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HIGH FREQUENCY DEEP WATER TRANSDUCER ARRAYS

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1. Introduction

About 12 months ago, we became interested in the possibility of using high resolution sector scanning sonar systems in deep water. The application areas are associated with manned or unmanned submersible operations in waters of limited optical visibility such as the North Sea. The uses for such equipment may be for short range, high accuracy navigation, general exploration or more specifically for the examination of rig structures.

The first requirement was for a transducer array capable of efficient operation at depths of up to 300 metres, whereas the long term objective is the development of an array to operate at up to 10,000 metres.

A major problem in the design of transducer arrays is the selection of a backing material which will firstly decouple the elements from the casing system and from each other and secondly provide the mechanical strength and stability required for the correct operation of the array. The backing materials which are used in current array construction are generally rather weak and of limited availability. We have investigated one potential backing material - a rigid, closed cell polyurethane foam which is widely used in the packaging industry and for a variety of other more specialised applications. It is characterised by low density (0.2 gm/cc) and high strength (42 kg/cm^2) and this paper describes the building of a 15 element, 300 kHz array using one of these foams as a backing material. This array is to operate at depths up to 300 m, but it may be possible to compromise the ceramic face efficiency for increased depth capability by increasing the density of the foam.

2. Design features

We believe that no useful purpose would be served by attempting to list potential or actual failings of various array design techniques since it is probable that each array has some failings to a greater or lesser degree. It is more constructive to list those features of array design which we have taken into consideration.

1. The pressure release material has an acoustic impedance of approximately 2×10^5 rayls and hence can yield an array efficiency of 80% combined with a strength capability equivalent to operation at depths of 300 m.

2. The acoustic window material which is directly bonded to the transducer faces has a high corrosion resistance and a low acoustic absorption coefficient.

3. The nylon casing combines excellent corrosion resistance properties, low specific gravity and high strength with ease of fabrication.

4. A reduction in deadweight by a factor of five over the conventional metal - oil array can be achieved with the important additional feature for submarine operation that neutral buoyancy can be obtained without excessive enlargement of the array case.

5. The cable terminating chamber is sealed from the transducer chamber and is filled with a soft silicon rubber which permits cable replacement in the event of damage.

6. The design is suitable for a large range of applications from single element hydrophones to 1 metre, double banked, curved transmitter arrays.

7. Individual elements may be replaced although recovered elements would have to be resilvered (and re-polarised).

8. In the event of the acoustic window suffering heavy barnacle growth (this is likely within two years if continuously immersed in sea water) the window may be skimmed clean and a new layer applied.

9. The square box design for the array casing suggests that large arrays may be composed of identical smaller units mounted within an external frame. Some elements within the array would be lost but in some circumstances this may be tolerable.

10. The prototype array was manufactured from raw materials to completion of initial tests in 10 man days. An array five times the length of the prototype receiving array would take between 15 and 20 days to manufacture. These times exclude the preselection of the individual elements.

3. Manufacture

The prototype array cross section is shown diagrammatically in figure 1. The nylon 'H' section case is machined from a solid block, although later versions may be partly cast in the required section. Heat treatment of the machined block may be necessary to relieve internal stresses. The polyurethane foam is 'foamed in place' using the foam chamber as a mould. The cured foam is machined to accept the array elements which are then wired and secured in position. The acoustic window, which is a neoprene type material, is cast hot and allowed to self level. The lead throughs are then wired and the wiring holes to the transducers sealed. On completion of cabling, the cable chamber is filled with silicone rubber and the nylon back plate is welded in position. The strength of the nylon weld approaches that of the nylon. Suitable cleaning and bonding techniques have been experimentally determined.

4. Test Results

Average efficiencies approaching 80% have been measured, and the array beam pattern shows good agreement with theory see fig. 2. No deterioration of the performance of a pre-prototype array has been detected over the past two months which may suggest that no serious incompatibility exists between the various materials used in the array construction. Sea trials for an array of the type described are to be undertaken in co-operation with Heriot Watt University, when the performance of the array will be measured at its depth limit.

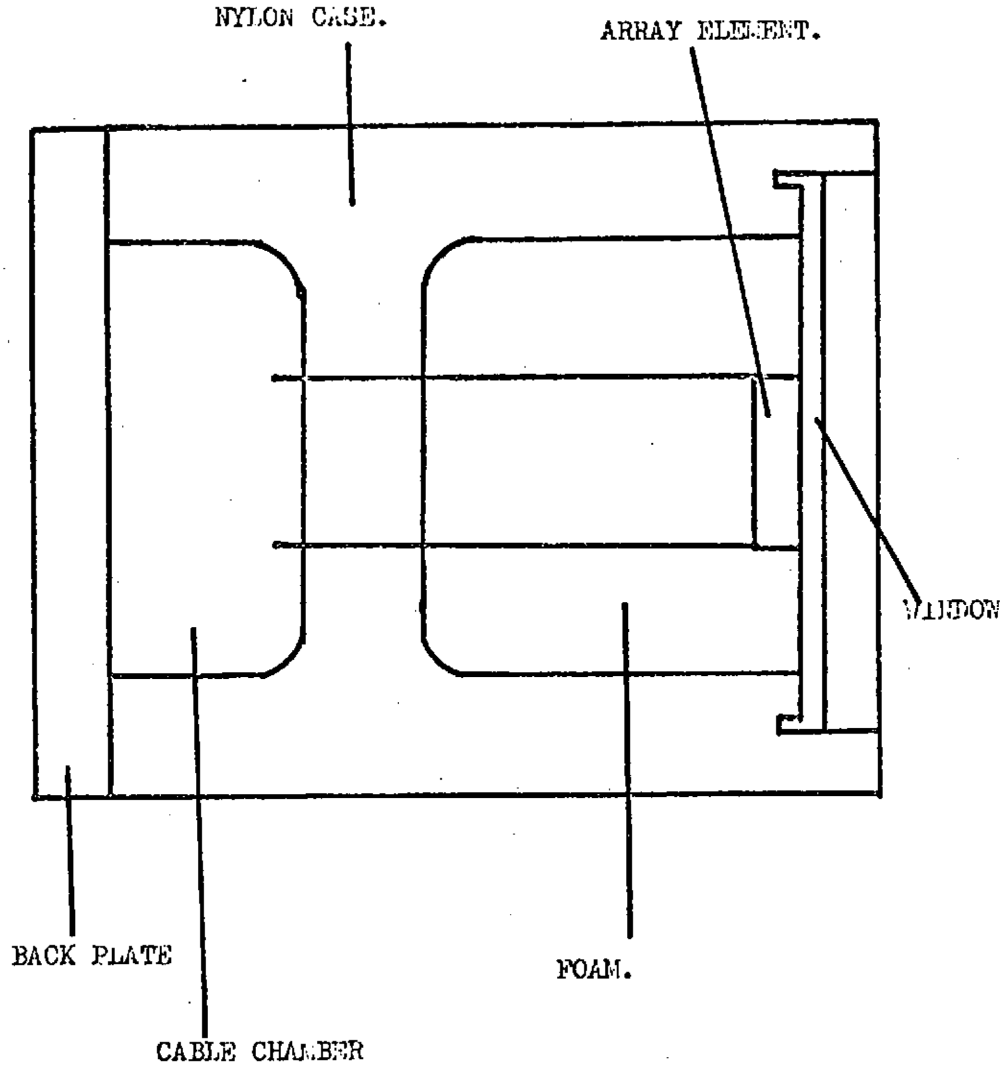

FIGURE 1. DIAGRAMMATIC CROSS SECTION OF ARRAY.

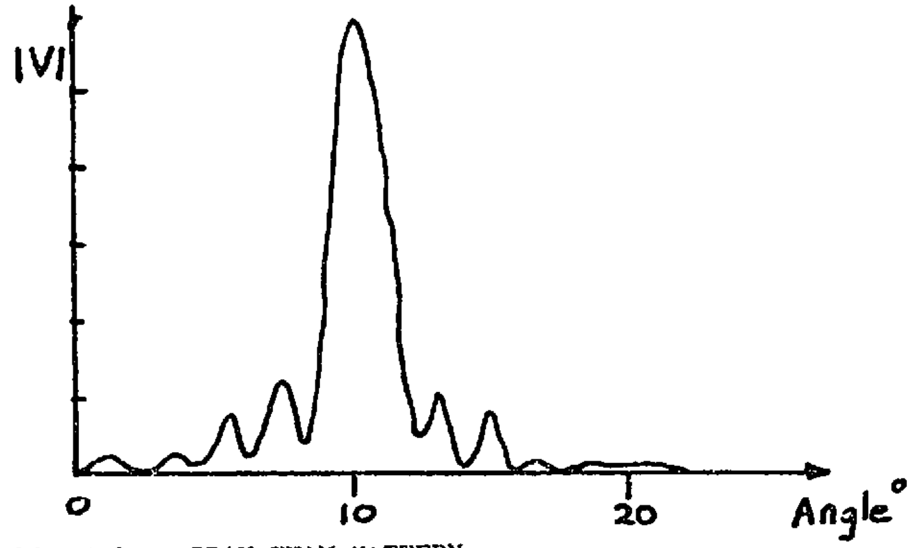

FIGURE 2. ARRAY BEAM PATTERN.