0.3 mm/s, and this amounts to a shift only 2% of a line width for 100,000 psi.

4. Instrumentation

The basic elements of a Mössbauer spectrometer are the source, velocity transducer, absorber (normally the substance under study), energy-selective gamma ray detector, and pulse-handling electronic apparatus. The Mössbauer spectrum consists of a plot of the energy-selected gamma ray counts received vs. Doppler velocity of the source relative to the absorber.

The radioactive source depends on the isotope under study. For iron studies, ^{57}Co is the source. The quantity of material in the source is typically so small that it can neither be seen nor weighed. It is diffused into another metal for handling ease, to provide a preferred chemical environment (e.g., to provide a single narrow line), and for enhancement of the Mössbauer fraction.

Most velocity transducers are now designed for constant-acceleration motion. This gives a linear velocity variation with time, which is equivalent to a linear frequency sweep. The displacement is then parabolic. Mechanical drives have been used, particularly where large masses must be moved. Extreme mechanical precision is essential to avoid velocity noise. The trend in drives has been toward electromagnetic units; the motion is caused by a current-carrying coil in a magnetic field. A desired velocity vs. time waveform is created electronically, and this voltage is compared continuously with the velocity feed-back signal. The difference signal is amplified and drives the motor in such a sense as to reduce the error. Advantages of the electromagnetic drive include flexibility of waveform, velocity range, freedom from precise machine work, and virtual freedom from wear.

The selective detector will be a proportional counter or possibly a photomultiplier coupled to a scintillation crystal. For optimum signal/noise in the Mössbauer spectrum, the gamma rays containing the Mössbauer fraction must be separated cleanly from the others present. In addition, a fast count rate capability is essential since the signal/noise ratio is proportional to the square root of the number of counts in any velocity interval. The detector emits pulses sized according to the energy contained in each detected gamma ray. After amplification and shaping, the desired height pulses are selected with a single-channel analyzer.

The counts are stored in a multichannel analyzer (MCA) of 400 or more channels. This MCA is best operated in the multiscaling mode, such that each channel gross-counts pulses for a selected time before switching the input to the next channel. The velocity of the transducer is slaved to this scan rate, such that each channel address corresponds uniquely to a definite velocity interval. The motion is of course cyclical, the sense of the acceleration being reversed periodically. The scan rate through the entire 400 or so channels is normally between 1 and 50 per sec. Exposure times range from an hour to several tens of hours, depending on the difficulty of the sample and the precision required.

Transmission geometry cannot be used for most metallurgical studies, since the sample can be only 0.001 in. thick. Mössbauer spectra have been obtained[13] in the back-scatter mode, in which the gamma rays strike the accessable surface of the sample and the consequences of resonant capture are detected from the same side. These consequences are (1) 6.5 keV Fe X-rays which arise from internal conversion of the excited ^{57}Fe nucleus, (2) Auger electrons also arising from internal conversion, and (3) 14 keV radiation re-emitted from the excited nuclei. The depth range of (1) and (3) is about 0.001 in., while in (2) the range is two orders of magnitude less. If the scattered 14 keV gammas are detected, care is needed that lead be excluded. Lead has a 14 keV X-ray which interferes, so that other shielding is required.

In the one-sided spectra shown here (Fig. 5), the 6.5 keV Fe X-rays were detected. The geometry is inherently poor. A wide solid angle is preferred for speed, but the " cosine broadening " effect can be troublesome. Consider gamma rays from source to detector in transmission geometry. Those passing along the central axis are doppler shifted by ν/c. Those emerging at an angle α relative to the velocity vector are shifted by $\nu \cos \alpha/c$. This " smears " the spectrum, whether it is taken in transmission or back-scatter, so long as a Doppler motion is used for the scanning mechanism.

A thermal drive is stable, but is limited in range. It is unaffected by the cosine broadening, and much better geometry is possible.