Dobson Troubleshooting Guide

For Instruments with the USA 1999 electronics and equipped with an encoder.

Definitions

- Photomultiplier Tube – (PMT): Cold Cathode tube that converts light in to Electrical current through the use of stepped potential grids.
  - Light knocks electrons off the cathode (High negative potential)
  - The stepped potential accelerates the electrons towards the anode, and electrons are swept up from the grids (cascade effect).
  - Electrons hit anode and go to ground through a resistor, producing the signal.
- Sensitivity: Amplification factor of the PMT – controlled by the high voltage applied to the PMT
- Dynode Chain – Voltage divider circuit giving the stepped potential to the grids in the PMT
- Photon-Coupled Interrupter (PCI): A packaged LED-Photo detector pair used as an optical switch on the shutter to synchronize the amplifier output.

Theory of operation

The optical part of the instrument produces two light sources, one (the longer wavelength) strong (more intense) -- the other (the shorter) weaker. The primary reason for the difference is the absorption by atmospheric ozone of the shorter. The idea is to reduce the longer light intensity to that of the shorter, by the use of an optical attenuator. The position of the attenuator where the microammeter reads zero represents the amount of ozone through which the shorter wavelength passed.

The electronics compare the signals – if one signal is stronger , the meter reads above zero. If the other is stronger the meter reads below zero.

The PMT converts the light to an electrical signal the strength of which is directly proportional to the light intensity. The motor spins a shutter that allows only one of the sources to be seen by the PMT at a time. The amplifier is synchronized to the shutter, so the signal from one source is amplified with the sense opposite the other source. The signals are then summed in the microammeter. If the signals are the same strength, the meter reads zero.

What can go wrong?

- Most common failures were in the older individual power supplies for the Amplifier and High voltage section (Polytron and Philbrick). We have yet to have a failure with the newer Lambda power supplies,
- The Bertan PMT supplies have been used since 1982 without failure.
- The resistors in the dynode chain are wire-wound, with 1% tolerance. Some of these very old resistors have opened. If one is to be replaced, a metal film must be used – no carbon resistors, as they generate noise in this kind of circuit.
- Some instruments have the wrong size fuses installed, and were blowing the fuses if all three switches were switched on at once. The proper fuse is a 3AMP Slow-Blow.
- In 2002, one instrument had a failure in a fuse holder that caused the fuse to blow when the instrument was plugged it, but not switched on.

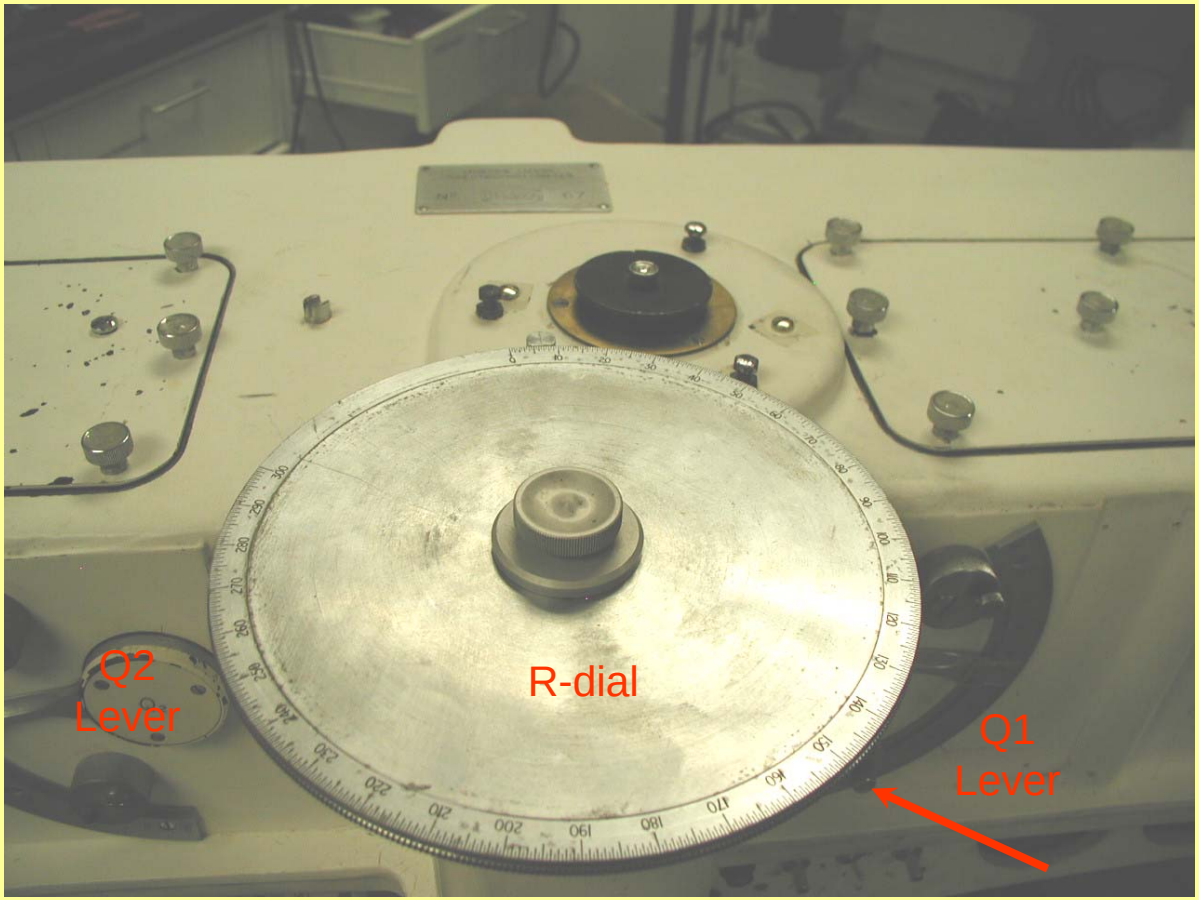
Getting started.

- Start with all switches off, the potentiometer on the micrometer fully on (CW), both PMT (sensitivity) controls turned fully CCW.
- Is the Microammeter working? Take the leads to the meter off the Dobson end, and touch the leads to your tongue – the meter should read a small current.
- Turn leftmost switch on -- does the motor spin (Sewing machine noise?)
  - if not check the fuses (3 amp slow blow) – and the power cord.
  - If the motor spins – we know we have power.
- Turn the middle switch on while looking at the meter -- did the meter "kick" as the switch was turned on?
  - The kick means that the amplifier circuit is working.
  - No kick, check power supply voltages.
- If the meter does kick, then turn on the third switch & attempt a measurement on the zenith -- use the left most PMT control first -- then the right most -- what happened?
  - If the meter at first is quiet, as the PMT voltage is increased, then suddenly the needle starts flailing back and forth – check the PCI.
  - If it's really dead, then remove the lid and check the voltage to the dynode chain.
    - **If the voltage checks good there, then check the resistance of the chain**.

Photomultiplier Tube Problems – There aren't many.

- The PMT does not have a hot cathode, so PMT do not "burn out" with age
- If a PMT "sees" a bright light, especially with high voltage applied, the cathode can be depleted of electrons – it will become "tired" for a period of time.
  - If the PMT is given too high a voltage for the light coming in the instrument, it can be momentarily "dead". It will recover if the voltage is reduced.
- A high voltage, and direct sun light can overheat a PMT, and even destroy it – this has not happened in two decades with the Dobson instrument.
- The precise position of the PMT in the instrument is critical, and requires a verification of the position if the PMT is replaced.

R-dial (optical attenuator readout) and Q-levers (Wavelength selectors)



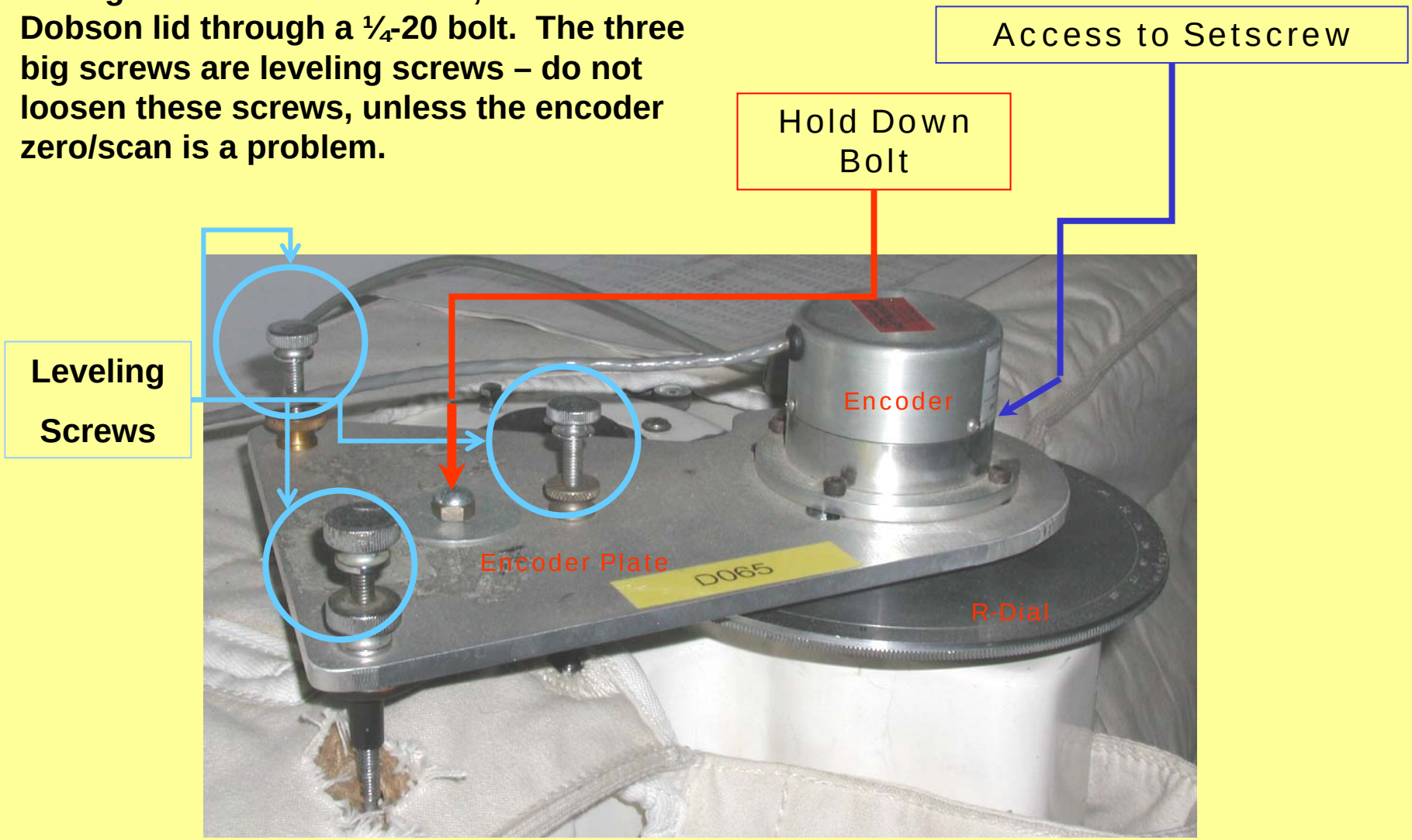
Ground Quartz Plate (GQP) and inlet window

Cleaning

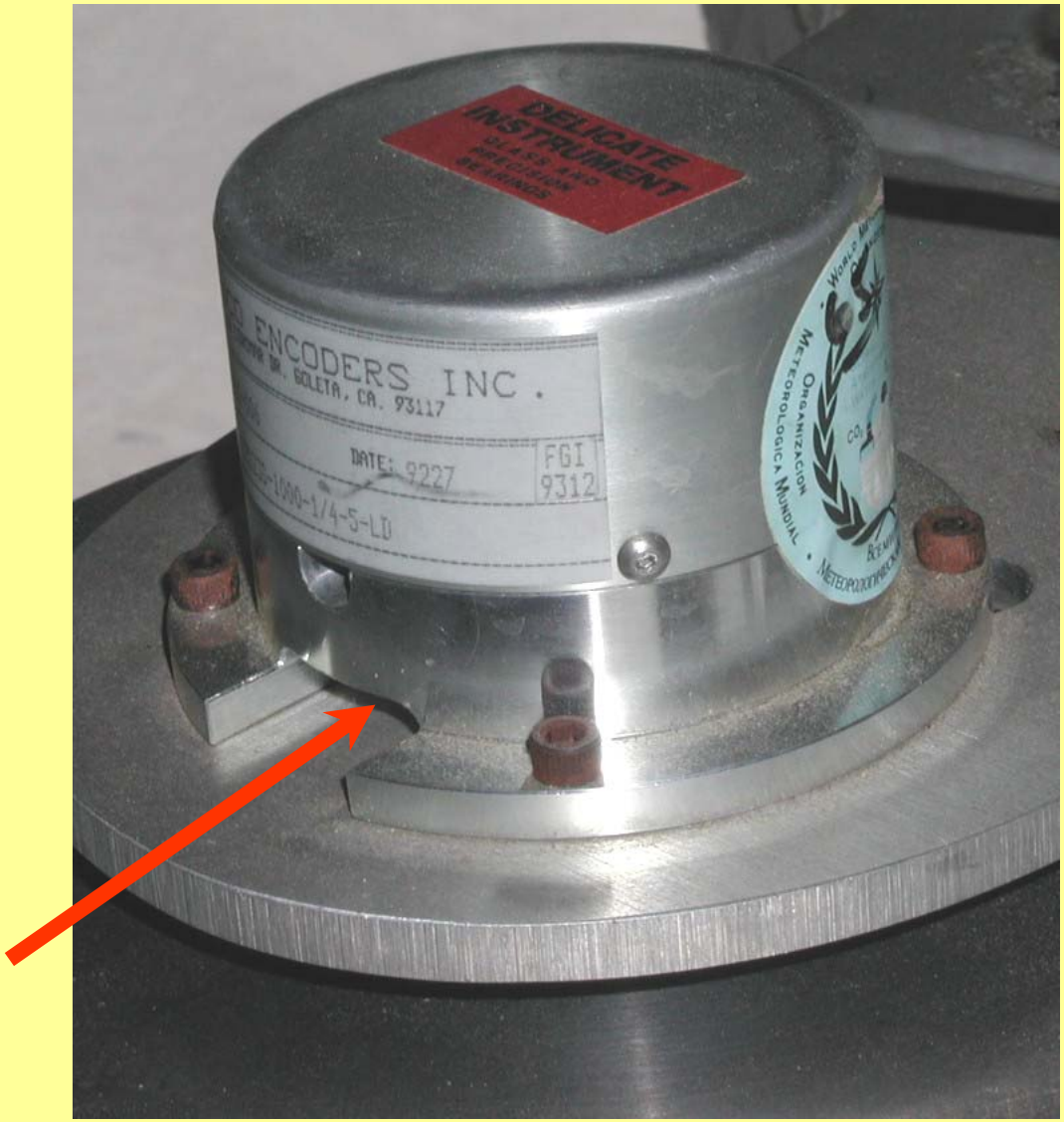
- The interior optics of the instrument are *not* to be cleaned, except under direction of Bob Evans (the Dobson guy).
- GQP and inlet window can be cleaned, but perform standard lamp tests before and after cleaning.
- Inlet window can be cleaned by breathing on it, then wiping with lint-free clean wipe.
- If soap is used to clean the GQP, rinse it with rubbing alcohol afterwards.
- Sun Director and lens can be cleaned at any time.

Removing the Encoder

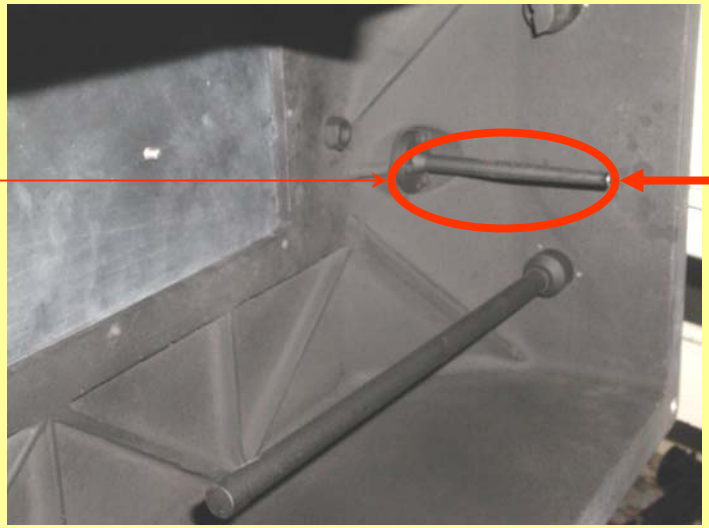
The encoder connects to the R-dial through a bellows connector, and to the Dobson lid through a ¼-20 bolt. The three big screws are leveling screws – do not loosen these screws, unless the encoder zero/scan is a problem.



Barrel (Bellows) connector access: Note that there might be two setscrews.



There are pins at each end of the lid (under the rings) that are designed to fit in to sockets in the base. When removing the lid, the lid must be lifted high enough to clear the socket. When replacing, the pins must enter the sockets. If the lid is raised or lowered without being approximately parallel to the base, the pin/socket will “jam”.

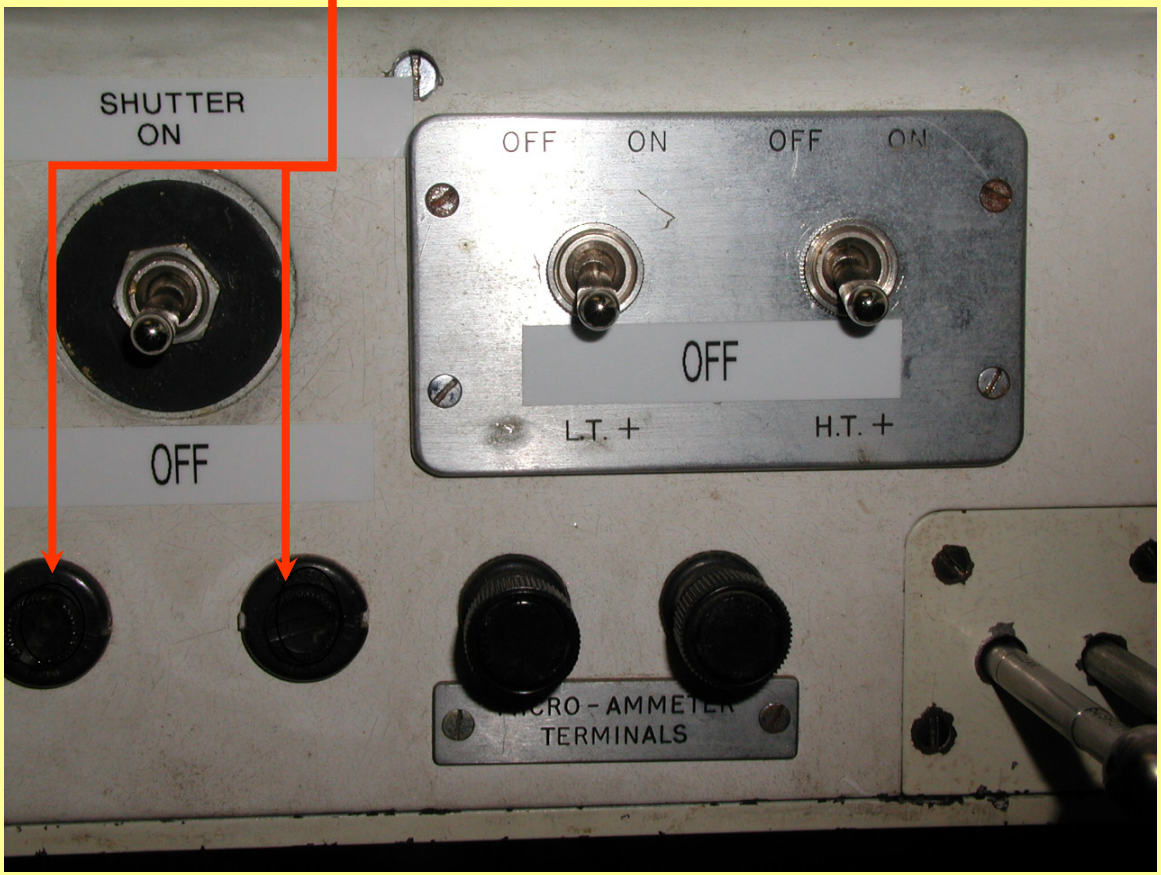


Removing the lid – After removing the encoder.

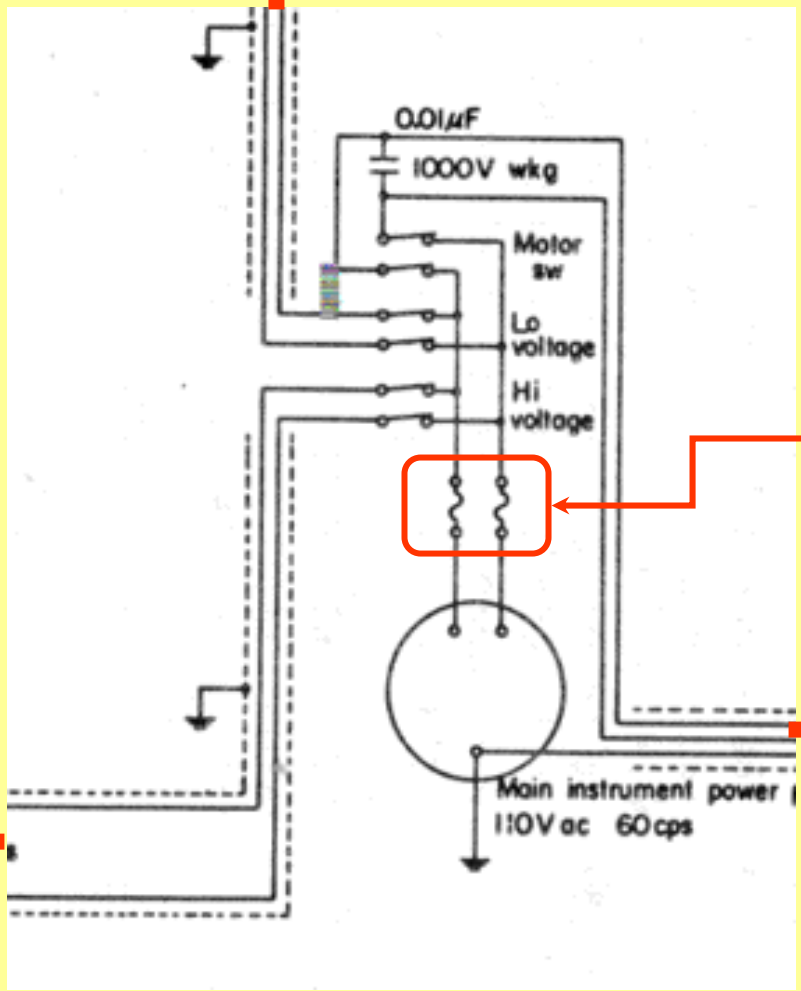
Lift the lid, keeping it parallel to the base, until it is about 12 inches above the base. Move the lid to a secure place. If you must place it on the floor, place it on a clean cloth.

Remove the nuts on these studs before attempting to remove the lid.

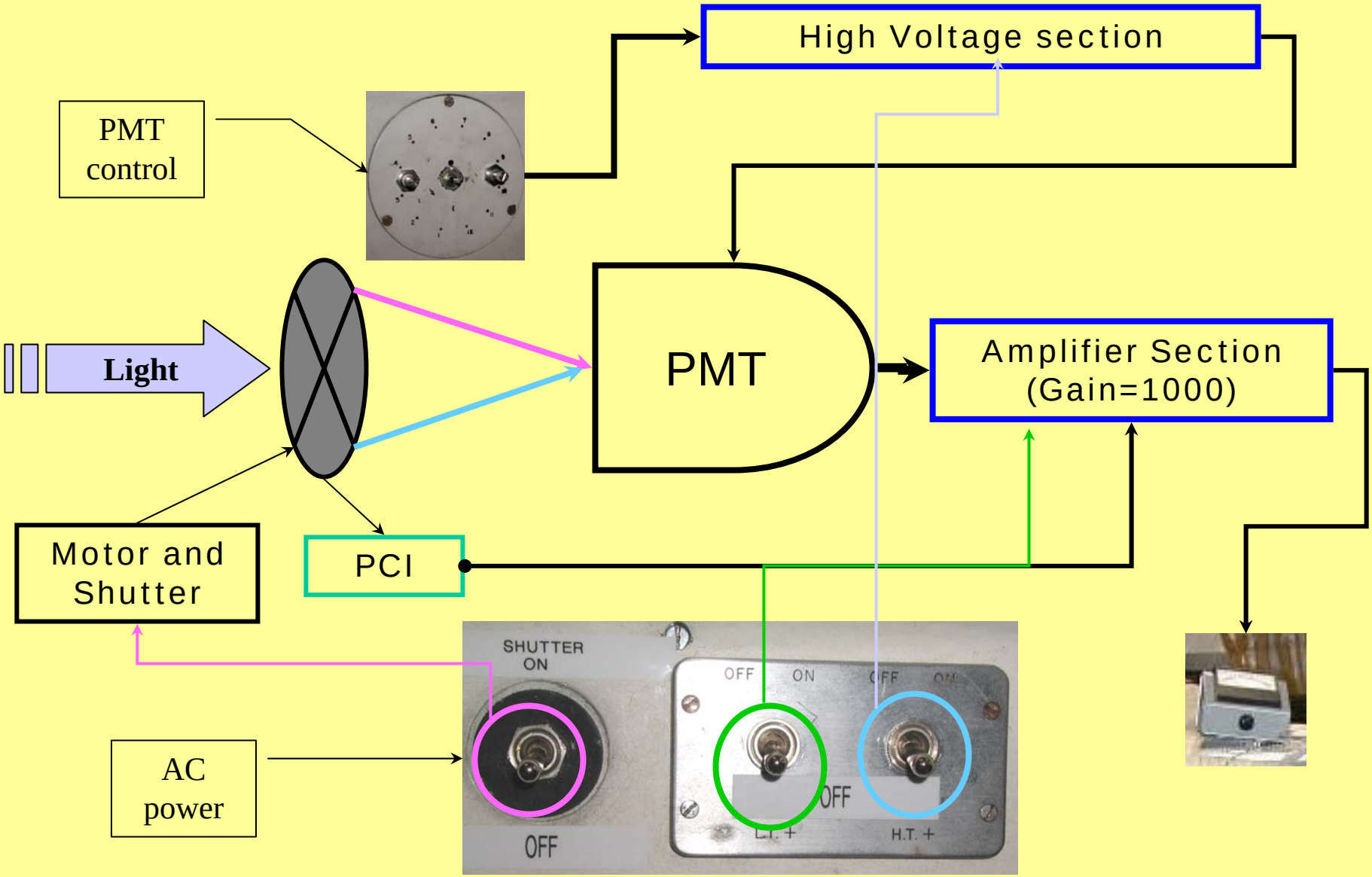
Fuses – 3amp slow-blow.



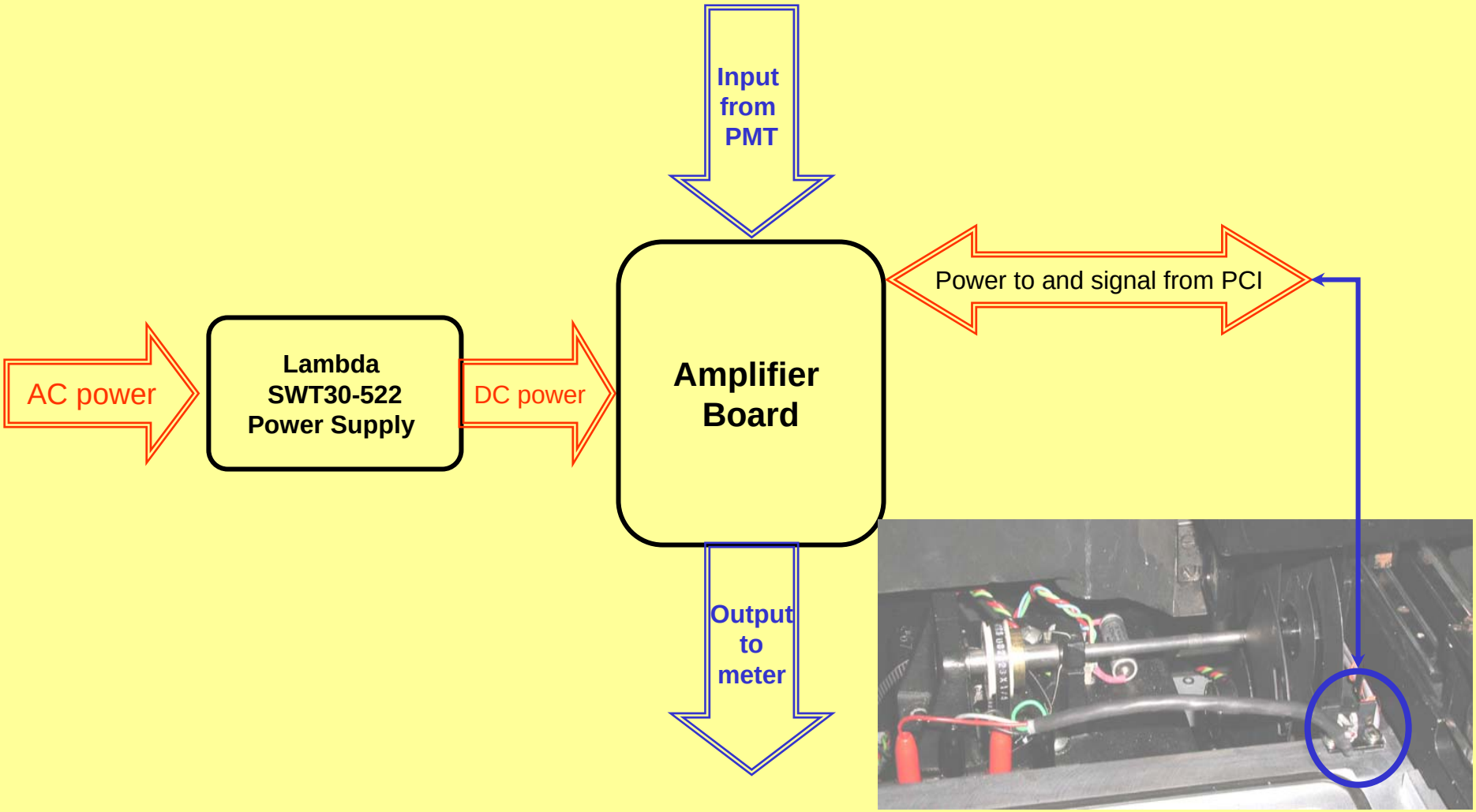
AC Power and switches – each section is independently switched.



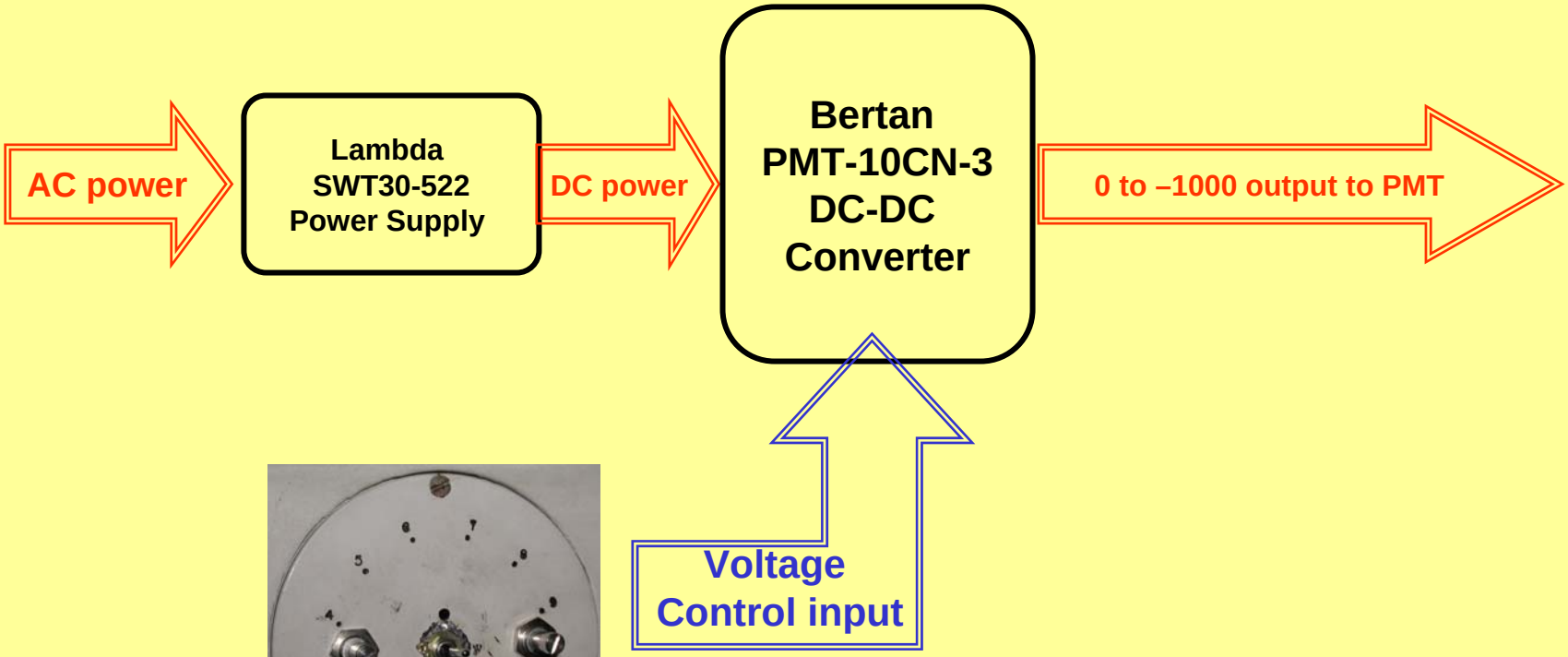
Block Diagram of Electronics



Block diagram of the amplifier circuit.

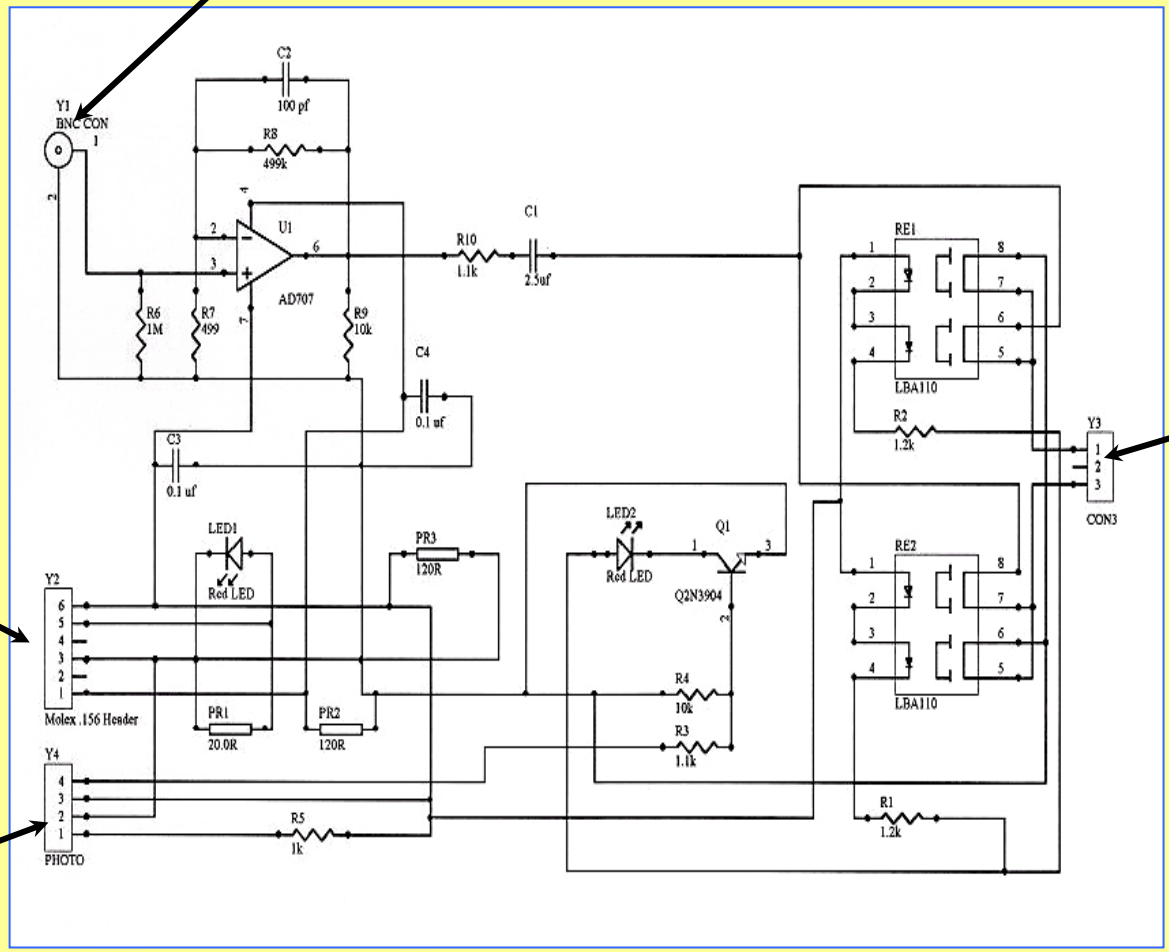


Block Diagram of the High Voltage Section.



1999 vintage amplifier circuit

Input from PMT Circuit



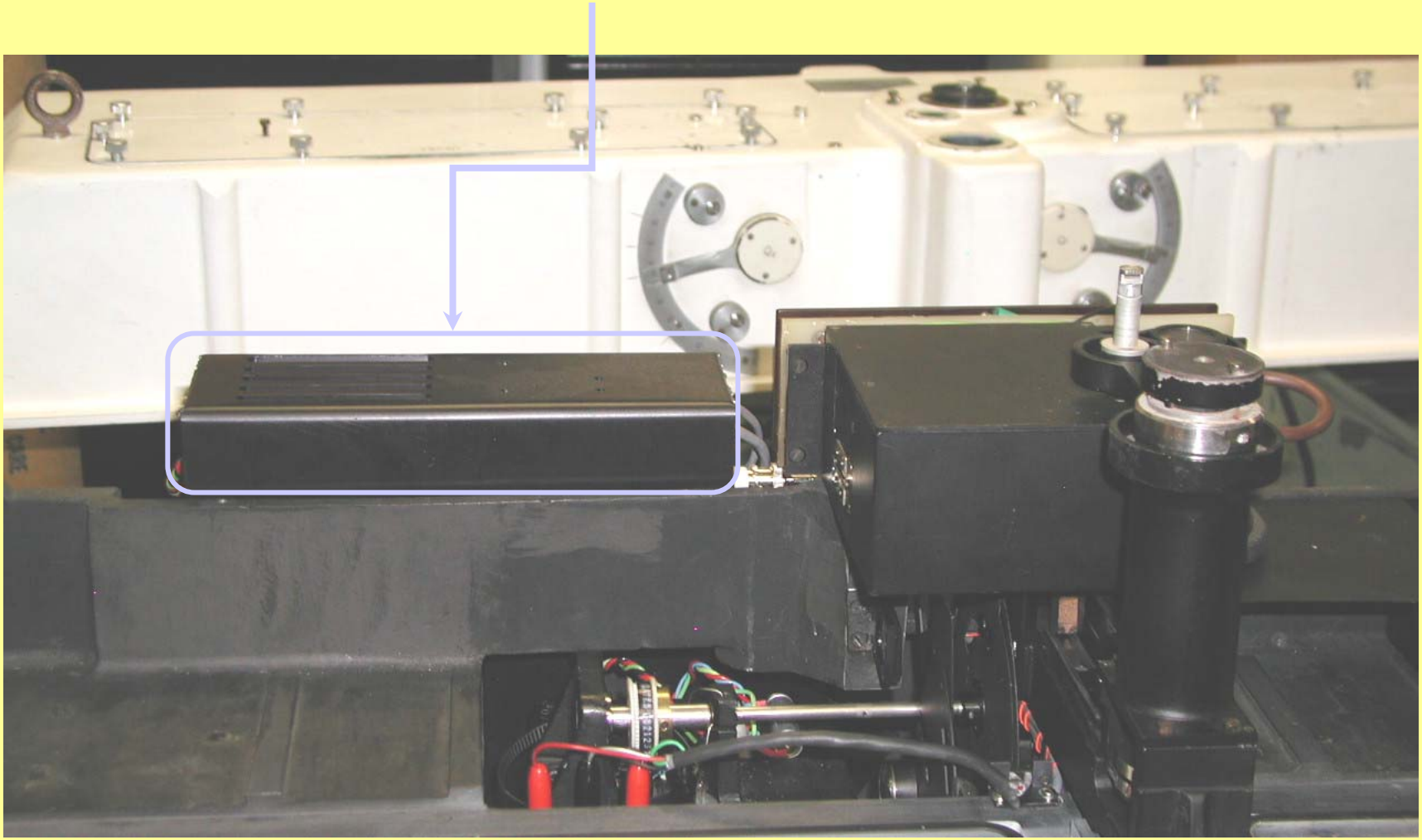
Power Supply Connector

Output to Micro-ammeter

To PCI detecting shutter position

Locating the amplifier

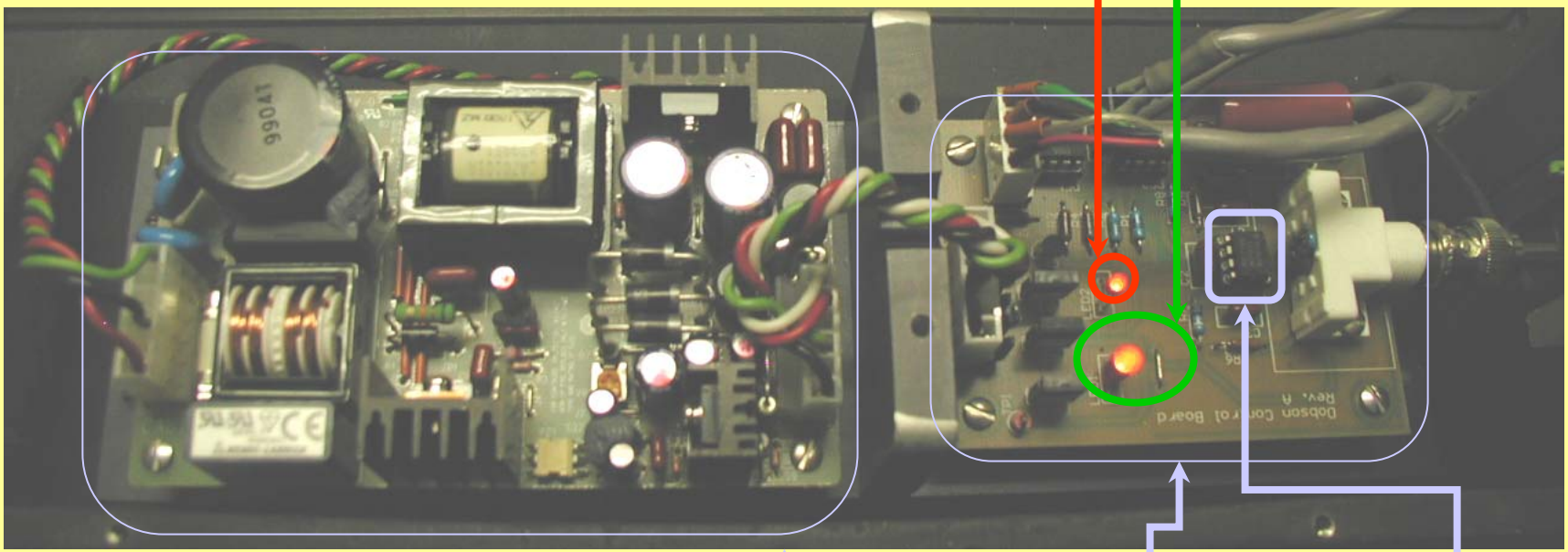
The amplifier section is located inside the instrument behind the spine on the left. There are two small holes to view the power-on LED and PCI status LED located on the amplifier board inside the box.



Amplifier Section

PCI LED – This LED will flash if the shutter is rotated. This shows that the PCI and Circuit is working.

Power LED – if this is on, there is power to the board



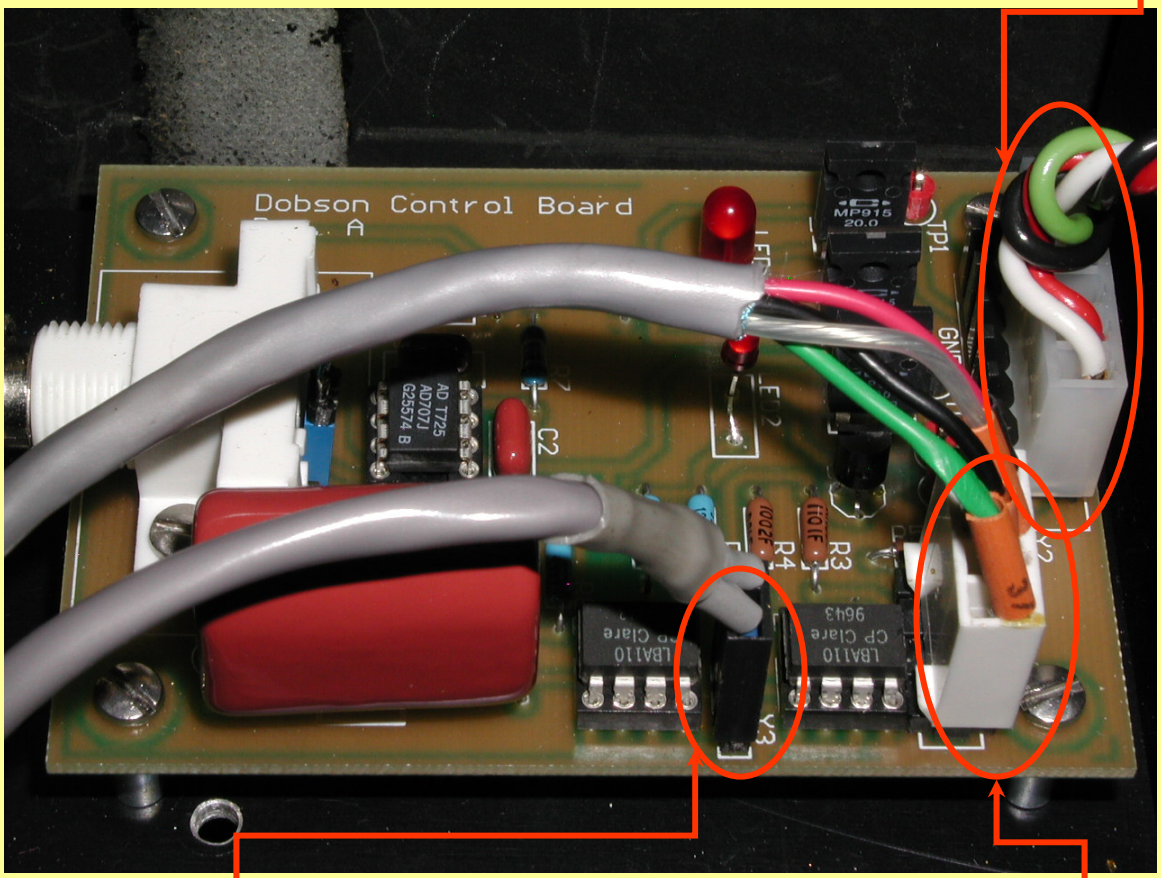
Lambda SWT30-522 Power Supply

Amplifier Board

OP-07

Another view of amplifier card

Power from Lambda



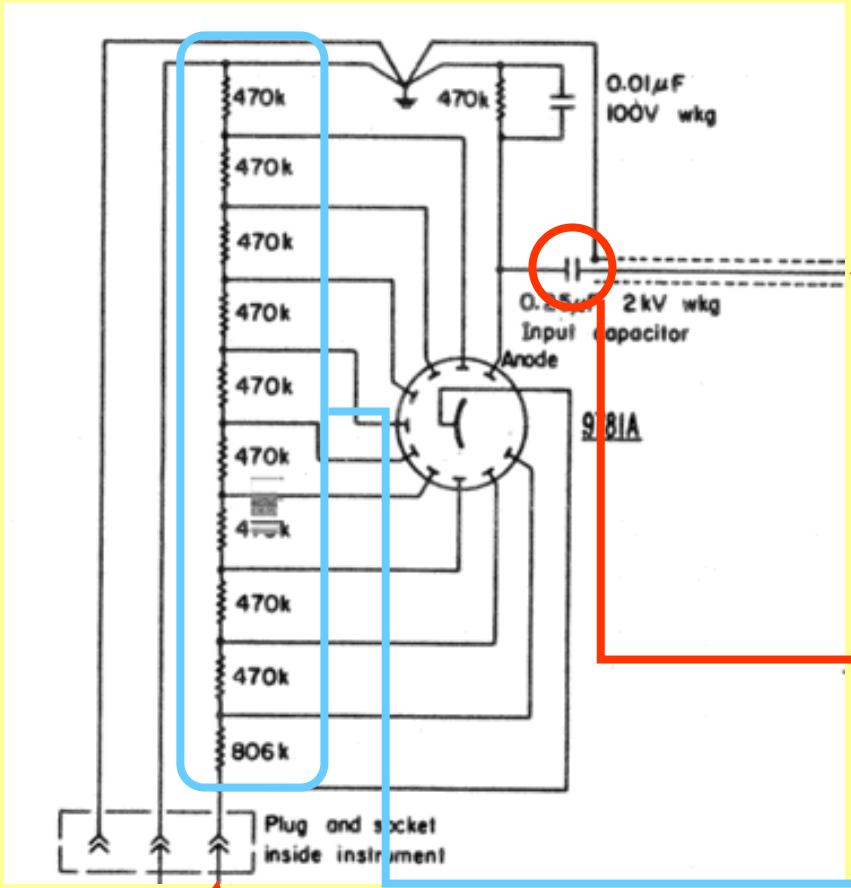
Connection to microammeter

Connection to PCI

Quick Test of the amplifier

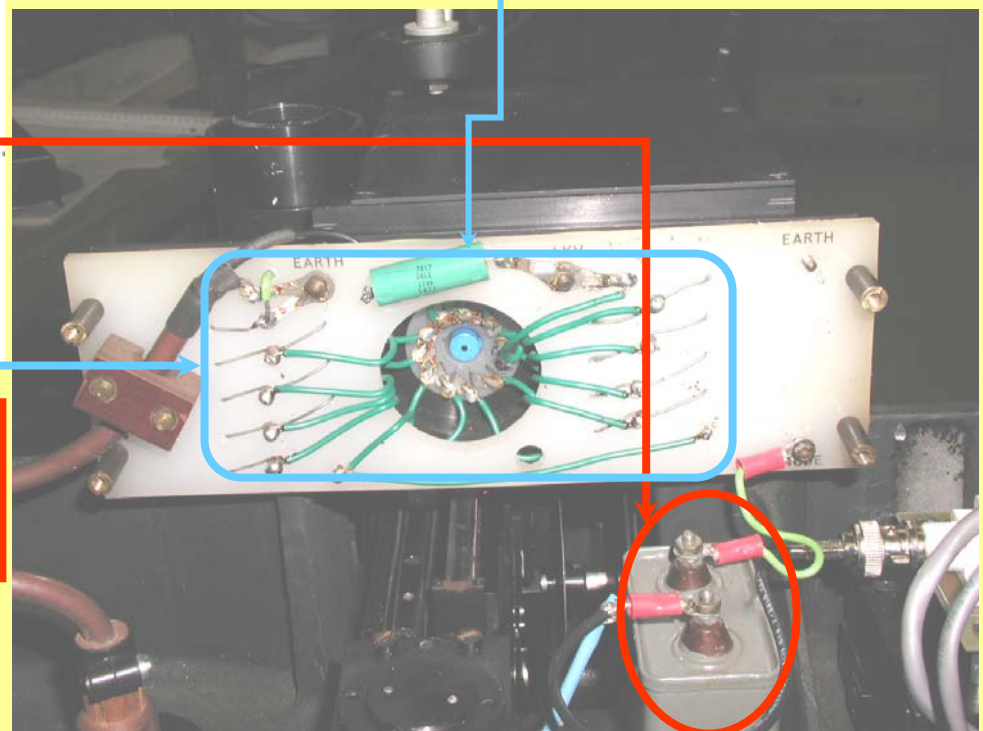
With the middle switch on, watch the microammeter and touch the back contact of the AC coupling capacitor. The meter should show the 60HZ from your finger.

PMT Circuit, Showing Dynode chain and AC coupling Cap.



Amplifier Circuit

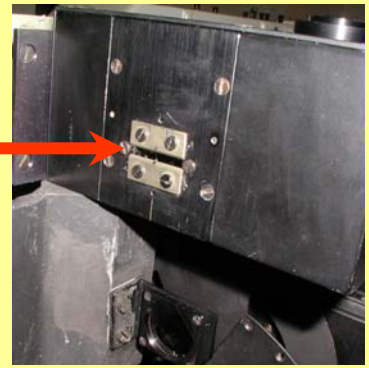
Dynode Resistors on other side of Board



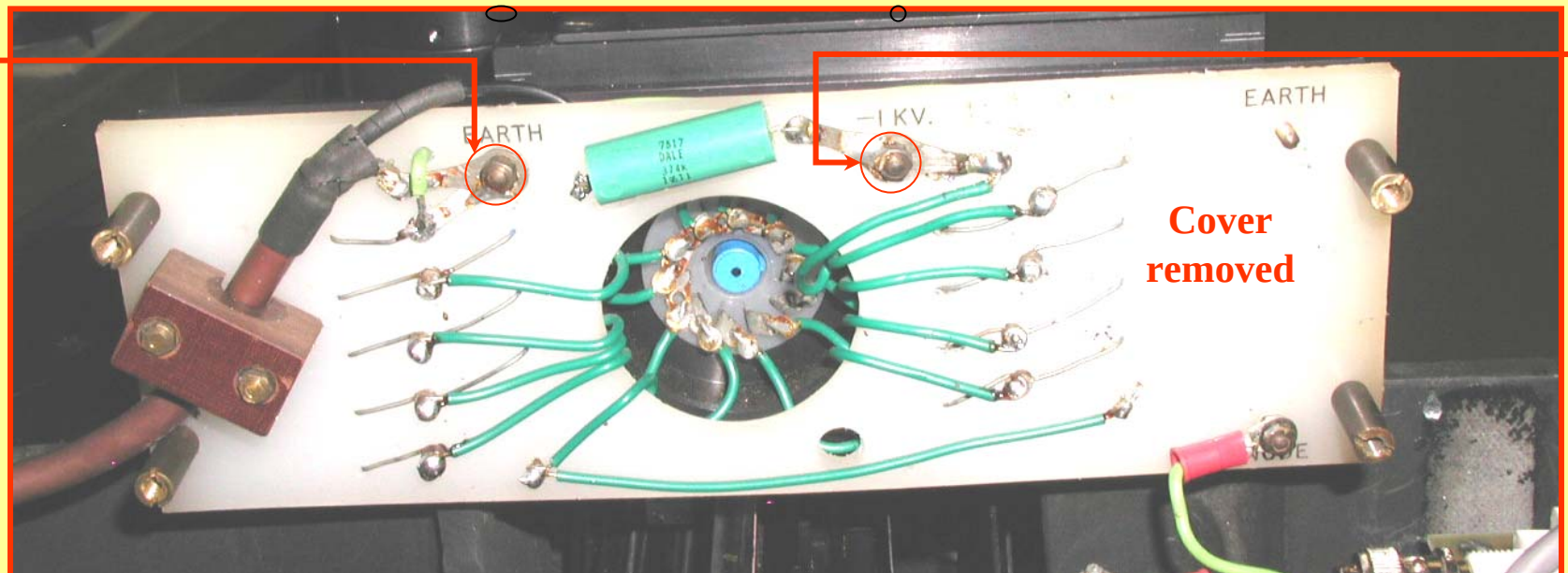
High Negative Voltage ~200 to 900VDC

Measuring the PMT Voltage

First, Put Black electrical tape over this slit.



Measure between these two points. Range should be – 0 to ~900 volts (There is an inline resistor in many of the circuits to limit the max voltage.) If the max voltage is 1000+, think open resistor in dynode chain



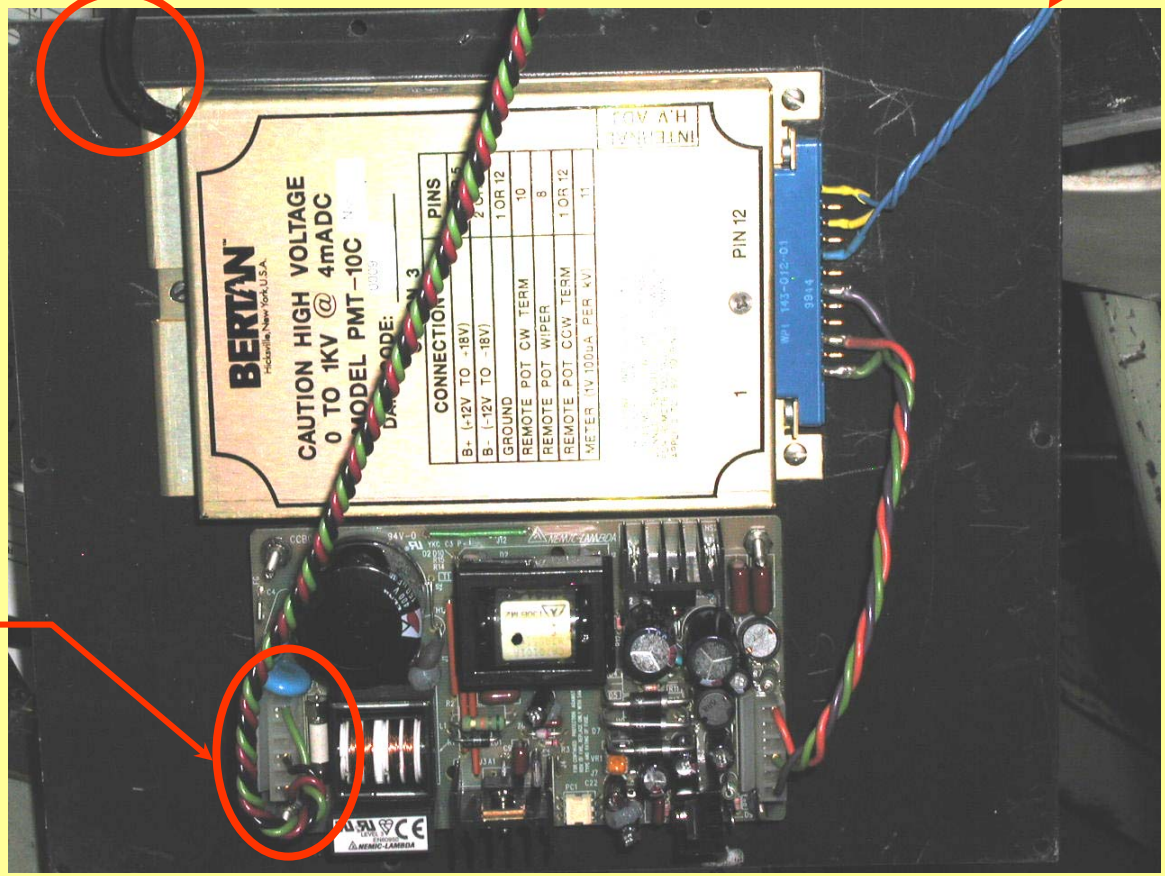
Bottom View – the instrument must be tilted back on to bean bags or other supports -- it's top heavy.

The Shutter motor is mounted on this plate

The high voltage is mounted on this plate

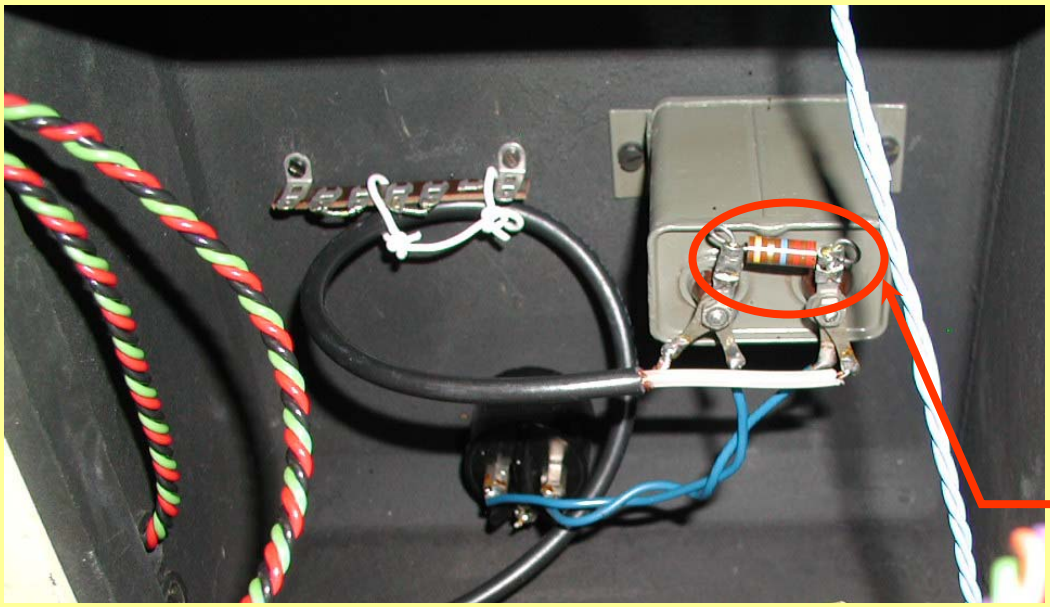
High Voltage section mounted on right bottom plate.

High voltage output



AC input

View into high voltage bay.

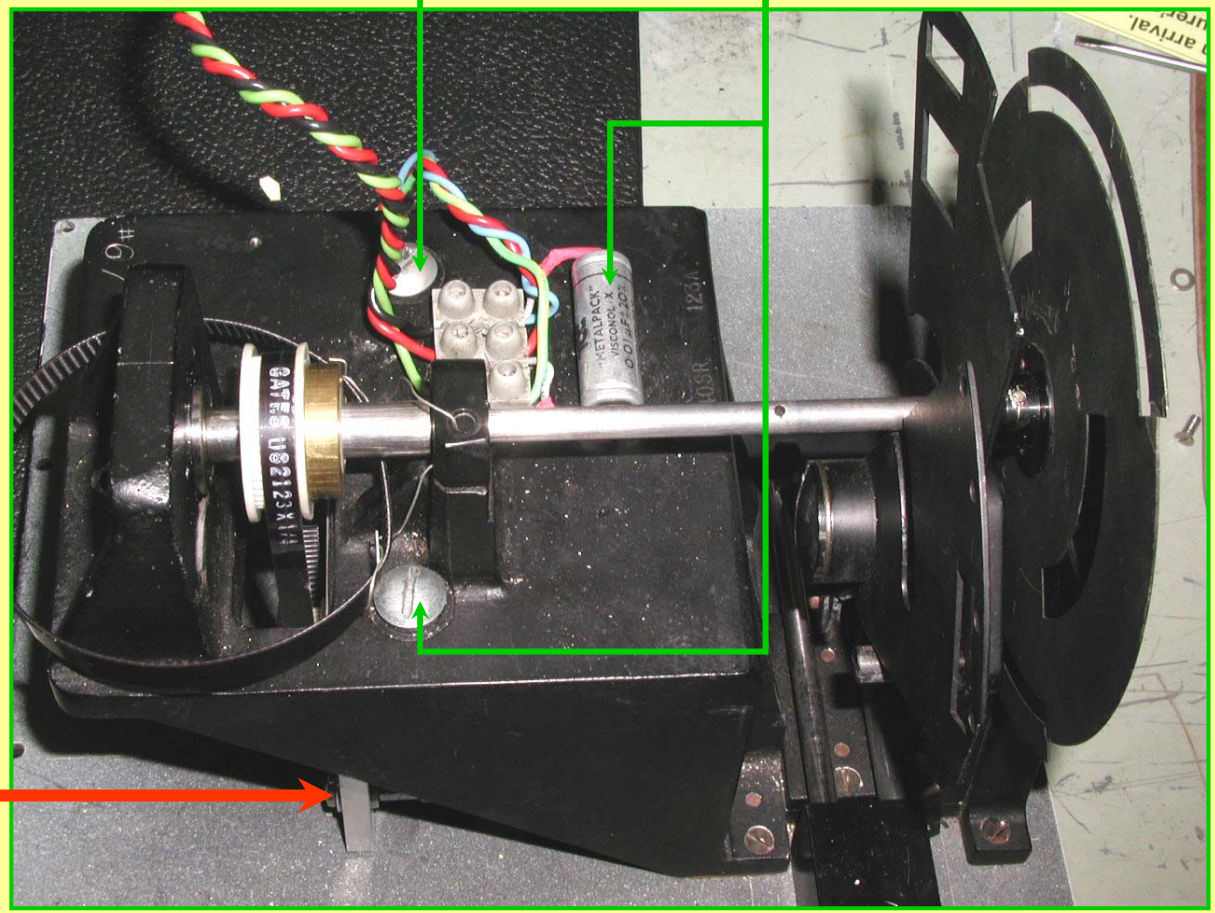


22M ohm bleeder Resistor

Motor and shutter removed from instrument.

This shutter drive has a spare belt installed.

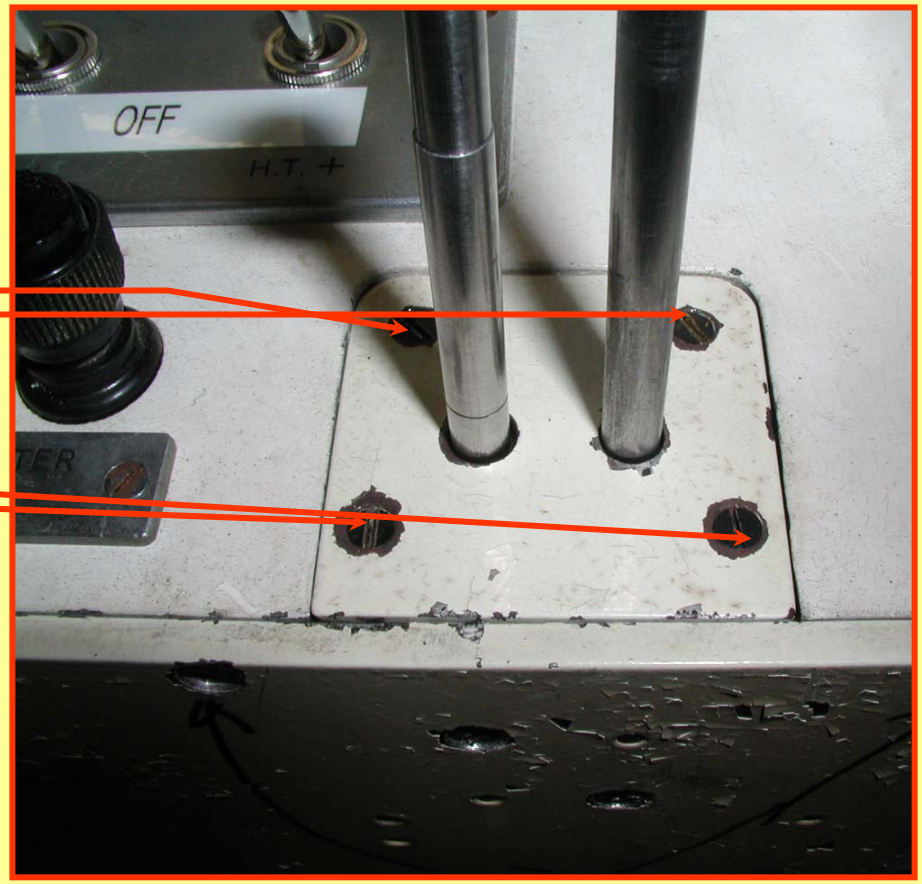
These three screws hold motor bracket in place (3rd screw under cap. in this picture)



Screws for adjusting belt tension under here.

Before removing shutter and motor….

These four screws must be removed.



Shutter wheel and PCI

Shutter must not hit the PCI – check by rotating shutter by hand after re-installing shutter and motor.