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Side Scan Sonar Applications

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A very short range high-resolution side-scan sonar

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Introduction

There are certain turbid water situations where a high resolution side-scan sonar would be useful even though its maximum range might only be 15 meters. Police forces have a need for such an equipment for rapid screening of inland waters such as lakes, ponds, canals and rivers where the time to search would be drastically reduced compared with the present manual search patterns employed. The objects of interest to the police range from large ones such as cars, down to small items such as knives and pistols. Obviously such an equipment would also be of use in directing the diver to selected targets, and it will also provide a means of surveillance in the interests of safety.

Even in ocean conditions, such an equipment attached to either a manned or unmanned submersible vehicle would produce a continuous and detailed record of surface geological, and other features. A useful extension of the sonar is to provide for the array to be scanned mechanically, thereby providing a forward search facility for navigation, archaeological, civil engineering and salvage surveying.

A requirement of all these applications is that the sonar should be a low cost portable equipment with both an on-line display and permanent record facility. The resolution requirement is dictated in general by the smallest target that is to be detected. As a rough indication, at mid-ranges the resolution cell (range x lateral extensions) should be small, say one-fifth, compared with the size of the target.

In a typical application this calls for a 50 mm. square mid-range resolution cell and necessitates narrow transmitting and receiving "beams". For example if the maximum range is taken as 15 meters, the horizontal angular transmit/receive product beamwidth is 0.4°. The beamwidth here is that which is measured between the first zeros of the directivity pattern. (ref.1.) To ensure adequate insonification in range a vertical beamwidth of the order of 45° is necessary.

With conventional resonant transducer structures which have bandwidths typically equal to 5% of the centre frequency, the 50 mm. range resolution dictates a minimum carrier frequency of nearly 800kHz (ref.2.) At this order of frequency it is obvious that there will be negligable penetration into the bottom sediments. (ref.3.)

Displays and Interpretation

For the pure side-scan mode of operation the horizontal scan on an intensity modulated CRT display can be made to move in accordance with the movement of the transducers relative to the bottom. Permanent records can be obtained directly from the CRT display by photographic means. A high speed chart recorder using an electronically-scanned multi-stylus system is an alternative.

No matter which type of display is used, the dynamic range of the input signal to the system will be much greater than the display dynamic range. Thus range compression by dynamic means or logarithmic processing is required.

Both in side-scan and forward search modes, the equipment will provide a slightly distorted plan view of the bottom, its contours and any other irregularities by means of the back-scattered energy. Objects protruding above the bottom will only be seen by virtue of their acoustic highlights (ref.4.) and identification of acoustically smooth targets will only be possible by observing the acoustic shadow which they cast. This acoustic shadow will not in general resemble the geometric shape of the object itself, and this means that considerable operator training will be needed to interpret the displays.

Various techniques are available which provide a pseudo-perspective display from raw sonar data (ref.5.) but the main disadvantage of known techniques is the considerable time taken to produce such a display. Alternatively several views of the same object from different angles will provide additional information and aid target recognition. This emphasises the need for permanent records of the display.

Specification for a System

To cover as many applications as possible, a sonar has been designed so that it can be used in either of the two modes of operation previously discussed. Any form of electronic beam scanning was considered both uneconomic and unjustified from the point of view of the time required to scan a complete sector. For example with a 0.4° beam, and for a range of 15 metres, only six seconds are needed to scan a 120° sector. With a long persistence cathode ray tube display, trace to trace correlation is still just possible. Provision is also made to limit the sector of the mechanically scanned transducer if objects in a selected area require detailed study, with a corresponding increase in .. trace to trace correlation.

The system was designed to the following summarised specification:

maximum range	15 m
mid-range resolution cell	50 x 50 mm.
carrier frequency	750kHz
pulse repetition frequency	40 pulses/sec.
transmitter transducer	45° x 1.4° (-3dB beamwidths)
receiver transducer	45° x 0.7° (-3dB beamwidths)
mechanical slew rate	13°/sec.
transmitter power	1 watt maximum
detection threshold	-10dB
minimum detectable target at 15 m	-50dB

With linear processing, the near field of the receiving transducer extends to about 8.5 m., and within this region the lateral resolution is never appreciably less than the 150 mm. horizontal dimension of the transducer (ref.1.) Thus linear processing is inadequate. Focussing would be unacceptable because of either complexity or the small depth of focussing, so that an alternative processing method had to be devised.

It is well known that multiplicative processing can be used to halve the far-field beam width, and in the near field it has been shown that the near-field resolution is highly directional along the axis (ref.1.) In multiplicative processing the array is divided into two halves and the outputs from each half of the array after amplification and dynamic range compression are multiplied together and time-averaged to produce a square-law detected output. Resolution is improved in the near-field because target echoes will be processed only when they occur in the overlapping sections of the two beams, see Fig.1.

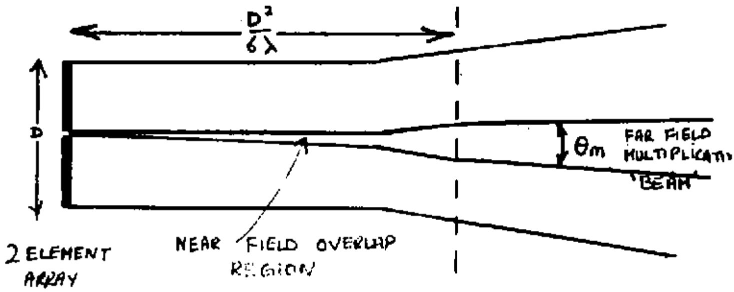

Fig. 1.

In a multiple target situation multiplicative processing of far-field targets can become degenerated so that little improvement over additive processing is obtained. However for the present application, most targets are within the near-field and the resulting beams are so narrow as not to permit multiple target situations.

References

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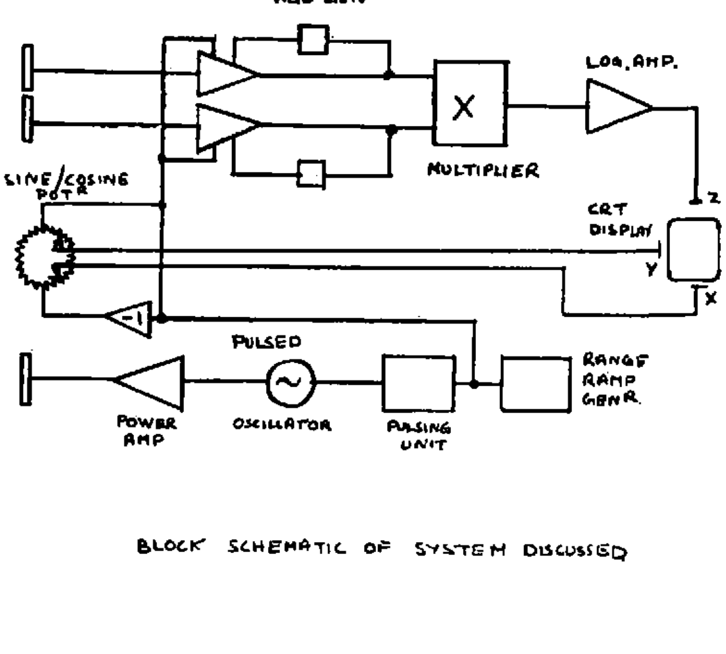
The talk will be illustrated with slides showing the potential of such a system and some of the difficulties associated with interpreting the display.



BLOCK SCHEMATIC OF SYSTEM DISCUSSED