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**NOTES ON THE NEW CONTROLLER
FOR THE ANAC TWO-AXIS MAGNET**

JOHN B. AIDUN

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Shock Dynamics Laboratory
Department of Physics
Washington State University
Pullman, WA 99164

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The ammeters on the new electromagnet controller were calibrated on 8 January 1988. These ammeters monitor the current generated by the two power supplies for the two-axis magnet built by ANAC. For convenience I assumed that the ammeters on the old controller gave true readings. The ammeters on the new controller were adjusted to give the same readings. The corresponding ammeters on the two controllers give the same readings to within 1 A at any current level.

In the notes on the magnet controller, which Paul Bellamy has on file, 0.0013Ω is noted as the shunt resistance in the 250-A power supply (P.S. 2) off of which the voltage is tapped and sent to the ammeter of the corresponding current controller. The shunt resistance in the 500-A power supply (P.S. 1) has a different resistance, but its value is not recorded. Because of this, and the difficulty of accurately measuring the shunt resistance, I decided to calibrate the new controllers ammeters relative to those of the old controller.

The following two points indicate that this calibration is adequate. First, by measuring the field intensity versus driving current relation (not done), the ammeter readings are useful for determining the magnetic field intensity without Hall probe measurements. (I am assuming that this relation is stable over time.) Second, the ammeter calibrations do not need to be highly accurate for safe operation of the power supplies. The power supplies are designed with a margin of safety that allows them to provide currents greater than their nominal ratings. Circuit breakers prevent the power supplies from being damaged if this safety margin is exceeded.

On the new controller, ammeter 1 gives the value of the current generated by the 500-A power supply to the nearest ampere. No decimal point appears on the display, and

there is a leading zero that should be ignored. Ammeter 2 gives the current to the nearest 0.1 A, and display an extraneous negative sign.

The "Current Adj." and "Voltage Adj." ("I" and "V" on the old controller) knobs, respectively, limit the current and voltage produced by the power supplies. To obtain a steady magnetic field for particle velocity measurements, steady magnet driving currents are needed. For this reason, the voltage-limiting control should be set high (e.g., 8 turns of the 10-turn range) and the current-limiting control used to adjust the current. The power supplies will then vary their voltage as necessary to keep the current constant as the resistance of the magnets changes as they heat up.

On the new controller, one full turn of current control knob #1 (#2) changes the current by approximately 75 A (45 A). When the 500-A (250-A) power supply is providing 400A (200A), "Current Adj." knob #1 (#2) is positioned at 8:00 (1:30) relative to a clock face. With this controller up to three Hall voltages can be monitored from F. W. Bell Hall probes BH-700 and/or GH-600. The controlling current for the BH-700 (GH-600) probes is put out from the port labeled I1 (I2). Recommended Hall probe controlling currents are 100 mA and 5 mA for the BH-700 and GH-600 probes, respectively.

In March 1988, Paul Bellamy and I checked the accuracy of the thermocouples used to monitor heating of the electromagnets. In successive measurements, the thermocouple for the dipole magnet (BNC connector #3 in the bottom of the target chamber) and the solenoid magnet (BNC connector #1) was attached to an ice-point compensator and monitored while the respective magnet was driven with 490 A. (The measurement was done in a rough-and-ready manner by simply attaching the second, monitoring thermocouple wire in parallel with one of the magnet thermocouple wires.) The temperature rises indicated by the two thermocouples agreed well with the set-point controller for the magnets.

We found that in both magnets, the temperature at the thermocouple location continues to rise after the driving current was shut off. This residual temperature rise was tolerably low in the solenoid magnet; it dissipates heat sufficiently fast. The alarm went off when the thermocouple potential was 3.60 mV (after running for 80 s) and the maximum

potential reached was 4.04 mV (210° F, in agreement with the set-point controller setting). The dipole magnet was run for just 60 s, at which time the thermocouple potential was approximately 2.0 mV. The thermocouple potential continued to rise, though the current was off. The alarm sounded 4 minutes after first turning on the current, when the thermocouple potential reached 3.20 mV (175° F, in agreement with the set-point controller setting). We did not record the maximum temperature reached.

In May 1990, Paul and I reset the left set-point controller, which controls the dipole magnet, from 175 degF to 120 degF so that the alarm will sound early enough to keep the maximum temperature ultimately reached from exceeding 175 degF. With this new setting the alarm went off after running for 80 s at 490 A. The thermocouple potential was 2.30 at this time, and it reached a maximum of 3.29 (approximately 180degF) 4.5 min. after the power was first turned on.

With this adjustment, the magnets are largely safe from overheating. Ten seconds after the alarm sounds, a thermal switch built into the magnets cuts off the current, if it continues to flow. (This switch connects to BNC connector #2 in the bottom of the target chamber.) Magnet users should bear this in mind. It means that you do not need to be overly concerned about making a mistake that might damage the magnet. However, it also means that once the alarm sounds, there is little time to make a particle velocity measurement, even if you leave the current on; After 10 s the current is automatically killed and with it goes the magnetic field and any gauge signal you hoped to record.

Finally, because the labels on the magnet terminals are fading, note that the dipole magnet terminals are the pair on the left. The left terminal of the pair is negative. The left terminal of the pair to the solenoid is positive. When power is connected according to these labels, the dipole field is directed upward and the solenoid field is directed down the gun barrel towards the breech.