DEVELOPMENT OF A CHARGED PARTICLE DETECTOR FOR WINDBORNE MARTIAN DUST. C.I. Calle[1], J.G. Mantovani[2], E.E. Groop[1], M.G. Buehler[3], C.R. Buhler[4], A.W. Nowicki[5]. [1]Electromagnetic Physics Laboratory, NASA Kennedy Space Center, YA-F2-T, Kennedy Space Center, FL 32899; [2]Florida Institute of Technology, 150 West Boulevard, Melbourne, FL 32901; [3]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109; [4]Swales Aerospace, YA-F2-T, Kennedy Space Center, FL 32899; [5]Dynacs Inc., Kennedy Space Center, FL 32899.

Introduction: Dust cloud electrification is a highly probable phenomenon in the low pressure, low humidity environment of Mars. Planet-wide windstorms have been observed to last for several months. Dust devils up to 10 km high with widths of the order of several tens of kilometers are seen with daily frequency [1]. A fairly steady rate of dust deposition on the solar panels equal to 0.3% per day was measured during the first 25 sols of the Pathfinder mission [2]. The electrostatic interactions between dust particles carried by the wind create several difficulties for lander missions.

A prototype of an aerodynamic electrometer to measure the electrostatic and triboelectric properties of Martian atmospheric dust has been constructed (Fig.1). The instrument will enable a more thorough understanding of the potential for electrostatic discharge of different materials on Mars. This knowledge will provide the necessary input parameters for design of landers, rovers, and habitation facilities.

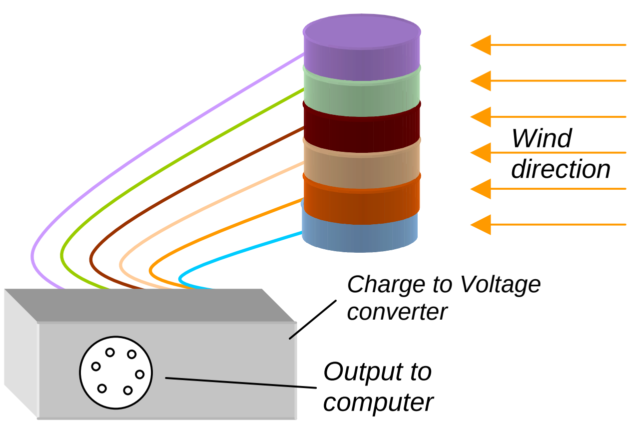

Figure 1. A prototype of the aerodynamic electrometer and its associated electronic housing is shown with sensor/guard probes embedded in six cylindrical insulators.

Electrometer Design: This instrument consists of an array of insulating materials with each material backed by a miniature electrometer. The instrument was designed to be exposed to mineral particles typical of the Martian environment. To simulate a wind storm, mineral particles were propelled toward the instrument at speeds reaching 20 m/s. The overall sensor array has an aerodynamic configuration to minimize turbulent flow. The electrometer sensor uses a simple reference capacitor design as was used on the Mars Environmental Compatibility Assessment (MECA) Electrometer [3], a flight-ready instrument that included five sensors in a line array with a resolution of 5 million elementary charges. The probe consists of a field-sensor electrode that is enclosed by a guard electrode, which in turn is enclosed by an electrically grounded shield. The probe is embedded in a cylinder to within 2.5 mm of the surface. The overall gain of the electronic circuit is 0.25 pC/mV. The current version of the instrument contains six sensors to measure the electric field induced by any net charge on six different insulator surfaces. The charge develops through frictional contact between the cylindrically shaped insulators and incident granular material.

Preliminary Results: We present data obtained with this prototype instrument using cylinders made of Teflon (1.9 cm diameter) and Fiberglass (2.5 cm diameter). The cylinders were exposed to windborne dust particles in separate experiments. Data were taken in a vacuum chamber containing a room temperature CO_2 atmosphere at 9 mbar. The vacuum chamber is backfilled twice with CO_2 to 133 mbar, and then pumped back down to 9 mbar before data were taken. A negligible amount of drift was observed in the electrometer output when this procedure was followed. We have tested granular materials such as JSC's Mars-1 simulant, SiO_2, and Fe_2O_3.

Windborne dust particles were generated using a dust particle impeller (Fig. 2) that was developed at Kennedy Space Center to simulate a Martian dust storm in a vacuum chamber. Constant wind speeds of 20 m/s have been measured with the dust impeller operating at gas pressures ranging from 5 mbar to 1 bar. After the impeller is turned on, a small amount of granular material is propelled towards the cylindrical electrometer. Data is presented in Figure 4 for Teflon and Fiberglass cylinders that were struck in separate experiments by JSC Mars-1 simulant, SiO_2, and Fe_2O_3. Fiberglass and Teflon were chosen due to their separation on opposite sides of the triboelectric series. Most materials when rubbed onto Fiberglass will charge it positive, whereas Teflon would most likely charge negative. The output voltage of the electrometer is a measure of the local electric field that is induced on the electrometer's probe sensor electrode. The amount of charge that develops on the insulator surface can be determined from the output voltage using the circuit gain 0.25 pC/mV. We have overlaid Teflon and Fiberglass data on each one of the graphs in Figure 4; therefore, only voltage differences have meaning.

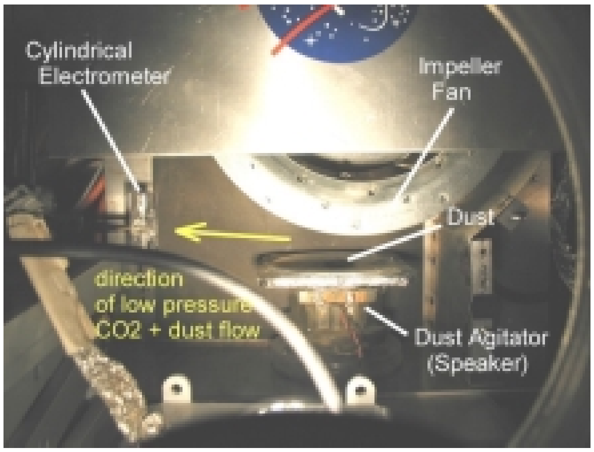

Figure 2. The KSC dust particle impeller operates at low pressures and is capable of propelling dust particles at atmospheric pressures and pressures as low as 7 mbar.

We obtain similar graphs for other combinations of insulating cylinders and incident granular materials after repeated experiments. However, the actual voltage levels attained during each run depend upon conditions that are difficult to control, such as the flow pattern of windborne dust particles, and the charging of dust particles due to particle-particle collisions.

Sensors in this instrument reveal the magnitude and sign of the electrostatic charging due to the interaction between airborne particles and the surfaces of the materials, as well as the charge developed when the materials are rubbed against the soil.

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References:

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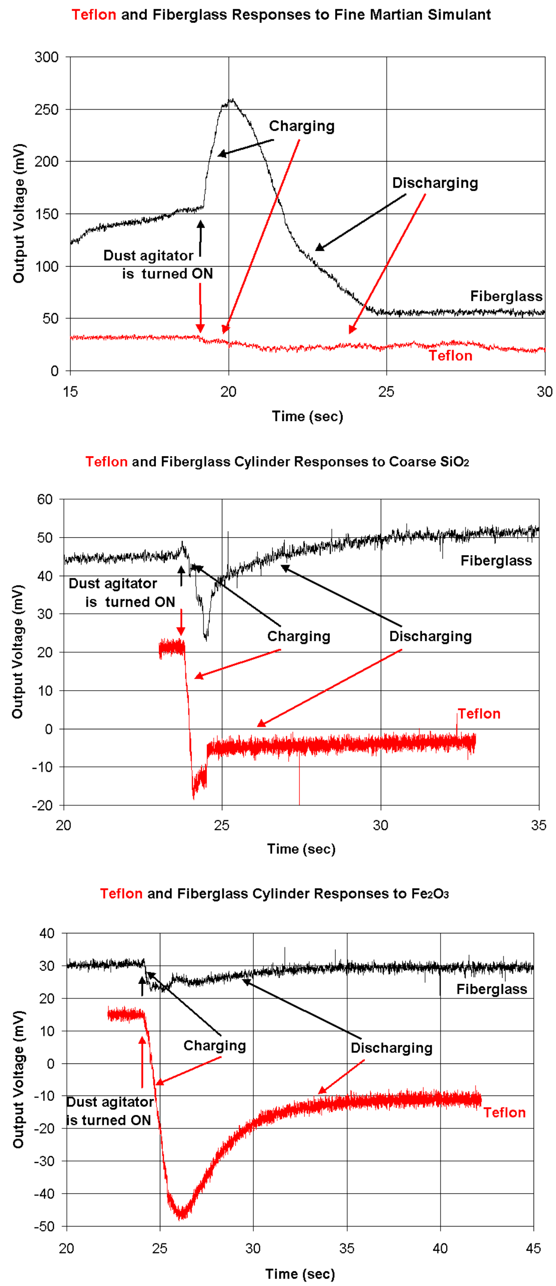

Figure 3. Particles propelled to the aerodynamic electrometer with the probe embedded in Teflon and Fiberglass cylinders. (a) 5 µm JSC Mars-1 soil simulant, (b) Coarse SiO_2, and (c) 5 µm Fe_2O_3 particles.