June 3, 1958 W. T. HARRIS 2,837,731

HYDROPHONE CABLE

Filed April 19, 1955

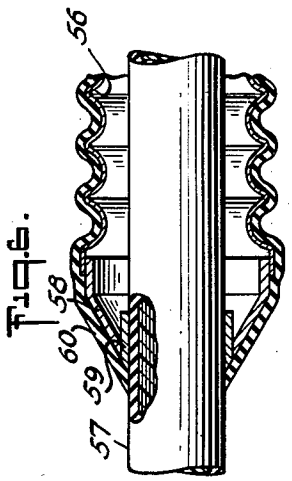


Fig. 6.

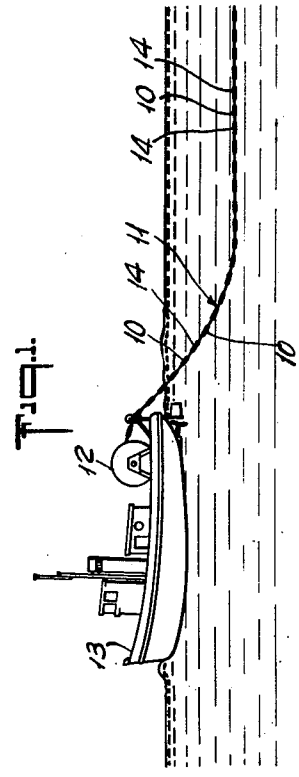


Fig. 1.

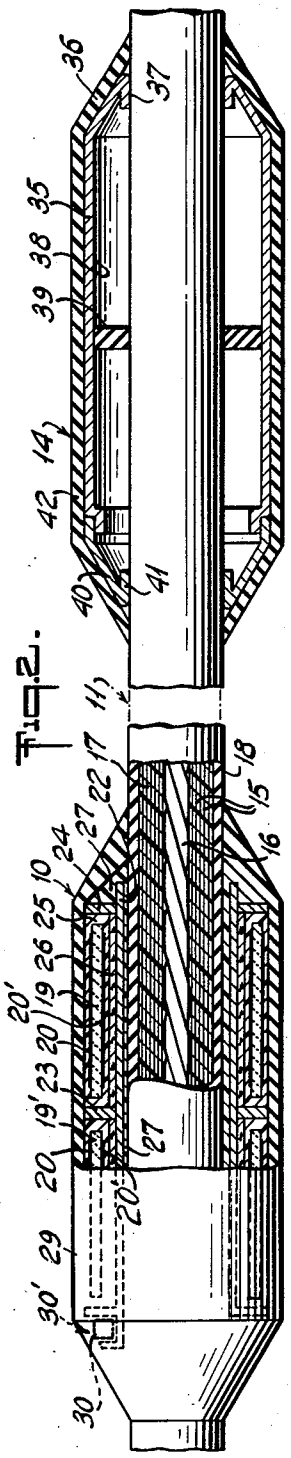


Fig. 2.

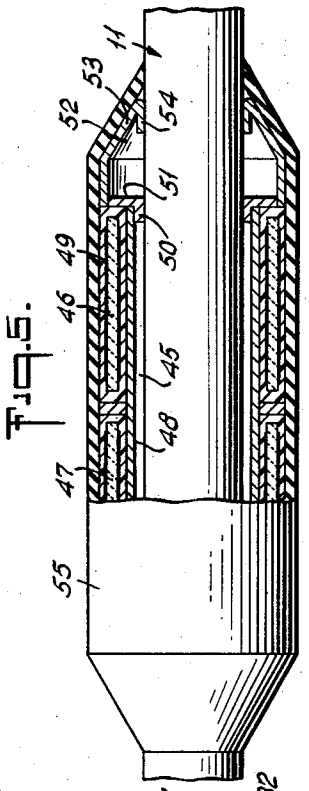


Fig. 5.

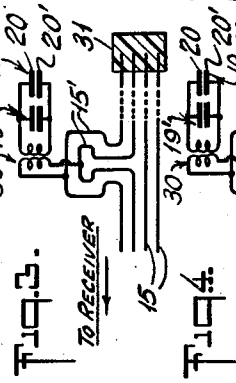


Fig. 3.

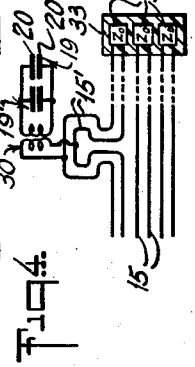


Fig. 4.

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HYDROPHONE CABLE

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Application April 19, 1955, Serial No. 502,434

1 Claim. (Cl. 340—17)

My invention relates to electro-acoustic transducers and, in particular, to arrayed constructions thereof. This application is a continuation-in-part of my copending application Serial No. 283,689, filed April 22, 1952 which has issued as Patent No. 2,408,742, dated May 17, 1955.

It is an object of the invention to provide an improved trnsducer array of the character indicated.

It is another object to provide an improved underwater transducer array which may lend itself to electric steering.

It is a further object to provide an underwater transducer array which is substantially neutrally buoyant.

A still further object is to provide improved cabling means for underwater acoustic arrays.

It is a general object to meet the above objects with a rugged, integral cable-transducer construction which will lend itself to a shipboard handling, as when necessary to pay the cable in and out.

Other objects and various further features of novelty and invention will be pointed out or will occur to those skilled in the art from a reading of the following specification, in conjunction with the accompanying drawings. In said drawings, which show, for illustrative purposes only, preferred forms of the invention:

Fig. 1 is a simplified side view illustrating a surface vessel towing a payed-out length of hydrophonic cable incorporating features of the invention;

Fig. 2 is an enlarged fragmentary view in partial longitudinal section illustrating the hydrophonic cable of my invention;

Fig. 3 is a simplified diagram illustrating electrical connections for the cable of Fig. 2;

Fig. 4 is a diagram similar to Fig. 3, but illustrating an alternative connection;

Fig. 5 is an enlarged fragmentary view in partial longitudinal section, illustrating an alternative construction for a part of Fig. 2; and

Fig. 6 is another fragmentary view in partial longitudinal section, illustrating an alternative for another part of Fig. 2.

Briefly stated, my invention contemplates an improved electro-acoustic array comprising a plurality of electro-acoustic devices integrally formed with the connecting cable. The electro-acoustic devices may be simply cylindrical or annular members incorporating means electrically responsive to stress resulting from radial deflection of said members. The members may surround the cable at spaced locations depending upon the desired acoustic properties of the array. The cable may be of the multi-conductor variety and have a flexible tension core, as of stranded steel. At the point of attachment of each transducer to the cable, pressure-release means may be provided of a sufficient volume to give the cable neutrally buoyant properties and, if desired, these properties may be enhanced by provision of annular floats integral with the cable at appropriate spacings. Ruggedness is achieved by employment of novel reinforcements and by using sound-transmitting potting materials of suitable toughness.

Referring to the drawings, I indicate generally in Fig. 1 that my array may comprise a plurality of transducer elements 10, spaced longitudinally along a single cable 11, and suitably supported for the intended purpose. In the case shown in Fig. 1, the cable is to be employed for underwater oil-prospecting, and I show the cable 11 being payed out from a drum 12, supported at the stern of a towing vessel 13. The various hydrophones 10 on the cable 11 may themselves be sufficiently neutrally buoyant but, if desired, additional buoyancy may be provided by novel floats 14 spaced from the hydrophones 11. The float and hydrophone constructions are shown in greater detail in Fig. 2.

As will be seen from Fig. 2, the supporting cable 11 may be of the multi-conductor variety (as indicated schematically by spaced longitudinally extending lines 15) filling the annular space around a tension core 16, which may be a stranded-stool cable. For ready identification, the conductors 15 may be color-coded, and they may be immersed in a layer or volume of insulating material 17; alternatively, the conductors 15 may be twisted as individual pairs, separately insulated, and merely packed around a plastic or rubber-coated stress core 16, the immersion in insulating material 17 being unnecessary in certain applications. A coating or jacket 18 completes the construction of the cable 11 itself.

The assembly of the cable 11 may in all respects be conventional except that I prefer, at each location where a hydrophone 10 is to be attached, that a different pair of conductors 15 (as, for example, the conductors 15′ in Fig. 3) be brought into a slightly enlarged loop for electrical connection to each particular hydrophone. This loop may be gathered and knotted externally of the filling 17 before application of the cover 18, so that when the cover 18 is applied, a small bump in the outer contour will show where incision must be made to gain access to the desired pair of conductors 15′. The cover 18 may be of tough plastic, such as vinyl, but I prefer to use rubber or a rubber-like material, such as neoprene.

The hydrophone unit 10 is, in each case, preferably non-directional and, therefore, small compared to a wave length. The basic transducer elements themselves preferably continuously envelop the cable 11, and I have shown annular transducer means 19 surrounding the cable 11 and slightly spaced therefrom. The annular member 19 may be a hollow magnetostrictive cylinder, with electrical means such as a winding toroidally enveloping the same, as disclosed in said application, Serial No. 283,689. However, in the preferred form shown, the transducer element 19 is piezo-electric, as of piezo-electric ceramic, such as barium titanate, with outer and inner conductive foils or electrodes 20—20′ constituting means electrically responsive to transient pressure excitation.

For a reason which will later become apparent, I prefer to provide the transducers in duplicate at each hydrophone unit 10 and, therefore, I show a second core element 19′ with associated foils or electrodes 20—20′ for the device 10. These foils may be connected with each other and across the looped conductor pair 15′ at each point of connection to the cable, as suggested at Fig. 3, the preferred connections to elements 19—19′ being in parallel, as shown.

It will be understood that the transducer elements 19—19′ for the hydrophone unit 10 may be connected to one pair of conductors in the cable 11, and that at another hydrophone-unit location the transducer windings thereof may be connected to the same pair or to a different pair of conductors, depending upon the desired overall performance of the device. When connected to different pairs of conductors at different hydrophone locations, it will be understood that the array may lend

itself to phased steering at the shipboard-receiving location, by employment of means which are known and are, therefore, not shown.

In the specific construction of Fig. 2, the transducer means 19—20 is protected against abuse by means of a reinforcement member 22 in the form of a cylindrical core, which may be of aluminum in order to reduce the density of the assembly. This core may be integrally formed with reinforcement flanges at spaced locations, or, as shown, rings 23—24 may be provided to ride on the cylinder 22. The rings 23—24 extend radially outwardly to an extent preferably at least equivalent to the outer dimensions of the transducer elements 19—19', and preferably slightly beyond, as shown. The wound cores may then be potted with a sound-transmitting material 25 (such as a suitable plastic) in the annular space defined between the reinforcement rings 23—24. I have shown a layer 26 of pressure-release material lining this annular space and riding on the outside of cylinder 22, so that the transducer means 19—19' may be primarily responsive to radial deformations due to external excitation.

After assembly, as described, on the cylinder 22, the transducer-element assemblies may be guided over the cable 11 and electrically connected to the proper conductor pair 15' at the desired location. Another layer 27 of plastic or other filling may then be applied to secure the cylinder 22 on the cable 11, and to provide a tapered end for the assembly. Finally, a jacket 29 of rubber or rubber-like material, such as neoprene, may be applied over the entire device and faired into the cable jacket 18, as suggested in the drawing.

When the cable means 11 is of substantial length, it becomes important that the electrical parameters of all conductor pairs 15—15', etc., be substantially the same. This may be readily achieved by making sure that all lines 15—15' are of substantially the same length, as suggested in Figs. 3 and 4. In Fig. 3, I show all lines to terminate at the far end of the cable in an open-circuit condition, as by casting the end of the cable in a block of insulating material, such as a block of plastic 31. Alternatively, all lines 15—15', etc., may be terminated with their characteristic impedances, as suggested in Fig. 4, where the impedances 32 (labeled Z_0) close each line and are cast in a single block 33 for ruggedness.

In elongated cables of the character indicated, it is important to note that unless enough piezoelectric cylinders are employed at each source location (e. g. for the two transducer elements 19—19' of the single unit 10 shown in Fig. 2) to make the source capacitance high compared to the stray capacitance between lead circuits 15 in the cable, then capacitative cross-talk between circuits is likely; in such event, a small impedance transformer 30 may be carried by each transducer unit 10 and serve to couple the elements 19—19' to the lead pair 15' associated therewith. In Fig. 2, I show that the impedance transformer 30 may conveniently be potted within a suitable protective recess 30' at one end of the reinforcement cylinder 22.

It is desirable that the overall density of the hydrophone unit 10, when assembled on the cable 11, shall be kept to a minimum, consistent with structural rigidity. To this end, the pressure-release means 26 may be of substantially greater volumetric proportions than those shown in the drawings, so as to render the hydrophone unit 10 more neutrally buoyant. However, in the form shown, I have provided float members, as at 14, to improve the neutrally buoyant characteristic of the hydrophonic cable as a whole. The float means 14 may comprise a cylindrical shell 35, tapered at one end 36, and with a hub 37 smoothly to ride the cable sheath 18. The shell 35 may define an annular air pocket 38, providing the desired buoyancy, and resilient washer means 39 may assure concentric mounting of the shell 35 on the cable 11. I have shown a cap member 40 fitting the open end of the shell 35 and including a hub 41 riding the cable sheath 18. A jacket of rubber or rubber-like material 42 may encase the buoy structure 14, so as to protect the same against damage in handling. I prefer that external dimensions of the buoy and hydrophone units shall be approximately the same in order to improve the ease of handling on board ship, as well as for uniformity of appearance.

In Fig. 5, I illustrate an alternative hydrophone-unit construction wherein an annular air pocket 45 provides the means for pressure-release internally of the transducer means 46—47; like the transducer means 19—19' of Fig. 2, the transducer elements 46—47 may be two parallel-connected, foiled piezoelectric units. I have shown the air pocket 45 to be defined by the cylindrical shell 48 upon which the members 46—47 and their potting 49 are supported. The cylinder 48 may be spaced from the cable 11 to the desired extent, as determined by a flange 50 on an end ring 51, and a further air pocket 52 may be provided at each end of the assembly by conical end pieces, such as the conical cap 53, fitting over the flange ring 51 and including a hub 54 riding the sheath of cable 11. As before, a jacket 55 of rubber or rubber-like material, such as neoprene, may encase the entire assembly so as to retain the same and so as to provide against damage in handling.

In Fig. 6, I illustrate an alternative float construction having greater flexibility than that illustrated in Fig. 2. In the arrangement of Fig. 6, a corrugated metal bellows or sleeve 56 is held in radially spaced relation with the cable sheath 57, by means of rigid end caps; each end cap may comprise a conical member 58 on a sleeve 59 riding the cable sheath 57. A jacket 60 of rubber or rubber-like material may be applied over the entire float unit and faired to the cable sheath to provide protection against damage in handling.

It will be appreciated that I have described extremely rugged hydrophone-cable constructions, which may not only provide great resistance to damage in handling but which also possess enough inherent flexibility to permit handling with conventional cable rigs, such as drums and ship-board cable-paying apparatus. The construction lends itself to relatively simple fabrication, and the described transducer-element connections render the hydrophone cable particularly attractive for use in arrays, including steered arrays, extending for great distances.

While I have described the invention in detail for the preferred forms shown, it will be understood that modifications may be made within the scope of the invention as defined in the claim which follow.

I claim:

An electro-acoustic array, comprising a continuous elongated multi-conductor electric cable with a continuous flexible tension core and a plurality of transducer units connected thereto and supported thereon in longitudinally spaced relation, each transducer unit comprising a rigid cylinder secured to and coaxially surrounding a continuous part of said cable, an annular piezoelectric member supported by and coaxially surrounding said cylinder and in radially spaced relation therewith, rigid protective radial flanges carried by said cylinder at the longitudinal ends of said piezoelectric member, said flanges extending radially outwardly of the periphery of said piezoelectric member, pressure-release means longitudinally coextensive with said piezoelectric member and radially intermediate said piezoelectric member and said cable, a potting of sound-transmitting material extending between said flanges and intimately covering the periphery of said piezoelectric member and securing said piezoelectric member in radially spaced relation with said rigid cylinder, and impedance-matching means electrically connecting conductors of said cable to said piezoelectric member, the rigid frame constituted by said cylinder and by said flanges having adjacent one of said flanges a protective recess accommodating said impedance-matching

means within the radial limits of said one flange, said impedance-matching means being fully potted in said recess within said limits, whereby said potted transducer units effectively form part of said cable and can be towed, wound and payed out by cable-handling gear without damage either to said piezoelectric members or to said impedance-matching means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,638,577	Harris	May 12, 1953
2,651,027	Vogel	Sept. 1, 1953
2,708,742	Harris	May 17, 1955