Serial Number 09/137,869

Filing Date 12 August 1998

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Attorney Docket No. 77188

TRIBOELECTRIC SENSOR FOR USE AS MICROPHONE OR HYDROPHONE

STATEMENT OF GOVERNMENT INTEREST

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 therefore.

BACKGROUND OF THE INVENTION

(1) Field Of The Invention

The present invention relates to triboelectric sensors and in particular, to a triboelectric sensor having a capacitor and which is useful as a microphone or hydrophone.

(2) Description Of The Prior Art

Triboelectric sensors, in general, are known in the prior art. Triboelectrification is the process of electrical charge transfer between two bodies, such as two conductors in an electrical cable, as a result of contact, separation and friction between the bodies. In signal cables having one or more conductors for transmitting signals, the movement and mechanical stressing of the cable causes triboelectric noise that interferes with the signals being transmitted. The triboelectric noise in signal cables is typically reduced or eliminated to prevent interference with the signal being carried by the cable. However, in triboelectric sensors, the triboelectric effect is

used to generate a desired signal in response to the movement or deformation of the cable, thereby acting as a sensor.

Existing triboelectric sensors, such as the type disclosed in U.S. Patent Nos. 2,787,784 and 4,374,299, include a cable that provides a sudden change in voltage in response to displacement or movement of the cable. These triboelectric sensors are suitable as a trip wire, e.g., in security systems, that provides a signal indicating that the cable has been moved or "tripped." However, these existing triboelectric sensors merely provide a sudden increase in DC voltage and have a limited used as a sensor. In particular, they cannot be used to provide varying charges or signals in response to vibrations or pressure changes acting on the cable, e.g., as a microphone or hydrophone.

Microphones or hydrophones are used to convert airborne, water-borne, or structure-borne energy or sound, in the form of vibrations or pressure changes, to a corresponding electrical voltage. In one example, piezoelectric sensors, such as ceramic microphones and hydrophones, are used to convert this mechanical energy to electrical energy.

One application for microphones or hydrophones is in a towed sensor array that is towed behind a vehicle, such as an underwater vehicle, to measure water-borne or air-borne energy (e.g., sound) in the surrounding environment. One type of towed array includes multiple point source sensors such as microphones or hydrophones which measure energy or sound over a large area. When point source sensors are used in towed arrays, however, flow noise generated by water or air flowing over the sensor

interferes with the acoustic energy being measured and transmitted.

To eliminate the effects of flow noise, longer hydrophones or microphones are desirable so that the flow noise is averaged over the length of the hydrophone or microphone. Existing triboelectric sensors cannot be used as hydrophones or microphones in towed arrays because they are not capable of measuring varying pressure or energy changes.

SUMMARY OF THE INVENTION

One object of the present invention is a triboelectric sensor having a low cost, high reliability and sensitivity, and capable of generating a varying charge in response to vibrations or pressure changes, for example, as used in a microphone or hydrophone to measure sound.

Another object of the present invention is a triboelectric sensor that eliminates the need for multiple point source sensors, as in, for example, in a towed array.

The present invention features a triboelectric sensor device comprising at least two insulated cables for generating at least one charge in response to relative movement of the insulated cables. A capacitor is coupled to the first end of each of the insulated cables for storing at least part of the charge. A shielding layer is disposed around the insulated cables, and an amplifier has input terminals coupled to the second end of the insulated cables and a negative terminal coupled to the shielding layer. The amplifier receives the charge generated by the

insulated cables and amplifies the charge to generate at least one signal.

According to the preferred embodiment, the insulated cables are twisted cables and each cable includes at least one copper conductor and an insulating layer surrounding the copper conductor. The shielding layer preferably includes a braided shield, and an insulating jacket is preferably disposed around the shielding layer. The capacitor preferably has a capacitance of about 0.1 microfarad. The amplifier preferably includes a high impedance preamplifier having a gain of about 60 db.

The present invention also features a hydrophone and a microphone for measuring acoustic energy using the triboelectric sensor device described above.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will be better understood in view of the following description of the invention taken together with the drawings wherein:

FIG. 1 is a schematic diagram of a triboelectric sensor, according to the present invention; and

FIG. 2 is a cross-sectional view of a cable used in the triboelectric sensor, according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A triboelectric sensor 10, FIG. 1, according to the present invention, is used as a sensor or transducer to detect or measure

airborne, water-borne or structure-borne energy, such as acoustic energy or sound. In the exemplary embodiment, the triboelectric sensor 10 is used as a microphone or hydrophone, for example, in a towed array towed by an underwater vehicle. The present invention also contemplates using the triboelectric sensor as a trip wire or in other applications where sensors or transducers are used to detect or measure pressure changes, vibrations, or other forms of transmitted energy.

The triboelectric sensor 10 includes a cable 12, such as but not limited to, a shielded, twisted pair cable, coupled at one end 13 to a capacitive element 14, such as a ceramic or other type of capacitor, and coupled at the other end 15 to an amplifier 16. When acoustic energy 2 or other forms of vibrations or pressure changes act on the cable 12, a charge is generated within the cable 12 as a result of the triboelectric effect caused by movement of the cable 12. The capacitive element 14 temporarily holds or stores the charge generated by the cable 12 and allows the charge to vary as the cable 12 is moved. The amplifier 16 receives the charge generated by the cable 12 and amplifies the charge to provide an output voltage or signal which corresponds to the movement of the cable 12 and therefore the energy 2 causing the movement of the cable 12. The impedance of the capacitive element 14 is preferably lower than the impedance of the amplifier 16 such that the charge generated by the cable 12 is received by the amplifier 16 as it is discharged by the capacitive element 14.

The triboelectric sensor 10 thereby acts as an AC circuit with an increase in bandwidth. By storing the charge and then allowing the charge to discharge or bleed off, the capacitive element 14 allows continuous, varying signals to be generated and transmitted by the triboelectric sensor 10. Existing triboelectric sensors without a capacitive element such as a capacitor, act as DC circuits that only measure a sudden change in voltage and are not capable of being used as transducers that measure a continuous signal or energy change. The triboelectric sensor 10 of the present invention can therefore be used in a microphone or hydrophone to measure sound or other varying signals or energy changes.

The capacitive element 14 is preferably a high quality capacitor having low leakage. The capacitance of the capacitor is preferably about 0.1 microfarad. The amplifier 16 is preferably a high impedance preamplifier, e.g., in a range of 25-100 Meg, with a gain of preferably about 60 db.

The cable 12 includes at least two insulated conductors 20a, 20b having first ends 21a, 21b coupled to the capacitive element 14 and second ends 22a, 22b coupled to the terminals of the amplifier 16. The insulated conductors 20a, 20b are preferably twisted within the cable 12 to allow the conductors 20a, 20b to vibrate, thereby enhancing the triboelectric effect and generation of electrical charge in response to the energy acting on the cable 12. The cable 12 also includes a shielding layer 24 disposed around the insulated conductors 20a, 20b to minimize the effect of stray electrical fields surrounding the cable 12. The

shielding layer 24 is left open or unconnected at the first end 13 proximate capacitive element 14 and is connected to the negative power terminal 18 of the amplifier 16 at the opposite end 15 of the cable 12.

According to the preferred embodiment of the cable 12, FIG. 2, each of the insulted conductors 20a, 20b includes a central conductor 26a, 26b made of a copper or other suitable conductive material and a dielectric insulating layer 28a, 28b made of a dielectric plastic, such as polytetrafluoroethylene (also known as PTFE and sold under the trademark TEFLON. This type of a dielectric insulating layer will facilitate movement of the insulated conductors 20a, 20b and the generation of static charge within the central conductors 26a, 26b that varies with the vibrations or movement of the cable 12 by the energy 2. The shielding layer 24 is preferably a braided shield, such as a 16-8-44 shield. The cable 12 further includes an insulating jacket 30, such as a PVC jacket, disposed around the shielding layer 24, for protecting and sealing the insulating conductors 20a, 20b and shielding layer 24 from moisture or debris.

The cable 12 generates a charge in response to vibrations or movement at any point along the cable 12, allowing the triboelectric sensor 10 to measure signals along the entire length of the cable 12. This triboelectric sensor 10 is particularly advantageous for use in a towed array in which one or more microphones or hydrophones are towed behind a vehicle to measure acoustic signals. The triboelectric sensor 10 of the present invention can replace multiple microphones or

hydrophones, thereby reducing the effect of flow noise by averaging the flow noise over the length of the triboelectric sensor 10.

Accordingly, the triboelectric sensor of the present invention is capable of measuring continuous energy changes, such as sound or acoustic energy, by providing a varying charge in response to movement of the cable. The triboelectric sensor of the present invention can replace multiple sensors or transducers by routing the same cable of the triboelectric sensor to different locations. The triboelectric sensor of the present invention can also replace multiple microphones or hydrophones at a low cost and relatively high reliability and sensitivity. The triboelectric sensor of the present invention is also immune to high shock.

In light of the above, it is therefore understood that the invention may be practiced otherwise than as specifically described.

Attorney Docket No. 77188

TRIBOELECTRIC SENSOR FOR USE AS A MICROPHONE OR HYDROPHONE

ABSTRACT OF THE DISCLOSURE

A triboelectric sensor is used to measure continuous energy changes, such as sound or acoustic energy, by providing a varying charge generated by the triboelectric sensor in response to movement caused by the energy changes. The triboelectric sensor includes a cable, such as a twisted cable pair, having two insulated conductors. A first end of the insulated conductors is coupled to a capacitive element, and a second end of the insulated conductors is coupled to an amplifier. The capacitive element holds the charge generated by the conductors and allows the charge to vary. The amplifier receives and amplifies the varying charge and provides a voltage output that corresponds to the movement of the cable caused by the sound or continuous energy change. The triboelectric sensor is suitable for use as a microphone or hydrophone, such as, for example, in a towed underwater array.

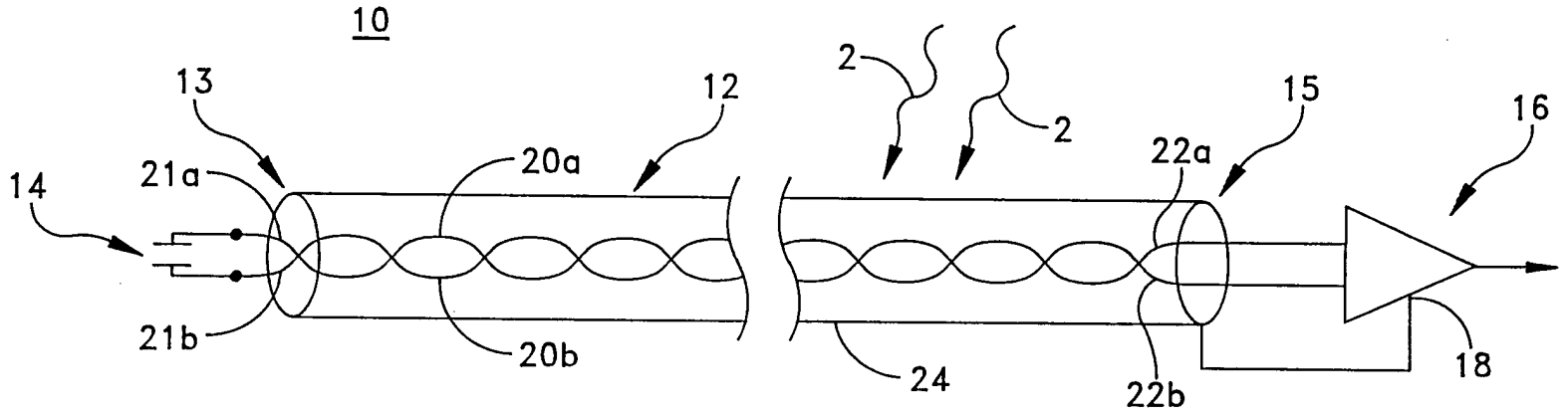
10
13
12
2
2
15
16
14
21a
20a
22a
21b
20b
24
22b
18

FIG. 1

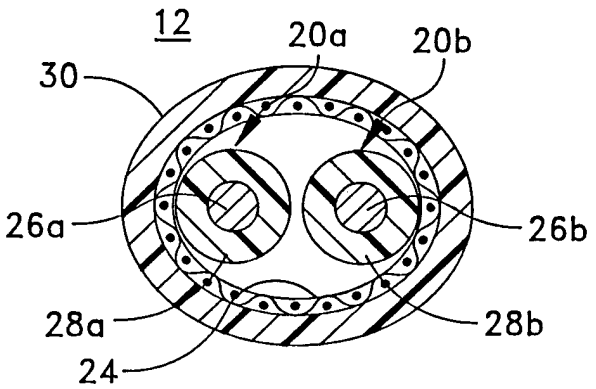
12
20a
20b
30
26a
26b
28a
28b
24

FIG. 2