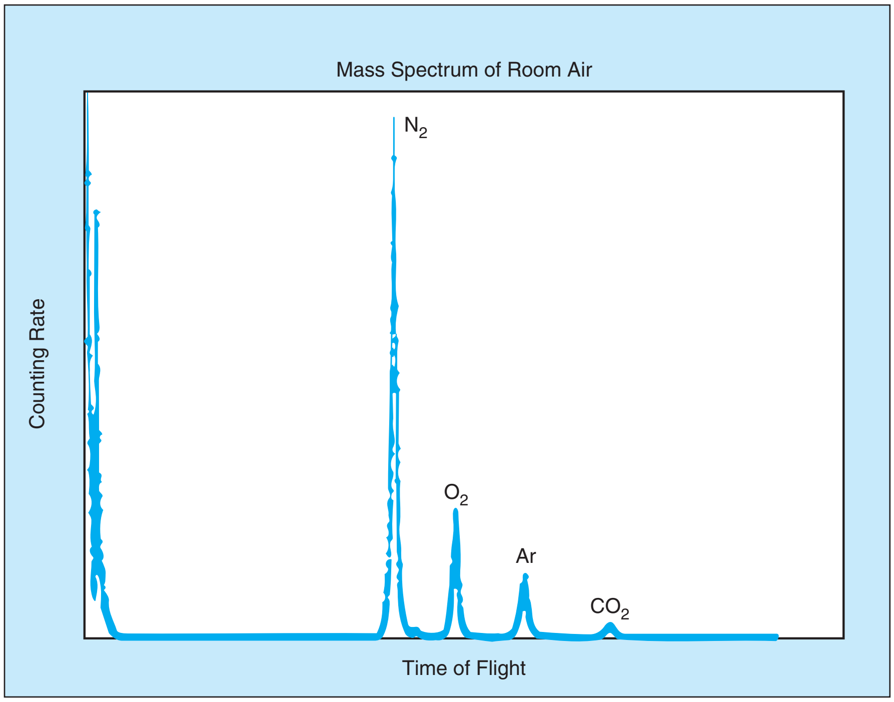

Figure 2. This **Uncalibrated Mass Spectrum** of air was acquired by use of the improved TOF-MS.

- Relative to prior mass spectrometers, it offers high sensitivity (ability to measure relative concentrations as small as parts per billion).
- Its resolution is one dalton (one atomic mass unit).
- An entire mass spectrum is recorded in a single pulse. (In a conventional mass spectrometer, a spectrum is recorded mass by mass.) The data-acquisition process takes only seconds.
- It is a lightweight, low-power, portable instrument.

Although time-of-flight mass spectrometers (TOF-MSs) have been miniaturized previously, their performances have not been completely satisfactory. An inherent adverse effect of miniaturization of a TOF-MS is a loss of resolution caused by reduction of the length of its flight tube. In the present improved TOF-MS, the adverse effect of shortening the flight tube is counteracted by (1) using charged-particle optics to constrain ion trajectories to the flight-tube axis while (2) reducing ion velocities to increase ion flight times.

In the present improved TOF-MS, a stream of gas is generated by use of a hypodermic needle. The stream of gas is crossed by an energy-selected, pulsed beam of electrons (see Figure 1). The ions generated by impingement of the electrons on the gas atoms are then focused by three cylindrical electrostatic lenses, which constitute a segmented flight tube. After traveling along the flight tube, the ions enter a charged-particle detector. The output of the detector is fed to a counting circuit to obtain data on the counting rate as a function of time. Inasmuch as time of flight is directly proportional to the ion mass, a plot of the counting rate versus time of flight is equivalent to a mass spectrum (see Figure 2).

This work was done by Isik Kanik and Santosh Srivastava of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1)*
NPO-30611

Cryogenic High-Sensitivity Magnetometer

Sensitivity would be about a million times that of a flux-gate magnetometer.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed magnetometer for use in a cryogenic environment would be sensitive enough to measure a magnetic-flux density as small as a picogauss (10^{-16} Tesla). In contrast, a typical conventional flux-gate magnetometer cannot measure a magnetic-flux density smaller that about 1 microgauss (10^{-10} Tesla).

One version of this device, for operation near the low end of the cryogenic temperature range, would include a piece of a paramagnetic material on a platform, the temperature of which would be controlled with a periodic variation. The variation in temperature would be measured by use of a conventional germanium resistance thermometer. A superconducting coil would be wound around the paramagnetic material and coupled to a superconducting quantum interference device (SQUID) magnetometer.

The SQUID magnetometer would be used to measure the change in current in the coil as a result of the change in temperature measured by the germanium resistance thermometer. The ratio between the current change and the temperature change would be computed, then used to infer the ambient magnetic field. This inference would be drawn from a lookup table established by prior calibration measurements performed at the same mean operating temperature.

In an alternative version of this magnetometer, for operation at a temperature near the high end of the cryogenic range, the coil and the SQUID magnetometer would be made from a high-temperature superconductor and the coil would be in the form of a thin film deposited on the same substrate as that of the SQUID. The paramagnetic material would be inserted in a hole at the center of the coil. The temperature of the whole substrate would then be modulated during measurements of the type described above.

Because of the oscillatory temperature excitation, this magnetometer would exhibit very little drift. The highest sensitivity and the lowest noise would be achieved by careful selection of the paramagnetic material and operating near the Curie temperature of that material.

Although the SQUID magnetometer and the superconducting coil must be kept cold, it would be possible to measure the magnetic field of a warm environment. For this purpose, the magnetometer could be kept at the required low temperature in a nonmagnetic Dewar flask, which could be brought to the warm measurement location.

While conventional SQUID magnetometers are routinely used to measure the change in magnetic flux density with similar sensitivity, the proposed implementation allows the full sensitivity of SQUID to be used to measure a small static magnetic flux density. Another implementation method involves flipping the pickup coil of a SQUID to measure the ambient static field. Although such a method had been used before, it involves cumbersome mechanical actuators to flip the coil at cryogenic temperatures and the wire of the coil can work harden and break after repeated flipping. Because of the absence of moving parts in the proposed magnetometer, reliability is improved.

This work was done by Peter Day, Talso Chui, and David Goodstein of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1). NPO-40748*

Wheel Electrometer System

John F. Kennedy Space Center, Florida

Two documents describe a prototype system of electrometers for measuring electrostatic fields and electrostatic responses of soils on Mars and the Moon. The electrodes of this electrometer are embedded in a wheel of an exploratory robotic vehicle, utilizing the wheel motion to bring the electrodes into proximity or contact with the soil. Each electrode resides in one of two types of sensor modules: electric-field (ELF) or triboelectric (TRIBO). In either type, what is measured is simply the electric charge induced on the electrode by exposure to the external distribution of electrostatic charge. In an ELF module, the electrode is bare and recessed radially from the wheel surface. The ELF sensor provides a measure of the charge on a small patch of undisturbed soil as the wheel rolls forward. In a TRIBO module, the electrode is only slightly recessed and covered with a polymeric insulator flush with the wheel surface. Through contact electrification, the insulator exchanges charge with the soil. There are five TRIBO sensors, each containing an insulator made of a different polymer. The charge data gathered by the five TRIBO sensors can be used to determine how the soil fits into a triboelectric series.

This work was done by Carlos I. Calle of **Kennedy Space Center**, *Martin G. Buehler of NASA's Jet Propulsion Laboratory, James G. Mantovani (an independent contractor), and Charles R. Buhler and Andrew Nowicki of Arctic Slope Research Corp. Further information is contained in a TSP (see page 1). KSC-12677*