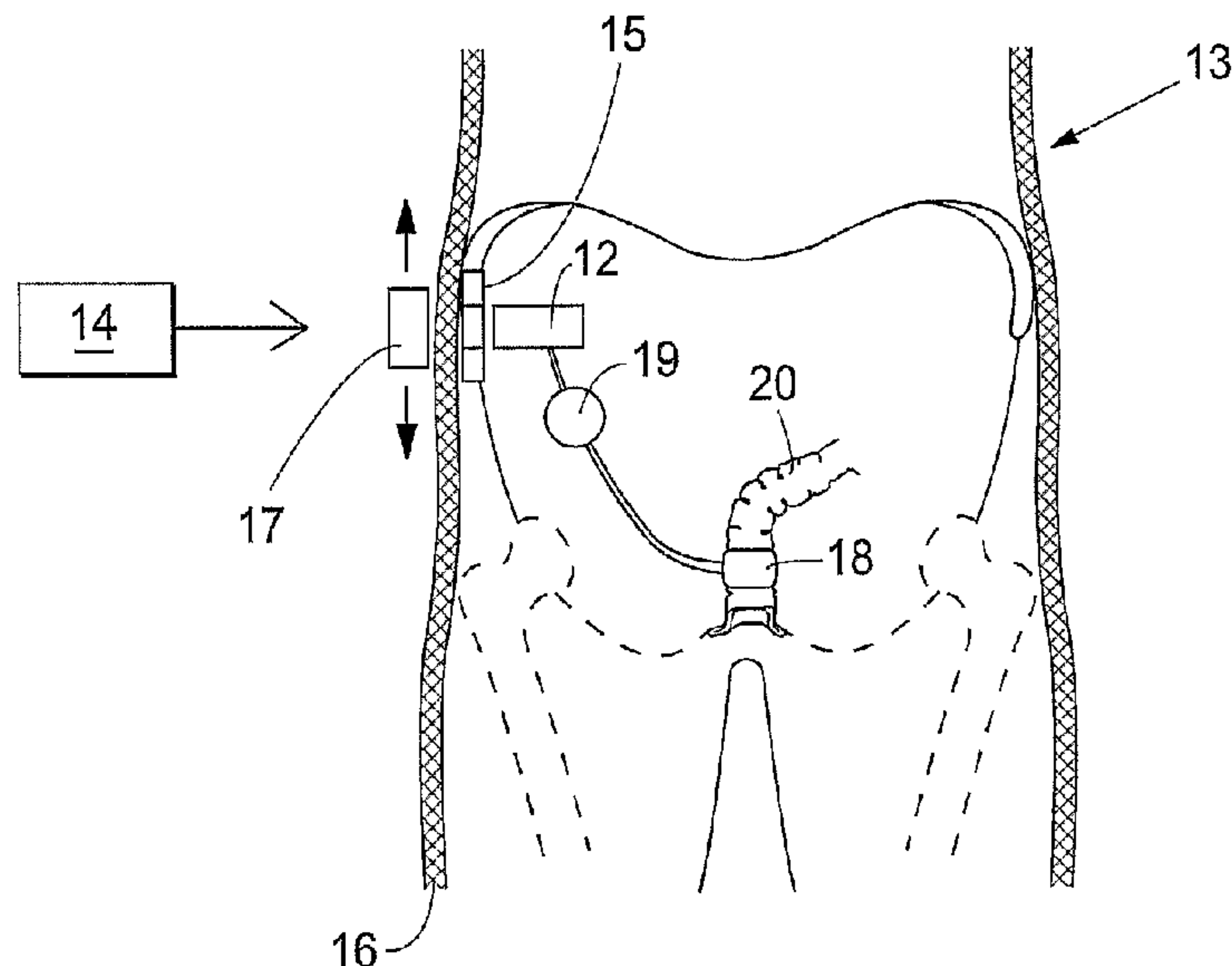




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(54) **Titre : DETECTION D'UN DISPOSITIF DE RECEPTION D'ENERGIE SANS FIL IMPLANTE**
(54) **Title: DETECTION OF IMPLANTED WIRELESS ENERGY RECEIVING DEVICE**



(57) **Abrégé/Abstract:**

An apparatus for detecting a wireless energy receiving device (12) that is subcutaneously implanted in a patient (13) is provided to enable accurate positioning of a wireless energy transmission device (14) outside the patient's body for transmission of wireless energy to the implanted energy receiving device. The apparatus includes a magnetic device (15) that emits a local magnetic field, and a magnetic detector (17) that detects the local magnetic field. The magnetic device (15) is subcutaneously implanted in the patient at the implanted energy receiving device (12) and the magnetic detector (17) is movable externally along the patient's body to establish a position at the patient's skin (16) where the local magnetic field is detected by the magnetic detector. As a result, the wireless energy transmission device (14) can be put in the established position, in order to efficiently transmit wireless energy to the implanted energy receiving device.



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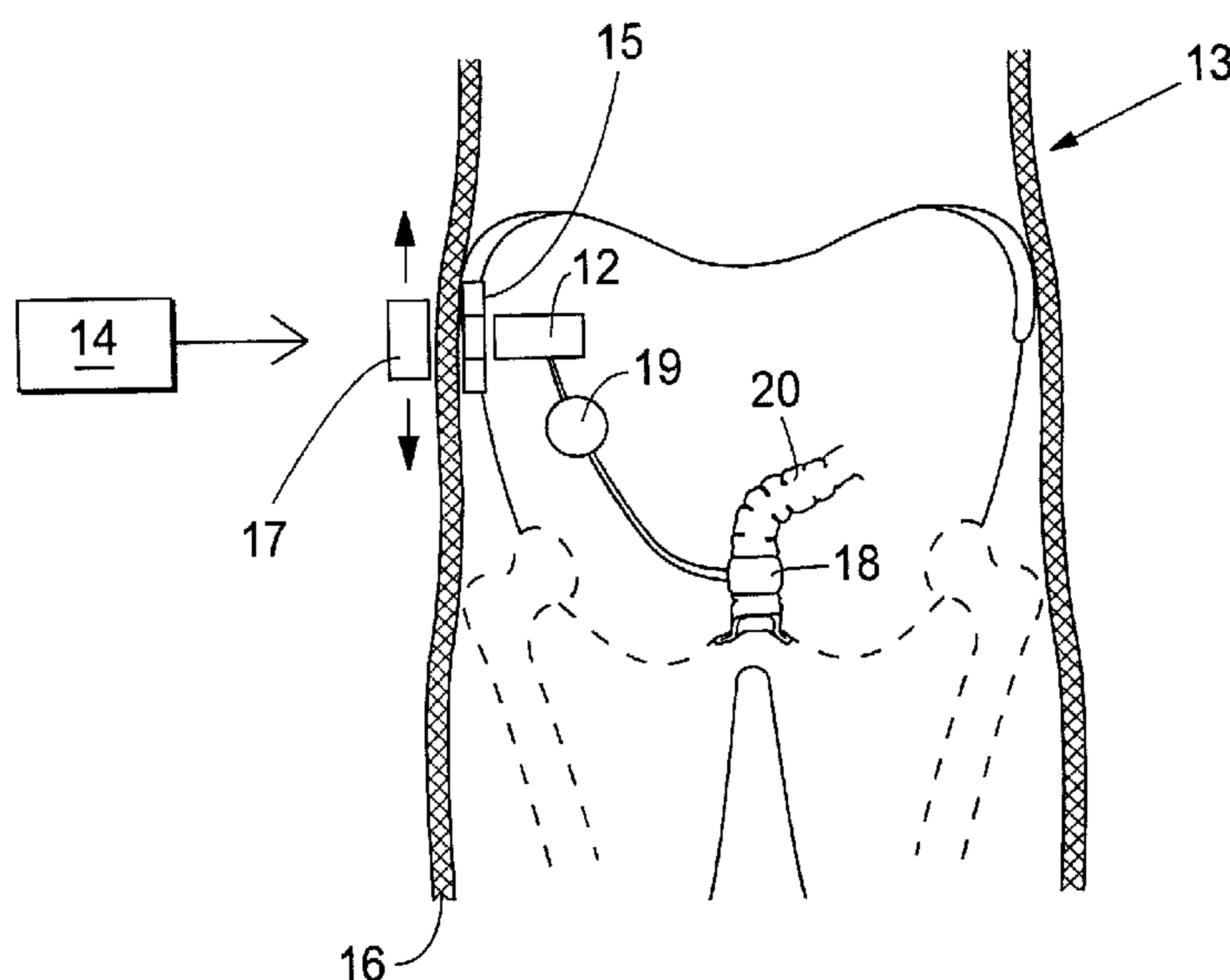
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(54) Title: DETECTION OF IMPLANTED WIRELESS ENERGY RECEIVING DEVICE



(57) Abstract: An apparatus for detecting a wireless energy receiving device (12) that is subcutaneously implanted in a patient (13) is provided to enable accurate positioning of a wireless energy transmission device (14) outside the patient's body for transmission of wireless energy to the implanted energy receiving device. The apparatus includes a magnetic device (15) that emits a local magnetic field, and a magnetic detector (17) that detects the local magnetic field. The magnetic device (15) is subcutaneously implanted in the patient at the implanted energy receiving device (12) and the magnetic detector (17) is movable externally along the patient's body to establish a position at the patient's skin (16) where the local magnetic field is detected by the magnetic detector. As a result, the wireless energy transmission device (14) can be put in the established position, in order to efficiently transmit wireless energy to the implanted energy receiving device.

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DETECTION OF IMPLANTED WIRELESS ENERGY RECEIVING DEVICE

The present invention relates to an apparatus and method for detecting a wireless energy receiving device subcutaneously implanted in a patient to enable accurate positioning of an exterior wireless energy transmission device.

5 In new generations of energy consuming implants wireless energy transmission may be used for supply of energy to such implants. To optimise the transfer efficiency of the wireless energy it is important to locate the wireless energy receiver, typically subcutaneously implanted in the patient, in order to be able to put an exterior energy transmission device close to the implanted energy receiving
10 device.

An object of some embodiments of the present invention is to provide an inexpensive apparatus for accurate detection of a wireless energy receiving device subcutaneously implanted in a patient, and further to provide an apparatus with parts to be implanted that are relatively small.

15 According to an aspect of the present invention, there is provided an apparatus for detecting a wireless energy receiving device adapted to be subcutaneously implanted in a patient to enable accurate positioning of a wireless energy transmission device outside the patient's body for transmission of wireless energy to the implanted energy receiving device, the apparatus comprising: a
20 magnetic device adapted to emit a local magnetic field, and a magnetic detector adapted to detect the local magnetic field emitted by the magnetic device, the magnetic detector comprising several magnetic field sensors grouped around a central point, wherein the magnetic device or magnetic detector is designed to be subcutaneously implanted in the patient at the implanted energy receiving device,
25 and the magnetic detector or magnetic device is movable externally along the patient's body to establish an energy transmission position at the patient's skin where the local magnetic field emitted by the magnetic device is detected by the magnetic

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detector, whereby the wireless energy transmission device can be put in the established energy transmission position, in order to efficiently transmit wireless energy to the implanted energy receiving device.

In this arrangement, the apparatus comprises a magnetic device
5 adapted to emit a local magnetic field, and a magnetic detector adapted to detect the local magnetic field emitted by the magnetic device. The magnetic device is designed to be subcutaneously implanted in the patient at the implanted energy receiving device, and the magnetic detector is movable externally along the patient's body to establish an energy transmission position at the patient's skin where the local
10 magnetic field emitted by the magnetic device is detected by the magnetic detector. Alternatively, the magnetic detector is designed to be subcutaneously implanted and the magnetic device is movable along the patient's body to establish the energy transmission position at the patient's skin where the local magnetic field emitted by the magnetic device is detected by the magnetic

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detector. As a result, the wireless energy transmission device can be put in the established energy transmission position, in order to efficiently transmit wireless energy to the implanted energy receiving device.

5 Thus, embodiments of the present invention provide an easy way of detecting the position of the wireless energy receiving device subcutaneously implanted in a patient, which enables accurate positioning of the wireless energy transmission device outside the patient's body for efficient transmission of wireless
10 energy to the implanted energy receiving device by using magnetism. Typical applications for such an energy receiving device are for energizing an implant in the patient, for example for treating reflux disease, obesity, anal or urinary incontinence, or impotence. The apparatus of embodiments of
15 the invention may conventionally be used for detecting an implanted energy receiving device coupled to such implants.

 In accordance with a main first embodiment of the invention, the magnetic device is designed to be subcutaneously implanted in the patient at the implanted
20 energy receiving device to emit the local magnetic field through a portion of the patient's skin adjacent to the energy receiving device, and the magnetic detector is movable externally along the patient's body to establish the energy transmission position where the local magnetic field is
25 detected by the magnetic detector. Suitably, the magnetic detector is adapted to establish the energy transmission position at least substantially in front of the subcutaneously implanted energy receiving device to enable a most efficient energy transmission. The magnetic detector may be adapted to
30 emit a sound when detecting the local magnetic field. Alternatively, the magnetic detector may be provided with at least one diode adapted to emit light when the detector detects the local magnetic field, or be provided with a

display adapted to indicate when the detector detects the local magnetic field.

In accordance with a second embodiment of the invention, the magnetic detector is designed to be subcutaneously implanted in the patient at the implanted energy receiving device, and the magnetic device is adapted to emit the local magnetic field through the patient's skin from outside the patient's body and is movable externally along the patient's body to establish the energy transmission position where the local magnetic field is detected by the implanted magnetic detector. Also in this second embodiment the magnetic device is suitably adapted to establish the energy transmission position at least substantially in front of the subcutaneously implanted energy receiving device. In its simplest form, the implanted magnetic detector may be adapted to emit a sound when detecting the local magnetic field. In a more sophisticated form, a sender may be implantable in the patient's body and be capable of sending information about the magnetic detector to outside the patient's body, as the magnetic detector detects the local magnetic field emitted by the magnetic device from outside the patient's body. For example, the implanted sender may send RF signals that inform when the implanted detector detects the local magnetic field, whereby an accurate energy transmission position at the patient's skin can be established. The accurate energy transmission position may be directly or indirectly correlated to the intensity of magnetism detected by the magnetic detector.

The magnetic device may be a solenoid or a permanent magnet, which is sending out a magnetic field.

In any of the above embodiments the magnetic detector includes a semiconductor circuit, preferably in the form of at least one Hall-element. By using one or more Hall-elements, a special type of semiconductor known in the art, it is easy to

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locate the centre of the magnetic field emitted by the magnetic device. The magnetic detector suitably comprises several Hall-elements grouped around a central point in a triangular or square configuration. For example, three Hall-elements may be arranged at the corners of an equilateral triangle. An important advantage is that the Hall-elements
5 are able to detect even a weak magnetic field emitted from the magnetic device.

According to another aspect of the present invention, there is provided use of the apparatus described above for detecting a wireless energy receiving device.

According to another aspect of the present invention, there is provided use of the apparatus described above for treating reflux disease, obesity, anal or urinary
10 incontinence, or impotence.

Another aspect relates to a method of detecting a wireless energy receiving device subcutaneously implanted in a patient. The method comprises providing a magnetic device capable of emitting a local magnetic field through the patient's skin, providing a magnetic detector adapted to detect the local magnetic field
15 emitted by the magnetic device, subcutaneously implanting the magnetic device or magnetic detector in the patient at the implanted energy receiving device, moving the magnetic detector or magnetic device externally along the patient's body, and establishing an energy transmission position at the patient's skin where the local magnetic field emitted by the magnetic device is detected by the magnetic detector.
20 Then, the energy transmission device can be positioned in the established energy transmission position where the local magnetic field has been detected to efficiently transmit wireless energy to the subcutaneously implanted energy receiving device. Where the magnetic detector is subcutaneously implanted and the magnetic device is moved along the patient's body, the method may further comprise implanting a sender
25 and using the sender to send information to outside the patient's body confirming when the implanted magnetic detector detects the local magnetic field emitted by the exterior magnetic device.

The present disclosure also provides a surgical method for treating a patient having a disease, comprising the steps of: insufflating the patient's abdomen with
30 gas; placing at least

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two laparoscopic trocars in the patient's body; implanting an operable implant designed for treating reflux disease, urinary incontinence, impotence, anal incontinence or obesity in the abdomen by using surgical instruments through the trocars;
5 subcutaneously implanting a wireless energy receiving device for supplying energy for use in the operation of the implant and a magnetic device at the energy receiving device for emitting a local magnetic field through the adjacent skin portion of the patient; post-operatively moving an exterior
10 magnetic detector along the patient's body to establish an energy transmission position in which the local magnetic field emitted by the implanted magnetic device is detected by the magnetic detector; bringing a wireless energy transmission device to the established energy transmission position; and
15 transmitting wireless energy from the wireless energy transmission device through the patient's skin to the implanted wireless energy receiving device.

As an alternative, the surgical method may comprise subcutaneously implanting a magnetic detector at the energy
20 receiving device and post-operatively moving an exterior magnetic device emitting a local magnetic field along the patient's body to establish the energy transmission position in which the local magnetic field emitted by the exterior magnetic device is detected by the implanted magnetic
25 detector.

The skilled person should appreciate that the detection technique described above is simple, inexpensive and very accurate, and could be used for several different implants in combination with wireless energy transmission.

30 Examples of embodiments of the invention are described in more detail in the following with reference to the accompanying drawings, in which

Fig.1 shows a connection diagram for a magnetic detector of the apparatus according to an embodiment of the present invention,

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Fig.2 schematically illustrates in a diagram the output of the magnetic detector positioned in front of a magnetic device of the apparatus of an embodiment of the invention,

Fig. 3 is a schematic view of an embodiment where the magnetic device is subcutaneously implanted in a patient, and the magnetic detector is movable externally along the patient's body,

Fig. 4 is a schematic view of an embodiment where the magnetic detector is subcutaneously implanted in the patient and the magnetic device is movable externally along the patient's body,

Fig. 5 is a schematic view of a hydraulically adjustable constriction device designed for treating reflux disease, urine incontinence, anal incontinence or obesity, and

Fig. 6 illustrates an embodiment according to the present invention using Hall-elements as the magnetic detecting device.

Referring to the drawing figures, like reference numerals designate identical or corresponding elements throughout the several figures.

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 shows a connection circuit 1 for a magnetic detector 2 of the apparatus according to an embodiment of the present invention. A magnetic device in the form of a ring-magnet 3, which can be a solenoid or a permanent magnet, is implanted in a patient's body. Located outside the body and positioned in front of the implanted ring-magnet 3 is magnetic detector 2, which includes three linear magnetic field sensors 4 (such as Hall-elements or the like) grouped in a triangular configuration. Sensors 4 are connected to signal-conditioning amplifiers 5, which in turn, are connected to an A/D-converter 6. A microprocessor 7 is connected to A/D-converter 6. To

visually display the output signals of sensors 4, a display-device 8 is connected to microprocessor 7.

The graph shown in Fig. 2 illustrates, in principle, how the information obtained by detector 2 can be presented. On the X-axis in the graph is the position of detector 2 relative to the magnetic device. On the Y-axis is the combined output of sensors 4 of detector 2. Thus, the graph of Fig. 2 shows the position "X" of detector 2 relative to the magnetic device as a function of detector 2's output "Y". To illustrate this method of detecting, a magnetic device in the form of a ring-magnet 9 is shown relative to the graph of Figure 2. Ring-magnet 9 is shown in cross-section to show the positions of its magnetic north pole N and south pole S, respectively. Fig. 2 depicts the case where magnetic detector 2 (not shown in Fig. 2) has been centred in front of ring-magnet 9 and where all of the sensors 4 produce a maximum output, which is shown as peaks 10,11 in the graph of Fig. 2. Sensors 4 are connected (e.g., by connection circuit 1 shown in Fig. 1) to display device 8, which may display the graph shown in Fig. 2, or alternatively, a numeral result from the measurements taken by sensors 4.

Fig. 3 shows an embodiment of the apparatus of the present invention for detecting a wireless energy receiving device 12 subcutaneously implanted in a patient 13 suffering from anal incontinence to enable accurate positioning of a separate wireless energy transmission device 14 outside patient 13's body for the transmission of wireless energy to energy receiving device 12. An operation device 19 is adapted to operate an implanted artificial sphincter 18 applied to the patient's rectum 20. Energy receiving device 12 powers operation device 19 with energy received from the energy transmission device 14. The implanted energy receiving device 12 may be of the type that transforms the received energy into electrical pulses. In this case, a sender may be implanted in

the patient for sending feedback information on the number of electrical pulses that have been provided by the energy receiving device. The apparatus also includes a magnetic device 15 subcutaneously implanted in patient 13 close to the energy receiving device 12. Magnetic device 15 emits a local magnetic field extending through a portion of patient 13's skin 16 adjacent to energy receiving device 12. The apparatus further includes an external, separate magnetic detector 17 that may be manually moved along the patient 13's body to establish an energy transmission position at the patient's skin where the local magnetic field emitted by magnetic device 15 is detected by magnetic detector 17. When this energy transmission position has been established, energy transmission device 14 can be located in the same position to efficiently transmit wireless energy to implanted energy receiving device 12.

Fig. 4 shows an embodiment of the invention identical to the embodiment according to Fig. 3, except that a magnetic detector 21 is subcutaneously implanted in patient 13 at energy receiving device 12 and an external separate magnetic device 22 that emits a local magnetic field through patient's skin 16 is provided. Magnetic device 22 may be manually moved externally along the patient 13's body to establish an energy transmission position at the patient's skin where the local magnetic field emitted by magnetic device 22 is detected by the implanted magnetic detector 21. A sender 23 is implanted in patient 13 and sends information about the status of magnetic detector 21. Thus, when magnetic detector 21 detects the local magnetic field emitted by external magnetic device 22, sender 23 sends information confirming that magnetic device 22 is in a proper position for energy transmission. When this energy transmission position has been established, energy transmission device 14 can be placed in

the same position to efficiently transmit wireless energy to the implanted energy receiving device 12.

Fig. 5 shows an example of the artificial sphincter 18 shown in Figs. 3 and 4. Sphincter 18 includes a hydraulically adjustable constriction device 24 to be applied around the patient's rectum (not shown in Fig. 5). Constriction device 24 has a cavity 25 which can be inflated by supplying hydraulic fluid thereto, to close the rectum, and be deflated by withdrawing hydraulic fluid therefrom, to open the rectum. A hydraulic operation device 26 for operating constriction device 24 is powered with energy from implanted energy receiving device 12. This type of constriction device may also be used as an artificial sphincter for treating patient's suffering from heartburn and reflux disease or urinary incontinence, when combined with the apparatus of the present invention. Furthermore, constriction device 24 may be used for forming an adjustable stoma opening in the stomach or esophagus of an obese patient to treat obesity or for restricting the penile exit blood flow to treat an impotent patient, when combined with the apparatus of the invention.

Fig. 6 shows an advantageous design of the embodiment shown in Fig. 3, in which the external magnetic detector 17 includes three symmetrically arranged Hall-elements 27 which are grouped around a central point in a triangular configuration. The magnetic device 15 is implanted and includes a ring-shaped magnet 28 surrounding the centre 29 of the implanted energy receiving device 12. When magnetic detector 17 is moved to a position in which Hall-elements 27 are placed symmetrically above and around ring-shaped magnet 28, as illustrated in Fig. 6, magnetic detector 17 detects a maximum intensity of the magnetic field emitted by the implanted magnet 28, whereby the most accurate position where the energy transmission device 14 should be placed is established. As an alternative, the design described above may

be practised in the embodiment shown in Fig. 4. Thus, the implanted magnetic detector 21 may include the three Hall-elements 27 and the external magnetic device 22 may include the ring-shaped magnet 28.

5 Although the present invention has been described in terms of a particular embodiment and process, it is not intended that the invention be limited to that embodiment. Modifications of the embodiment and process within the spirit of the invention will be apparent to those skilled in the art.

10 The scope of the invention is defined by the claims that follow.

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CLAIMS:

1. An apparatus for detecting a wireless energy receiving device adapted to be subcutaneously implanted in a patient to enable accurate positioning of a wireless energy transmission device outside the patient's body for transmission of
5 wireless energy to the implanted energy receiving device, the apparatus comprising:

a magnetic device adapted to emit a local magnetic field, and

a magnetic detector adapted to detect the local magnetic field emitted by the magnetic device, the magnetic detector comprising several magnetic field sensors grouped around a central point,

10 wherein the magnetic device or magnetic detector is designed to be subcutaneously implanted in the patient at the implanted energy receiving device, and the magnetic detector or magnetic device is movable externally along the patient's body to establish an energy transmission position at the patient's skin where the local magnetic field emitted by the magnetic device is detected by the magnetic
15 detector, whereby the wireless energy transmission device can be put in the established energy transmission position, in order to efficiently transmit wireless energy to the implanted energy receiving device.
2. An apparatus according to claim 1, wherein the magnetic device is designed to be subcutaneously implanted in the patient at the implanted energy
20 receiving device to emit the local magnetic field through a portion of the patient's skin adjacent to the energy receiving device, and the magnetic detector is movable externally along the patient's body to establish the energy transmission position where the local magnetic field is detected by the magnetic detector.
3. An apparatus according to claim 2, wherein the magnetic detector is
25 adapted to establish the energy transmission position at least in front of the subcutaneously implanted energy receiving device.

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4. An apparatus according to claim 1, wherein the magnetic detector is designed to be subcutaneously implanted in the patient at the implanted energy receiving device, and the magnetic device is adapted to emit the local magnetic field through the patient's skin from outside the patient's body and is movable externally
5 along the patient's body to establish the energy transmission position where the local magnetic field is detected by the implanted magnetic detector.
5. An apparatus according to claim 4, wherein the magnetic device is adapted to establish the energy transmission position at least in front of the subcutaneously implanted energy receiving device.
- 10 6. An apparatus according to claim 4 or 5, further comprising a sender implantable in the patient's body and capable of sending information about the magnetic detector to outside the patient's body, as the magnetic detector detects the local magnetic field emitted by the magnetic device from outside the patient's body.
7. An apparatus according to any one of claims 1 to 6, wherein the
15 magnetic detector is adapted to emit a sound when detecting the local magnetic field.
8. An apparatus according to claim 2 or 3, wherein the magnetic detector is provided with at least one diode adapted to emit light when the detector detects the local magnetic field.
9. An apparatus according to claim 2 or 3, wherein the magnetic detector
20 is provided with a display adapted to indicate when the detector detects the local magnetic field.
10. An apparatus according to any one of claims 1 to 9, wherein the magnetic device is a solenoid or a permanent magnet.
11. An apparatus according to any one of claims 1 to 10, wherein the
25 magnetic detector comprises a semiconductor circuit.

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12. An apparatus according to claim 11, wherein the semiconductor circuit of the magnetic detector comprises at least one Hall-element.

13. An apparatus according to claim 12, wherein the magnetic detector comprises several Hall-elements grouped around a central point in a triangular or
5 square- configuration.

14. An apparatus according to any one of claims 1 to 10, wherein the magnetic field sensors are grouped around the central point in a triangular or square-configuration.

15. Use of the apparatus according to any one of claims 1 to 14 for
10 detecting a wireless energy receiving device.

16. Use of the apparatus according to any one of claims 1 to 14 for treating reflux disease, obesity, anal or urinary incontinence, or impotence.

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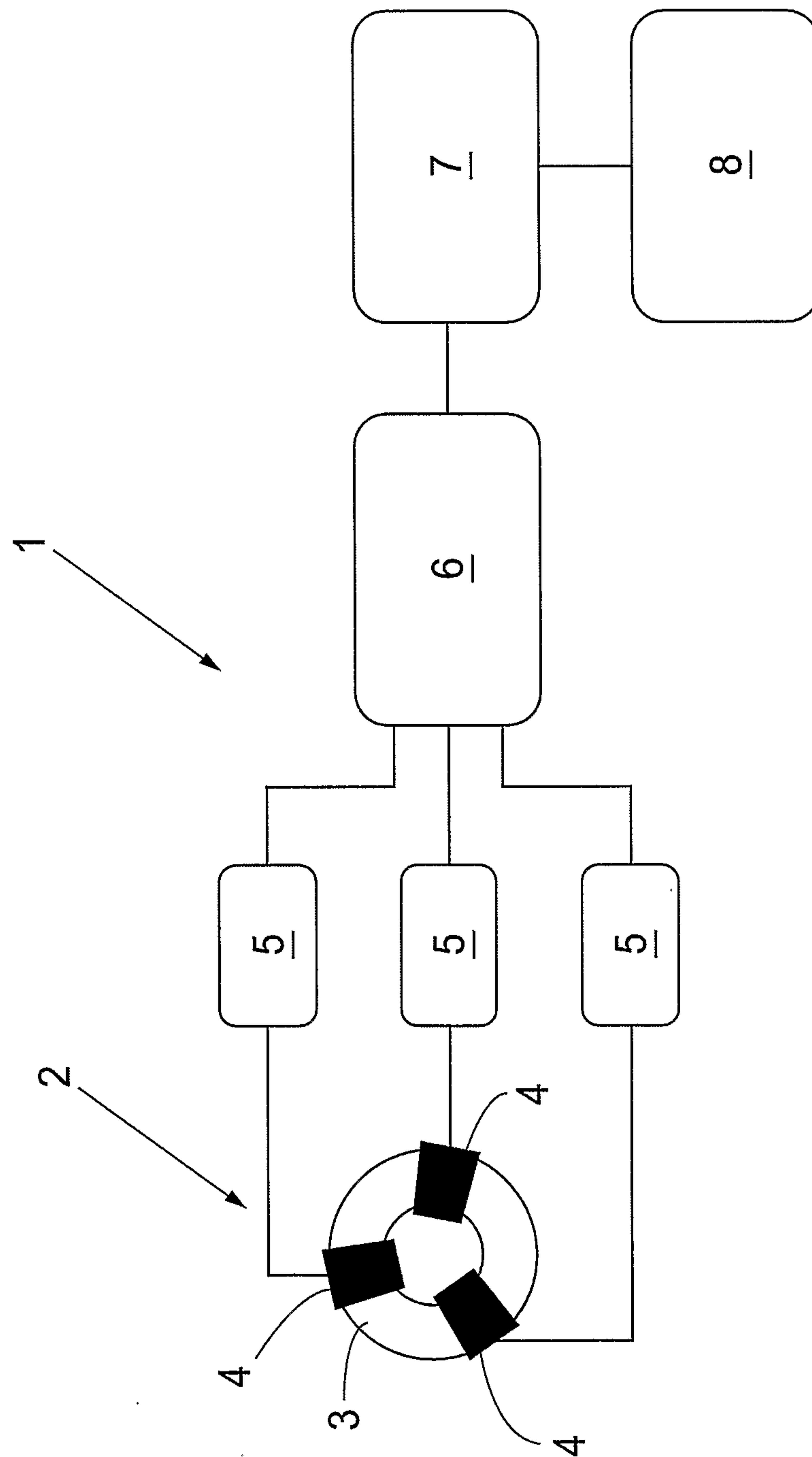


Fig. 1

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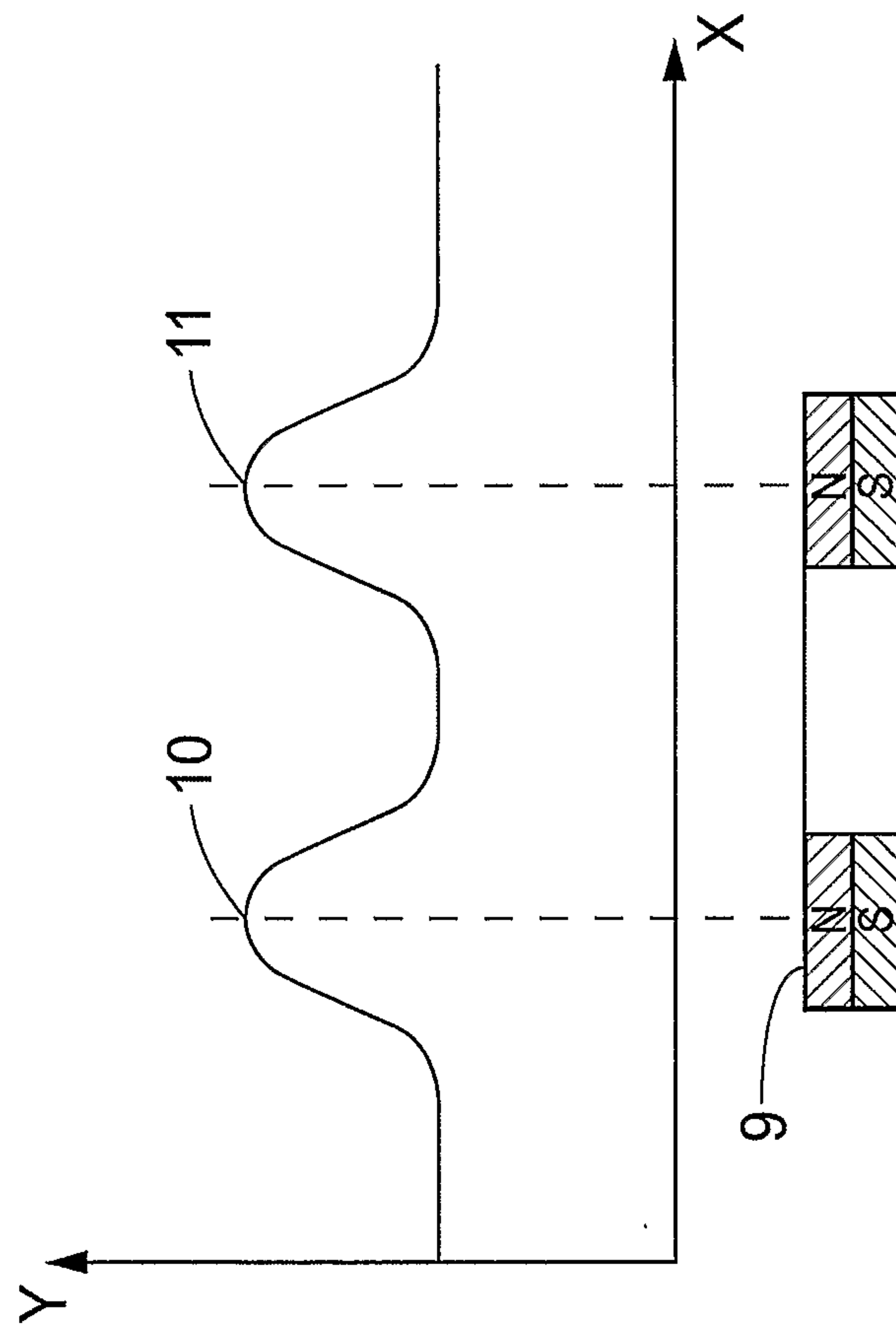


Fig. 2

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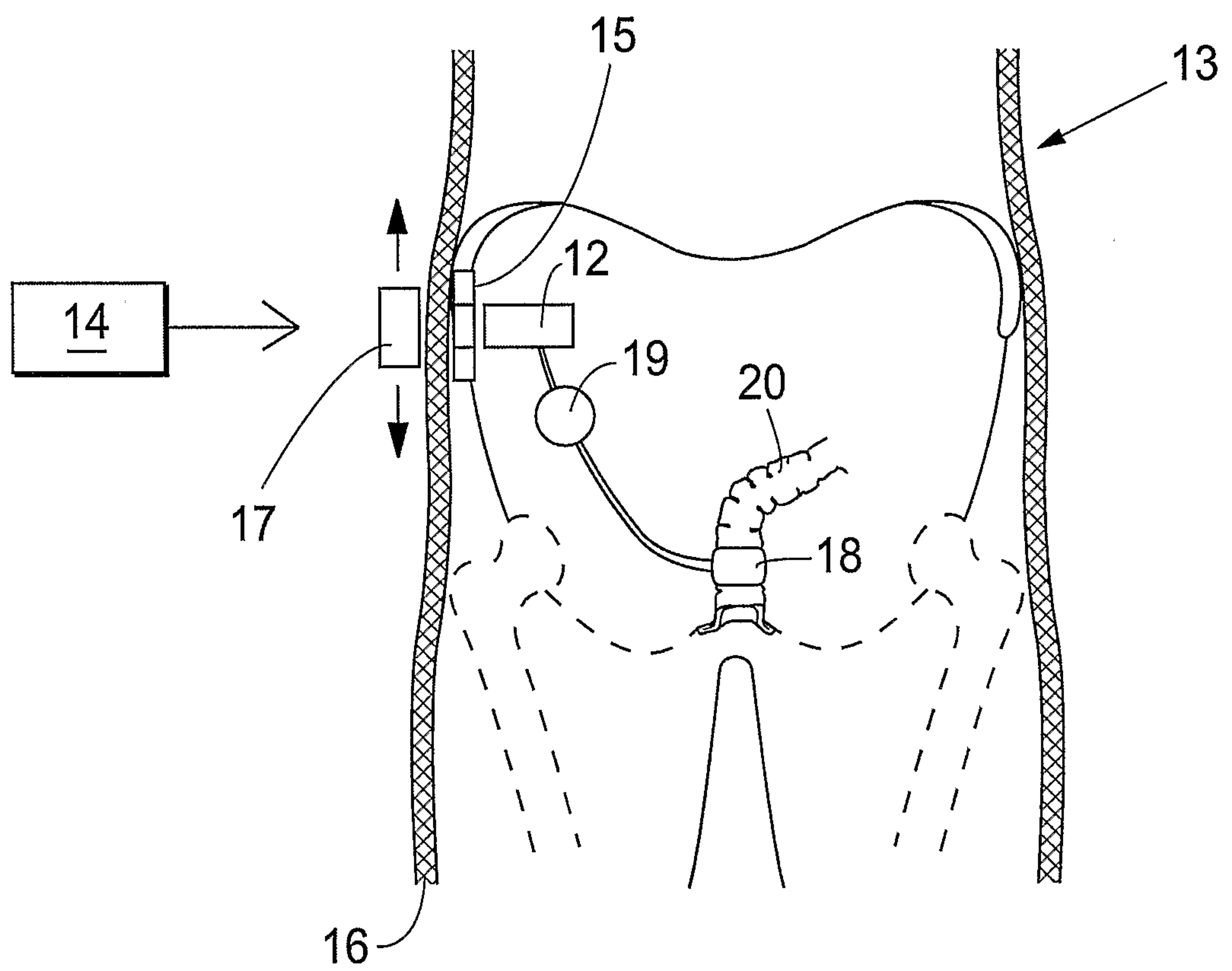


Fig. 3

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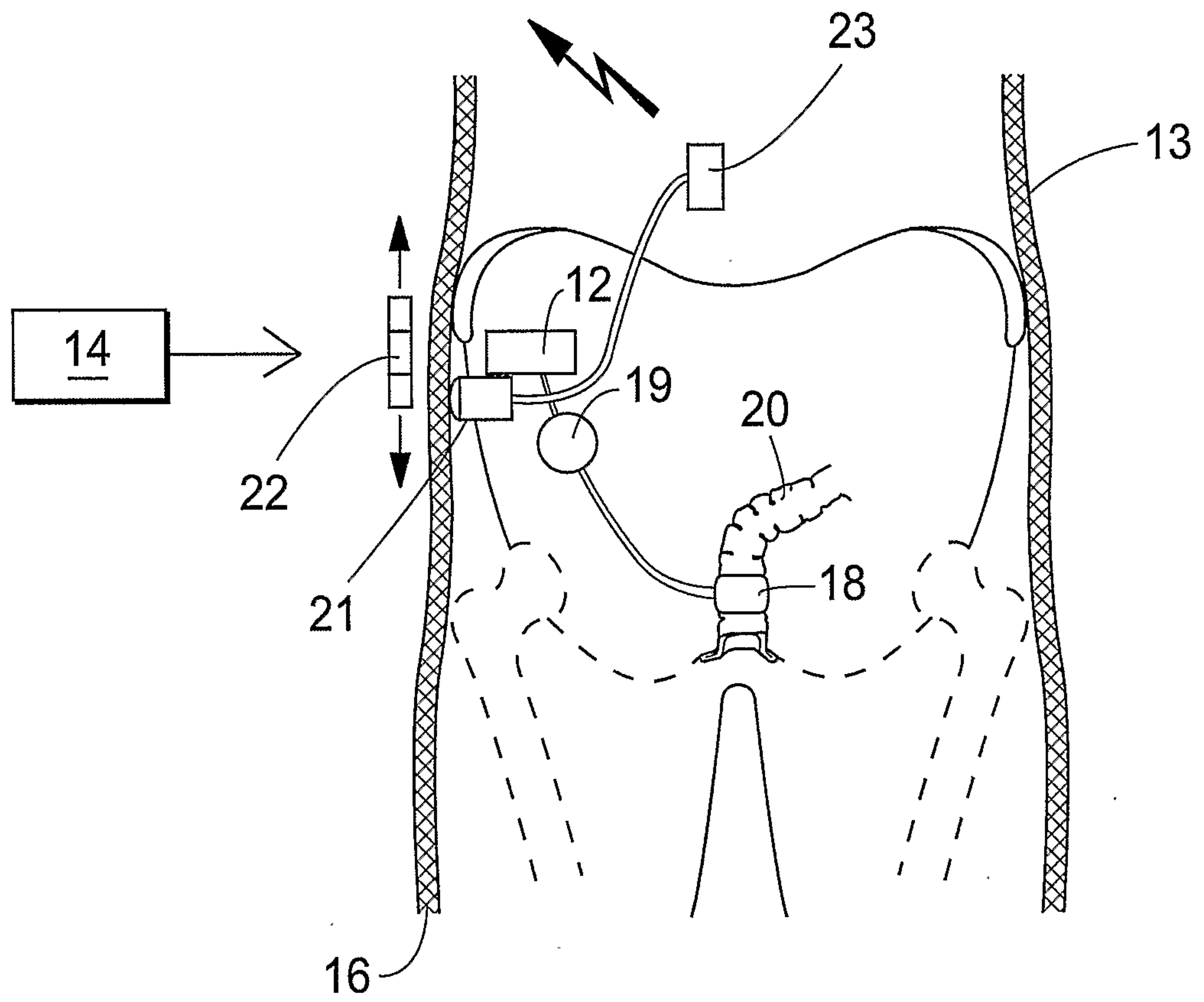


Fig. 4

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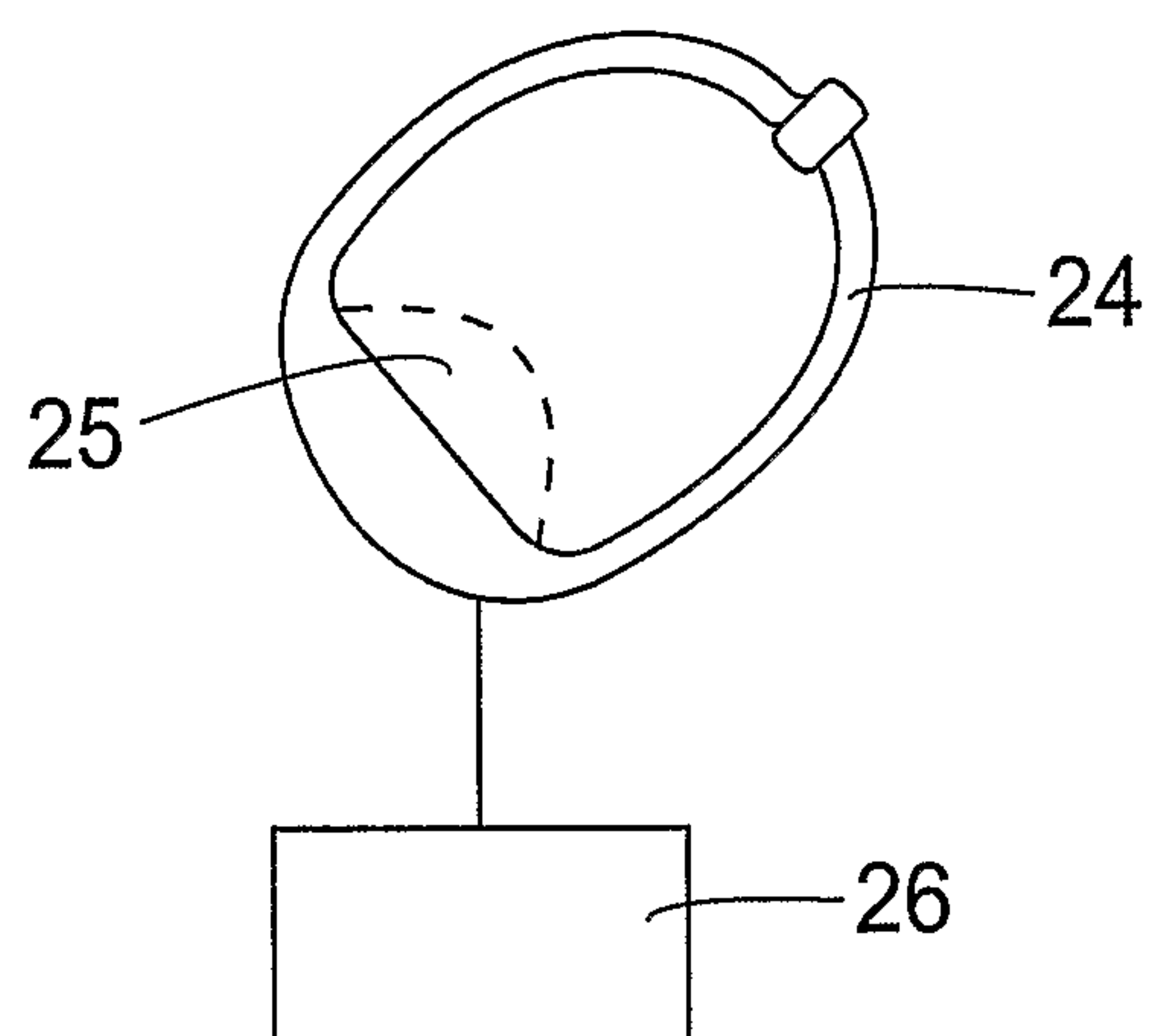


Fig. 5

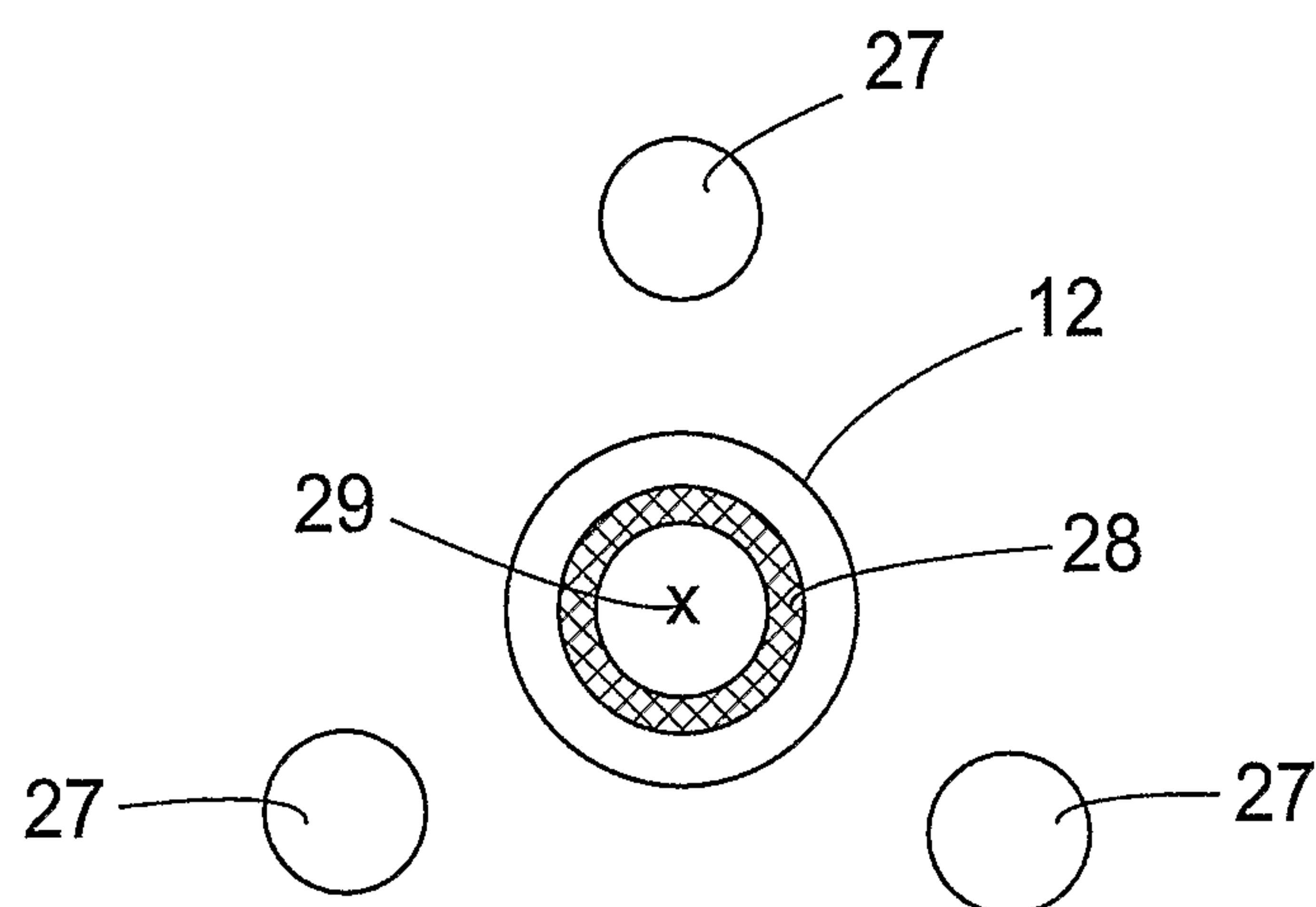


Fig. 6

