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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.

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(54) Title: VIBRATOR DAMPING

(57) Abstract: The invention relates to a vibrator of the variable-reluctance type for generating vibrations in a bone anchored hearing aid, i.e. a hearing aid of the typein which the sound information is mechanically transmitted via the skull bone directly to the inner ear of a person with impaired hearing. The vibrator comprises in the known way a vibrator plate (4) and a bobbin base (3) with a vibrator gap (7) therebetween. Said vibrator gap (7) between the vibrator plate (4) and the bobbin base (3), or some other spacing in the vibrator where a relative movement between two surfaces is generated during the vibratory function, is at least partially filled with a fluid or gel (6) for providing the main part of the damping of the resonance frequency of the vibrator. Preferably, the fluid or gel (6) comprises ferro-magnetic particles, a so-called ferro-fluid, in order to keep the fluid in place and increase the magnetic conductivity in the magnetic circuit.

A vibrator for generating vibrations in a bone-anchored hearing aid apparatus.

The present invention relates to a vibrator of the variable-reluctance type for generating vibrations in a bone anchored hearing aid, i e a hearing aid of the type in which the sound information is mechanically transmitted via the skull bone directly to the inner ear of a person with impaired hearing. The vibrator can be used for conventional, bone anchored as well as implantable bone conducting hearing aids.

For persons with impaired hearing, the hearing aid devices which are most commonly used today are those based on the principle that the sound is amplified and fed into the auditory meatus and stimulates the eardrum from the outside. In order to prevent acoustic feedback problems in these devices, the auditory meatus is almost completely plugged by a hearing plug or by the hearing aid device itself. This causes the user a feeling of pressure, discomfort, and sometimes even eczema. In some cases it even causes the user problems like running ears due to chronic ear inflammations or infections in the auditory canal.

However, there are other types of sound transmitting hearing aids on the market, i e bone anchored hearing aids which mechanically transmit the sound information to a persons inner ear via the skull bone by means of a vibrator. The hearing aid device is connected to an implanted titanium screw installed in the bone behind the external ear and the sound is transmitted via the skull bone to the cochlea (inner ear), i e the hearing aid works irrespective of a disease in the middle ear or not. The bone anchoring principle means that the skin is penetrated which makes the vibratory transmission very efficient.

This type of hearing aid device has been a revolution for the rehabilitation of patients with certain types of impaired hearing. It is very convenient for the patient and

almost invisible with normal hair styles. It can easily be connected to the implanted titanium fixture by means of a bayonet coupling or a snap in coupling. One example of this type of hearing aid device is described in US Patent No. 4,498,461 and it is also referred to the BAHA® bone anchored hearing aid marketed by Entific Medical Systems in Göteborg.

Other types of bone conducting hearing aids are described in US Patent 4,904,233 and our Swedish patent application 0002071-9.

A common feature for the hearing aid devices which have been described so far is that some type of vibratory generating means, vibrators, are required. Different types of vibrators are well known in the art. There are a number of known vibrator principles today. In traditional as well as in bone anchored hearing aid devices it is normally used a vibrator principle which was described already by Bell in 1876. There is a detailed description of this principle applied on a bone anchored, bone conducting hearing aid device in "On Direct Bone Conduction Hearing Devices", Technical Report No. 195, Department of Applied Electronics, Chalmers University of Technology, 1990. Other vibrators of this type are described in our Swedish patent applications 0002072-7 and 0002073-5.

In order to reduce the risk for acoustic feed back problems in the hearing aid it is necessary to damp the resonance frequency of the vibrator. In this context it is referred to Swedish Patent No. 85.02426-3 in which it is illustrated a vibrator comprising a vibrator plate and a coil which is wound around a bobbin base having a core and two side walls. It also comprises means for damping the resonance frequency of the vibrator in the form of a spring provided with a layer of damping material or a built-in damping material.

It has turned out that this type of vibrator with a damping spring not always gives an optimal function of the hearing aid. The damping spring is a mechanically complicated and exposed part in the hearing aid.

It is an object of the present invention to provide a vibrator device having a more rugged damping system and having only a few mechanically sensitive parts. According to the invention the vibrator comprises at least one gap or spacing in which a relative movement between two surfaces is generated during the vibratory function and which gap or spacing at least partially is filled with a fluid or gel for providing the main part of the damping of the resonance frequency of the vibrator.

According to a preferred embodiment said fluid or gel is arranged in the vibrator gap between the vibrator plate and the bobbin base.

According to a further preferred embodiment the fluid comprises ferro-magnetic particles, forming a so-called ferro-fluid.

In the following the invention will be described more in detail with reference to the accompanying drawing which illustrates a cross-sectional view of a preferred embodiment of the vibrator.

The figure shows a cross-section through the centre axis of a vibrator 1 of the variable-reluctance type. The vibrator comprises a coil 2 which in the known way is wound around a bobbin base 3 having a core 3a and two side walls 3c, 3d. In the two side walls there are two annular permanent magnets 8 arranged. The entire coil and magnet arrangement is housed in a casing 1a which forms a part of the magnetic circuit and protects the vibrator and reduces magnetic leakage. The bobbin base and the casing are made of a material with high magnetic conductivity. The vibra-

tor further comprises a vibrator plate 4 attached to a spring 5 which spring in turn is attached to the casing of the vibrator. In order to damp the resonance frequency of the vibrator, the gap 7 between the vibrator plate 4 and the upper part of the bobbin base, in this case the end surface of the core of the bobbin core 3a, is filled with a fluid or gel 6.

Through its viscosity and capillary properties the fluid 6 has the ability to damp the resonance frequency of the vibrator and thereby reduce the risk for acoustic feed back problems in the hearing aid. In order to keep the fluid in place, but also in order to increase the magnetic conductivity of the magnetic circuit, the fluid is preferably a so-called ferro-fluid, which fluid in addition to the fluid itself (oil, hydraulic oil) comprises small ferro-magnetic particles to make the fluid magnetic conductive.

If the vibrator 1 is squeezed together and if the surfaces of the vibrator plate and the bobbin base which then are pressed against each other are adapted to each other, for instance if the surfaces are plane and smooth, there is a risk that the ferro-magnetic particles are crashed by the pressure. Therefore it could be an advantage to provide the surfaces with certain irregularities so that the ferro-magnetic particles in the fluid could be transported to areas where they are not exposed to such pressure. These irregularities could for instance be designed as circular grooves, holes, cavities, bosses or the like while the contact surfaces otherwise are plane and smooth.

In the example illustrated here the fluid or gel 6 is schematically illustrated in the gap between the vibrator plate 4 and the bobbin base 3, which gap or spacing is exposed to the magnetic field. It should be understood, however, that the fluid or gel could be disposed in another gap or spacing in the vibrator where there is a relative movement between two surfaces during the vibratory func-

tion but without the magnetic field, for instance on that part of the vibrator plate which is faced away from the bobbin base. This location is symbolically illustrated by reference numeral 6´ in the figure.

As an alternative the fluid or gel could be disposed in a gap where there is a relative side movement between two surfaces when the vibrator is working, for instance on the outer edge of the vibrator plate. This is symbolically illustrated by reference numeral 6´´ in the figure.

CLAIMS

1. Vibrator of the variable-reluctance type for generating vibrations in a bone anchored hearing aid, i e a hearing aid of the type in which the sound information is mechanically transmitted via the skull bone directly to the inner ear of a person with impaired hearing and which comprises a vibrator plate (4) and a bobbin base (3) c h a r a c t e r i z e d i n that the vibrator comprises at least one gap or spacing in which a relative movement between two surfaces is generated during the vibratory function and which gap or spacing at least partially is filled with a fluid or gel (6) for providing the main part of the damping of the resonance frequency of the vibrator.

2. Vibrator according to claim 1 c h a r a c t e r i z e d i n that said fluid or gel (6) is arranged in the spacing between the vibrator plate (4) and other parts of the vibrator.

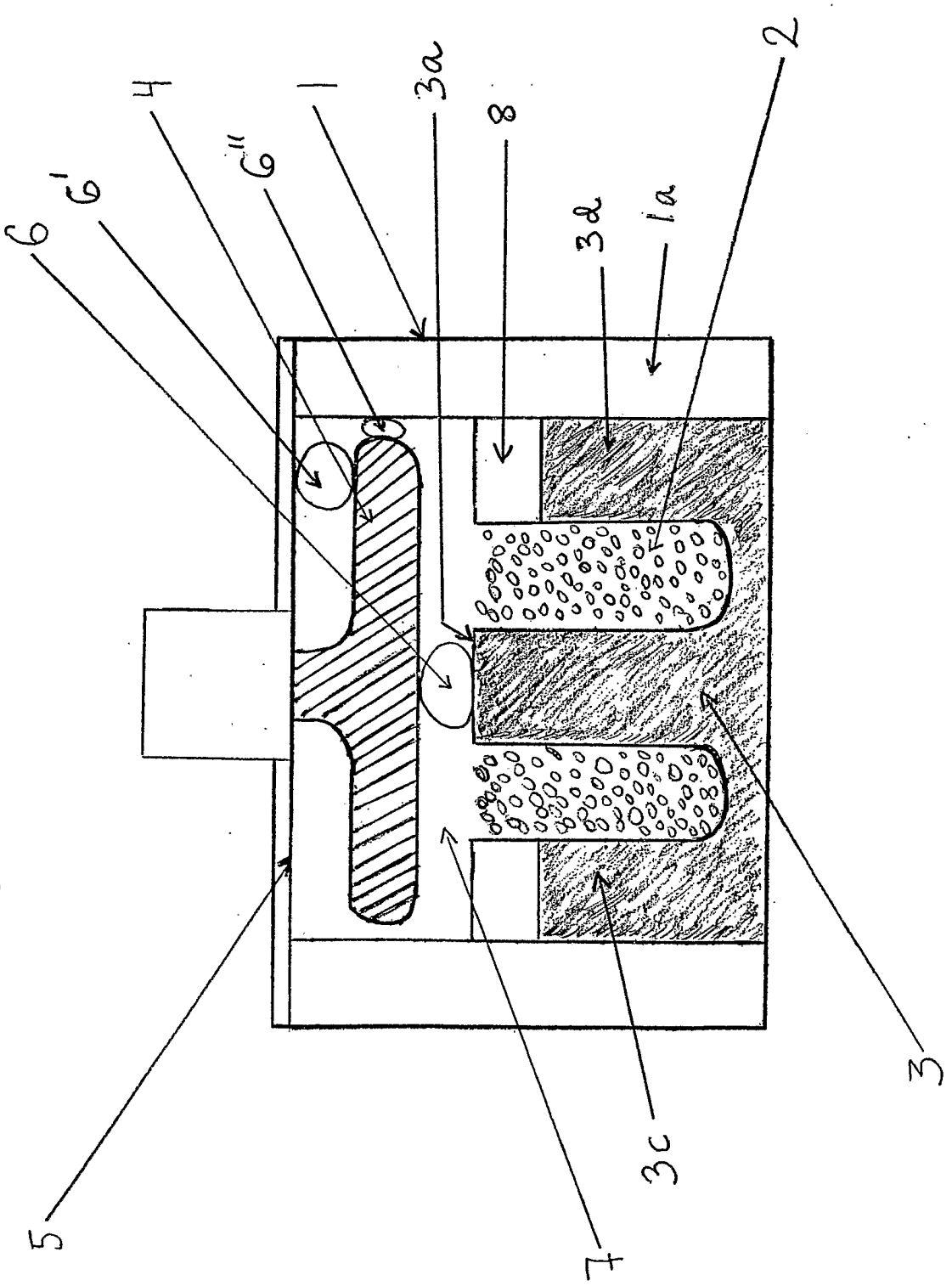
3. Vibrator according to claim 2 c h a r a c t e r i z e d i n that said fluid or gel (6) is arranged in the vibrator gap (7) between the vibrator plate (4) and the bobbin base (3).

4. Vibrator according to claim 2 c h a r a c t e r i z e d i n that said fluid or gel (6) is arranged in the spacing between the vibrator plate (4) and the casing (1a) of the vibrator.

5. Vibrator according to claim 4 c h a r a c t e r i z e d i n that said fluid or gel (6) is arranged in the gap between the outer edge (4a) of the vibrator plate and the casing (1a), in which gap there is a relative side movement between the vibrator plate (4) and the casing (1a) when the vibrator is working.

6. Vibrator according to claim 1 c h a r a c t e r i z e d i n that said fluid or gel (6) comprises ferro-magnetic particles, forming a so-called ferro-fluid.

7. Vibrator according to claim 6 c h a r a c t e r i z e d i n that the contact surfaces of the vibrator gap (7) are provided with cavities, holes or the like where the ferro-fluid particles can be collected when the contact surfaces are squeezed together in the vibrator gap.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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/01087

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04R 25/00 // B60B 1/04
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)

IPC7: H04R, B60B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4123675 A (R. MOSKOWITZ ET AL), 31 October 1978 (31.10.78), column 1, line 46 - line 49	1
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A	US 4414437 A (H TRAUERNICHT ET AL), 8 November 1983 (08.11.83), column 1, line 67	1,6
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X	US 4654554 A (K. KISHI), 31 March 1987 (31.03.87), column 2, line 66 - column 3, line 5	1,2,4,6
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X	US 5255328 A (Y. AKINIWA ET AL), 19 October 1993 (19.10.93), column 2, line 65 - column 3, line 5	1,2,4,6
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 Sept 2002	01 -10- 2002
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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