BACKSCATTER MÖSSBAUER SPECTROMETER (BaMS) FOR PLANETARY APPLICATIONS: TRANSDUCER DESIGN CONSIDERATIONS; T.D. Shelfer, M.M. Pimperl, D.G. Agresti, E.L. Wills, Department of Physics, University of Alabama at Birmingham, Birmingham, AL 35294; and R.V. Morris, Code SN2, NASA Johnson Space Center, Houston, TX 77058.

Introduction. With ^{57}Fe Mössbauer spectroscopy quantitative information on the distribution of iron among its oxidation states and the relative amounts of each iron-bearing phase can be accurately determined in a non-destructive fashion. Many interesting extraterrestrial systems are known to be rich in iron-containing minerals; thus Mössbauer spectroscopy should be an excellent analytical tool for use on planetary surfaces [1,2].

The typical laboratory Mössbauer spectrometer is clearly not suitable for planetary missions because of its volume, mass, and power consumption. Here, as part of our ongoing project to develop a Mössbauer spectrometer for planetary missions, we discuss our progress in developing a miniature velocity transducer, the Mössbauer drive.

Results and Discussion. The first device we have investigated is a commercially available multi-element piezoelectric transducer (PZT) [Micro Kinetics, CT-6156-25]. We chose this device because of its small size and relatively large excursion for a piezoelectric device (26.5 μm at 1250 volts). To test the suitability of the PZT as a Mössbauer drive we have measured its response to sinusoidal input signals over a range of frequencies and amplitudes. Figure 1 shows a graph of the motion at 100Hz for two different input amplitudes. Measurements made at other frequencies also show a non-sinusoidal response that depends on frequency as well as amplitude of the input signal.

Based on the non-sinusoidal response of this particular device, it is clearly not suitable for use as a Mössbauer drive. It is possible that this strong anharmonic behavior is due to the fact that the PZT is a stack of individual piezoelectric disks, forming a complex coupled oscillator. The hysteresis exhibited by piezoelectric devices may also contribute to the non-sinusoidal response.

The motion of the PZT was measured by coupling a conventional Mössbauer drive to the PZT through a threaded rod. The conventional drive (so-called loudspeaker design) employs a moving coil in a stationary magnetic field. A second coil, the pickup coil, serves to measure the motion. This design results in a sinusoidal response for sinusoidal input, which is characterized by a Nyquist diagram (figure 2). In this figure, the input signal was maintained at 177mV rms for a range of frequencies from 10 to 350Hz. The amplitude of the pickup signal (rms, mV) is plotted radially, while the phase shift with respect to the input signal is plotted as the polar angle.

We are currently constructing a miniature (95% volume reduction), single-coil drive of loudspeaker design, which will be driven by a digitally generated waveform as the input to control the motion of the drive. This design will avoid the need of an error correcting feedback circuit and its associated pickup coil. The Nyquist diagram of this new drive will determine the coefficients of the Fourier components needed to construct the necessary waveform.

We are continuing our study into the causes for the non-linear response of the PZT drive as well as investigating other alternatives for the velocity transducer, including a monolithic piezoelectric element, magnetostrictive devices, and electrostrictive devices.

References: [1] Morris et al. (1989) Mössbauer backscatter spectrometer: A new approach for mineralolgical analysis on planetary surfaces. In Lunar and Planetary Science XX, pp. 721-722. Lunar and Planetary Institute, Houston. [2] Agresti et al. (1990) Development of a solid-state Mössbauer spectrometer for planetary missions. In Lunar and Planetary Science XXI, pp. 5-6. Lunar and Planetary Institute, Houston.

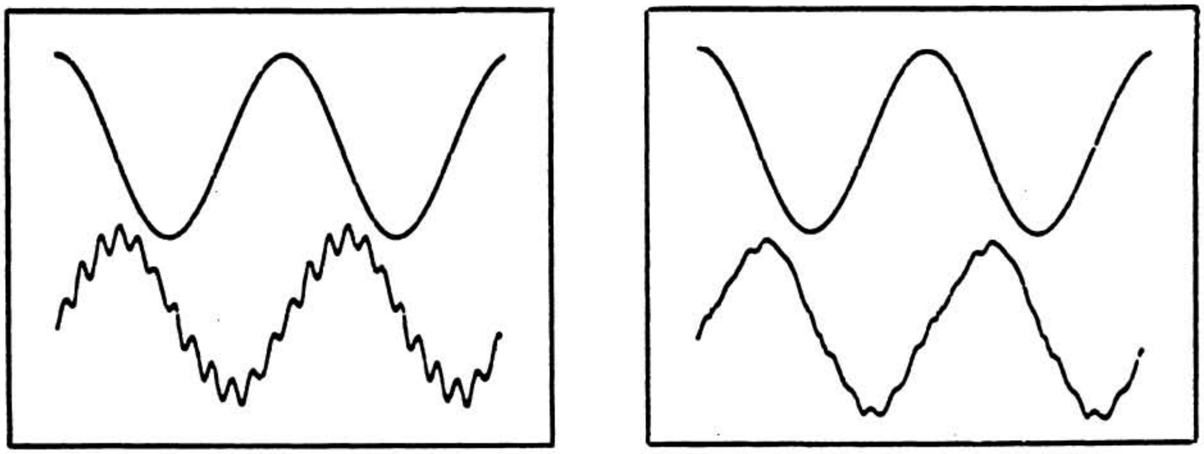

Figure 1. PZT response (lower trace) to 100Hz sine-wave input (upper trace) at 200V peak-to-peak (left) and 800V (right).

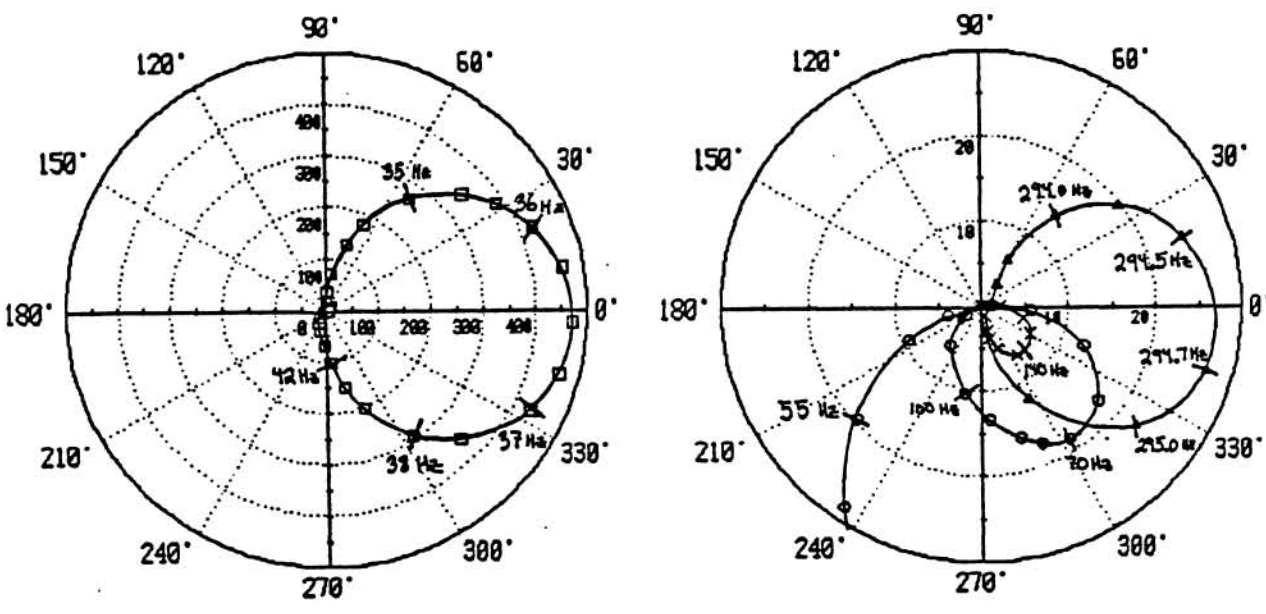

Figure 2. Nyquist diagram of a conventional loudspeaker drive showing main resonance at 36.5Hz (left). Secondary resonances are shown with expanded scale (right).