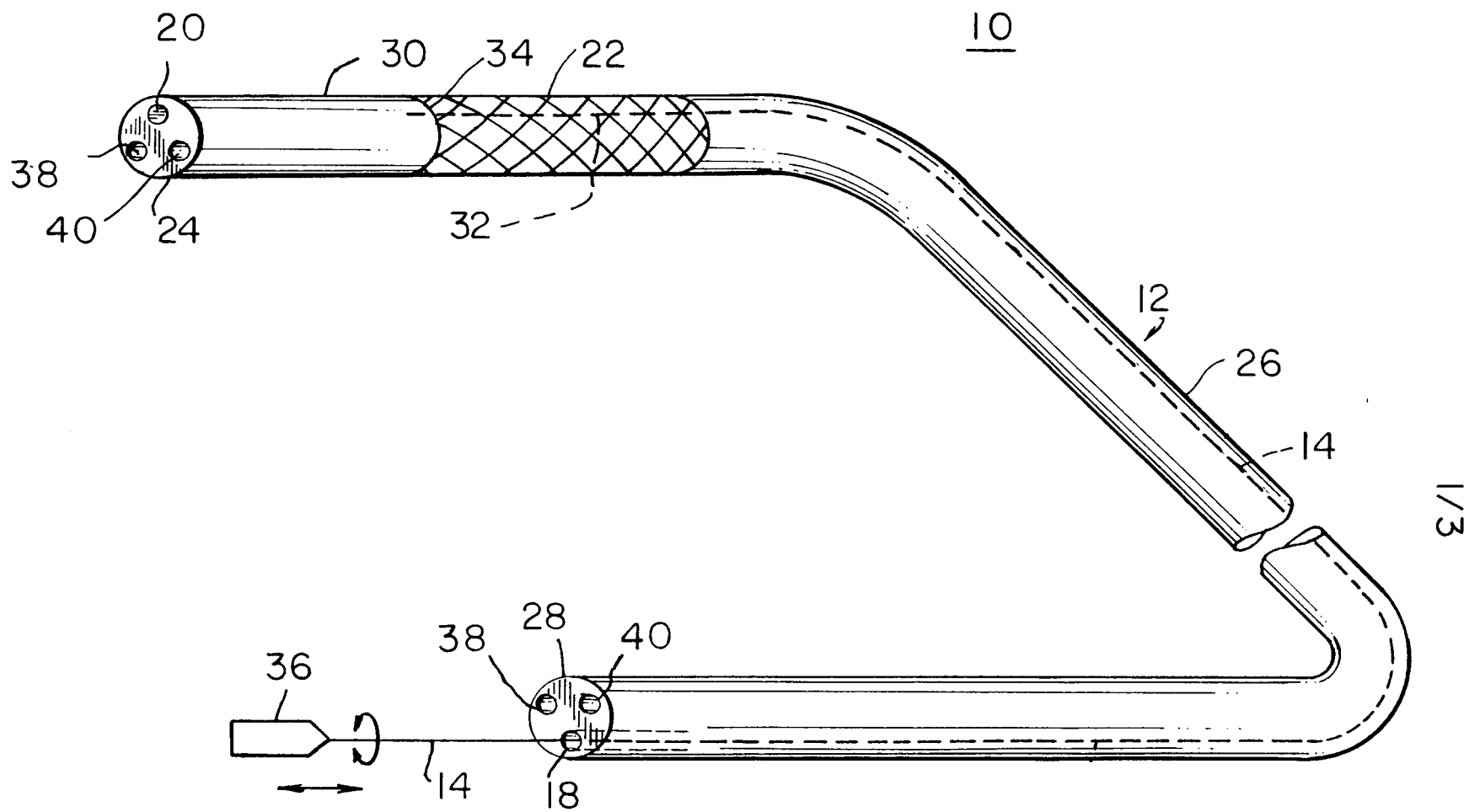
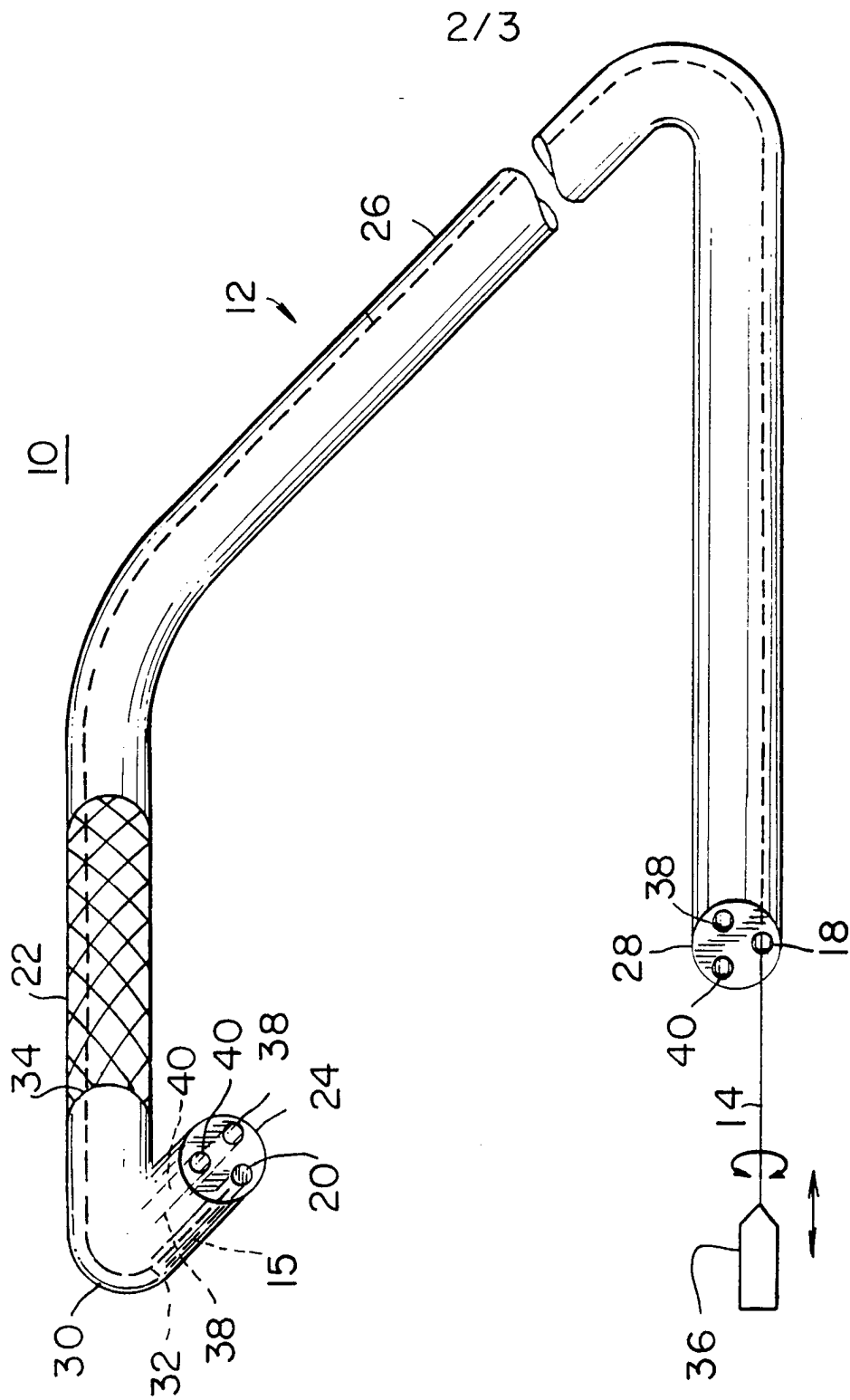


FIG. 1



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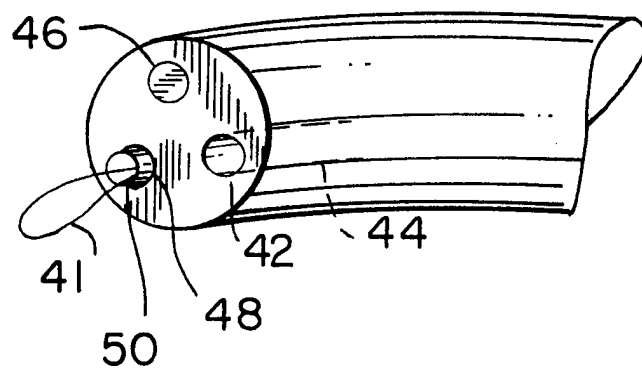


FIG. 3

INTERNATIONAL SEARCH REPORT

Inter: nal Application No
PCT/US 97/20142

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61M25/01 A61M25/00 A61B1/005

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 6 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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 14506 A (RAYCHEM) 3 September 1992 see page 13, paragraph 2 – paragraph 5; figures ---	1-3, 5-7, 13-15, 17-19, 25-27, 29, 37-45
A	US 5 318 528 A (HEAVEN) 7 June 1994 see the whole document --- -/--	1-4, 8-10, 13, 15, 17-22, 25-45

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

11 March 1998

Date of mailing of the international search report

20/03/1998

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 97/20142

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 96 30072 A (HEARTPORT) 3 October 1996 see page 22, line 15 - line 36; figure 4 ---	1,3,7, 11,13, 15,19, 23, 25-29, 37-44
A	US 5 487 757 A (TRUCKAI) 30 January 1996 see column 7, line 41 - column 9, line 59; figures ---	1,12,13, 24,25
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Information on patent family members

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