PATENT SPECIFICATION (11) 1 559 227

1 559 227

(21) Application No. 41919/77 (22) Filed 7 Oct. 1977 (19)

(31) Convention Application No. 2 646 389

(32) Filed 14 Oct. 1976 in

(33) Fed. Rep. of Germany (DE)

(44) Complete Specification published 16 Jan. 1980

(51) INT. CL.^{3} H04R 17/00

(52) Index at acceptance

H4J 30M 31J EA

(54) PIEZO-ELECTRIC TRANSDUCERS

(71) We, INTERATOM, INTERNATIONALE ATOMREAKTORBAU G.m.b.H., a German company of Bergisch-Gladbach, Germany (Fed. Rep.), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to piezo-electric transducers.

Some ceramic substances, for example lithium niobate, exhibit piezo-electric properties in the same way as quartz crystals, that is variations in charge are produced along an electric axis when they are subjected to stress in the direction of a mechanical axis, or conversely they react mechanically to variations in electric charge by expanding or contracting. An advantage of such materials, e.g. lithium niobate, over the other known piezo-electric materials is stability at high temperature, when certain conditions are maintained, as will hereinafter be explained.

More particularly lithium niobate can be used to construct instruments of small dimensions which have high sensitivity. Also, its transmission characteristic extends to frequencies sufficiently high to make it particularly suitable for use in electroacoustic transducers, with the aid of which noises due to disturbances such as, for example, vibrations due to boiling in liquid-metal-cooled nuclear energy plants, can be detected. Such "boiling noises" are to be expected primarily in the early stages of disturbances in operation, and in the higher frequency range they contrast more clearly with the background noise emanating from pumps, etc.

However, liquid-metal cooled nuclear reactors are operated at temperatures of the order of 900 K, and it is found that lithium niobate is decomposed by reduction at such temperatures if the ambient oxygen partial pressure is lower than that in the ceramic material itself. In order to deal with this problem it has already been proposed to dispose the lithium niobate in closed steel capsules having introduced additional oxygen-emitting materials, for example nickel oxide, into the steel capsules to compensate for the absorption of oxygen by the steel (see J. Bishop/G. H. Broomfield/J. Foley: "High-temperature Acoustic Transducers for use in LMFBR", IAEA Specialist Meeting on In-Core and Primary Circuit Instrumentation of LMFBR's, December, 1975). However, this process has not been as succesful as anticipated. An alternative method of maintaining the necessary oxygen partial pressure is to feed air or pure oxygen to the capsule from the outside. However, this method is unsuitable for use in liquid metal-cooled reactors since the liquid metal has a high chemical affinity for oxygen, and this may result in problems with respect to the maintenance of the necessary oxygen ducts.

According to the present invention, there is provided an electroacoustic transducer comprising a ceramic piezo-electric transducing member sealed in an envelope which, at a temperature at which the ceramic material of the transducing member would decompose in the absence of ambient oxygen, is substantially impermeable to and substantially non-absorbent of oxygen, the transducer being such that partial pressure of oxygen in the envelope prevents decomposition of the ceramic material at the said temperature.

The envelope may be made of an electrically conductive material, so that it can at the same time provide an electrical connection to the piezo-electric ceramic transducing member. A preferred group of metals, from which may be chosen a material of the envelope is the noble metals. The envelope, then, is preferably made from a noble metal in the form of thin sheeting. In addition to good electrical conductivity such metals possess sufficient resistance to radiation for use in nuclear reactors, and good reistance to corrosion.

When operating temperatures of up to 950 K are to be expected, a recommended material for the envelope, which is to be substantially impermeable to and substantially non-absorbent of oxygen at such elevated temperatures, is sheet platinum. Owing to its relatively low melting point, gold is less suitable for this purpose, and rhodium is somewhat difficult to process.

The envelope will not generally be in tight overall contact with the piezo-electric transducing member because, as will hereinafter be explained, the envelope will generally be provided with ducts for electric conductors to pass in and out. Any voids accordingly present in the envelope may be filled with oxygen, so that the lithium niobate is doubly protected from decomposition.

The transducer may comprise two ceramic piezo-electric transducing members arranged so that their respective electrical polarities, when the transducer is in use, are oppositely directed, separated from one another by a metal foil sandwiched between the two said members which foil is preferably made from the same material as the envelope and is used as an electrode. The difference of electric potential which is set up across the transducing members owing to the action of mechanical vibrations can thus be picked up between two electrodes constituted respectively by the envelope and the foil between the two members. A conductor insulated from the envelope can be led therethrough from the foil, to the outside. The envelope may consist of two halves which are conductively connected together by soldering for example.

The electroacoustic transducer may be provided with a sound-transmitting diaphragm for receiving or emitting sound, the or each piezo-electric ceramic transducing member contained in its envelope being pressed against the diaphragm by means of a stressed spring in the transducer, so that a satisfactory transfer of vibrations from the diaphragm to the or each transducing member is provided.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing in which:—

Figure 1 shows an axial section, through an electroacoustic transducer, in a plane corresponding to line B—B of Figure 2,

Figure 2 shows a cross-section taken on line A—A of Figure 1, and

Figure 3 shows a plan view of a portion of the transducer of Figures 1 and 2, partly in section along line C—C of Figure 2.

A transducing unit consists of two transducing members 1 and 2, of lithium niobate ($LiNbO_3$), between which there is sandwiched a noble metal foil 3 forming one of two electrodes of the transducer. The transducing unit is sealed in an envelope 4, also consisting of noble metal, formed from two shells hard-soldered together and in tight contact with the greater part of the outer surface of the unit comprising the members 1 and 2, and serving as a second electrode. Current is supplied to this electrode by means of a metallic housing 9, which is made of material chosen so as to meet the requirements with regard to resistance to corrosive attack by the medium in which it is employed. The envelope 4 includes a duct 6 with a "metal-ceramic" stopper 5, fabricated, for example, by powder metallurgy techniques, by means of which a supply conductor 15 is led to the first electrode 3 while being electrically insulated from the envelope 4. The envelope has another duct 7 by means of which (in a manner not shown here) its interior can be evacuated and thereafter filled with oxygen. The duct 7 is then sealed by fusion.

Separated from the main part of the housing 9 by thin-walled portions 8 is a thickened portion 10 in the form of a diaphragm which, when subjected to sonic and ultrasonic vibrations, mechanically loads the lithium niobate members 1 and 2 by way of the interposed envelope 4 and thereby produces piezoelectric effects in the lithium niobate. The mechanical coupling between these parts is improved by means of a plunger 11 which presses together the members 1 and 2 and thereby presses both against the diaphragm 10. The plunger 11 is loaded by a spring 12 comprising a material resistant to high temperature, for example a nickel - chromium - cobalt alloy. The strength of the pressing force can be adapted to requirements by means of a screw-threaded plug 13 which serves as an abutment for the spring 12 and which can be screwed to a variable depth into the housing 9.

The housing 9 is secured at one end to a tubular handle 14 (not shown completely) through which an electric conductor 15 extends, and by means of which the transducer can be brought to the place of use, for example for monitoring the flow of coolant in the fuel element of a liquid sodium-cooled nuclear reactor.

WHAT WE CLAIM IS:—

1. An electroacoustic transducer comprising a ceramic piezo-electric transducing member sealed in an envelope which, at a temperature at which the ceramic material of the transducing member would decompose in the absence of ambient oxygen, is substantially impermeable to and substantially non-absorbent of oxygen, the transducer being such that partial pressure of oxygen in the envelope prevents decomposition of the ceramic material at the said temperature.

2. A transducer as claimed in claim 1, wherein material forming part of the said envelope is electrically conductive and provides an electrical connection to the transducing member.

3. A transducer as claimed in claim 1 or 2, wherein the said envelope is made from a noble metal in the form of thin sheeting.

4. A transducer as claimed in claim 3, wherein the said noble metal is platinum.

5. A transducer as claimed in any preceding claim, wherein voids present in the said envelope are filled with oxygen.

6. A transducer as claimed in any preceding claim, further comprising a second such transducing member sealed in the said envelope and arranged adjacent to the transducing member of claim 1 but separated therefrom by a metal foil that is sandwich between the two transducing members to serve as an electrode of the transducer, the arrangement of the two transducing members being such that their respective electrical polarities, when the transducer is in use, are oppositely directed.

7. A transducer as claimed in any preceding claim, having a sound-transmitting diaphragm against which the transducing member of claim 1 is pressed by means of a stressed spring in the transducer.

8. A transducer as claimed in any preceding claim, wherein the or each transducing member is made of lithium niobate.

9. An electroacoustic transducer, substantially as hereinbefore described with reference to Figures 1 to 3 of the accompanying drawing.

HASELTINE, LAKE & CO.,
Chartered Patent Agents,
Hazlitt House,
28, Southampton Buildings,
Chancery Lane,
London WC2A 1AT,
also
Temple Gate House,
Temple Gate,
Bristol BS1 6PT,
and
9, Park Square,
Leeds LS1 2LH,
Yorks.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1980.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

1559227 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

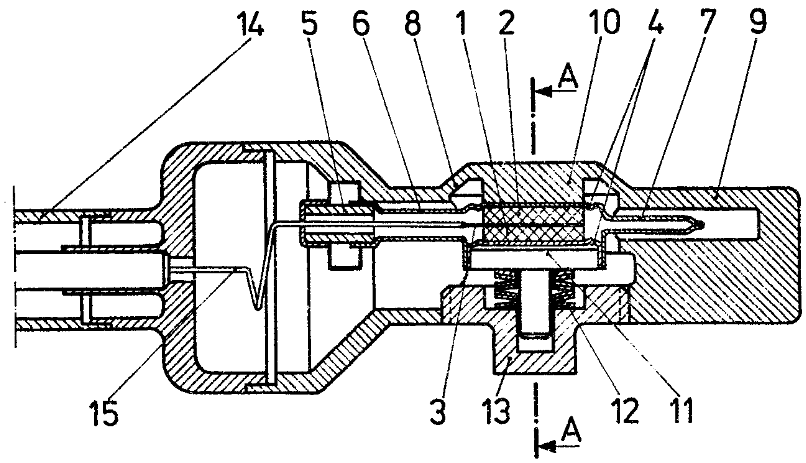

Fig. 1

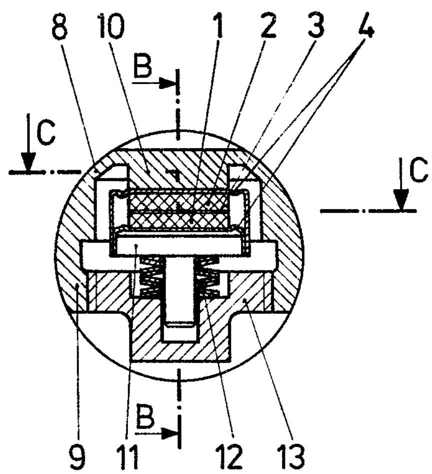

Fig. 2

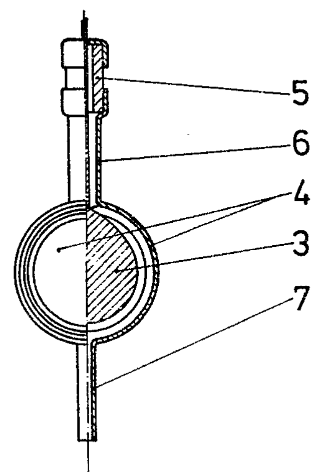

Fig. 3