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LOW FREQUENCY ELECTROMAGNETIC HYDROPHONE

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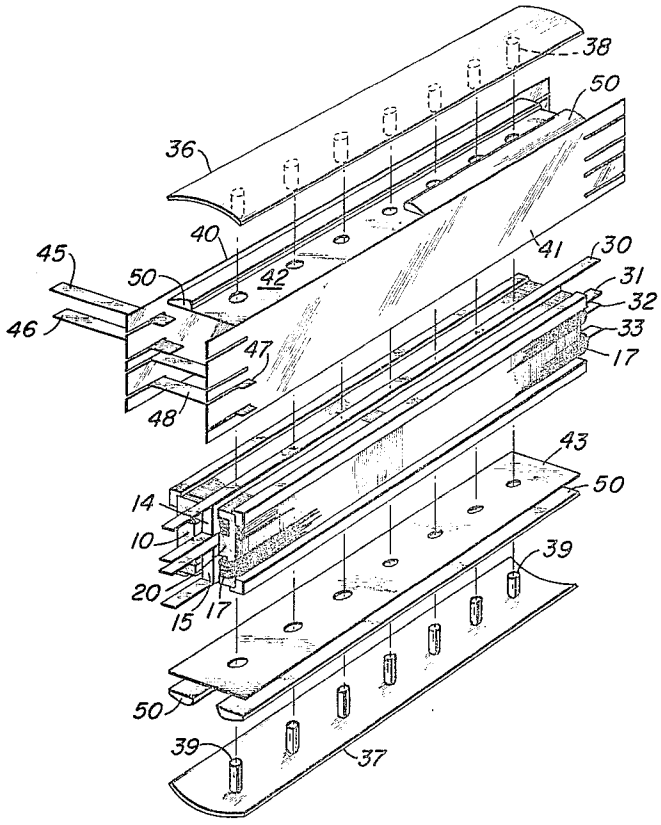


FIG. 1

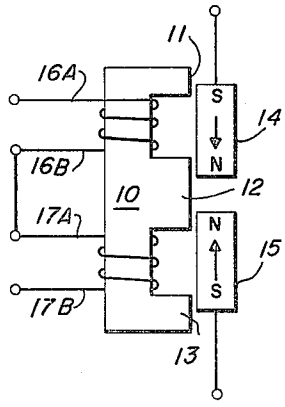


FIG. 3

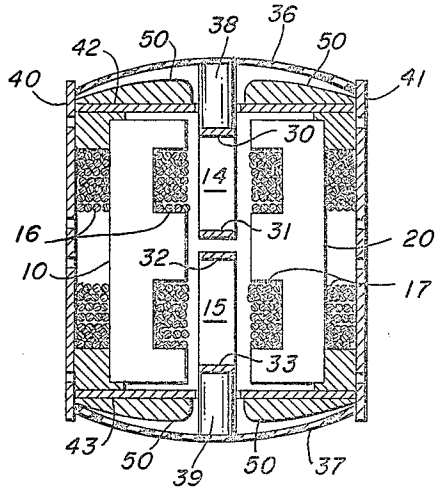


FIG. 2

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LOW FREQUENCY ELECTROMAGNETIC HYDROPHONE

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3 Claims. (Cl. 340—14)

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.

This invention relates to hydrophones and is particularly directed to an electromagnetic means which is sensitive to varying acoustic pressure in water for generating a faithful electrical reproduction of that pressure.

Listening devices lowered into the sea may be towed or anchored. In either case the device is subjected to lateral acceleration in the direction of the diaphragm of the device as by buffeting and turbulence. The voltages induced in the output circuit of the device hence may mask the wanted signals in the circuit. This noise is particularly prevalent at the lower frequencies such as 100 cycles per second and below. Hence, under most sea conditions, the low frequency signals are lost or must be filtered out.

An object of this invention is to provide a hydrophone which is insensitive to acceleration and yet will be sensitive to pressure waves of all frequencies including the very low frequency band.

It has been found that since hydrophones must be towed, sometimes at considerable speed, the hydrophones are preferably small in diameter and arranged end to end in a rope-like array to reduce turbulence and drag in the water.

A further object of this invention is to provide a hydrophone that is cylindrical in configuration and is small in diameter.

The ceramics of piezoelectric transducers are not particularly rugged in terms of shipboard handling and since the long rope-like transducer array must be wound on a drum the ceramics are easily fractured.

It is accordingly a further object of this invention to provide an improved hydrophone, obviating the piezoelectric ceramics.

The objects of this invention are attained by a hydrophone comprising a magnetic circuit including a horseshoe core with coplanar pole faces and with a flattened armature or bar of ferromagnetic materials, said bar being spaced from and overlapping the pole faces of the core. The bar is resiliently mounted to permit free motion only parallel to the pole faces of the magnet. An acoustic diaphragm is mechanically connected to the bar to produce relative motion and to change the reluctance of the magnetic path to induce voltages in an electric circuit coupled to the magnetic circuit.

Other objects and features of this invention will become apparent to those skilled in the art by referring to the preferred embodiment described in the following specification and shown in the accompanying drawing in which:

FIG. 1 is an exploded quarter view partly in section of a hydrophone of this invention;

FIG. 2 is a cross-section of the hydrophone of FIG. 1 taken on line 2—2 of FIG. 1; and

FIG. 3 is a schematic circuit diagram of the hydrophone of FIG. 1.

Four magnetic circuits are employed in the hydrophone disclosed here. The four circuits are employed for symmetry of construction and for other advantages which

will appear, although a single magnetic circuit could, if desired, be employed. The first two magnetic circuits shown in FIG. 3, comprise the two horse-shoe or U-shaped portions of the ferromagnetic core **10** of E-shaped cross section with legs **11**, **12** and **13**. Conveniently, the cores may be made of any length by stacking E-shaped stampings of thin iron sheets, with the expected reduction in eddy current losses. The ends of the legs are smoothed and are coplanar. The two magnetic circuits are completed, respectively, with iron bars **14** and **15**, which overlay the pole faces **11–12** and **12–13**. By means to be shown, the bars **14** and **15** are suspended in close spaced relation to the pole faces and are free to move parallel to the faces. Coils **16** and **17** are laid in each of the two channels, respectively, of the E-shaped core. A pair of external leads **16***a*, **16***b*, **17***a*, **17***b*, are provided for each coil, as suggested in FIG. 3.

Symmetrically disposed E-shaped core **20** is disposed on the opposite sides of the armatures **14** and **15**. The pole faces of core **20** are closely spaced from the armatures, and coils corresponding to **16** and **17** are laid in the two slots of the E.

Flat flexible springs **30** and **31**, preferably of Phosphor bronze or the like, are attached to top and bottom side edges of armature **14** to permit armature **14** free movement parallel to the pole faces. The springs are of the leaf type and are rigid against movement toward or away from the pole faces, so that movement of the armatures differentially changes the amount the armatures overlay the pole faces, and the cross section area and reluctance of the air gaps. The reluctance of the magnetic circuit including the E-core and armature is a function of the displacement from center of the armature. Springs **32** and **33** likewise are attached to the side edges of armature **15** for yieldably supporting armature **15** between the pole faces of the two E-shaped cores.

A relatively high steady magnetic field is provided in the four magnetic circuits shown. The magnetic field may, preferably, be created by permanent magnetism in the armatures **14** and **15**. Alternatively, the fields may be established by a biasing direct current applied to coils in the slots.

It will now be recognized that the magnetic circuits with the movable element constitutes the essential parts of an alternating current generator. That is, movement of armature **14** will induce in coils **16** a voltage proportional to the rate of displacement of the armature. Conversely, alternating power applied to the coil will cause the armature to oscillate. To this end, armature **14** is connected to flexible diaphragm **36**. The attachment in the embodiment shown comprises a series of pins **38** brazed at one end to the armature and vulcanized at the other end to the diaphragm. In the embodiment shown the diaphragms are preferably of rubber-like material. Armature **15** is likewise mechanically coupled to diaphragm **37** through pins **39**.

In normal operation a pressure wave causes in-phase displacement of the two diaphragms **36** and **37**. Opposing motion of the armatures changes the cross section of the effective flux paths through the top and bottom legs **11** and **13** of the E-cores. There results a variation in the flux which is nearly proportional to the displacement of the armature from their rest position. This results in voltages in each core winding which is proportional to velocity of motion of the armatures.

The two windings of each E-core are connected in series, and are so polarized that currents are additive when the armatures move toward or away from each other. It is significant, on the other hand, that sidewise acceleration of the device causes the two armatures to accelerate in the same direction which results in opposed

voltages or currents in the series circuit. Therein lies gain in the signal-to-noise ratio.

The specific packaging arrangement shown in FIG. 1 comprises a rectangular metal box with two side panels **40** and **41** and top and bottom plates **42** and **43**. The sides and panels are so sized as to receive the E-core arrangement. Across the ends of the box are provided the four transfer spring members **45** and **46** for receiving and holding the ends respectively, of spring members **30** and **31**. Likewise cross-springs **47** and **48** are attached to the ends of spring members **32** and **33**. Flexibility of the springs in one direction permit free movement of the armatures **14** and **15** parallel to the pole faces yet rigidly hold them against displacement toward the pole faces. Similar cross springs are provided at the opposite end of the box.

The hydrophone assembly may be elongated as desired to increase the acoutic sensitivity of the diaphragm. The diaphragm-to-armature pins **38** and **39** reciprocate through enlarged openings in the panels **42** and **43**. Fillets **50** are provided along the side edges of the elongated diaphragms to facilitate attachment to the box, and prevent collapse of the diaphragm under hydrostatic pressure.

Many modifications may be made in the specific structure of the hydrophone of this invention without departing from the scope of the appended claims. For example, specific details of the armature mounting for permitting free motion of the armatures may be varied according to many acceptable mechanical designs.

What is claimed is:

1. A hydrophone assembly comprising;

a plurality of magnetic circuits including two E-shaped cores with coplanar pole faces and flattened armature bars of ferromagnetic material disposed between opposing legs of said E-shaped cores,

support means for permitting relative motion of said armatures and said pole faces to vary the magnetic reluctance of the magnetic circuits in each pair of E-shaped legs, said support means comprising leaf springs which are flexible in one direction only being attached to said bars and being so supported at opposite ends as to permit said bars to travel only parallel to said coplanar pole faces,

an electric circuit inductively coupled with the two slots of each E-shaped core, and

an acoustic diaphragm mechanically linked to each armature to produce relative motion and induce a voltage in each of said electrical circuits.

2. Means for generating a signal voltage representation of pressure waves at the terminals of a hydrophone while neutralizing the effects of acceleration of the hydrophone in the direction of said wave, said means comprising;

an E-shaped magnetic core with coplanar pole faces

two movable magnetized armatures disposed, respectively, in the air gaps between the two pairs of poles of said core for varying the reluctance of the magnetic circuits,

two coils inductive coupled, respectively, with the two magnetic circuits of the core,

two pressure-sensitive diaphragms, oppositely disposed and connected, respectively, to said armatures so that the induced voltages in said coils are a function, respectively, of motions of said diaphragm, and

said coils being connected in series aiding and polarized to produce an output voltage when said diaphragms are accelerated in opposite directions and produce substantially zero voltage when said diaphragms are accelerated in the same direction.

3. Hydrophone means comprising;

two E-shaped magnetic cores, each core having three coplanar pole faces,

a coil inductively coupled, respectively, with each horse-shoe portions of each core,

two flattened armature bars of magnetic material,

the pole faces of the two E-shaped cores being symmetrically disposed face-to-face on opposite sides of said armatures,

the coils of one core being connected in series aiding and in multiple with the coils of the other core, and

oppositely directed acoustic diaphragms mechanically linked, respectively, with said two bars.

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