

ULTRASONIC FLAW DETECTION OF TRANSIENT INHOMOGENEITIES
INDUCED BY INTENSE FOCUSED ULTRASOUND IN A PLASTIC BLOCK ⁺

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W. J. Fry, one of the present authors¹, previously proposed the application of an ultrasonic pulse of appropriate energy content (at a level that would not injure tissue) to a region of soft tissue during in vivo ultrasonic visualization in order to provide a sharp gradient in the acoustic impedance at tissue boundaries where ordinarily ultrasonic echoes are produced that are too weak to detect so that it is temporarily easy to detect echoes from such an interface when examining pulses are incident on it. He also experimentally demonstrated this effect². This was demonstrated by producing inhomogeneities^{**} in the focal region of an irradiator by an ultrasonic pulse of appropriate energy content in material with "heat reversible" characteristics. In such experiments it was observed that the inhomogeneity produced distinct acoustic reflections when detected by another ultrasonic beam, but the phenomenon disappears in a specific time interval^{***3} following cessation of the heating beam.

This paper shows that when such transient reflections are observed by an intensity modulation technique one cannot only distinctively recognize its growth and disappearance, but also one can acquire information relative to the "dose" of ultrasound required.

Measurement Devices

The sample is a rectangular lucite block of about 50 mm length, the ultrasonic focusing transducer (3 MHz, focus length 140 mm) is focused at a depth of 10 - 15 mm in the sample as shown on Fig. 1. The examining transducer axis

is oriented at right angles to the direction of the beam mentioned above and at about 10 cm length so that the reflection from the inhomogeneity is maximized. The complete assembly is placed in degassed, distilled water. Figure 2 shows a block diagram of the electronic assembly.

Observation and Results

The series of pictures shown in Figure 3 represent transient inhomogeneities detected on an A-scope. The duration of the focused radiation was one second at an intensity of 960 w/cm^2 at the focal center in water.

The time durations listed under each picture are those recorded at the initiation of irradiation; the focused energy was applied repeatedly to the same position.

Since the frequencies of the continuous waves which are seen in (3) - (5) of Figure 3 are the same as that of the focused beam, it is assumed that the focused beam is scattered and then received by the examining transducer, when the inhomogeneity reaches some specific state. One detects the rise and fall of the reflection from the inhomogeneity by this process, but it requires many experiments and considerable time.

Figure 4 is obtained by applying intensity modulation only to that part of the reflection emanating from the inhomogeneity - decreasing the intensity of other parts and scanning very slowly along the abscissa since one is concerned only with the reflection from the inhomogeneity. This type of picture is more convenient than that of Figure 3 insofar as observation of the initiation of scattering of the focused beam is concerned or in regard to the detection of the rise and fall of the amplitude of the reflected wave after the application of the focused beam.

Figure 5 shows the pictures obtained after changing irradiation time at a

constant power level of 960 w/cm^2 . The same type of picture was obtained after changing power level. From these experiments it was determined that a proper irradiation dosage to provide sufficient reflection but not to cause a permanent inhomogeneity is 710 w.sec/cm^2 for the conditions outlined in this paper.

Figure 6 is an example of the process by which a permanent inhomogeneity grows. (Focused beam; 1600 w/cm^2 , 3 sec. scanning; 5 sec/div).

The observation method that is presented here is considered useful for examining tissue in vivo, although the characteristics of the transient reflection wave that is described here are different from those seen in the living tissue case.

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- * This research was carried out at the Interscience Research Institute, Champaign, Ill. A summary of this work was reported at the 71st meeting of A.S.A., June, 1966.
- ** The meaning of inhomogeneity that is used here is that of optical or acoustical inhomogeneity.
- *** It was observed that the inhomogeneity remained optically even after a transient of this kind.

References

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