Title
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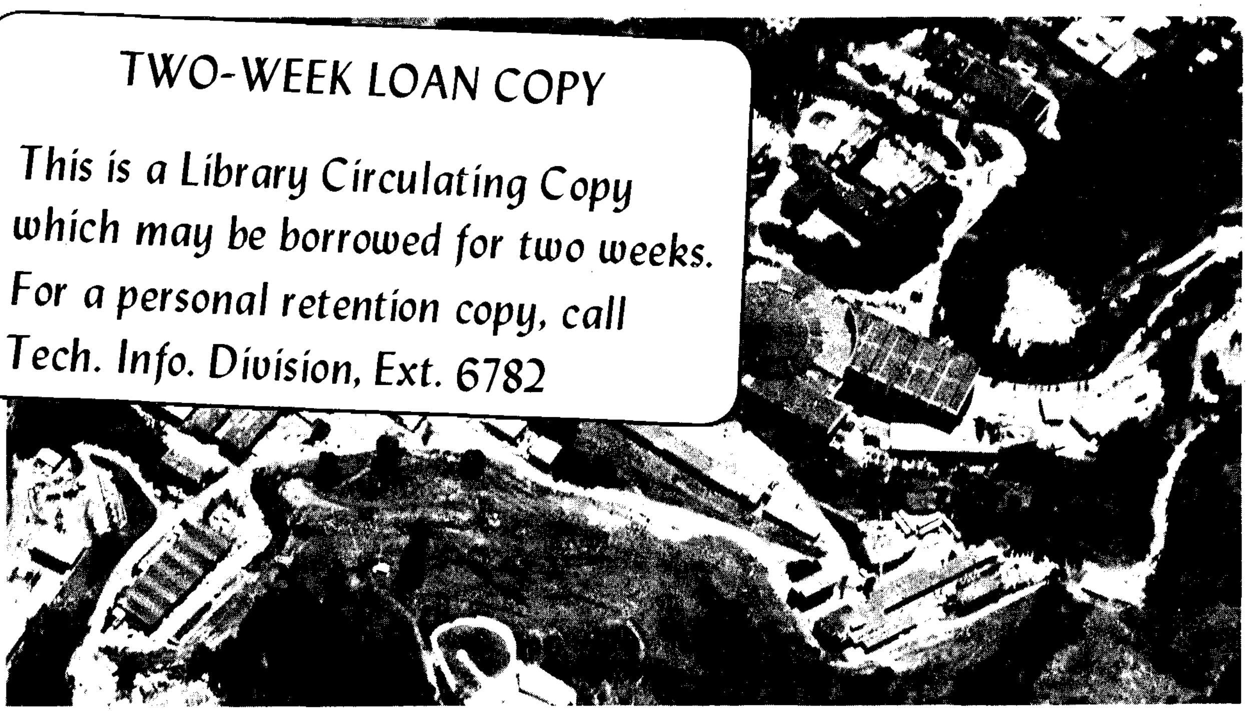

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ABSTRACT

Various types of malignant and benign breast tumors are associated with clusters of calcifications with grain sizes 0.1 to 1 mm spread out over volumes of a few tens of mm^3. The calcification grains form clusters whose shape ranges from spherical to elongated chains. The ultrasound technique described here consists of a single emitter (2.25 MHz mean frequency) surrounded by an array of receive transducers which detect the scattered sound at angles of 120° to 160° relative to the forward direction. Tomographic images of these distributions are obtained by a combination of transit time recording and positioning of the transducer array. The simultaneous detection of the scattered signals from the cluster minimizes the probability of detecting a reflection at a tissue interface. Measurements have been done on grain sizes as small as 0.3 mm with a clean signal above tissue scattering background.

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SUMMARY

Various types of malignant and benign breast tumors are associated with clusters of calcifications with grain sizes ranging from 0.1 to 1 mm or larger.[1] These clusters contain, in some cases, as few as 5 or 6 grains and can contain many tens of grains. The sizes vary from spherical shapes of 1 cm size to elongated structures. Ultrasonic techniques can be used to detect such calcifications.

We have done measurements on gelatin samples containing tissue-simulating additives (Solkafloc)[2] with various arrangements and sizes of clusters to determine to what extent it is possible to detect these clusters by the scattering of ultrasound amid the background produced by scattering of normal tissue. We have also performed measurements on excised breast tissue samples into which we introduced calcium carbonate grains of sizes 0.4 to 0.6 mm.

The prototype ultrasound equipment consists of an emitter transducer operating at a mean frequency of 2.25 MHz surrounded by an array of four receive transducers placed around the send transducer to detect the scattered ultrasound at angles ranging from 120° to 160° (Fig. 1). The physics principle we utilize is that the scattering of sound by structures whose size is comparable to the wavelength of the sound will have an appreciable intensity over the range of angles used here. Since the scattering is uniform over the

azimuthal angle, all of the receive transducers should receive comparable signals modified by different tissue absorption, depending on path length. This criterion favors the detection of scattered sound from small objects and discriminates against specular reflections from a given tissue interface which might produce a large signal in one transducer oriented in the appropriate direction; but from geometrical considerations the other transducers should not detect this large signal. A microprocessor will use the information received by the transducer array to distinguish "cluster" scattering from other forms of simi-specular reflection and produce a composite display.

In Fig. 2 we show the scatter signal seen by one transducer from a cluster of 30 $CaCO_3$ grains of mean size 0.4 to 0.6 mm, embedded in a Solkafloc medium. It is seen that the cluster signal is clearly above the simulated tissue background. Addition of a suitable bandpass filter increases the signal-to-noise of the cluster signal from 4 to 10, since the frequency spectrum of scattering from the clusters is higher than the normal tissue background.

Preliminary tomographic images were obtained with a single receive transducer. The samples were mounted on a manually operated screw-driven x-y-z positioner. For each positive lobe in the received signal, the amplitude and transit time from the emitter was measured and stored in a small computer. Fig. 3 shows the patterns produced by a spherical cluster (40 grains) and an elongated cluster (24 grains). The horizontal axis is the transit time; the vertical axis is the position of the sample perpendicular to the emitter beam. The amplitude of the detected lobe is displayed in 8 shades of gray. For comparison, x-ray pictures of two clusters are shown in Fig. 4. The general shape of the clusters is seen to be quite similar. Images obtained from multiple receiver arrays will be presented.

In summary, we present here a tomographic ultrasound method capable of detecting and displaying the approximate shape, size and position of breast tissue calcifications. In order to diagnose the type of tumor, malignant or benign, additional information, such as that obtained from mammography or biopsy is needed. However, since this ultrasound method is non-invasive and of negligible risk to the patient, it can provide the basis for a screening procedure.

REFERENCES

1. W. A. Murphy and K. DeSchryver-Kecskemeti, Radiology 127, 335-341 (1978).

2. Solkafloc was developed by Picker Corporation for the simulation of liver and breast tissue.

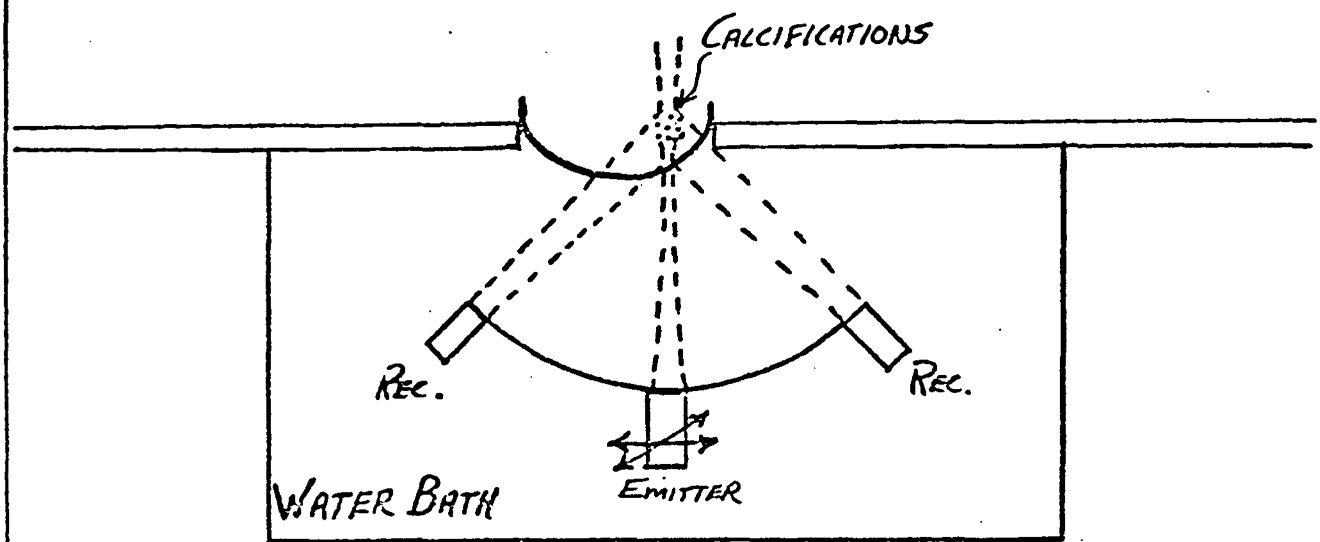
FIGURE CAPTIONS

Fig. 1 Ultrasonic array. Central emitter and four receivers, each at 135° relative to forward direction.

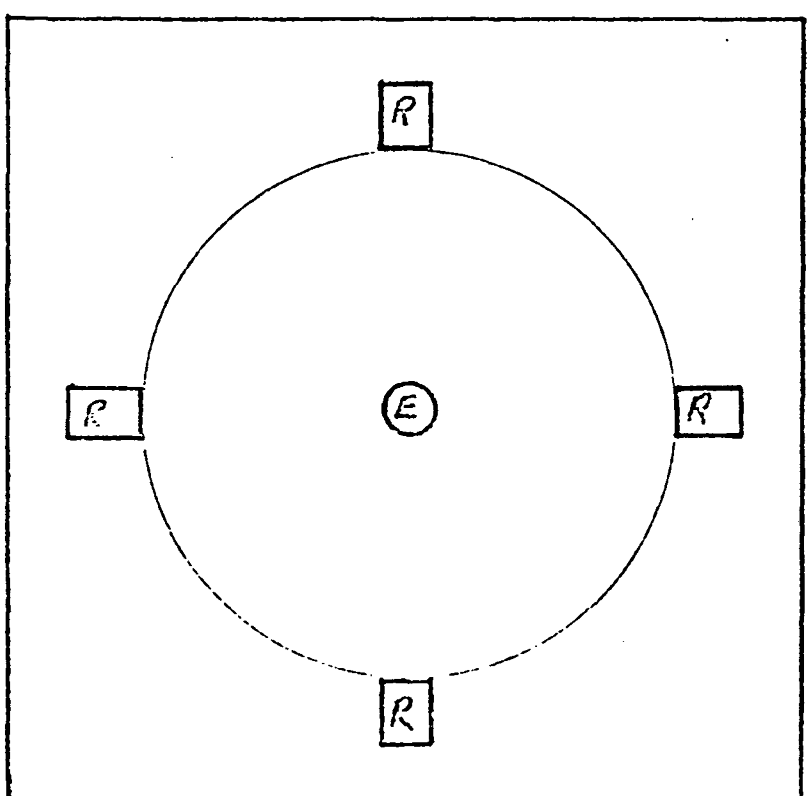
Fig. 2 Received signals as function of receiver angle from cluster of 30 grains, 0.4 mm to 0.6 mm in size.

Fig. 3 Computer tomographs of calcification clusters. A)Spherical and B)Elongated.

Fig. 4 X-rays of same clusters as in Fig. 3.



SIDE VIEW



BOTTOM VIEW

FIG 1

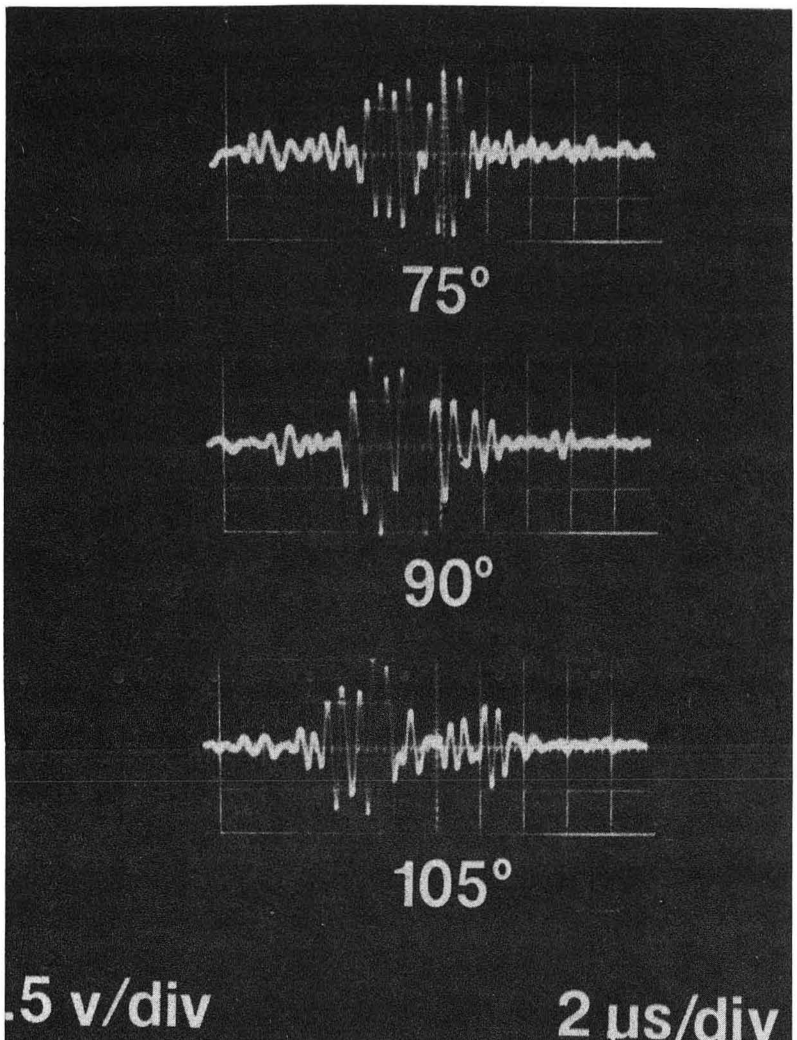


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Fig. 2 Page 5

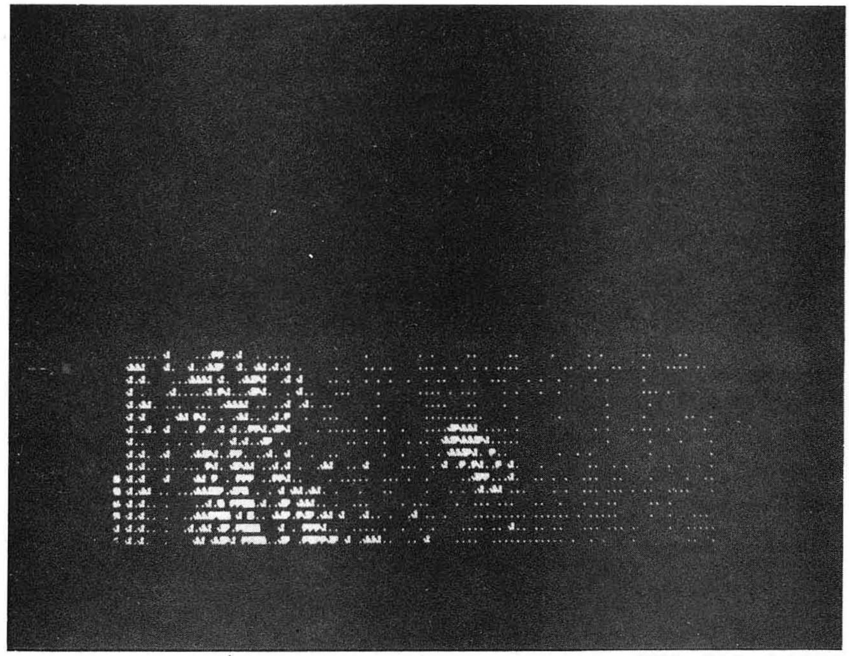

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Fig. 3 Page 6

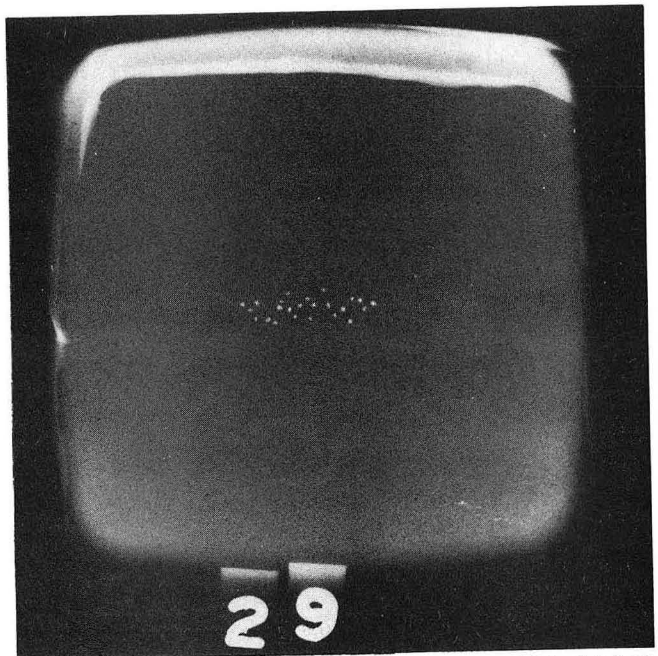

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Fig. 4 Page 7

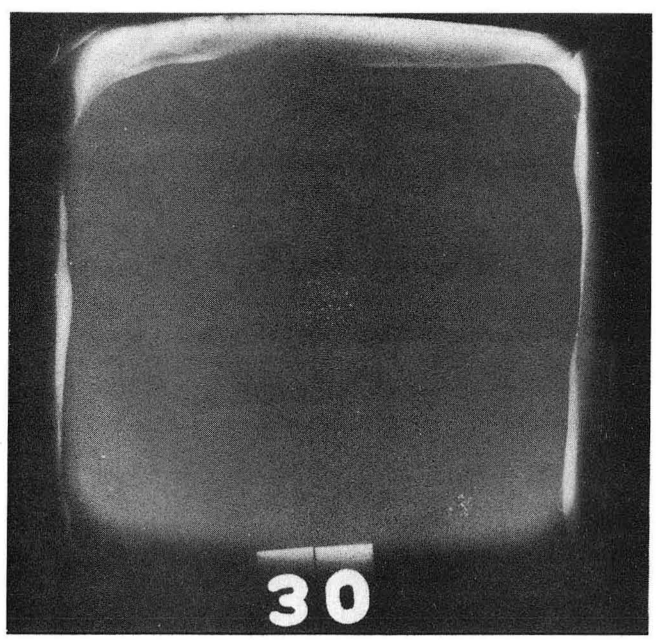

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Fig. 4 Page 7

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