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NASA TECH BRIEF

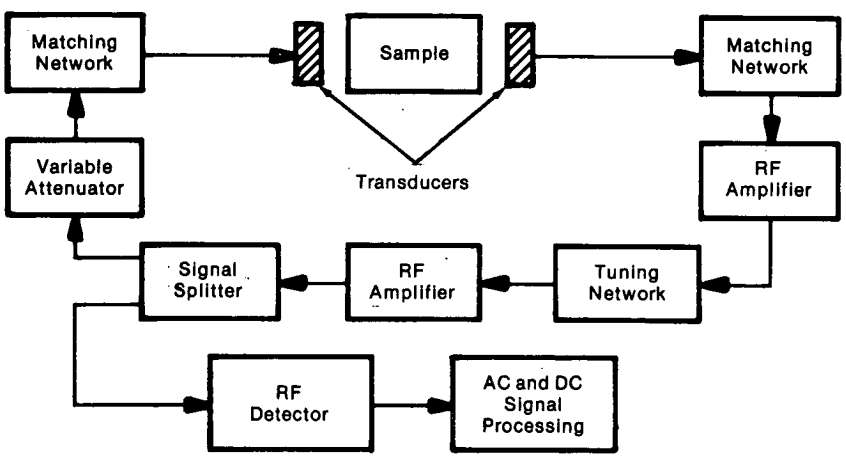
Langley Research Center

Transmission Oscillator Ultrasonic Spectrometer [TOUS]: A New Research Instrument

A new continuous-wave ultrasonic research instrument, a transmission oscillator ultrasonic spectrometer (TOUS), is capable of measuring very small changes in acoustic attenuation and phase velocity. Its high sensitivity to small changes in ultrasonic absorption results in part from operation under marginal conditions. In spite of this high sensitivity, the TOUS system is relatively simple, inexpensive, and compact. These characteristics suggest that the TOUS may be suitable not only for precise laboratory measurements of the physical properties of materials but also for field applications in nondestructive testing and certain areas of medical monitoring.

A block diagram of the TOUS is shown. The central feature of the system is the ultrasonic resonator assembly which consists of two piezoelectric transducers mounted opposite each other in such a way as to produce an ultrasonic standing wave in the material under test between them. The use of this resonator substantially enhances sensitivity to changes in the ultrasonic properties of the tested material. These changes result in a small increase (or decrease) in ultrasonic attenuation. This change in attenuation is multiplied by the sensitivity enhancement factor of the resonator.

The analog electronics portion of the system consists of a carefully gain-stabilized, automatic-leveling amplifier that is made to oscillate by providing it with a feedback path through the ultrasonic resonator. The extremely high sensitivity to small changes in ultrasonic attenuation is achieved by operating the unit on the verge of dropping out of oscillation. The device is thus a marginal oscillator system.



Transmission Oscillator Ultrasonic Spectrometer (TOUS)

(continued overleaf)

To be utilized for the TOUS, the small signal gain of the amplifier must exceed the attenuation; i.e., the product of the linear region gain and the loss must be greater than 1.0. Under these conditions, oscillations when initiated grow in amplitude. The gain of the amplifier decreases with this increase in oscillation level due to gradual amplifier saturation. Stable oscillations occur when the amplitude increases sufficiently, and thus the gain decreases sufficiently, so that the product of the gain and the loss equals 1.0.

An experiment has been conducted using a photoconducting resonator sample of CdS in a TOUS. The ultrasonic absorption of the CdS resonator was modulated with light, and the resulting TOUS output signal was compared to that of a conventional continuous-wave (CW) spectrometer using the identical experimental arrangement. Although the same amplifiers and signal processing were used for each test, the TOUS output was two orders of magnitude larger than the CW output and, more significantly, the TOUS signal-to-noise ratio was considerably less.

The high sensitivity of the TOUS is best achieved in cases where the small changes in acoustic attenuation of interest occur with characteristic frequencies in the audio range. An example is that of the small changes in acoustic attenuation produced by the presence of particulate or gaseous impurities in flowing fluids. At the present time, a TOUS system is being utilized to detect impurities in the blood circulated extracorporeally during open heart surgery. The use of the TOUS to provide in-line monitoring of particulate matter in lubricating and hydraulic systems is also being investigated.

Note:

Requests for further information may be directed to:

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Patent status:

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