

FIG. 1A

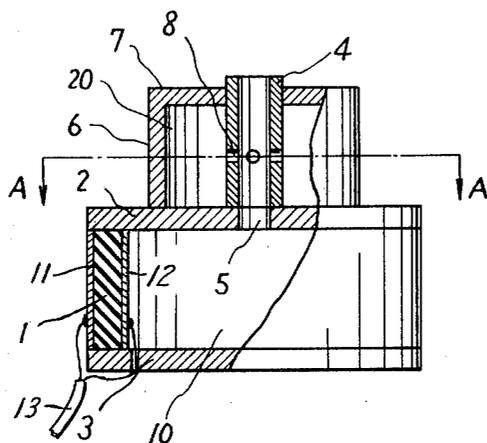


FIG. 1B

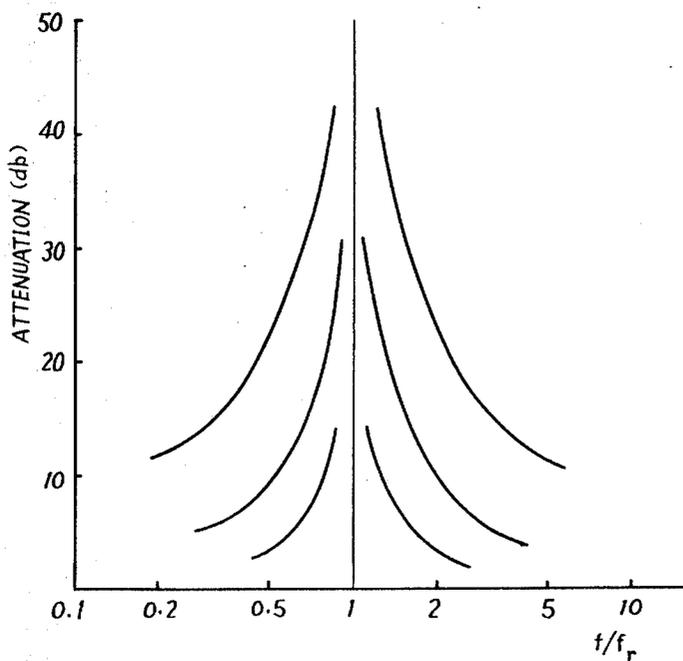


FIG. 2

ACOUSTIC TRANSDUCER FOR DEEP SEA

This invention relates to a deep sea acoustic transducer and more specifically to a novel and improved transducer including a piezoelectric ceramic element.

In general, prior cylindrical ceramic vibrators or transducers used in shallow depths have had structures in which the unnecessary radiating surface, such as the inner face of the cylinder, is covered with sponge rubber or cork rubber including a number of discrete foams as an acoustic shielding material and were enclosed in a rubber casing filled with castor oil.

It has been well known in the art that the sensitivity of such a cylindrical vibrator is improved by shielding the inner surface and, therefore, the above mentioned structure exhibits a high sensitivity and is very useful in shallow seas. However, it could not be used at a depth of 200 meters at most, since the foams in the shielding material were crushed and, therefore, the shielding effect at high depth was reduced.

Therefore, one object of this invention resides in the provision of an acoustic transducer for deep seas which does not lose its acoustic sensitivity at high water pressures.

According to this invention, the transducer comprises a ceramic element, an enclosure for enclosing the unnecessary radiating surface of said element which forms a static water pressure chamber therein, a first passage extending from the interior to exterior of said chamber, a resonance cavity provided around said first passage, and a plurality of second small passages communicating with the interior of said first passage and said resonance cavity, whereby a muffler for the unnecessary radiating surface of the element includes said water pressure chamber and said resonance cavity.

The features of this invention will be described in further detail in the following description and the accompanying drawings.

In the Drawings:

FIG. 1(A) is a cross-sectional plan view taken along the line A-A of FIG. 1(B) of an embodiment of an acoustic transducer according to this invention,

FIG. 1(B) is a side view in partial section of the embodiment of FIG. 1(A), and

FIG. 2 is a characteristic diagram representing sensitivity of the transducer according to this invention.

Referring to FIGS. 1(A) and (B), the acoustic transducer of this invention comprises a static water pressure chamber 10 and a resonant cavity 20 which are arranged coaxially with each other and cooperate to serve the function of a muffler for the inner surface of the vibrator or element 1. Vibrator 1 is operated in a conventional manner by electrodes 11 and 12 applied to opposing surfaces and connected to lead 13. The static water pressure chamber 10 is comprised of a hollow, cylindrical ceramic vibrator 1 and a pair of circular discs 2 and 3 closing both ends thereof. The upper disc 2 has a communication hole 5 bored in the center and the communication hole 5 is concentrically aligned with the inner end of a pipe 4 coupled to the upper disc 2. On the upper disc 2 and around the pipe 4 is a cylindrical resonance cavity 20 coaxially aligned with the pipe 4 and the water pressure chamber 10 and formed by a cylindrical side wall 6 and an upper wall 7. The in-

terior of the pipe 4 is connected through a plurality of small holes 8 formed in the pipe wall to the resonance cavity 20.

As the water pressure is applied equally to the outside and inside of the static water pressure chamber, that is, to both faces of the ceramic vibrator or element 1 due to presence of the communication hole 5, the transducer of this invention can withstand a water pressure substantially up to the mechanical compressive strength of the ceramic vibrator itself, which is about 800 kg/cm² and corresponds to the water pressure at a depth of 8000 meters.

As well known in the art, the attenuation L_R of the resonance cavity 20 is given by the following equation: where

f : sound frequency,

f_r : resonance frequency, $= (C/2\pi) \sqrt{GV/V}$

V : volume of the cavity 20,

S : inner cross-sectional area of the pipe 4,

C : sound velocity,

$G = n\pi a^2 / (t + (\pi/2)a)$,

t : wall thickness of the pipe 4,

a : radius of the small hole 8, and

n : number of the small holes 8.

This equation is represented on a graph as shown in FIG. 2 by plotting f/f_r on the abscissa and L_R on the ordinate with reference to $\sqrt{GV/2S}$ as a parameter. As clearly indicated by the characteristic curves on the graph, the attenuation is remarkably increased when f equals f_r or the resonance cavity resonates with the sound. This means that a great improvement of reception sensitivity at a specific frequency band that is, a so-called filter effect can be obtained by appropriately selecting the geometries of various components.

As the vibrator can be driven at a high water pressure without reduction of sensitivity in accordance with this invention as heretofore described, it becomes possible to provide a supersonic transducer which is highly suitable for searching in deep seas.

Although the above description has been made in conjunction with a cylindrical vibrator, it is evident that the structure may be arranged to shield acoustically the surfaces of a vibrator in lateral vibration other than its radiating surface and to provide a pressure balance between the interior and exterior portions of the shield casing.

What is claimed is:

1. An acoustic transducer comprising a ceramic vibrator which has an unnecessary radiating surface, said transducer further including an enclosure for enclosing said unnecessary radiating surface to form a static water pressure chamber therein, a first passage in the form of a tubular member extending from and communicating with the interior of said chamber and open to the fluid surrounding said chamber, a resonant cavity adjacent said tubular member, and at least one second passage communicating with the interior of said tubular member by means of an opening therein and with said resonant cavity.

2. An acoustic transducer according to claim 1 including a hollow cylindrical ceramic vibrator and wherein said enclosure consists of a pair of circular discs closing both the ends of said cylinder, said first passage is composed of a pipe coupled to an opening formed in the center of one of said pair of discs, said resonant cavity is cylindrical and disposed coaxially about said pipe and said second passage is a hole formed in the wall of said pipe and opening into said resonant cavity.

[54] **METHOD AND APPARATUS FOR OFFSHORE GEOPHYSICAL EXPLORATION WITH LOW POWER SEISMIC SOURCE**

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[52] U.S. Cl. **340/15.5 MC, 340/7 R, 340/15.5 R**
 [51] Int. Cl. **G01v 1/00, G01v 1/24**
 [58] Field of Search **340/7 R, 15.5 TD, 340/15.5 MC, 15.5 CP**

[56] **References Cited**

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[57] **ABSTRACT**

This invention relates to novel methods and apparatus for making offshore geophysical surveys with a low power seismic source. A first vessel, which is provided with air guns or the like, is anchored at a predetermined location, while a second vessel tows a streamer cable along a preselected course past the first vessel. The second vessel transmits command signals to cause the air guns on the first vessel to be fired at appropriate intervals, whereby a sequence of seismic pulses is refracted along a common path on the course, and whereby each of these pulses is detected by succeeding receiver stations of the cable. All of the pulses detected at a common surface point are gathered for each of the various common surface points along the course, and are then stacked to provide a single pulse of greatly improved signal-to-noise ratio for each common surface point. The stacked signals may then be arranged to provide a refraction profile of the course, in order to define traps and the like in subterranean earth formations.

14 Claims, 9 Drawing Figures

