BRITISH ACOUSTICAL SOCIETY

71SBA8

SPRING MEETING 1971

5th - 7th April

A FAST COMPOUND SECTOR SCANNING SYSTEM

by J. Szilard and G. Scruton

Introduction

In any type of echo sonography using the B-scan technique, the scanning ultrasonic beam which has finite width is represented by a narrow time-base line on the cathode-ray oscilloscope screen. Thus an ultrasound beam when scanning across a point target results in an elongated image of the target on the screen. If the target is larger, the two edges of it will be elongated by the above said process.

Previous attempts to improve lateral resolution have been concentrated on trying to represent the narrow time-base line on the screen by a similarly narrow ultrasonic beam. These attempts have inherent limitations.

Now let us reverse our train of thought and proceed in the opposite direction, as explained below.

Principles of Operation

Let us now try to represent the ultrasonic beam by displaying its width and divergence to scale on the C.R.T. screen. In other words, we should reproduce an image of the ultrasonic wave front, as it propagates in the medium. Thus, using brightness modulation, when the beam hits a target, an arc will be painted on the screen, (Fig. 1), showing the position of the wave front at that moment.

If now we test from much more than one position of the probe, a number of different arcs are produced having a common intersection at the point representing the target (Fig. 1). What we have got to do is to adjust the brightness level of the display, such that the individual arcs should remain below a threshold level and a visible image be built up by superposition of a number of arcs at the crossover point. Thus the image of a small target will appear as a small dot.

Instead of slowly scanning across the whole target area, to achieve high speed of operation and because of economical aspects we will restrict the number of probe positions.

Echo amplitudes do carry some information but in this system very little amplitude variation can be tolerated. This can be achieved by various methods of signal processing.

However, losing the amplitude information is of no great importance, because the target characteristics will now be much better resolved.

Let us now consider the problem of having more than one small target in the scanned area (Fig. 2). In this case arcs will intersect at some points which do not correspond to the location of any true target. However, the number of arcs crossing at any one "false target" point will be, in general, considerably less than at real target points. With increasing number of arcs on the screen the probability of multiple "false" intersections increases, but it would require an exceptional situation to produce a multiple false intersection nearly as bright as a real one.

Consequently if the brightness level of the individual arcs is set in accordance with the number of arcs expected to intersect at a real target point, the false indications would not normally appear at all. As a further safeguard against such false indications the wide angle beams can be split up into narrower sections (Fig. 3).

Larger targets will create a more difficult problem (Fig. 4). The echoes will be prolonged to an extent depending on the ratio of ultrasonic wavelength/surface irregularities, producing correspondingly thicker arcs. In spite of this it is seen in Fig. 4 that there is little distortion in the displayed shape of the target. The problem will be overcome to some extent by splitting the beams (Fig. 3). As with a conventional system, image thickness bears no relation to the axial extent of the target.

Principles of Construction

To make scanning faster, an electronically switched array of probes will be used instead of one moving probe. Acoustic lenses were adopted to produce the required beam pattern and probes will be mounted in triple units giving a beam pattern as shown in Fig. 3.

A dead zone for the array is defined by the distance over which no intersection of arcs is possible, (Figs. 1, 2). Consequently immersion technique is necessary, or the use of some other means of delay between probes and body, such as a liquid-filled rubber bag or a suitable plastic construction.

The array may be straight or curved.

For representing the ultrasonic wavefront on the screen a raster (Fig. 5) is generated using waveforms as shown in Fig. 6, which are combined perpendicularly.

Assuming a maximum depth range of 30 cm, which should be more than enough, the round trip time of a pulse is 0.4 ms. A suitable p.r.f. is 1500/sec., i.e., a period of 0.67 ms. It is intended that the array shall comprise 12 triplet probe units giving a total scan time of 24 ms, which is approximately equivalent to 40 frames/sec.

Results

At the moment the final system is being simulated by putting a single probe sequentially into each of the positions corresponding to those in the final array and photographing each resulting image on the same film. Some results will be shown during the course of the talk.

Proposed Applications

This project is being sponsored by the Meat and Livestock Commission and the primary aim is to develop an instrument for measuring cross-sectional areas of muscle and fat in live animals.

However, it could also be used for various medical diagnostic purposes, where ultrasonography is already a useful tool. The virtually instantaneous image at a rate of 40 frames/sec. will enable observation even of moving objects, e.g., when searching for a foreign body in the eye. It should also be applicable in the field of veterinary science in which case it could be used without tranquillising the 'patient'. The speed of the operation will facilitate quick examination of a patient at a number of positions until the best position for viewing is found. Thus there will be a considerable saving both in time and in the number of Polaroid photographs taken.

Acknowledgments

As mentioned above the project is sponsored by the Meat and Livestock Commission. We gratefully acknowledge their support and permission to present this paper. Thanks are also due to our colleague, Mr. S.Y. Raikar, for his invaluable collaboration in the design and construction of the electronic system.

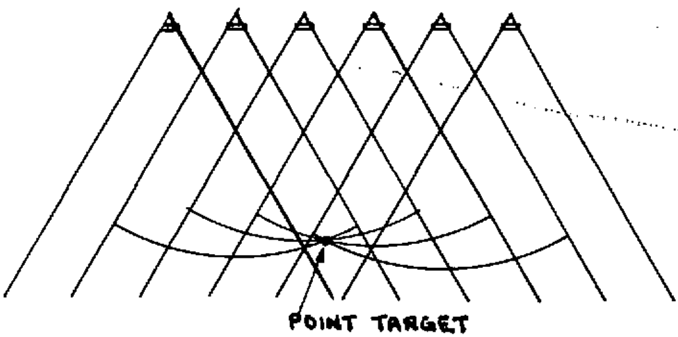


FIGURE 1.

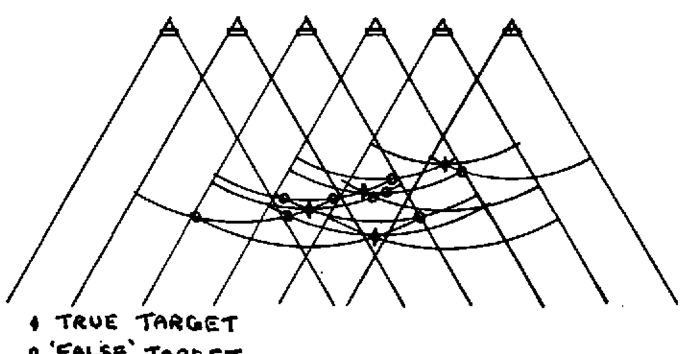


FIGURE 2

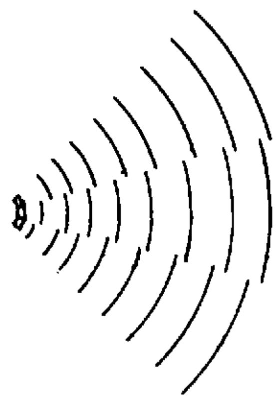
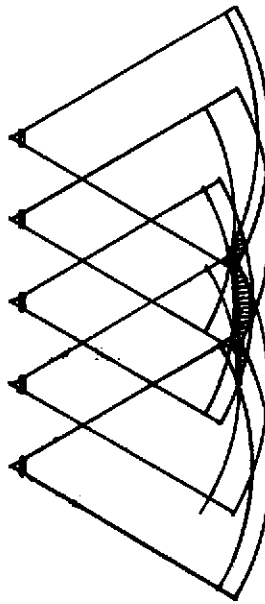


FIGURE 3



SOLID LINE - LINE TARGET   HATCHED AREA - DISPLAYED PRESENTATION

FIGURE 4

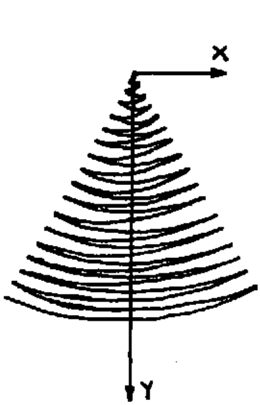
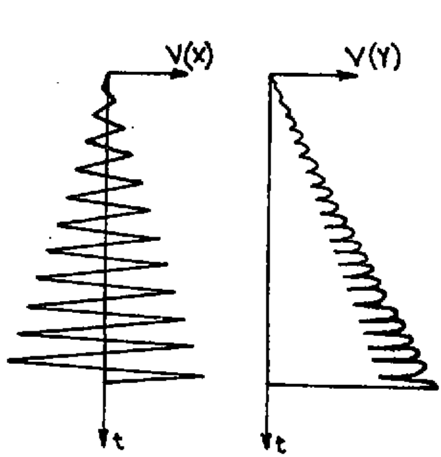


FIGURE 5



(a)   (b)

FIGURE 6