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ULTRA COMPACT RECEIVER

STATEMENT OF GOVERNMENT INTEREST

[0001] 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

[0002] The present invention is directed to AM receivers. In particular, the present invention is directed to a combination AM receiver and sound reproducer.

(2) DESCRIPTION OF THE PRIOR ART

[0003] Traditional receivers for an AM electromagnetic signal use electronics exclusively to convert the electromagnetic signal to an audio signal. They only use an acoustic device to change the electromagnetic signal to sound waves in the last step of the receiving process. It is possible, however, that the entire receiving process can be done acoustically by driving a piezo-ceramic device with the electromagnetic signal. Such an alternative approach has the advantages of small size, simple construction, reliability and ruggedness.

SUMMARY OF THE INVENTION

[0004] It is a general purpose and object of the present invention to receive an AM electromagnetic signal without the use of electronics.

[0005] It is a further object of the present invention to drive a piezo-ceramic device with an electromagnetic signal to receive the signal acoustically.

The above objects are accomplished with the present invention by a combination AM receiver and sound reproducer. A hollow sphere (or cylinder) of piezoelectric material completely coated with a thin layer of conductive material is configured such that it receives the electromagnetic energy associated with an AM signal. The thickness of the piezoelectric material is selected to resonate at the AM signal's carrier frequency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] A more complete understanding of the invention and many of the attendant advantages thereto will be more readily appreciated by referring to the following detailed description when considered in conjunction with the accompanying drawings, wherein like reference numerals refer to like parts and wherein:

[0007] FIG. 1 is a spherical receiver;

[0008] FIG. 2 is a cylindrical receiver;

DETAILED DESCRIPTION

[0009] Referring to FIG. 1, there is illustrated a hollow spherical shape 10 made of piezoelectric material having a concentric outer surface 12 and an inner surface 14. The sphere-like shape can be a perfect sphere (with constant wall thickness); however, other similar shapes (and minor variations to the perfect sphere) will also work. Other shapes include (but are not limited to) spheroids and ellipsoids.

[0010] The sphere 10 serves as a receiver of AM signals by virtue of the dimensions of the sphere that allow it to resonate at the electromagnetic frequency of the AM signal. The outer spherical surface 12 is completely coated with a thin layer of electrically conductive material 16 (copper for example) that acts as an electrode capable of receiving an electromagnetic field. The layer of conductive material 16 also serves to electrically shield the inner surface 14, thereby creating a voltage difference across the inner surface 14 and the outer surface 12. A layer of conductive material 18 is also necessary on the inner surface, not for operation of the device, but for poling. Poling is a process of applying a constant electric field to the piezoelectric material to align the individual dipole moments.

[0011] Through a correlation of the dimensions of the sphere 10 with the frequency of the AM signal, the AM signal drives the piezo-electric sphere 10 at the resonant frequency of the sphere 10 generating an acoustic signal. Specifically, the wall thickness should be approximately equal to the sound speed divided by the frequency of the AM signal. For example, a 4 MHz AM signal will drive a sphere 10 with a wall thickness of approximately 1 millimeter if the piezoelectric material has a sound speed of approximately 4000 m/s. This will drive the hollow sphere 10 into its radial or "breathing" vibrational mode.

[0012] Once the AM signal is converted into radial vibrations by the sphere 10, the audio signal must then be separated from the carrier wave (having a frequency of $\omega/(2\pi)$). This is done acoustically. Since the sphere 10 is in a resonant state, nonlinearities will be at a maximum because of the large amplitudes in acoustic pressure and particle velocity. These nonlinearities will separate out the modulating signal. For example, the AM signal:

$$y(t) = f(t)\sin\omega t$$

when squared, becomes

$$y^2(t) = f^2(t)\sin^2\omega t = \frac{1}{2}f^2(t)\left[1-\cos 2\omega t\right].$$

[0013] Therefore, the signal $f^2(t)$ is in the audio range and can be detected by the ear. The second term (at twice the carrier frequency) is effectively filtered by the ear, which cannot detect signals at frequencies that high. The electromagnetic signal y(t) can also be modified before transmission to remove the nonlinear distortion that would occur in the receiver, so that when f(t) is squared, it becomes the intended audio signal. In other words, transmitting the following signal will reduce distortion:

$$y(t) = \sqrt{|f(t)|}\sin\omega t.$$

This leads to an audio signal having the form $|f(t)|$, which has much less distortion than $f^2(t)$.

[0014] Alternatively, when subharmonics are generated at resonance, the sphere 10 will recover the original signal without distortion. Subharmonics have been observed in piezoelectric devices at ½ the resonant frequency when driven at their resonant frequencies. The processes causing these will act in a manner analogous to traditional rectification, without the nonlinear distortion.

[0015] Nonlinearities in the speed of sound in the piezoelectric material (or more precisely, nonlinearities in the pressure as a function of density) will generate square terms like those above, especially at resonance, when the acoustic pressure amplitude is maximized. This can also be aided through selection of materials having a more nonlinear voltage/strain response. A piezoelectric material having a low mechanical damping will further maximize the amplitude at resonance.

[0016] An alternative embodiment of the ultra compact receiver would involve an open ended hollow cylinder 20 made of piezoelectric material having a concentric outer surface 22 and an inner surface 24. The outer spherical surface 22 is completely coated with a thin layer of electrically conductive material 26 (copper for example) that acts as an electrode capable of receiving an electromagnetic field. The layer of conductive material 26 also serves to electrically shield the inner surface 24, thereby creating a voltage difference across the inner surface 24 and the outer surface 22. A layer of conductive material 28 is also necessary on the inner surface, not for operation of the device, but for poling. An ultra-compact receiver in the shape of an open ended hollow cylinder 20 would work in a similar way to the manner as described above for a hollow sphere 10. For example, the AM signal would induce radial vibrations that would remove the carrier wave through the material nonlinearities. However, the entire cylinder 20 (including the open ends) needs to be shielded with an electrically conducting layer 26 and 28 to maintain a voltage difference between the inner and outer cylinder surfaces.

[0017] The advantages of the ultra compact receiver are the small size (on the order of millimeters) and the absence of electronics, which make the receiver versatile enough for a multitude of wireless applications.

[0018] While it is apparent that the illustrative embodiments of the invention disclosed herein fulfill the objectives of the present invention, it is appreciated that numerous modifications and other embodiments may be devised by those skilled in the art. Additionally, feature(s) and/or element(s) from any embodiment may be used singly or in combination with other embodiment(s). Therefore, it will be understood that the appended claims are intended to cover all such modifications and embodiments, which would come within the spirit and scope of the present invention.

ABSTRACT

The invention as disclosed is a combination AM receiver and sound reproducer. A hollow sphere (or cylinder) of piezoelectric material coated with a thin conductive layer is configured such that it receives the electromagnetic energy associated with an AM signal. The thickness of the piezoelectric material is selected to resonate at the AM signal's carrier frequency.

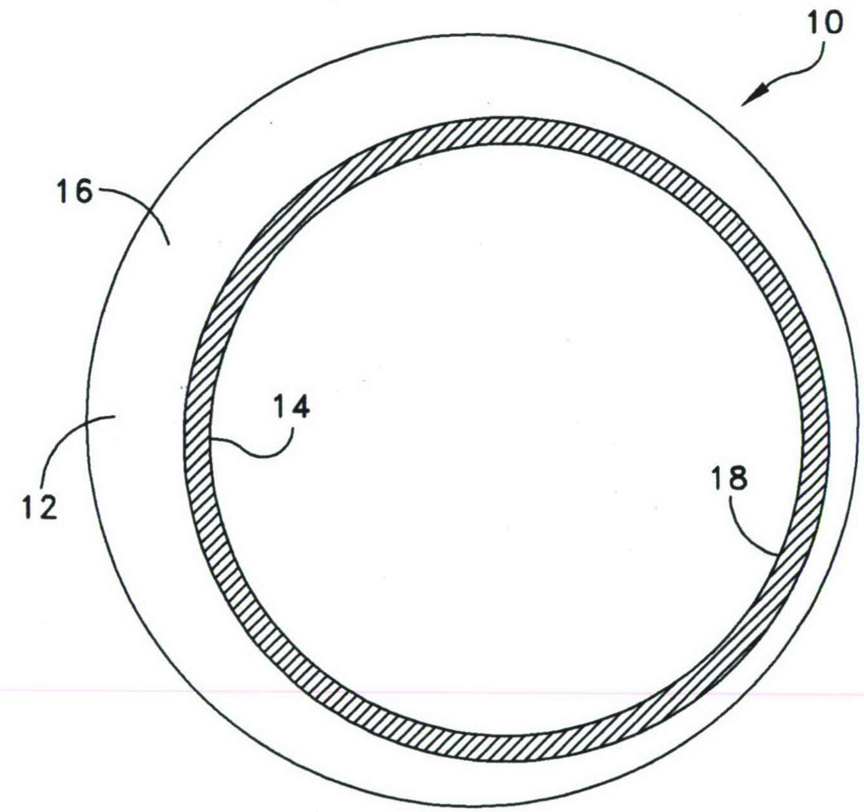

FIG. 1

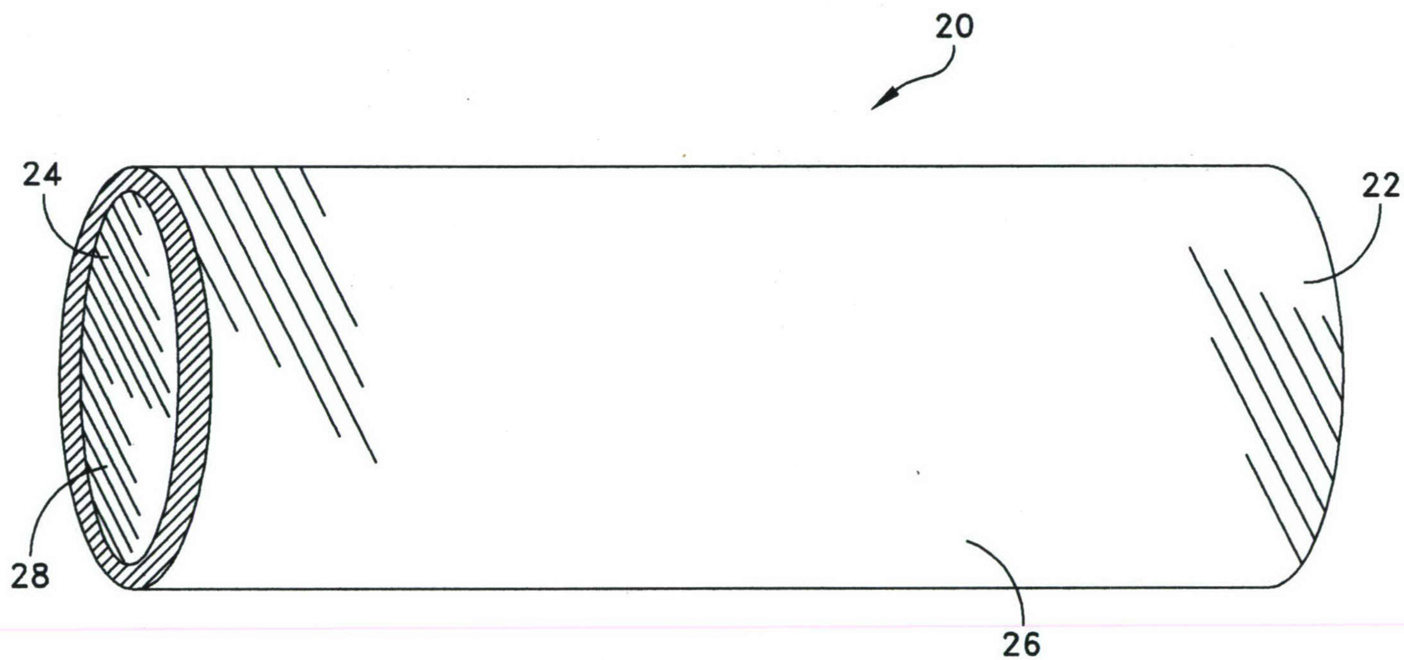

FIG. 2