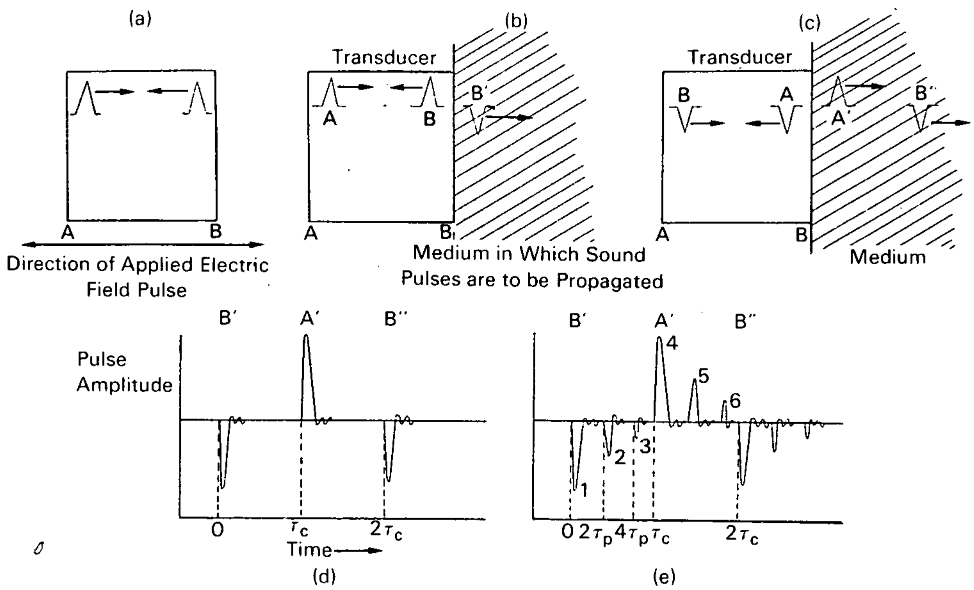
AEC-NASA TECH BRIEF

Thick Transducers Used for Generating Short-Duration Stress Pulses in Thin Specimens



The problem:

To develop a method of producing short-duration stress pulses in thin specimens for both sound velocity and sound attenuation measurements. The pulse-echo technique, conveniently used for such measurements, becomes difficult to use when thin specimens are being studied because the echoes begin to interfere or "pile up" upon one another and are not sufficiently resolved. As test specimens become thinner, the pulse lengths must become shorter to retain proper resolution.

The solution:

By generating short stress pulses with thick transducers, the pulse-echo method for determining sound velocities and acoustic attenuation can be applied to thin specimens. The stress pulses are generated at the faces of a thick transducer and are allowed to enter a specimen where one pulse is reflected several times before a succeeding pulse enters the specimen. This method is described in conjunction with its use in the observation of phase transformations in which both transit-time data and attenuation measurements are used to determine the mechanism and kinetics of the transformation. Results are shown for the $\beta \rightarrow \alpha$ phase transformation in high-purity plutonium.

How it's done:

The mechanism of pulse generation by thick transducers and propagation into a coupled medium is shown in the figure. The expressions "thick transducer" and "short pulse" are relative to each other; a thick transducer is one in which the time required for a sound or stress pulse to travel from one face of the transducer to the other is significantly longer than the

(continued overleaf)

duration of the pulse. In the experiments, the ratio of transit time in the transducer to the pulse length is about 15:1.

When sound pulses are propagated into a medium, eventually there are several pulses in the medium, each separated from the other by the transit time in the transducer (τ_c). Part (d) of the figure illustrates the amplitudes at some point in the medium as a function of time. In this case, the acoustic impedance of the medium is less than that of the transducer.

A significant change in the echo pattern occurs when the transducer is coupled to a thin medium instead of a thick one. If the medium is thin enough so that the transit time in it is less than the transit time in the transducer, a pattern similar to the part (e) of the figure is obtained. Pulses B′, A′, and B″ are the same as shown in (d), but there are pulses between them due to the sound echoing in the thin medium.

When the pulses passing through the thin medium are detected, the transit time through the medium and the amplitudes of successive echoes in the medium can be measured, and velocity and attenuation can be calculated. However, the transit time must be long enough so that successive pulses can be resolved. Thus, the minimum specimen thickness depends upon the pulse length. The maximum is limited by the fact that at least two pulses must pass through the sample before another echo series starts; thus the maximum sample thickness depends upon the transducer thickness.

To detect the pulses, another thick transducer is coupled to the opposite face of the specimen, and when a pulse impinges upon it, a voltage will appear as a step function across this transducer. This step pulse will reverse its polarity when the stress pulse reaches the other face of the transducer and is reflected back to the thin specimen.

If the two transducers do not have the same transit times and acoustical impedances, a confusing pattern will result. However, if both are made of the same material and have the same thickness, each echo series will start at a time τ_c after the previous series starts. Thus, a series of echoes produced by multiple reflections within the transducers superimpose themselves upon previous series so as to reinforce the echo patterns of the previous series.

Attenuation of the stress pulses in a thin specimen can be found from the decrease in the amplitudes of successive echoes in a given series of pulses. This loss in amplitude is not solely from energy absorption or scattering inside the specimen since a significant amount of sound energy is transmitted into each transducer each time a pulse reaches a transducer-specimen interface.

Notes:

1. Additional information and numerous examples are presented by R. G. Peterson and M. Rosen in "Use of Thick Transducers to Generate Short-Duration Stress Pulses in Thin Specimens," *Journal of the Acoustical Society of America,* Vol. 41, No. 2, pp. 336–345, February, 1967.
2. This information may be of interest to persons and organizations concerned with nondestructive testing techniques for examining thin specimens.
3. Inquiries concerning this report may be directed to:

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Source: R. G. Peterson and M. Rosen,
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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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