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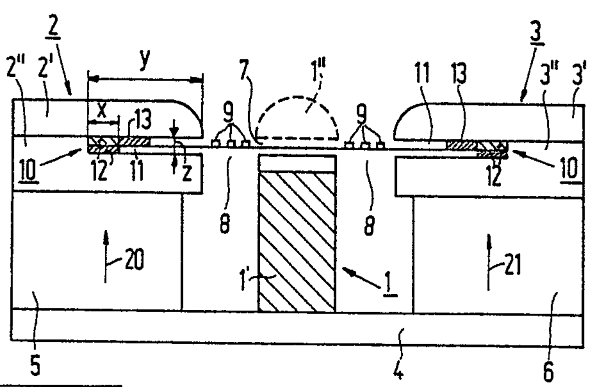
(54) Electrodynamic transducer.

(57) The conductor (9) on the diaphragm (7) of an electrodynamic transducer of the ribbon type is made of a copper-silver alloy, the silver content being between 0.01% and 0.5% by weight.



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"Electrodynamic transducer"

The invention relates to an electrodynamic transducer comprising a magnet system having a first pole and a second pole forming an air gap, and a diaphragm arranged in the air gap, on which diaphragm a conductor is arranged. Such a transducer is known from the published Netherlands Patent Application 79,03,908 which has been laid open to public inspection. The transducer disclosed in said Application is a transducer of the ribbon type, whose voice coil is constituted by the conductor on the diaphragm. A drawback of the known transducer is that its life is limited because the conductor on the diaphragm will break in the course of time.

It is the object of the invention to provide a transducer in which the conductor on the diaphragm is less susceptible to breakage, enabling the life of the transducer to be extended.

To this end the electrodynamic transducer in accordance with the invention is characterized in that the conductor is made of a copper-silver alloy, the silver content being between 0.01% and 0.5% by weight.

The inventive step is based on the recognition of the following fact. The conductor in the known transducer is obtained by applying a photo-etching process to an alumination-plastics laminate. In order to obtain a maximum sensitivity the aluminium material used for the conductor is of a maximum purity. The maximum permissible electric power for the known transducer is first of all determined by the maximum permissible temperature. For example, if the diaphragm is made of the material polyimide temperatures up to approximately 400°C are permissible.

However, for the aluminium conductor this temperature gives rise to problems. It is known that the recrystallisation temperature of pure aluminium lies between 150°C and 200°C. In this range the tensile strength of aluminium is substantially zero.

When the electrical load applied to the voice coil is high the temperature rises considerably. The aluminium track pattern of the conductor then expands in the longitudinal direction, causing the diaphragm to become wrinkled in the stationary condition. In the event of a fluctuating (high) electrical load the voice coil, and hence the diaphragm, is continually wrinkled and smoothed. This results in a higher distortion in the acoustic output signal of the transducer. Moreover, in the long run this gives rise to fatigue effects, finally causing breakage in the conductor tracks.

Apparently, the maximum permissible power for a specific life expectancy is substantially lower than can be anticipated only on the basis of the thermal properties of the polyimide material.

It is true that by the addition of other metals to aluminium the recrystallisation temperature can be raised substantially, but this results in an excessive reduction of the conductivity, which is at the expense of the sensitivity.

In accordance with the invention it is proposed to use a different material for the conductor, so that a substantially higher permissible electrical load can be achieved and a longer life can be obtained, whilst the distortion in the output signal of the transducer can be reduced significantly.

Pure copper has a recrystallisation temperature which lies at approximately 150°C. By the addition of small amounts of silver, however, the recrystallisation temperature increases. An addition of the order of from 0.01% by weight of silver, yields a significant rise in recrystallisation temperature, which already lies above the recrystallisation temperature of aluminium. As long as the addition does not exceed 0.5%, adding silver to the copper hardly effects the conductivity. Therefore the value of 0.5% should be regarded as an upper limit, because a higher value results in a (no longer acceptable) reduction in conductivity.

Now a conductor material is obtained which is far better capable of withstanding the high temperatures occurring during use of an electrodynamic transducer without its correct operation being adversely affected. Preferably, the silver content is selected to be between 0.025% and 0.25% by weight. In this range a recrystallisation temperature is obtained which already lies above 260°C, whilst for example in the case of 0.1% by weight of silver this temperature already lies at approximately 330°C, the specific resistance still being low (substantially equal to that of pure copper).

An additional advantage of a substantially higher recrystallisation temperature is that the coefficient of linear expansion of the material and, similarly, the temperature coefficient of the electrical resistance is smaller. This means that (substantially) no wrinkling of the diaphragm will arise. Moreover, a possible loss of sensitivity as a result of the higher specific mass of the silver-copper alloy relative to that of aluminium will be compensated for by a reduced compression. (In this respect "compression" is to be understood to mean: doubling the input voltage causes the output power to rise by less than 6 dB.)

The behaviour of copper alloys, in particular alloys of copper and silver, is described in "Kupfer und Kupferlegierungen in der Technik" by Kurt Dies, Springer Verlag 1967, see in particular Chapter 5.1.

An embodiment of the invention will now be described in more detail, by way of example, with reference to the sole Figure. The Figure shows an embodiment of the electrodynamic transducer in accordance with the invention.

Figure 1 is a sectional view of an electrodynamic transducer in accordance with the invention. The construction of the magnet systems corresponds to the construction of the magnet system of the transducer known from Netherlands Patent Application 81,02,572 (PHN 10,062) which has been laid open to public inspection. The transducer may be of circular or rectangular shape. In the latter case the Figure is a sectional view of the transducer taken perpendicularly to the longitudinal direction of the conductors in an air gap. The magnet system of the transducer comprises a first pole in the form of a pole plate 2, 3 comprising two plate-shaped parts 2′, 2″ and 3′, 3″, a second pole in the form of a centre pole 1, a closing plate 4, and the parts 5 and 6. The magnetic field in the magnet system can be obtained by constructing the parts 5 and 6 as permanent magnets. The direction of magnetisation is indicated by the arrows 20 and 21. However, the direction of magnetisation may also be reversed. The other parts of the magnet system are made of a soft-magnetic material, for example soft-iron.

If the transducer is of the circular type 5, 6 represents a sectional view of an annular magnet. In the rectangular version 5 and 6 are cross-sections of two bar magnets which extend parallel to one another. It is also possible to make the parts 5 and 6 of a soft-magnetic material and to construct the centre pole, at least its hatched portion 1′, as a permanent magnet.

In the circular version an air gap 8 is formed between the pole plate 2, 3 and the centre pole 1. The air gap 8 and the pole plate 2, 3 are then annular. In the rectangular version air gaps 8 are formed between the pole plate 2 and the centre pole 1 and between the pole plate 3 and the centre pole 1, which air gaps, like the pole plates 2 and 3, extend parallel to one another. In the air gap (gaps) 8 a diaphragm 7 is arranged, on which at least one conductor 9 is arranged, which extends over the diaphragm surface in a direction perpendicular to the plane of drawing. The Figure shows either three conductors which extend over the diaphragm surface parallel to each other in an air gap, or one conductor which extends over the diaphragm surface in three spiral turns around the centre pole. The conductors are connected to an audio amplifier (not shown) in such a way that the signal currents in the conductor(s) 9 between the pole plate 2 and the centre pole 1 are directed perpendicularly to the plane of drawing and the signal currents in the conductor(s) 9 between the pole plate 3 and the centre pole 1 flow in exactly opposite direction. Since the magnetic field in the air gap 8 between the upper plate 2 and the centre pole 1 extends in or parallel to the plane of the diaphragm and is directed oppositely to the magnetic field in the air gap 8 between the pole plate 3 and the centre pole 1, the diaphragm has an excursion which is substantially in phase over the entire surface area. Therefore, this transducer is referred to as an isophase transducer, or more specifically: a ribbon loudspeaker.

The pole plate (plates) 2, 3 (each) comprise two plate-shaped parts 2′, 3′ and 2″, 3″. The two plate-shaped parts 2′, 3′ and 2″, 3″ adjoin each other over a part of their facing major surfaces, which major surfaces extend substantially in and parallel to the diaphragm plane. Another portion of said major surface of one or both plate-shaped parts (one of the parts in the Figure) recede(s) slightly, as is indicated by the reference numeral 10, so that a space 11 is obtained. The diaphragm 7 is now arranged between the plate-shaped parts 2′, 3′ and 2″, 3″ in such a way that a peripheral portion of the diaphragm situated in said space(s) 11. The diaphragm 7 may be clamped for example on or in a frame 12 which is secured between the two plate-shaped parts. However, alternatively the diaphragm may be clamped between the parts 2′, 2″ and 3′, 3″. The width $\underline{x}$ of the frame 12 is smaller than the width $\underline{y}$ of the space 11. Moreover, the height $\underline{z}$ of the space 11 is such that the movable portion of the periphery of the diaphragm 7, which is situated in the space 11, can move freely and cannot contact the pole plate (plates) 2, 3.

Instead of making at least one of the major surfaces recede, the space 11 between the plate-shaped parts can also be realised by interposing, for example, a plate of a soft-magnetic material between the two facing major surfaces. The thickness of plate of soft-magnetic material must then correspond to the height $\underline{z}$ of the space 11.

Further, a damping material (not shown) may be arranged in the spaces 11 underneath and/or above the diaphragm, which material comes in mechanical contact with the diaphragm. This damping material damps the higher natural resonances in the diaphragm (i.e. free vibrations of the diaphragm in a resonant pattern corresponding to the resonant frequency of the diaphragm in response to the drive of the diaphragm), which yields an improvement of the transducer output signal, which then exhibits less distortion.

Preferably, the centre pole 1 also extends to the other side of the diaphragm. The part 1″ at this side of the diaphragm is indicated by a dashed line. The part of the diaphragm which is situated between the two parts 1 and 1″ of the centre pole is freely movable. The part 1″ is retained in the indicated position by a support, not shown. For an improved impedance matching of the medium into which the transducer radiates its acoustic signals the end faces of the parts 1", 2' and 3' which face the air gap 8 are rounded. This means that in a direction perpendicular to the plane of the diaphragm these end faces diverge increasingly as the distance from the diaphragm increases, so that a horn-like radiation aperture is obtained.

The conductor(s) 9 is (are) made of a copper-silver alloy, the silver content being between 0.01% and 0.5% by weight. Preferably, the silver content is between 0.025% and 0.25% by weight. In particular a silver content of approximately 0.1% by weight yields very satisfactory results as regards the thermal and mechanical loadability of the transducer.

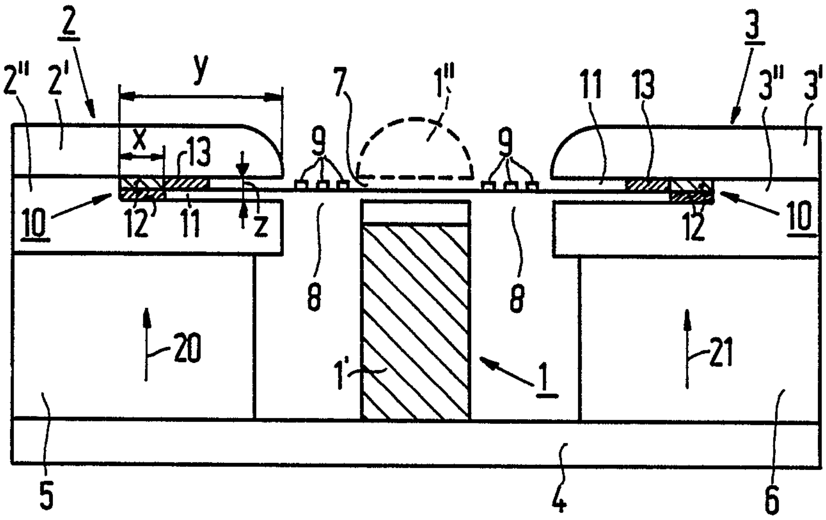
In this respect it is to be noted that the inventive step is not limited to the embodiment shown. The invention also applies to those embodiments which differ from the embodiment shown in respects which are irrelevant to the invention. For example, the invention may also be applied to a transducer described in the Applicant's Netherlands Patent Application 85,01,166 (PHN 11,359), which has been laid open to public inspection.

Claims

1. An electrodynamic transducer comprising a magnet system having a first pole and a second pole forming an air gap, and a diaphragm arranged in the air gap, on which diaphragm a conductor is arranged, characterized in that the conductor is made of a copper-silver alloy, the silver content being between 0.01% and 0.5% by weight.

2. An electrodynamic transducer as claimed in Claim 1, characterized in that the silver content is between 0.025% and 0.25% by weight.

3. An electrodynamic transducer as claimed in Claim 2, characterized in that the silver content is approximately 0.1% by weight.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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 20 0476

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	GB-A-2 029 162 (SONY) * Page 6, lines 13-23; claim 1; figures * ---	1-3	H 04 R 9/04 H 04 R 9/00
Y	PATENT ABSTRACTS OF JAPAN, vol. 6, no. 40 (C-94)[918], 12th March 1982; & JP-A-56 156 732 (FURUKAWA DENKI KOGYO K.K.) 03-12-1981 * Abstract * ---	1-3	
Y	PATENT ABSTRACTS OF JAPAN, vol. 6, no. 250 (C-139)[1128]; & JP-A-57 145 954 (FURUKAWA DENKI KOGYO K.K.) 09-09-1982 * Abstract * -----	1-3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			H 04 R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09-06-1988	MINNOYE G.W.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document