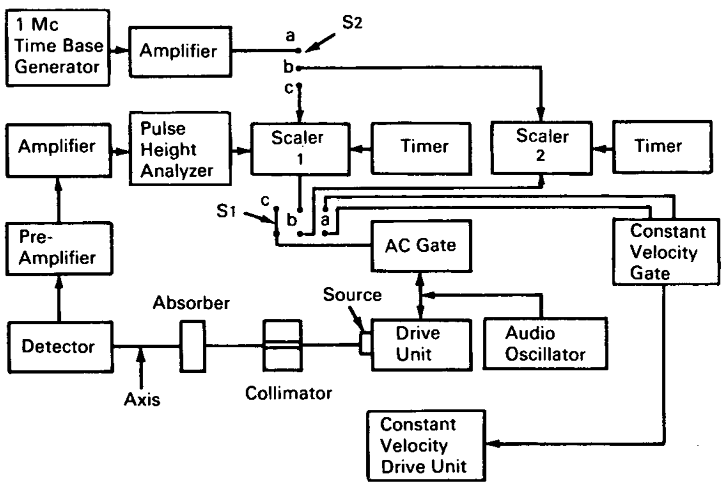
September 1967 Brief 67-10339

NASA TECH BRIEF

Vibration Analysis Utilizing Mossbauer Effect



An instrument has been designed for the measurement of mechanical vibrations in transducers at amplitudes in the range of a few to 100 angstroms. Vibration measurements in this amplitude range cannot be accomplished by ordinary optical means. This instrument utilizes the Mossbauer effect, the phenomenon of the recoil-free emission and resonant absorption of nuclear gamma rays in solids, which was discovered by Rudolf L. Mossbauer in 1957.

The instrumental setup, shown in the diagram, includes a Mossbauer gamma ray source fixed to a drive unit consisting of a piezoelectric transducer, a standard collimator, a gamma ray absorber, and a detector. The detector is preferably a cleaved thallium-activated sodium iodide crystal with a 1 mil beryllium window mounted on a standard photomultiplier tube. The drive unit is energized by a standard audio oscillator, which is also connected to the ac gate control system. The detector, responsive to the gamma rays emitted by the source, is connected through the amplifiers to a pulse height analyzer. The output of the analyzer is connected to scaler 1. The output of the ac gate is connected through contacts b-c of switch S1 to both scalers, which are connected to timers. However, neither timer is operative during ac gate operation. The time base generator is connected through an amplifier and contacts b-c of switch S2 during ac gate operation to scaler 2 to obtain a time base count measure. The total time during which scaler 2 is actuated by the gate pulse may be accurately determined in terms of the number of timing pulses counted by scaler 2. Thus, the number of counts per unit of time received by scaler 1 through the pulse height analyzer may be accurately measured.

The source used was cobalt-57 diffused into a palladium matrix. The 14.4 keV gamma ray, which exhibits Mossbauer behavior, arises from the first excited state of iron-57, the daughter product of

(continued overleaf)

cobalt-57. When the absorber is composed of unexcited iron-57 in palladium, full resonance absorption can occur; i.e., maximum absorption occurs for zero relative velocity between source and absorber. If the absorbing iron-57 is diffused in stainless steel, partial resonance occurs; i.e., the ground state of the absorber is shifted with respect to the ground state of the source. For this case (partial resonance), the zero velocity count corresponds to some point intermediate to resonance absorption and nonresonance absorption. If the absorbing iron is in a chemical compound, e.g., $FeSO_4 \cdot 7H_2O$ in which the iron nucleus resides in a local electric field, the excited state is split into two components. In this case two absorption maxima are found at proper relative velocities (quadrupole split resonance). If the absorber is composed of raw iron, the nucleus is influenced by the presence of a local magnetic field, thereby splitting the excited state into four components and the ground state into two components. This case results in six resonance absorption lines due to the Zeeman effect. The instrument utilizes these phenomena for analyzing vibration. A theoretical method for utilizing each case was established and experimentally verified.

Note:

A discussion of this development is given in "The Mossbauer Effect and Its Application to Measuring Technology", by Helmut G. Lackner, NASA SP-132, for sale by the U.S. Government Printing Office, Washington, D.C. 20402; price $1.00. Inquiries may also be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B67-10339

Patent status:

No patent action is contemplated by NASA.

Source: Norbert A. Roughton
(MFS-11974)