July 29, 1969 A. E. WALLEN 3,458,855

UNDERWATER ACOUSTIC GENERATOR WITH VARIABLE RESONANT FREQUENCY

Filed April 23, 1968 5 Sheets-Sheet 1

FIG. 1

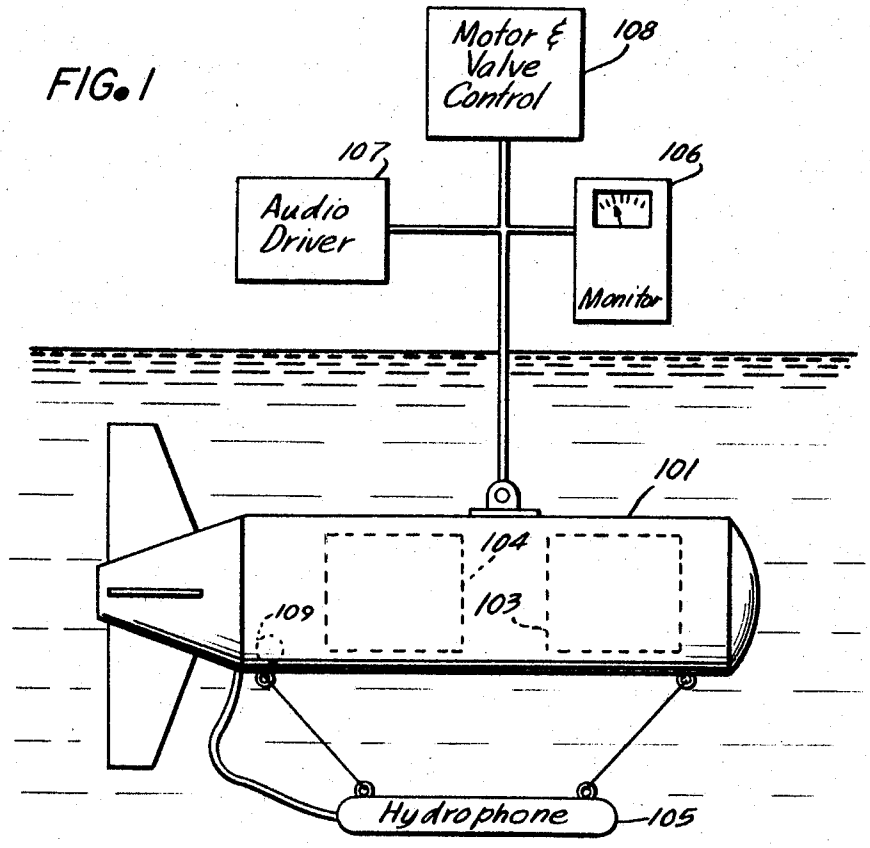
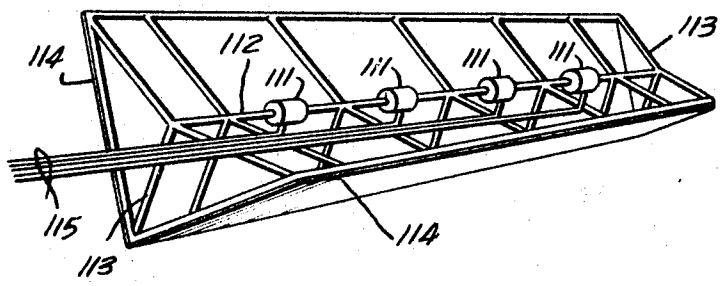


FIG. 2



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FIG. 3

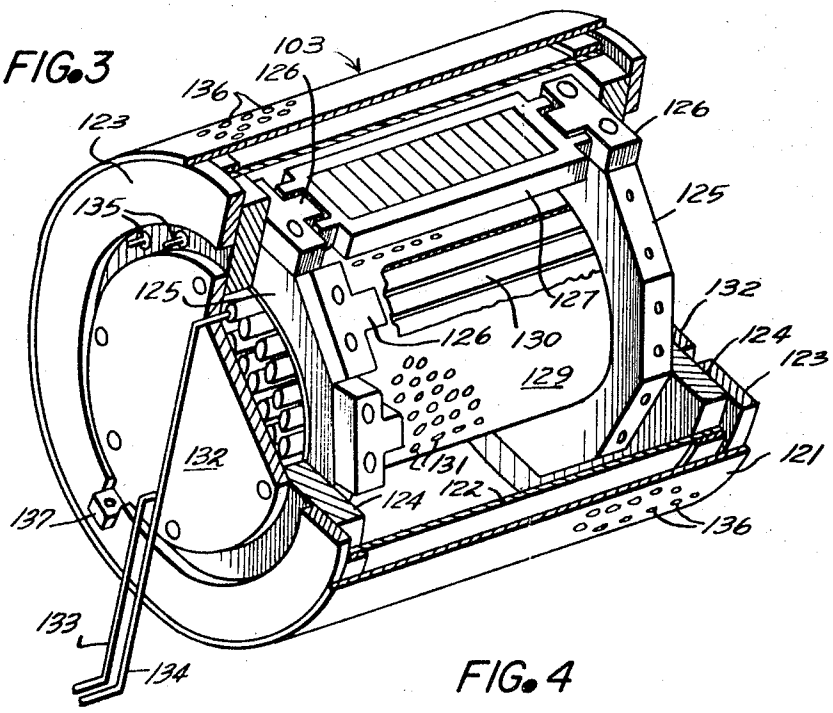


FIG. 4

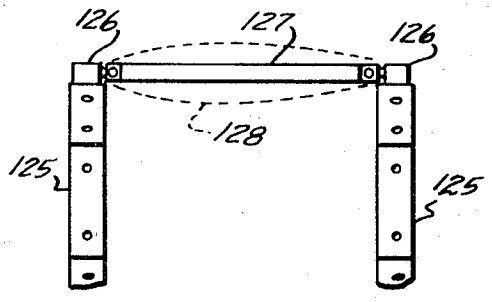
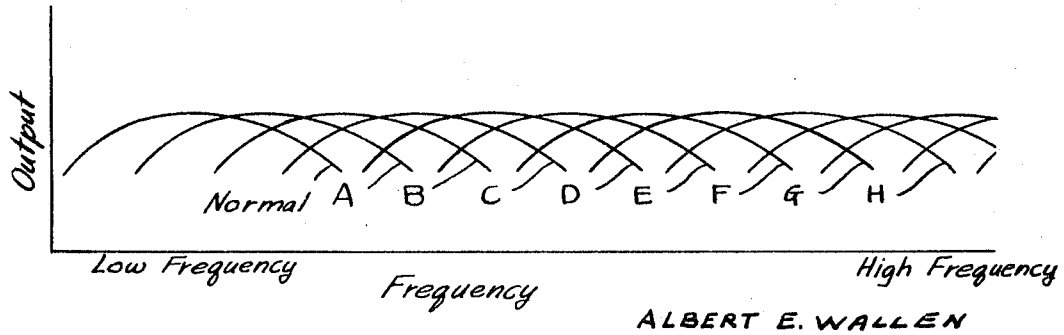


FIG. 5



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FIG. 6

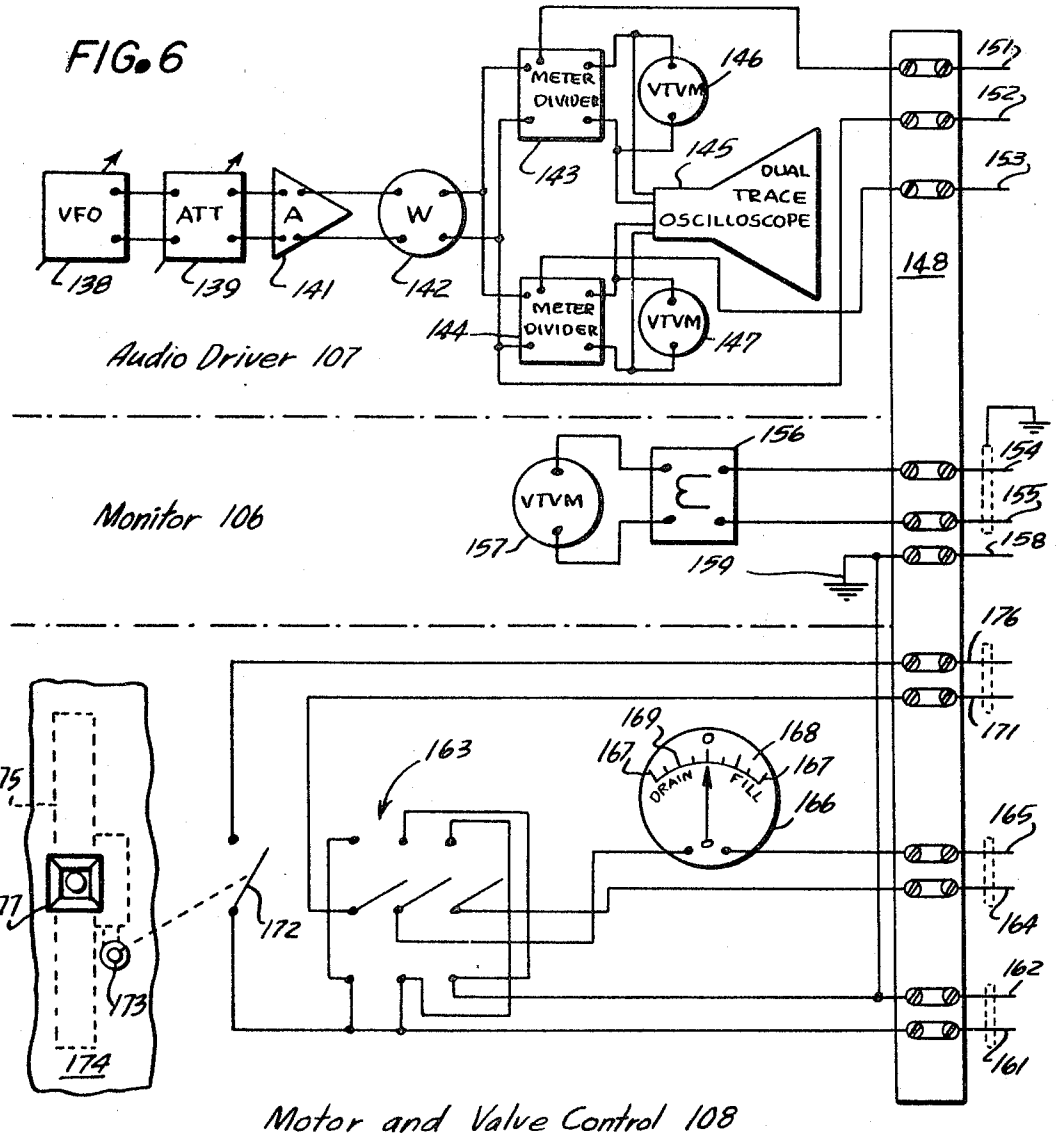
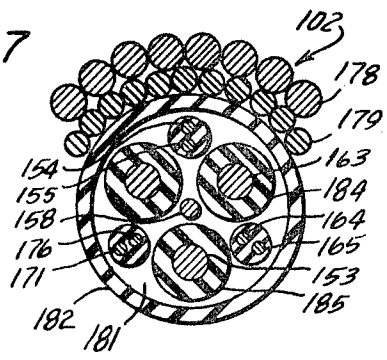


FIG. 7



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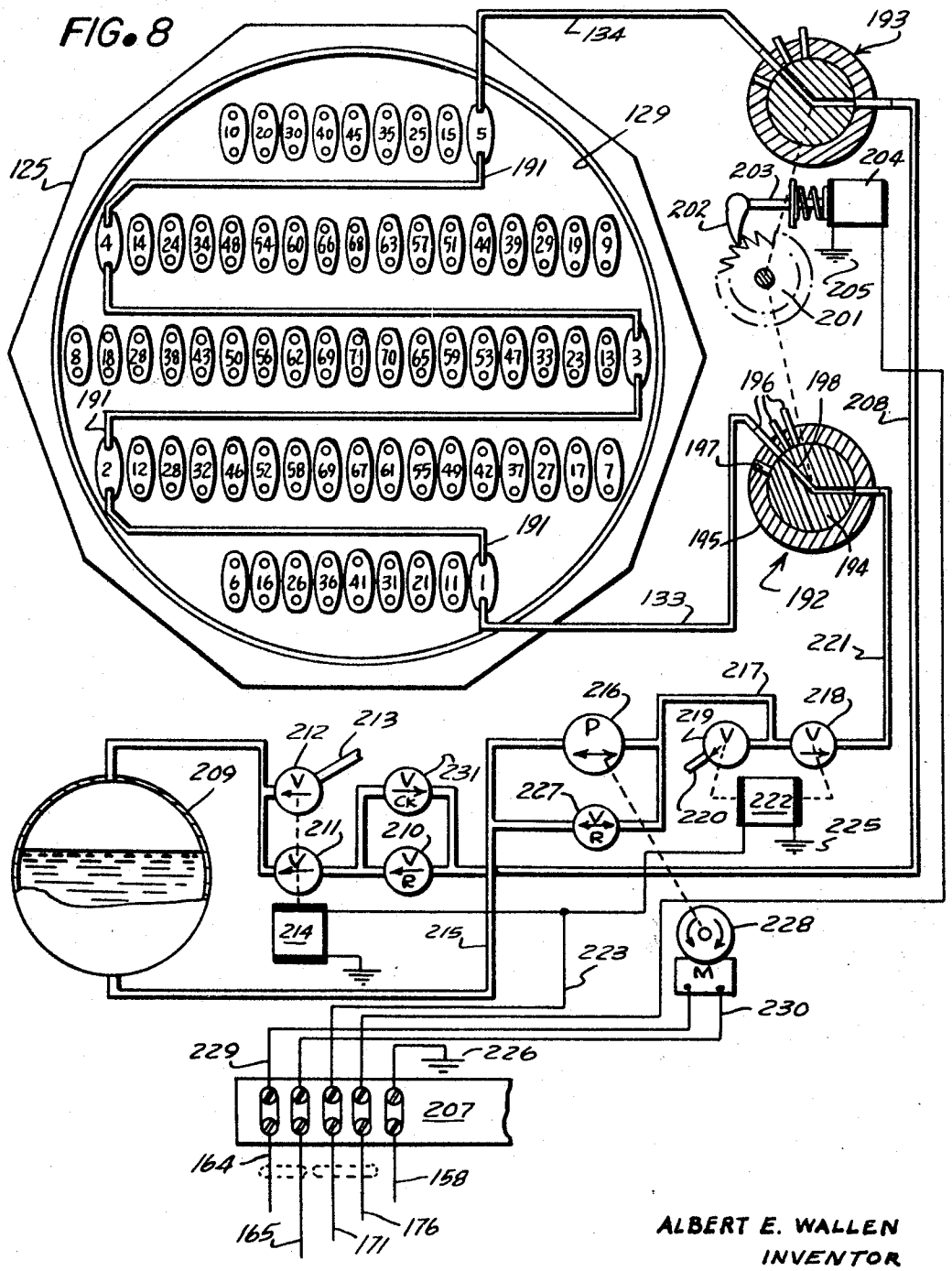
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UNDERWATER ACOUSTIC GENERATOR WITH VARIABLE RESONANT FREQUENCY

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FIG. 8



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FIG. 9

POS.	TUBES FILLED
A	1 2 3 4 5
B	6 7 8 9 10
C	11 12 13 14 15
D	16 17 18 19 20
E	21 22 23 24 25
F	26 27 28 29 30
G	31 32 33 34 35
H	36 37 38 39 40
I	41 42 43 44 45
J	46 47 48
K	49 50 51
L	52 53 54
M	55 56 57
N	58 59 60
O	61 62 63
P	64 65 66
Q	67
R	68
S	69
T	70
U	71
X	CALIBRATION BLANK

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UNDERWATER ACOUSTIC GENERATOR WITH VARIABLE RESONANT FREQUENCY

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Int. Cl. H04b 13/02
U.S. Cl. 340—5 10 Claims

ABSTRACT OF THE DISCLOSURE

The output frequency of an underwater acoustic generator employing bender-bar transducers is altered from the surface by causing compliant tubes, used in providing loading of the bender-bars, to be selectively filled with, or exhausted of, an incompressible fluid.

This invention relates to an improved underwater acoustic generator with a variable frequency output. More particularly, the invention relates to an underwater acoustic generator the output of which may be varied over several octaves by a remote control of the resonant frequency without removing the generator from the water.

It is known, in the prior acoustic generator art, to employ a grouping of compliant tubes to provide a loading of piezoelectric radiating elements. It is also known, in the prior art, to alter the resonant frequency of such units by altering the number of such tubes. Heretofore, this alteration required recovery of the underwater housing, disassembly of the housing, altering the number of tubes, reassembly, outgassing the insulating oil, repositioning the acoustic generator. This technique while technically satisfactory, requires the expenditure of considerable time and effort.

The present invention overcomes the aforesaid laborious steps by selectively filling certain ones of the enclosed compliant tubes with the insulating oil. This effectively removes the tube from the generator without physically removing the tube. The selective filling and exhausting of certain tubes may be accomplished by employing commercially available control and fluid handling apparatus.

It is, accordingly, an object of this invention to provide a method and apparatus for altering the frequency of an underwater acoustic generator.

More particularly, this invention has, as an object thereof, provision for altering the number of compliant tubes effective in loading a piezoelectric acoustic generator without disassembly of said acoustic generator.

A further object of the invention is the provision of a control system to alter the resonant frequency of a submerged bender-bar-type acoustic generator without recovery of the acoustic generator from its submerged location.

Another object of the present invention is the provision of a control system to permit the filling or exhausting of selected compliant tubes in a submerged acoustic generator from a remote surface control position.

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:

FIG. 1 is a diagrammatic showing of the major components of the system of the invention showing a towed form of the acoustic generator;

FIG. 2 is a showing of an array of acoustic generators, each controlled in accordance with the invention, designed for fixed location;

FIG. 3 is a simplified illustration, in quarter section, of a preferred form of the acoustic transducer of the system;

FIG. 4 is an elevation of the mounting of a single bender-bar element;

FIG. 5 is a graphic representation of the output of the bender-bar transducer with different number of compliant tubes filled;

FIG. 6 is a schematic representation of a portion of the control system according to the invention;

FIG. 7 is a cross section of a control cable useful in connecting the control elements shown in FIG. 6 to a towed acoustic generator;

FIG. 8 is a schematic representation of a portion of the control system located at the acoustic generator including a simplified showing of the interconnection of several of the compliant tubes; and

FIG. 9 is a table of the order of filling of the compliant tubes shown in FIG. 8.

Referring to FIG. 1, there is shown an underwater acoustic generator housing **101** adapted to be towed beneath the surface of a body of water by means of an electrical conductor carrying tow cable **102**. The housing encloses a forward bender-bar transducer **103** and an aft bender-bar transducer **104**, shown by broken line outline. Identical transducers **103** and **104** are positioned behind acoustic windows, not shown, and their combined output is monitored by hydrophone **105** and suitable monitor readout circuitry **106**. Hydrophone **105** is illustrated as being suspended below the generator housing **101**. Such an arrangement is satisfactory, and even preferred, for accurate calibration, however, a mounting placing hydrophone **105** within the aft portion of the generator housing **101**, as indicated at **109**, is preferred for operational units. Similarly, the showing of the attachment is illustrative only and a more forwardly placed attachment is preferred for operational units as will be understood by proficient practitioners of hydrodynamic design. The transducers **103** and **104** are driven by an audio driver, shown diagrammatically at **107**. Transducers **103** and **104** have a mechanism for filling and exhausting compliant tubes associated therewith. The filling and exhausting mechanism is controlled by suitable control means illustrated diagrammatically at **108**.

The invention is not limited to towed or otherwise mobile acoustic generators, but may employ with equal facility stationary submarine arrays, such as that illustrated, for example, in FIG. 2. This arrangement employs four bender-bar acoustic generator assemblies **111** on a common axial support **112**. Support **112** is incorporated in a framework **113** which also provides support for two reflectors **114** at approximately one-quarter wavelength distance from the transducer assemblies **111**. Each of the generator assemblies **111** is equipped with apparatus, herein described, to vary its resonant frequency in response to electrical control signals carried by suitable cables **115**. Cables **115** connect each generator assembly **111** with a remote, generally surface located, control point.

The particular housing and mounting structure depicted in FIGS. 1 and 2 are illustrative of the general types of mounting contemplated by the invention and are not considered limiting. Many of the known towed vehicle housings used in anti-submarine warfare and minesweeping arts, not resembling housing **101** of FIG. 1, are suitable for housing the apparatus of the invention. Similarly, the invention is useful in fixed installations other than that shown in FIG. 2, which resembles, in certain details, a Honeywell model S–1232–A1 line array. However, for purposes of explanation, the general embodiment of FIG. 1 will be described.

FIG. 3 is a quarter section view of bender-bar transducer **103** of the invention, with some parts removed for purposes of illustration. Within a protective shell **121** and an acoustic window **122**, also serving as an outer casing, which are supported by pairs of annular rings **123** and **124**, respectively, are positioned two mountings **125**. A series of bender-bar supports **126**, five shown, are positioned about the periphery of mountings **125**. The supports **126** are arranged in pairs, one member of each pair on opposite mountings **125**, so as to support a plurality of piezoelectric bender-bars **127**.

As shown in FIG. 4, each bender-bar **127** is mounted so as to flex, as shown by broken lines **128**, upon electrical excitation. The complete structure of the assembly of bender-bars **127**, supports **126**, and mountings **125** may be visualized as a wooden-barrel-like structure in which the staves, bender-bars **127**, are caused to vibrate so as to vary the volume of the structure. When alternating current is applied to the bender-bars, they will all bend inward toward the compliant tubes on one-half of the sine wave, thus compressing the entrapped oil surrounding the compliant tubes. Spacing between the bars is about $\frac{1}{32}$ of an inch and will only allow a very small amount of oil to flow from the compliant tube chamber to the area between the bender-bars **127** and the acoustic window **122**, this flow is not fast enough to provide pressure relief and the pressure will continue to build up until relieved by the compression of the compliant tubes. On the other half of the sine wave, all the bars bend outward releasing the internal pressure and creating a pressure between the bender-bars **127** and the acoustic window **122**, thus establishing a pressure against the water surrounding the acoustic window **122**. On the next half of the cycle, the first part is repeated again thus generating an alternating pressure wave in the water. Filling the tubes with oil reduces the amount of internal pressure relief, thus restricting the oscillatory amplitude of the bender-bars which causes them to oscillate at a higher frequency. Although the structure illustrated is shown as providing for ten bender-bar elements, the exact number of bender-bar elements may be altered to meet various design parameters. The bender-bars **127** of the preferred form of the invention are made of lead zirconate, but, as in the case of the number of bars, the skilled acoustic generator artisan may make appropriate substitutions without departing from the teachings of the invention.

Again referring to FIG. 3, in the center region of the bender-bar transducer **103** are located compliant tubes **130**. An inner separator **129** surrounds the compliant tubes **130**. Perforations **131** in the inner separator **129** permit the entire cavity within casing **122**, including the interstices between individual ones of compliant tubes **130**, to be filled with a suitable incompressible insulating oil. End plates **132**, mounted on rings **124**, make the cavity oil tight. Compliant tubes **130** have closed ends except for interconnecting tubing which join selected groups of compliant tubes **130** into a series of chambers. Each of the groups of compliant tubes **130** are connected to a fluid supply tube, shown at **133**, and a vent tube, such as shown at **134**. It should be understood that each of the groups of tubes have associated therewith a fluid supply tube **133** and a vent tube **134**. However, for purposes of illustration only a single tube of each type is illustrated and described. Feed through terminals **135** permit electrical connection to the piezoelectric bender-bar elements **127**, within the casing **122**, by suitable internal wiring, not shown, and bender-bar supports **126**. A series of perforations **136** permit contact with the outer, acoustically-transparent casing **122** by fluid within which the transducer is submerged, while permitting protective shell **121** to prevent mechanical contact between outer casing **122** and large objects. Shell **121** may be the outer surface of a towed acoustic generator housing **101**. However, if desired, other mounting structure, such as apertured flange **137**, may be employed.

It has been observed in prior art bender-bar transducers that the removal of a number of compliant tubes increases the resonant frequency of the bender-bar element. However, the relationship of the number of tubes removed to the change in frequency is not linear. The smaller the number of tubes remaining the greater the frequency-deviation-per-tube becomes. The proximity of the removal compliant tube to the bender-bar element is also controlling on the frequency change produced by the removal. The nearer the compliant tube to the bender-bar the more pronounced is the change. Of course, general expressions have been developed for the relationships noted above but the variations between units has made the arrival at a precise frequency a rather time-consuming, empirical task.

By means of a number of tube pairs **133** and **134** and apparatus herein described, the selected ones of compliant tubes **130** may be filled with the same insulating oil as surrounding the tubes, and thereby effectively removed without physical removal. The acoustic output energy of the device with sequential filling of selected groups of compliant tubes **130** is represented by FIG. 5.

In FIG. 5, the left-most curve, labeled normal, represents the output of the device with all tubes gas filled. As shown, the output of the bender-bar transducer exhibits a rather broad peak. Because the bender bars **127** will tend to oscilalte at the lowest possible frequency, the filling of selected groups of compliant tubes **130**, which may be interconnected to form fluid circuits, with fluid shifts the curve up the frequency scale. It should be understood that the device operates on only a single one of the nearly identical curves shown in FIG. 5 at a time. As the resonant frequency increases a lesser amount of drive power is required to make the individual bender-bar elements **127** achieve the maximum deflection permitted by the reduced compliance afforded by the fluid filled tubes. This reduced deflection amplitude is offset, somewhat, by an increased coupling efficiency at the higher resonant frequency. As a result, a linear power output over the operational range is obtainable with only minor adjustments of the driving power and appropriate selection of compliant tubes to be filled.

The precise number of circuits is a matter of design dictated by the requirements of the particular installation. The simplest embodiment would be a two frequency system in which a certain number of the compliant tubes would be filled to shift the resonant frequency. With only a moderate increase in complexity over the two frequency system, a more comprehensive system may be provided.

The control and instrumentation of the audio generator is accomplished by the apparatus and circuit arrangement shown in FIG. 6. The circuit and apparatus diagram is divided into three sections, an audio driver section **107**, a monitor section **106** and a motor and valve control section **108**. As shown, the audio driver section **107** includes a variable frequency oscillator **138**. The variable frequency oscillator **138** is connected to an attenuator **139**. The output of attenuator **139** is connected to amplifier **141**, a 5 kva. amplifier. The output of amplifier **141** is connected via a wattmeter **142** to meter dividers **143** and **144** and those to a terminal strip **148**. This connection arrangement permits monitoring the audio driver circuit **107** while the two individual transducers are driven an arrangement which has proven optimum for acoustic generator operation. Meter dividers **143** and **144** are frequency compensated voltage dividers and current transformers. They reduce the voltage and current 1000/1 for safe monitoring on a VTVM. The electrical signal is fed from meter dividers **143** and **144** to suitable measuring devices, dual trace oscilloscope **145** and vacuum tube voltmeters **146** and **147**, which provide an indication of the electrical drive signal fed to each of the individual bender-bar assemblies **103** and **104**. The output of audio driver circuit **107** is, as noted above, fed to a suitable terminal strip **148** and is carried therefrom by conductors **151**, **152**, and **153** as two in-phase signals having a common conductor **152**.

The acoustic energy radiated from acoustic generator housing **101** impinges hydrophone **105**, which as previously noted may be mounted within acoustic generator housing **101**, to produce an electrical output which is transmitted via shielded conductors **154** and **155** to terminal strip **148** and monitor circuit **106**. The electrical signal carried by conductors **154** and **155** is fed to a repeater coil **156** which, in turn, feeds a suitable indicator such as a vacuum tube voltmeter **157**. A conductor **158** from acoustic generator **101** is connected to terminal strip **148** and then to a suitable common ground **159**. Although shown as a portion of the monitor circuit **106**, the conductor **158** and common ground **159** serve as a reference and DC return for the audio driver circuit **107**, monitor circuit **106**, and motor and valve control circuit **108**.

Referring to the motor and valve control circuit **108** shown in the lower portion of FIG. 6, DC power is brought into terminal strip **148** by conductors **161** and **162**. A three pole switch **163**, which has a neutral center position, has two of its poles connected to conductors **161** and **162** to have a selective, polarity-reversed output. The output of the polarity-reversing position of switch **163** is routed to terminal strip **148** and thence, via conductors **164** and **165**, to a reversible motor in acoustic generator **101**. The current drain of said motor is monitored by a reversible DC ampmeter **166**.

The faces of meter **166** has two calibration markings in each current direction, the manner in which the marking serve their intended function will be explained in discussion of the motor and valve apparatus. Mark **167**, near the full-scale point, is used in calibration of the generator and may be suitably labeled, if desired. An intermediate marking **168** on one polarity scale is used to indicate that the filling of one group of compliant tubes **130** is completed and may be suitably labeled if desired. Marking **169**, nearest the zero-current position on the opposite polarity scale, is used to indicate that one group of compliant tubes **130** are emptied of fluid and may be suitably labeled, if desired.

The third pole of switch **163** is used to operate suitable valve mechanisms, to be later described, by connecting conductor **171**, via terminal strip **148**, to the positive DC power conductor **161**, when switch **163** is in either of extreme positions.

A second switch **172** is operated by a button **173** which is mounted on the panel **174**, which may comprise part of the housing of the motor and valve control **108**. Button **173** also rotates indicia bearing drum **175** past a viewing aperture **177** by suitable linkage not shown. Upon each closure, switch **172** operates a distribution valve, to be later described, by connecting conductor **176**, via terminal strip **148**, to the positive DC power conductor **161**. Like conductors **154** and **155**, conductors **164** and **165**, and conductors **171** and **176**, are contained in suitable shielding to prevent the various audio frequency and DC switching circuits from interfering with one another. As previously noted, the electrical conductors joining the control circuitry and audio generator **101** are carried within tow cable **102**.

Referring to FIG. 7, tow cable **102** is, preferably, covered with a double layer of armor cable. The outer layer **178** of armor is comprised of twenty-four strands of .070 diameter steel wire in a left hand lay. The inner layer **179** of armor comprises twenty-four strands of .055 wire in a right hand lay. The electrical conductors are contained in an insulation material **181**, which may be made of a material known under the trade name "Permagum," surrounded by an outer, waterproof layer **182**. Layer **182** is made of polyethylene and has a thickness of .045 inch. The individual conductors **151**, **152**, and **153** are, preferably, No. 16 AWG 7 tinned wire with .058 inch insulating layers **183**, **184**, and **185**, of polyethylene suitably color coded. Conductor **158** may be, preferably, a number of 20 AWG wire and is centered between conductors **151**, **152**, and **153**. Conductor **158** serves as the instrumentation ground return. The shielded conductor pairs **154**, **155**; **164**, **165**; and **171**, **176** are spaced between layer **182** and the conductors **151**, **152**, and **153** in the space between the individual conductors **151**, **152**, and **153**. Conductors **158**, **164**, **165**, **171**, and **176**, used in the control of the filling and exhausting of compliant tubes **130**, terminate within audio generator housing **101**, in a suitable connection means.

Referring to FIG. 8, contained within mounting **125** are shown a plurality of compliant tubes **1–71**. It should be understood that more tubes are generally used but are grouped into clusters with common connections to the filling and exhausting mechanism, however, for purposes of illustration and explanation it is sufficient to consider the transducer as including seventy-one compliant tubes as illustrated in FIG. 8. The compliant tubes are connected in fluid circuits by suitable internal tubes **191**. In the example of FIG. 8, only a single circuit comprising individual compliant tubes **1**, **2**, **3**, **4**, and **5** is illustrated, but the remaining tubes are grouped in similar circuits, as will be explained. In the system of FIG. 8 the seventy-one tubes are connected in twenty-one fluid circuits; nine with five compliant tubes each; seven with three; and five with one.

The fluid circuit is connected by tube **133** to a distribution valve **192** and by tube **134** to a distribution valve **193**. Valves **192** and **193** are physically identical and, for purposes of explanation, only the former will be described in detail.

Valve **192** has a cylindrical center portion **194** which is fitted in, and rotated with respect to, an outer portion **195**. The outer portion **195** has twenty-one fluid passing connections **196** (three shown) and a single blank space **197**. Center portion **194** fits outer portion **195** with a fluid tight fit and, thereby, seals all of fluid passing connections except one which communicates with a fluid passage **198** in center portion **194**. Center portion **194** is mechanically joined to the center portion of valve **193** in such a manner that the two valves align with corresponding fluid passing connections. The two valve assemblies **192** and **193** may be made integrally, if so desired.

Center portion **194** and the center portion of valves **193** are mechanically joined to a twenty-two tooth ratchet **201**. This ratchet **201** cooperates with a pawl **202** mounted on plunger **203** of solenoid **204**. One electrical lead of solenoid **204** is connected to ground point **205** and the other electrical lead **206** is joined to conductor **176** at terminal strip **207**. Terminal strip **207** is shown for purposes of illustration and, like terminal strip **148**, may be any suitable multi-wire electrical connection, if desired.

From center portion of valve **193** a fluid conduit **208** provides a passage for the oil to a fluid reservoir **209** via relief valve **210** and isolation valve **211**. Relief valve **210** is bypassed for gas flow by a check valve **231**. Isolation valve **211** is paired with a similar isolation valve **212** which is fed by fluid conduit **213** from the other bender-bar transducer **104**. Both isolation valves **211** and **212** are actuated by common solenoid **214**.

From fluid reservoir **209** the oil is conducted by conduit **215** to a reversible pump **216**. The output of pump **216** is conducted via conduit **217** through isolation valve **218** and conduit **221** to distribution valve **192**. Isolation valve **218** is paired with isolation valve **219** to provide a connection from conduit **217** to bender-bar transducer **104** via conduit **220**. Isolation valves **218** and **219** are actuated by solenoid **222**. Solenoids **214** and **222** have one lead each connected to electrical conductor **223** which is joined to electrical conductor **171** at terminal strip **207**. The other leads from solenoids **214** and **222** are grounded at points **224** and **225** respectively. Electrical conductor **158** is connected by terminal strip **207** to a ground point **226**.

Pump **216** is bypassed by a suitable two-way relief valve **227**, the relief pressure thereof is greater than the relief pressure of relief valve **210**. A reversible DC motor **228**, connected by suitable electrical conductors **229** and

230 to electrical conductors 164 and 165 at terminal strip 207, drives pump 216 in a direction determined by the position of switch 163 (FIG. 6) to either fill or exhaust the particular compliant tube circuit selected by distribution valves 192 and 193.

As previously mentioned, the shift of resonant frequency is proportional to the percentage of the compliant tubes 130 filled and inversely to the distance the particular compliant tube is removed from the bender-bar elements. Assuming it is desired to increase the resonant frequency in the most nearly linearly related steps, the tubes are grouped into circuits such that a plurality of individual compliant tubes near the bender-bar elements are filled first. With each depression of button 173, selector valves 192 and 193 connect another group of compliant tubes near the bender-bar elements and symmetrically positioned with respect to the compliant tubes comprising the circuit previously filled. Each depression of button 173 also rotates drum 175 to expose sequentially related indicia in viewing aperture 177. Each indicium corresponds to a particular position of distribution valves 192 and 193 and therefore to a particular tube circuit. The tube circuits corresponding to the twenty-one positions of the device of FIGS. 6 and 8 are given in the chart of FIG. 9. After selecting the desired circuit of complaint tubes with button 173, switch 163 is moved in the appropriate direction to fill or exhaust the circuit as desired. With the use of a calibration chart of the general form shown in FIG. 5, the transducer may be tuned to the particular resonant frequency desired with the use of button 173 and switch 163. To reduce the resonant frequency, it is necessary to depress button 173 twenty-one times for selection of the previously filled circuit before throwing switch 163. In practice the resonant frequency is not altered so frequently as to make this operation troublesome, but a reversible selector valve actuator could be incorporated by the use of normal skill at some increase of connecting cable complexity.

When switch 163 is operated to energize motor 228, solenoids 214 and 222 open the isolation values to permit a complete fluid circuit to fill or exhaust the tubes in both transducers 103 and 104. In the position of distribution valves 192 and 193 shown in FIG. 8, tubes 1, 2, 3 ,4 and 5 are filled in sequence and the oil then passes through relief valve 210 into reservoir 209. Relief valve 210 is held open by the action of pump 216. When relief valve 210 and the corresponding valve associated with bender-bar transducer 104 are held open, the load on motor 228 stabilizes to a value determined by the relief pressure of the valves. This load is monitored on meter 166 (FIG. 6) and calibration marking 168 corresponds to this load.

When the fluid circuit selected by distribution valves 192 and 193 is desired to be exhausted, switch 163 is placed in the appropriate position to cause the pump 216 to move the oil from the compliant tubes to fluid reservoir 209 via conduits 133, 221, and 215. The gas in reservoir 209 is forced out, via conduit 208, by the incoming fluid and bypasses relief valve 210 through check valve 231. When the oil is exhausted from the circuit, pump 216 cavitates and offers only a light load to motor 228. The calibration marking 169 on meter 166 indicates that this condition has been obtained.

When the blank space 197 is selected no oil can flow through conduits 217 and 221 or valve 218. The pressure build-up, when the pump is activated with valves 192 and 193 in this position, opens valve 217 to bypass pump 216. The load on motor 228 is at a maximum for this condition and is indicated by marks 167 on meter 166. Markings 167 are used to calibrate the distribution valves 192 and 193 and indicia wheel 175 in the following manner: First the button 173 then switch 163 (normally in the "full" direction) are pressed serially until a reading on meter 166 indicates that the calibration position has been reached, then the connection between conductor 176 and switch 172 is interrupted. Indicia bearing drum 175 is then rotated until the indicium corresponding to the calibration position appears in viewing aperture 177. The connection between conductor 176 and switch 172 is then reestablished.

The operation of the audio driving circuitry is straightforward. The desired frequency is set on the variable frequency oscillator 138. The attenuator 139 is adjusted to provide the necessary driving power as indicated on wattmeter 142. Meters 146 and 147 and dual trace oscilloscope 145 provide the desired instrumentation of the power to each of the bender-bar transducers 103 and 104. The above operational adjustments, together with the changing of the resonant frequency of the transducer, are assisted by the monitor circuit 106.

The foregoing description is applicable to the towed acoustic generator of FIG. 1. If the fixed array of FIG. 2 is to be employed, it is obvious that the apparatus will be modified. Each of transducer assemblies in acoustic generators 111 would require its own pumping and valve apparatus such as shown in FIG. 6, with the exception that valves 212 and 219 would not be required. The control circuits for the pumping and valve apparatus could be shared. The audio drive circuit of FIG. 6, likewise, could be modified to provide the drive energy for four, rather than two, bender-bar transducers. Such modifications, although not specifically illustrated and described herein, are considered within the scope of competence of a proficient artisan employed in the electro-acoustic industry having the benefit of the teaching herein set forth.

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 invention.

What is claimed is:

1. An underwater acoustic generator comprising:
a casing having acoustically transparent, fluid impervious walls;
an electrically insulating fluid filling said casing;
at least one electroacoustic transducer located within said casing and immersed within said electrically insulating fluid;
a plurality of compliant tubes located within said casing in such a fashion as to be immersed within said electrically insulating fluid and operatively coupled thereby to said electroacoustic transducer; and
fluid supply means located outside said casing and operatively joined to said compliant tubes to selectively fill or exhaust predetermined ones thereof.

2. An underwater acoustic generator according to claim 1 further comprising:
a plurality of fluid conducting tubes connected between predetermined individual ones of said compliant tubes for forming a plurality of fluid circuits.

3. An underwater acoustic generator according to claim 2 in which said fluid supply means includes a pump driven by an electric motor.

4. An underwater acoustic generator according to claim 3 in which said fluid supply means includes distribution valve means connecting each of said fluid circuits successively to said pump.

5. An underwater acoustic generator according to claim 4 in which said distribution valve means has one position isolating said pump from any of said fluid circuits.

6. An underwater acoustic generator according to claim 5 in which said fluid supply means inlcudes additional valve means to isolate said compliant tubes during periods when said pump is inoperative.

7. An underwater acoustic generator according to claim 6 further comprising:

a source of electrical energy to drive said electroacoustic transducer element;

an electrical control circuit for controlling said fluid supply means;

a housing means enclosing said casing and said fluid supply means; and

waterproof electrical conductor means providing operative electrical connection from said source of electrical energy and said electrical control circuit to said electroacoustic transducer means and said fluid supply means, thereby permitting said source of electrical energy and said electrical control circuit to be located above the surface of a body of water when said acoustic generator housing means is submerged within said body of water.

8. An underwater acoustic generator according to claim **7** in which said control circuit includes means to measure the electrical current used by said electric motor.

9. An underwater acoustic generator according to claim **8** in which said control circuit further includes means to control the operation of said distribution valve means to effect the sucecssive connection of said fluid circuits to said pump.

10. An underwater acoustic generator according to claim **9** in which said means to control the operation of said distribution valve means additionally indicates to which of said fluid circuits said pump is connected.

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