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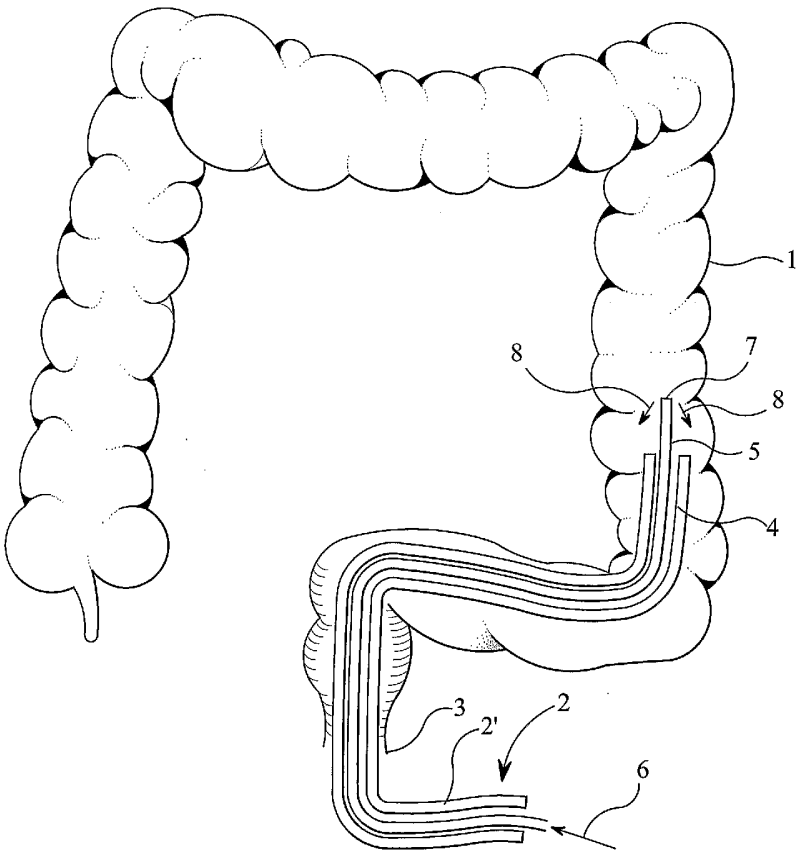
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[Continued on next page]

(54) Title: FLUID PROPELLED ENDOSCOPE



(57) Abstract: An endoscope, more particularly a colonoscope, is provided for introduction into and along a passageway in a human or animal body in a desired direction of travel, the endoscope having a fluid propulsion device for effecting introduction. The fluid propulsion device comprises a conduit having an inlet for fluid under pressure and at least one outlet for expelling the fluid in a direction at least partly opposed to the desired direction of travel of the endoscope. The outlets may be atomising nozzles. The conduit may be movable lengthwise of the endoscope, but constrained to substantially follow the path of the endoscope. In one embodiment the endoscope is caused to travel over a pre-installed guidewire.

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FLUID PROPELLED ENDOSCOPE

The present invention relates to fluid propelled endoscopes, and to methods for using such endoscopes. The invention is particularly directed to endoscopes for use in the colon, i.e. colonoscopes, and more particularly to colonoscopes for use in the human colon. The following description focuses primarily on such colonoscopes. It is to be understood, however, that the invention is also applicable to other types of endoscope, for example, for use in the small bowel, and to endoscopes, whether or not they are colonoscopes, for use in the colons of non-humans.

One of the main difficulties in inserting a colonoscope into the colon is that the colon is an elastic tube that follows a tortuous path. As the colonoscope is pushed around a bend it does not always slide smoothly along the colon wall, but frequently catches on it, so that as the colonoscope is pushed further in, the colon is stretched and a loop is formed. In view of this, it would be desirable to provide traction at or near the tip of the colonoscope, to pull the colonoscope and so obviate, or at least lessen, the need for pushing.

One method which has been described in the prior art (see US Patent No. 4,735,501) for exerting traction on the tip region of an endoscope involves the use of fluid propulsion. Thus, in US Patent No. 4,735,501, various devices generically referred to as borescopes are described which have a fluid conduit along the length thereof, with an outlet at the distal end directed oppositely to the intended direction of insertion of the borescope. Fluid expelled from that outlet produces a reaction force which urges the borescope in its intended direction of insertion.

However, although US Patent No. 4,735,501 mentions the possibility of adapting what is described therein to propelling and guiding endoscopes, no detailed description is given as to how this might be done, and it does not address the particular problems arising in the case of an endoscope and, more particularly, in the case of a colonoscope. The present invention, in its various aspects, seeks to address those problems.

One reason why fluid propulsion is attractive for endoscopy is that very little mechanism is required inside the patient, and complex components, such as a pump for providing pressurised fluid, and a control system, can all be placed well away from the patient, where size is not a problem. However, there is a problem in using fluid

propulsion in endoscopy, which is that, in practice, the thrust that can be produced is not very large. There are two reasons for this. Firstly, the flow rate is limited by the need not to overload the colon with water. The second is that the velocity of the fluid must not be so high that the fluid jet may pierce the wall of the colon or other body organ, or damage it in some other way, and it is at least desirable that it should not cause significant discomfort to the patient. In at least some of its aspects the present invention seeks to address these problems.

According to a first aspect of the invention, there is provided an endoscope for introduction into and along a passageway in a human or animal body in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope, wherein the or each said outlet is an atomising nozzle.

According to a second aspect of the invention there is provided an endoscope for introduction into and along a passageway in a human or animal body in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope, wherein said conduit is movable lengthwise of the endoscope, but is constrained to substantially follow the path of the endoscope.

The invention further provides a method of using an endoscope according to the second aspect, in which:

(a) said conduit is moved a certain direction in the desired direction of travel;

(b) the endoscope is allowed to move in the said desired direction; and

(c) steps (a) and (b) are repeated until the endoscope has been introduced to the desired extent.

The invention further provides a method of introducing an endoscope into and along a passageway in a human body, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet, wherein a guidewire is introduced into and along said passageway, and the endoscope is caused to travel over said

guidewire, in the desired direction of travel, by expelling fluid from said outlet in a direction at least partly opposed to the desired direction of travel. The guidewire may, for example, be introduced into and along said passageway by a method as described in UK Patent Application No. 0307715.3, corresponding to co-pending US Patent Application Serial No. 10/409,270 (Swain et al) and PCT/US2004/009982 (published as WO2004/089456), the contents of which are incorporated herein by reference.

The present invention additionally provides an endoscope adapted for use in the method just defined, where a guidewire is introduced as a preliminary step, the endoscope comprising an elongate main body having a leading end and a proximal end, and a guidewire receiving element exterior to the main body, at or adjacent the distal end thereof, for defining an opening through which the guidewire can pass. The guidewire receiving element is preferably in the form of a short tube, i.e. a tube short compared to the length of the main body, secured to, or integral with, the main body.

In yet another aspect, the present invention provides an endoscope for introduction into and along a passageway in a human or animal body in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope, wherein the endoscope has: (a) a mass per unit length, over a majority of its length, of not more than 1 gram/cm; and/or (b) a diameter of less than 6mm over a majority of its length.

In a yet further aspect, the invention provides a colonoscope for introduction into and along a human or animal colon in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope.

Where a fluid is referred to herein it is to be understood that this is preferably a liquid, and that the liquid is preferably aqueous. The liquid would normally be water, or an aqueous liquid which is isotonic with the liquid expected to be found in the passageway into which the endoscope is being introduced. It may be desirable to add a biologically acceptable anti-foaming agent or other additive. Also, it may be desirable to warm the water to body temperature.

Some embodiments of the invention will now be described, with reference to the accompanying drawings, in which:

Figure 1 shows an embodiment of colonoscope according to the present invention in the process of being introduced into, and passed along, the colon;

Figure 2 is a longitudinal section through an atomiser head for use at the distal end of an embodiment of the invention;

Figure 2a is a cross-sectional view on line II-II in Figure 2, but omitting the central tube;

Figure 3 shows an endoscope according to the present invention mounted on a guidewire for travel along that guidewire;

Figures 4a and 4b show two possible arrangements for supplying liquid under pressure to the endoscope.

Referring now in more detail to Figure 1, this shows a colon 1 and an endoscope 2 which, in the position shown, has been introduced through the anus 3 so that the leading end of the endoscope is located part way along the length of the colon. The endoscope 2 has a flexible, elongate main body 2' with a biopsy channel 4 extending along the length thereof. It will be understood that the endoscope is shown only diagrammatically, and that the diameter of the biopsy channel would in practice be much smaller in relation to the diameter of the endoscope body than is shown in the drawing. Also, for simplicity, the optics of the endoscope have been omitted, as have the controls which are positioned at the proximal end of the endoscope. The endoscopes and controls can be entirely conventional, and form no part of the present invention.

A flexible conduit 5 passes through the biopsy channel 4, emerging from the channel at both ends. The conduit can be made of, for example, a medical-grade plastics material and is longitudinally slideable within the biopsy channel. The upstream end of the conduit 5 is connected to a liquid supply, indicated by the arrow 6, for supplying liquid under pressure. The distal end 7 of the conduit 5 is closed to prevent liquid emerging therefrom, and outlets are formed laterally in the conduit through which jets of liquid 8 emerge. The embodiment of Figure 1 has four such outlets, arranged at 90° to one another around the distal end region of the conduit, of which two are visible in Figure 1. However, it is to be understood that there might be only one, two or three outlets, or there might be more than four. The outlets are so

formed that the jets of liquid, as they leave the outlets, have a component directed lengthwise of the conduit 5 in a direction away from its distal end and towards its proximal end. In the embodiment illustrated in Figure 1 the jets are angled backwards, i.e. they not only have the component just defined but also a component at right angles to the length of the conduit and, as illustrated, towards the adjacent part of the colon wall. It is to be understood, however, that the outlets could be so formed that the jets were directed parallel to the length of the conduit in the distal end region, i.e. they had no component directed towards the adjacent part of the colon wall.

A description will now be given of the way in which the endoscope of Figure 1 is advanced further into the colon, starting from the position shown in the figure. Initially, the physician carrying out the endoscopy holds the proximal end of the endoscope main body 2' and the adjacent portion of the conduit 5, so that they cannot move longitudinally with respect to one another at that point. Liquid under pressure is then supplied to the proximal end of the conduit 5 from the above-mentioned liquid supply and emerges from the distal end of the conduit in the form of liquid jets 8. These jets produce a reaction force on the distal portion of the conduit which cause the conduit to move forwards, further into the colon. Although the conduit 5 is slideable within the biopsy channel 4 of the main body 2', it has surprisingly been observed that forward movement of the conduit 5 is accompanied by forward movement of the endoscope main body. This is due not to friction between the conduit and main body but to the tendency of the main body to try to straighten in response to forward movement of the leading end of the conduit 5, which of course tends to straighten that conduit. In this way, the liquid jets 8 provide what appears to be, at least in substance, equivalent to a traction force on the distal end of the conduit main body 2', which is what is desired.

The endoscope main body 2' is preferably of the type which has a steerable tip, endoscopes with such tips being well known in the art. Altering the angle of that tip with respect to the remainder of the body has the effect of altering the direction in which the distal end portion of the conduit points, and therefore altering the direction in which the liquid jets 5 exert their propulsion force. In this way the leading end of the endoscope can be steered along the tortuous path which is followed by the colon. If the endoscope did not have such a steerable tip it might bury itself into the wall of the colon or into a diverticulum, so that further thrust from the tip would not advance the

endoscope. It is therefore desirable to provide some other means for altering the direction of the jets 8, or at least altering the direction of the force provided by those jets. Although this would be feasible, for example by providing means for independently controlling the velocity and/or volumetric flow rate through individual ones of a plurality of jets, a steerable tip on the endoscope provides a simpler solution to the need for steering.

As mentioned above, when using jet propulsion in endoscopy it is important that the velocity of the fluid is not so high that it pierces the wall of the colon or other body organ, or damages it in some way, and it is at least desirable that it should not cause significant discomfort to the patient. With this in mind, the present invention provides, in one of its aspects, an endoscope in which fluid propulsion is provided by means of one or more atomising nozzles. Surprisingly, it has been found that atomising the liquid to produce a spray causes very little reduction in the efficiency of propulsion, while potentially providing the benefits of reduced risk of damages and greater comfort already mentioned.

An atomiser head for use in this aspect of the invention is shown in Figure 2. The head 20 comprises a distal body portion 21 and a proximal body portion 22 within which are formed cavities which enable atomised liquid jets to be formed. In Figure 2 dense hatching represents liquid, and sparse hatching represents spray. Liquid enters the head through a tube 23 which leads into a plenum chamber 24. From the chamber 24 liquid passes through a plurality of pairs of bores 25, the bores of each pair being angled so that they meet at their downstream ends. The liquid travelling through one bore of the pair collides at its downstream end with liquid travelling through the other bore of the pair, and this collision causes atomisation, i.e. the break up of the liquid into a fine spray of droplets. It has been found that disposing the bores at angles of 20° to the longitudinal axis of the head, i.e. so that the bores of a given pair converge at an angle of 40°, produces good atomisation. In the particular experiment from which this result was derived, the bores were drilled in the member 21 with a 0.52 mm drill bit. It is to be understood, however, that these dimensions are given by way of example, and that other dimensions may be used.

Each pair of bores leads into a respective nozzle 26 which has a convergent upstream portion 26a, a constant diameter throat portion 26b and a divergent outlet portion 26c. The atomised jet emerges from the downstream end of the outlet portion

26c. In the embodiment shown in Figure 2 there are eight nozzles 26 arranged as shown in Figure 2a. It is to be understood, however, that there might be more nozzles or fewer nozzles. It is also to be understood that although the nozzles 26 are shown in Figure 2 as pointing directly backwards, i.e. their direction of flow has no net component directed towards the adjacent walls of the colon, the nozzles might be directed in some fashion other than as shown in Figure 2, for example they might be directed to produce fluid jets angled as shown in Figure 1. It is also to be understood that many other types of atomising nozzles are known in the atomising art, and that such other nozzles might be used instead of a nozzle of the type illustrated.

In one aspect of the invention the endoscope is guided by means of a pre-installed guidewire. Attention has already been directed above to UK Patent Application No. 0307715.3, corresponding to US Patent Application Serial No. 10/409,270, which describes one suitable method for installing a guidewire in, for example, the colon. It is also to be understood that it is not essential that the guidewire should be pre-installed by the method described in UK Patent Application No. 0307715.3, and that any suitable alternative method for pre-installation of a guidewire might be used instead.

With the guidewire thus pre-installed, the endoscope can be threaded onto the portion of the guidewire protruding from the patient, and then caused to advance along the colon by fluid propulsion. Figure 3 shows this process in the case of one suitable embodiment of endoscope. Figure 3 shows a pre-installed guidewire 30 and, running generally parallel thereto, a flexible conduit 31 with a small endoscope head 32 on the leading end thereof. The head 32 may, for example, comprise a gut-imaging camera. At least one length of tube 33 is attached to the conduit 31 and is slideable over the guidewire 30. Two lengths of tube are shown, but there may be three or more or there may be only one. The conduit 31 has backwardly pointing nozzles from which emerge propulsive jets 34, which operate like the jets 8 in Figure 1. In addition to providing a passageway for propulsive liquid to travel to the nozzles, the conduit could also carry

electric wires to enable power to be supplied to the head or electric signals conducted from the head. The conduit 31 and head 32 together constitute a lightweight endoscope (the conduit preferably has a mass of not more than 1g/cm) which, except for the head, and thus over a majority of its length, is of low diameter (the conduit preferably has a diameter of less than 6mm).

The use of a pre-installed guidewire is particularly valuable where the endoscope is very lightweight (note more than 1g/cm) and/or of low diameter (less than 6mm). To put the matter another way, having a pre-installed guidewire means that there is no need to provide the endoscope itself with any means for steering it, and this in turn means that the endoscope can be reduced to bare essentials, say optics plus a fluid conduit with at least one propulsion outlet at its distal end.

Figures 4a and 4b show alternative arrangements for delivering pressurised liquid, in this case water, to an endoscope of the present invention. The arrangement shown in Figure 4 provides water at constant pressure. The arrangement comprises a reservoir 40 made from a length (5 m) of 2 inch diameter copper pipe. Water is supplied to the reservoir from a water inlet via an inlet valve 41. The water in the reservoir is pressurised to a suitable pressure, which depends on the internal diameter of the tube delivering the liquid, but which may, for example, be 6-8 Bar, by means of a cylinder 42 of pressurised nitrogen, connected to the reservoir 40 via a pressure regulator 43. The gas supply is capable of being connected to the outside atmosphere, to vent it, via a valve 44. Water under pressure is supplied to the endoscope via an outlet valve 45.

It is preferred for safety reasons to use a supply of liquid at constant volumetric flow rate, rather than at constant pressure, and for this reason the supply arrangement shown in Figure 4b is preferred to the arrangement shown in Figure 4a. Figure 4b shows a pump 50 designed to supply liquid at a constant volumetric flow rate, the pump being driven by an electric motor 51 via a flexible coupling 52. The pump has a water inlet, and has a water outlet connected to the endoscope. The pressure of the water being supplied is monitored by a pressure gauge 53, and a branch tube 54 is provided to allow water to go to waste when not required by the endoscope. Flow through the branch tube 54 is controlled by a needle valve 55 which can be open or closed. For reasons of electrical safety, care should be taken to ensure that there is no possibility of electric current passing from the pump motor to the patient.

CLAIMS:

1. An endoscope for introduction into and along a passageway in a human or animal body in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope, wherein the or each said outlet is an atomising nozzle.

2. An endoscope according to claim 1 wherein said conduit is movable lengthwise of the endoscope, but is constrained to substantially follow the path of the endoscope.

3. An endoscope for introduction into and along a passageway in a human or animal body in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope, wherein said conduit is movable lengthwise of the endoscope, but is constrained to substantially follow the path of the endoscope.

4. An endoscope according to claim 2 or 3, wherein said conduit is movable lengthwise of the endoscope along a channel thereof.

5. An endoscope according to claim 4, wherein said channel is a biopsy channel.

6. A method of using an endoscope according to any one of claims 2 to 6, in which:

(a) said conduit is moved a certain direction in the desired direction of travel;

(b) the endoscope is allowed to move in the said desired direction; and

(c) steps (a) and (b) are repeated until the endoscope has been introduced to the desired extent.

7. A method of introducing an endoscope into and along a passageway in a human body, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet, wherein a guidewire is introduced into and along said passageway, and the endoscope is caused to travel over said guidewire, in the

desired direction of travel, by expelling fluid from said outlet in a direction at least partly opposed to the desired direction of travel.

8. An endoscope adapted for use in the method of claim 7, wherein the endoscope comprises an elongate main body having a leading end and a proximal end, and a guidewire receiving element exterior to the main body, at or adjacent the distal end thereof, for defining an opening through which the guidewire can pass.

9. An endoscope according to claim 8, wherein the guidewire receiving element is in the form of a tube short compared to the length of the main body, secured to, or integral with, the main body.

10. An endoscope according to any one of claims 1 to 5, 8 or 9, wherein the endoscope has: (a) a mass per unit length over a majority of its length of not more than 1 gram/cm; and/or (b) is less than 6 mm in diameter over a majority of its length.

11. An endoscope for introduction into and along a passageway in a human or animal body in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope, wherein the endoscope has: (a) a mass per unit length over a majority of its length of not more than 1 gram/cm; and/or (b) less than 6mm in diameter over a majority of its length.

12. An endoscope according to any one of claims 1 to 5, or 8 to 11, in the form of a colonoscope for introduction into and along a human or animal colon.

13. A colonoscope for introduction into and along a human or animal colon in a desired direction of travel, the endoscope having fluid propulsion means for effecting said introduction, said fluid propulsion means comprising a conduit having an inlet for fluid under pressure and at least one outlet for expelling said fluid in a direction at least partly opposed to the desired direction of travel of the endoscope.

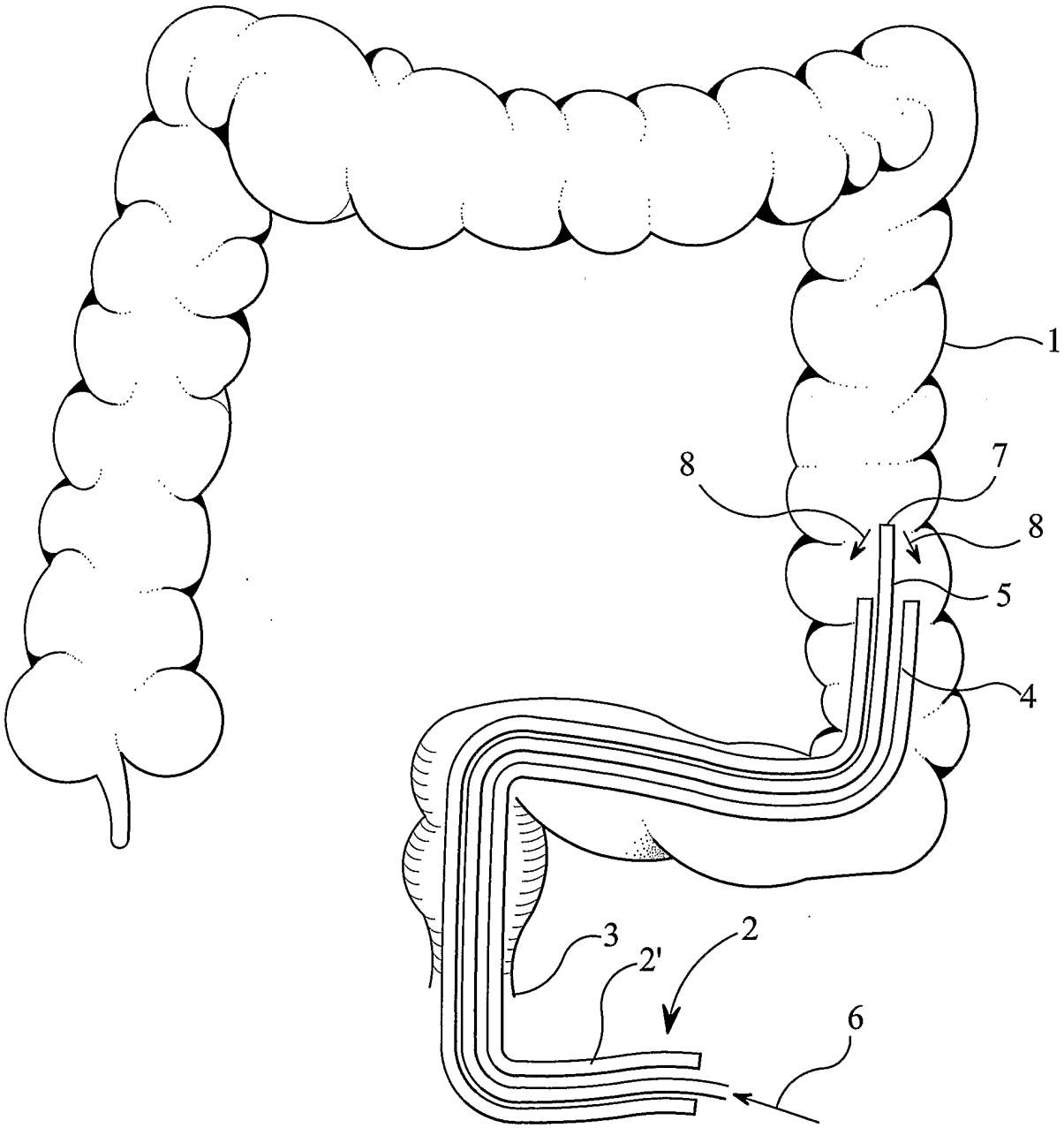


FIG 1

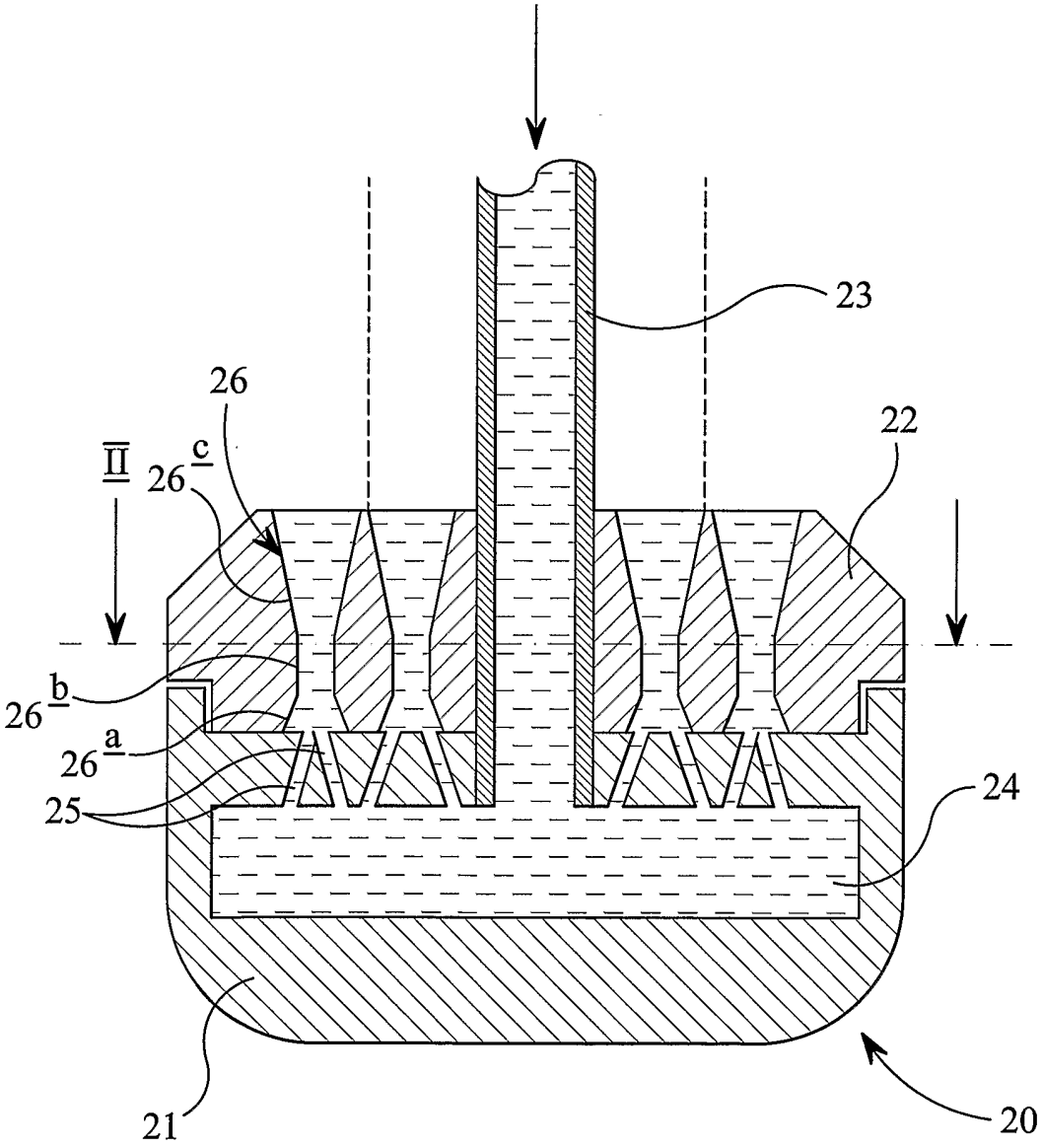


FIG 2

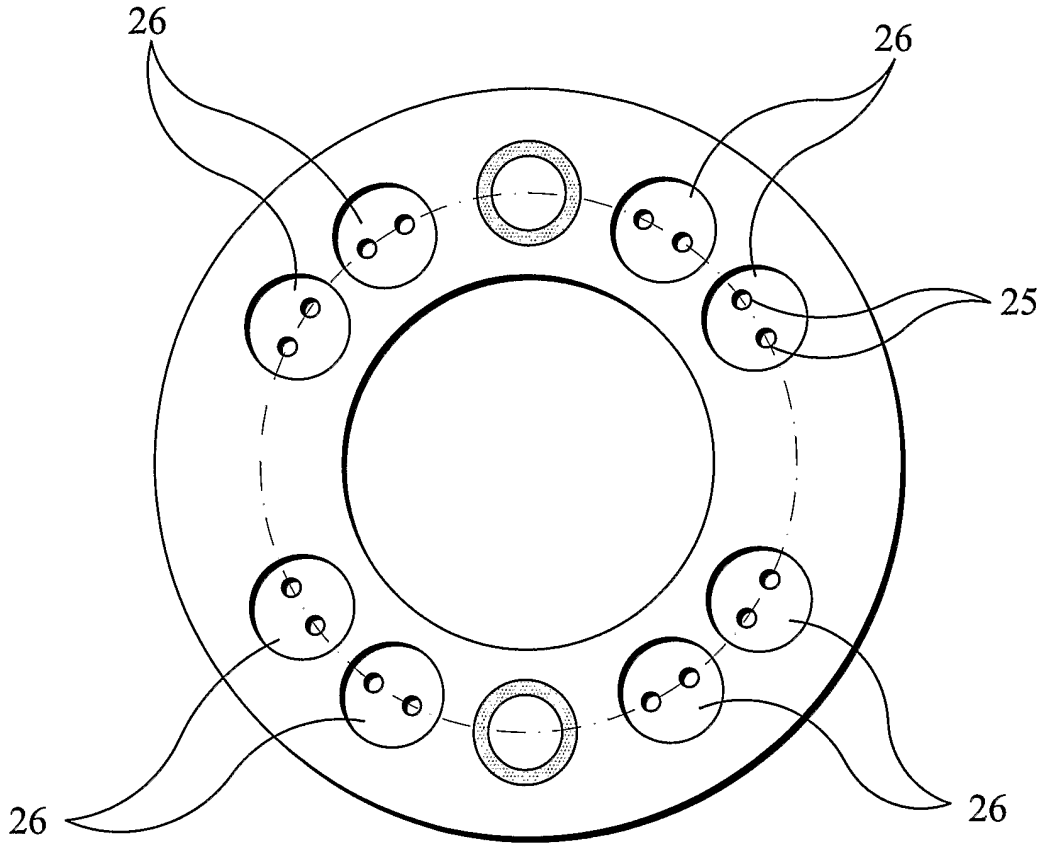


FIG 2a

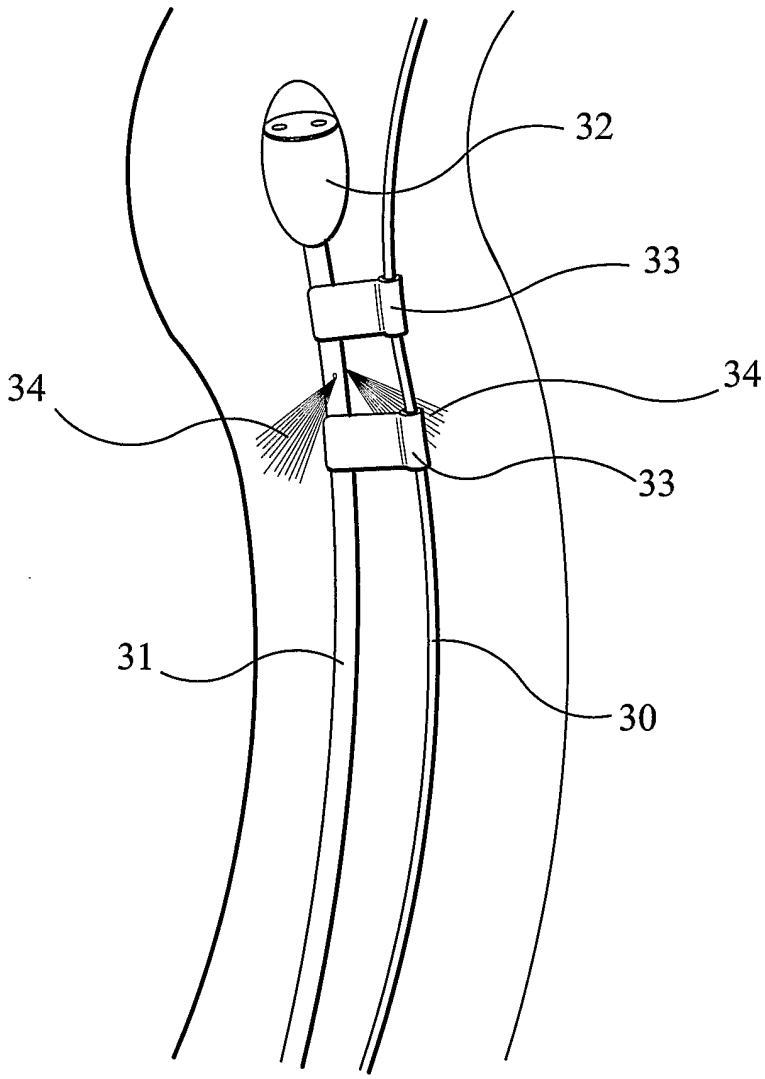


FIG 3

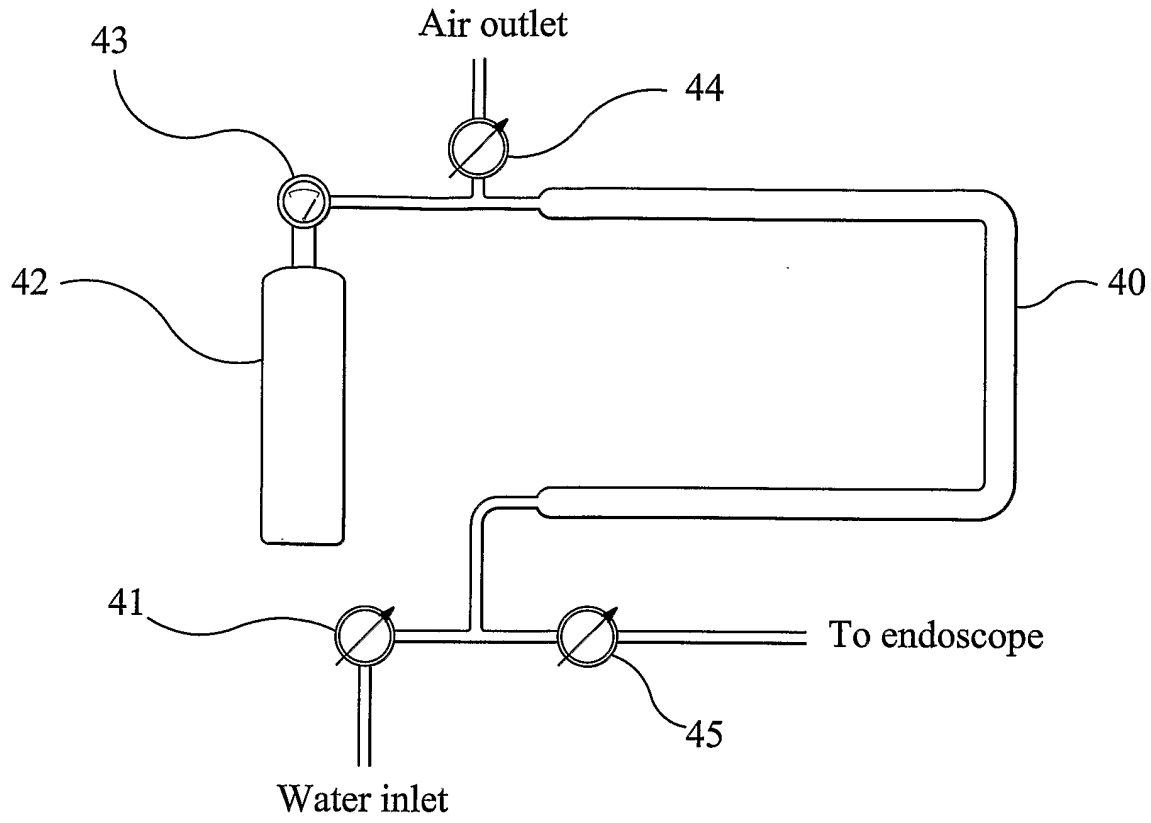

Air outlet
43
44
42
40
41
To endoscope
45
Water inlet

FIG 4a

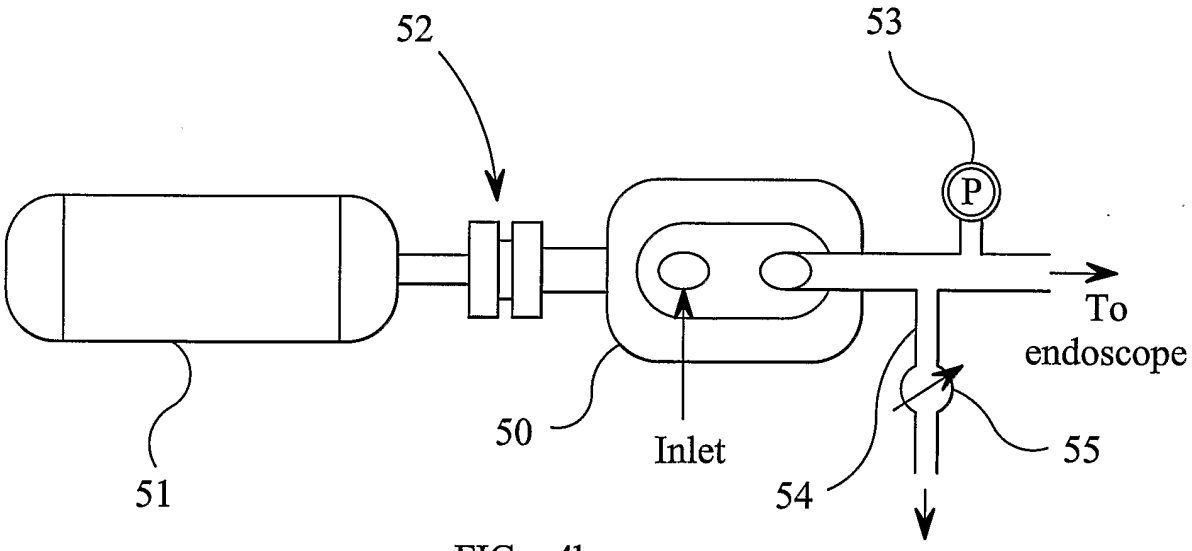

52
53
P
To
endoscope
50
Inlet
55
54
51

FIG 4b

INTERNATIONAL SEARCH REPORT

PCT/GB2005/001617

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B1/31 A61B1/12

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 475 902 A (SCHUBERT ET AL) 9 October 1984 (1984-10-09) column 2, line 25 - column 3, line 35; figures 1,2	13 1,2
Y	GB 652 879 A (CLOVIS DE PAIVA AGUIAR) 2 May 1951 (1951-05-02) page 1, lines 9-30 page 2, lines 25-30; figure 3	1,2
A	US 2 356 659 A (AGUIAR CLOVIS DE PAIVA) 22 August 1944 (1944-08-22) column 1, lines 28-32 column 3, lines 7-16 column 3, lines 34-38 column 4, lines 1-4; figures 1-4	1,2,13

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

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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1

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

PCT/GB2005/001617

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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

1. [X] Claims Nos.: 6,7
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

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

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

see additional sheet

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

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

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

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

1, 2, 13

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1,2,13

Atomising nozzle

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2. claims: 3-5

Lengthwise of the endoscope movable conduit

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3. claims: 8-10

Guidewire receiving element exterior to main body

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4. claims: 11,12

Constructional parameters of endoscope

INTERNATIONAL SEARCH REPORT

Information on patent family members

PCT/GB2005/001617

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4475902 A	09-10-1984	DE 3111497 A1	14-10-1982
GB 652879 A	02-05-1951	GB 650053 A	14-02-1951
		US 2393728 A	29-01-1946
US 2356659 A	22-08-1944	NONE	