BRITISH ACOUSTICAL SOCIETY: Meeting on Tuesday 27th March 73 at the Fisheries Laboratory, MAFF, Lowestoft.

SONAR IN FISHERIES

Paper No.73/26 Development of a Commercial Digital Sonar Equipment

Dr. W. P. Williams and Mr. I. A. Leonard

Marconi International Marine Company Limited

A number of systems have been developed to provide displays of both range and bearing information of underwater sonar targets. The most common of these simply utilises a narrow beam transducer fixed to a mechanically rotatable mount and having a display whose scan moves in sympathy with the rotatable transducer mount. A more sophisticated system uses electronic scanning of the sonar beam and thus avoids the problem of mechanical design associated with heavy gear being remotely moved underwater. A third technique which has been developed utilises an analysis technique which calculates the bearing of targets and displays this information on an oscilloscope tube type of display. It is this third technique with which this paper is concerned.

The equipment has become known as the Digital Sonar chiefly because all electronic processing is carried out digitally but a more correct title would be a phase correlation sonar. In this system, originally developed by Birmingham University, a transducer array consisting of seven elements is utilised for the receiver and a further element is used to transmit the sonar pulse into the water. Received echoes from targets within the sector covered by the transmitted beam are amplified by seven separate receivers connected to the receiving array. The bearing of targets is measured by measuring the relative phase of target signals between consecutive elements of the receiving arrary. This information is then displayed as a positive or negative deviation on a 'B' scan oscilloscope display. It is necessary however to differentiate between targets and noise prior to phase measurement in order to avoid clutter on the display. This differentiation between targets and noise is achieved by temporal and spacial correlation carried out in real time in the processor. A block diagram of the complete system is shown in Fig.1 The elements of the complete system developed are described in the sections below -

1. Transducer and Housing

As mentioned above the transducer consists of an array of seven receiving and one transmitting element. All of the elements are similar and consists of magneto-strictive units having a working face area of 3cm by 15cm. They are mounted in an appropriate frame and potted in silicon rubber. Magneto-strictive elements as opposed to piezo-electric elements were used for this design because commercial experience with echo sounding equipment showed that these elements are capable of withstanding very considerable shock loads caused by pounding of a ship. The transducer is designed to be as small as possible and is in fact only 15cm by 24cm. The first housing designed for fitting on a seagoing vessel is shown in Fig.2.

The principle behind this housing is to set the transducer forward looking in the hull of the vessel with the beam pointing slightly downwards (approximately 8°) so that the vertical beam did not stroke the surface under normal operation. The housing is designed so that it can be fitted on the sloping part of the hull of a vessel and sufficiently up the slope so that the base of the transducer housing does not protrude below the keel line.

2. Receivers and Processing Unit

The equipment utilises seven receivers one for each receiving element in the transducer array. The receivers are required to provide a hard limited output from their own self generated noise. They must be capable of providing the necessary amplification and limiting without phase distortion since the accuracy of the equipment depends upon accuracy of the phase measurement between consecutive elements.

The processor performs the correlation process and also makes the average phase count measurement across the array which determines the bearing of a target.

The processing unit is designed as a separate unit from the display and includes all the electronics with the exception of the display circuits. The system is designed so that there are no controls on this unit and therefore it can be fitted in any convenient location within reasonable distance of the display unit. This technique minimises the size of the display which has to be fitted in the bridge at a suitable location for the operator.

3. Display Unit

The basic display unit is essentially a special purpose storage oscilloscope but since the output of the processor is in digital form this unit also contains necessary digital to analogue converters. This display unit itself has been designed around a storage tube oscilloscope which while providing only a small screen size allows the use of a variable persistance display. This was thought to be important in sonar systems because of the very low data rate associated with the rather low velocity of propagation of pressure waves in water. Experiments with early equipments showed that conventional long persistance tubes were not suitable for daylight viewing when the equipment was operated on very long ranges.

However, the small display area of the storage tube does have certain disadvantages in some specialised applications. This particularly applies where maximum range and bearing resolution are required and where the tube resolution may be the limiting factor. Since the output of the processor is essentially the necessary drives for a conventional oscilloscope a large display oscilloscope can be used and the necessary outputs have been provided to drive such an additional display.

The operators controls are also located on the display unit. They include ON/OFF switch, range selector switch, tube persistance control, transmitter pulse width and noise level control. This latter control is unique to this type of equipment and in fact sets the preset correlation level in the processor. It can be thought of as very roughly equivalent to a gain control in a more conventional sonar.

The equipment was designed to operate in an environment of -10°C to +50°C and was designed mechanically to withstand the conventional marine specification.

4. Experimental Results

The equipment has been tested both on inland lakes and has been fitted to the Scottish Fisheries Research Vessel 'CLUPEA'. The results of the initial sea trials were disappointing but they did indicate a number of modifications now incorporated in the equipment. The most recent trials carried out at various inland sites in the U.K. have proved very promising.

Passive targets consisting of 40cm diameter airfilled spheres have been successfully tracked to a distance of 500 yards. The limitation on range of passive targets on inland sites, (such as Lake Windermere) is bottom reverberation which produced bottom target information on the screen tending to obliterate wanted target information. Tests with divers in Lake Windermere showed that they also can be tracked as passive targets to ranges in excess of 500 yards.

However, the most interesting results have been obtained using transponder beacons. These transponder beacons used as active targets and interrogated on a different frequency from the receiving frequency have been successfully tracked to the limit of range of the present equipment 2000 yards. The limitation on the use of these active targets appears to be simply a limitation on interrogation rather than reception of the re-transmitted signal. This is because the active target has to be set at a relatively low sensitivity to avoid unwanted triggering by acoustic noise.

The accuracy of the equipment is difficult to specify because it is dependent on received signal-to-noise ratio. The bearing accuracy of the equipment has a theoretical maximum of 1/128th of the total sector width in use. However, this theoretical maximum can only be achieved with 100% correlation. It is always necessary to accept less than this ideal since noise interferes with the received target information. Experience to date has indicated that satisfactory target identification can be achieved with 90 - 95% correlation. This degree of correlation implies a bearing accuracy of $\pm 1^{\circ}$ using a 60° sector.

The theoretical range resolution is 6ins although this can only be achieved using a high resolution display such as the large display oscilloscope.

CONCLUSIONS

Experiments with the practical Digital Sonar equipment have shown that it could be a useful new research and operational sonar tool with a number of fisheries applications. Transponder beacons are available today capable of being fitted on individual fish and these could certainly be tracked at very considerable ranges. The equipment has also been shown to operate satisfactorily on passive targets but on passive targets it tends to be bottom reverberation limited. It thus seems that its most likely application will be in shoal fishing applications where it can provide a long range indication of mid-water fish shoals for purse seine and pelagic fishing.

ACKNOWLEDGMENTS

The authors wish to thank colleagues at Marconi Marine for assistance in the preparation of the paper and the Management of the Company for permission to publish it. They would also like to acknowledge gratefully assistance provided by Birmingham University who originally developed the Digital Sonar equipment.

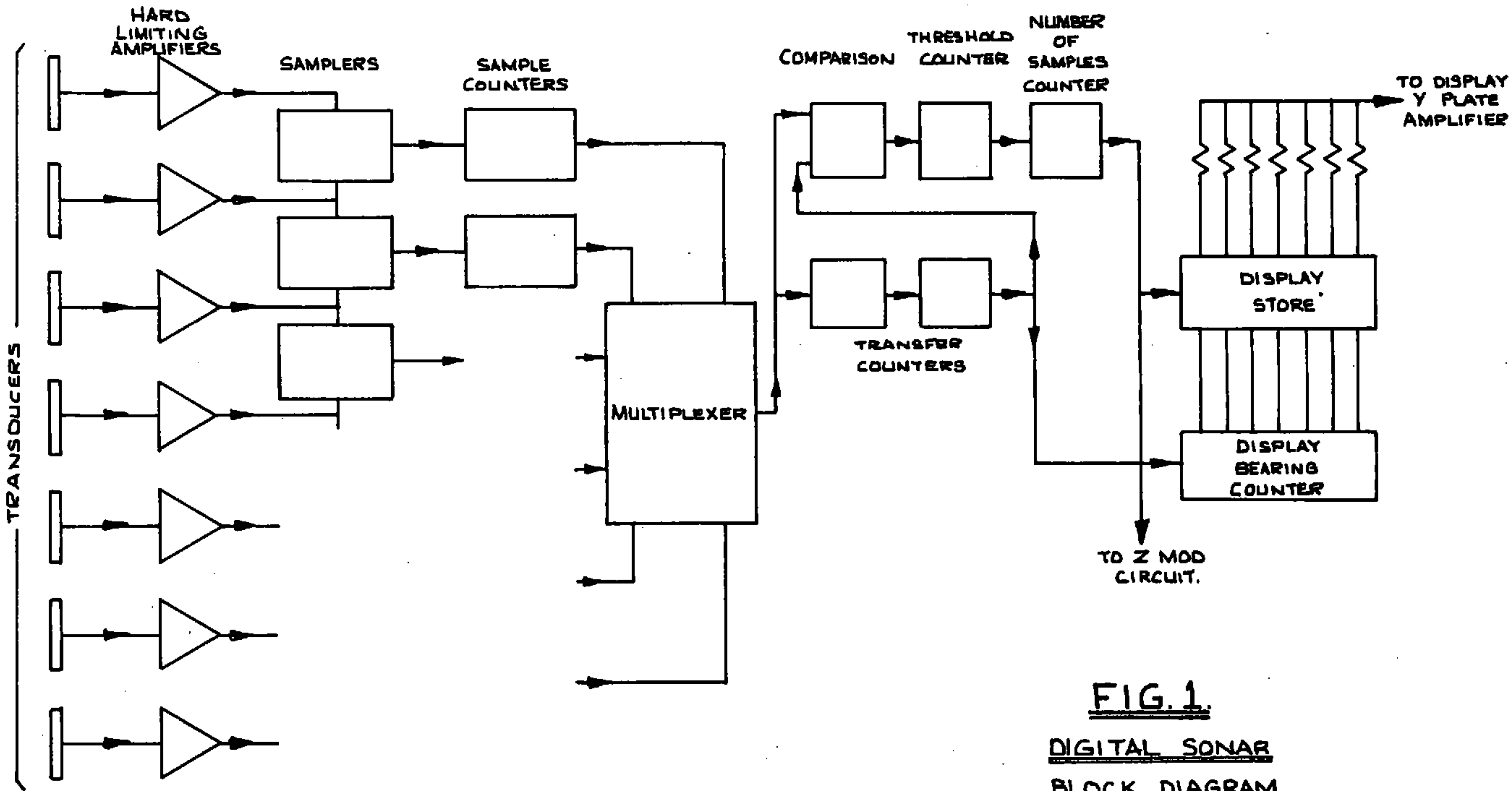

FIG. 1.

DIGITAL SONAR BLOCK DIAGRAM.