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3,474,402

VARIABLE FOCUS ELECTROACOUSTIC TRANSDUCER

Filed May 6, 1968

3 Sheets-Sheet 1

Fig. 1

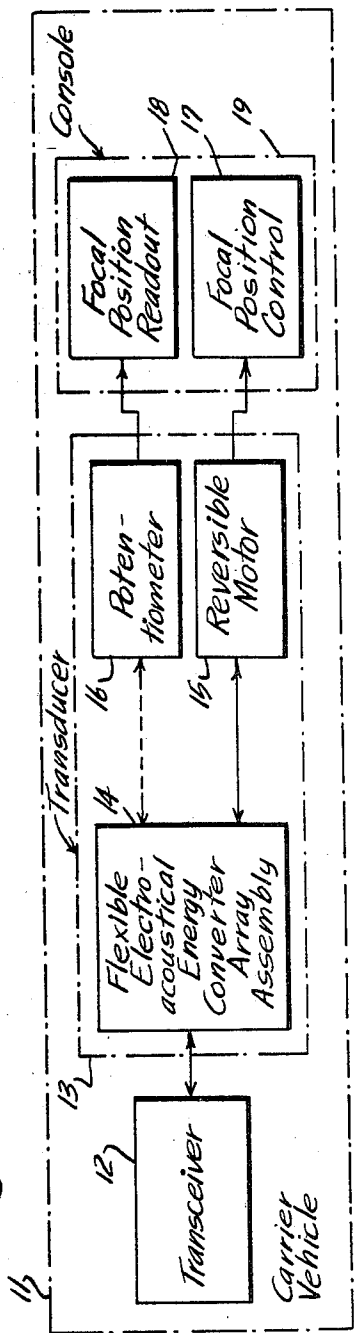
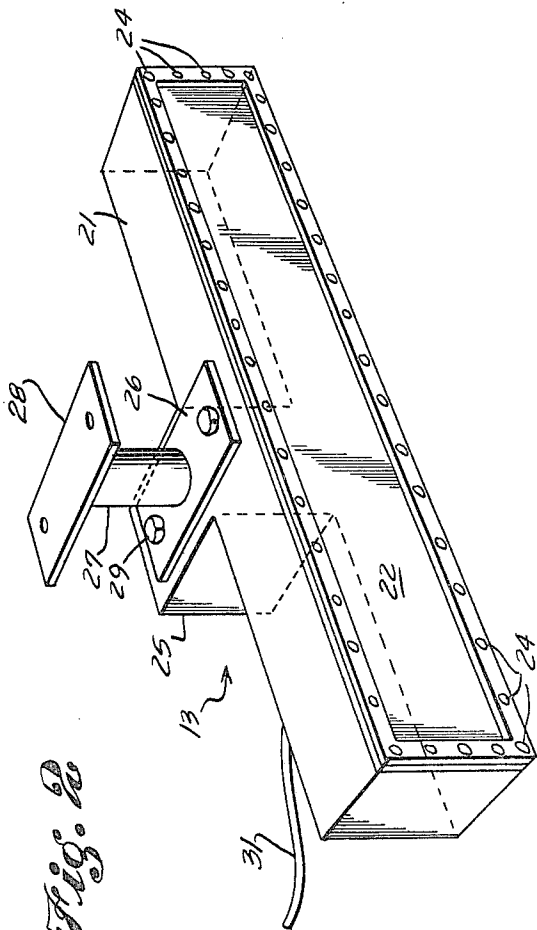


Fig. 2



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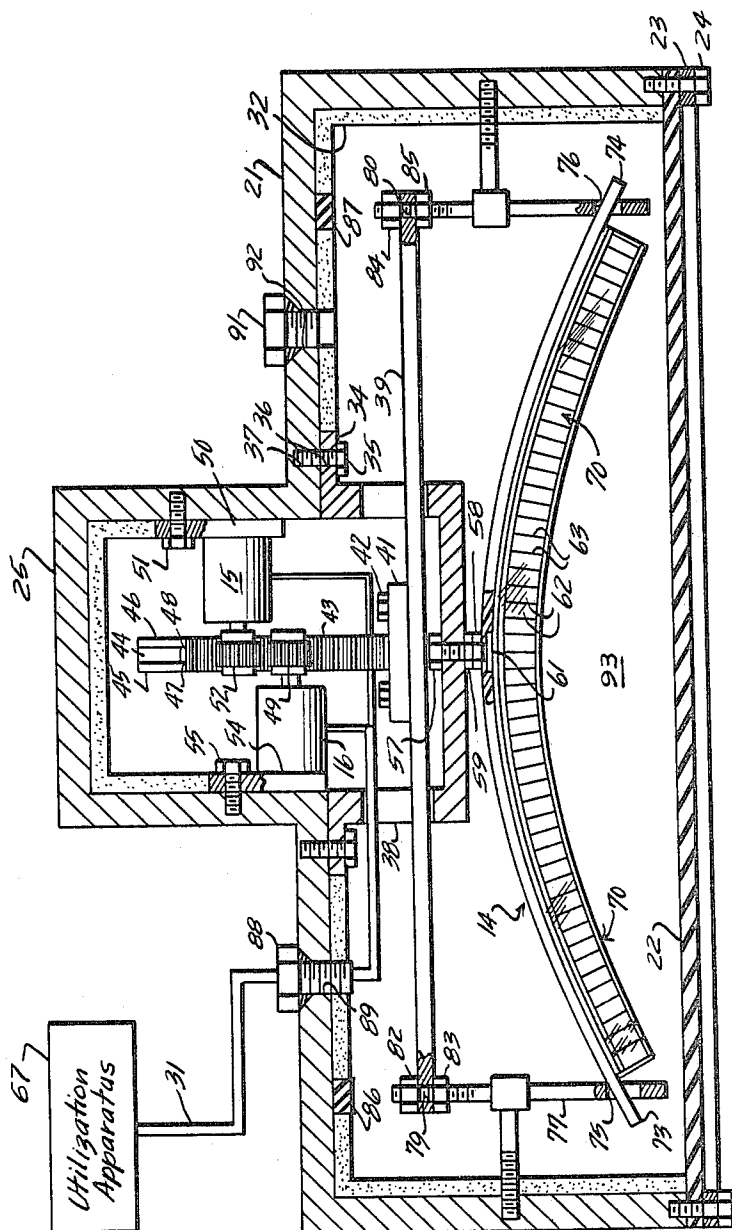


Fig. 3

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3 Sheets-Sheet 3

Fig. 4

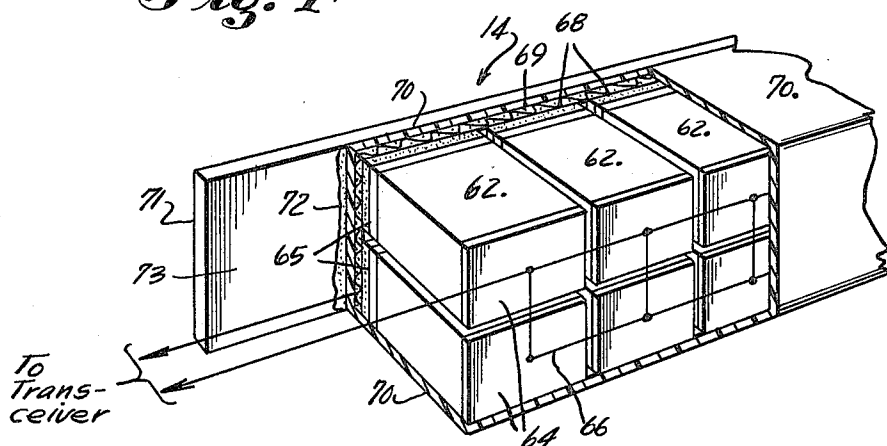


Fig. 5

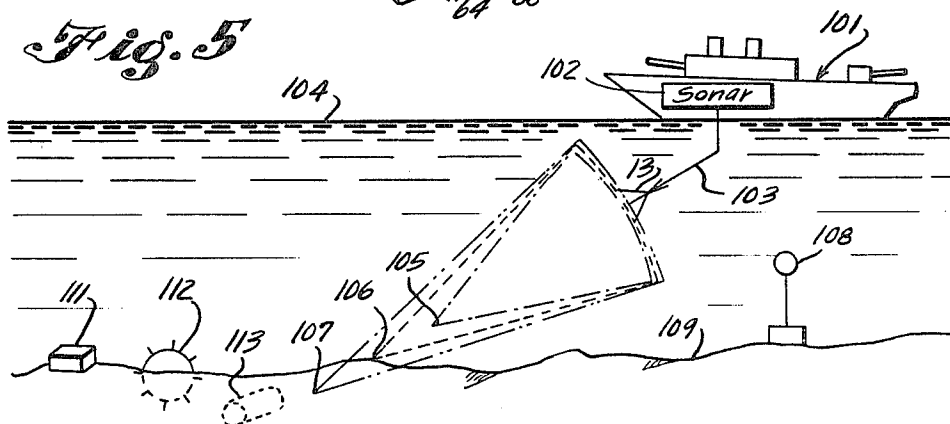


Fig. 6

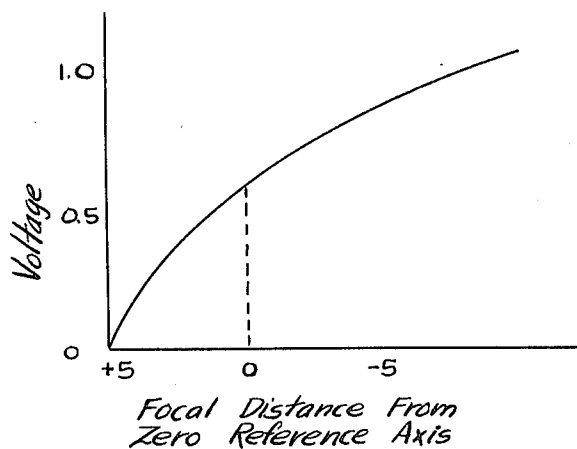
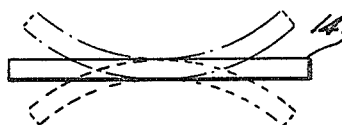


Fig. 7



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3,474,402
**VARIABLE FOCUS ELECTROACOUSTIC
TRANSDUCER**

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U.S. Cl. 340—9

10 Claims

ABSTRACT OF THE DISCLOSURE

A reversible variable focusing electroacoustical transducer having an array of electrically energizable diced electroacoustical energy converters attached to a curved flexible backing plate for movement within a predetermined range of radii. An electrically controlled motor and mechanical linkage assembly varies the curvature of said backing plate in response to predetermined electrical signals supplied thereto. The backing plate radius of curvature is proportional to the focal length of said array at any given instant. An electrically energized potentiometer is mechanically connected to said mechanical linkage assembly in such manner as to pick off a voltage that is proportional to the transducer focal length. Said voltage is supplied to an appropriate indicator for read-out in terms of said focal length.

The present invention relates generally to energy converting transducers and, in particular, is a reversible electroacoustical transducer which may be adjusted to vary the focus thereof with respect to the acoustical energy broadcast or received thereby.

Heretofore, electroacoustical transducers have been employed for converting electrical energy to acoustical energy and vice versa; and, of course, such electroacoustical transducers have been incorporated in sonar system and disposed in aqueous mediums for the purpose of broadcasting and receiving acoustical energy therein. For many practical purposes, such transducers have been quite satisfactory. However, in many instances, they have left a great deal to be desired because the focusing characteristics thereof, if any, were exceedingly difficult to control. For the most part, the prior art electroacoustical transducers are either substantially omnidirectional or substantially unidirectional with a fixed focal length. Those having a focus capable of being changed either have to be disassembled, redesigned, and reassembled, or they must be subjected to undue stresses which severely limited their operational life.

The present invention overcomes most of the disadvantages of the prior art electroacoustical transducers, in that it is constructed in a relatively simple manner which facilitates the varying of the operational focus thereof by remote control without adversely affecting the structure thereof or without having to reconstruct it.

It is, therefore, an object of this invention to provide an improved electroacoustical transducer.

Another object of this invention is to provide an electroacoustical transducer, the focus of which may be varied within a predetermined range of focal lengths.

Still another object of this invention is to provide an improved variable focus electroacoustical transducer, the focus of which may be remotely controlled.

A further object of this invention is to provide an improved method and means for selectively broadcasting concentrated acoustical energy to a predetermined restricted location within a given range of locations.

Still another object of this invention is to provide an improved method and means of selectively receiving con-

centrated acoustical energy from a predetermined restricted location within a given range of locations.

Another object of this invention is to provide an improved method and means for increasing, within limits, the operational flexibility, accuracy, and resolution of a sonar system with which it is combined.

A further object of this invention is to provide an improved sea bottom following electroacoustical transducer.

Another object of this invention is to provide an improved method and means for varying the geometrical configuration of the operative face of a reversible electroacoustical transducer.

Still another object of this invention is to provide an electroacoustical transducer having improved signal-to-noise characteristics for a predetermined range of focal lengths.

Another object of this invention is to provide a high target resolution electroacoustical transducer.

Still another object of this invention is to provide an improved variable focus transducer array that is easily and economically manufactured, operated, and maintained.

Other objects and many of the attendant advantages will be readily appreciated as the subject invention becomes better understood by reference to the following detailed description, when considered in conjunction with the accompanying drawings wherein like parts have like reference numerals and wherein:

FIG. 1 is a block diagram of a representative system which may incorporate the subject invention to an advantage;

FIG. 2 is a quasi-perspective view of the variable focus electroacoustical transducer constituting this invention;

FIG. 3 is a more detailed top view, partially in cross-section, and partly with parts broken away, of the transducer of FIG. 2;

FIG. 4 is an exemplary preferred embodiment of the piezoelectric energy converters incorporated in the electroacoustical transducer array of FIG. 3;

FIG. 5 is a quasi-pictorial view which discloses several of the various modes of operation of the invention;

FIG. 6 is a graphical representation of a typical voltage versus focal distance calibration curve that may be used to determine the focal length setting of the subject invention at any given instant, even during remote control operations; and

FIG. 7 is a schematic representation of the flexible energy converter array which illustrates the design possibility of either focusing or dispersing the acoustical aspects of the subject invention.

Referring now to FIG. 1, there is shown a carrier vehicle 11 which has mounted thereon in any suitable arrangement a transceiver 12. Transceiver 12 is connected to a variable focus transducer 13 constituting this invention and, in actuality, is connected to the flexible electroacoustical energy converter array assembly 14 thereof in such manner as to both supply and receive electrical energy thereto and therefrom, respectively. Said flexible electroacoustical array assembly 14 is mechanically coupled to both a reversible motor 15 and a potentiometer 16, the former of which is connected to the output of a focal position control 17, and the latter of which has its output connected to the input of a focal position readout 18. Focal position control 17 and focal position readout 18 are preferably located on an appropriate console 19, which is convenient for being operated by a human or other operator, as desired.

Variable focus transducer 13 of FIG. 1 is shown in perspective in FIG. 2. As may readily be seen, it depicts the outside appearance thereof and illustrates that it may be designed as a unitary device which may be mounted in

any convenient or appropriate manner on any appropriate carrier vehicle being used at the moment. Hence, FIG. 2 shows that the subject invention has an elongated housing 21 that contains an acoustic aperture or window 22 which is held in position around the periphery of housing 21 by means of frame 23 and a plurality of bolts 24 intermittently disposed around the periphery thereof. Said acoustic window may, for instance, be made of rubber or Absonic-A materials as convenient, the latter of which is manufactured by the B. F. Goodrich Company. Of course, conceivably it could be made of metal in the event very low frequency signals are to be transmitted therethrough. The rear end of the subject transducer contains a subhousing 25 which, as will be discussed more fully subsequently, contains various and sundry drive and indicator means and devices.

It should be understood that any suitable mounting means may be employed to dispose the subject variable focus transducer in any predetermined disposition with respect to its carrier vehicle and ambient environment. However, in this particular preferred embodiment, a flange 26 having a connecting rod 27 fixedly mounted thereto, as by welding or the like, and another flange 28 attached to the other end of said rod 27, likewise as by welding or the like, is herewith disclosed as being an example of mounting means that may be used to an advantage with this invention. Of course, bolts 29 may be used to bolt flange 26 to housing 21 or, if so desired, flange 26 may also be connected by means of welding or the like.

Electrical cable 31 is shown as entering housing 21 of subject invention and contains several sets of electrical conductors which are connected between the various operational elements thereof and any suitable utilization apparatus, as will be discussed more fully below in conjunction with the device of FIG. 3.

FIG. 3 discloses a simplified version of the subject invention in greater structural detail but in sufficient detail as to enable one skilled in the art to make and use it. Therefore, it should be understood that numerous design changes may be incorporated therein in order to accommodate it to any given operational or environmental circumstances.

Housing 21, in this particular instance, is a metal housing but may be made of any suitable material which has sufficient structural strength to withstand the rigors of the ocean depths. Furthermore, inasmuch as it is intended to be operated within a corrosive subaqueous medium—such as sea water or the like—housing 21 should be constructed of such metallic material as will also resist corrosion and still be unattractive to any parasites which may adversely attach themselves thereto. Accordingly, an anodized aluminum or a painted aluminum may be used for this purpose.

As previously mentioned, housing 21 has a subhousing 25 attached to the rear portion thereof. Although subhousing 25 is herewith shown as being an integral part of housing 21, it should be understood that it may be a separate unit which is connected thereto in such manner as to provide a watertight seal thereat, in order to facilitate the attachment and detachment thereof therefrom for maintenance purposes, etc.

Mounted within the inner chamber of housing 21 is a plurality of sheets of acoustical energy absorbing material which are arranged in such manner as to constitute an anechoic lining 32 therefor on substantially the entire inner surface thereof not occupied by other elements. Although numerous acoustical energy absorbing materials are appropriate for such lining, it has been found that SOAB, manufactured by the B. F. Goodrich Company, is imminently suitable therefor.

A cup-shaped support bracket 33 having flanges 34 are mounted within the chamber of housing 21 in such manner as to be substantially in line with subhousing 25 and become a forward extension thereof. Bracket 33 may be

mounted in any desired manner; however, in this particular embodiment, it is preferable to employ a plurality of threaded bolts 35 which extend through bolt holes 36 in flange 34 into complimentary threaded holes 37 located in housing 21. Disposed within said bracket 33 is a pair of holes 38 which are elongated sufficiently in the fore and aft directions to allow the movement of a cross bar 39 therein.

Connected to the rear surface of cross bar 39 by means of a suitable flange 41 and a plurality of bolts 42 is a supporting rack 43. In actuality, flange 41 and rack 43 may be integrally connected, or if more expedient from a construction standpoint, one may be welded to the other. Rack 43 extends rearwardly and is positioned in such manner as to slidably move within a groove 44 containing side tracks 45 and 46 which ride in slots 47 and 48 located on both sides of rack 43, respectively.

Reversible motor 15 is mounted by means of supporting plate 50 and bolts 51 on the inside surface of subhousing 25. Connected to the shaft thereof is a pinion gear 52 containing teeth which mate with the teeth located on the aforesaid rack 43 for the driving thereof. Likewise, potentiometer 16 is mounted by means of support plate 54 and bolts 55 to the inside surface of subhousing 25 in such manner as to allow pinion gear 49 connected to the shaft thereof to mate with the teeth of rack 43 for rotation thereby, as rack 43 moves backward and forward in groove 44.

Cup shaped bracket 33 contains a threaded hole 56 in which is screwed a bolt 57 with the head thereof located in the rear end direction. The front end of bolt 57 contains a pair of nuts 58 and 59 which are locked together in such location thereon that the front surface of nut 59 is located at a predetermined position. The aforementioned flexible electroacoustical energy converter array assembly 14 is connected to the forward end of bolt 57 and locked in place by means of nut 59. If so desired, a suitable metallic threaded ring 61 may be embedded in the rear portion of array assembly 14 to provide sufficient strength and support with respect to said bolt 57. Of course, said ring 61 is threaded in such manner as will make it compatible with the external threads of bolt 57 and thus provide an attachment means therebetween. Obviously, various and sundry other connecting means between support bracket 33 and array assembly 14 may be employed in the event operational and or construction circumstances so warrant. But for the purpose of maintaining a simplicity of disclosure with respect to this invention, the aforementioned bolt 57, ring 61, and array assembly 14 combination is herewith disclosed.

Array assembly 14 contains a plurality of piezoelectric ceramic bars 62 which are contiguously disposed in a substantially solder course manner with sufficient gap or space 63 between adjacent ones thereof for relative movement therebetween.

As may be seen in FIG. 4, said piezoelectric ceramic bars are in actuality diced or serrated ceramic crystals which have been cut in such manner as to separate them to provide the aforementioned gaps 63. Attached, as by fusion, to the forward and rearward surfaces thereof are silver electrodes 64 and 65. Electrical conductors 66 interconnect electrodes 64, as by soldering or the like, which are adapted to be connected to a utilization apparatus 67 for the energization thereof or for the response thereto, as the case may be. On the rearward electrode surfaces thereof is attached, as by liquid air drying solder 68, a nickel mesh wire 69, preferably of the order of .002 inch thick, which, in fact, acts as the interconnection for the other electrodes of piezoelectric crystals 62. Of course, said wire mesh is likewise electrically connected to the aforementioned transceiver 12 or other utilization apparatus 67. Encapsulating all of the aforesaid piezoelectric crystals and their associated electrodes and their electrical conductors is an acoustically clear polyurethane material 70 which is sufficiently pressure releasing and resilient to

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enable it to be bent in such manner as to form a radius of curvature for the entire array in order to effect the focusing thereof as desired. Also, if so desired, each bar may be partially or separately encapsulated or potted in said material, as well. The rearward surface of said encapsulating material 70 is attached to a resilient bendable backing plate 71 which is preferably made of a phenolic sheet, the thickness of which is not critical but may be of the order of .0005 to .0031 inch thick. Any suitable adhesive 72 may be used for the purpose of attaching backing plate 71 to encapsulating material 70.

As may be seen in FIG. 3, said backing plate 71 has extended ends 73 and 74 which extended through apertures 75 and 76, respectively, of a pair of push rods 77 and 78, which are attached to the extremities of the aforesaid cross bar 39. The stud portions located at the ends thereof are inserted through holes 79 and 80, with nuts 82 and 83 firmly holding push rod 77 thereto and nuts 84 and 85 holding push rod 78 thereto.

In this particular preferred embodiment, push rods 77 and 78 are capable of moving array 14 backwards and forwards at the ends thereof relative to the center thereof because they are effectively connected to reversible motor 15 by means of cross bar 39, flanges 41, movable rack 43, and pinion gear 52.

Disposed in any suitable location on the rearward inner surface of housing 21 is a pair of resilient stops 86 and 87 which prevent the jarring of cross bar 39, in the event it is inadvertently moved to its most rearward position.

A threaded packing gland 88 extends through a comparably threaded hole 89 in housing 21 and energy absorbing material 32, which enables all necessary electrical conductors to pass therethrough while providing a fluid seal thereat.

As previously mentioned, acoustical window or diaphragm 22 is mounted on the front end of transducer housing 21 in such manner that any energy projected by energy converter array 14 or any energy received by array 14 will pass therethrough with a minimum of restriction. Furthermore, it is mounted on said housing in such manner as to provide a fluid seal thereat.

Housing 21 also contains a filler plug 91, which is threaded into a comparable threaded hole 92 that extends through housing 21 and energy absorbing material 32. When completely assembled, an appropriate fluid transmission medium 93 is poured through the filler hole left by removing filler plug 91 from housing 21. The entire volume of said housing 21 not occupied by other elements is, thus, completely filled therewith. Although there are many types of fluids which meet the physical characteristics desired for said transmission medium 93, it has been found that castor oil or a silicone base oil is imminently satisfactory for such purpose.

FIG. 5 depicts a typical application of the subject invention. In this particular application, a ship 101 acts as the carrier vehicle, and a sonar 102 acts as the utilization apparatus. Thus, the variable focus transducer 13 constituting this invention is physically and electrically connected to sonar 102 by any appropriate connectors 103.

While traveling along a target hunting course, acoustical energy is broadcast through sea water 104 and is timely focused at any number of focal points, including 105, 106, and 107. The shortest focal point 105 disclosed will more readily detect and facilitate classification of objects 108 located above sea floor 109, while focal points 106 and 107 will more readily detect and facilitate classification of objects 111, 112, and 113 laying on, partially buried in, or completely buried in said sea floor 109, respectively.

The graph of FIG. 6 teaches that the output voltage of electrically energized potentiometer 16 may be calibrated to indicate the focal distance at which the energy converter array 14 is focused at any given instant. Of course, readout 18, to which potentiometer 16 is attached, may likewise be calibrated to readout in terms of focal distance or any other useful parameter, as described.

FIG. 7 discloses flexible electroacoustical energy converter array 14 in three different possible configurations. Of course, practically an infinite number of configurations could be effected merely by making the proper adjustment of focal position control 17. Therefore, it may readily be seen that the range of adjustment varies between some maximum convex dispersive adjustment to some minimum concave focal distance. Obviously, one skilled in the art having the benefits of the teachings presented herewith could easily make such design changes as would be necessary to produce any type of configuration desired for array 14.

Moreover, although the electroacoustical energy converter elements of the disclosed preferred embodiment of the subject invention are indicated as being piezoelectric materials, such as barium titanate or lead zirconate, etc., which are combined with suitable electrodes and electrical conductors in order to be operable, it should be understood that electrostrictive and magnetostrictive elements of other suitable materials combined with appropriate electrostatic plates or suitable inductive coils, respectively, may be substituted therefor, so long as their respective components are configured and disposed in such manner as to allow a relative tilting movement therebetween which, in turn, allows the focusing characteristics to be effected.

The operation of the subject invention will now be discussed briefly as follows in conjunction with all of the figures of the drawings.

As may be seen in FIG. 5, a carrier vehicle such as ship 101 effectively acts as the support platform for the invention which may, for example, have the external appearance of the device shown in FIG. 2. Although a ship is indicated as being said carrier vehicle in this particular case, it should be understood that other carriers such as submarine boats, aircrafts, helicopters, stationary platforms, floats, buoys, and the like, may be used therefor, in the event the operational requirements so warrant. Moreover, the preferred embodiment of the invention is herewith disclosed as being included as part of sonar system 102, where the environmental medium within which it operates is water or sea water 104, or some other aqueous or subaqueous medium; but it should be obvious that it could be used in the atmosphere or in any other space, providing the necessary physical characteristics for the propagation of acoustical energy therethrough are present. Of course, it would be well within the purview of one skilled in the art having the benefit of the teachings herewith presented to make the necessary design changes to convert the invention to any particular type that would be operable for similar purposes in any suitable environmental medium.

As ship 101 travels along its course, the instant variable focus transducer 13 is energized by the transmitter portion of sonar transceiver 102. Acoustical energy is generated thereby which is broadcast in the direction of suspected underwater targets. In this particular representation, it is directed toward the sea floor 109, and while it is so broadcast, the focal length of transducer 13 is varied to concentrate acoustical energy of focal points 105, 106, and 107. Hence, concentrated target reflections or echoes from target 108 located above the sea floor, target 113 buried under the sea floor, target 112 partially buried within the sea floor, and target 111 laying on the sea floor will be received by the subject transducer 13 and processed by the receiving portion of transceiver 12 connected thereto. The aforementioned concentration of acoustical energy, of course, is the thing that vastly improves the signal-to-noise ratio and, thus, the probabilities of target detection and classification, even though they occur at different ranges or within different ambient mediums.

The focal length of the subject transducer is adjusted by means of motor 15 and associated linkage mechanism and any conventional focal position motor control 17. An operator manipulates focal position control 17 in such

manner as is normal with respect thereto, to in turn, cause motor 15 to run for the proper amount of time and speed in the proper direction. Pinion gear 52 attached to the motor shaft turns and drives rack 43 backward or forward in its groove 44, as the case may be, and the movement of rack 43, in turn, drives cross-bar 39 and push rods 77 and 78. If, for example, cross-bar 39 is moved in the forward direction, ends 73 and 74 of backing plate 71 are moved forward in such manner as to decrease the radius of curvature of energy converter array 14, thereby decreasing the focal length of the acoustically operative portion thereof. Of course, the aforesaid radius of curvature of converter array may be varied as described because of its flexible construction shown in FIG. 4. The flexible backing plate, electrodes, diced or serrated piezoelectric crystal construction all act in concert to enable the operative aspect of each crystal to be effected at different places relative to that of the others; hence, the combined interactions thereof, in turn, produce a total result—that is, a resultant concentration of acoustical energy at substantially a predetermined point—whether broadcasting or receiving. Because the rear center position of said backing plate 71 is held stationary by bolt 56 and nuts 58 and 59, the same amount of forward or backward movement of push rods 77 and 78 cause substantially the same amount of focal length change of the transducer.

As rack 43 is moved back and forth, pinion gear 56 turns and sets electrically energized potentiometer 16 in such manner as to supply a voltage proportional thereto to focal position readout 18 for indication thereof, as is depicted in FIG. 1. Although only three different focal lengths are depicted in FIG. 5, it would be obvious that, within limits, almost a finite number could be attained by properly controlling the direction and amount of rotation of motor 15 by control 17.

As may readily be seen in FIG. 6, the voltage output from potentiometer 16 is a function of the focal distance from a predetermined zero reference axis at any given setting; hence, focal position readout 18 may be calibrated in terms of focal length merely by using a curve similar to that of said FIG. 6. Of course, other curves of a comparable family of curves may also be employed merely by using different supply voltages to electrically energize the resistance portion of potentiometer 16, with the supply voltage employed being contingent upon the readout instrumentation used.

It should also be understood that only exemplary concave radii of curvature have been shown in FIGS. 3 and 5. Not only may the various linkage mechanisms for moving array 14 be designed as disclosed in FIG. 3 to effect a large plurality of acoustical focal points, as briefly mentioned previously, they may also be designed to movably position the electroacoustical array in such manner as to have a convex geometrical configuration, which causes a substantially collimated or a variety of acoustically dispersive patterns to be effected, too.

FIG. 7 symbolically portrays both of the aforesaid concave and convex configurations, as well as an intermediate substantially straight configuration, in order to illustrate that the subject variable focus transducer need not be limited to that disclosed in the preferred embodiment thereof.

Although no particular operator is disclosed herein as manipulating focal position control 17, it should be understood that either a human operator or an automatic instrumented servomechanism type of operator may be employed. Hence, if rapid automatic focal adjustments are desired during target search operations, an appropriate overridable automatic system may be used. Then, once a target is acquired, a human operator may, if desired, take over by overriding the automatic system and adjusting the transducer focus to give optimum acoustical energy impact on the target and maximum echo response therefrom. So doing obviously not only enables a target

to be more readily detected, but also facilitates the classifying thereof by observation of whatever readout is included in transceiver 12. Accordingly, it may readily be seen that the variable focus electroacoustical transducer constituting this invention is an improvement over those known heretofore.

Obviously, other embodiments and modifications of the subject invention will readily come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing description and the drawings. It is, therefore, to be understood that this invention is not to be limited thereto and that said modifications and embodiments are intended to be included within the scope of the appended claims.

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.

What is claimed is:

1. A variable focus electroacoustical transducer comprising in combination:

a plurality of contiguously disposed, relatively movable, reversible electroacoustical energy converter means for converting received acoustical energy into electrical energy proportional thereto, and for converting received electrical energy into acoustical energy proportional thereto;

means connected to said plurality of contiguously disposed, relatively movable, reversible, electroacoustical energy converter means for mounting each thereof in such flexible, curved geometrically configured array as to effect the acoustical focusing thereof at substantially the same focal point on an axis bisecting the angle of curvature thereof; and

means connected to said array mounting means for varying the curvature of the aforesaid flexible geometrically configured array in such manner as to move the acoustical focal point thereof along the aforesaid axis in response to predetermined signals applied thereto.

2. The device of claim 1 wherein said means connected to array mounting means for varying the curvature of the aforesaid flexible geometrically configured array in such manner as to move the acoustical focal point thereof along the aforesaid axis in response to predetermined signals applied thereto comprises:

means connected to the rearward middle section of said array for the holding thereof in a predetermined fixed position;

movable means effectively connected to the ends of said array for the disposing thereof at predetermined positions relative to the fixed position of said rearward middle section thereof;

means connected to said movable array ends disposing means for the driving thereof; and

means connected to said driving means for controlling the amount of movement thereof.

3. The device of claim 1 wherein said means connected to said plurality of contiguously disposed, relatively movable, reversible, electroacoustical energy converter means for mounting each thereof in such flexible, curved geometrically configured array as to effect the acoustical focusing thereof at substantially the same focal point on an axis bisecting the angle of curvature thereof comprises:

a resilient acoustically clear encapsulating means disposed completely around said plurality of energy converter means for the flexible holding thereof; and

a flexible backing plate attached to said resilient acoustically clear encapsulating means in such manner as to maintain it in said curved configuration as to effect the aforesaid acoustical focusing thereby.

4. The invention of claim 3 further characterized by a resilient wire mesh screen disposed between the inside

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surface of said acoustically clear encapsulating means and the non-projecting rearward surfaces of said energy converter means.

5. The invention of claim 1 further characterized by: a housing, having an aperture in the front section thereof, for encasing said variable focus electroacoustical transducer;

an acoustically clear diaphragm mounted in said aperture for transmitting the acoustical energy there-through that is received and broadcast by said plurality of electroacoustical energy converters; and

a sound absorbing material mounted within said housing for absorbing the acoustical energy not directed in such manner as to pass through said diaphragm.

6. The invention according to claim 5 further characterized by a fluid means disposed within the unoccupied space of said housing for coupling the acoustical energy passing between said diaphragm and the aforesaid plurality of electroacoustical converter means.

7. The device of claim 1 wherein said plurality of continuously disposed, relatively movable, reversible electroacoustical energy converter means comprises:

a plurality of piezoelectric bars;

a plurality of pairs of electrodes connected to said plurality of piezoelectric bars at opposite ends thereof, respectively;

a first electrical conductor means connected to one electrode of each pair of said plurality of pairs of electrodes and adapted for being connected to a predetermined utilization apparatus; and

a second electrical conductor means connected to the other electrode of each pair of said plurality of pairs of electrodes and adapted for being connected to the aforesaid predetermined utilization apparatus.

8. The device of claim 7 wherein said piezoelectric bars are barium titanate.

9. The device of claim 7 wherein said piezoelectric bars are lead zirconate.

10. The device of claim 7 wherein one of said pair of electrical conductor means is an insulated electrical wire and the other thereof is a wire mesh screen.

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