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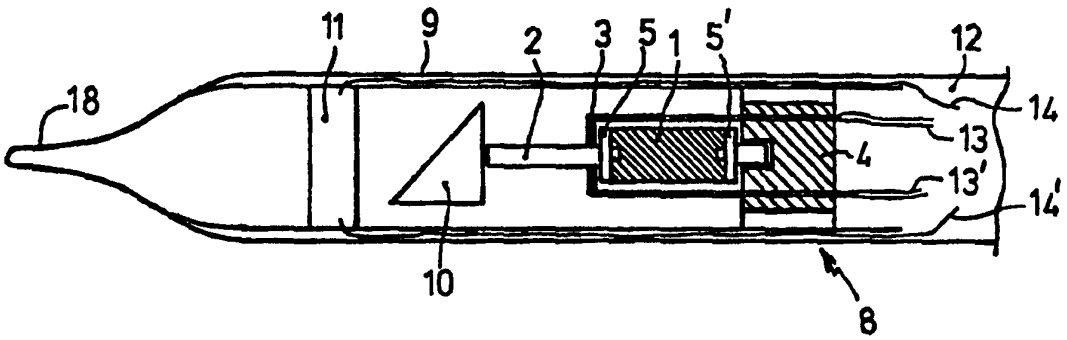
(54) Title: MICRO MOTOR AND GUIDE WIRE, IN PARTICULAR FOR GUIDING CATHETERS, WITH SUCH A MICRO MOTOR



(57) Abstract

Micro motor provided with a stator and a rotor. The rotor contains a number of magnetic poles arranged about the rotor shaft. The micro motor further contains a connector for electrically connecting the stator with a power source. The stator consists of self-supporting current conductor paths, one end of each of the conductor paths being attached to the connector. Preferably one end of the rotor shaft is borne in the connector and the other end of the rotor shaft is borne in the other end of the stator. Guide wire, in particular for guiding catheters, provided with a suchlike micro motor. Near one end of the guide wire a casing of a material which is transparent for sound waves is integrated in the guide wire. Inside this casing are arranged a rotatable acoustic mirror, means, having electrically connecting elements, for generating sound waves and receiving echoes from the sound waves, and a micro motor for permitting the acoustic mirror to be rotated. The guide wire contains wire conductors for electrical connection of the connector of the micro motor and the electrically connecting elements to the other end of the guide wire.

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Micro motor and guide wire, in particular for guiding catheters, with such a micro motor

The invention relates to a micro motor provided with a stator, with a rotor with a rotor shaft, the rotor containing a number of magnet poles arranged about the rotor shaft, with a bearing for rotatably bearing the rotor, and with a connector for electrically connecting the stator to a power supply.

The invention also relates to a guide wire, in particular for guiding catheters, having such a micro motor.

A micro motor of the type named in the opening paragraph is described in the United States patent specification 5,240,003. This known micro motor contains a rotor mounted on a rotor shaft with two magnet poles. The rotor is accommodated in a non-magnetic, cylindrical stator housing. Two bearings are arranged at the ends of the stator housing for rotatably bearing the rotor shaft. On the inside of the stator housing a flexible Kapton printed circuit board is arranged, which printed circuit board carries current conductor paths. A connector electrically connects the current conductor paths to a power supply. The United States patent specification 5,240,003 further discloses the use of such a micro motor in an ultrasonic instrument for the examination and/or treatment of blood vessels, for example. This ultrasonic instrument contains a catheter with a distal end on which a small tip, of material which is transparent for sound waves, is attached. Inside this tip there is a rotatable acoustic mirror, means for generating sound waves and for receiving echoes of the sound waves, and a micro motor for rotating the acoustic mirror. The space inside the tip is filled with a fluid to vouch for an sufficiently efficient acoustic action of the instrument. The catheter can also be

provided with a capillary tube for containing a guide wire.

It would be desirable to make the external diameter of the catheter as small as possible so as to also be able to examine smaller blood vessels. Thus for this purpose the external diameter of the micro motor should also be as small as possible. It has appeared that there are difficulties attached to reducing the external diameter of the known micro motor to below 1 mm. Besides, it appears in practise that the action of the known micro motor can be disturbed if a guide wire is inserted into the capillary tube or if, for example, ferriferous material is present in the vicinity of the micro motor. In addition, it has appeared that completely filling the space in the tip of the catheter where the micro motor is situated with liquid is not easy and sometimes unfilled spaces or air bubbles remain behind, which can have a disadvantageous effect on the acoustic action of the instrument as well as on the running of the motor.

It is an object of the present invention to provide a micro motor with a construction such that the external diameter of the micro motor can be considerably reduced as opposed to the known micro motors, this construction also providing the possibility of by and large removing disturbances which adversely affect the working of the micro motor and improving the filling of the catheter tip with fluid.

For this purpose a micro motor of the type according to the invention named in the opening paragraph is characterized in that the stator consists of self-supporting current conductor paths, one end of each of the current conductor paths being attached to the connector. Because of this the stator consists exclusively of self-supporting current conductor paths, whereby the non-magnetic housing

and the flexible print circuit board of the known micro motor have become unnecessary for carrying the conductor paths, as a result of which the external diameter of the micro motor is reduced.

Preferably one end of the rotor shaft is borne in the connector and the other end of the rotor shaft is borne by the other ends of the current conductor paths. In this way the bearing of the rotor shaft is realized by the self-supporting current conductor paths themselves, and the known non-magnetic stator housing is, for that reason, superfluous, this leading to a saving of space. Because of the construction of a micro motor according to the invention micro motors with an external diameter of as small as 0.1 mm are possible.

The bearing of the rotor shaft can take place one-sidedly as well as directly in the connector and in the stator, but for obtaining identical bearings at the ends of the rotor shaft bearing preferably occurs by means of bearing blocks.

The self-supporting current conductor paths, that is the stator, can be formed by self-supporting coils. A stator consisting of four (for two-phase operation) or six (for three-phase operation) lips of electrically conductive material which are placed about the rotor, is, however, easier to make and the micro motor according to the invention can, at the same time, have a very open structure. The control of the micro motor preferably takes place in two or more separate phases, lips facing each other being connected to the same phase.

As a result when the micro motor is placed in the catheter tip the space in the tip can easily be filled with liquid, without formation of air bubbles or open space, this being necessary for an acoustic action. Moreover, it is also

possible to influence the running characteristics of the rotor by influencing the current covering via variations in the cross section of the lips.

Preferably the rotor has a through shaft or two axially spaced shaft journals spaced in the direction of the shaft. In this way supporting surfaces are obtained by the shaft journals for the bearing blocks or for the direct bearing by the stator and the connector. The number of magnet poles is placed between the shaft journals, or is alternatively placed radially outside the stator.

Preferably one or more current conductor paths are of electrically as well as of magnetically conductive material.

If the micro motor is provided with a housing of soft magnetic material for screening the number of magnet poles, which housing is attached to the rotor, then the rotor can be fully screened from the outside by the screening housing which rotates with the rotor. Although the external diameter of the micro motor is enlarged by this screening housing, micro motors with an external diameter as small as 0.4 mm are possible, which are not adversely affected by possible disturbance sources. Although guide wire is generally made of non-magnetic stainless steel, it appears that by making these by means of drawing the guide wire shows sufficient magnetic characteristics to still function as source of disturbance for the micro motor.

The invention also provides a guide wire, in particular for guiding catheters, near one end of the guide wire a casing of material which is transparent for sound waves being integrated in the guide wire, within which casing are arranged a rotatable acoustic mirror, means, having electrically connecting elements, for generating sound waves and receiving echoes from the sound waves, and a

micro motor according to any one of the preceding claims for rotating the acoustic mirror, which guide wire contains wire guiders for electrical connection of the connector of the micro motor and the electrically connecting elements to the other end of the guide wire.

A micro motor according to the invention can also be used as generator.

Because of the minor external diameter of the micro motor according to the invention it is possible to integrate the micro motor in a guide wire. Not only is it possible because of this to examine very small blood vessels, but a more efficient examination and/or operation in blood vessels or other cavities is possible. In the past it was first of all necessary to insert a guide wire and then subsequently to insert an exploratory catheter over the guide wire, in order to examine the blood vessel, for example, then to remove the exploratory catheter and insert an operation catheter over the guide wire to carry out an operation and then to remove the operation catheter and insert the exploratory catheter over the guide wire to check whether the operation has been carried out correctly and finally to remove the exploratory catheter and the guide wire. Now only the guide wire according to the invention has to be inserted first and the operation catheter then inserted over that. In addition, the operation catheter only has to be withdrawn along a small distance to be able to check the operation.

A few embodiments of a micro motor and a guide wire according to the invention will now be described in more detail on the basis of the drawing, in which

fig. 1 schematically shows in cross section an embodiment of a micro motor according to the invention,

fig. 2 schematically shows in cross section an alternative embodiment of a micro motor according to the invention,

fig. 3 schematically shows in cross section the micro motor according to the figure 1 with a screening housing,

fig. 4 schematically shows in cross section an alternative embodiment of a micro motor with screening housing according to the invention,

fig. 5 schematically shows, in part in cross section, a guide wire with integrated micro motor according to the invention,

fig. 6 shows an example of making a stator to be used in the micro motor according to the invention,

fig. 7 shows some examples of stator cross sections.

The embodiment of the micro motor according to the invention shown according to a longitudinal cross section in fig. 1 comprises a rotor 1 which is mounted to a rotor shaft 2. The micro motor further contains a stator 3 consisting of self-supporting current conductor paths and a connector 4 for electrically connecting the stator 3 to a power supply. The stator 3 is fixedly attached with one end to the connector 4. The rotor shaft 2 is rotatably borne 15' in, on the one hand, the connector 4 and, on the other hand, in opening 15 in the stator. The bearing can take place directly in the connector and the stator. In cases in which high demands are made on the bearing, for example in connection with life span or reduction of friction, it is preferable having the bearing occur by means of bearing blocks so that both ends of the rotor shaft can be borne identically. Suitable bearing blocks are of the type as are used, for example, in the watch industry and are, for example, made of corundum.

The rotor shaft 2 is provided with two spaced journals 5, 5'. These shaft journals 5, 5' provide a step-like widening of the rotor shaft, as a result of which support surfaces for exactly defining the bearing are provided. The rotor 1 is situated between the shaft journals 5, 5' and contains a number of magnet poles. The number of magnet poles can be two or more. The magnet poles are made of a permanent-magnet material and can be integrally formed as a magnet bounded with synthetic. The self-supporting current conductor paths of the stator 3 surround the rotor 1. The current conductor paths can be made of a number of turns of conductor wire wound spirally and provided with an insulating layer. A layer of synthetic is arranged about the insulating layer which, when heated, adheres to the synthetic layer of the turn next to that, so that a self-supporting conductor path can be formed. Suchlike conductor wires with an insulation layer and a synthetic layer are frequently used with cathode ray tube deflection coils. A stator consisting of lips of electrically conductive material, such as copper are more easily made and therefore cheaper. Such a stator 3 is, for example, made as shown in figure 6. In figure 6A a view is shown of an etched or pressed "prestator" 3' cut out of copper foil, which prestator 3' contains an opening 15 in a central ring part 16 and four lips 17. The lips 17 are bent to the position shown in figure 6B, whereby the stator 3 is formed. However, apart from that, the stator can be made of separate lips or can be cut, pressed or etched of bush- shaped material. The number of lips is four for two-phase control of the micro motor and six for three-phase control of the micro motor.

It has been shown that the running characteristics of the rotor can be influenced by varying the cross section of the lips of the stator. The cross section of the lips should be preferably such that a sinus-shaped current covering is obtained without a higher harmonic. A cross

section of the lips 17 as shown in figure 6C, the so-called rectangular cross section, provides the desired running characteristics in conjunction with a magnet with a good sinus-shape field. If higher demands are to be made on the running characteristics, which implies the sinus-shaped current covering should be improved, then this can be answered by adapting the cross section of the lips, for example by etching. A banana-shaped cross section (figure 7A) and a stepped cross section (figure 7B) are suitable for this. Further improvement of the sinus-shaped current covering is possible by forming an overlap between the lips, as is shown in figures 7C, 7D and 7E.

Because of this structure of the micro motor the rotor shaft is borne by the self-supporting conductor paths and the connector, as a result of which a micro motor is obtained with a diameter as small as 0.1 mm.

In figure 2 an alternative embodiment of a micro motor according to the invention is shown in which the rotor 1 with magnet poles is bush-shaped and surrounds the stator 3. The bush-shaped rotor is fixedly connected to the rotor shaft.

Precisely because of its very small dimensions the micro motor according to the invention is extremely susceptible to disturbances, such as adhesive couple of magnetic material which is near the micro motor. In order to take away these disturbances the micro motor according to the invention is provided with a housing 6 of soft magnetic material for screening the rotor, this housing being attached to the rotor 1 and 2, as is shown in the figures 3 and 4. Through this the screening housing 6 turns with the rotor 1, whereby no additional magnetic losses, no disturbing adhesive couple occur as a consequence of tolerance inaccuracies and a strengthening of the magnetic field with corresponding better motor working in comparison with a

stationary screening housing.

In the embodiment shown in figure 3 the screening housing 6 surrounds the construction as shown in figure 1. In the embodiment shown in figure 4 the rotor is attached to the inside of the screening housing 6 and the stator 3 is surrounded by this. In these two embodiments the micro motor is impervious to disturbances from outside.

Although the micro motor according to the invention is suitable for use in all kinds of areas, the advantages of the small micro motor according to the invention particularly come to the fore in use in the watch industry or in catheters for examination of and/or operation of blood vessels. When used in catheters the connector functions as fit in the catheter, one or more slots or holes being arranged in the connector for filling the micro motor with liquid. Because of the small dimension, however, the micro motor according to the invention is not only suitable in catheters, but it can even be integrated in a guide wire which is used for guiding these catheters. A suchlike guide wire 8 is schematically shown in figure 5. The basic body 12 of the guide wire 8 is built up of woven threads of stainless steel. The end 18 of the guide wire is made in the known way as search end and is also called "pig's tail". Near one end of the guide wire 8A a casing 9 of material which is transparent for sound waves is integrated with the guide wire 8. Inside this casing 9 are arranged a rotatable acoustic mirror 10, means 11, having electrically connecting elements, for generating sound waves and receiving echoes from the sound waves, and a micro motor (1, 2, 3, 4, 5, 5') arranged according to the invention. The rotor shaft 2 of the micro motor is connected to the acoustic mirror 10 to permit it to rotate. The guide wire 8 further contains electric wire conductors 13, 13' 14 and 14' for connecting the stator 3 of the micro motor with an electrical source and for feeding the

means 11, respectively and subsequently transporting signals of converted echoes of sound waves given out by the means 11. A suchlike guide wire considerably simplifies the examination and the operation of blood vessels.

In order to obtain an efficient acoustic action of the guide wire 8, the space inside the casing 9 should be filled with liquid. Because of an open costruction of the micro motor according to the invention, the filling of this space can take place without air bubbles or empty, that is to say, not filled portions being left behind. In this way the acoustic action of the guide wire is promoted.

AS/FL

Claims

1. Micro motor provided with a stator, with a rotor with a rotor shaft, the rotor containing a number of magnet poles arranged about the rotor shaft, with a bearing for rotatably bearing the rotor, and with a connector for electrically connecting the stator to a power supply, **characterized in that** the stator substantially consists of self-supporting current conductor paths, one end of each of the current guide paths being attached to the connector.

2. Micro motor according to claim 1, **characterized in that** one end of the rotor shaft is borne in the connector and in that the other end of the rotor shaft is supported by the other ends of the current conductor paths.

3. Micro motor according to claim 1, **characterized in that** the rotor is single-sidedly borne.

4. Micro motor according to claim 2 or 3, **characterized in that** the ends of the rotor are supported by bearing blocks.

5. Micro motor according to any one of the preceding claims, **characterized in that** the stator consists of four, six or more lips of electrically conductive material, which are placed about the rotor.

6. Micro motor according to claim 5, **characterized in that** the micro motor control takes place in two or more separate phases, lips opposite each other being connected to the same phase.

7. Micro motor according to any one of the preceding claims, **characterized in that** the rotor has a through shaft.

8. Micro motor according to any one of the preceding claims 1 to 6, **characterized in that** the rotor has two axially spaced shaft journals spaced in the direction of the shaft.

9. Micro motor according to claim 8, **characterized in that** the number of magnet poles is placed between those journals.

10. Micro motor according to claim 1,2 or 5, **characterized in that** one or more of the current conductor paths are of electrically as well as of magnetically conductive material.

11. Micro motor according to any one of the claims 1 to 8, **characterized in that** the number of magnet poles is placed radially outside the stator.

12. Micro motor according to any one of the preceding claims, **characterized in that** the micro motor is provided with a housing of soft magnetic material for screening the number of magnetic poles, which housing is attached to the rotor.

13. Micro motor according to any one of the preceding claims, **characterized in that** the micro motor is used as generator.

14. Guide wire, in particular for guiding cathetders, **characterized in that** near one end of the guide wire a casing of a material which is transparent for sound waves is integrated in the guide wire, within which casing are arranged a rotatable acoustic mirror, means, having electrically connecting elements for generating sound waves and receiving echoes from the sound waves, and a micro motor according to any one of the preceding claims for rotating the acoustic mirror, which guide wire contains

wire conductors for electrical connection of the connector of the micro motor and the electrically connecting elements to the other end of the guide wire.

AF/FL

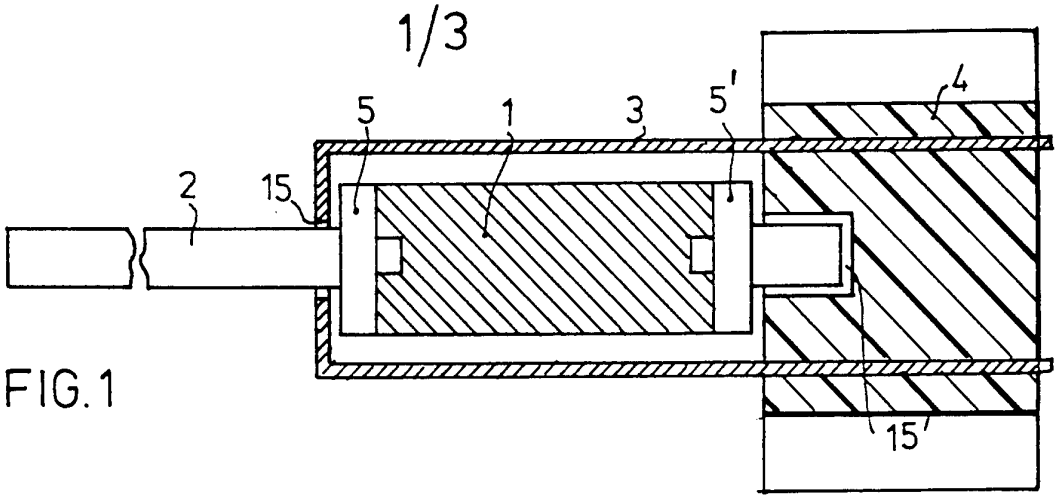

FIG.1

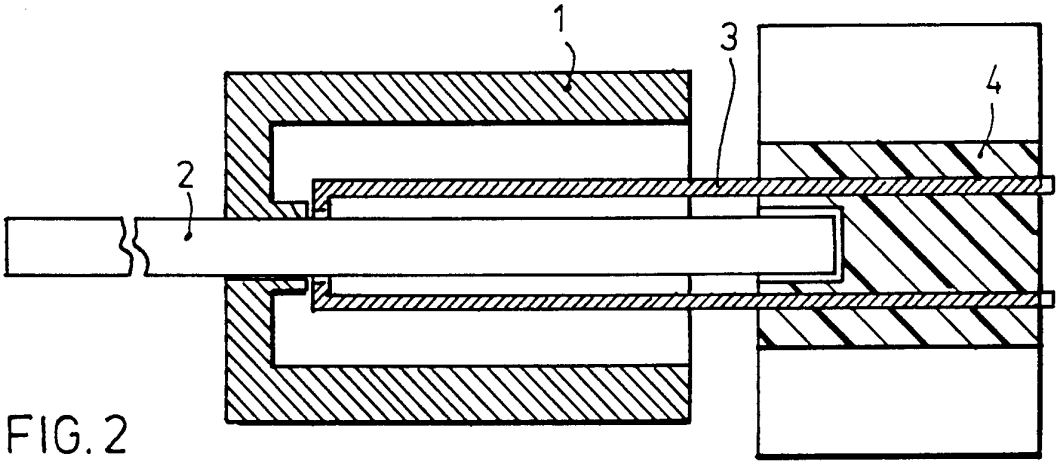

FIG.2

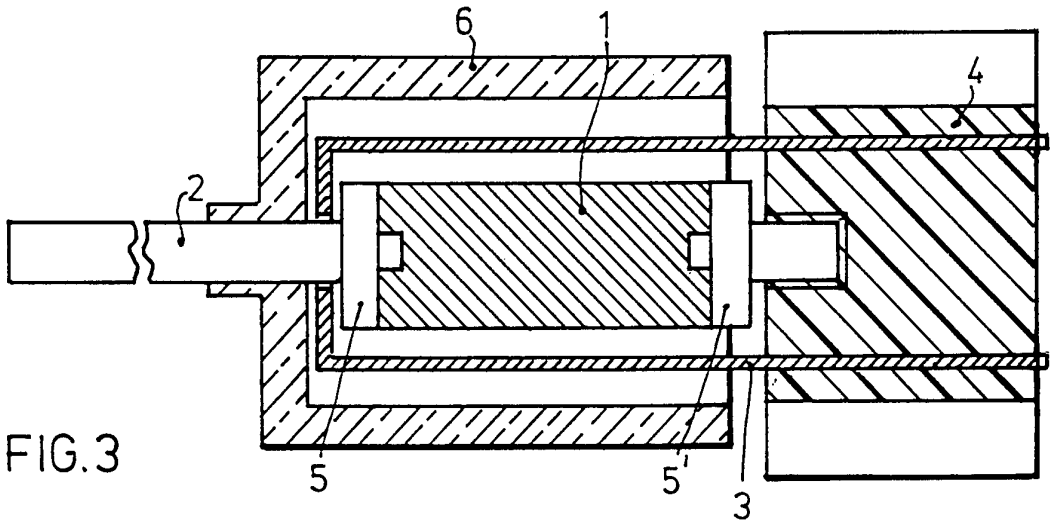

FIG.3

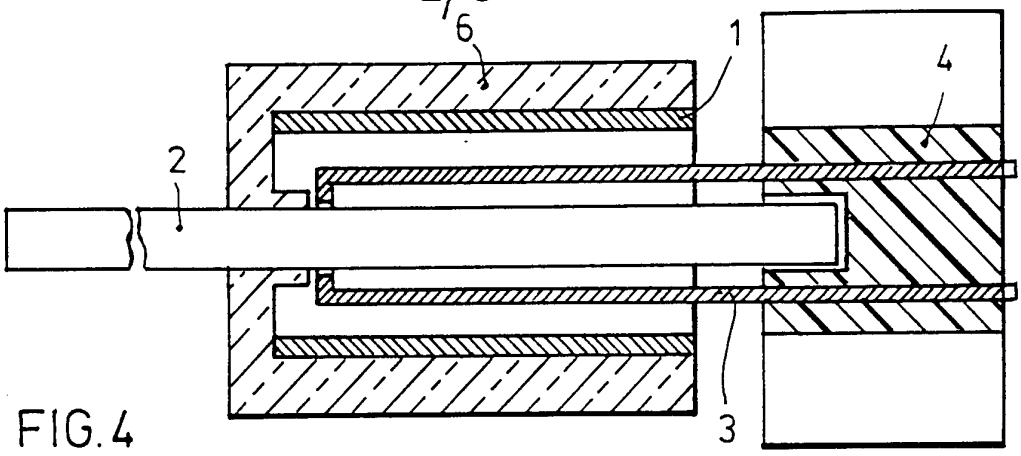

FIG. 4

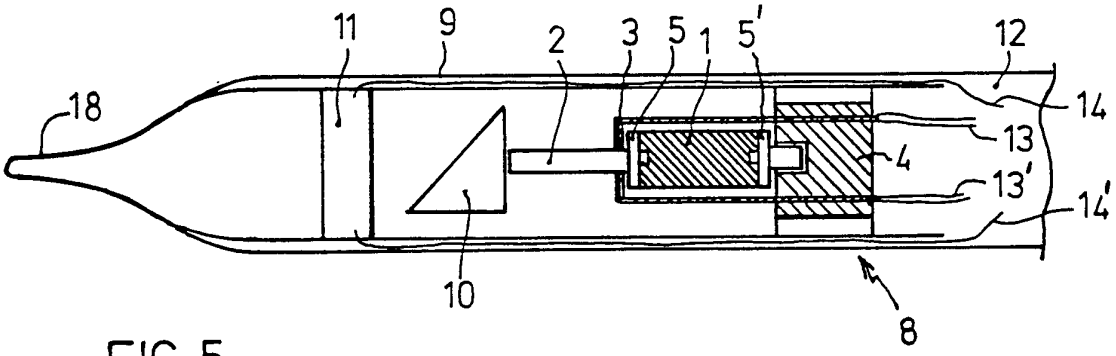

FIG. 5

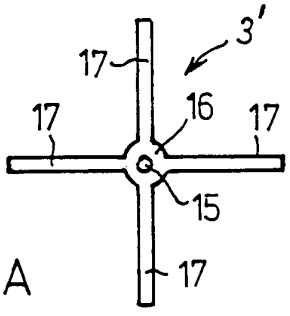

FIG. 6A

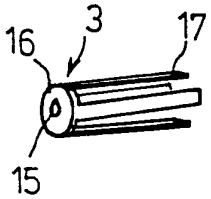

FIG. 6B

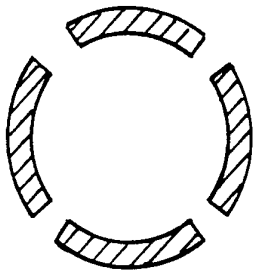

FIG. 6C

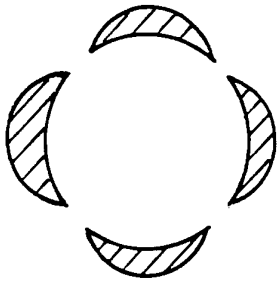

FIG. 7A

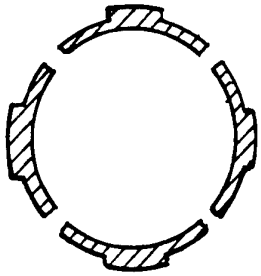

FIG. 7B

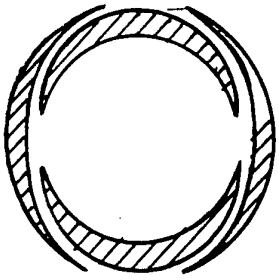

FIG. 7C

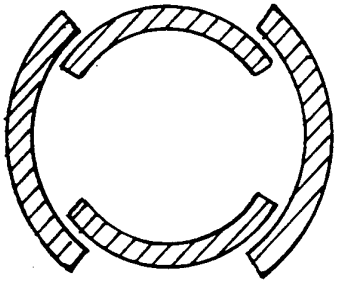

FIG. 7D

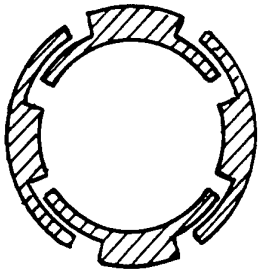

FIG. 7E

INTERNATIONAL SEARCH REPORT

Int. ..uonal Application No
PCT/NL 95/00180

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H02K3/47 H02K3/26 A61B8/12

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 6 H02K G04C A61B

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	DE-A-42 05 985 (DR. FRITZ FAULHABER GMBH) 16 September 1993 see column 1, line 47 - line 68 see abstract; figures 1,2	1,4,7, 11,12 2,3,5,6, 8-10
Y A	CH-A-345 832 (FABRIQUES MOVADO) 31 May 1960 see page 1, line 48 - page 2, line 20 see page 2, line 68 - line 75 see claims 3,5	1,4,7, 11,12 2-14
A	US-A-4 883 981 (S.R. GERFAST) 28 November 1989 see column 2, line 8 - line 60 see column 4, line 48 - line 68 see abstract; figures 1,4,12	1-13

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[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
18 August 1995	13.09.95

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

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO-A-93 05712 (DU-MED BV.) 1 April 1993 cited in the application see abstract -----	14

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. ..ional Application No
PCT/NL 95/00180

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