United States Patent [19]
Cuomo

[11] 3,831,137
[45] Aug. 20, 1974

[54] ACOUSTO-OPTIC UNDERWATER DETECTOR

[75] Inventor: Frank W. Cuomo, East Providence, R.I.

[73] Assignee: The United States of America as represented by the Secretary of the Navy, Washington, D.C.

[22] Filed: Apr. 14, 1972

[21] Appl. No.: 246,092

[52] U.S. Cl. .... 340/8 R, 73/71.1, 250/227, 340/13, 350/96 B
[51] Int. Cl. G01v 1/16
[58] Field of Search .... 350/96, 193; 181/.5 NP, 181/.5 H; 356/4, 106; 73/67.2, 67.5, 71.1, 71.3; 340/8, 12, 13; 250/227

[56] References Cited

UNITED STATES PATENTS

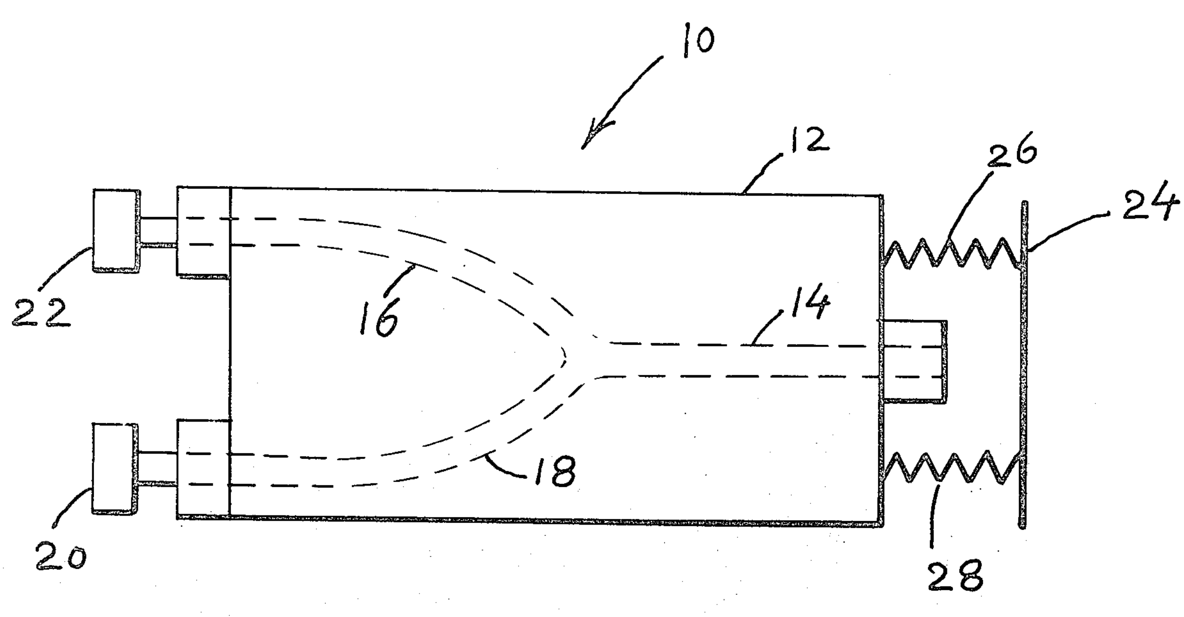
3,533,056	10/1970	Clark	340/8 X
3,541,848	11/1970	Thurstone	73/67.5
3,580,082	5/1971	Strack	73/71.3
3,584,227	6/1971	Matsas	350/96 B
3,642,090	2/1972	Bennett	181/.5 H

Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—H. J. Tudor
Attorney, Agent, or Firm—Richard S. Sciascia; Arthur A. McGill; Prithvi C. Lall

[57] ABSTRACT

A low frequency or pressure-gradient hydrophone comprising an optical reflector experiencing displacements responsive to acoustic waves. A beam light from a light source is carried by a first group of fiber optics guides and is incident upon the optical reflector. The light reflected from the reflector is carried by a second group of fiber optics guides to a light detector. Any displacements of the reflector due to pressure gradient due to acoustic waves impinging on the opposite sides of the reflector are detected by changes in intensity of reflected light from the light source.

4 Claims, 4 Drawing Figures



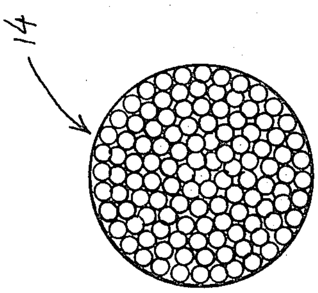


Fig. 4.

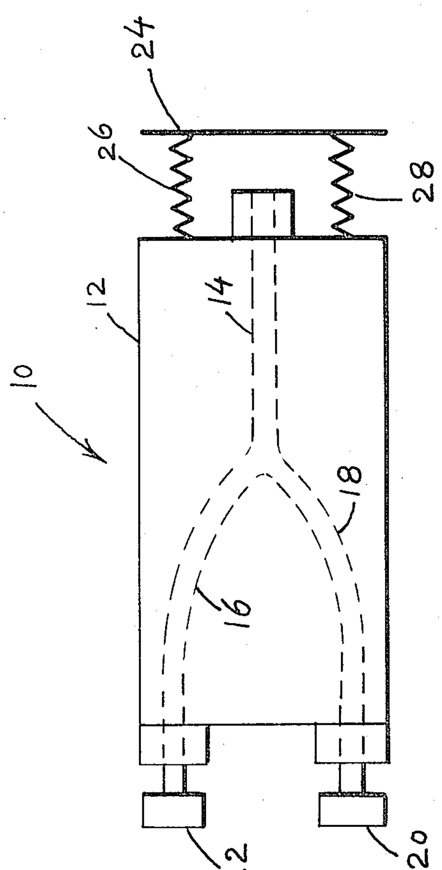


Fig. 1.

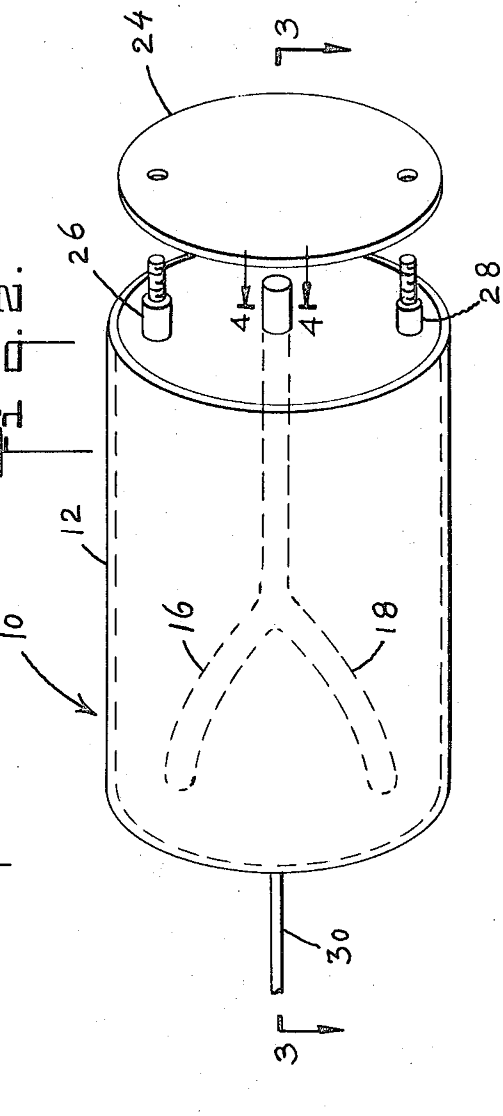


Fig. 2.

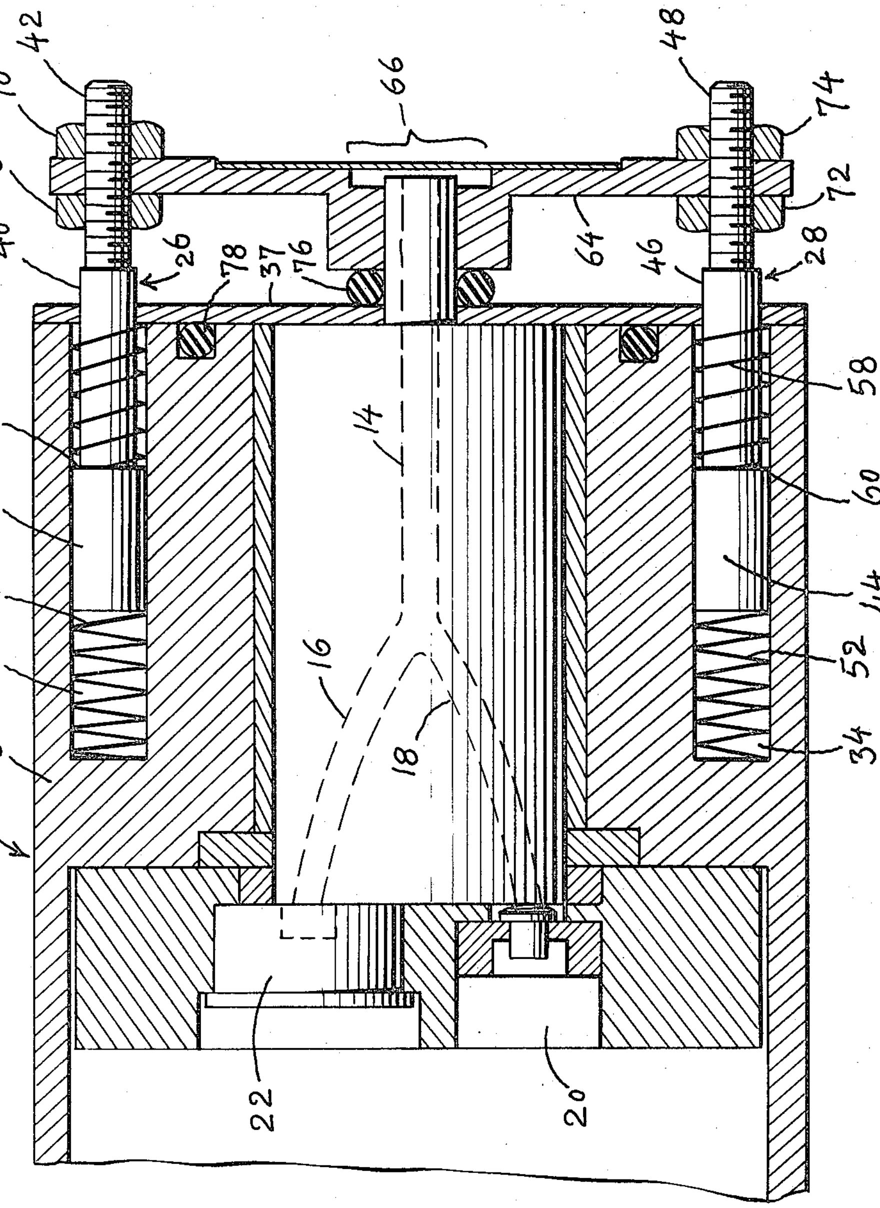

42
70
68
40
26
78
37
76
66
64
46
28
48
74
72
56
38
50
32
36
12
14
16
18
58
60
44
52
34
22
20

Fig. 3.

ACOUSTO-OPTIC UNDERWATER DETECTOR

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 therefor.

BACKGROUND OF THE INVENTION

The present invention relates to underwater communication and particularly pertains to low frequency hydrophones wherein any displacements of an optical reflector resulting from pressure gradient on the opposite sides of the reflector because of impinging acoustic waves are detected by changes in intensity of light reflected by the reflector.

Transducers used in underwater communication for detecting acoustic waves generated by various sources usually employ piezoelectric crystals of materials such as barium titanate, lead zirconate as acoustic elements. However, such transducers are not very efficient at low frequencies, e.g., a few hundred hertz, or below. This is because of relatively high resonant frequencies of piezoelectric crystals used and their relatively low detection efficiency at these frequencies. Furthermore, they display omnidirectional patterns and have sizes of 12 inches or longer in order to have receiving responses averaging −90 decibels (abbreviated as dB) for generating signals of 1 volt per microbar pressure of acoustic waves. Besides, these transducers do not have a uniform low frequency response and different piezoelectric crystals need be used to cover low frequency region. Consequently, their omnidirectional characteristics, relatively large size, and inefficient operation at low frequencies impair their usefulness in some underwater acoustic detection systems with particular reference to torpedo applications.

SUMMARY OF THE INVENTION

The objects and advantages of the present invention are accomplished by utilizing an acousto-optic transducer which comprises a bifurcated fiber-optic bundle housed in a light-tight box, a lightweight optical reflector which is flexibly attached to the light-tight box by means of a plurality of springs, a source of light, and a light detector. Light from the light source is carried through the box by the first group of the bifurcated fiber optics bundle to the reflector. The second group of the bifurcated fiber optics bundle carries the reflected light through the box to the light detector, the light-tight box preventing any extraneous light from interfering. Pressure exerted by an incoming acoustic wave displaces the optical reflector with resulting displacement of the reflector being proportional to the pressure differential on the opposite sides of the reflector and thus varies the intensity of the light reflected from the reflector. By changing the springs used for attaching the reflector to the box, it is possible to change the resonant frequency of the detector and thus the frequency band of the transducer for a uniform response. The frequency response of the transducer can also be varied by using optical reflectors of different masses.

An object of this invention is to have an acousto-optic transducer having a uniform low frequency response.

Another object of this invention is to have an acousto-optic transducer which has a directionality characteristic instead of being omnidirectional.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates schematically an acousto-optic transducer of subject invention;

FIG. 2 illustrates a partially exploded perspective view of the transducer;

FIG. 3 illustrates a cross-sectional view of the transducer taken along the line 3—3 of FIG. 2; and

FIG. 4 illustrates a cross sectional view of the transducer taken along the line 4—4 of FIG. 2.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring more specifically to the drawings, FIG. 1 illustrates an acousto-optic transducer 10 which comprises a light-tight box 12, a bifurcated fiber optics bundle 14 having branches 16 and 18, a light source 20, an optical detector 22, an optical reflector 24 attached to box 12 by means of spring biased pistons 26 and 28 schematically shown in FIG. 1 and in a perspective view in FIG. 2. Bifurcated bundle comprises a multiplicity of optical fibers as shown in FIG. 4 which is a cross sectional view of FIG. 2 along line 4—4. The optical fibers as shown in FIG. 4 are arranged in such a way that each transmitting fiber which transmits light from light source 20 to the optical reflector 24 is completely surrounded by receiving fibers which carry the light reflected by the optical reflector 24 to detector 22 for increasing the efficiency of the transducer. Cable 30 shown in FIG. 2 provides power to light source 20 and detector 22.

FIG. 3 shows a cross sectional view along line 3—3 of the transducer shown in FIG. 2. Two generally identical pistons 26 and 28 are spring biased and mounted in holes 32 and 34 respectively in wall 36 of box 12 and cover plate 37 which is attached to box 12 by set of screws not shown in the drawings. Piston 26 comprises a wider section 38 fitting tightly in hole 32, a narrower section 40, and a threaded section 42. Likewise piston 28 comprises a wider section 44, a narrower section 46, and a threaded section 48. Springs 50 and 52 are inserted in holes 32 and 34 respectively. Spring 54 is slipped on section 40 of piston 26 abutting common shoulder 56 of sections 38 and 40. Likewise spring 58 is slipped on section 46 of piston 28 abutting common shoulder 60 of sections 44 and 46. Pistons 26 and 28 are then inserted into holes 32 and 34 respectively, the end of piston 26 abutting spring 50 and the end of piston 28 abutting spring 52. Reflector 24 is supported by a back plate 64 attached thereto all around except a small area 66 of the reflector 24. Back plate 64 is attached to the threaded sections 42 and 48 of pistons 26 and 28 respectively by means of nuts 68, 70 and 72, 74. O rings 76 and 78 are used to protect fibers 14 from water. The reflector 24 is light and is generally made of materials such as glass, brass, and mylar coated with a reflector paint. However, it should be understood any reflector which is lightweight and having a high reflection coefficient can be used regardless of the material from which it is made. By adjusting the position of the back plate **64** of the optical reflector **24** or by changing springs **50, 52, 54,** and **58,** it is possible to change resonant frequency of the transducer and thereby change frequency band for a uniform low frequency response of the transducer. Furthermore, by using reflectors of different masses, it is also possible to change frequency characteristics of the transducer. Replacement of the springs and the reflectors can be achieved without making any major modifications in the transducer. The transducer can be either free flooding by making water flow on both sides of the reflector **24** or by making water flow only one side of the reflector **24** by adjusting the spacing between box **12** and reflector **24.**

Thus, an optical reflector which is adjustably attached to a light box having a bundle of fiber optics transmitters and receivers passing therethrough is displaced by an acoustic wave resulting from the pressure differential on the opposite sides of the reflector. This displacement of the optical reflector causes changes in intensity of light reflected by the optical reflector and carried by fiber optics receivers to a light detector. Due to flexibility in the choice of mass of the optical reflectors used, it is possible to change low frequency response of the transducer.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A pressure-gradient hydrophone comprising:

a light-tight box having a first side and a second side opposite said first side;

a cover plate attached to said second side;

a source of light secured to said box;

a light detector secured to said box;

a bifurcated fiber optics bundle comprising a first bifurcated branch having a first multiplicity of fiber optics guides and a second bifurcated branch having a second multiplicity of fiber optics guides, an end of said first bifurcated branch being in communication with said source of light and an end of second bifurcated branch being in communication with said light detector, said first multiplicity of fiber optics guides of said first branch and said second multiplicity of fiber optics guides being intermingled at the opposite ends of said first and second bifurcated branches proximate said cover plate and passing therethrough; and

an optical reflector having opposite sides, said reflector being adjustably attached to the side of said cover plate distal said bifurcated bundles, said sides being disposed to allow an incident acoustic wave to impinge thereon;

whereby light is transmitted from said source of light through said first bifurcated branch and reflected by said optical reflector, intensity of light reflected by said reflector being proportional to displacement of said reflector because of pressure gradient across the both sides of said reflector due to said incident acoustic wave impinging thereon, then carried by said second bifurcated branch and detected by said detector.

2. The hydrophone of claim **1** wherein said reflector is attached to said box by a plurality of pistons, said plurality of pistons being secured to said optical reflector on one side thereof and to said cover plate on said second side of said box;

3. The hydrophone of claim **2** wherein said plurality of pistons are spring biased at ends connected to said cover plate.

4. The hydrophone of claim **3** wherein said bifurcated fiber optics bundle is attached to said cover plate, passing therethrough, and having its end facing said reflector.

* * * * *