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(54) **TOOL FOR REMOVING OBJECT FROM THE BODY OF A PATIENT**

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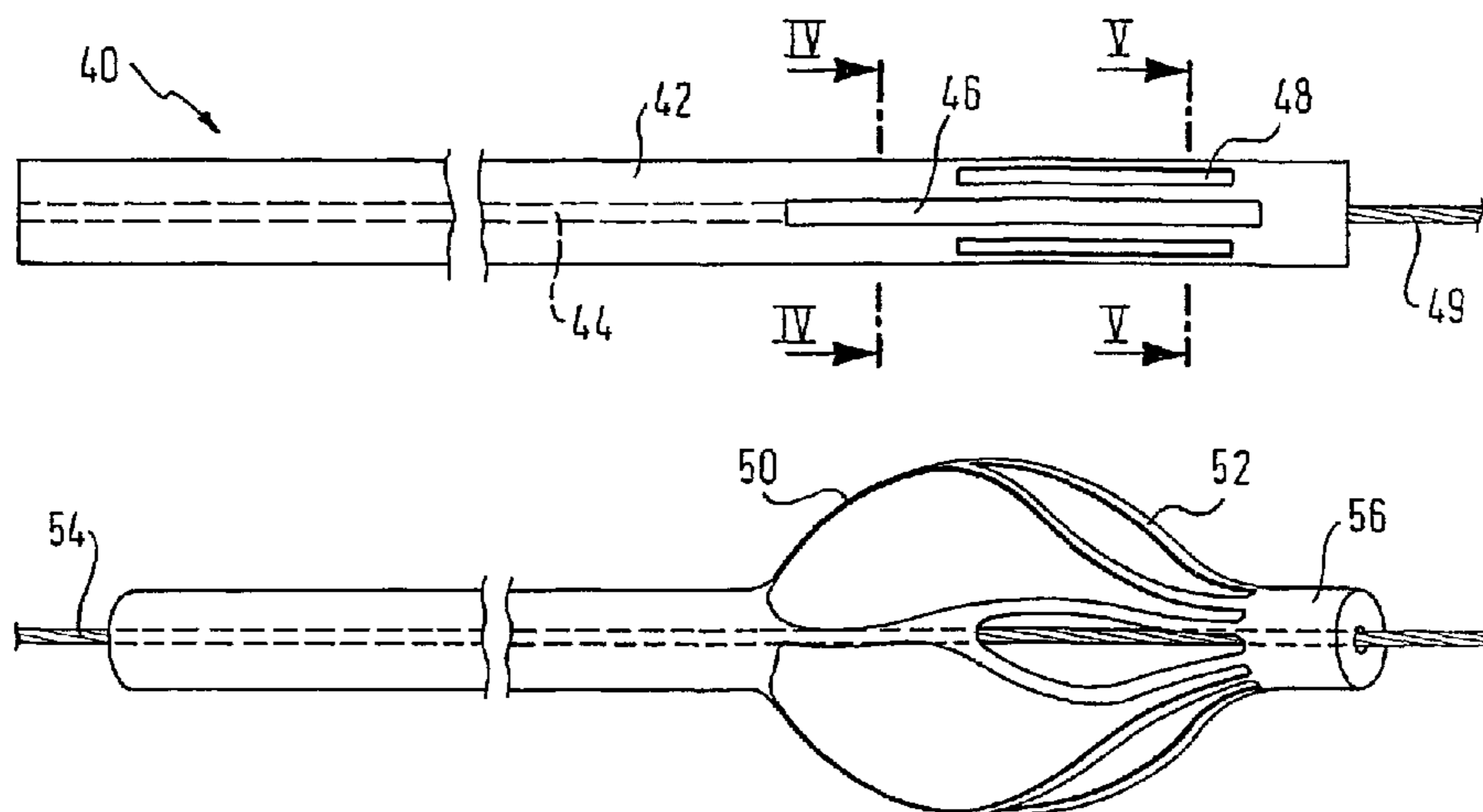
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(57) **ABSTRACT**

Disclosed is a device for removing a foreign object from the body of a human or animal patient, the device being formed from a single length of tubing, slit lengthwise at its distal end to define an envelope of a basket cavity, the envelope featuring a set of second strands, each formed by slitting one of the first strands over a distal portion of the first strand, which distal portion is less than the full length of the first strand.

**18 Claims, 3 Drawing Sheets**



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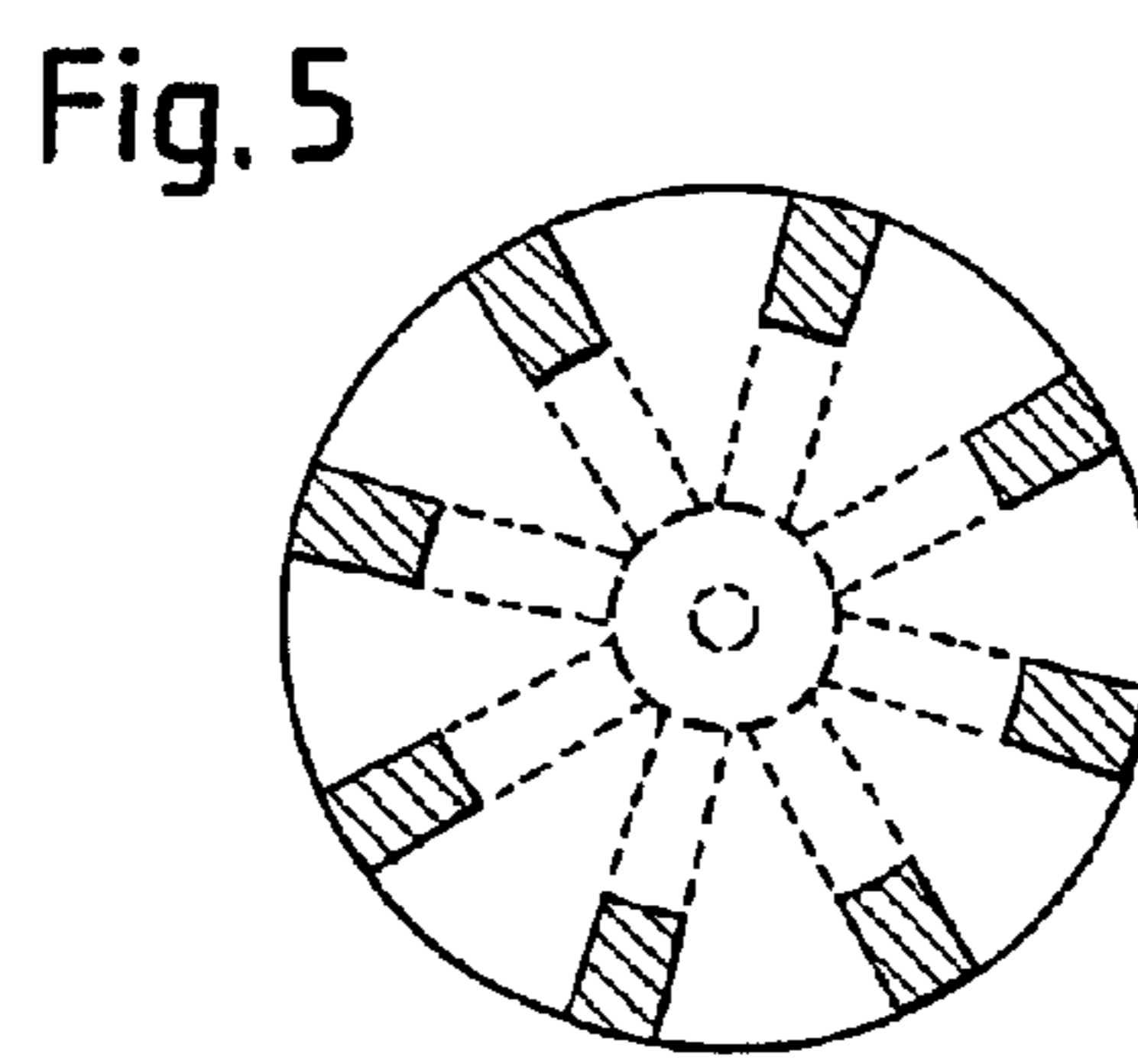
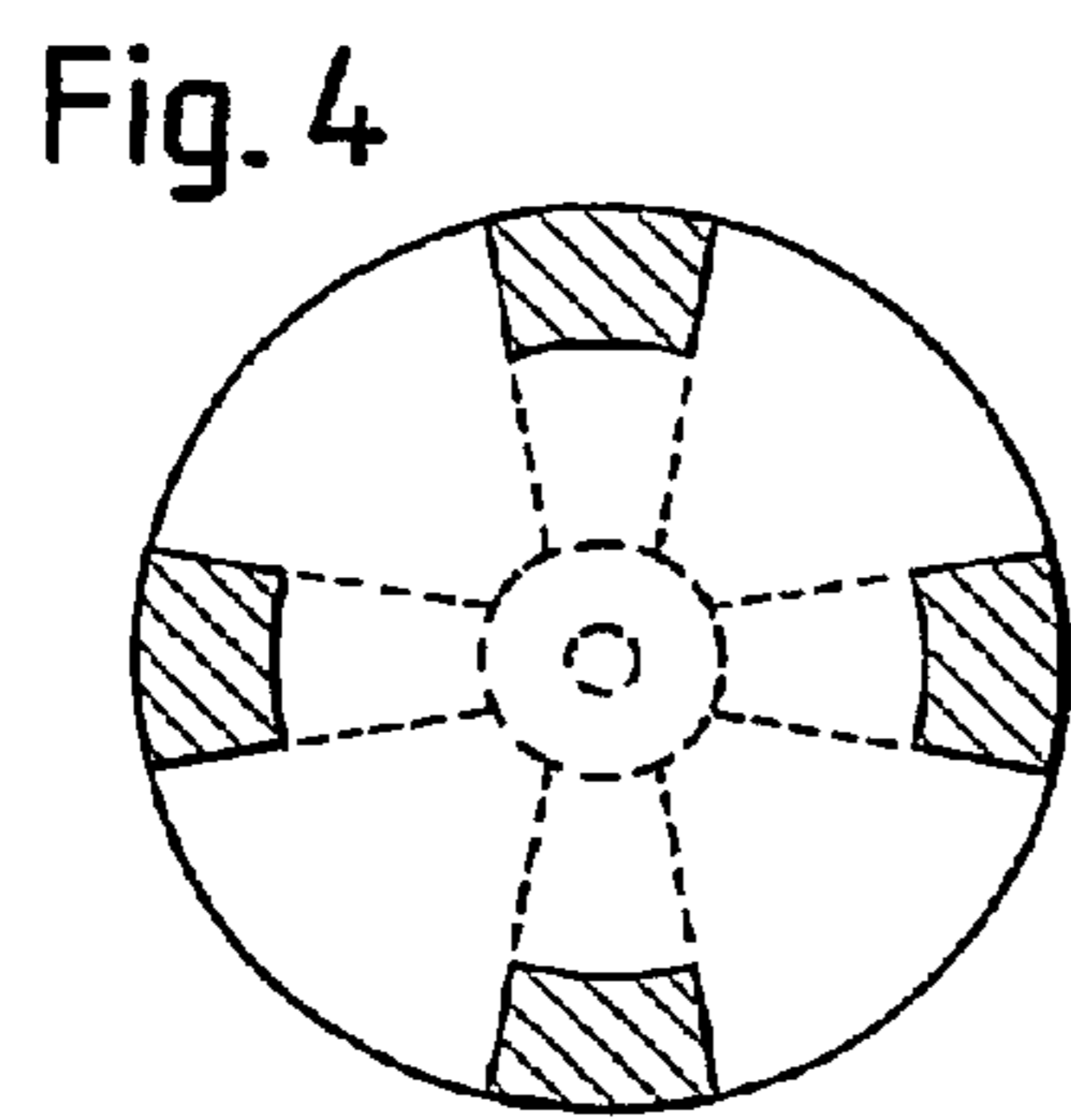
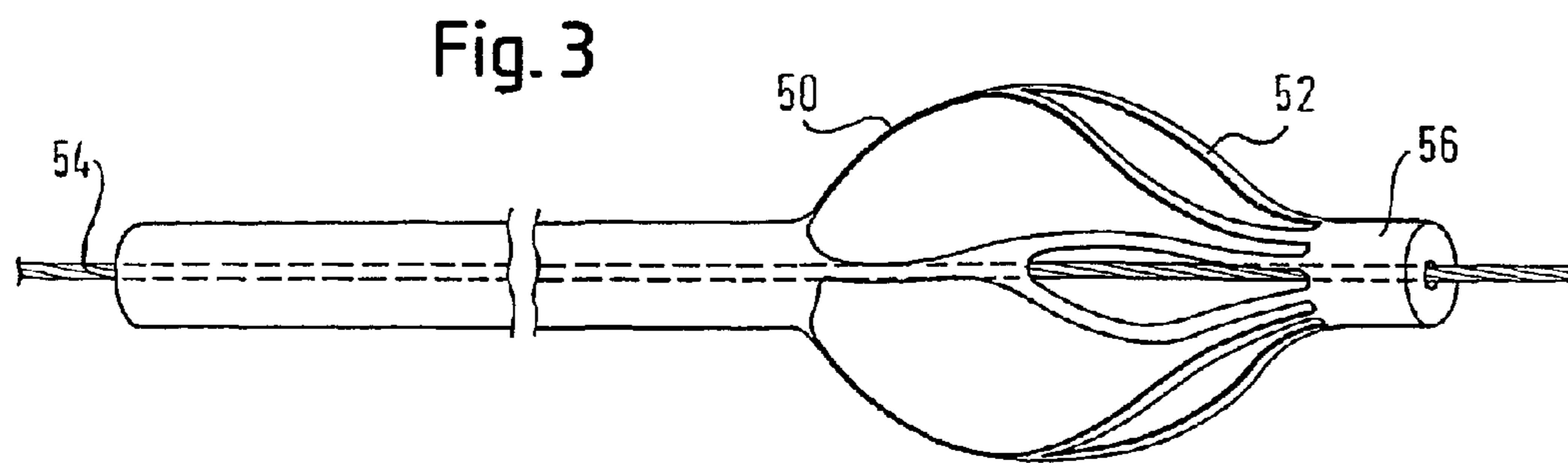
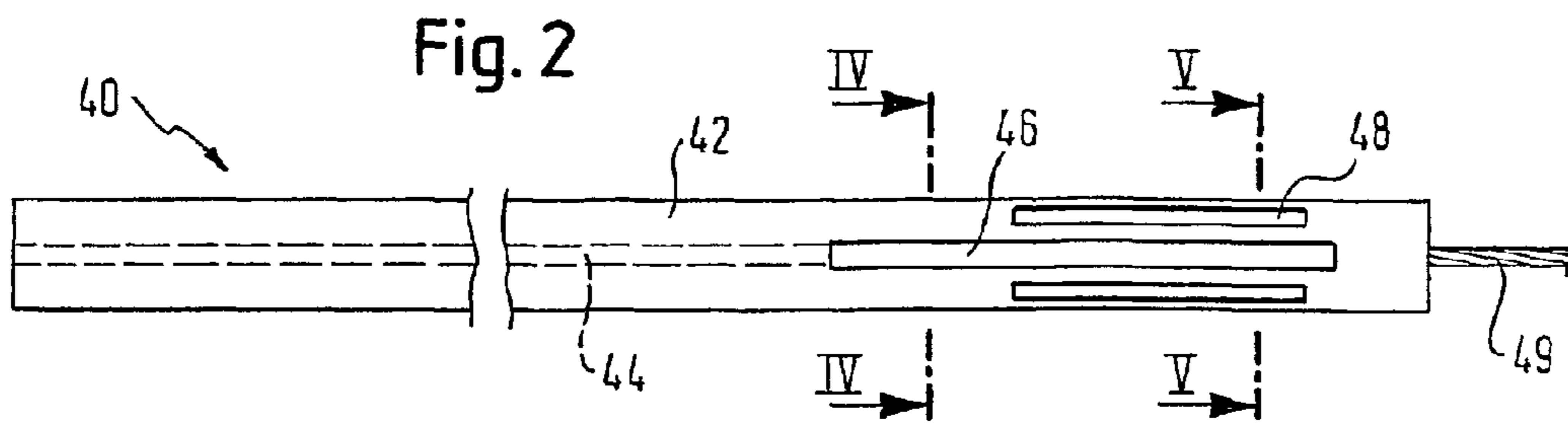
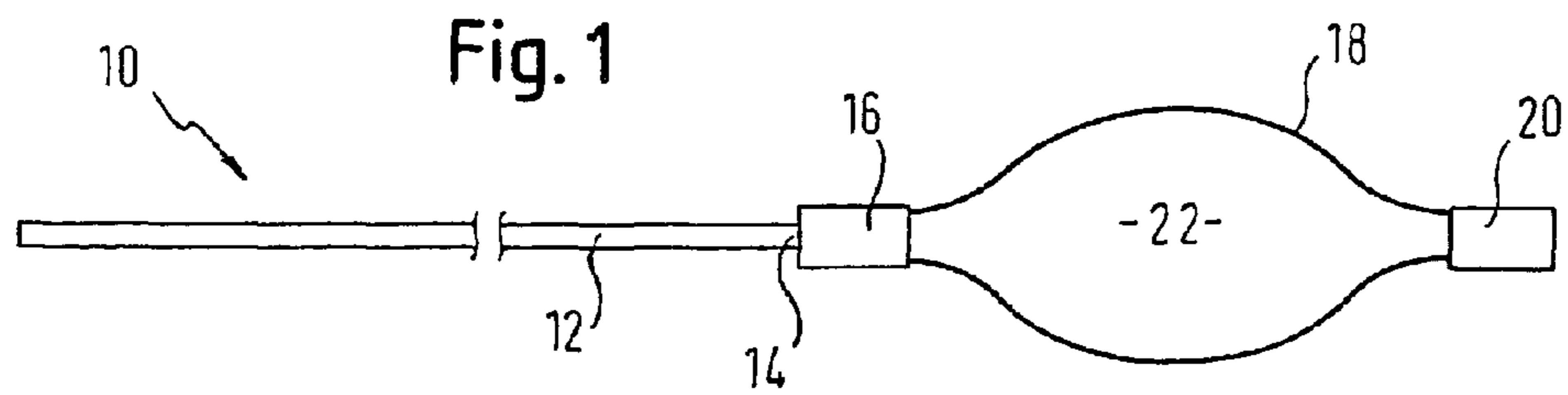
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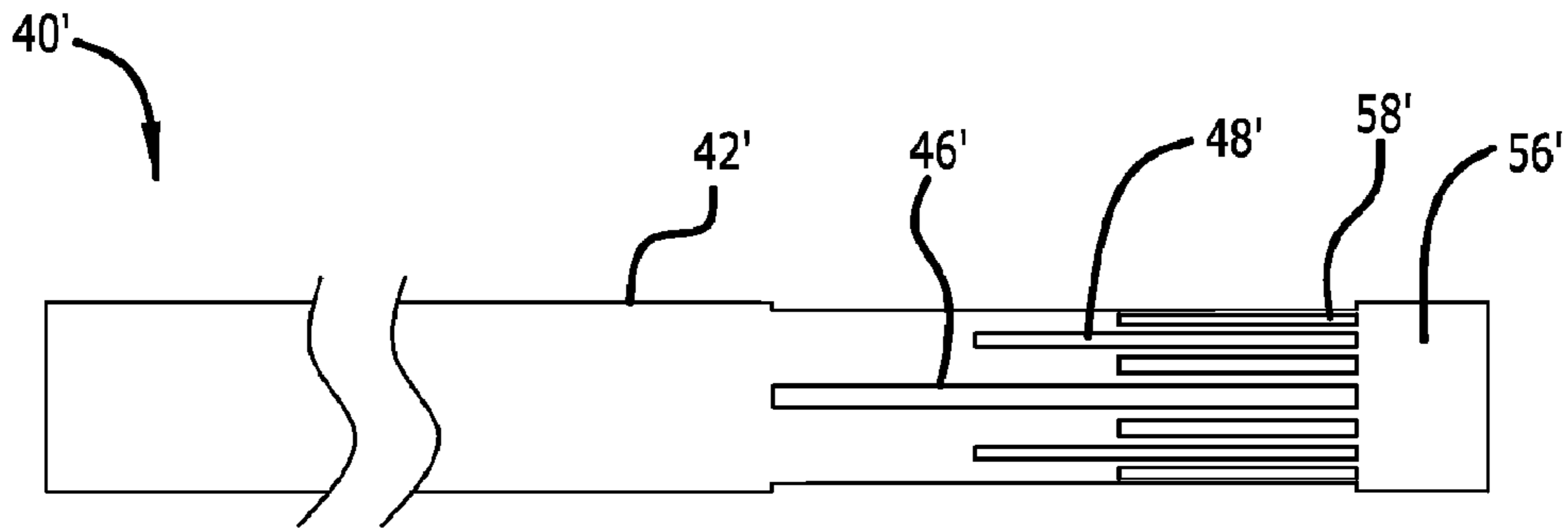


Fig. 6

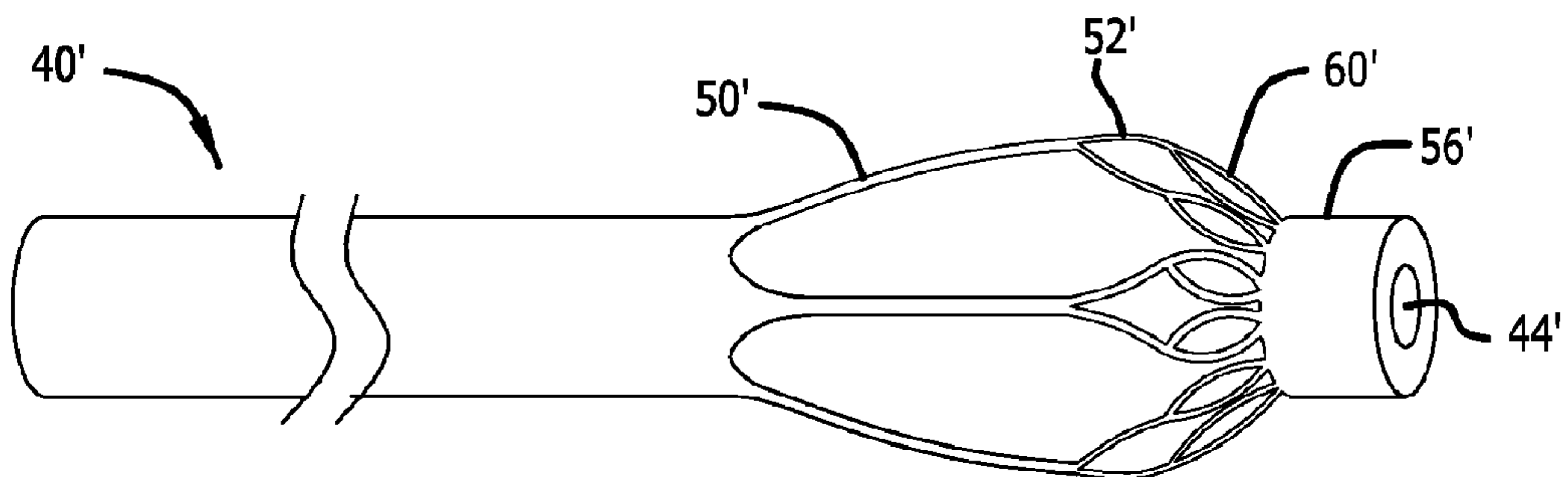


Fig. 7

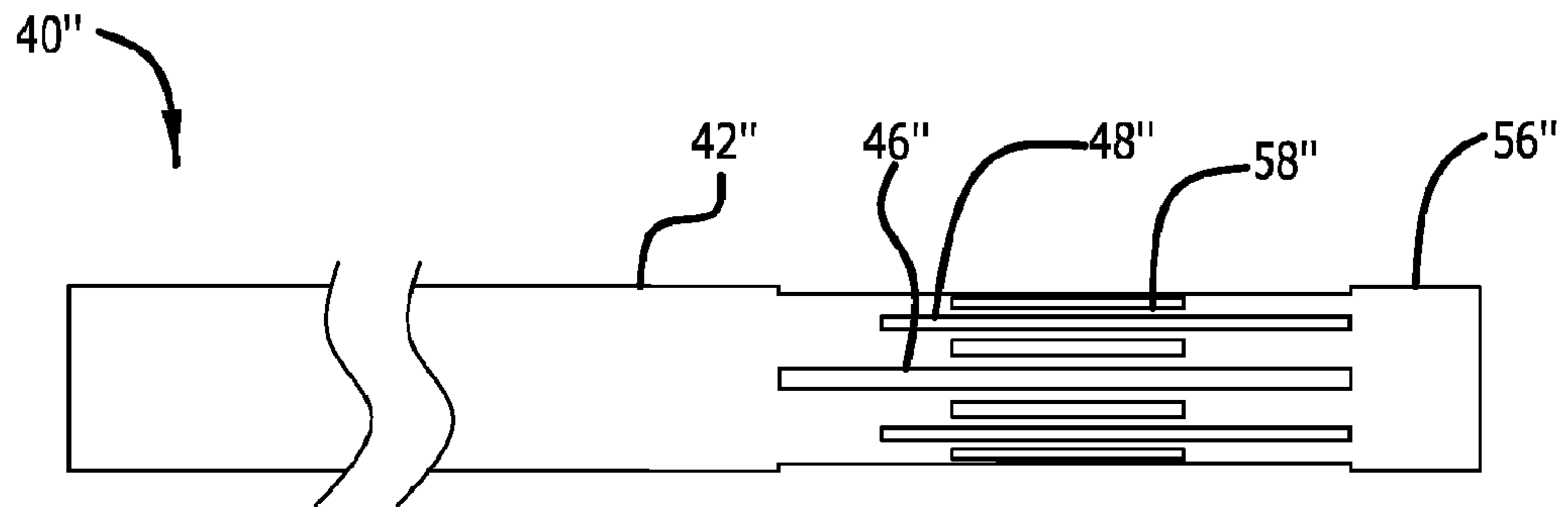


Fig. 8

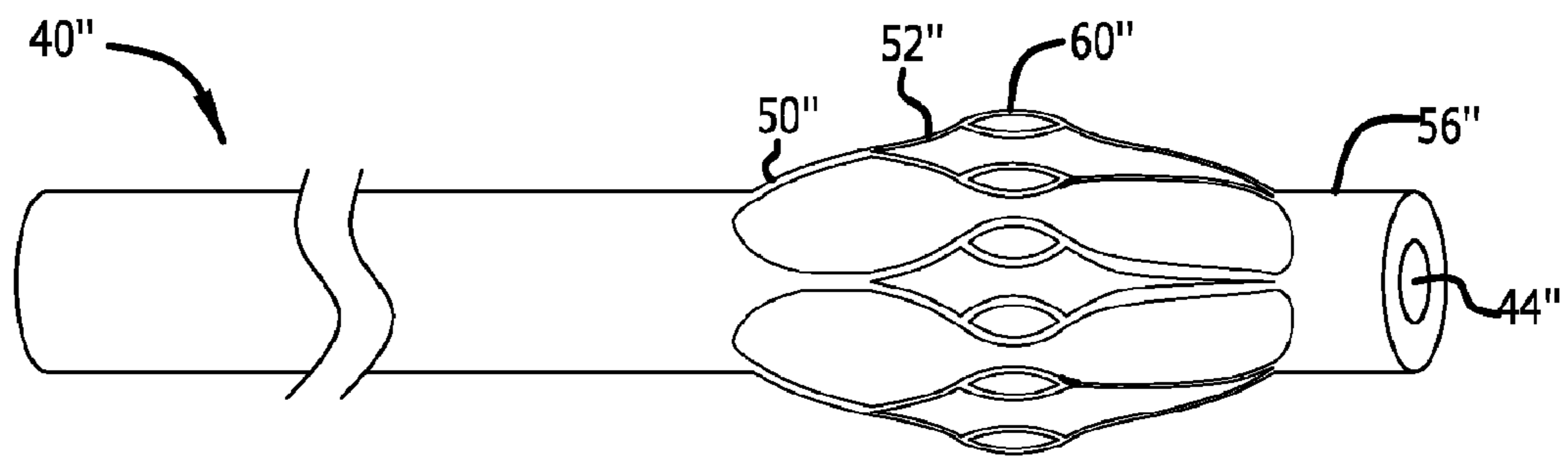


Fig. 9

## TOOL FOR REMOVING OBJECT FROM THE BODY OF A PATIENT

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.**

### TECHNICAL FIELD

This invention relates to a tool which defines a basket cavity for removing a discrete object from the body of a human or animal patient, said tool having an elongate shaft having a tool head at a distal end thereof, said tool head having a radially compact disposition and a radially spread disposition for embracing said object.

### BACKGROUND ART

The present applicant manufactures a device for catching, fixing and removing foreign objects from the body of a human patient. These foreign objects can include stones, fragments and concretions in the medical fields of urology and gastroenterology. In the present device, both ends of a number of individual wires are held together by a ring. Normally, the wires have a circular cross-section. One of these rings forms the distal end of a shaft and the other ring is spaced distally axially from the first ring. When the individual wires are all bowed radially outwardly and are distributed at regular intervals around the circumference of the axis, then these wires form longitudinal strands of an envelope defining a cavity centered on the long axis of the shaft. The wires are resilient and are given an outwardly bowed symmetrically or helically twisted shape so as to define a basket cavity radially inwardly of the envelope defined by the wires. The number of wires is usually in a range of from two to six. The entire device is placed within a sheath. For catching the foreign object, the distal end of the shaft and basket assembly is advanced out of the distal end of the sheath, allowing the resilience of the wires to form the basket by outward bowing. Once the foreign object is fished into the basket, then the shaft can be withdrawn proximally, to a greater or lesser extent, in order that the distal end of the sheath should squeeze down the diameter of the basket so that the basket wires grip the foreign object in the reduced diameter basket cavity immediately adjacent the distal end of the sleeve. Then the shaft and sleeve can together be withdrawn in the proximal direction to carry the foreign object in the basket out of the body.

In endoscopic surgery, a small diameter of the sheath is desirable. Currently the devices on the market have a sheath diameter falling within a range of outside diameters from 0.63 to 1.83 mm, which corresponds to a range of 1.9 to 5.5 French (1 French= $\frac{1}{3}$  mm).

One disadvantage of the presently marketed devices is that soldered, welded or glued joints are used to fix the individual wires to the rings and to the shaft. These connections represent a potential failure risk and, in any event, their ultimate strength has to be ascertained by extensive examination and testing.

Apart from this, the jointing of the wires at the rings defines the greatest outer diameter of the shaft element of the device, which therefore determines the inner diameter of the sheath and therefore indirectly determines the outer diameter of the sheath, setting a limit on the minimization of the outer sheath diameter.

Furthermore, the envelope of wires determines a characteristic mesh size of the basket and this mesh size has to be suitable both for fishing an object into the basket and then for retaining it within the basket until it has been removed from the body. Whereas a small mesh helps retention and removal, it does not help in the process of fishing the foreign object into the basket. A compromise mesh size has to be adopted.

EP-A-818 180 discloses an endoscope accessory in the form of a tube with a slitted distal end portion. The slits can be deformed radially outwardly to define a plurality of openings, by pulling from the proximal end of the tube on a pull wire 13 connected at its distal end to the distal end of the slitted portion. The disclosure of EP-A-737 450 is, in these respects, similar and U.S. Pat. No. 4,807,627.

EP-A-512 729 discloses an endoscopic surgical instrument which includes a tube having a slitted portion at its distal end. In a relaxed disposition of the wall portions between the slits, they are spaced apart from one another to form a basket. The slitted tube is itself co-axially within an outer tube having a distal end, and the basket can be closed down by drawing the basket, beginning at its proximal end, proximally into the outer tube, past the distal end of the outer tube. The slitted tube is made of a polyurethane material and the basket is formed by the application of steam heating to the slitted end.

DE-A-197 22 429 discloses a Nitinol tube, slitted at its distal end, for use as a basket to gather stones from bodily cavities. It is said to differ from previous such baskets in that the strands of the basket are unitary with the tube.

WO 94/18888 is another disclosure of a stone-gathering basket made from a plurality of Nitinol wires. The wires are arranged around the circumference of the basket in pairs and given a helical twist, which is said to increase the number of points of contact between the basket and entrapped calculi and to require of the physician no more dexterity than the prior art baskets, having a smaller number of contact points, required.

WO 96/23446 discloses a stone-gathering basket in which a distal half of the basket envelope exhibits a greater number of basket strands than the proximal half of the basket envelope. Each lengthwise strand in the proximal half of the baskets splits at half distance over the basket envelope into a plurality of strands which help to define the proximal half of the basket envelope. At the distal end of the basket is a cap to which all of the filaments defining the basket envelope are welded.

WO 99/16365 discloses a stone-gathering basket defined by a plurality of legs and with discussion what cross-sectional shapes of the legs are useful, and what surface topography on the inward facing surface of each leg.

WO 99/48429 is another disclosure of a stone gathering basket made unitary from a tube with longitudinal slits at its distal end, the basket being relaxed in its expanded configuration and of a material which can be a nickel titanium shape memory alloy such as Nitinol.

### SUMMARY OF THE INVENTION

The present invention aims to mitigate some or all of the above-mentioned difficulties and, in any event, aims to improve present technology.

According to one aspect of the present invention, there is provided a medical device as described above, for removing a foreign object from the body of a human or an animal patient, which is characterized in that:

1. the shaft and tool head are formed from a single length of a tubing;

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2. said tubing is slit lengthwise within a length contained within said tool head and stopping short of a distal end surface of said tube, thereby to form at least three parallel first strands which together define an envelope of said basket cavity; and
3. the tool is provided with a set of second strands, each formed by slitting one of the first strands over a distal portion of said first strand, which distal portion is less than the full length of the first strand.

In this way, it can be arranged that the mesh size of the basket structure, of the distal end of the basket, is provided as smaller apertures than are present at the proximal end of the basket. In this way, foreign objects can be fished into the basket at its proximal end, after which they can be retained in the smaller aperture mesh at the distal end of the basket. In one preferred embodiment, the second strands have a length in a range of from 45% to 80% of the length of the first strands.

It will be appreciated that, in the tool of the present invention, no joints are required. The basket is instead made from the base tubing of the shaft of the tool.

Further, it will be appreciated that the largest diameter of the tool is represented by the basic tubing itself, there being no larger diameter of rings at each end of the basket.

Conceivably, a basket could be constructed by slitting each of the second strands over a portion of its length which is less than the full length of the second strand, thereby to define a set of third strands over part of the length of the basket, setting an aperture size in that zone of the length of the basket smaller than would otherwise be the case in the absence of the third strands. For example, the zone of the third strands could be in a "belly portion" of the basket where its diameter is close to its maximum, thereby to achieve an aperture size in this belly portion smaller than an aperture size in a proximal half of the basket envelope, thereby better to retain an object captured in the proximal half of the basket in the smaller mesh size of the distal half of the basket.

Conveniently, the tubing is made from nickel titanium shape memory alloy and the strands are formed by a narrow diameter laser beam which cuts through the wall of the tubing.

It will be appreciated that, the device being based on a tube, there is the possibility to provide a guide wire or other core wire during use of the tool. For example, one could advance the tool into position along a previously placed guide wire. For laser cutting, one could set within the tubing work piece a core, so that the incident laser beam passes through one wall thickness and into the core, but not beyond the core into the wall thickness of the tubing on the opposite side of the core. In this way, one could slit the tube at 120° intervals around its circumference in order to create three first strands, and then the laser could be used to slit each of the three first strands, along a distal portion of its length, into two second strands, making a total of six second strands distributed at sixty degree intervals around the circumference of the tubing.

#### BRIEF DESCRIPTION OF THE DRAWINGS

For better understanding of the present invention, and to show more clearly how the same are recurred into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

FIG. 1 is a longitudinal diagrammatic section of a prior art tool for removing a foreign object from the body of a patient;

FIG. 2 is a similar section through a first embodiment of a tool in accordance with the present invention, in its compact disposition;

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FIG. 3 is a section corresponding to FIG. 2, and showing the FIG. 2 tool in spread disposition;

FIG. 4 shows a transverse section through line IV-IV in FIG. 2;

FIG. 5 is a transverse section through line V-V of FIG. 2;

FIG. 6 is a longitudinal diagrammatic section of another embodiment of a tool in accordance with the present invention, in its compact disposition;

FIG. 7 is a section corresponding to FIG. 6, and showing the FIG. 6 tool in spread disposition.

FIG. 8 is a longitudinal diagrammatic section of yet another embodiment of a tool in accordance with the present invention, in its compact disposition; and

FIG. 9 is a section corresponding to FIG. 8, and showing the FIG. 8 tool in spread disposition.

#### DETAILED DESCRIPTION

Referring to FIG. 1, a conventional tool has a shaft 12 with a distal end 14 on which is mounted a first ring 16. Welded within the open distal end of the ring 16, side by side, are four nickel titanium shape memory alloys circular section wires 18. All four distal ends of the wire 18 are welded within an end ring 20 spaced from the distal end 14 to the shaft 12 and itself representing a distal end of the device 10. Each of the wires 18 is given a bowed shape, as shown in the figure, by thermal treatment as is understood by those skilled in this art. The entire device is telescoped within a sleeve (not shown) having an inner diameter big enough to accommodate the rings 16 and 20.

For catching and removing foreign objects, the distal end of the sleeve is advanced to a desired location within the body and then the shaft 12 is advanced until the basket 18 opens just distally beyond the distal end of the sleeve. Moving the sleeve, the medical practitioner fishes the target object into the cavity 22 within the basket defined by the wires 18, and the shaft 12 is withdrawn proximally by a distance sufficient for the distal end of the sheath to squeeze the wires 18 onto the foreign object, thereby retaining it within the basket cavity 20. Then the sheath and shaft are together withdrawn proximally, carrying the object out of the body.

The method of use of a tool in accordance with the present invention is similar. However, the manufacture of the tool is quite different, as can be seen from FIG. 2.

FIG. 2 shows a tool 40 based on a single length of tubing 42 having a lumen 44 which runs its full length. The tube is of Nitinol shape memory alloy. Near the distal end of the tube 42 is provided a plurality of slits, comprising a set of four first slits 46 arranged at ninety degree intervals around the circumference of the tube 42. Evenly spaced between each pair of first slits 46 are the slits of a set of four second slits 48, again made by laser. FIG. 2 shows a core wire 49 which can be placed within the lumen 44, at the distal zone of the tubing 42, if it is desired for the incident laser beam to penetrate only one wall thickness of the tubing 42, and not go beyond the lumen 44 (as would be appropriate if, for example, an arrangement of three first slits 46, at 120 degree intervals around the circumference of the tubing 42, were to be specified). The length of the set of first slits 46 corresponds to the desired length of the object-catching basket of the tool 40.

Now referring to FIG. 3, the basket of the FIG. 2 tool can be seen in its spread disposition. Just as Nitinol stents are given a remembered dimension by heat treatment, so the tool of FIG. 2 is given by heat treatment the basket shape illustrated in FIG. 3. Thus, when the tubing 42 is advanced into a surrounding sheath, the strands 50 between adjacent first slits 46, and the strands 52, between adjacent first and second slits 46,

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48, are squeezed down from the spread disposition of FIG. 3 into the compact disposition shown in FIG. 2. Then, when the distal end of the tubing 42 is advanced distally out of the distal end of the sleeve, the strands 50 and 52 can take up the remembered deployed disposition of FIG. 3.

FIGS. 3, 4 and 5 reveal a valuable technical effect of the present invention, namely, that the mesh size of the basket can be varied, from one end of the basket to the other, allowing foreign objects to be introduced into the basket envelope through the relatively wide aperture zone of the proximal end of the basket, but then more securely retained within the basket at the relatively smaller diameter aperture portions at the distal end of the basket. Note also in FIG. 3 the presence of a guide wire 54. The tool could be advanced on such a guide wire, into a desired location, then the guide wire 54 could be withdrawn proximally, to leave the basket cavity empty, and then the foreign object could be fished into the basket.

FIG. 6 shows a tool 40' based on a single length of tubing 42' having a lumen 44' that runs its full length. Near the distal end of the tube 42' is provided a plurality of slits, comprising a set of four first slits 46' arranged at ninety degree intervals around the circumference of the tube 42'. At a distal end of the first slits 46' and evenly spaced between each pair of first slits 46' are the slits of a set of four second slits 48', again made by laser. At a distal end of the second slits 48' and evenly spaced between each pair of second slits 48' are the slits of a set of eight third slits 58', again made by laser. Other slit arrangements are contemplated, such as, for example, three first slits 46' at 120 degree intervals around the circumference of the tubing 42'. The length of the set of first slits 46' corresponds to the desired length of the object-catching basket of the tool 40'.

Referring to FIG. 7, the basket of the FIG. 6 tool can be seen in its spread disposition. The basket may be constructed by slitting each of the first strands 50' over a distal portion of its length, which is less than the full length of the first strand, thereby defining a set of second strands 52'. These second strands 52' may be further slit over a distal portion of its length which is less than the full length of the second strand, thereby defining a set of third strands 60' over a distal part of the length of the basket, setting an aperture size in that zone of the length of the basket smaller than would otherwise be the case in the absence of the third strands 60'. The resulting strands achieve an aperture size smaller at the distal end than at the proximal end of the basket envelope, thereby better to retain an object in the smaller mesh size of the distal half of the basket, yet captured in the larger mesh size of the proximal half of the basket.

FIG. 8 shows a tool 40" based on a single length of tubing 42" having a lumen 44" which runs its full length. Near the distal end of the tube 42" is provided a plurality of slits, comprising a set of four first slits 46" affanged at ninety degree intervals around the circumference of the tube 42". Evenly spaced between each pair of first slits 46" are the slits of a set of four second slits 48", again made by laser. Evenly spaced between each pair of second slits 48" are the slits of a set of eight third slits 58", again made by laser. Other slit arrangements are contemplated, such as, for example, three first slits 46" at 120 degree intervals around the circumference of the tubing 42". The length of the set of first slits 46" corresponds to the desired length of the object-catching basket of the tool 40".

Referring to FIG. 9, the basket of the FIG. 6 tool can be seen in its spread disposition. In this embodiment, the first strands 50" extend along the a distal region of the tool head, stopping short of a distal end surface of the tubing. Second strands 52" are within a distal portion of the first strand 50", where the length of the second strand 52" is less than a length

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of the first strand 50". In a spread disposition, the second strand 52" extends from a side of the first strand 50" and is directed distally along its length toward the distal end of the tubing 42". Third strand 60" is within a portion of the second strand 52", where the length of the third strand 60" is less than the length of the second strand 52". In the spread disposition, the third strand 60" extends from a side of the second strand 52" and is directed distally along its length toward the distal end of the tubing 42". The distalmost ends of the first strands 50" and second strands 52" may be secured together at the tip 56". In one embodiment, the zone of the third strands could be in a "belly portion" of the basket where its diameter is close to its maximum, thereby to achieve an aperture size in this belly portion smaller than an aperture size in a proximal half of the basket envelope, thereby better to retain an object captured in the proximal half of the basket in the smaller mesh size of the distal half of the basket.

Not immediately evident from the drawings is a further useful technical effect of the present invention. Whereas the distal ring 20 of the prior art device has a relatively significant length, the unslitted distal tip 56 of a device in accordance with present invention could be made relatively much shorter in length. This could improve the performance of the device when it is desired to fish into the basket an object which lies rather close to a tissue wall surface within a cavity or lumen of a body.

The cutting by laser of slits within the cylindrical wall surface of a tube of Nitinol shape memory alloy is a technology which is by now relatively well understood by those companies which specialize in the manufacture of self-expanding stents. For such companies, it will be apparent from the above description that the accompanying drawings and specific description given above represents only one example of how the concept of the present invention can be realized.

The concept of the invention permits a new combination of stone destruction insitu by lithotripsy. The technique of lithotripsy involves hitting a stone with a probe which is itself struck by a projectile at the proximal end of the lithotripsy probe, to provide a kinetic energy ballistic impact on the stone to fragment the stone. It is envisaged that the device of the present invention would trap the stone and then a lithotripsy probe would be introduced into the proximal end of the tubular shaft and advanced into the basket at the distal end, to attack the stone trapped therein. A suitable probe can be obtained from EMS Electromedical Systems SA, CH-1347, Le Sentier, Switzerland.

To such readers, variations and modifications of these specific description above will be evident. The scope of the claims which follow is not to be taken as limited to the specific details of the description given above.

The invention claimed is:

1. A tool for removing a discrete object from the body of a human or animal patient, comprising:
  - a single length of tubing including an elongated shaft having a tool head at a distal end thereof, said tool head having a radially compact disposition and a radially spread disposition defining a basket cavity for embracing said object, said elongate shaft being longer than said tool head;
  - said tubing including at least three longitudinal slits within the tubing of the tool head, extending along the tool head and stopping short of a distal end surface of said tubing, defining at least three parallel first strands between the at least three longitudinal slits which together define an envelope of said basket cavity;
  - at least one second strand defined by an additional slit within a distal portion of at least one of said first strands,



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a length of the at least one second strand being less than a length of the at least one of said first strands; and at least one [said] third [strands] *strand* defined by another additional slit within the at least one second strand over a portion of the length of said second strand, a length of the at least one third strand being less than the length of the at least one second strand.

2. [A] *The tool as claimed in claim 1 wherein said strands have a relaxed disposition which defines the spread basket envelope.*

3. [A] *The tool as claimed in claim 1 wherein the length of the at least one second strand is between 45% and 80% of the length of the first strand.*

4. A tool as claimed in claim 1 further including at least one third strand defined by another additional slit within the at least one second strand over a portion of the length of said second strand, a length of the at least one third strand being less than the length of the at least one second strand.]

5. [A] *The tool as claimed in claim 1 in which the unslitted distal end of the tubing has a length which is less than twice an outside diameter of the tubing.*

6. [A] *The tool as claimed in claim 1 wherein the tubing is of a shape memory material.*

7. [A] *The tool as claimed in claim 6 wherein the tubing is made of nickel titanium shape memory alloy.*

8. [A] *The tool as claimed in claim 1 in combination with a sheath.*

9. [A] *The tool as claimed in claim 1 wherein the elongate shaft has a lumen that extends distally to the tool head further in combination with a lithotripsy probe dimensioned to be received within the lumen.*

10. A method for forming a tool for removing a discrete object from the body of a human or animal comprising:

providing a tubular member having a lumen extending therethrough, the tubular member having a distal region, said entire tubular member being substantially longer than the distal region;

forming at least three slits at the distal region, lengthwise of the tubular member, to form a plurality of first strands, each strand being disposed between adjacent of said slits;

forming, along a distal portion of at least one of the first strands, a plurality of longitudinally extending second strands;

maintaining the distal most ends of the strands secured together; and forming a third group of longitudinally extending strands at the distal region of at least one of the second strands by slitting the distal region of said second strand.

11. [A] *The method as defined in claim 10, further comprising:*

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forming a third group of longitudinally extending strands at the distal region of at least one of the second strands by slitting the distal region of said second strand.

12. [A] *The method as defined in claim 10, wherein the step of providing the tubular member comprises selecting a tubular member of a shape memory material.*

13. [A] *The method as defined in claim 12, wherein the shape memory material has characteristics at normal body temperature such that the strands will tend to assume, at the body temperature, a radially enlarged basket-like configuration.*

14. [A] *The method as defined in claim 10, further comprising:*

placing a lithotripsy probe within the tubular member to be in position to direct energy toward a volume embraced by the strands.

15. A medical device, comprising:

an elongate shaft terminating in a first tube section, said elongate shaft being longer than said first tube section; a second tube section disposed proximate to the first tube section;

at least one first strand extending from an end of the first tube section to an end of the second tube section, the at least one first strand having a side and defining at least one aperture communicating with an interior of the device;

at least one second strand extending from the side of the at least one first strand to the end of the second tube section;

wherein the elongate shaft, first tube section, and the second tube section are formed from a single length of tubing; and at least one third strand extending from a side of the at least one second strand to the end of the second tube section.

[16. The medical device of claim 15, further comprising at least one third strand extending from a side of the at least one second strand to the end of the second tube section.]

17. The medical device of claim 15, the at least one second strand having a side and defining at least another one aperture communicating with the interior of the device.

18. The medical device of claim 15, the single length of tubing being a shape memory metal.

19. The medical device of claim 15, the device having four first strands and four second strands.

20. The medical device of claim 15, the first tube section having an outer diameter and defining a central axis, at least a portion of the first or second strands extending radially from the axis to a diameter greater than the outer diameter of the first tube section.

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