Ultra-Fast Hall Effect Measurement Facility

Dr. Patrick Hemenger is pictured operating his ultra- fast Hall Effect Measurement Facility. It utilizes a circuit that Pat developed that allows one to rapidly measure very high resistance samples to the range of 10^{12} ohms which are basically insulators. He published his circuit design in the Review of Scientific Instruments 44, 698 (1973).

Measurement of the temperature dependence of the resistance of a semiconductor down to near absolute zero is essential for semiconductor development programs. The difficulty in getting this data is that the resistance of a semiconductor increases exponentially with decreasing temperature. **Pat's circuit was recognized worldwide as a major breakthrough in the field of scientific equipment.**

Pat utilized his facility initially among other things to assist Bomar of Canada to develop room temperature light emitting diodes (LEDs) on their cost share program jointly funded by the US and Canada. Bomar brought out the first calculator with a LED display. Ultimately Texas Instruments and HP brought out calculators such as the HP 65 with LED displays that ultimately dominated the calculator market.

Pat also used his facility to qualify ultra-high purity silicon crystals for the DOD Critical Material Stockpile. These silicon crystals are essential for the manufacture of infrared detectors appropriate for directing the IR Maverick to its target.

All electrical circuits possess resistance (R). The problem is that they also have an intrinsic inductance (L) and an intrinsic capacitance (C). As a result, as the resistance of the circuit increases, it takes a longer time proportional to R/CL for the current in the circuit to settled down to its equilibrium value. The impedance/ac resistance (Z) of a circuit is given by

$$Z = [\, R^2 + (X_L - X_C)^2 \,]^{1/2} \text{ in ohms where } X_L = 2\pi fL \text{ and } X_C = 1/2\pi fC$$

Note, the resistance of the voltmeter must be much higher than that of the sample to measure the correct value. The circuit utilizes four Keithley electrometers which have an infinite internal resistance which are shown in the photo at the upper left of Pat's head. The magic of Pat's circuit is that it can electronically produce $X_L = X_C$ resulting in the desired result of Z=R. As a result the equilibrium current is established "immediately" revealing the actual sample resistance "immediately".

The whole world now uses Hemenger's circuit in all semiconductor development programs. Keithley now sells a clone of Hemenger's electronic circuit for around $25,000.