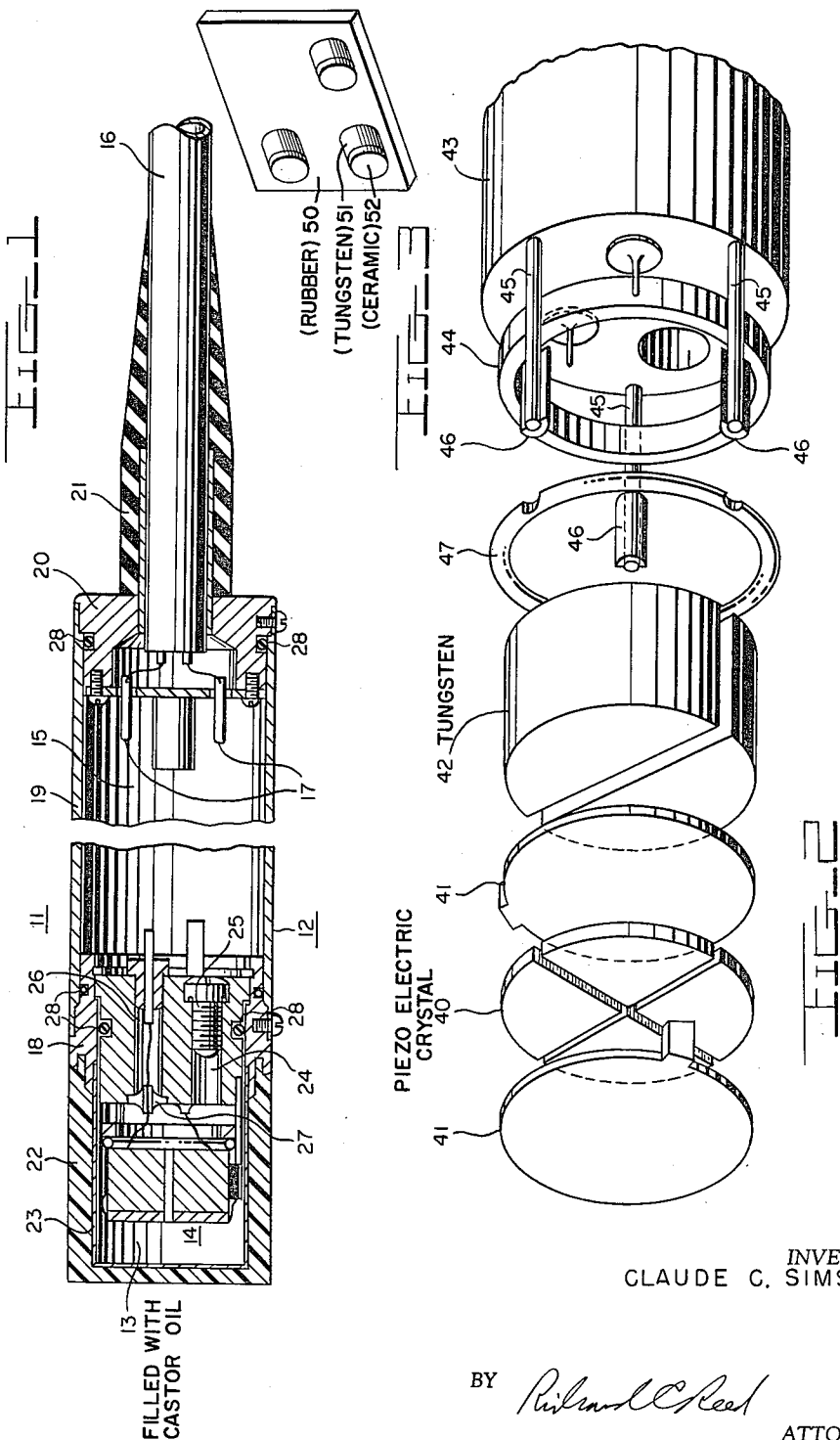


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HIGH PRESSURE PIEZOELECTRIC HYDROPHONE
WITH TUNGSTEN BACKING PLATE
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HIGH PRESSURE PIEZOELECTRIC HYDROPHONE WITH TUNGSTEN BACKING PLATE

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5 Claims. (Cl. 340-10)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to sound transducers. More particularly the invention relates to a broadband calibration hydrophone which employs a piezoelectric crystal motor.

The various methods of mounting piezoelectric crystals may be grouped roughly into three classes, inertia drive, symmetric drive, and clamped drive. The first of these generally requires an air pocket or other compensation device to prevent unbalanced stresses from distorting the crystal at the ambient pressure encountered in undersea work. As the pressure increases, the design of an air pocket or other compensating device becomes increasingly difficult. The symmetric drive systems generally require a preamplifier housing in the plane of the wavefront, so that the distance from the transducer at which free-field calibrations can be made is determined by the size of the preamplifier housing rather than by the smaller size of the transducer itself. The frequency response of this transducer is also sensitive to changes in ambient temperature and pressure which alter the phasing of its components.

The clamped drive crystal transducer in which the crystal of small mass is attached to a more massive backing element provides a very stable structure for use at high pressures. It also makes a satisfactory hydrophone from the standpoint of directivity and broadband stability. Clamped drive presents some unique problems of its own, but they are avoided by following the teachings of the present invention.

An object, therefore, of the present invention is to provide a crystal transducer for receiving sound waves in liquids under pressures such as are found thousands of feet under the sea.

A further object of the invention is to provide a novel clamped-drive crystal transducer for underwater use.

These and other objects of the invention will be better understood with reference to the accompanying drawing in which:

FIG. 1 shows a side view of a transducer of the invention in section to disclose inner details;

FIG. 2 shows an exploded view of the clamped crystal assembly of FIG. 1 and its mounting; and

FIG. 3 shows a directional transducer array using a plurality of the clamped crystals made in accordance with the invention.

Referring to FIG. 1, there is shown one form which the present invention may take. The transducer 11 includes a cylindrical housing 12 which has a forward chamber 13 for a crystal assembly 14 and a rear chamber 15 for a preamplifier (not shown). A cable 16 leads from the back of the housing and contains conductors 17 to carry operating voltages from an external power supply (not shown) to the preamplifier, as well as to transmit signals generated by the transducer.

The crystal assembly is best shown in FIG. 2. The crystal is a thin disc 40 of lithium sulfate, although other materials such as Tourmaline, PZT, or barium titanate could have been used. PZT is the common designation of lead

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zirconate titanate. The crystal is cut radially into a plurality of sections.

A layer of gold foil 41 is cemented to each of the broad faces of the crystal sections, which are themselves cemented, and the combined structure is cemented to a tungsten backing plate 42. The tungsten plate is cylindrical and is also radially split and cemented together.

The radial splitting of these elements prevents undesired modes of resonance from occurring during operation of the device. Tungsten is preferred for the backing plate because of its high acoustic impedance compared to water and the crystal. It also has a high density, so that its large mass is easily decoupled from the case. The crystal in the example to be described is one inch in diameter and one-sixteenth of an inch thick. The backing plate is one half an inch thick. The assembly including the crystal and backing plate has a major resonance for the thickness mode of vibration in the vicinity of 800 kc.

The crystal assembly is mounted on a cylindrical forward wall member 43 which forms the end of the preamplifier chamber. For this purpose a metal mounting ring 44 having a diameter substantially equal to that of the crystal assembly is attached to the wall member by means of stiff metal wires 45. The wires extend past the ring to engage the sides of the assembly and to center it on the mounting ring. Rubber mounts 46 and a rubber ring mount 47 are cemented to the wires and mounting ring, respectively, to decouple these elements from the crystal assembly.

The forward wall member 43 is secured in the end of collar 18 secured to the end of a hollow tubular member 19 which forms the side walls of the preamplifier housing. A rear wall member 20 is secured to the opposite end of the tubular member to complete the preamplifier chamber. The rear wall is apertured and provided with a conventional gland assembly 21 to admit the connecting cable.

The wall and tubular members are made from a metal which resists corrosive action of the fluid in which the transducer is to be used, as for example stainless steel.

To avoid galvanic action the same materials should be used for each member. O-ring seals 28 are provided at appropriate points to provide fluid-tight connections.

The remaining walls of the chamber for the crystal assembly are provided by a cylindrical cup-shaped boot 22 fastened to the collar 18. The boot is lined with metal 23 to prevent the fluid penetrating to the crystal chamber and to provide a shield for the crystal. The forward wall member contains an aperture 24 which is used to fill the crystal chamber with an inert fluid such as castor oil. The chamber is then closed by means of a threaded plug 25. Electrical connection between the crystal and the preamplifier chamber is made through additional openings such as aperture 26 which is closed at the crystal chamber end by a dielectric seal 27.

The transducer shows no change in response over the frequency range from 150 kc. to less than 10 c.p.s. as the ambient pressure was varied from 0-1000 p.s.i. The transducer is also very temperature stable, varying less than 0.3 db re 1 V/ μ bar as the temperature varied from 25° C. to 1° C.

FIG. 3 shows another manner in which the invention may be reduced to practice. If desired, the crystal 52 and backing 51 with proper waterproofing (not shown) may be immersed directly in the fluid medium. A number of crystal assemblies may be mounted on a sound pervious support 50 such as rubber, for example, and operated in or out of phase to provide directional arrays. The size of the transducer may be scaled up or down to vary the frequency range. While tungsten is preferred as a backing plate material, useful transducers can also be made with tungsten alloys and some steels.

Obviously many modifications and variations of the

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present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A transducer for converting sound energy over a selected frequency band in a fluid medium to electrical energy comprising a piezoelectric crystal immersed in said fluid medium, said crystal having first and second opposed sound radiating faces, and a tungsten backing plate cemented to the second of said faces, said crystal having a mass equal to a small fraction of the mass of said backing plate.

2. The transducer according to claim 1 wherein said fluid medium is enclosed in a sound conducting housing, said housing having at least one resilient exterior wall in contact with said fluid medium, at least one sound conducting wall opposite said first crystal face, and resilient mounting means supporting said crystal and backing plate within said housing.

3. In combination, a plurality of piezoelectric crystal motors arrayed to produce a directional receiving response pattern, each of said crystal motors having a tungsten

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backing plate, said crystal motors each having a mass equal to a small fraction of the mass of said backing plate and a support structure transparent to sound waves interconnecting said motors.

4. The transducer according to claim 1 wherein said backing plate is split normal to said radiating faces to prevent undesired resonant modes therein.

5. The transducer according to claim 2 wherein said resilient mounting means includes three resilient wires projecting from said housing, a mounting ring supported at an intermediate point on said wires and a resilient material on said ring and the ends of said wires engaging said backing plate.

References Cited in the file of this patent

UNITED STATES PATENTS

2,384,465	Harrison	Sept. 11, 1945
2,430,013	Hansell	Nov. 4, 1947
2,484,626	Keller	Oct. 11, 1949
2,520,938	Klein	Sept. 5, 1950
2,733,423	Camp	Jan. 31, 1956