April 12, 1966 H. F. BENSON 3,246,287

PIEZOELECTRIC TRANSFORMER

Filed Sept. 21, 1965

Fig. 1.

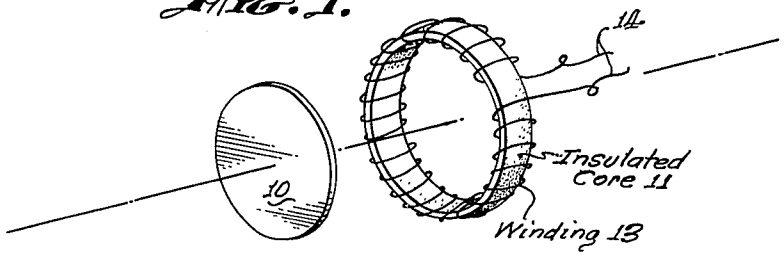


Fig. 2.

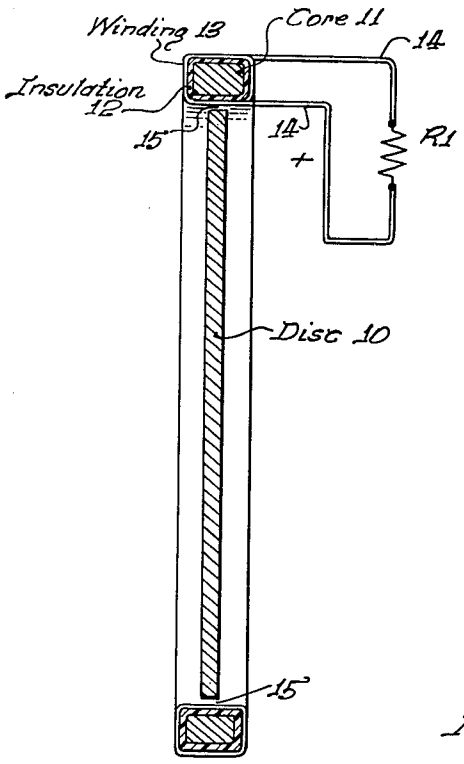
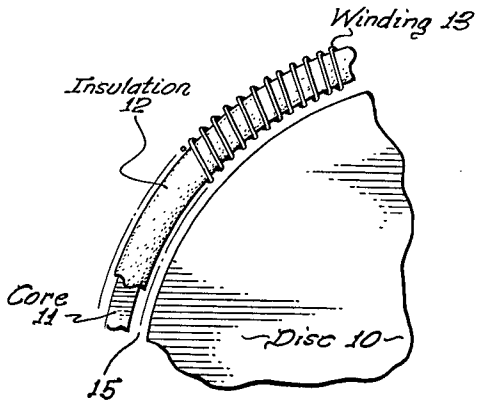


Fig. 3.



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PIEZOELECTRIC TRANSFORMER

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5 Claims. (Cl. 340—10)

This invention relates to piezoelectric apparatus and more particularly to a piezoelectric pickoff transformer which permits operation in ionizable solutes such as sea-water.

Piezoelectric devices have been utilized in various types of underwater signaling systems and the operation principle thereof is well known in that they function to convert electric oscillations into elastic waves or vice versa.

The present invention provides a transformer which operates on this known principle and can be effectively utilized in amplifying a signal produced from acoustic waves in a solute such as sea-water.

Therefore, it is an object of this invention to provide a transducer.

A further object of the invention is to provide a transformer which cooperates with a device which operates on the piezoelectric principle.

Another object of the invention is to provide a transformer-like pickup device for a piezoelectric element which will permit operating the device in ionizable solutes such as sea-water.

Another object of the invention is to provide a transformer which requires no moisture sealing.

Other objects of the invention will become readily apparent from the following description and accompanying drawings wherein:

FIG. 1 is a partially exploded view illustrating components of the invention;

FIG. 2 is an enlarged cross-sectional view of the FIG. 1 components operatively connected to a load; and

FIG. 3 is a partial front view of the FIG. 2 device with portions cut away for clarity.

Broadly, the present invention relates to a piezoelectric transducer element adapted for use in sea-water or like ionizable solute environs. The transducer essentially comprises a piezoelectric disc having its two charge-collecting faces electrically insulated from each other, the thus insulated disc being mounted in the center opening of a flattened toroidal pickoff coil. Upon immersion in an ionizable solute and upon subjecting the disc to external pressure, the disc acts as a battery with the enveloping ionizable medium functioning like a single turn primary coil to provide a transformer-type operation in conjunction with the toroidal coil, which serves as the secondary.

Referring now to the drawings, the transformer of the present invention is composed of a piezoelectric crystal or disc **10**, a flattened toroidal core **11** of magnetic material and rectangular cross-section, a coating of insulating material **12** on core **11**, a flattened toroidal coil or winding **13** positioned around the insulated core, and output leads **14** connected to coil **13**. A resistive load R_1 is shown connected to the output leads **14** for purposes of operational description. If desired, the faces or sides of the disc **10** may be silvered almost to the periphery to speed up the collection of the current producing electrical charges between the disc faces.

While not shown, a spacing or mounting device is provided for maintaining the disc **10** centered within the toroidal winding **13** which functions for maintaining a solute-gap **15** (see FIGS. 2 and 3) between the disc **10** and the winding **13**. The disc mounting device may be a snap-in spider type housing holding the outer edge of the disc still while permitting the center of the disc to bow in and out under pressure of the impinging acoustic waves. Also, a center-mounting post may be used for holding the center of the disc still while permitting the outer edge to bow to and fro, past the mounted center. The type of mounting device for disc **10** will thus be dependent on which portion of the disc is to be maintained fixed and which portion is desired to be moved by the impinging waves.

In operation, with the components assembled as shown in FIGS. 2 and 3 and submerged in an ionizable solute such as sea-water, an impinging acoustic wave, arriving through the solute surrounding the device, mechanically bows the disc **10**, either at its edge relative to its fixed center, or at its center relative to its fixed edge, depending on the type of mounting means for disc **10** as described above. Because the disc **10** is of piezoelectric material, it generates a charge between the faces of the disc when the disc is warped mechanically. This charge generated between the faces of disc **10** sets up an electrical current between the faces, since the device is bathed in the solute, and the solute-gap **15** does not prevent such a current. The path of the current will be from the electrical center of one face of the disc **10**, around the edge of the disc, and to the electrical center of the other face of the disc. This current flow will make the conducting solute look, electrically, like a single turn transformer primary winding of low impedance. Since the current must go through the solute-gap **15**, since it cannot go through the high-dielectric disc **10**, nor through the insulated magnetic toroidal core **11**, it is forced to travel across the edge of the disc in a direction parallel to the toroidal coil windings **13**. The current thus first travels radially from the center of one face of the disc **10** to the edge of disc, then axially across the edge of the disc cutting the turns of the winding **13**, then radially toward center of the second face of the piezoelectric disc **10**.

In performing this migration, the current induces a current flow in the transformer secondary (the toroidal winding **13**). The toroidal core **11** functions in conventional manner to increase the inductance of the secondary of the transformer. This current is brought out via output leads **14** to a point of use such as load R_1.

It is apparent that, ignoring the lossy primary (the solute) and some mechanically limited electrical phase lag, due to slower conduction of current within the solute, the usual ratios of ampere-turns in the primary versus ampere-turns in the secondary will apply, as in any normal transformer, thus permitting the number of turns in the secondary toroidal winding to establish the determined output voltage.

It may be desirable to mask the outside of the toroidal structure with an insulating baffle in the same plane as the disc in order to prevent any bucking current from flowing around the outside of the assembly.

It has thus been shown that this invention provides a novel piezoelectric transformer which function is caused by impinging acoustic waves in an ionizable solute, thereby advancing the applications of the piezoelectric art.

Although a particular embodiment of the invention has been illustrated and described, modifications and changes will become apparent to those skilled in the art, and it is intended to cover in the appended claims all such modifications and changes as come within the true spirit and scope of the invention.

What I claim is:

1. A piezoelectric transducer adapted for use in sea-water and like ionizable solutes comprising: a piezoelectric disc having two charge-collecting faces electrically insulated from each other, said disc being positioned in the center opening of a flattened toroidal pickoff coil, said toroidal pickoff coil surrounding a toroidal magnetic core, said core being provided with a coating of insulating

material, and output leads operatively connected to said coil, whereby upon immersion of the transducer in an ionizable solute and upon subjecting said disc to external pressure, the disc generates an electrical charge and the enveloping ionizable medium functions like a single turn primary coil to provide a transformer-type operation in conjunction with the toroidal coil which functions as the secondary.

2. A transformer comprising: a piezoelectric disc, a toroidal magnetic core having an insulating coating thereon, a toroidal coil positioned around said core, said disc being positioned within the central opening of and spaced from said core and said coil, and output leads connected to said coil and adapted to be connected to a point of use.

3. The transformer defined in claim 2, wherein said piezoelectric disc comprises a pair of face surfaces and a layer of dielectric material disposed intermediate said face surfaces, at least a portion of said face surfaces being provided with a silver coating.

4. The transformer defined in claim 2, wherein said toroidal core and said toroidal coil are flattened to define a substantially rectangularly configured cross-section.

5. A transformer comprising: a piezoelectric disc, a core of magnetic material, a layer of insulation material surrounding said core, a coil wound around said insulated core, and output leads operatively connected to said coil, said insulated core and said coil being positioned around said disc so as to define a gap therebetween.

No references cited.

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