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Spacecraft Charging Research

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Why do we need the Capacitive Resistance Apparatus?

Picture1-Disassembled view of C.R.A..

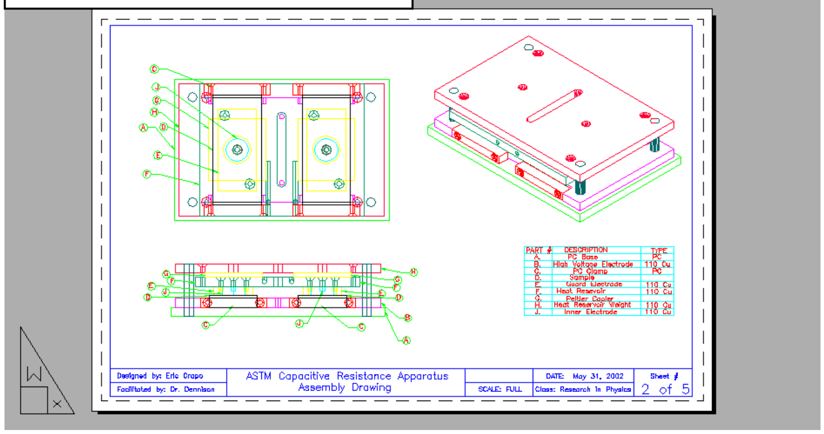
Current research in spacecraft charging effects is inadequate. A key to modeling spacecraft charging is how fast accumulated charge is dissipated from insulating surfaces, as determined by resistance measurements. According to A.R. Frederickson of the Jet Propulsion Laboratory in Pasadena, CA. "discharge…pulses were repeated by a large number of researchers, but all for similar conditions… the old scaling laws appear to be inapplicable in space conditions." (Frederickson). My research is to create a system that can hopefully be used to improve the old data thus making American space missions have one less variable to have to worry about.

Theory behind the Capacitive Resistance Apparatus.

The Capacitive Resistance Apparatus is essentially a modified simple capacitor system designed to measure resistance of the film insulators (Standard Test Methods for DC Resistance or Conductance or Insulating Material). Charge is placed on the plates, and then both charge leakage rate and punch-through voltages can be measured. ("Punch-Through" is a term used to describe the voltage at which arcing occurs across a thin film insulating sample.) The C.R.A. will interface with a specially designed computer constructed by Carl Elsworth. The C.R.A. system will not only measure leakage and punch-throughs, but also environmental variables such as applied voltage humidity, temperature, and pressure. We hope that by varying these environmental conditions relative to what occurs in space, we can have more accurate and appropriate data acquisition for the construction and design of future spacecraft.

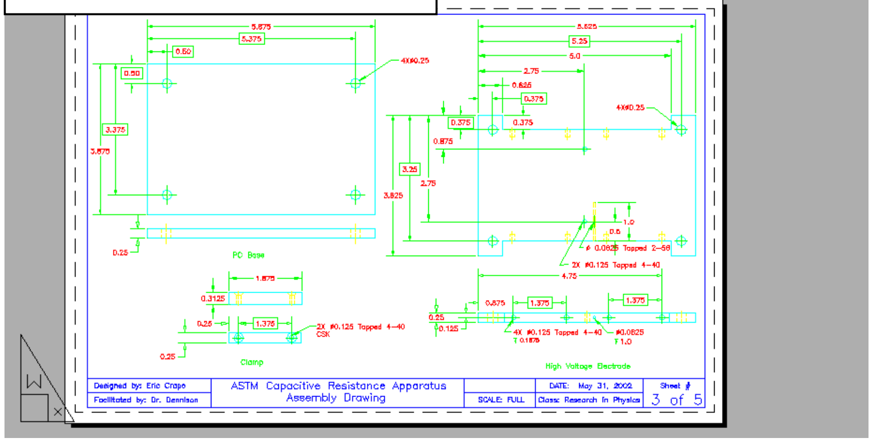
How was the Capacitive Resistance Apparatus constructed?

Picture2-Autocad 2000 assembly drawing for C.R.A.



In coordination with Dr. J.R. Dennison and Dr. A.R. Frederickson, a general design was planned and drawn out on paper. These rough sketches were used to start the drafting process for the C.R.A. using Autocad 2000® Architectural Desktop. After the drawings were completed, they were given to Dr. Ali Sabbah who then machined the parts.

Picture3-Autocad 2000 base plate drawing.



Once this was completed, the assembly of the C.R.A. was begun followed by the wiring and attachment of all the peripheral devices. Once the unit was assembled, the vacuum components were then disassembled and cleaned in an ultrasonic bath of dichloromethane followed by a rinsing in a methanol solution. This standard ultra high vacuum cleaning process was necessary to maintain a high vacuum environment.

Error and Interpretation Analysis

Most of the problems with this project developed at the wiring stage of the C.R.A.. Platinum resistance temperature devices were too fragile and consequently broke while trying to attach the leads to a wiring feed through. Successful attachment of the Peltier cooler wiring to the feed through also was challenging because of the small work area within the C.R.A. and also because of my novice wiring skills. With exception to the wiring details, the project went together as planned and appears to be able to meet the design requirements.

Next Steps

There are many materials used in spacecraft construction. The ability to test many samples at a time is very important because of time constraints involved with testing the samples. (For example, potential difference leakage tests can take up to a month.) Switching samples can also be rather tedious with this C.R.A. For these reasons, design and construction has begun on a larger and more accurate testing chamber. This new chamber will yield more accurate testing results than the C.R.A. and demonstrate that the old methods of testing spacecraft materials were grossly inaccurate. It is capable of handling more samples easier, and in a more controlled environment than the C.R.A. will. In order to finish this project, Carl will finish the computer and Jerilyn will complete the assembly and testing of this project. Then the unit will be used to measure the resistively of many thin film insulating spacecraft materials.

Conclusions

I have learned that the design process for even reasonably simple things can actually become quite complicated. It is difficult to realize the many variables that must be taken into account that ultimately can ruin what seemed to be a good idea. With exception to the platinum resistors and the wiring, progress went well (as well as can be expected). I have learned that with patience, diligence, and applied Physics, great things can come about.

The success of this project will help the spacecraft designers of tomorrow construct safer, and more space-friendly vehicles.

Works Cited

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