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Progress in acoustical holography

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We are investigating acoustical holography principally to determine its possible usefulness in non-destructive testing; however we have also investigated to some extent its possible usefulness in medical diagnostics using biological specimens. As with all ultrasonic diagnostics, the problem is to interpret the ultrasonic signals in terms which yield pertinent information. Most of the difficulties stem from the vagaries of ultrasonic propagation and ultrasonic holography appears to be a very good way of examining the anomalies which arise. This paper will be concerned with showing illustrative examples.

The holographic system which has been developed is a mechanical scanning system of a type well described in the literature (e.g. ref. 1) and this particular system has been described elsewhere (ref. 2). Its salient features are: it is a pulsed system using pulse lengths down to 1 microsec and carrier frequencies 2½, 5 and 10 MHz; the objects are generally viewed by direct reflection using the same scanning transducer for both send and receive; the receiving transducer is a focussed one and the resolution of the system is varied to suit the object being examined by using transducers of different cone angles; the scan is similar to a television raster producing a plane rectangular aperture for the hologram; the reference is electronic and corresponds to a skew plane acoustic beam; the hologram is recorded on a facsimile recorder which is then photographed to produce the optical transparency. A hologram of a simple object and the resulting image will be shown to illustrate the quality obtainable for such a case.

The first example of anomolous ultrasonic propagation concerns the mid section of a plaice. The top skin is like tough tissue paper and scatters 10 MHz in much the same way as frosted glass scatters light and it is impossible to see through it. This is demonstrated in that if part of the top skin is stripped off then the skeleton can be seen beneath it, also it can be seen through the soft underskin.

The second example concerns a pattern of shallow conical holes drilled into the bottom of a stainless steel cylinder. The cylinder is about 2½ inches long and 2 inches diameter and the view is from the top through the body of the steel using 10 MHz ultrasound. The problem here stems from the fact that the optical reconstruction depends upon there being only one mode of ultrasound propagation; this is obviously not true unless precautions are taken, e.g. in an isotropic metallic solid, there is at least a compressional mode, a shear mode and a surface mode. So far the compressional mode has always been used and in order to render the other modes, insignificant, the resolution of the scanning transducer has been curtailed. If this is not done the image, as will be shown, is almost destroyed and negligible improvement can be obtained by optical processing. Experimentally it has been found that optical processing is of little use unless the ultrasonic conditions are right, i.e. it cannot compensate for ultrasonic anomolies.

This cylinder was obtained from drawn bar, and it is of interest that the difference in propagation of ultrasound in the material in the vicinity of the draw marks and the main body gives rise to indentations in the cylinder image. Whilst these indentations loom large ultrasonically, they do not appear to be of any great metallurgical or mechanical importance.

The final example concerns two foreign bodies in an excised eye (ref. 3), one being a short piece of plastic rod and the other two pieces of lead shot. (The range gating facilities were used to cut out the front of the eye from the lens outwards.) The foreign bodies were inserted through a cut in the rear of the eyeball and afterwards the cut was held together with two nylon stitches. The plastic rod, as viewed, was situated in front of these stitches and, as will be shown, in absence of prior knowledge it is very easy to view its image as that of the two nylon stitches. In these circumstances it is essential to have accurately related the position of the image plane on the optical bench with the corresponding one in the ultrasonic situation; accurate range gating to remove unwanted objects is also helpful but this means more holograms. In this hologram the images of the lead shot appear as two very bright dots which cannot be confused with anything else.

To conclude, whilst ultrasonic holography eases the problem of interpreting ultrasonic information it underlines the need to correlate the conclusions drawn with those drawn from other data.

<u>References</u>

1. Metherell A. F., El-Sum H. N., Larmore L., Acoustical Holography, Vol. 1, 1969, Plenum Publishing Corp., N.Y.

2. Aldridge E. E., Clare A. B., Shepherd D. A., "Progress in Ultrasonic Holography at Harwell" Conf. Industrial Ultrasonics, Loughborough, Sept. 1969, I.E.R.E. Conf. No. 16.

3. This work was carried out with the co-operation of Dr. J. E. Wright and Dr. G. A. S. Lloyd of the Moorfields Eye Hospital.