

[54] **MOTOR DEVICE WHOSE CIRCUIT, COMPRISES A THIN LAYER OF HARD MAGNETIC MATERIAL**

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[51] **Int. Cl.:** H02k 21/12

[58] **Field of Search:** 310/156, 266, 257, 310/162-169, 40 MM

[56]

References Cited

UNITED STATES PATENTS

3,539,845	11/1970	Stcherbatcheff.....	310/156 X
3,469,124	9/1969	Willcox.....	310/266 X
3,508,091	4/1970	Kavanaugh	310/257 X

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[57]

ABSTRACT

Micro-motor with a homopolar structure, comprising a coil on the base on which a tubular core is fitted, a second tube fitted on a pole piece carrying a pinion, these two tubes being fitted one in the other, and a rotor comprising a bell with a thin cylindrical wall made of hard magnetic material.

4 Claims, 3 Drawing Figures

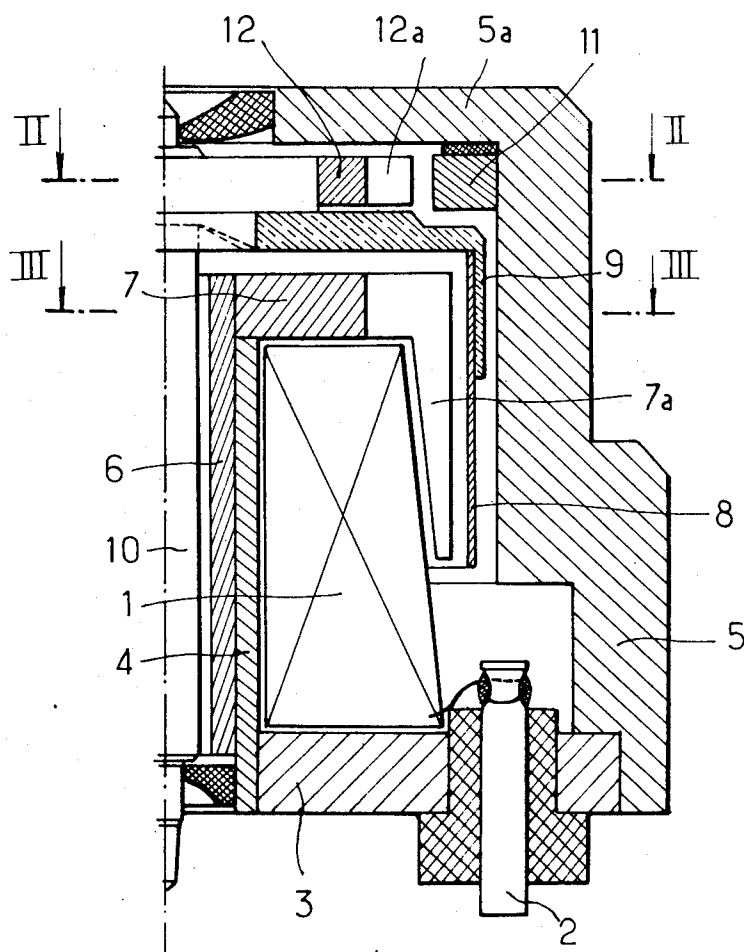
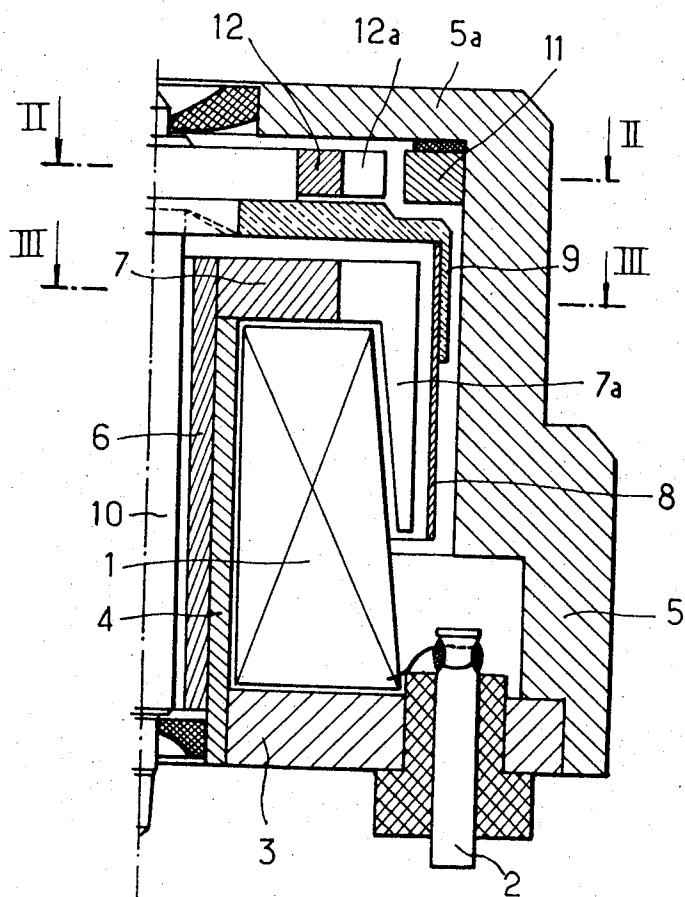


Fig-1



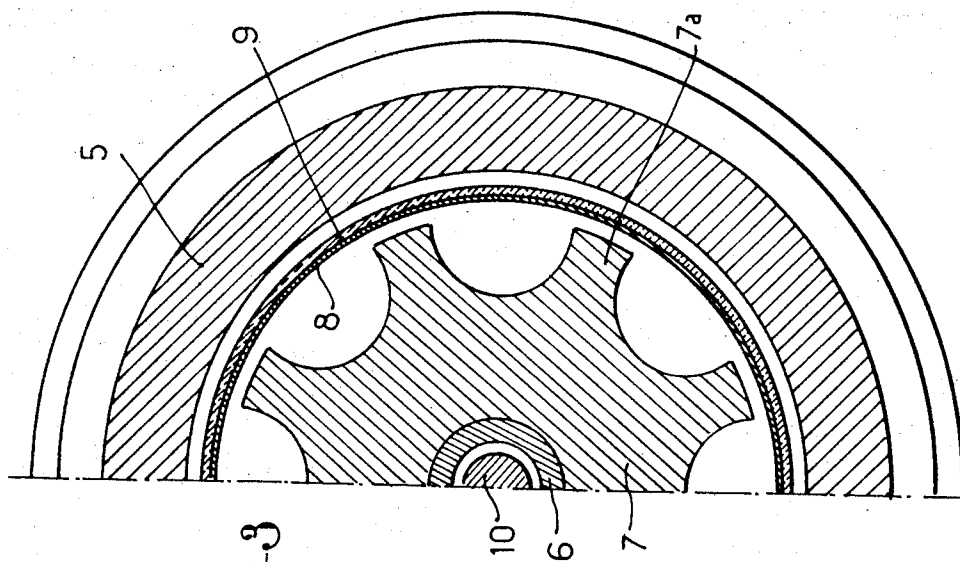


Fig-3

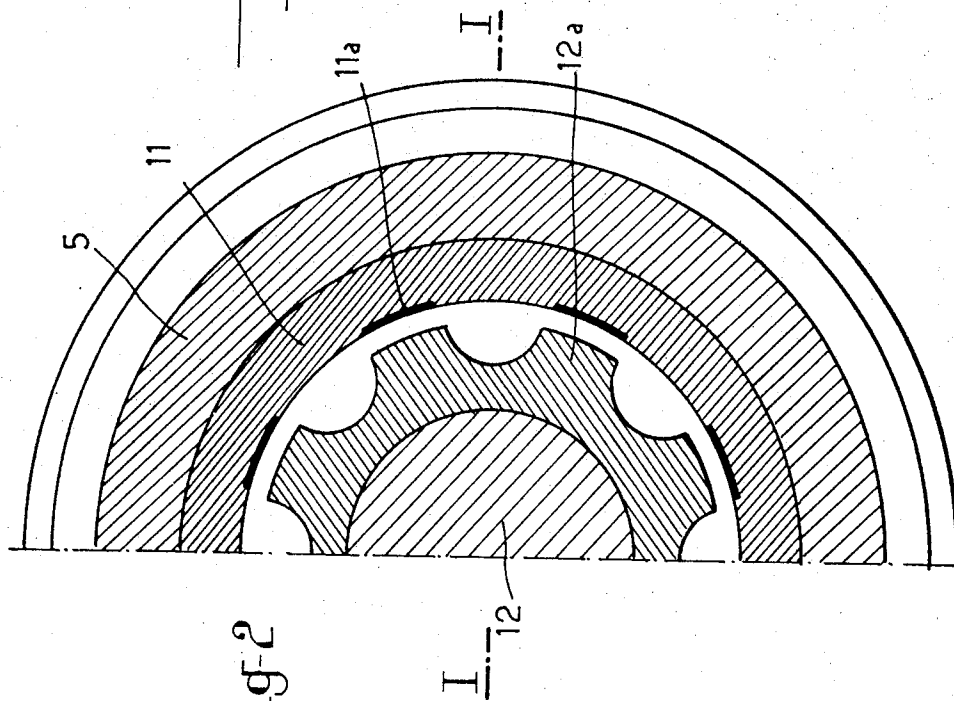


Fig-2

MOTOR DEVICE WHOSE CIRCUIT, COMPRISES A THIN LAYER OF HARD MAGNETIC MATERIAL

The invention relates to the micro-motors used, in particular, in watch-making applications, and designed to operate by the step by step method.

In the prior U.S. Pat. No. 3,539,845, filed on Nov. 10, 1970, in the name of Georges Stcherbatcheff, for : "Motor whose magnetic circuit comprises a thin layer of hard magnetic material," there is disclosed, in particular, a micro-motor of this kind with a homopolar structure: the rotor consists of a bell with a cylindrical portion made of hard magnetic material, while the stator comprises two pole pieces each fitted with a homopolar pinion, these two pinions respectively being polarized positively and negatively by the current which flows in the coil, and their facing teeth define a gap in which said cylindrical portion is placed. The latter is magnetized with alternately positive and negative polarities in the same step as the pinions of the stator.

In accordance with a basic characteristic of the U.S. patent above referred to, the magnetization is radial, the flux being substantially perpendicular to said cylindrical portion, and the thickness of the latter is such that the ratio x of the product $H_c \cdot L$ of the coercive field through said thickness to the product $B_r \cdot e$ of the remanent induction through the dimension of the gap is substantially less than one, preferably at least equal to 0.1.

In the U.S. patent above referred to, it was explained that this use of a magnetically hard "thin layer" makes it possible considerably to reduce the residual torque C_0 of the motor in the absence of current, without thereby notably reducing the torque C_1 due to the current. This residual torque is usually considerable in this kind of polarized motor wherein the flux of the magnet traverses the coil and, reciprocally, the flux due to the current traverses the magnet. The result is that it is usually very difficult to make these motors work step by step when only a very small number of ampere-turns is available. The U.S. Pat. above referred to describes, not only means of reducing C_0 (the chief of which is the use of the "thin layer") but also means of superimposing on this inevitable natural residual torque, an artificial "at rest" torque with a component C_{02} at a frequency double that of C_1 and, in the important case where it is desired to operate the motor by means of current impulses with a constant signal, a component C_{01} at the frequency of the current, these two components having to have a clearly defined phase in relation to that of C_1 .

The present invention offers a further means of improving the step by step working of a motor of this kind and of increasing its output.

In accordance with the invention, the polar piece of the stator which carries the inside pinion is carried at the end of a tube made of soft magnetic material, and this tube is fitted telescopically inside another tube made of soft magnetic material which constitutes the core of the coil. In accordance with a preferred method of embodiment, the other polar piece of the stator does not comprise any pinion and consists of a smooth ring made of magnetically soft material fitted on a base, also made of magnetically soft material, on which said core is itself fitted.

Other peculiarities, as well as the advantages of the invention, will emerge clearly from the following description. In the attached drawings:

FIG. 1 is a half-section along the line I—I in FIG. 2 of a micro-motor in accordance with a preferred mode of embodiment of the invention, shown in the drawing on a greatly enlarged scale.

FIG. 2 is a half-section along the line II—II in FIG. 1.

FIG. 3 is a half-section along the line III—III in FIG. 1.

FIG. 1 shows that this motor comprises a coil 1 connected to a feed conductor 2 which traverses its base 3. On the latter are fitted, on the one hand a tube 4 which constitutes the core of the coil, and on the other hand a ring 5 with a smooth inside wall, terminated at the top by a bearing support 5a and not comprising any pinion.

A second tube 6 is fitted on a polar piece 7 which carries a pinion 7a (also shown in FIG. 3). The assembly is done in the following manner:

The unit 6-7 on the one hand, and the unit 3-4 on the other hand, are first annealed separately at high temperature, which practically welds the assembled parts.

Then, the two tubes 6-4 are slipped one into the other, with a play of about 10 microns. This assembly makes it possible to orient them perfectly perpendicularly to the base. The magnetic joint formed has a large surface.

The bell 9 which constitutes the rotor is integral with a shaft 10.

Moreover, in accordance with the technique described in the copending U.S. patent application filed in the names of Georges Stcherbatcheff and Claude Oudet on May 12, 1972 for: "Method and devices for adapting a monophasic synchronous motor to step by step working," artificial "at rest" torques have been devised by means of a polarized system which has no effect on the magnetic circuit of the part of the motor just described.

This polarized system is made up of a permanent magnet 11 and a toothed wheel 12.

The magnet 11 is fixed inside the ring 5, above the bell 9, and it comprises poles, represented by thickened lines (such as 11a) in FIG. 2.

These poles are equal in number to the teeth of the pinion 7 and alternately positive and negative.

The wheel 12, made of soft magnetic material, is wedged at the top end of the shaft 10 above the bell 9.

FIG. 2 shows that the teeth 12a which it comprises are equal in number to the poles of the magnet 11 (i.e.: 8 in the non-limiting example described).

It is clear that this polarized system is identical to that which has been shown in unbroken lines in FIGS. 1 and 2 of the above-mentioned patent application (magnet 3 cooperating with the toothed wheel 2).

The law of torque thus takes the form illustrated in FIG. 3 of said application, with the advantages which have been explained therein.

It goes without saying that various modifications of detail may be made to the motor described, without departing from the spirit of the invention.

In the present text, as well as in the attached claims, H_c is expressed in Oersted units and B_r in Gauss units.

I claim:

1. Micro-motor of the type comprising a rotor with a cylindrical portion made of hard magnetic material and a stator comprising two polar pieces respectively polarized positively and negatively by the current which flows in a coil, these polarized pieces defining an air gap in which said cylindrical portion is placed and

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one at least of these two polar pieces is fitted with a set of substantially equispaced salient stator poles, said cylindrical portion being magnetized radially and being of such thickness that the ratio x of the product $H_c L$, H_c being the coercive field of said hard magnetic material and L the value of said thickness, to the product $B_r e$, B_r being the remanent induction and e the dimension of the said air gap, is substantially below unity, characterized by the fact that the polar piece of the stator which carries the said set of stator poles is carried at the end of a tube made of soft magnetic material, this tube being fitted telescopically inside a further tube made of soft magnetic material which constitutes the core of the coil.

2. Micro-motor in accordance with claim 1, further comprising a base on which said core is fixedly mounted, the said tube forming a magnetic joint with

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the said set of stator poles and the said core forming a further magnetic joint with the said base, the said magnetic joints being of the type having a negligibly small reluctance resulting from annealing at high temperature.

3. Micro-motor in accordance with claim 1, characterized by a polarized system consisting of an annular permanent magnet fixed above said cylindrical portion and by a toothed wheel made of soft magnetic material wedged on the shaft of the rotor, facing said magnet which encircles it.

4. Micro-motor in accordance with claim 3, characterized in that said magnet comprises alternate poles equal in number to the number of teeth on said wheel and to the number of stator poles of the said set.

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