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(71) Applicant *(for all designated States except US)*: **C.R.F. SOCIETA CONSORTILE PER AZIONI** [IT/IT]; Strada Torino, 50, I-10043 Orbassano (IT).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **PERLO, Piero** [IT/IT]; c/o C.R.F. Società Consortile per Azioni, Strada Torino, 50, I-10043 Orbassano (IT). **GRASSO, Valentina** [IT/IT]; c/o C.R.F. Società Consortile per Azioni, Strada Torino, 50, I-10043 Orbassano (IT). **VALERIO, Federica** [IT/IT]; c/o C.R.F. Società Consortile per Azioni, Strada Torino, 50, I-10043 Orbassano (IT). **MARTORANA, Brunetto** [IT/IT]; c/o C.R.F. Società Consortile per Azioni, Strada Torino, 50, I-10043 Orbassano (IT).

(74) Agents: **MARCHITELLI, Mauro** et al.; c/o Buzzi, Notaro & Antonielli d'Oulx Srl, Via Maria Vittoria, 18, I-10123 Torino (IT).

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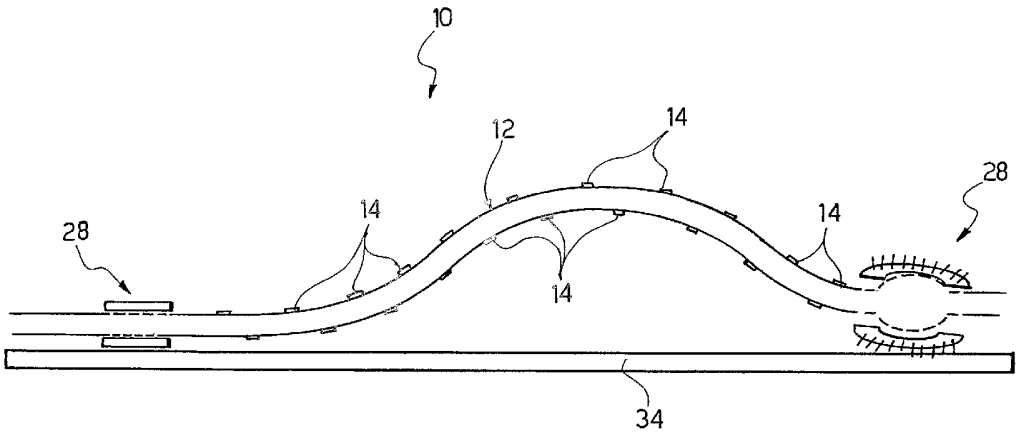
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A PROBE, IN PARTICULAR FOR TUBULAR CAVITIES



(57) Abstract: A probe, in particular for cavities, comprising a body (12) that is capable of varying its shape under the action of an energy field and means (14) for generating a variable energy field, in such a way as to cause the advancement of the body (12) as a result of successive changes in its shape.

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"A probe, in particular for tubular cavities"

* * *

The present invention relates to a probe, in particular for tubular cavities.

The present invention was developed for the purpose of providing a probe which can be used in a miniaturised and remotely controlled robotic system, usable to explore tubular cavities. The present invention can, for example, be used in the diagnostic or surgical field, to explore anatomic cavities and blood vessels, or in the industrial field for the exploration of tubular cavities of various kinds.

The object of the present invention is to provide a probe with an actuating system which allows easily to move the probe within small tubular cavities.

According to the present invention, said object is achieved by a probe having the characteristics set out in the claims.

The present invention shall now be described in detail with reference to the accompanying drawings, provided purely by way of non limiting example, in which:

- Figures 1 and 2 are front schematic views of a probe according to the present invention, rotated by 90° relative to each other,
- Figure 3 is a schematic view showing the planar development of the probe shown in Figures 1 and 2,
- Figures 4 and 5 are schematic views showing the probe at rest and under the action of an energy field,
- Figures 6 and 7 are schematic views showing two alternative embodiments of the actuator means for generating the energy field,
- Figure 8 is a schematic view showing a probe according to the present invention provided at its ends

with expandable devices for anchoring to the walls of a tubular cavity,

- Figure 9 is a schematic view showing one of the expandable end devices of the probe according to the invention,

- Figure 10 is a schematic view showing the operating principle of the device according to the present invention,

- Figure 11 is a schematic view of a probe according to the invention, provided with a vision device, and

- Figure 12 is an enlarged scale schematic view of the vision device.

With reference to Figures 1 and 2, the number 10 schematically designates a probe according to the present invention. The probe 10 comprises a body 12 with tubular shape, capable of varying its shape under the action of an energy field. In a first embodiment of the present invention, the tubular body 12 is constituted by a nano-composite or by a micro-composite formed by a polymeric matrix in which are dispersed metallic particles which are sensitive to a magnetic field. The magnetic particles form bridges in the network of the crossed bonds of the polymeric structure. When the material is subjected to the action of a magnetic field, changes accumulate in the molecular conformation and this leads to macroscopic changes in the shape of the tubular body 12.

In an alternative embodiment, the body 12 of the probe according to the present invention is constituted by shape memory material, capable of varying its shape under the action of a field of thermal energy.

In Figures 1 and 2, the reference number 14 schematically designates a device generating an energy field, applied onto an external surface of the body 12.

If the body 12 is made of composite metal/polymer material sensitive to the action of a magnetic field, the devices 14 are of the type able to generate a magnetic field. If the body 12 is made of a shape memory alloy, the devices 12 are essentially constituted by resistors capable of producing a field of thermal energy by local heating. The devices 12 are preferably arranged according to a general helical configuration on the outer surface of the tubular body 12. Figure 3 schematically shows the planar development of the outer surface of the tubular body 12. In Figure 3, the reference number 16 designates conductive lines which carry the electrical power supply to the individual devices 14 for the generation of the field of magnetic or thermal energy.

Figures 4 and 5 schematically show the probe according to the present invention in a resting position and in a deformed position under the action of an energy field. In the configuration shown in Figure 4, all magnetic or thermal energy field generator devices are deactivated. In this condition, the body 12 has for example the shape of a tube with rectilinear axis. The devices 14 for generating the energy field are activated in such a way as to create an energy field that is not uniform along the axis of the tubular body 12. In Figure 5 the number "1" designates the devices in the excited state and the number "0" designates the deactivated devices. The application of the field of magnetic or thermal energy field in non uniform fashion along the axis of the tubular body 12 causes a deformation, for instance of a sinuous type, of the tubular body 12. Said deformation generally causes a decrease in the distance between the opposite ends of the tubular body.

Figures 6 and 7 schematically show a scene and the manner in which the devices 14 for generating the energy field can be obtained. In the example shown in Figure 6, the device 14 is able to generate a field of thermal energy. In this case, a platelet 18 made of highly resistive material is applied in contact with the outer surface of the body 12. The platelet 18 is connected to two highly conductive electrodes 20. A layer 22 of insulating material insulates the body 12 of shape memory alloy from the electrodes 20.

In the example shown in Figure 7, the device 14 is able to generate a magnetic field and is associated to a body 12 made of plasto-magnetic material. The device 14 comprises a platelet 24 of magnetic material applied on the outer surface of the body 12 and positioned between two electrodes 26.

Figure 8 shows a probe according to the present invention provided at its ends with expandable devices 28 capable of being activated with an electrical command. Figure 9 schematically shows one of the two devices 28 in an expanded configuration. Preferably, each expandable device 28 has an elastic sheath 30 which is dilated by means of the electrical excitation of an element 32 with variable geometry which can be constituted by shape memory material or by plasto-magnetic material.

Figure 10 schematically shows the manner in which the probe according to the present invention advances on a sliding plane 34. Starting from the non deformed configuration shown in Figure 8, at first the expandable device 28 positioned at the front end of the probe 10 with reference to the direction of advance is activated. In its expanded state, the device 28 determines an anchoring against the inner walls of a tubular cavity or produces a suction cup effect on the

sliding plane 34. Subsequently, while the rear expandable element 28 is deactivated, the tubular body 12 is deformed by activating the thermal or magnetic energy field generator devices 14. The deformation of the tubular body 12 causes an advance of the rear expandable device 28 in the direction indicated by the arrow 35 in Figure 10. Subsequently, the rear expandable device 28 is activated. Then, the front expandable element 28 is deactivated and the devices 14 are deactivated to in such a way as to return the body 12 to the non deformed position. This causes an advancement of the front end of the probe 12. This process is repeated in sequence in order to cause the advancing motion of the probe.

Figures 11 and 12 schematically show the probe according to the present invention in a resting position and in a deformed position under the action of an energy field.

The vision device, globally designated by the reference number 36, can be positioned at an end of the tubular body 12. As schematically shown in Figure 12, the vision device 36 comprises a transparent outer case 38 and a focusing lens 40 to focus the image on an image plane 42 formed by a video camera, for instance of the CMOS or CCD type, positioned orthogonally to the axis of the tubular body 12. When a CMOS video camera is mounted in the inner part of the front end of the probe, the dimensions of the section of the probe do not exceed 5 mm, whilst the tubular body 12 can have a diameter of less than 2 mm. The probe can therefore be used in a great variety of diagnostic applications and surgical operations exploiting the possibility of inserting the probe and controlling its motion within anatomical cavities of the human body.

Naturally, without altering the principle of the invention, the construction details and the embodiments may vary widely from what is described and illustrated herein, without thereby departing from the scope of the present invention as defined by the claims that follow.

CLAIMS

1. A probe, in particular for exploring or conducting operations or work processes in cavities, comprising a preferably cylindrical hollow or solid tubular body (12) capable of varying its shape under the action of a magnetic or thermal field and independent means (14), connected by means of conducting strips (16) to a power supply system able to activate the means (14) one by one or in groups, said means (14) being positioned locally on the body (12) in such a way that their magnetic or thermal activation induces local deformations of the body (12) to produce the movement of the body (12) itself as a result of successive changes in its shape.

2. A probe as claimed in claim 1, characterised in that the body (12) is constituted by a matrix of polymeric material in which are dispersed particles of magnetic material.

3. A probe as claimed in claim 1, characterised in that the body (12) is constituted by an alloy of shape memory material.

4. A probe as claimed in claim 2, characterised in that said generator means (14) are provided to generate a field of magnetic energy.

5. A probe as claimed in claim 3, characterised in that said generator means (14) are provided to generate a field of thermal energy.

6. A probe as claimed in claim 1, characterised in that said body (12) under resting conditions has a substantially hollow or solid cylindrical shape.

7. A probe as claimed in claim 1, characterised in that it comprises a pair of expandable devices (28) associated to the ends of said body (12).

8. A probe as claimed in claim 1, characterised in that it comprises a vision device (36) positioned at an end of said body (12).

9. A probe as claimed in claim 1, characterised in that said energy field generating means (14) are provided for generating a non uniform energy field along an axis of said body, in such a way as to produce an approach between the ends of said body in a deformed condition.

All substantially as described and illustrated herein and for the purposes specified herein.

FIG. 1

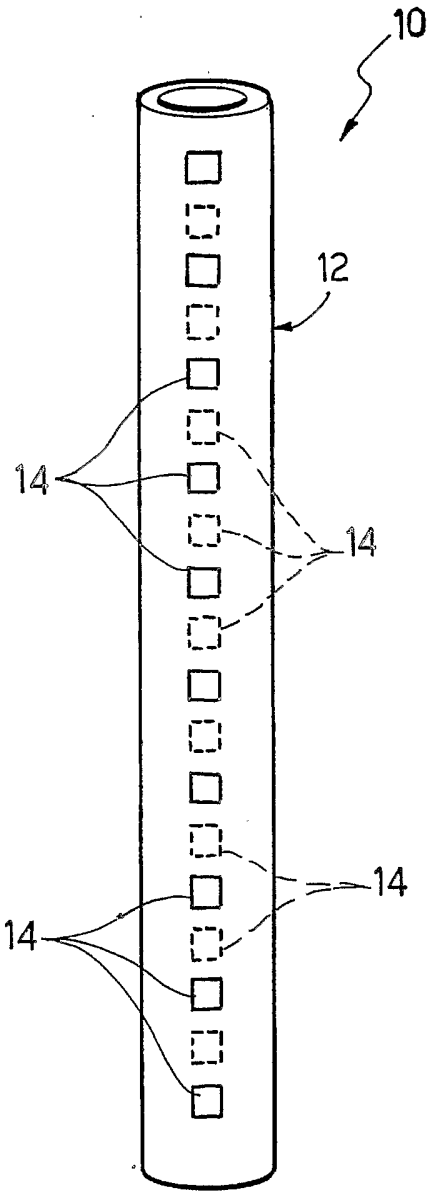


FIG. 2

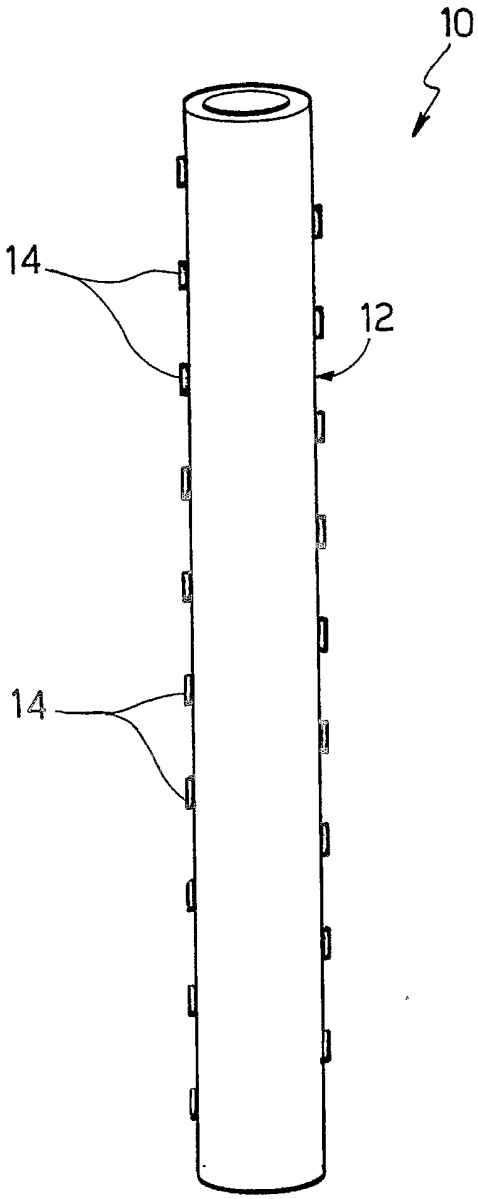


FIG. 3

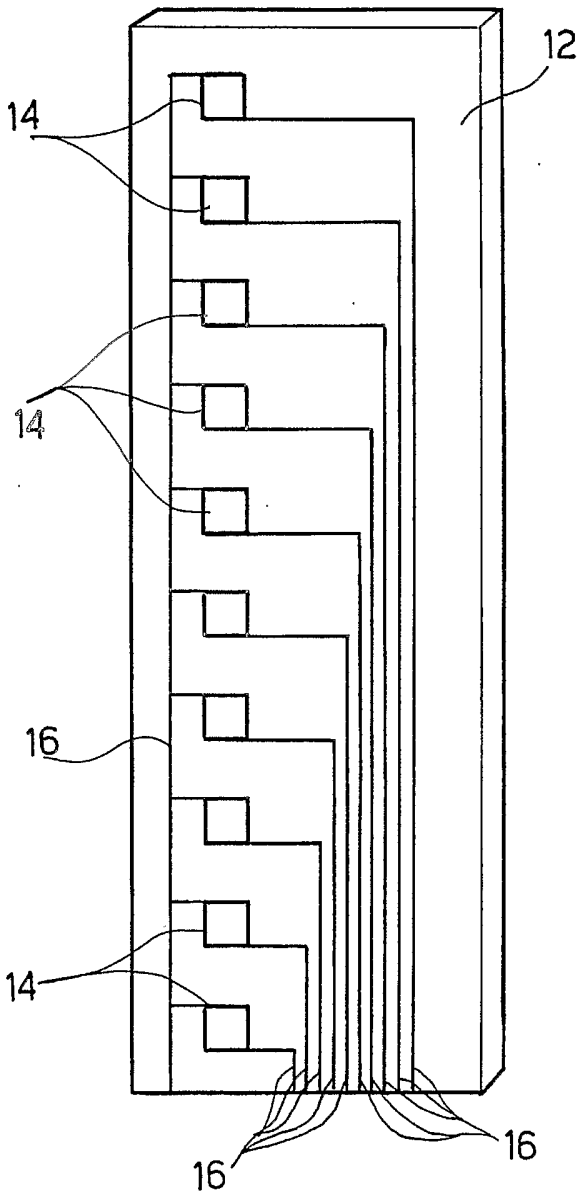
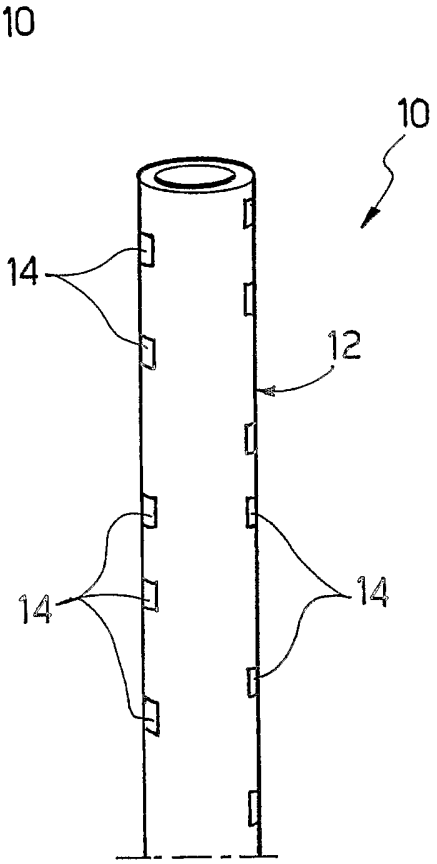


FIG. 4



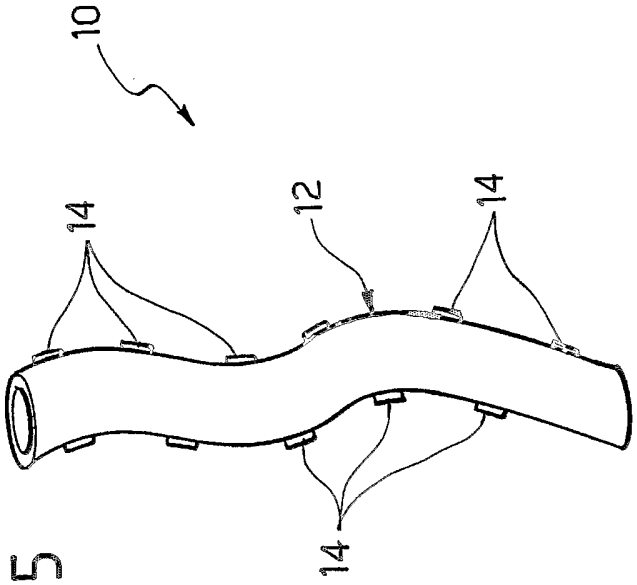


FIG. 5

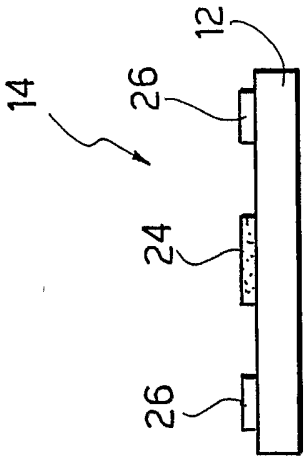


FIG. 7

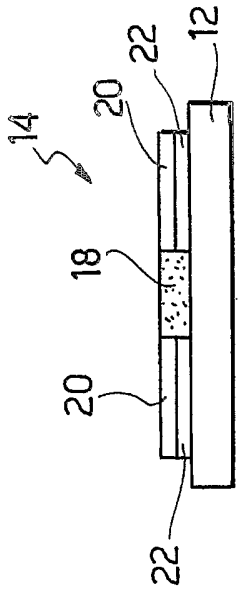


FIG. 6

FIG. 8

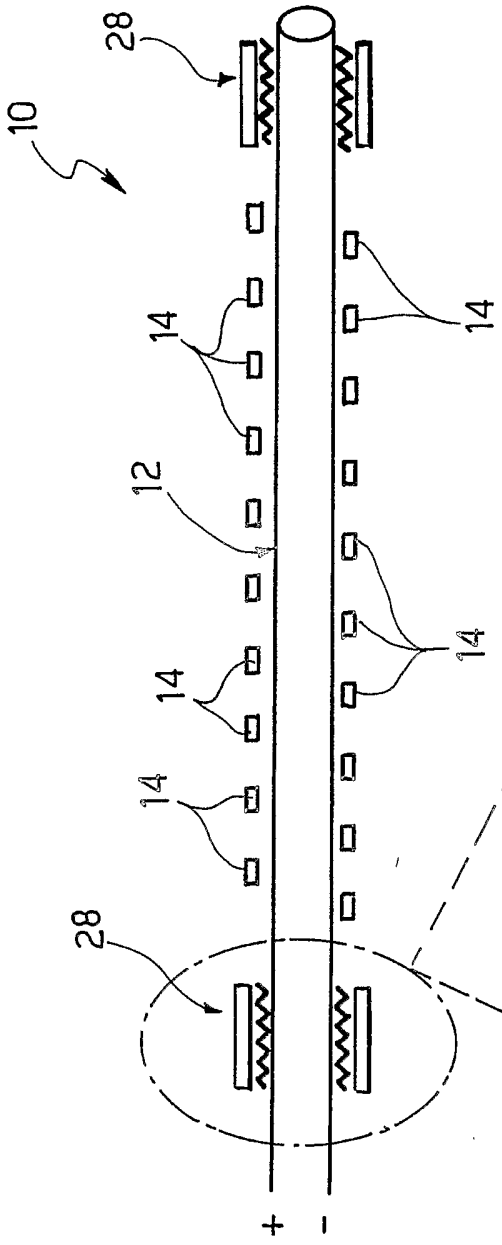


FIG. 9

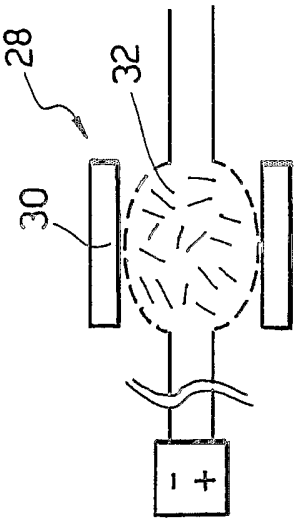
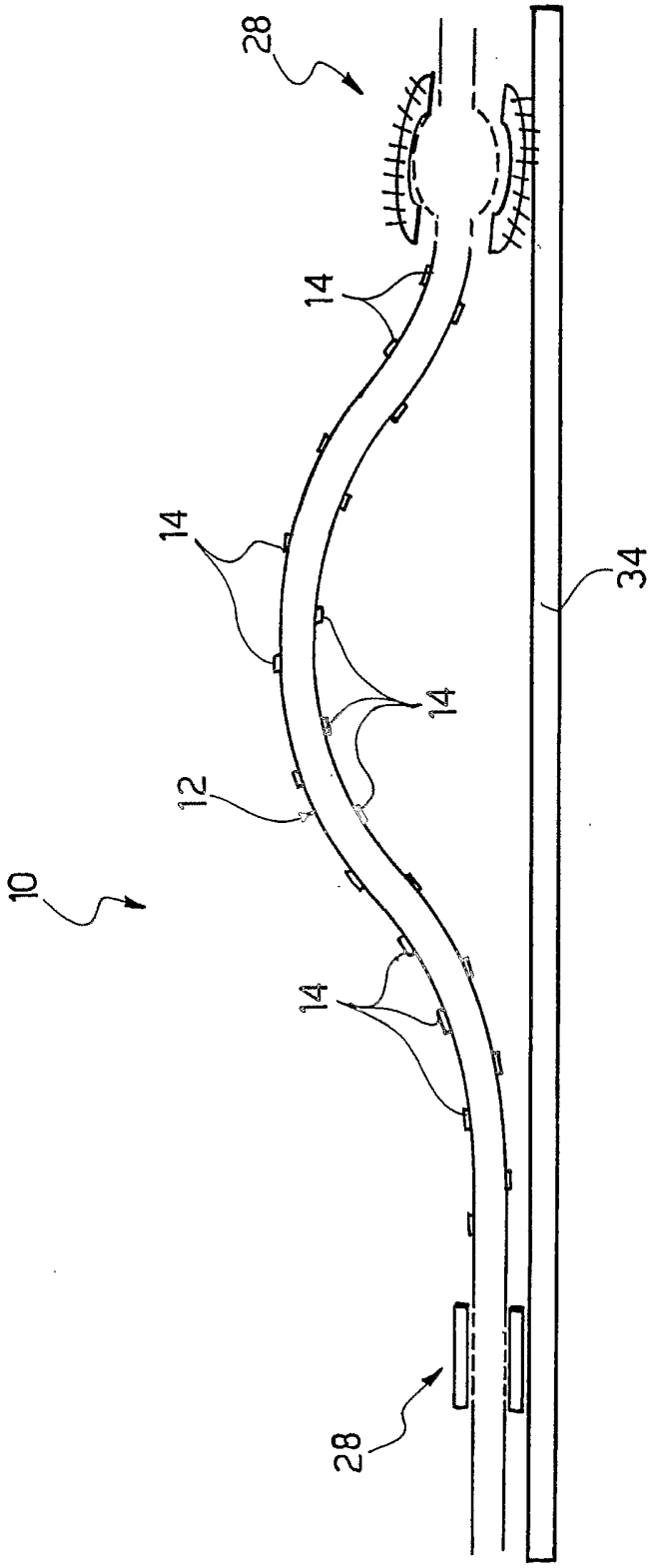


FIG. 10



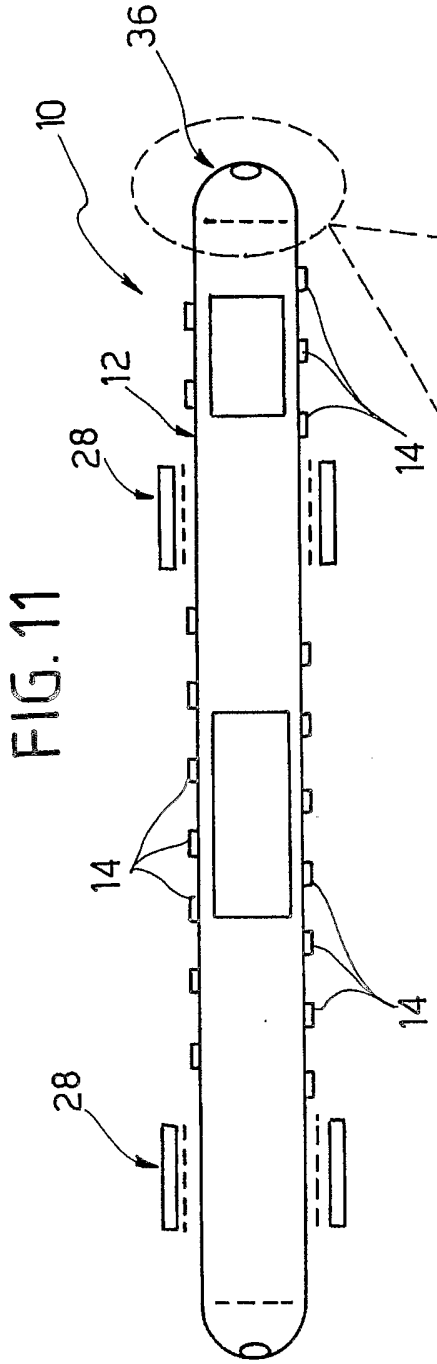


FIG. 11

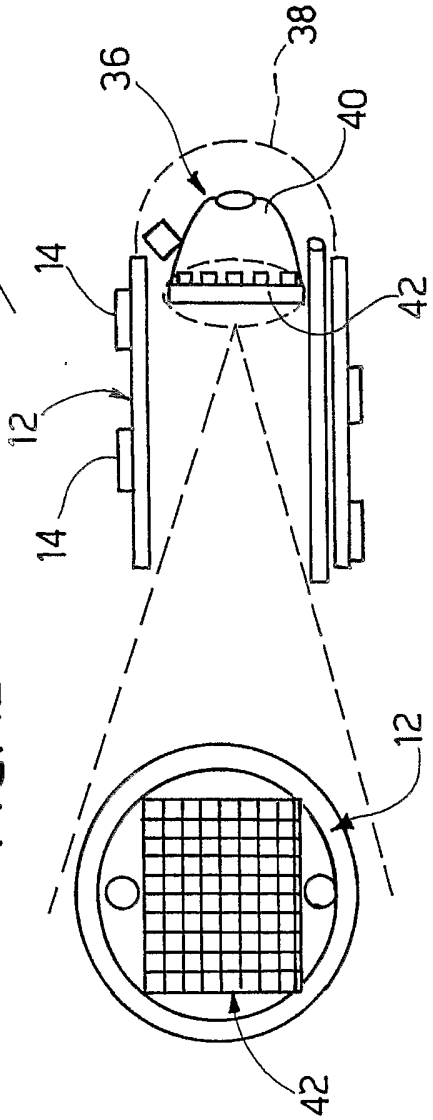


FIG. 12

INTERNATIONAL SEARCH REPORT

tional Application No
PCT/IB2004/000652

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 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 7 A61B A61M F03G A61L

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

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 5 405 337 A (MAYNARD RONALD S) 11 April 1995 (1995-04-11) column 5, line 65 - column 6, line 21 column 7, line 67 - column 8, line 2 column 12, line 67 - column 13, line 11 column 13, line 39 - column 13, line 59 column 16, line 4 - column 17, line 5 column 18, line 8 - column 18, line 35 column 21, line 51 - column 22, line 51 column 23, line 14 - column 23, line 19 figures 1A,3A,6 ----- -/--	1-6,8,9 7

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
2 July 2004	12/07/2004

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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P,Y	US 2003/065250 A1 (QUINN ROGER D ET AL) 3 April 2003 (2003-04-03) paragraph '0043!; figures 8A,8B	1-9

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