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[56]

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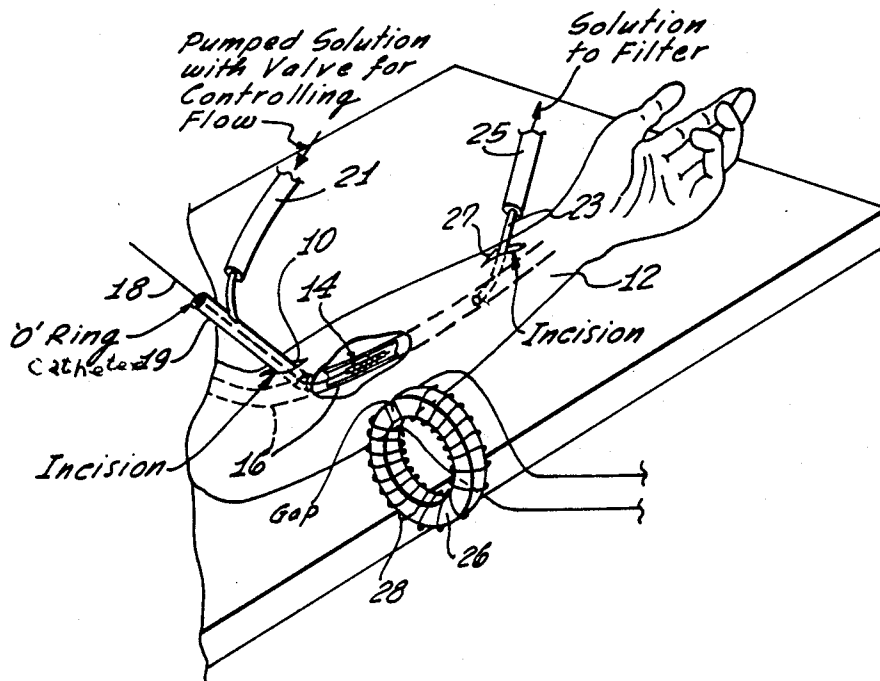
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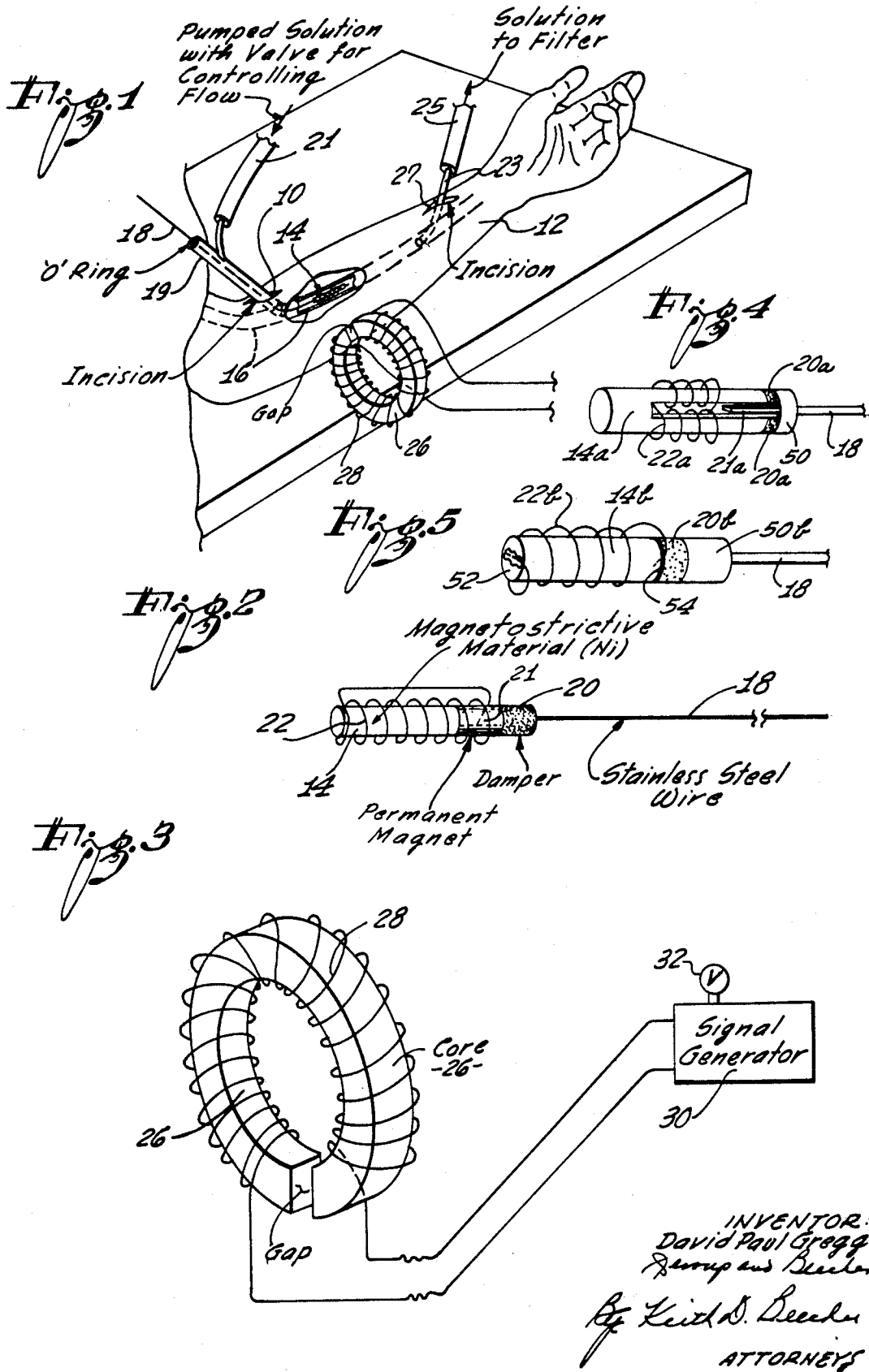
[54] **MAGNETOSTRICTIVE MEDICAL INSTRUMENT**
 9 Claims, 5 Drawing Figs.

[52] U.S. Cl. 128/24,
 128/303
 [51] Int. Cl. A61h 1/00,
 A61b 17/00
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ABSTRACT: A medical instrument which may be inserted into an artery of a patient, and which includes a magnetostrictive element that serves to remove cholesterol or other fatty deposits from the interior wall of the artery. The term "magnetostrictive" as used herein is intended to embrace the equivalent elements, such as "piezoelectric" and "electrostrictive" in which mechanical vibrations may be set up by the application of electrical energy.



Gregg



MAGNETOSTRICTIVE MEDICAL INSTRUMENT

BACKGROUND OF THE INVENTION

As is well known, the arteries are the vascular tubes which carry the blood away from the heart. The larger arteries normally have a smooth endothelial lining. The blood flow through the arteries is often impeded by the partial occlusion thereof, and this occlusion often is caused by the deposit of cholesterol or other fatty materials on the endothelial lining of the arteries. Prior to the advent of the present invention, the aforesaid deposits were usually removed from the arterial walls by inserting a catheter type of instrument and scraping the deposits from the arterial wall. This technique, however, is not entirely satisfactory, since it may dislodge particles, or damage the arterial lining.

The instrument of the present invention, as mentioned above, includes a magnetostrictive element which is inserted through an incision into the artery to be treated, and which can be moved along the interior of the artery, for example, by a stainless steel wire, or the like, which is attached to the element and which extends out through the incision. The instrument further includes, for example, a secondary winding which is wound about the magnetostrictive element. This secondary winding is excited by a high frequency ultrasonic signal by means of a primary winding, for example, which may be positioned externally of the patient and yet in an inductively coupled relationship with the secondary winding.

The excitation of the aforesaid secondary winding by the ultrasonic current in the primary winding, sets up high frequency ultrasonic vibrations in the magnetostrictive element. Suitable damping means may be provided at one end of the magnetostrictive element, so that when the element is moved along the interior of the artery, the ultrasonic vibrations of its other end cause the deposits on the arterial wall to be dislodged and washed away by an externally introduced solution.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a representation of the arm of a patient, and showing the instrument of the invention inserted into an artery for accomplishing the stated purpose of the invention;

FIG. 2 is a view of the magnetostrictive element which is included in the embodiment of the invention to be described;

FIG. 3 is the structure which is used to excite the element of FIG. 2 and which, in the illustrated embodiment, may be positioned externally of the patient;

FIG. 4 is a representation of a second embodiment; and

FIG. 5 is a third embodiment of the invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

In the practice of the invention, insofar as the illustrated embodiment is concerned, and as shown in FIG. 1, the instrument of the invention may be inserted through an incision 10 in, for example, the arm 12 of the patient. The magnetostrictive element 14 of the instrument of the invention is inserted through the incision 10, and into the interior of an artery 16 by means, for example, of a stainless steel wire 18 which extends through a tubular catheter 19. The wire may have sufficient rigidity, so that it may be used to push the element 14 along the interior of the artery 16. The magnetostrictive element 14 may be excited in the manner to be described; or it may carry its own primary and secondary exciting coils, or other excitation means, which may be energized through electrical conductors in the wirelike element 18.

In the illustrated embodiment, and as shown in FIG. 2, the internal element 14 may be composed of a rod of magnetostrictive material, such as nickel, a ferrite formed, for example, of sintered oxides or iron, nickel, copper, or any other suitable magnetostrictive material. The rod, for example, may have a diameter of 1 millimeter. A damper 20 is mounted at one end of the rod 14. The damper 20 may be composed of any appropriate material, and should exhibit a relatively large mass

with respect to the element 14, so that magnetostrictions set up in the element 14 result in a rapid movement of the end of the element remote from the damper 20. A biasing permanent magnet 21, formed of Alnico, ferrite or other appropriate permanent magnet material, should be interposed between the damper and the rod, as shown. In this way, the latter end of the element is caused to vibrate so as to dislodge and disperse cholesterol and other fatty deposits which have formed on the arterial wall. However, the dispersion is very fine, rather than in particles which could cause embolisms. These deposits become partially dissolved and are washed away by an externally introduced solution, introduced upstream of the point at which the rod is located.

The magnetostrictive effect is set up in the illustrated embodiment by a secondary winding 22 which is wound about the periphery of the magnetostrictive element 14 and around the permanent magnet 21, and which has its ends short circuited, so that an appreciable current flows through the winding 22 when it is excited. The winding 22 may be excited by an external primary winding assembly including, for example, a ring core 26 having a primary winding 28 wound about it.

The core 26 has an airgap formed in it as shown. As shown in FIG. 1, for example, the core may be positioned over the arm of the patient so that the artery 16 being treated passes through the airgap even though the core 26 and primary winding are positioned externally of the patient.

The primary winding 28 may be energized by an appropriate high frequency signal from a signal generator 30 of any suitable design. The frequency of the signal generated by the generator 30 may, for example, be in the range of from 25 kilohertz to 1 megahertz. Peak displacements of the order of 1 micrometer may be attained in the rod 22 when such parameters are used.

A millivoltmeter 32 may be included in the circuit, and its peak reading may serve as a detection indicator to indicate the proper position of the external core 26 and primary winding 28 with respect to the internal moving element 14 and its secondary winding 22. That is, the external primary winding 28 and core 26 should be moved along the exterior of the artery 16 and turned as necessary as the element 14 is moved along its interior, with an optimum coupling relationship between the two being indicated by a maximum power flow through the meter 32. Furthermore, the meter 32 indicates the power level of the cleansing process, and it also indicates any tendency for the core temperature to rise to a level at which it would injure the artery. Such a temperature rise may be offset by increasing the flow of solution introduced into the artery through the catheter 19 by means of a tube 21. The solution is carried out of the artery to a filtering device through a second catheter 23 and tube 25. The catheter 23 extends through a second incision 27. This permits the fatty or other removed material to be studied and analyzed.

Although the element 14 is shown as directed and guided by the wire 18, the element could be configured so as to be inserted into the artery, and to move within the artery independently of any external guides, and by the arterial fluid itself. The movement of the element 14 could then be followed by the external coil 28 and core 26, as indicated by the deflection of the meter 32.

It will be appreciated, of course, that the embodiment illustrated in the drawing and described above is merely one aspect of the structural concept of the invention. For example, electrostrictive material such as barium titanate may be used, as will be described in conjunction with FIG. 5, and appropriate electrostatic fields produced by the voltage developed across an open secondary winding, rather than the current through a closed secondary winding as in the embodiment of FIG. 2. Moreover, a piezoelectric crystal may be used with plate contacts, and with the secondary winding connected to the plate contacts and establishing control voltages across the crystal. The piezoelectric and electrostrictive rods do not require biasing.

In the embodiment of FIG. 4, the magnetostrictive element 14a is split, as shown, to have a U-shape defining a longitudinal slot therein. The biasing permanent magnet 21a extends into the slot, out of contact with the element 14a. The permanent magnet 21a is mounted on a disc 50 attached to the end of the push rod, or wire, 18. The element 14a may be attached to the disc 50 by compliant cement 20a which also forms the aforesaid damper. The secondary winding 22a is closed, as before, and is wound in a series-aiding relationship on the element 14a, as shown.

In the embodiment of FIG. 5, a piezoelectric or electrostrictive rod 14b is used, and the ends of the rod are metallized by electrical contacts 52 and 54. The secondary winding 22b has its ends connected to the contacts 52 and 54 so as to provide an open circuit, with a voltage being applied across the contacts when the primary induces such a voltage in the secondary winding. A damper 20b is provided between the rod 14b and the head 50b of the push rod or wire 18. The secondary winding in the embodiment of FIG. 5, as in the previous embodiments may be gold plated, nickel wire, or any other electrically conductive material which will not adversely affect the patient.

I claim:

1. A medical instrument for removing deposits from the interior wall of an artery, or the like, of a subject, including: an element composed of magnetostrictive material configured to be received into the interior of the artery and can be moved therealong so as to establish mechanical vibrations within said artery with respect to an applied signal; an electrical winding mounted on said element to establish the aforesaid magnetostrixtions therein upon the passage of an alternating current of ultrasonic frequency through said winding; a magnetic core of magnetizable material physically separated from said element and positioned externally of the subject; a primary winding mounted on said magnetic core and inductively coupled to the aforesaid electrical winding on said element; and means for causing an alternating current of ultrasonic frequency to flow in said primary winding.

2. The instrument defined in claim 1, and which includes a ring-shaped core of magnetizable material supporting said primary winding and having an airgap therein.

3. The instrument defined in claim 1 and which includes a power source coupled to said primary winding for producing

said alternating current in said primary winding, and an indicating meter coupled to said source to indicate the position of the aforesaid element with respect to said primary winding.

4. A medical instrument for removing deposits from the interior wall of an artery, or the like, including: an element composed of material configured to be received into the interior of the artery and to be moved therealong and to establish mechanical vibrations in response to an applied signal; and means coupled to said element for applying a signal thereto for establishing said vibrations therein as said element moves along the interior of the artery so as to cause the element to remove deposits from the interior wall of the artery, in which said element has an elongated rodlike configuration, and which includes electrical contacts mounted on the ends of said element, and which includes an electrical winding mounted on said element and having ends connected to said contacts to establish mechanical vibrations in said element upon the passage of an alternating current of ultrasonic frequency through said winding.

5. The medical instrument defined in claim 4, in which said element is composed of electrostrictive material.

6. The medical instrument defined in claim 4, in which said element is composed of piezoelectric material.

7. A medical instrument for removing deposits from the interior wall of an artery, or the like, including: an element composed of magnetostrictive material configured to be received into the interior of the artery and to be moved therealong and to establish mechanical vibrations in response to an applied signal; means coupled to said element for applying a signal thereto for establishing said vibrations therein as said element moves along the interior of the artery so as to cause the element to remove deposits from the interior wall of the artery, and which includes a biasing permanent magnet coupled to said element.

8. The medical instrument defined in claim 7, and which includes a damping member mounted on said element, and in which said biasing permanent magnet is mounted on said element and interposed between said damping member and one end of said element.

9. The medical instrument defined in claim 7, and which includes a damping member mounted on said element, and in which said biasing permanent magnet extends into a slot in said element.

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