

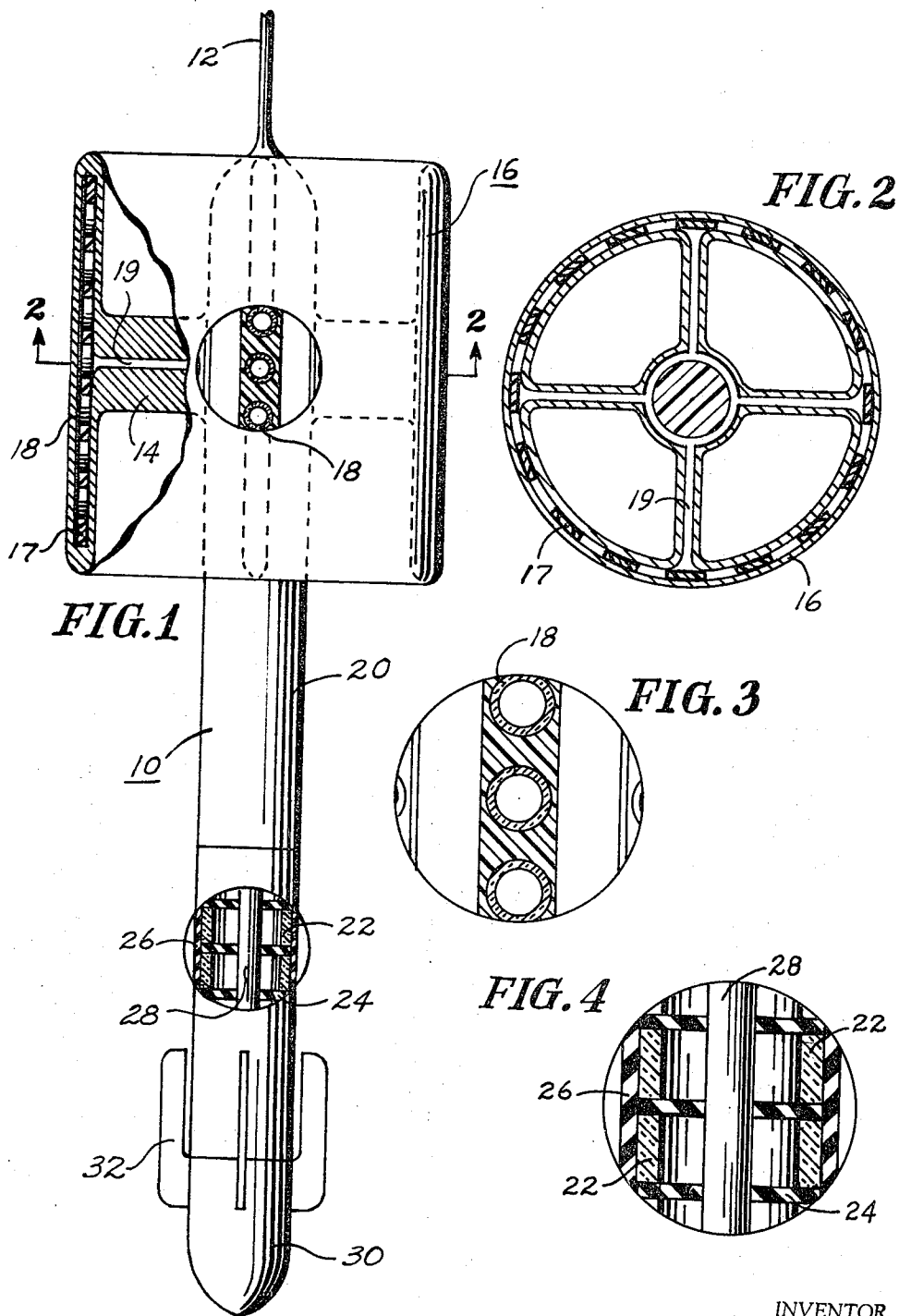
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UNDERWATER TRANSDUCER CONFIGURATION

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ABSTRACT OF THE DISCLOSURE

An underwater transducer configured for high speed descent into the water and ascent out of the water having an elongated cylindrical body with fins at its lower end, a transmitter section near the fins containing a number of axially arranged transducer elements, a large diameter cylindrical receiver section fastened to the body near its upper end by means of hollow struts, the receiver section containing a plurality of receiving transducer elements arranged and connected electrically in axially-aligned groups, and electronic signal processing means in said body.

This invention relates to underwater transducer equipment, and more specifically to a transducer having unusually good hydrodynamic properties.

In some applications involving underwater mapping or searching, a premium is placed on being able to cover a substantial area in a minimum of time. In such operations it is conventional for the transducers used to be lowered at the end of a cable and retrieved by winding in the cable by means of a hoist mechanism. Where it is necessary to operate at considerable depths, it is apparent that an appreciable amount of time must be involved in the lowering and raising operation. The time involved in getting the transducer to the operating depth and in returning it to the accompanying seaborne or air-borne vehicle may be greatly in excess of the time the transducer is in operating position. Thus the rate of descent and ascent of the transducer has a very direct bearing on the number of locations to which it may be moved in a given period of time and, therefore, upon the area which it may cover.

In order to extend this area substantially, the applicants herein have devised a transducer having uniquely good hydrodynamic properties such that it descends rapidly and substantially vertically into the water, ascends rapidly and vertically out of the water, and yet has acoustic performance at least equivalent to conventional transducers which have relatively poor hydrodynamic qualities. It is, therefore, an object of the present invention to provide a transducer configuration for operation at great depths which will descend substantially vertically and much more rapidly into the water than transducers presently in use.

It is another object of the present invention to provide a transducer configuration which may be pulled substantially vertically out of the water from considerable depths much more rapidly than transducers presently in use.

It is another object of the present invention to provide a transducer configuration which accomplishes the above objectives and which may be dropped into the water or pulled out of the water by means of a cable

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with a minimum of turbulence from non-axial movement or hydrodynamic drag.

It is a further object of the present invention to provide a transducer configuration which accomplishes the above objectives and which is of such configuration that a minimum of interference in the operation of the receiving transducer elements is caused when said transmitting elements are energized.

Other objects and advantages will become apparent from the following specification taken in connection with the accompanying drawings in which:

FIGURE 1 is an elevation, partially in section, of a transducer configuration according to my invention;

FIGURE 2 is a section taken on line 2-2 of FIGURE 1;

FIGURE 3 is an enlarged view of a portion of FIGURE 1 shown in section; and

FIGURE 4 is an enlarged view of another portion of FIGURE 1 shown in section.

Referring now to FIGURE 1, the transducer body 10 is an elongated, generally cylindrical member with rounded or ogival ends to provide a streamlined contour for passage through the water in either direction. At the upper end is shown a cable 12 which is attached to a hoist mechanism (not shown) carried on the accompanying water-borne or air vehicle. The hoist mechanism, which forms no part of the present invention, may be any of several types known in the art. Attached to the upper end of the body 10 by means of a plurality of radially extending support members or struts 14 is a drum-shaped member 16 of considerably greater diameter than body 10 which serves as a housing for the receiving or "listening" transducer elements. The transducer elements 18 are arranged in groups longitudinally and retained in retainer members 17 such that each group operates as a single unit or "stave." A number of such staves are positioned around the periphery of member 16 facing outwardly so that they will respond to acoustic energy reaching them from the surrounding water. Each stave responds as the acoustic energy reaches it, converting the acoustical signal into an electrical signal which is processed to form an output pattern which is normally displayed on the face of a cathode ray tube in the accompanying vehicle. Passages 19 are incorporated in struts 14 to accommodate the wiring from the "staves" to the interior of body 10.

An electronic package for processing the transducer signals is located near the central and upper parts of the body 10, such as within the interior of section 20. Positioned below the electronic package is an axially arranged array of ring-shaped transmitting transducer elements 22 which may be of piezoelectric material and which are separated by means of spacer members 24 which may be of rubber or any elastomer having the desired properties for operation at substantial depths and which are contained within a rubber sheath 26. The spacers 24 and sheath 26 are essentially transparent to acoustic signals but serve to retain within the interior of the sheath 26 an essentially noncompressible liquid such as kerosene so that the pressures may be equalized across the transducer elements. Passing through the center of the transducer elements is a center post 28 which is typically used in combination with a threaded member (not shown) to compress the transducer elements 22 and the spacers 24 to-

gether in axial alignment and which may also serve as an acoustic loading member for tuning the transmitting transducer. Tuning may be accomplished by varying the diameter of post 28: the larger the diameter, the smaller the space between itself and the inside of the transducer elements 22 and the higher the mechanical resonant frequency of the assembly.

The lower or nose section 30, aside from being ogival or streamlined in configuration to minimize resistance through the water, should be symmetrical such that it does not cause the transducer to steer away from as nearly vertical a descent as possible. A plurality of fins 32 are attached to nose section 30 to inhibit nutation or non-axial movement of body 10 on ascent. Since successful operation of the entire assembly depends upon the center of gravity being substantially below the center of the body 10, extra weight may be added by making section 30 as heavy as required to assure a proper location for the center of gravity. In general, the entire assembly should be made as dense as possible compatible with the desired location of the center of gravity to assure a swift and straight descent. Both because of the high hydrostatic pressures encountered and because of the need for maximum density, voids in the electronic package 20 should be eliminated.

With the structure shown, the behavior of the transducer during descent is straight and essentially vertical, and its characteristics are much like those of an arrow. The cross-section of struts 14 and the receiving transducer support 16 should be such as to make the resistance to movement through the water in both directions as small as possible, but the support 16 does provide the necessary resistance to keep itself on the trailing or upper end of the assembly on descent. This orientation is further maintained by having the center of gravity of the assembly as low as possible and at least substantially below the center of the body 10. The substantially vertical orientation is maintained when the transducer is stationary in operating position due to its high density and relatively small cross-sectional area which gives it substantial resistance to tipping from the action of cross-currents. When a pulse is transmitted from transducer members 22, it is radiated essentially normal to the direction of body 10, or horizontally. Reflections from underwater objects will be returned and sensed at the surface of member 16 at the various staves which respond to these echo signals at the time they are received. This time relationship means that a given echo signal having a particular direction will arrive at adjacent staves at slightly different times or, stated differently, in slightly different phase relationship. This phase relationship is used in the electronic package to determine the bearing of the reflecting object. With this bearing information and with synchronized means for determining the elapsed time between the transmitted pulse and the reception of the echo, both bearing and range can be determined and transmitted through the cable 12 to be displayed on a cathode ray tube in the associated vehicle. Obviously, the specific functions ascribed to the electronic package 20 are typical only and do not form a part of the present invention since all or part of the signal-processing functions described may be located in auxiliary equipment at the opposite end of cable 12.

Removal from the water is effected by winding in cable 12, and again it is desirable that the orientation of the transducer remain as close to vertical as possible with a minimum of turbulence and non-axial movement which would load the hoisting mechanism and slow the rate of ascent. Even with the configuration shown, the transducer had some tendency to nutate with the nose section 30 moving in a circle on ascent until the fins 32 were added. These provided sufficient resistance to lateral movement that ascent through the water remained essentially straight and vertical.

While only one embodiment has been shown and described herein, modifications within the spirit and scope

of the present invention may be made to suit particular requirements. While body 10 has been shown as essentially cylindrical, it could be made with a somewhat larger diameter toward the lower end which would permit larger transmitting elements, if needed, at some cost in resistance to flow through the water so long as the contours permit smooth flow with a minimum of turbulence. Similarly the diameter of member 16 may be varied within limits to accommodate greater or lesser numbers of staves depending on the resolution required of the transducer. The fins 32 may be of a variety of sizes and shapes so long as enough area is present to provide the required lateral stability. More than two oppositely directed fins must be used to provide stability in more than one plane. Other modifications will occur to those skilled in the art, and I do not wish to be limited to the particular configuration shown or otherwise than by the appended claims.

We claim:

1. A transducer for connection to cabling means and adapted to be operated at substantial depths comprising a smooth elongated body connected at its upper end to said cabling means and substantially circular in cross-section;
 - a plurality of support members extending radially from said body;
 - a hollow cylindrical member attached to the outside ends of said support members and spaced from said body to permit water to flow between said body and said member, said cylindrical member containing a plurality of transducer elements electrically connected in groups such that each group responds to received acoustic signals as an individual unit;
 - a plurality of transmitting transducer elements located in said body, and an acoustically transparent sleeve member containing said transmitting elements;
 - electronic amplification and signal-processing means in said body connected to said transducer elements; and
 - a plurality of fins extending radially from said body near the opposite end from said cabling means, said electronic means, said transmitting transducer elements and said cylindrical member being arranged relative to said body such that the center of gravity of said transducer is located a substantial distance below said cylindrical member.
2. A transducer as set forth in claim 1 wherein said body is generally streamlined in configuration to aid in rapid descent into the water and removal from the water.
3. A transducer as set forth in claim 1 wherein the weights of the parts are such that the center of gravity is nearest the end of said body carrying said fins.
4. A transducer as set forth in claim 3 wherein additional weight is added to aid in rapid descent into the water.
5. A transducer as set forth in claim 1 wherein a center post structure is located within said transmitting elements to serve as a structural member and also as an acoustic tuning means.
6. A transducer as set forth in claim 1 wherein said groups of receiving transducer elements are physically arranged as a plurality of groups aligned axially with respect to said elongated body.
7. A transducer as set forth in claim 1 wherein said support means are attached near the upper end of said body and said transmitting transducer elements are located near the lower end of said body.
8. A transducer for connection to cabling means and adapted to be operated in water at substantial depths comprising a smooth elongated body substantially circular in cross-section having a length several times greater than its diameter;
 - a plurality of hollow support members extending radially from the end of said body nearest said cabling means;
 - a hollow cylindrical member of substantially greater

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diameter than said body member attached to the outside ends of said support members, said cylindrical member containing a plurality of transducer elements arranged and electrically connected in axial groups such that each group responds to received acoustic signals as an individual unit;
 5 a plurality of transmitting transducer elements located in said body near the opposite end from said cylindrical member and acoustically transparent means surrounding said transmitting elements;
 10 electronic amplification and signal-processing means in said body connected to said transducer elements; and a plurality of fins extending radially from said body at the opposite end from said cylindrical member.

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