

[54] DIRECTIONAL SONAR APPARATUS

[75] Inventor: George R. Douglas, Pittsburgh, Pa.

[73] Assignee: Westinghouse Electric Corp.,
Pittsburgh, Pa.

[22] Filed: June 12, 1973

[21] Appl. No.: 369,329

[52] U.S. Cl. 340/6 R, 343/100 LE

[51] Int. Cl. G01s 3/80

[58] Field of Search..... 340/6 R, 6 S, 16 R, 9;
343/100 LE

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Primary Examiner—Richard A. Farley
Attorney, Agent, or Firm—D. Schron

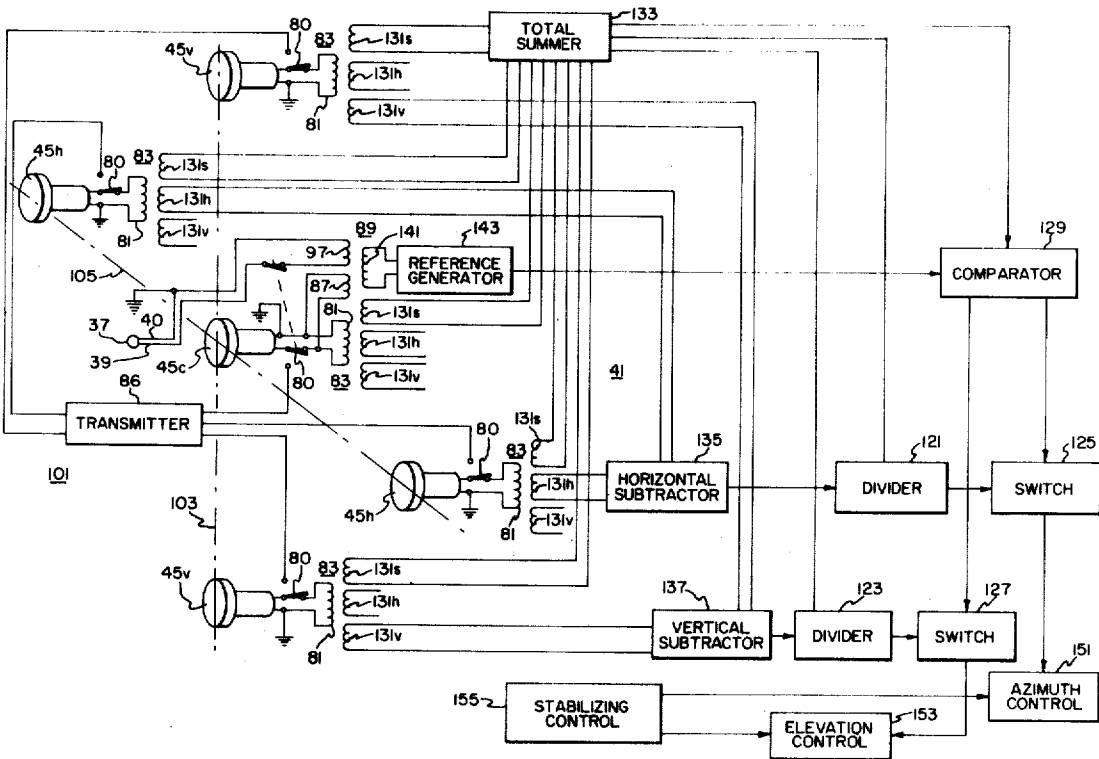
[57] ABSTRACT

The apparatus, typically a homing torpedo, includes an array of main directional sonar electroacoustic transducers, typically Tonpiltz oscillators, so distrib-

uted as to have directional response to signals and connected to generate commands to control the apparatus. The response pattern of this array alone has a main lobe and side lobes, the response to signals along the direction of the main lobe being substantially higher than to signals along the direction of the side lobe. An auxiliary predominately omnidirectional electroacoustic transducer (a hydrophone) is spaced of the order of one wavelength of the signal outwardly from a central main transducer and the combined response of this auxiliary transducer and central main transducer is compared to the total response from the array. If the combined response exceeds the total response, the control commands for the signals are suppressed and if the total response exceeds the combined response the control commands for the signals are enabled to control the apparatus.

There is also apparatus including an array of main electroacoustic transducers and an auxiliary predominately omnidirectional electroacoustic transducer associated with, and spaced outwardly from, each main transducer. Each pair of main transducers and auxiliary transducers are so spaced and their response so combined as to suppress side lobes in the reception pattern of the apparatus.

12 Claims, 21 Drawing Figures



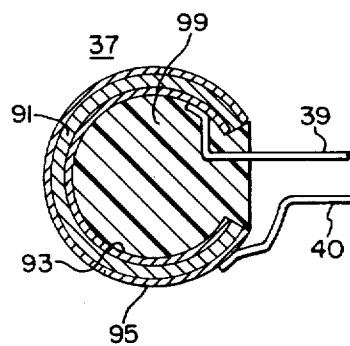
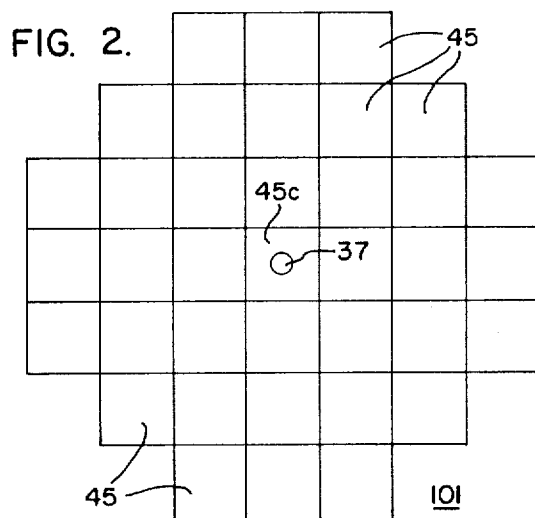
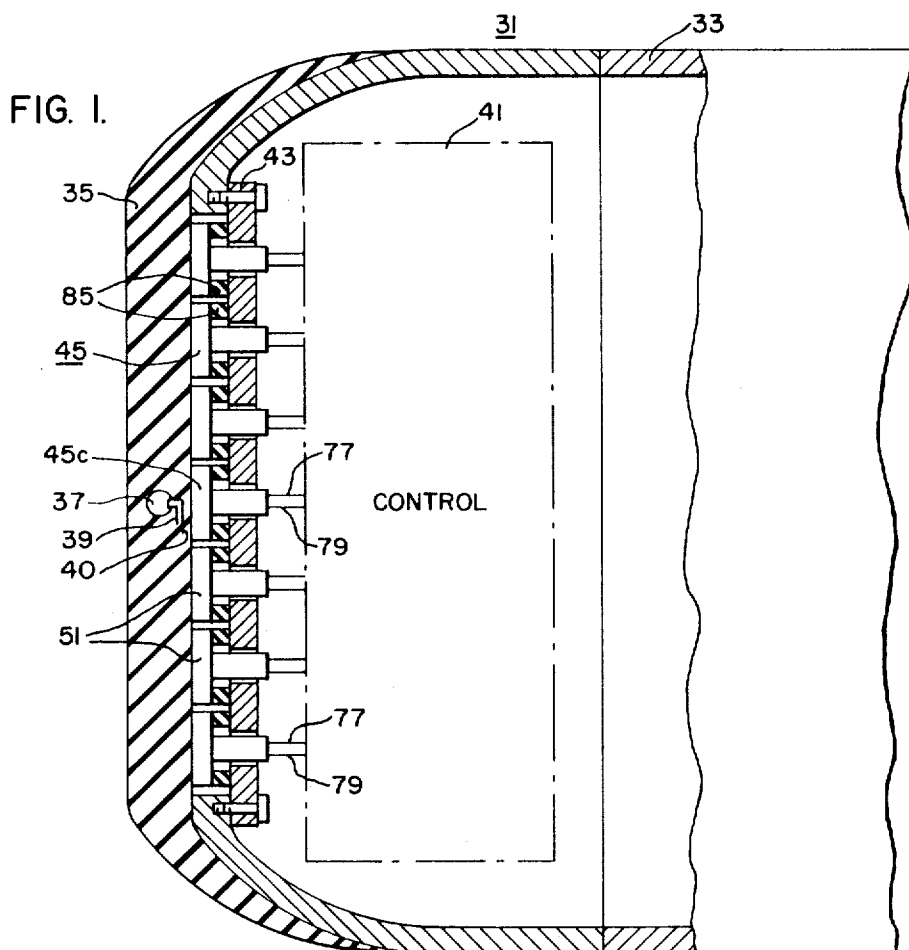


FIG. 4.

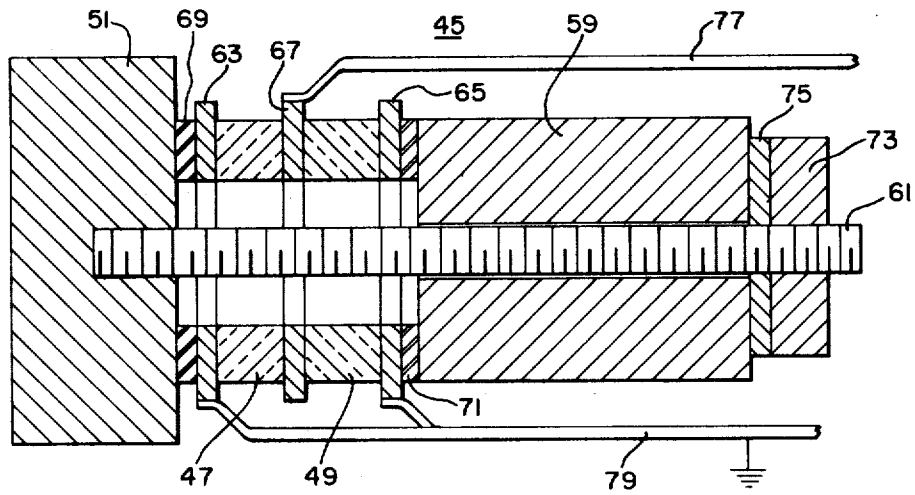


FIG. 3.

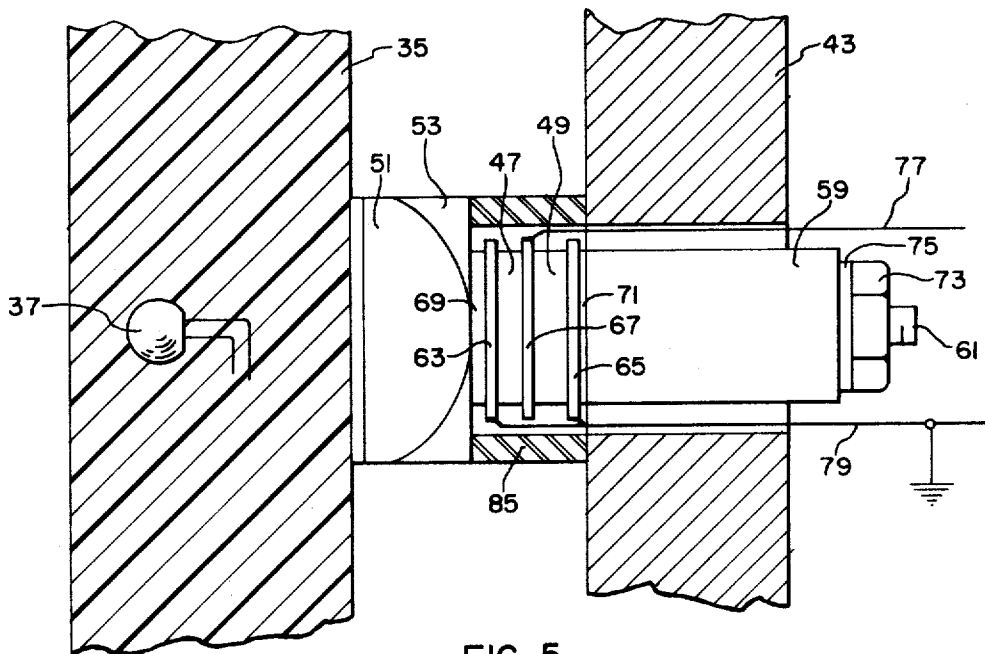


FIG. 5.

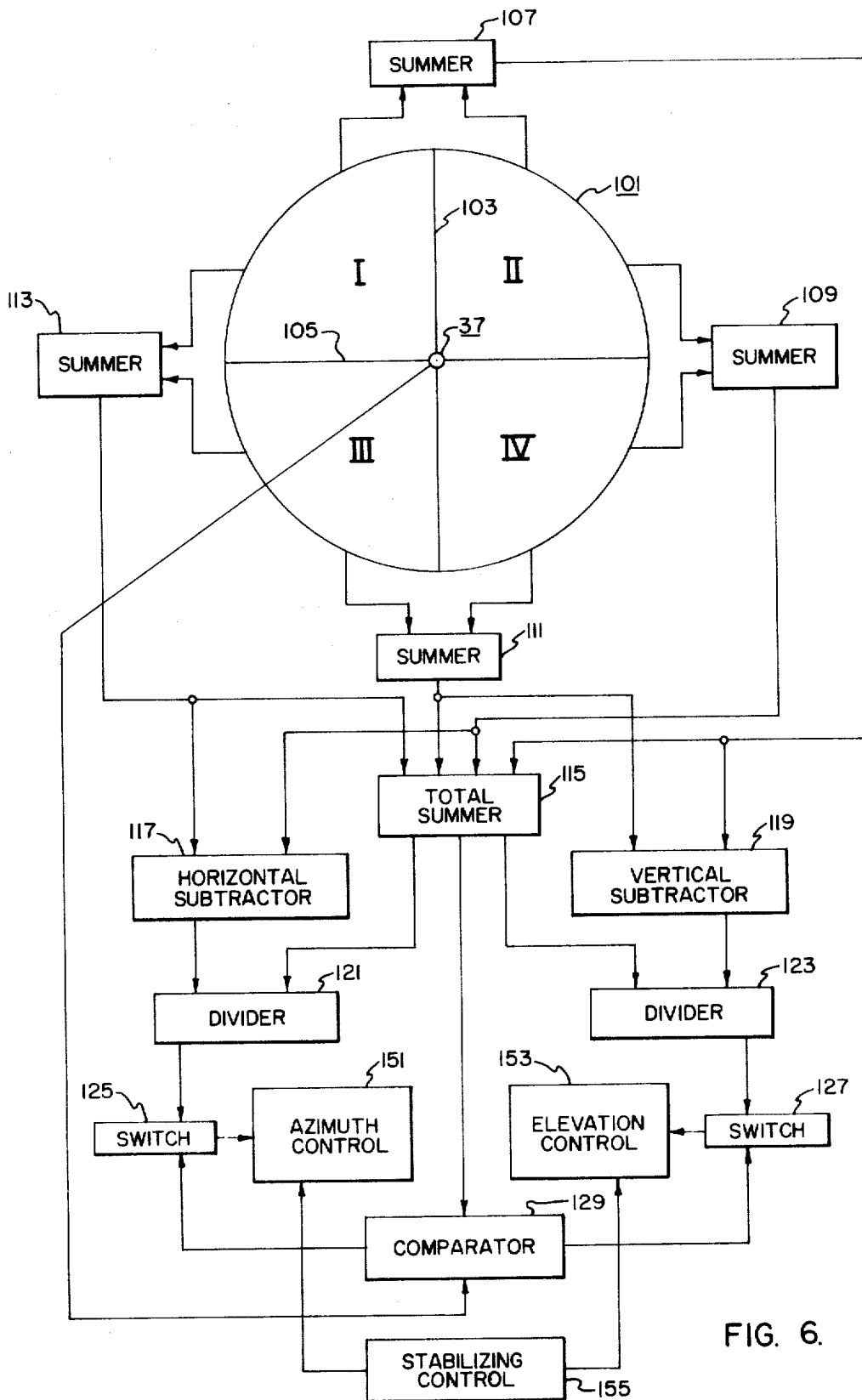


FIG. 6.

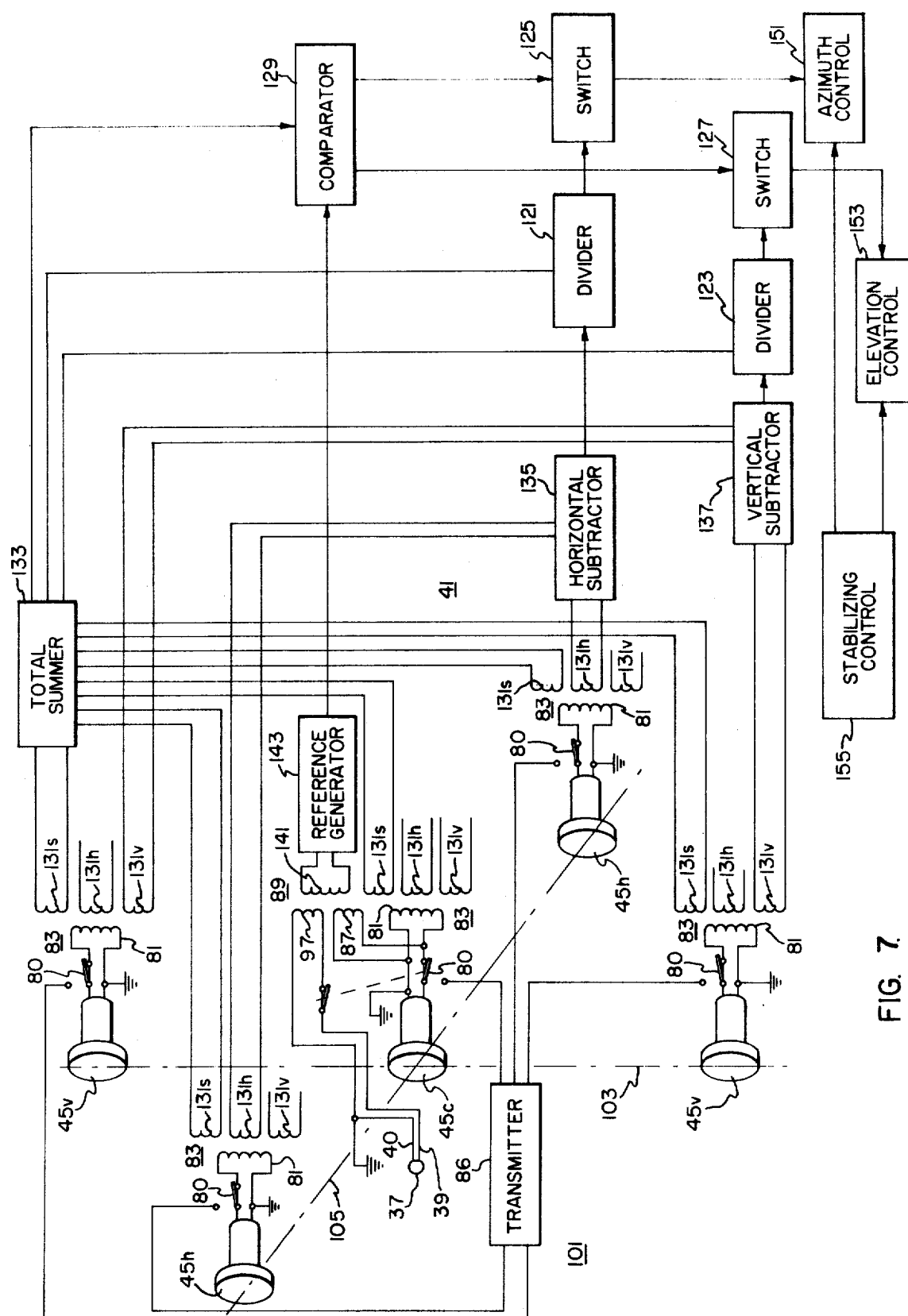


FIG. 7.

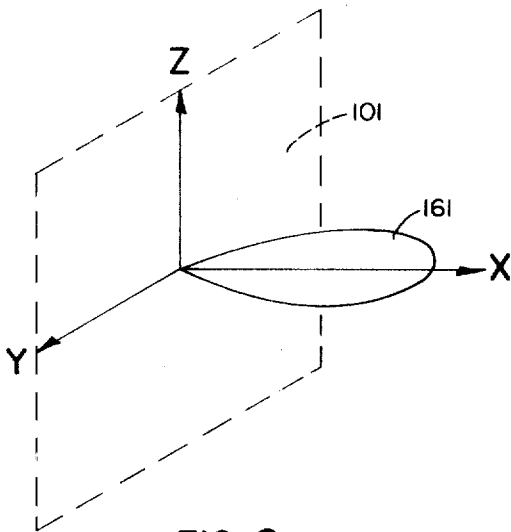


FIG. 8.

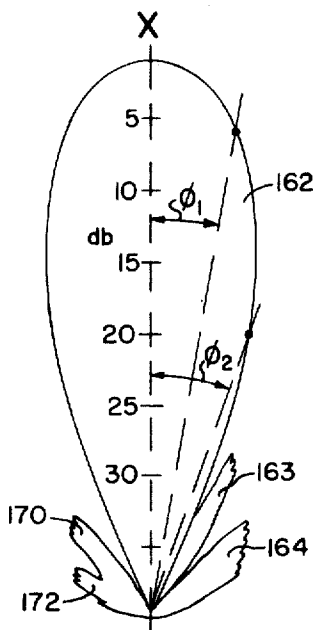


FIG. 9.

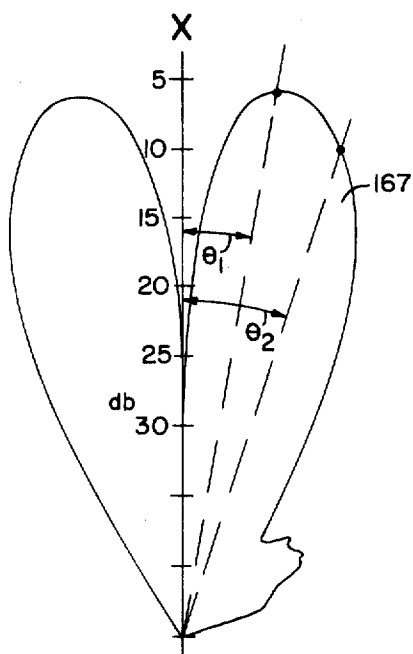


FIG. 10.

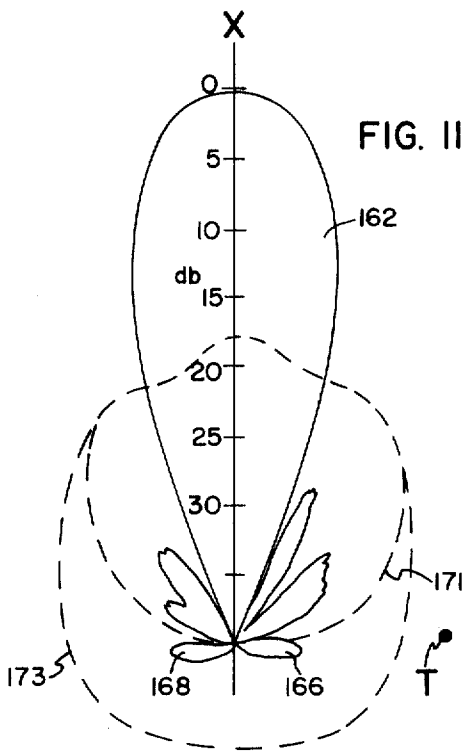


FIG. 11.

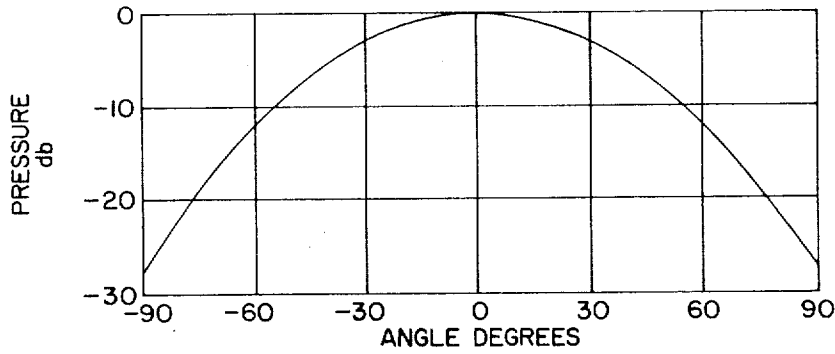


FIG. 12.

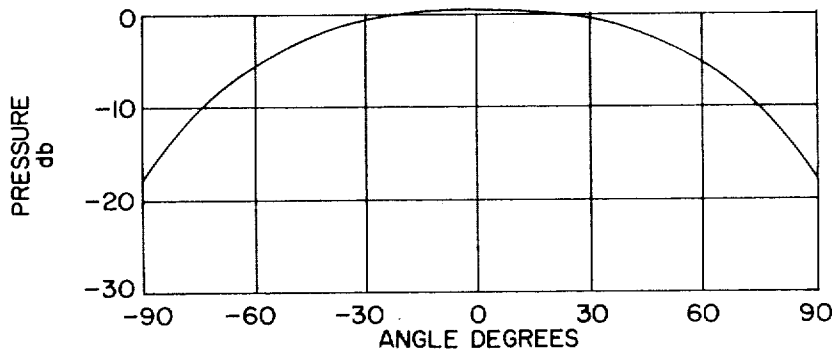


FIG. 13.

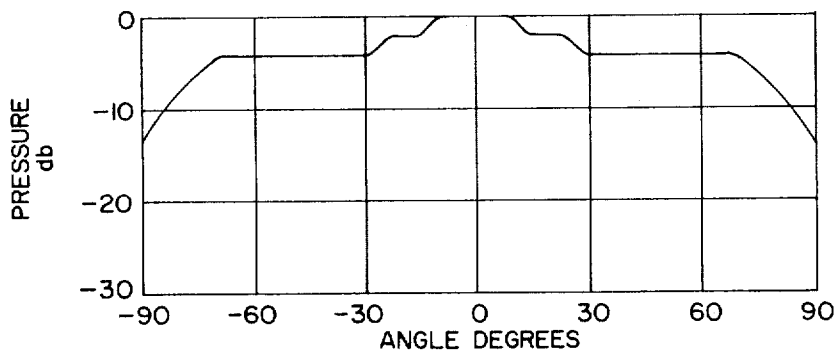


FIG. 14.

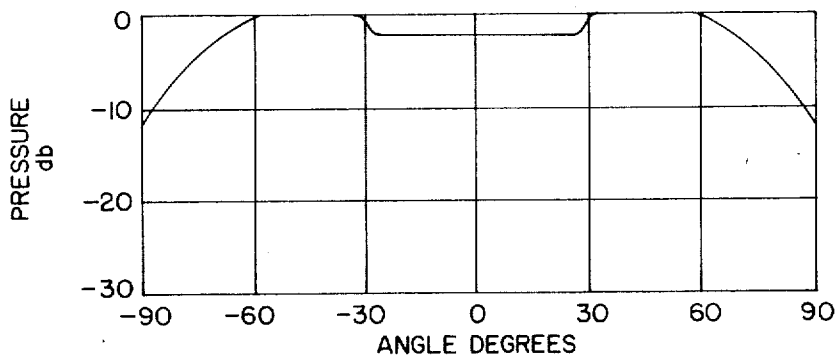


FIG. 15.

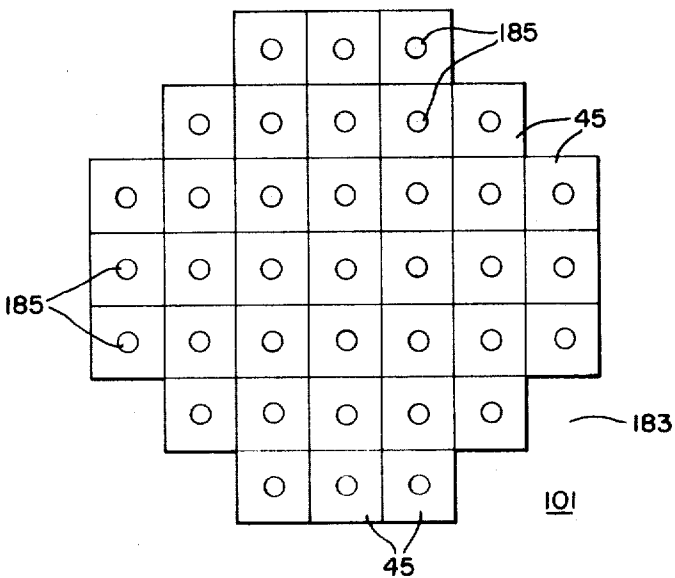


FIG. 17.

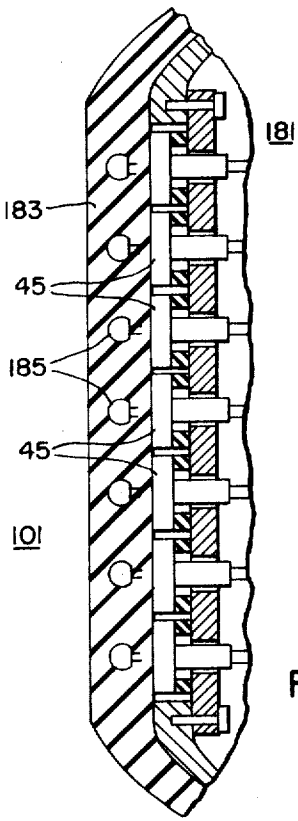


FIG. 16.

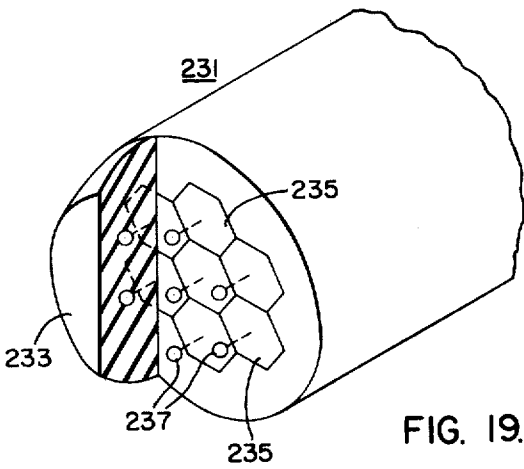


FIG. 19.

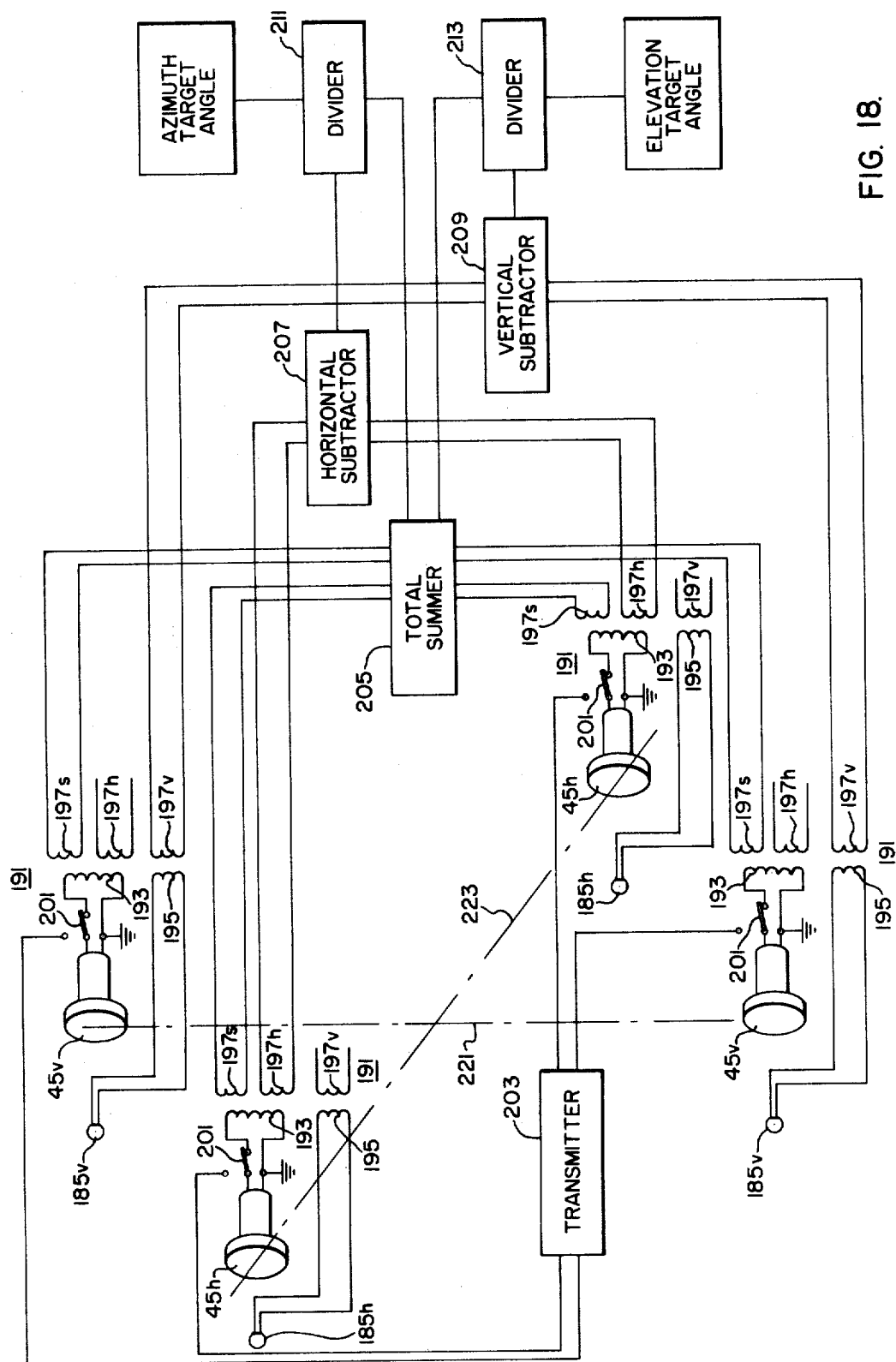


FIG. 18.

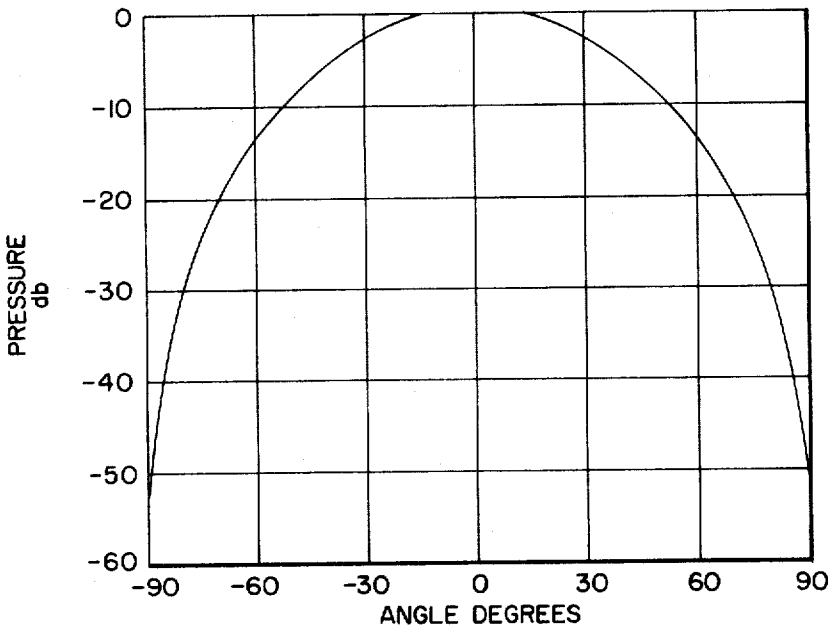


FIG. 20.

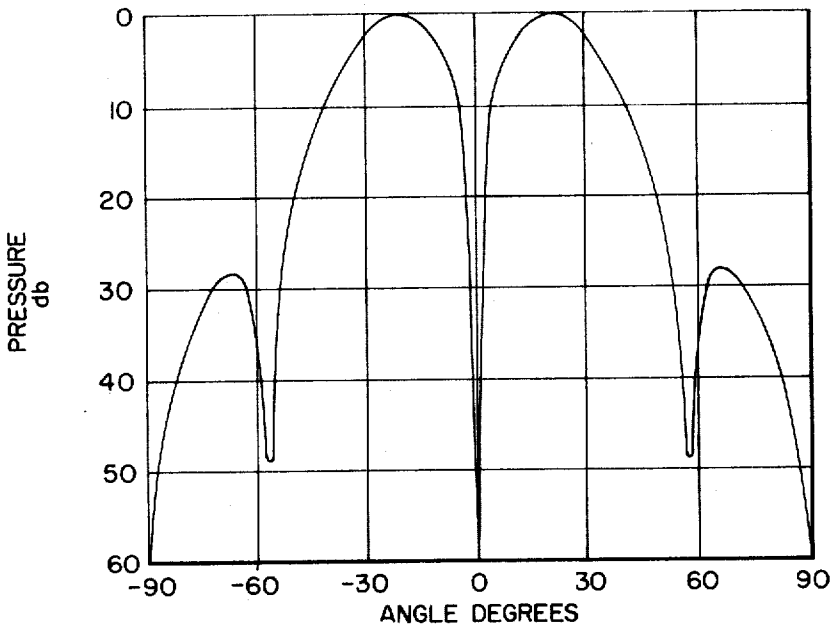


FIG. 21.

DIRECTIONAL SONAR APPARATUS**BACKGROUND OF THE INVENTION**

This invention relates to the sonar art and has particular relationship to directionally-responsive sonar apparatus. Specifically this invention concerns itself with directionally responsive sonar apparatus which is typically located in the nose of a homing torpedo, and serves for detection of a target and for guiding the torpedo so that it homes on the target. In the interest of facilitating the understanding of this invention, this application, where it deals with specifics, will confine itself concretely to the homing torpedo with the understanding that sonar control of other apparatus is well within the scope of this invention.

In accordance with the teachings of typical prior art, the torpedo has a flat nose in which an array of electroacoustic transducers, typically Tonpiltz piston oscillators, are disposed under a thick elastomeric window, typically of polyurethane or neoprene, transparent to the sonar signals used for the homing. The electroacoustic transducers are driven from a transmitter to transmit the homing signals to the targets; the resulting signals reflected by the targets are picked up by the array and actuate a homing control for the torpedo.

The electroacoustic transducers are so distributed in the array and so controlled that the response pattern of the array has a narrow main lobe but also has undesirable side lobes. Any signal received along the direction of the main lobe produces a substantially higher response than a signal of the same magnitude (voltage or energy) received along the direction of any of the side lobes. However, reflection from a phantom target or decoy near the torpedo along the direction of a side lobe could produce a response which would cause the torpedo to home towards the phantom or decoy. To suppress this effect of the side lobes the response level of a broad-beamed or predominately omnidirectional reference transducer of the array is compared to the overall response of the array. In accordance with the teachings of the prior art this reference transducer is one of the transducers, usually a central transducer, of the array. Ideally, this reference transducer should have a response level higher than that corresponding to the side lobes throughout the whole solid angle of response of the array but substantially lower than that corresponding to the main lobe. This would demand a truly omnidirectional reference transducer. Actually the reference transducer, while broad-beamed, is not truly omnidirectional, its pattern having nulls in the side and back directions and falling off substantially between the front direction and these nulls. The expression "predominately omnidirectional" as used in this application means broad-beamed but with decreasing responses over certain angles and not truly omnidirectional. The prior art array in conjunction with the reference transducer does not then have a response which prevents the confusing of the homing operation by phantoms or decoys at certain angles.

It is an object of this invention to overcome the above-described disadvantages of the prior art and to provide directional sonar apparatus in which side lobe effects shall be effectively suppressed.

SUMMARY OF THE INVENTION

In accordance with an aspect of this invention a hydrophone or predominately omnidirectional auxiliary

electroacoustic transducer is associated with the central transducer of the array of main electroacoustic transducers and this pair of transducers are interconnected so that their combined response, typically the sum of their responses, serves as reference for the overall response of the array. The auxiliary transducer is embedded in the elastomeric window forward of the main transducer. The individual magnitudes and phases of the responses of the auxiliary and main transducers are set so that their combined response has a pattern without nulls between 90° and 180° about the dead-ahead axis and effectively suppress false side-lobe pickup from phantoms or decoys.

The auxiliary transducer is of generally spherical form and the main transducer has a longitudinal axis, and, if it is a Tonpiltz oscillator, has the form of a cylinder with a square or rectangular piston at its end adjacent the window. The center of the auxiliary transducer is centered on the axis of the associated main transducer. The spacing between the center of the auxiliary transducer and the vibrating surface of the associated main transducer is of the order of one wavelength and typically may be about one-quarter or one-half wavelength; the diameter of the auxiliary transducer is small compared to this spacing between the center of the auxiliary transducer and the main transducer. The reference pattern may also be produced by a plurality of generally central main electroacoustic transducers of the array with an auxiliary transducer embedded in the window outwardly from, and along the axis of, each of the plurality of main transducers.

In accordance with another aspect of this invention, a predominately omnidirectional auxiliary transducer is associated with each or most of the main transducers of an array. In this case again each auxiliary transducer is embedded in the window centered along the axis of the main transducer. The spacing between each auxiliary and main transducer and the individual magnitudes and phases of the responses of the transducers of each pair are set so as to suppress side lobes in the overall response.

BRIEF DESCRIPTION OF THE DRAWING

For a better understanding of this invention, both as to its organization and as to its method of operation, together with additional objects and advantages thereof, reference is made to the following description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a view in longitudinal section of the flat nose of a homing torpedo embodying an aspect of this invention;

FIG. 2 is a diagrammatic plan view showing the array of main electroacoustic transducers and the auxiliary electroacoustic transducer of the apparatus shown in FIG. 4;

FIG. 3 is a view in section enlarged showing a main electroacoustic transducer typically used in the practice of this invention;

FIG. 4 is a view in section enlarged showing an auxiliary acoustic transducer used in the practice of this invention;

FIG. 5 is a fragmental view in side elevation with the supports in section showing a pair of electroacoustic transducers consisting of a main transducer and its associated auxiliary transducer as used in the practice of this invention;

FIG. 6 is a generally diagrammatic view showing the manner in which the main transducers are interconnected in the practice of this invention to control a homing torpedo;

FIG. 7 is a schematic showing the manner in which the main and auxiliary electroacoustic transducers are interconnected in the practice of the aspect of this invention shown in FIGS. 1 and 2;

FIG. 8 is a three-dimensional graph showing the manner in which the plane of the polar graphs presented in this application may be visualized;

FIG. 9 is a polar graph of a typical directional response in one plane of an array of main transducers included in apparatus such as is shown in FIG. 1;

FIG. 10 is a polar graph of a typical directional response produced by subtracting the response of the transducers of one part of an array from the transducers of the remainder of the array;

FIG. 11 is a polar graph illustrating the manner in which the practice of this invention suppresses false response which would manifest itself in the practice of the prior art;

FIG. 12 is a graph in Cartesian coordinates of the response pattern of the central reference main electroacoustic transducer of an array as shown in FIGS. 1 and 2;

FIG. 13 is a graph in Cartesian coordinates of the response pattern of a spherical auxiliary electroacoustic transducer of the apparatus shown in FIGS. 1 and 2;

FIG. 14 is a graph in Cartesian coordinates of the reference pattern formed of the combined response of a central main electroacoustic transducer and a spherical auxiliary electroacoustic transducer of half the sensitivity of the main transducer and whose center is spaced one-half wavelength of the signal from the main transducer;

FIG. 15 is a similar graph where the auxiliary transducer has twice the sensitivity of the main transducer and its center is spaced one-half wavelength from the main transducer;

FIG. 16 is a view in longitudinal section showing a modification of this invention;

FIG. 17 is a diagrammatic plan view showing the array of main and auxiliary electroacoustic transducers of the apparatus shown in FIG. 16;

FIG. 18 is a schematic showing the manner in which the electroacoustic transducers of FIGS. 16 and 17 are connected;

FIG. 19 is a diagrammatic view of a further modification of this invention;

FIG. 20 is a Cartesian graph for a pair of main and auxiliary electroacoustic transducers of FIG. 19, the transducers being spaced one-half wavelength of the received signal and produce opposite phase responses; and

FIG. 21 is a Cartesian graph for the array of FIG. 19 presenting the difference of the responses for the main and auxiliary transducers on opposite sides of the vertical center of the array.

DETAILED DESCRIPTION OF EMBODIMENTS

The apparatus shown in FIGS. 1 and 2 includes the forward portion of a homing torpedo 31. The torpedo 31 includes a cylindrical shell 33 typically of titanium or aluminum to which a flat nose 35 is vulcanized or molded. The nose is composed of a material, typically neoprene or polyurethane, transparent to the sonar sig-

nal, and viewed from the aft end of the torpedo, is cup shaped with a thick circular base, typically about 1 to 3 inches in thickness. A spherical hydrophone 37, which serves as the auxiliary electroacoustic transducer, is molded centrally in the nose with its conductors 39 and 40 extending out of the nose into the control 41 within the torpedo aft of the nose. The flat surface of the nose 35 of the torpedo 31 has a diameter typically of 12 inches and the torpedo is flared aft to a diameter typically of 21 inches.

A circular plate 43 of titanium or stainless steel is bolted to an overhanging lip of the shell 33. The plate 43 has holes through which main electroacoustic transducers 45 extend. Typically the transducers 45 are arrayed in a square of 7 units by 7 units with the corner units removed so that the array fits into the nose 35.

Each main electroacoustic transducer 45 includes piezo-ceramic rings 47 and 49 (FIG. 5) typically composed of lead zirconate titanate ($\text{pb Zr O}_3 \cdot \text{Pb Ti O}_3$) or of barium titanate (Ba Ti O_3), electrically poled axially. The piezo-ceramic rings 47 and 49 form an electroacoustic converter which, when energized by electrical oscillations, vibrates a head 51 or, when the head 51 is vibrated, convert the vibrations into electrical oscillations. The head or piston 51, typically of aluminum, is in the form of a rectangular parallelepiped with square surfaces fore and aft and with the corners of the aft portion 53 turned to form a truncated cone. The transducer 45 also includes a reaction mass 59 typically of stainless steel. A rod 61 is secured or cemented centrally to the head 51 by epoxy resin or the like. The rod 61 is threaded at the end remote from the head 51. The electroacoustic converter 47-49 includes ring electrodes 63, 65, 67, of open work or screen conductive material. The electrode 63 is interposed between a ceramic, electrically insulating ring 69 and the piezo-ceramic ring 47; the ring 65 between ceramic electrically insulating ring 71 and piezo-ceramic ring 49; and ring 67 between piezo-ceramic rings 47 and 49. The piezo-ceramic rings 47 and 49, the electrodes 63, 65 and 67 and the ceramic rings 69 and 71 are cemented or bonded together between the mass 59 and the head 51 and secured by a nut 73 screwed into the end of rod 61 acting through a Bellville spring washer 75. The nut 73 is screwed in so that the piezo-ceramic rings 47 and 49 are subjected to precompression stress between the head 51 and mass 59. The compression is sufficient to preclude the rings 47 and 49 from going into tension while vibrating. Electrodes 63 and 65 are connected together to a common conductor 79 and electrode 67 to another conductor 77. Conductor 79 is grounded (FIG. 57) and conductor 77 of all units 45, except the central unit 45c, is selectively connected through switch 80 (a T-R switch) to the primary 81 of a transformer 83 (FIG. 7) in the control 41 during reception and to a transmitting 86 during transmission. The conductor 77 of central unit 45c is also connected to one primary 87 of a summing transformer 89 (FIG. 7). The piezo-ceramic rings 47 and 49 of each transducer are so controlled during transmission and reception that they operate cumulatively and not adversely.

Between the head 51 and the plate 43 a hydrostatic pressure-release hollow cylinder 85 (FIG. 5) is interposed. This cylinder typically is composed of paper or of syntactic foam formed of spheres of glass or ceramic embedded in epoxy resin. The cylinder 85 prevents the piezo-ceramic rings 47 and 49 and their cooperative

parts from being subjected to the hydrostatic pressure impressed through the window 35 and is sufficiently compliant not to restrain the dynamic vibration of the head. Typically the head 51 is about 1 to 2 inches square and the transducer 45 has a length of about 4 inches.

The auxiliary electroacoustic transducer (FIG. 4) includes a hollow sphere 91 of piezo-ceramic material electrically poled radially whose inner and outer surfaces have coatings 93 and 95 of silver. The coatings are connected to the conductors 39 and 40 which are in turn connected to another primary 97 (FIG. 7) of transformer 89. The conductor 40 is grounded. The sphere is filled with a material 99 such as polyurethane. The sphere operates as a predominately omnidirectional electroacoustic transducer or converter converting sonar waves into electrical oscillations. Typically the sphere 91 has a diameter of about $\frac{1}{4}$ to $\frac{1}{2}$ inches. The center of the sphere is on the longitudinal axis of the central main transducer 45c and is spaced about 1 to 4 inches from the fore surface of this transducer.

FIG. 6 shows diagrammatically how the computations for the control of the torpedo 31 are carried out in the practice of this invention. Structurally the computations may be carried out as shown in FIG. 7. With reference to FIG. 6 the array 101 of main electroacoustic transducers 45 and 45c may be regarded as divided into four quadrants labeled I, II, III, IV. The dividing plane 103 between quadrants I and III and II and IV is vertical and the dividing plane 105 between I and II and III and IV is horizontal. The respective transducers of quadrants I and II, II and IV, IV and III, and III and I are each regarded as connected to a summer 107, 109, 111, 113. All summers 107 through 113 impress their sums on a total summer 115. Summers 113 and 109 impress their sums on horizontal subtractor 117 which computes the difference between the latter sums; likewise summers 107 and 111 impress their sums on vertical subtractor 119 which computes the difference between these latter sums. Horizontal subtractor 117 and total summer 115 impress their output computations on divider 121 which computes the quotient of the difference from horizontal subtractor 117 divided by the total sum. Vertical subtractor 119 and total summer 115 impress their outputs on divider 123 which computes the quotient of the difference from subtractor 119 divided by the total sum. The quotient from the divider 121 is supplied to a computer to compute the azimuth target angle through a switch 125 and the quotient of divider 123 to a computer for computing elevation target angle through a switch 127. Switches 125 and 127 are typically solid state components. Switches 125 and 127 are supplied from a comparator 129. This comparator compares the sum of the outputs from auxiliary transducer 37 and central main transducer 45c with the total sum. If the total sum exceeds the sum of the outputs, the switches 125 and 127 are closed and the command control for homing the torpedo 31 on the target is enabled and if the sum of the outputs is greater than the total sum, the command control remains disabled.

FIG. 7 is a schematic showing as typical of like positioned units, the transducers 45h along the horizontal center line of the array 101 and the transducers 45v along the vertical center line of the array and including the central electroacoustic transducer 45c. The transformer into which each transducer 45 supplies its out-

put has a plurality of secondaries 131s, 131h, 131v. From secondaries 131s the total sum for all units 45 is derived; from secondaries 131h the difference for the transducers to port and starboard of the vertical center plane 103 are derived and from the secondaries 131v the difference for the transducers 45 above and below the horizontal plane 105 are derived. Because of the availability of the secondaries for the separate computations the summers 107, 109, 111, 113 of FIG. 6, which symbolize like computations and are used to clarify the the invention, are not shown. The turns ratios of the transformer 83 are predetermined to set the relative amplitudes of the potentials supplied by these transformers. The amplitude and angles at which the side lobes occur can be to an extent determined by these relative shading factors.

The outputs of all secondaries 131s are impressed on, and added by, the total summer 133. The secondaries 131h of the transducers 45h on opposite sides of the plane 103 are impressed on the horizontal subtractor 135. In the horizontal subtractor 135 the difference is computed between the sum of the outputs of transducers on the port side of plane 103 and the transducers on the starboard side of plane 103. Likewise the secondaries 131v of all transducers symbolized by 45v are impressed on the vertical subtractor 137 which computes the difference between the outputs of all transducers above the plane 105 and all transducers below the plane 105. The secondaries 131v for the transducers along the plane 105 are open as are the secondaries 131h for the units along plane 103.

The secondary 141 of transformer 89 supplies a reference generator 143 with the sum of the outputs of auxiliary transducer 37 and central transducer 45c. The output of the reference generator 143 is impressed on the comparator 129 where this output is compared with the total sum from summer 133.

The outputs of total summer 133 and of horizontal subtractor 135 are supplied to divider 121 and the outputs of the total summer 133 and vertical subtractor 137 to divider 123. The output of divider 121 is supplied to the azimuth control 151 through switch 125 and the output of divider 123 to elevation control 153 through switch 127. The switches 125 and 127 are set closed or open by the comparator 129 depending on whether the total sum from summer 133 exceeds the reference signal from generator 143 or is exceeded by the latter. The azimuth control 151 and the elevation control 153 also receive stabilizing signals from the stabilizing control 155 of the torpedo 31.

The functioning of the apparatus shown in FIGS. 1 through 7 will be described with reference to the graphs shown in FIGS. 8 through 15. FIG. 8 is a three dimensional presentation of the response of array 101. It is assumed that the array 101 is positioned parallel to the YZ plane and that the dead-ahead direction is the positive X direction. The lobe 161 which presents the response for any signalling source (for example a target sending back reflected pulses) as a function of the angle of reception has its maximum along the X axis. As a rule the polar graphs present the intersections of the lobe 161 with the XZ or XY planes.

FIG. 9 presents the response as a function of angular displacement from the dead-ahead direction on the XZ plane for an array 101 of electroacoustic transducers 45. Response in decibels (db) below the maximum is plotted radially as a function of angle of reception θ .

The graph of FIG. 9 presents the response as derived from the total summer 133 (FIG. 7). Typically at angle ϕ_1 the response is 6 db below maximum on the main lobe 162 and at angle ϕ_2 , 20 db below maximum. The response has side lobes 163, 164, 170, 172 which, for a decoy target T, would produce false received signals of substantial magnitude and deflect the torpedo 31 in an improper direction. In FIG. 10 the response for an array 101 of units 45 of the horizontal subtractor 135 (XY plane), in db below maximum at dead-ahead, is plotted as a function of angle of reception. At angles θ_1 and θ_2 the reception is along the right-hand lobe 167. The azimuthal direction of the target is thus established with relative precision and unless confused by decoys the torpedo 31 would home on the target.

FIG. 11 shows the same response from the array 101 as FIG. 9 but in addition shows in broken lines exaggerated the reference lobe 171 produced in the practice of the prior art and the reference lobe 173 resulting from the combined response of the auxiliary transducer 37 and central main transducer 45c in the practice of this invention. Because the reference lobe 171 falls off sharply to port and starboard, the response for this lobe is less than for side lobes 166 and 168 at certain angles and for decoys at these angles the comparator 129 (FIG. 7) would close switches 125 and 127 and misdirect the torpedo 31. The response for lobe 173 is at all angles greater than the response for the side lobes 166 and 168 and the effects of side-lobe response would be suppressed. On the other hand, over the useful angle of reception, the response of the main lobe 162 exceeds the response of the lobe 173 and at these angles the comparator 129 (FIG. 7) would close the switches 125 and 127.

In FIGS. 12 through 15 angular departure from dead-ahead is plotted horizontally and drop in response from maximum in db is plotted vertically. In FIG. 12 is a graph of the response for a typical central main electroacoustic transducer 45c. This response drops off by 30 db at 90°. The response for a typical auxiliary transducer 37 is shown in FIG. 13. This response drops off by 20 db at 90°. FIG. 14 shows the combined response for a central main transducer 45c and an auxiliary transducer 37, having one-half the sensitivity of the main transducer spaced one-half wavelength from the main transducer. This response drops off only about 14 db at 90° and is, over an angle of about 70°, substantially flat. FIG. 15 is similar to FIG. 14 except that the auxiliary transducer 37 has twice the sensitivity of the main transducer 45c. This response drops off only 12 db at 90° and is, over an angle of 60°, substantially flat.

The apparatus shown in FIG. 16 is a torpedo 181 having a flat nose 183 of material transparent to the sonar signals. An array 101 of main electroacoustic transducers 45 similar to the array 101 of FIGS. 1 and 2 are secured to the flat aft surface of the nose 183. An auxiliary electroacoustic transducer 185 is associated with each main transducer 45. Each transducer 185 is embedded in the window of the torpedo 181 with its center along the axis of the associated transducer 45 spaced of the order of 1 wavelength of the sonar signal from the transducer 45.

FIG. 18 is a schematic showing, as typical, the circuit connections for the central pairs of main transducers 45h and auxiliary transducers 185h for producing the horizontal difference in response and the central pairs of main transducers 45v and auxiliary transducers 185v

for producing the vertical difference in response. With each pair of transducers 45 and 185 throughout the array a transformer 191 is associated. The transformer 191 has primaries 193 and 195 and secondaries 197s, 197h, and 197v. Transducer 45 may be selectively connected, by operation of a T-R switch 201, to energize primary 193 by the signal received or to be energized by transmitter 203. Primary 195 is connected to be energized by the signal received by the associated auxiliary transducer 185. Each secondary 197s supplies the total summer 205; each secondary 197h the horizontal subtractor 207; and 197v the vertical subtractor 209. The total summer 205 sums the total response of all pairs of transducers 45 and 185, the horizontal subtractor 207 derives the difference between the responses of the pairs on the port side and starboard side of the vertical center plane 221 and the subtractor 209 the difference between the responses for the pairs 45-185 above and below the horizontal center plane 223. The total summer 205 and the horizontal and vertical subtractors 207 and 209 are respectively connected to dividers 211 and 213 from which the azimuth target angle and elevation target angle are derived. By choosing the turns ratio of coils 193, 195, 197s, 197h, 197v of the transformers 191 and properly setting the spacing between the main and auxiliary electroacoustic transducers, side lobes of the overall response of the array of pairs 45-185 at selected angles, for example, 90°, may be suppressed and a desired response pattern achieved.

FIG. 19 shows a torpedo 231 having a generally spherical nose 233. The nose 233 is a thick elastomeric window aft of which, on its flat inner face, an array of seven, or any other number of, main electroacoustic transducers 235 having hexagonal heads are secured. The transducers 235 are nested as shown. Within the window forward of each transducer 235 an auxiliary predominately omnidirectional electroacoustic transducer 237 is embedded. The centers of the transducers 237 are on the axes of the main transducers 235. The control transducer for the torpedo 231 carrying this array of pairs of main transducers 235 and auxiliary transducers 237 is similar to that shown in FIG. 18. The side lobes of the response pattern at predetermined angles may be suppressed by appropriate setting of the spacing between the auxiliary and main transducers and by proper phasing of their received signals, in addition to setting their relative amplitudes.

The response pattern of a pair consisting of a main transducer 235 and auxiliary transducer 237 is shown in FIG. 20. Angular displacement from dead-ahead is plotted horizontally and decrease from maximum in db vertically. The response is down about 60 db at 90°. The low response in the side directions results from the cancellation of the two response laterally. The pairs of transducers have a highly directional main beam with the same low level in the side directions. The usefulness of this cancellation can be understood from FIG. 21 in which a horizontal-difference response is plotted as a function of angular displacement from dead-ahead. The peak responses occur at about $\pm 22^\circ$ from dead-ahead. The difference response has side lobes at about $\pm 65^\circ$ and is 60 db down at about $\pm 90^\circ$.

While preferred embodiments of this invention have been disclosed herein, many modifications thereof are feasible. This invention is not to be restricted except insofar as is necessitated by the spirit of the prior art.

I claim:

1. Directional sonar apparatus for receiving signals from sources in predetermined directions with respect to said apparatus, said apparatus including an array of main electroacoustic transducers, said electroacoustic transducers being spacially distributed with respect to each other so that the response of said array to said signals is directional, the directional pattern of said response having a main lobe and at least one side lobe, the response to said signals along the direction of said main lobe being substantially greater than the response to said signals along the direction of said side lobe, at least one predominately omnidirectional auxiliary electroacoustic transducer in receiving relationship with said signals, said auxiliary transducer being connected to at least one of said main electroacoustic transducers to produce a combined response with said one transducer, actuable means connected to said array and said auxiliary transducer to be actuated thereby, and means connecting said auxiliary electroacoustic transducer and said one main electroacoustic transducer in comparison relationship with said array of main transducers so that said combined response of said auxiliary transducer and said one main transducer modifies the response of said array so as to suppress the actuation of said actuable means responsive to signals along the direction of said side lobes but to permit actuation of said actuable means along the direction of said main lobe.

2. The apparatus of claim 1 wherein the each main electroacoustic transducer is broad-beamed but generally directional.

3. The apparatus of claim 1 wherein the one electroacoustic transducer is substantially centrally located in said array.

4. The apparatus of claim 1 wherein the auxiliary transducer is spaced of the order of one wavelength of the signal from the one main transducer.

5. The apparatus of claim 1 including an enclosure for the array, the enclosure including a window transparent to the signals, said window being disposed over the array so that the signals are received by the array through the window, the auxiliary electroacoustic transducer being embedded in the window.

6. The apparatus of claim 1 wherein the spacing of the auxiliary transducer from the one main transducer is such as to maximize the combined response of the auxiliary transducer and of the one main transducer in the direction of the side lobe.

7. The apparatus of claim 1 wherein the actuable means includes:

- a. summing means for summing the response to signals of substantially all main electroacoustic transducers of the array;

b. subtracting means for subtracting the response to said signals received by the predominant number of said transducers of a part of said transducers of a part of said array from the response to said signals of the predominant number of the remainder of said transducers of said array;

c. means for deriving a measure of the relationship between the total response of said summing means and the net response of said subtracting means;

d. means, connected to said deriving means, when enabled, for actuating said actuable means in dependence upon said measure;

the comparing means comparing the combined response of the auxiliary transducer and the one main transducer with the sum produced by the summing means, and the said actuable means also including means, responsive to the comparing means, for enabling said actuable means only when the sum produced by the summing means exceeds the combined response.

8. Directional sonar apparatus for receiving signals from sources in predetermined directions from said apparatus, the said apparatus including an array of main electroacoustic transducers, an auxiliary predominately omnidirectional transducer associated with each main transducer, means interconnecting each main transducer and its associated omnidirectional transducer so that a combined response to said signals is derived from each pair of main and auxiliary transducers, the transducers of said array and their respective associated auxiliary transducers being spatially distributed with respect to each other so that the response to said signals is directional, the spacing and interconnection between each auxiliary transducer and its associated main transducer being such as to suppress response to said signals laterally of said array.

9. The apparatus of claim 8 including an enclosure for said array, the enclosure including a window to the signals, said window being disposed over said array so that said signals are received by the array through the window, the auxiliary electroacoustic transducers being embedded in said window.

10. The apparatus of claim 8 wherein each auxiliary transducer is spaced from its associated main transducer about one wavelength of the signals.

11. The apparatus of claim 8 wherein each main electroacoustic transducer has a longitudinal axis and each auxiliary transducer is of generally spherical form, the center of the auxiliary transducer being along the axis of the main transducer.

12. The apparatus of claim 8 wherein each main electroacoustic transducer is directional.

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