AN EXPERIMENTAL SONAR RECEIVER USING A CIRCULAR ARRAY

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1. INTRODUCTION

Circular arrays have many advantages including wide bandwidth operation and ability to scan electronically over 360 degrees with a constant beam shape. Over the past year a joint project between Loughborough University (LUT) and University College, London (UCL) has been investigating the application to a sonar array of some of the ideas that have been developed in the radio and radar fields. A companion paper from UCL (Ref.1) describes the background theory of circular arrays and the concepts which will be examined. This paper describes the work which has been carried out at Loughborough on the design of the experimental arrays and the data capture system. Some of the early results on beam pattern measurement are also presented.

2. THE ARRAYS

Two arrays have been made although all the measurements described in this paper were made on the first array produced. This comprised seven 1/2" diameter hydrophones spaced equally on a circle of 2" diameter shown diagrammatically in figure 1. The individual hydrophones had a relatively flat frequency response within the range of frequencies over which the tests where carried out. A second array comprising a set of ceramic elements mounted on a solid backing has been constructed but no measurements have yet been made using this array.
The choice of 7 elements was somewhat arbitrary. It is necessary for the elements to be spaced by less than half a wavelength and hence the larger the number of elements the larger the array can be in terms of wavelengths with the consequent improvement in directivity. On the other hand the larger the number of elements the larger the number of channels of processing that would be required and this would increase the cost and complexity. As is shown in the companion paper the outputs of the array are normally Fourier transformed before being subject to further processing and thus it might have seemed that a sensible choice of the number of elements would have been a power of 2 e.g., 8. However there are advantages in using prime number transforms (Ref 2) and for this reason the number of elements was fixed at 7.

3. THE MEASUREMENT SYSTEM

A block diagram of the system is shown in figure 2. The output of each of the hydrophones is amplified by a separate wide-band 40dB amplifier before being fed to a set of 100kHz anti-alliasing filters. Initially these signals were then directly used to measure the beam patterns using an analogue beam pattern measuring system (Ref 3) but later the signals were fed to a set of 12 bit A/D converters and then captured on a PC for subsequent processing.
Another hydrophone situated about 2m from the array was used as a transmitter to provide the signal for measuring the beampatterns. This was driven from a flexible signal source generator (Ref. 4) which enabled the parameters such as frequency, pulse length and pulse shape to be controlled at will.

The choice of operating frequency is a compromise between two limiting factors. The size of the tank means that multipath problems exist with reflections mainly from the surface and bottom. This limits the length of the pulse which can be unambiguously separated at the receiver to about 0.5 ms and hence limits the lowest frequency to a few kHz. The highest frequency is limited by the need for the elements to be spaced by a maximum of 0.5 of a wavelength i.e., about 30kHz for this array.

4. PRELIMINARY RESILTS

Figure 3 shows a set of beam patterns for the individual elements measured with the other hydrophones not present. It will be noticed that there is some variation in the sensitivity with angle. In figure 4 we see the same beampatterns but now with the other hydrophones present and it can be seen that this causes considerable variability in the patterns. To overcome this problem a soft absorbing material was placed in the centre of the array which suppresses the signals arriving from across the array and gives each element its own beam pattern. In figure 5 we see the resulting beampatterns and in Figure 6 these are normalised so that they lie on top of one another. Although there is some variability it can be seen that there is a relatively good match. It is this set of curves which have been used in the companion paper for analysis.

5. CONCLUSIONS

A simple 7 element array together with a data capture system has been built and the results obtained so far are in keeping with those expected. The system is now ready to be used for the collection of data for testing the various algorithms.

6. REFERENCES

1 Griffiths H.D.,Eiges R. and Davies D.E.N. "Circular Array Processing For Sonar Applications", ibid

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4 Griffiths J.W.R. et al "A Versatile Signal Generator" Proc. Second International Conference on Transputer Applications July 1990 Southampton U.K. I.O.S. Press.

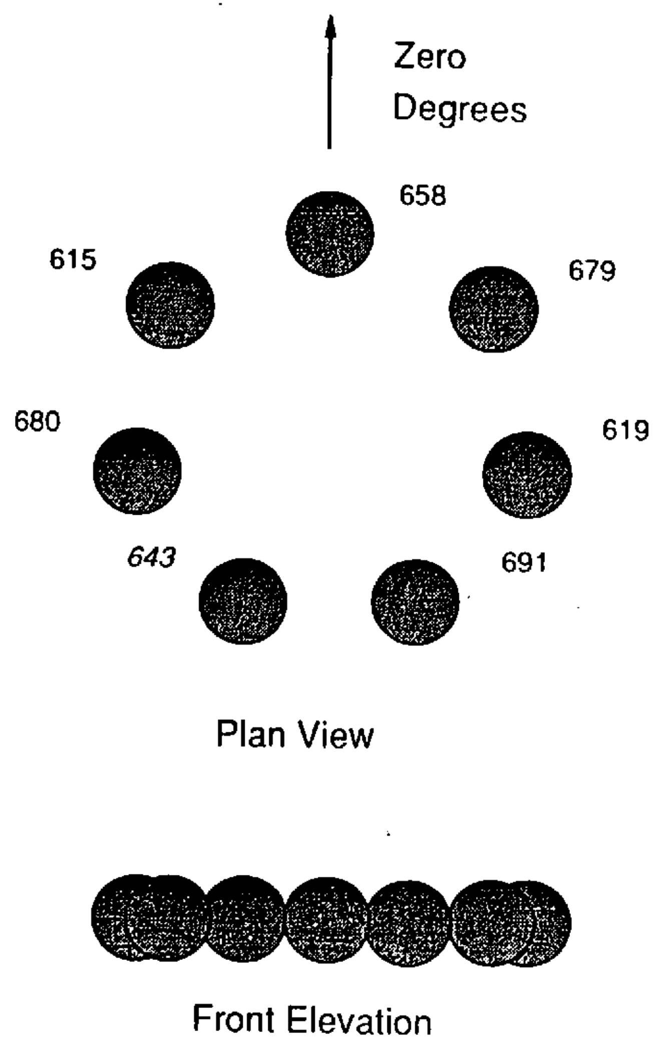

Fig. 1. Hydrophone layout

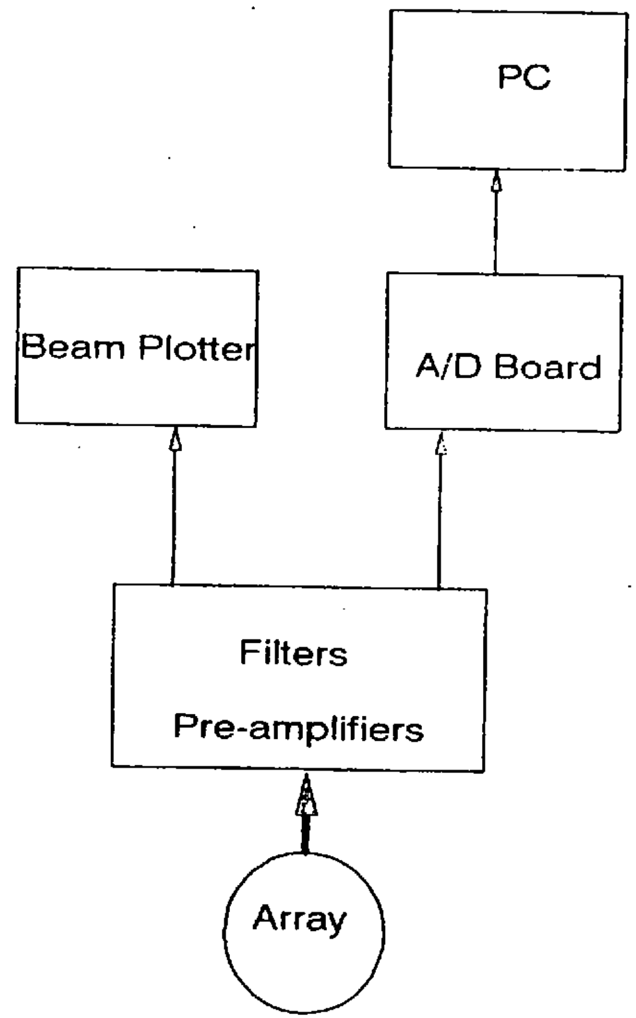

Fig. 2. Block Diagram of System

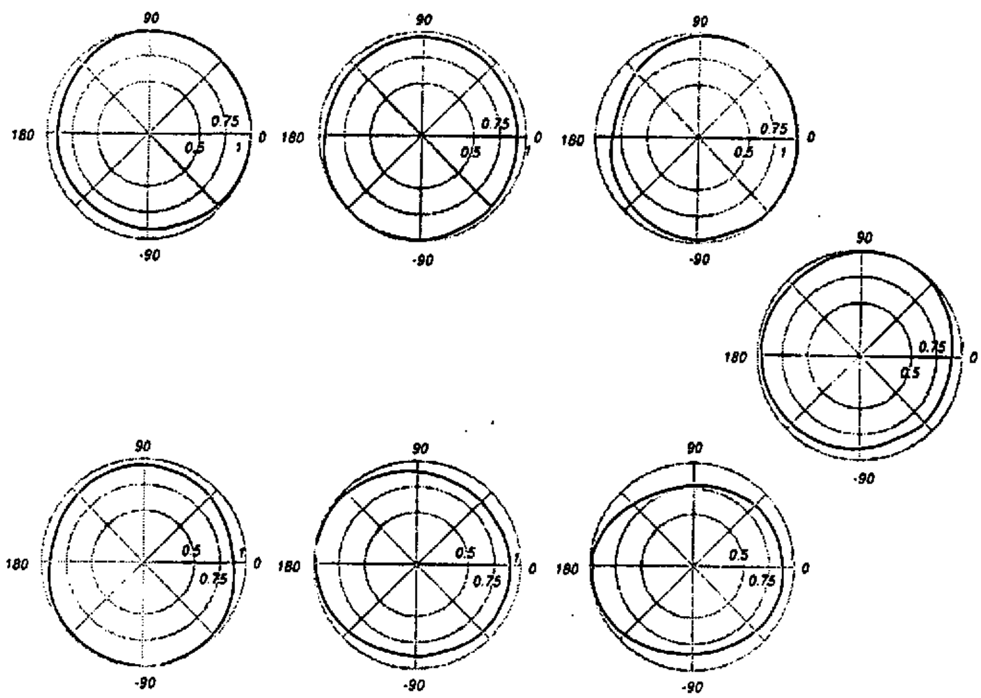

Fig. 3. Beam patterns of individual elements with others absent

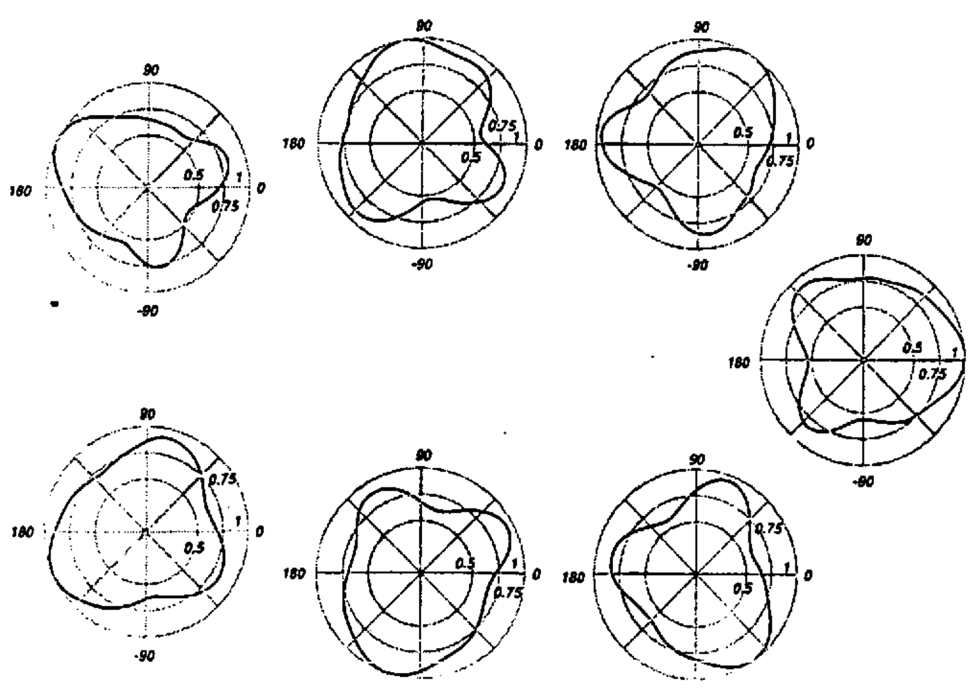

Fig. 4. Beam patterns of individual elements with other present

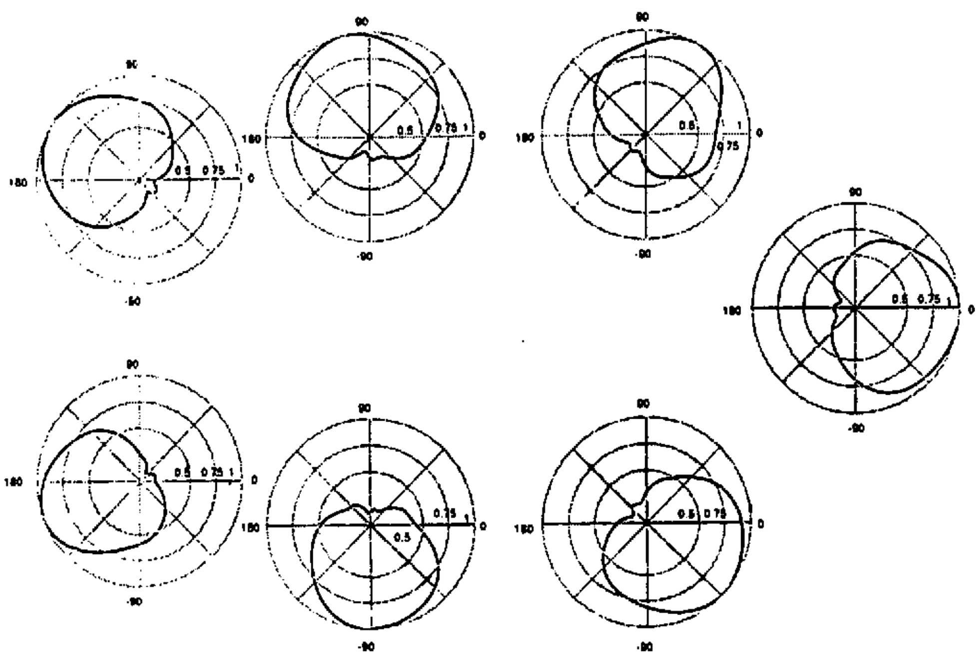

Fig. 5. Beam patterns with absorber

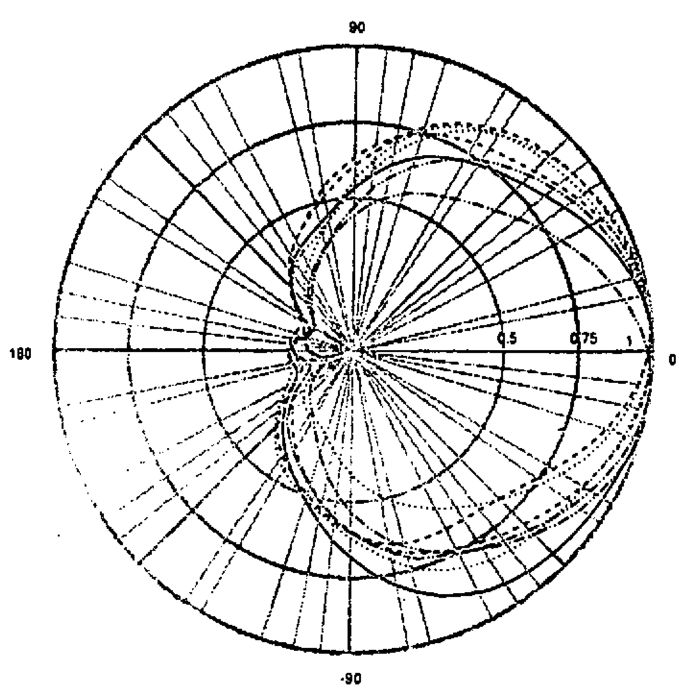

Fig. 6. Normalised beam patterns