LK Technologies

Instruction Manual

Reverse View 8" LEED Optics with Retraction
Model RVL2000/8/R

Customer: ____________________
Serial Number: ____________________
Ship Date: ____________________
Flange-sample focus: ____________________

LK Technologies, 1590 S. Liberty Drive, Bloomington, IN 47403
Tel: 812-332-4449, Fax: 812-332-4493, email: lktech@lktech.com

I. WARRANTY AND REPAIR INFORMATION

1. Warranty

****WARNING****

BEFORE OPENING THE LEED OPTICS YOU MUST READ THIS MANUAL. FAILURE TO FOLLOW THE PROSCRIBED PROCEDURES IN THE HANDLING, UNPACKING, OR OPERATION OF THIS UNIT COULD VOID THE FACTORY WARRANTY!

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LK Technologies warrants this product against defects in material and workmanship for a period of 12 months from the date of shipment to the purchaser. Liability under this warranty is expressly and exclusively limited to replacement or repair of defective or non-conforming parts. The seller may at any time discharge its warranty to this product by refunding the purchase price and taking the product back. This warranty applies only to parts manufactured and labor provided by the seller under valid warranty claims received by the seller within the applicable warranty period and subject to the following terms and conditions.

All warranty replacement or repair of parts shall be limited to equipment malfunctions which, in the sole opinion of the seller, are due or traceable to defects in the original workmanship. Malfunctions caused by abuse, neglect, or improper operation are expressly not covered by this warranty. Expendable items such as filaments and coatings, cannot be warranted beyond being functional on delivery. The seller expressly disclaims responsibility for any loss or damage caused by the use of its product other than in accordance with proper operating and safety procedures. Reasonable care must be taken by the user to avoid hazards.

Any parts repaired or replaced under warranty are warranted only for the remaining unexpired portion of the original warranty period applicable to them. After the expiration of the applicable warranty period the purchaser shall be charged at the seller's current prices for parts and labor, plus transportation.

Except as stated herein, THE SELLER MAKES NO WARRANTY EX-PRESSED OR IMPLIED INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS. Except as stated herein, the seller shall have no liability for special or consequential damages of any kind or from any cause arising out of sale, installation, or use of its products. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF. Alterations to this warranty may be made only in writing by an authorized officer of the seller. Alterations or modifications of this product voids all warranties.

2. Repair Service

All repairs to the LEED optics should be performed by LK Technologies. Please obtain a Return Authorization Number from LK Technologies before any products are shipped. The original PO number for the equipment must accompany the returned equipment or any correspondence.

II. UNPACKING, HANDLING AND INSTALLATION

******WARNING******
This unit can cause lethal shocks! Never handle this unit unless all electrical connections are removed!
****

1. Uncrating

a) The LEED optics is packed in a box that is in a bigger box. Cut the straps on the big box and remove the top. Clear the packaging material away from the inner box and open the inner box.

b) Remove soft and rigid foam layer off of the LEED.

c) To remove LEED, grasp round handles and lift straight up, carefully, with rotary feedthrough pointing away from you.

d) Set LEED on table on the "runners". Remove white plastic bag.

2. Unpacking Optics

Before removing the Plexiglas cover from the optics, prepare an oil and dust free surface on which to set the optics. This is best done in a laminar flow hood. With a damp cloth, remove any dust on the cover or flange. Look through the view port and Plexiglas cover to see if there are any loose parts. With the optics horizontal, that is, handles vertical and stand runners horizontal on the table, remove the four nuts holding the Plexiglas cover. Slowly slide off the Plexiglas cover. Remove the rubber bands and aluminum foil that cover the end of the optics. Install Plexiglas cover and finger-tighten the nuts. Inspect plastic bag for screws or pieces that may have come loose during shipping. Save all packing material in case future shipment is necessary.

3. Handling

******WARNING******
NEVER apply any voltages to the optics unless the ambient pressure is below $2x10^{-6}$ torr!
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All parts have been UHV cleaned prior to shipment so standard clean room techniques should be used when handling internal optics parts. Use only degreased tools and electrical probes in all operations that require the optics' internal parts to be touched. Because dust or other small particles may fall into the grids or onto the screen and cause charging problems, it is best to keep the optics covered at all times. Never lean over the optics because dust or heavier objects may fall into the grids and damage them. It is always best to use a mirror from the side when visually inspecting the grids. The time that the optics is in an upright position should be minimized.

4. Visual Inspection And Continuity Checks

Before installing the optics into the vacuum system, inspect them for any damage during shipment. Check for loose wires or screws. If any are found, contact LK Technologies at once. In most cases loose wires or screws can be replaced in the field. However, it is always best to discuss any repairs with LK Technologies if there is any doubt about the consequences. Make sure that none of the ceramic feedthroughs have been cracked or damaged. Inspect the grids with a small mirror to insure that no dust or other foreign particles have fallen into the grids.

Check the continuity of all electrical feedthroughs before installation. With an ohmmeter check that all pins are isolated from ground and from each other. Only pins F1 and F2 should be shorted together with a resistance of about 0.1 to 2 Ohms, depending on the type of filament. If a short is found, visually determine where it is occurring. Usually, shorts caused by rough handling are due to movement of lead wires. These can be corrected by gently bending the wire until they do not touch. The μ-metal shield may have to be removed if shorts appear in either the gun or the grids. Refer to Section II.4 on how to remove the μ-metal shield. If any of the grids are shorted and the problem does not appear to be wires touching, contact LK Technologies before proceeding.

Next, check the translator mechanism. Remove the Plexiglas cover. Rotate the rotary motion feedthrough so that the optics retracts toward the flange. Notice the bearing plate, which holds the linear bearings, lead screw nut, and bearing support tube. When the bearing support tube touches the flange, stop turning the feedthrough. Turn the feedthrough the other direction to extend the optics. Notice that the moving bearing plate will approach a stationary mounting plate. The three linear bearings protruding from the bearing plate will touch the stationary plate at the end of the travel. Do not try to turn the feedthrough past these two end stops. While extending the optics, notice the BeCu connectors that pass through the stationary plate. Ensure that each electrical connection is open to ground when the BeCu connectors are near the stationary plate.

5. Degaussing

The LEED optics is housed in a μ-metal shield to exclude magnetic fields from both the grids and gun. It is possible for parts to become magnetized by bending or bumping or exposure to small residual magnetic fields in the lab. If the user thinks the LEED optics needs degaussing, contact LK Technologies before proceeding.

******WARNING******
NEVER EXPOSE THE μ-SHIELD TO LARGE MAGNETIC FIELDS OR IT WILL BECOME PERMANENTLY MAGNETIZED.
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6. Installation And Degassing

The LEED optics should never be installed too close to strong magnetic fields. This includes too close to ion pumps, magnetic field analyzers or any other magnetic parts such as heater straps etc. Using the handles, secure the optics into the vacuum chamber being careful not to bump them on the sides of the chamber. Never support the weight of the optics by holding onto the μ-metal shield. The optics may be installed in any orientation, but it may be more convenient to use if the electrical feedthroughs are situated down, so that the cables will not block the viewport.

After installing the optics, recheck for electrical discontinuity before pumping on the system. With the system pressure kept below 4×10^{-6} torr, bake out the chamber and optics. DO NOT EXCEED 200°C during bakeout. The optics should be thoroughly cooled before attempting to translate the optics.

******WARNING******
NEVER ATTEMPT TO TRANSLATE THE OPTICS WHILE IT IS HOT. THIS COULD DAMAGE THE MOVING PARTS OF THE IN-VACUUM TRANSLATOR.
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After bake-out, the gun should be outgassed while the chamber is still hot to prevent gas buildup on the internal gun walls. Refer to the operational manual for the LK Technologies LEED/Auger controller as well as Sec. III.1 on how to make electrical connections to the optics.

a) Gun outgassing. To outgas the gun, slowly turn up the filament current, watching the system pressure at the same time. Never let the system pressure exceed $5x10^{-8}$ Torr. If the pressure rises above this limit, lower the current slightly and wait a few minutes before increasing the current. If a LaB_6 filament is installed, raise the filament current to 1.40 Amps, while monitoring pressure. Let the filament run at 1.4 A for 20 minutes. Do this whenever the system has been vented. The LaB_6 can then be raised to normal operating current. For initial outgassing, 1.80 A is good. If a Tungsten filament is installed, raise the current to 2.8 A. Let the filament and gun outgass for at least 15 min. Always refer to the Performance Data Sheet for the proper operating voltages and currents.

******WARNING******
NEVER EXCEED A FILAMENT CURRENT OF 3.2 AMPS FOR TUNGSTEN. NEVER EXCEED A FILAMENT CURRENT OF 2.0 AMPS FOR LaB_6.
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b) Phosphor screen break-in. The phosphor screen is susceptible to water adsorption. It is therefore best not to turn on the screen high voltage until the system has been baked. Another concern is charge that collects on the screen in normal operation. Because of the screen capacitance, this charge cannot discharge instantaneously across the screen. Fast voltage transients can cause high current discharges across the screen that will damage the phosphor. In order to extend the screen lifetime it is always best to turn the screen voltage on and off slowly. Roughly a 1.0 kV/min change is recommended.

7. Retraction

On standard units, the flange to sample distance is 10.0 inches. Units equipped with retractable optics operate via a rotary feedthrough and lead screw. The translation is 0.05 inches per turn. The fully extended position is approximately 9.2 inches from the flange face and the retracted position is approximately 6.6 inches form the flange face. Care should be taken to avoid any possible contact of the sample or sample holder with the LEED optics since the end of the optics is only 0.75 inches from the sample during operation.

III. OPERATION

1. Electrical Connections

Attach cables between the optics and the LEED controller or the LEED/Auger controller. There is a one-to one correspondence between the optics connectors and the outputs of the LEED or LEED/Auger controller. Use either LK Technologies supplied cables or any SHV connectors and cables rated to 5 kV DC. Never use BNC connectors on the optics since they can damage the UHV feedthroughs, causing leaks in the system. A schematic of the optics and the electrical connections are shown in Fig. 1. Refer to the appropriate LEED controller manual for more information on the electrical connections.

2. Leed Operation

a) Basic theory of operation. Low Energy Electron Diffraction (LEED) uses the wave nature of electrons to produce a diffraction pattern of the top few surface layers. The wave length of an electron of energy E is:

$$\lambda(\text{Å}) = \sqrt{\frac{150.4}{E(eV)}}.$$

LEED operates in the following way. An essentially mono-energetic, collimated electron beam is produced by the electron gun. These electrons strike the sample. Some of these electrons are elastically diffracted from the surface atoms back towards the optics. A large fraction of the incident electrons are inelastically scattered into the optics as well. The LEED optics are designed to be a high pass energy filter to select out only the elastically backscattered electrons. Since the mean free path of an electron at 100 eV is only 10 Å, the elastically scattered electrons that pass through the optics must come from the top few surface layers. This is how surface sensitivity is achieved in LEED. The electrons that pass through the energy filter are accelerated into a phosphor screen to produce an image of the diffraction pattern for viewing.

Each grid plays an important part in producing the diffraction pattern. Grid 1 (G1) is held at the same potential as the sample (usually ground) to produce a field free region around the sample so that electrons that scatter from the surface travel in straight line trajectories. The sample is located at the common center of all four grids. Because the optics are in reality a momentum selector and not an energy selector, it is important that electrons leaving the sample pass through the grids on trajectories normal to the grid surface (i.e. the trajectories must be radial). Stray magnetic fields or non-radial electric fields can cause severe distortion of the LEED pattern or a broadening of the pass energy of the optics. In essence, Grid 1 shields the sample from electric field caused by the other grids in the optics.

Energy selection is done by grids 2 and 3. The suppress voltage is applied to these grids so that only electrons with energies higher than VS are passed through the filter. Two grids instead of one are used to improve the energy resolution of the high pass filter.

Grid 4 is grounded. This grid is primarily used in the Auger mode. For Auger operation, an AC modulation voltage is applied to grids 2 and 3. If grid 4 were not present, the modulation voltage would capacitively couple to the phosphor screen (the detector for Auger mode) and swamp the small Auger signal that is subsequently amplified in the detection circuitry.

The position of the LEED spots on the phosphor screen are a function of both electron energy and the surface atomic structure. Figure 2 shows the typical experimental geometry where the incident and scattered electron trajectories are along a high symmetry direction in the surface. There is a simple expression for the angular position of the spots,

$$\frac{n}{a} = \frac{1}{\lambda}\left(\sin\theta_f - \sin\theta_i\right)$$

where a is the unit cell size of the surface structure along the high symmetry direction. The constant n is an integer for the nth diffraction beam, λ is the electron wavelength and θ_f and θ_i are the scattered and incident angles, respectively, as shown in Fig. 2. When the energy is increased, the diffraction spots collapse towards the specular reflection. Only the specular diffraction spot's position (n = 0) is independent of electron energy.

b) <u>Viewing a pattern and pattern contrast</u>.

In general the sample surface must be set perpendicular to the incident electron beam. This can be done in the following approximate way. Turn the screen voltage to zero. Turn on the electron gun. The light from the gun filament will be reflected off the sample and should show up as a faint circle of light on the phosphor screen. Adjust the sample tilt until this circle is centered around the gun.

The next important procedure is to make sure that the sample is at the center of curvature of the optics. This is best done by accurately measuring the sample position from the optics mounting flange. The sample should be set at a maximum of 10.0 inches from this flange. NOTE: Custom length units will have a different focus. Small misalignment will not effect the image. Larger errors (~ 0.25 in.) will cause a degradation of the energy resolution of the optics.

In all LEED measurements, the contrast (signal to background) must be as high as possible. Contrast is determined by a number of factors: sample order, gun focus, and diffuse electrons. The first two affect the spot intensity and the last term affects the background.

If the samples are not well annealed and ordered, the diffraction pattern will be dominated by a large diffuse electron background. When trouble-shooting the optics because of poor patterns, be sure that you know that the sample is clean and ordered.

The gun must be well focused to observe a pattern. The spot diameter on the screen is determined by the angular divergence of the electron beam from the gun. Since the brightness of the spot in the screen is inversely proportional to the square of the beam divergence, pattern contrast is markedly improved by focusing the gun. To focus the gun, follow the instruction in Sec. III.2.C.

Finally, pattern contrast is improved by lowering the diffuse background electrons. There are two types of diffuse electrons: elastic and inelastic. Inelastic (or secondary) electrons are formed by inelastic collisions of the incident electrons with the sample. These secondary electrons are always at a lower energy than the elastic scattered electrons. They can be removed from the pattern by increasing the suppress voltage on Grids 2 and 3 (G23). Most of these electrons have energies between 0-100 eV regardless of the incident energy. So a suppress voltage ~ +50 eV below the gun energy is sufficient to remove them from the pattern. For gun energies below 150 eV, however, the difference between the suppress voltage and the gun voltage will have to be smaller (~10 eV). In general however, the suppress voltage can visually be adjusted to get the best contrast.

The elastic diffuse electrons cannot be removed from the pattern by adjusting the suppress voltage. These electrons come from the thermal vibrations of the surface atoms. While they cannot be removed, their intensity can be lowered two ways. The least practical method is cooling the sample. The second and more practical way is to set the gun energy as low as possible. You will note that at higher gun energies the pattern becomes brighter. This is because the gun current increases with gun energy. However, even though the pattern brightness goes up with energy, the contrast goes down because of the increasing elastic diffuse electron background.

c) Electron gun and focus. The electron gun is designed to produce a small angular divergence electron beam with a 0.5 eV energy spread. The gun operates in the following manner. A hairpin cathode is directly heated by passing current through pins F1 and F2. Electrons produced from the cathode are accelerated to the CAN aperture by applying a potential V1 to the CAN. These electrons are focused onto the screen by adjusting the FOCUS voltage V2. Because of space charge effects in the beam, the electron current from the CAN is a strong function of the gun energy. At high gun energies the current is high and is conversely low at low gun energies. To increase the beam current at low voltages (< 150 eV) the gun can be operated in a retarding mode. In this mode the gun energy is set to 150 eV. The electrons from the CAN pass through the focusing element and are then decelerated by the retarding element V3. The unipotential design of the gun ensures that the focus conditions are only a function of the ratio (V2-Vg)/(V3-Vg). As long as the gun provides these potentials in this ratio, the gun focus will be independent of energy.

To operate the gun, first increase CAN to 30 V. Then slowly turn up the filament current to ~ 2.7 amps (for Tungsten, or 1.6 A for LaB_6) to get an emmission current of 1.0 mA. To focus the gun, first set RETARDto +100 V and the gun Energy to -50 eV. Turn on the screen voltage to 4 kV and adjust the Suppress voltage on Grid 23 to ~ 10 V. Set CAN to about +3.0 V and adjust FOCUS until a pattern is visible (~+69 V). You will have to sweep the gun energy ± 50 eV to help in identifying the pattern. You can sharpen the pattern by adjusting CAN first and then readjusting FOCUS. The focus is also determined by the brightness of the cathode. There will be an optimum brightness setting, so you may have to lower the filament current to improve the contrast. If the gun is operated in the retarding mode, RETARD will influence the FOCUS settings. Since optimum FOCUS is a function of CAN, FOCUS, RETARD, and filament current, several iterations of these voltage adjustments will be necessary to reach maximum focus.

3. Voltage And Current Limitations

Never exceed the listed operational voltages given below. Operation above these limits can burn out the filament, damage the optics feedthroughs and phosphor screen and void the warranty.

Filament Current MAX:	2.9 Amp DC
Screen Voltage MAX:	5.0 kV DC
Gun Voltage MAX:	3.0 kV DC
Grid Voltage:	2.5 kV DC

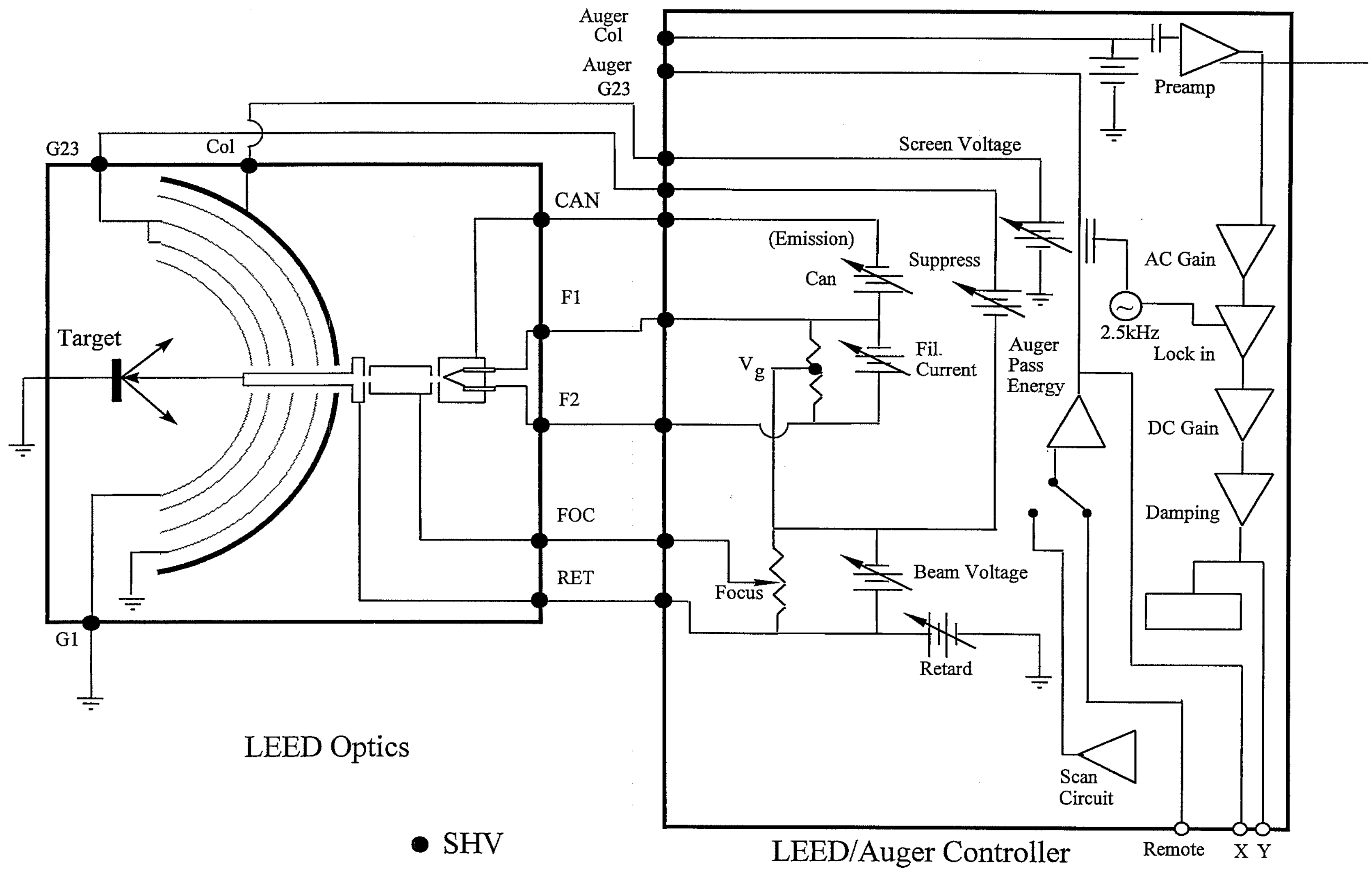

Figure 3 Electrical schematic of the LEED/Auger optics. Connections are shown for LEED Mode. For Auger Mode, Col. and G23 are connected to Auger Col. and Auger G23, respectively, on LEED Auger Controller

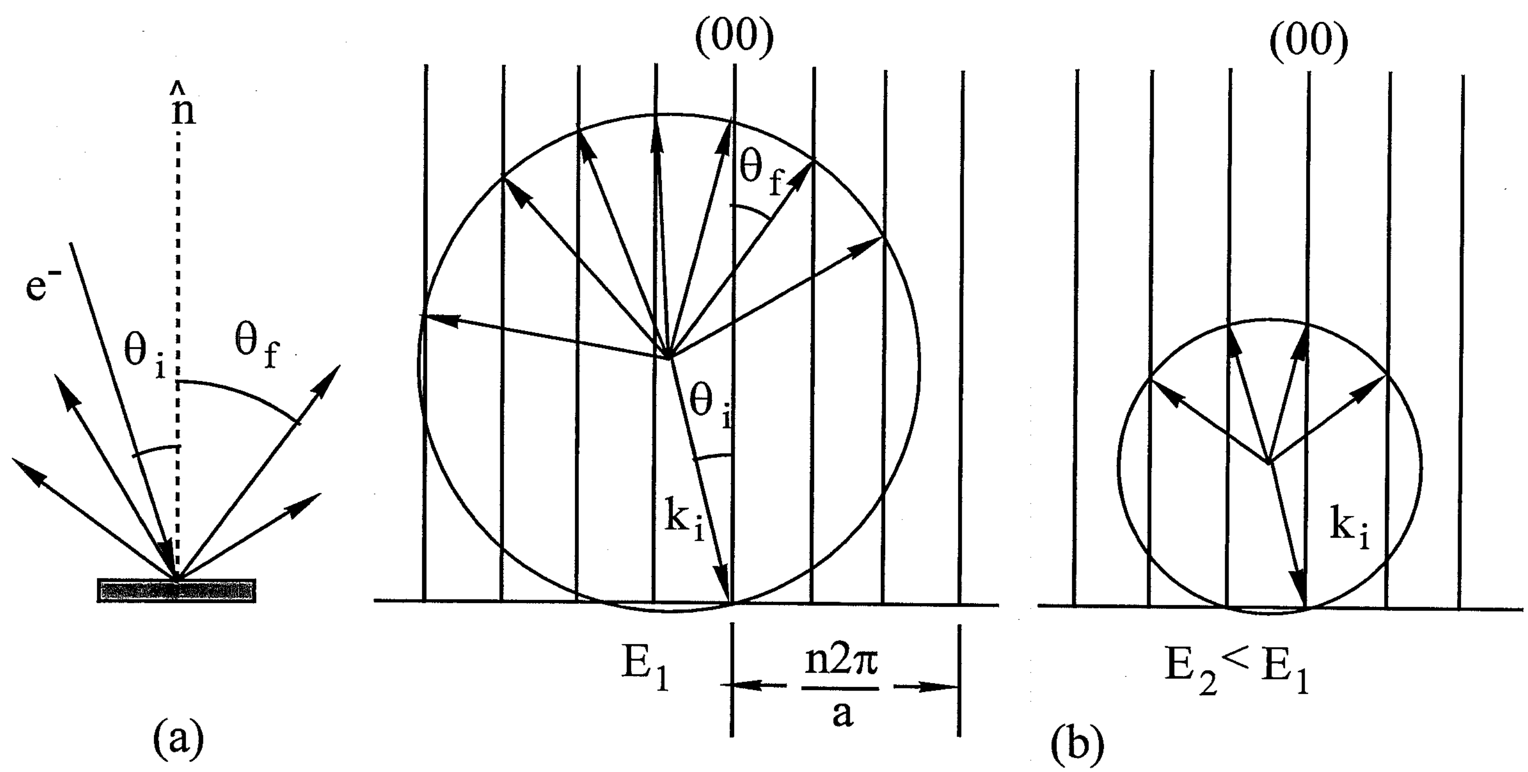

Figure 2. Schematic scattering geometry. (a) Real space picture. $\lambda = 2\pi/k$. (b) Reciprocal space picture. The circles represent the intersection of the diffraction pattern with the phosphor screen. The (00) beam is the specular beam where $\theta_i = \theta_f$. Two different incident energies are shown.

IV. PROBLEM SOLVING

Most problems with the LEED optics are due to shorted wires or broken connections. Before calling LK Technologies, be sure that electrical continuity is intact as outlined in Sec. II.3. The other major problems are listed below.

1. No Current From The Gun

Check to make sure the filament is not broken by measuring the resistance between F1 and F2. The resistance should be less than 0.2 Ω. If the filament is intact, make sure there is an emission current between the filament and the CAN. No emission current means that the bias voltage between the CAN and the filament is not being applied (this can be due to a broken connections or an electrical problem in the control electronics).

If there is an emission current, then there are three possible sources of the problem. First and most likely, the filament has not been centered during installation. Recheck the position of the filament, making sure the filament is clearly visible as viewed through the drift tube. The other two possible sources of the problem prevent the electron beam from traveling through the gun. They are strong magnetic fields, or an insulator dropped into the gun. Use a Gauss meter to check if any parts of the gun or the μ-metal shield itself have become magnetized. If they have not, then look for dust "bunnies" in the gun that can charge up and deflect the beam

2. Bright Spots On The Screen

Bright spots on the screen are caused by field emission from whiskers or dust particles on Grid 4. Inspect the grids to make sure that no dust or small particulate matter has attached itself to the grid. Removing these particles with a tweezers is very risky and should only be done by LK Technologies. High points on an otherwise clean grid can be removed by "high potting" in UHV. This is done by applying a 10 kV voltage pulse to the screen. A 1.0 MΩ current limiting resistor should be connected in series with the power supply. Remember that prolonged high currents to the screen can permanently damage the screen. Voltage pulse duration should not exceed 1.0 second.

3. Dark Spots On The Screen.

Dark spots are common on phosphor screens and, unlike bright spots, do not generally interfere with viewing LEED patterns. These spots are caused by either insulating materials on the grids or poisoned phosphor and are most prevalent when the suppressor voltage is near the electron energy. If dark spots become large or numerous, they may need to be repaired. To determine which effect is causing the dark spot, increase the beam voltage from 50 eV to 1000 eV. If the spots are caused by insulating materials, the secondary emission ratio will change and cause the spots to move or change shape. If the spots do not change then the phosphor is poisoned.

To minimize dark spots on the screen never expose the screen to evaporation sources. It is also best to point samples away from the optics while they are being sputtered or heated to high temperatures. Never touch the phosphor coating; it is very sensitive to mechanical damage. Finally, never operate the screen at high pressures or high voltages except as discussed in this manual. The phosphor screen can be repaired by sending it back to LK Technologies. Since the conducting oxide coating is very durable, it usually does not have to be recoated and only a minimum charge for the phosphor coating will be assessed.

4. Pattern Distortion.

Distortion of the LEED pattern is generally caused by either stray magnetic fields or large electric fields. To check for magnetic or electric fields deflect the specular diffraction spot onto the phosphor screen by tilting the sample. Electric fields are caused by charge buildup on insulators or improperly grounded conductors. These insulators take time to charge. To determine if the distortion is caused by electric fields raise the gun energy quickly and watch the motion of the specular spot. If there is a considerable delay in the motion of the spot after the energy is changed, the distortion is due to electric fields from insulators. Make sure your sample is properly grounded and that insulators are not in positions where scattered electrons can cause them to charge.

Under high current conditions and low gun energies, it is possible that the ceramic spacers on the grids will charge. The charging can be eliminated by turning up the gun voltage to at least 500 eV. This will cause the ceramics to quickly discharge.

Magnetic fields can be found in a similar way used to find electric fields. Raise and lower the gun energy. If magnetic fields are present, the specular spot will smoothly move in proportion to the energy. The motion will be more pronounced at low energies. If the distortion is determined to be due to magnetic fields, degauss the optics as outlined in Sec.II.4.

V. MAINTENANCE AND REPAIRS

All maintenance and repairs should be performed by LK Technologies. Filament replacement in the field is possible, please contact LK Technolgoies for instructions.

******WARNING******

Any damage caused by repairs other than those done by LK Technologies will void LK Technologies's warranty for this product!

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LK Technologies

Instruction Manual

LEED/Auger Control Electronics
Model RVL/AES

Customer: ________________
Serial Number: ________________
Ship Date: ________________

LK Technologies, 1590 S. Liberty Drive, Bloomington, IN 47403
Tel: 812-332-4449, Fax: 812-332-4493, email: lktech@lktech.com

I. WARRANTY AND REPAIR INFORMATION

1. Warranty

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****

LK Technologies warrants this product against defects in material and workmanship for a period of 12 months from the date of shipment to the purchaser. Liability under this warranty is expressly and exclusively limited to replacement or repair of defective or non-conforming parts. The seller may at any time discharge its warranty to this product by refunding the purchase price and taking the product back. This warranty applies only to parts manufactured and labor provided by the seller under valid warranty claims received by the seller within the applicable warranty period and subject to the following terms and conditions.

All warranty replacement or repair of parts shall be limited to equipment malfunctions, which, in the sole opinion of the seller, are due or traceable to defects in the original workmanship. Malfunctions caused by abuse, neglect, or improper operation are expressly not covered by this warranty. Expendable items, such as filaments and coatings, cannot be warranted beyond being functional on delivery. The seller expressly disclaims responsibility for any loss or damage caused by the use of its product other than in accordance with proper operating and safety procedures. Reasonable care must be taken by the user to avoid hazards.

Any parts repaired or replaced under warranty are warranted only for the remaining unexpired portion of the original warranty period applicable to them. After the expiration of the applicable warranty period, the purchaser shall be charged at the seller's current prices for parts and labor, plus transportation.

Except as stated herein, **THE SELLER MAKES NO WARRANTY EX-PRESSED OR IMPLIED INCLUDING WARRANTIES OF MERCHANT-ABILITY AND FITNESS**. Except as stated herein, the seller shall have no liability for special or consequential damages of any kind or from any cause arising out of sale, installation, or use of its products. **THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF**. Alterations to this warranty may be made only in writing by an authorized officer of the seller. Alteration or modification of this product voids all warranties.

2. Repair Service

All repairs to the LEED Control electronics should be performed by LK Technologies. Please obtain a Return Authorization Number from LK Technologies before any products are shipped. The original PO number for the equipment must accompany the returned equipment or any correspondence.

II. INTRODUCTION

******WARNING******
This unit can cause lethal shocks! Never open this unit unless it has been unplugged from the AC source! All connections between this unit and the corresponding LEED optics must be made before the unit is turned on, unless otherwise specified in this manual.
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1. Unpacking

Prior to turning on this unit, check for any obvious shipping damage. It is the responsibility of the buyer to inspect and immediately report any physical damage to the carrier.

2. Front And Rear Panel Controls

Refer to Figs. 1 and 2 for front and rear panel layouts.

FRONT PANEL LAYOUT

a)	POWER:	Turns on and off main AC power.
b)	MAN./REMOTE:	Remote control of ENERGY is possible. Consult factory.
c)	SWITCH M2:	In the Auger position, meter M2 displays Auger pass energy for Grid 23. The other 10 positions on the Switch adjust the phosphor screen voltage between 0.5 kV and 5 kV, and displays it on meter M2.
d)	METER M2:	Displays Screen Voltage or Auger pass energy in kV on meter M2.
e)	SWITCH M4:	Selects FILAMENT current, SUPPRESS voltage, CAN voltage, or EMISSION current to be displayed on meter M4.
f)	METER M4:	Displays Filament Current (Amps), Suppress Voltage (Volts), Can voltage (Volts) and Emission Current (mAmps) according to SWITCH M4 position.
g)	SWITCH M3:	Selects Gun ENERGY, FOCUS voltage, or RETARD voltage to be displayed on M3.
h)	METER M3:	Displays Gun ENERGY, FOCUS Voltage, and RETARD Voltage, in volts, according to SWITCH M3 position.

i)	SWITCH M1:	Selects Modulator Amplitude, or Lock-In output to be displayed on M1.
j)	METER M1:	Displays Modulation amplitude (Volts peak-to-peak) and Lock-In output (V) according to SWITCH M1 position.
k)	CAN:	Adjusts the potential on gun element CAN.
l)	SUPPRESS:	Adjusts the potential on Grids 2 and 3 (G23).
m)	FILAMENT:	Adjusts the filament current.
n)	ENERGY and EN FINE:	Adjusts the gun bias (Vg), which effectively adjusts the gun energy.
o)	FOCUS:	Adjusts the gun focus (gun element FOC).
p)	RETARD:	Adjusts the retarding potential (gun element RET).
q)	MODULATOR AMPLITUDE	Sets peak-to-peak modulation for Auger mode
r)	PHASE	Sets Lock-In phase
s)	FINE PHASE	45° of adjustment
t)	AC GAIN	Sets preamp gain of the Auger signal before the Lock-In Amplifier.
u)	DC GAIN	Sets postamp gain of the Auger signal after the Lock-In Amplifier.
v)	DAMPING	Sets Lock-In Amplifier time constant.
w)	LOCAL/REMOTE	Allows Auger voltage to be changed by the FP pots (Local) or by the Computer (Remote).

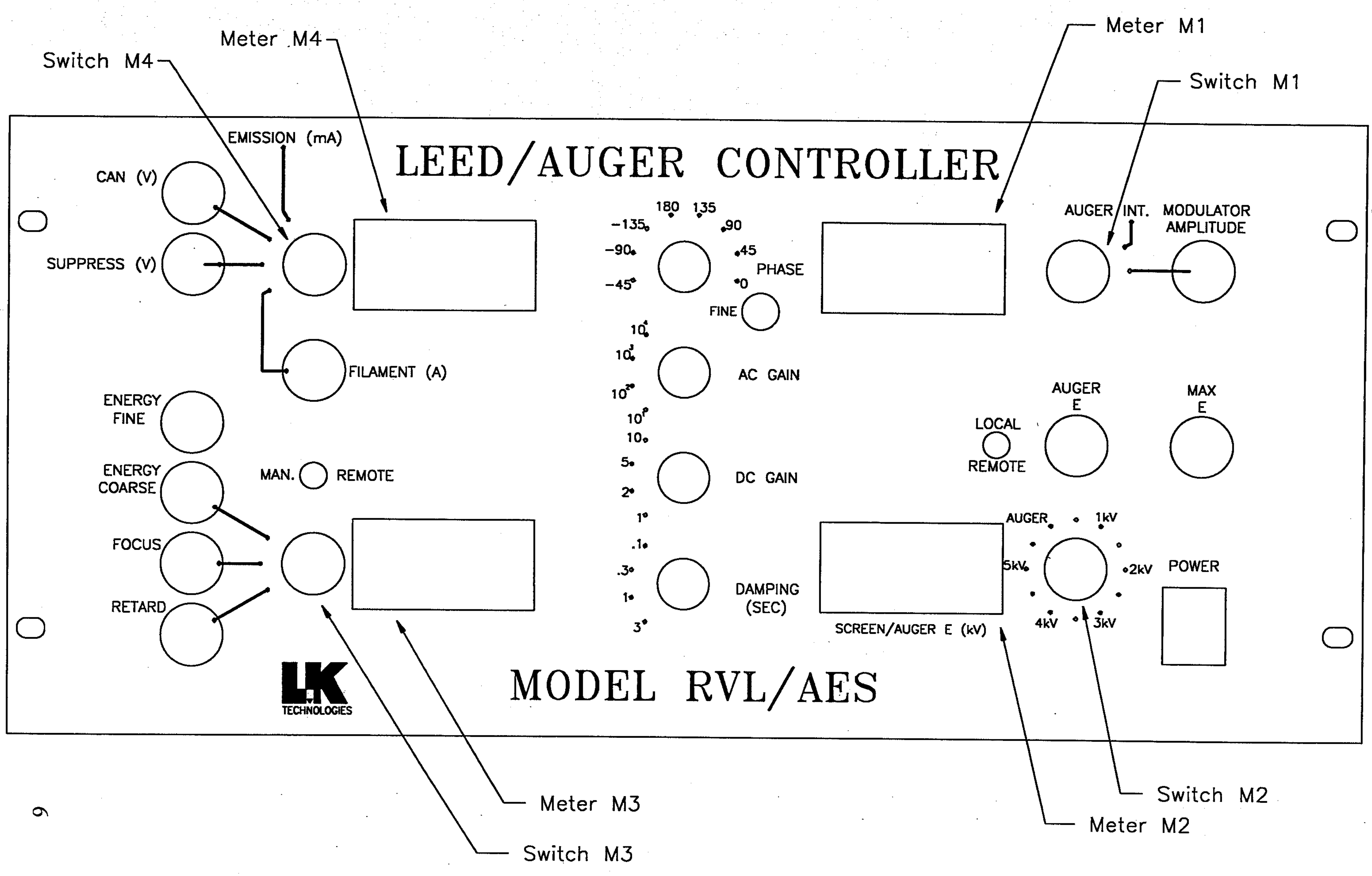


Figure 1. Front Panel

BACK PANEL LAYOUT

OUTPUTS

Leed Operation

a)	G2, G3 (G23):	Grids 2 and 3 output voltage (SHV)
b)	COL:	Phosphor Screen output voltage (SHV)
c)	F1:	Filament output (SHV)
d)	F2:	Filament output (SHV)
e)	CAN:	Can voltage output (SHV)
f)	FOC:	Focus voltage output (SHV)
g)	RET:	Retard voltage output (SHV)

Auger Operation

a)	Auger G23:	Grids 2 and 3 Pass Energy outputs for Auger Mode. (SHV)
b)	Auger COL:	+300V Screen bias and preamp input for Auger. (SHV)
c)	INTENSITY	Auger Intensity Out (BNC)
d)	E MON	Auger E/1000 (BNC)
e)	2.5 kHz	Lock-In Modulation Reference Signal (BNC)
f)	PREAMP	Preamp Output (BNC)

INPUTS

a)	AC power cord	
b)	COMPUTER:	Computer control of Auger Energy (DIN)

3. Specifications

All voltage outputs are short circuit protected.

a)	AC power source:	100 or 115 VAC 50/60 Hz, 1.5A SloBlo fuse 230 VAC, 800 mA SloBlo fuse. Consult factory before changing input voltage.
b)	Screen	0 to 5 kVDC @ 500 µamps, 11-pos. Switch, 500 V increments. (w.r.t. earthground)
c)	Filament Current:	0 to 4.0 Amps @ 10 V, Ten-turn pot. (w.r.t. energy)
d)	Suppress Voltage:	0 to 90 VDC (w.r.t. energy)
e)	Can voltage:	0 to 60 VDC @15 mA. (w.r.t. energy)
f)	Energy voltage:	0 to -2700 VDC @ 500 µamps. (w.r.t. retard)
g)	Focus Voltage:	0 to 100% of Beam voltage. (w.r.t. retard)
h)	Retard Voltage:	0 to 100 VDC (w.r.t. earthground)
i)	Auger pass energy:	0 to -2500 VDC
j)	Auger Collector:	300 VDC bias and preamp

III. INITIAL SYSTEM CHECK AND INSTALLATION

1. Initial System Check (LEED Operation)

Connect the power cord to the appropriate AC source. All standard units are designed to operate on 115 VAC @ 50/60 Hz. If your unit was custom ordered to operate on a different power source, check the front cover of this manual for the correct operating AC line source.

Follow the procedure in the order given below before connecting this unit to the LEED optics. If any discrepancy is observed, refer to Sec. V on trouble shooting.

a) Turn on the AC power Switch.

b) The panel meters should come on.

If steps (a) and (b) were successful, then proceed. Hook up the SHV cables to the control box, but not to the LEED optics. The "Test Box" is provided to facilitate the following measurements. Attach the appropriate cable to the unlabelled SHV, remove cover, and measure on the internal lug of the SHV. A HIGH VOLTAGE PROBE should be used in making measurements over 1000VDC.

c) Set MAN./REMOTE Switch to MAN. Set SWITCH M3 to RETARD voltage. Adjust RETARD voltage control knob until the meter reads zero. Repeat this procedure for the FOCUS voltage and ENERGY.

d) Set SWITCH M4 to SUPPRESS voltage. Adjust SUPPRESS voltage until the meter reads zero. Repeat this procedure for the CAN voltage.

e) Make sure that the FILAMENT current knob is turned fully counter clockwise.

f) Connect a 1.0 Ω 20W resistor between the F1 and F2 output connectors on the back panel, or use the test box, which contains a NiChrome wire in place of the resistor. (NiChrome wire resistance is probably not 1 ohm.) Use a floating DVM to measure the voltage across the resistor. Set SWITCH M4 to FILAMENT current. Turn the filament Control clockwise to 2.0 A. The meter reading should be ~2.0 V.

g) Turn the FILAMENT control fully counter clockwise and remove the meter from the back panel.

h) Connect a 0-2000 VDC meter between output connectors CAN(+) and F1(-), by connecting CAN to the unlabelled SHV on the Test Box, and F1 to F1 on the Test Box. Set SWITCH M4 to the CAN voltage and turn CAN pot fully clockwise. The meter reading should read 50 to 60 V. Make sure that the panel meter reading coincides with the DC volt meter ±2.0 V.

i) Turn the CAN control fully counter clockwise and remove the voltmeter.

If the unit successfully performed steps (c)-(i) then the current control circuits are performing correctly. You may now proceed. If any of the steps above did not indicate correct operation, refer to the problem solving section.

j) Set SWITCH M3 to ENERGY. Connect a 0-2000 VDC meter between output connectors F1 (+) and ground (-). Turn the ENERGY control clockwise. Make sure that the panel meter reading coincides with the DC voltmeter ± 1.0 V. The fully clockwise position of the ENERGY control should produce a -2700 VDC output.

k) Turn the ENERGY control knob fully counter clockwise and remove the meter.

l) Set SWITCH M4 to SUPPRESS. Connect a 0-2000 VDC meter between output connectors LEED G23 (+) and F1 (-). Turn the SUPPRESS control clockwise. Make sure that the panel meter reading coincides with the DC voltmeter ±1.0 V. The fully clockwise position of the SUPPRESS control should produce a ~+90 VDC output.

m) Turn the SUPPRESS control knob fully counter clockwise and remove the meter.

n) Set SWITCH M3 to RETARD. Connect a 0-2000 VDC meter between output connectors RET (+) and ground (-). Turn the RETARD control clockwise. Make sure that the panel meter reading coincides with the DC voltmeter ±1.0 V. The fully clockwise position of the RETARD control should produce a ~+100 VDC output.

o) Turn the RETARD control knob fully counter clockwise and remove the meter.

p) Set SWITCH M3 to ENERGY. Connect a 0-2000 VDC meter between output connectors FOC (+) and ground (-). Turn the ENERGY control up until the front panel meter reads -100 V. Now set SWITCH M3 to FOCUS and turn the FOCUS control clockwise. Make sure that the panel meter reading coincides with the DC voltmeter ± 1.0 V. The fully clockwise position of the FOCUS control should produce an output approximately equal to the ENERGY value.

q) Turn the FOCUS control knob fully counter clockwise and remove the meter.

r) Connect a 0-2000 VDC meter between the output connector on the back panel COL (+) and ground (-). Turn the Auger-5kV control clockwise two positions <u>only</u> so that the DC meter reads 1.0 kV and observe that the meter reading and the front panel meter coincide.

s) Turn the Auger-5KV control knob fully counter clockwise and remove the meter.

2. Initial System Check (Auger Operation)

a) Turn on the AC power.

b) Set the LOCAL/REMOTE switch to LOCAL. Connect a High Voltage Probe between AUGER G23 SHV and ground. Set MAX E pot to 10.0 (dial setting). Adjust AUGER E pot and observe the voltage. AUGER E should go to ~-2700 VDC. Set AUGER E on –1000 VDC. Reduce MAX E. The AUGER E should decrease as MAX E pot is turned CCW.

c) Now set AUGER E to –100VDC and place an oscilloscope between AUGER G23 SHV and ground. Use AC coupling. Set SWITCH M1 to MODULATOR AMPLITUDE position. Verify that 2.5kHz sine wave is present on scope. Verify that amplitude on the scope corresponds to the front panel meter M1.

If the unit successfully performed steps (a)-(c) then the Auger control circuits are performing correctly. You may now proceed. If any of the steps above did not indicate correct operation, refer to the Problem Solving section VI.

If all of the above procedures check out, you may now connect the LEED/AUGER control unit to the LEED optics.

3. Installation

There are two sets of COLLECTOR and G23 outputs on the back panel. The lower pair is used in LEED mode and the upper pair is used for AUGER mode. Use either supplied cables or any SHV connectors and cables rated to 7 kVDC. Never use BNC connectors on the optics since they can damage the SHV feed-throughs causing leaks in the system. A schematic of the optics and the electrical connections is shown in Fig. 3. In most applications Grid 1 is grounded. Use G1 SHV shorting plug.

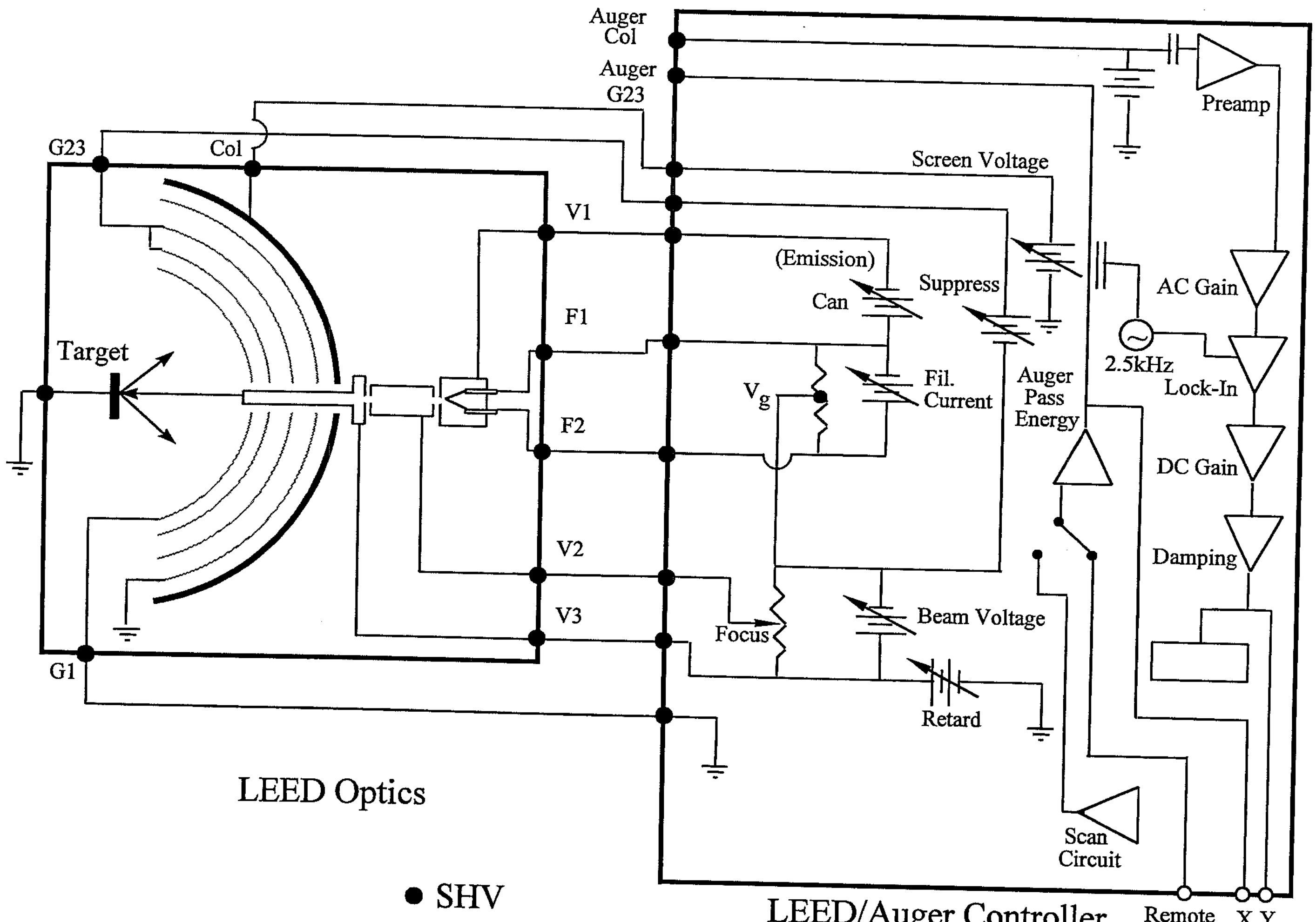


Figure 3 Electrical schematic of the LEED/Auger optics. Connections are shown for LEED Mode. For Auger Mode, Col. and G23 are connected to Auger Col. and Auger G23, respectively, on LEED Auger Controller

IV. OPERATION IN LEED MODE

1. Leed Operation: Manual Control

With the initial checkout complete, all connections to the LEED optics made, and the system under UHV, you are ready to operate the LEED control unit. Use the lower pair of back panel connectors for the COL and G23. Be sure that the base vacuum pressure is below the limits specified for the LEED optics. It is assumed that a clean and well-ordered sample surface is available at the LEED optics center.

Begin by turning on the LEED controller AC power. Your eyes should be dark-adapted before viewing a LEED pattern. Begin by setting the MAN./REMOTE Switch to MAN.

a) Screen Voltage: Slowly increase the Auger-5KV screen voltage while watching for arcs. If the system has been in air for an extended period, it is best to increase the screen voltage over a period of 15 min to prevent arcing. If the LEED optics arcs, switch off the power immediately to prevent damage to both the phosphor screen and the HV power supply.

b) Gun Energy and Retarding mode: The electron energy is controlled by both the ENERGY and the RETARD controls. To operate at voltages above 100 eV, use SWITCH M3 to set the RETARD voltage to zero. The gun energy is now adjusted by varying the ENERGY control pot.

Below 100 eV, space charge effects limit the current from the CAN. To improve gun current below 100 eV, the LEED control unit can provide a retarding potential to gun element RETARD. Electrons exiting the focusing electrode FOCUS are slowed down by the RETARD potential. The electron energy leaving the gun is then Vg-RET (where Vg = bias of the gun and RET = RETARD.) To operate in this mode, first use SWITCH M3 to set ENERGY to zero. Then adjust the RETARD control until the RETARD voltage on the meter reads +100 V. Increase the gun ENERGY to the desired voltage. The ENERGY display automatically shows the electron energy leaving the gun (i.e., the difference between the beam voltage and RET. Note that the ENERGY display only reads the correct voltage when the ENERGY is greater than the RETARD voltage.

c) Turning on and focusing the e-gun: The following filament settings are approximate and refer only to a Tungsten filament. Use the filament settings that are recorded on the Performance Data Sheet that is sent with each instrument. Set SWITCH M4 to the CAN bias position and increase CAN bias to > 30 V. Set SWITCH M4 back to the FILAMENT current position. Slowly increase filament current to 2.2 A. SWITCH M4 can now be set back to EMISSION (Note that the emission current may read a small positive value even though the filament current is zero). The emission current should read approximately 1.0 mA. If the current is not 1.0 mA, you can increase the FILAMENT current until it reaches this value. If more than 3 amps is necessary to get 1.0 mA, consult the factory. **THE CAN VOLTAGE MUST BE > 30 V FOR THIS ADJUSTMENT. DO NOT ADJUST THE FILAMENT CURRENT UNLESS THE CAN IS > 30 V.** Filament lifetime is optimized when 1 mA Emission is produced with a CAN voltage > 30 V. **NEVER EXCEED 4 mA EMISSION!** Note that you will have to decrease the FILAMENT current to prevent the emission current from rising. This is because as the filament temperature increases, the emission increases. It is filament emission and NOT filament current that determines the filament lifetime. If no emission current registers, or if it stays below 1 mA, check the LEED optics manual for troubleshooting.

To focus the gun, first use SWITCH M3 to set the RETARD voltage to +100 V, the SUPPRESS voltage to +10 V, and the gun ENERGY to 100 eV (-100 V). Set SWITCH M4 to the CAN position and decrease CAN to about +3.0 V. Note that the EMMISSION current will decrease when the CAN voltage is decreased. Adjust the FOCUS until a pattern is visible. You will have to sweep the gun energy ± 20 eV to help in identifying the pattern (~20 V). You can sharpen the pattern by adjusting the CAN voltage first and then readjusting the FOCUS. The gun focus is also determined by the brightness of the cathode. There will be an optimum brightness setting, so you may have to lower the FILAMENT current to improve the contrast. Since optimum focus is a function of CAN, FOCUS, RETARD, and FILAMENT current, several iterations of adjustments of these voltages and currents will be necessary to reach maximum focus.

d) Suppress operation: Secondary electron background can be suppressed to increase the pattern contrast by adjusting the SUPPRESS voltage. At SUPPRESS voltages within 5.0 V of the electron energy, the LEED pattern will begin to blur. In general, a setting of +10 or +20 V is sufficient to cut off most of the secondary electrons.

2. Leed Operation: Computer Control

External control for the ENERGY is possible. Consult the factory.

V. OPERATION IN AUGER MODE

1. Auger Operation: Theory

******WARNING******

NEVER SHORT THE AUGER COLLECTOR OUTPUT. DOING SO WILL DESTROY THE PREAMP. THIS PREAMP CAN ONLY BE INSTALLED BY THE FACTORY.

****

In Auger mode the two upper connectors on the back panel are used for the COL and G23. Turning the AUGER/5kV Switch to Auger allows the Screen meter (M2) to read the Auger pass energy. The LEED/AUGER controller has a built-in ramp that can be manually or computer controlled to set the voltage on G23 (the Auger pass energy). All Auger controls are on the front panel. Computer control of the Auger controller is possible from the rear panel COMPUTER connector using the REMOTE mode option. This voltage makes the 4-grid optics act like a high pass energy filter so that only electrons with energy greater than V_{23} hit the phosphor screen. In Auger mode the phosphor screen is used as a Collector to measure the electron current from the sample. The COL output puts a +300 V bias on the phosphor screen to collect all electrons hitting the screen.

In Auger Spectroscopy it is necessary to measure dN(E)/dE in order to enhance the small number of Auger electrons emitted from the sample that are riding on top of a large secondary electron background. In a retarding field analyzer (i.e., 4-grid optics) the signal at the Collector is an integral of N(E) from the Auger pass energy up to the incident electron beam energy. It is therefore necessary to take two derivatives of the collected current to measure dN(E)/dE. To measure dN(E)/dE the LEED/AUGER controller has a built in Lock-In Amplifier. A small AC modulation voltage (at 2.5kHz) is applied to the DC voltage on grids 2&3. The Lock-In Amplifier is tuned to twice the modulation frequency (5kHz). Detecting at 2f means that the signal from the Lock-In is proportional to dN(E)/dE.

It should also be noted that the magnitude of the signal from the Lock-In is proportional to the modulation amplitude squared. Increasing V_{mod} will therefore dramatically increase the Auger signal, but the cost of doing so is a loss of energy resolution. The energy resolution is directly proportional to the modulation voltage. Typically the modulation amplitude is set to 4 V_{pp} for pass energies below 100 eV and 6-10 V_{pp} above 100 eV. The actual operating modulation amplitude is determined from requirements of energy resolution and signal/noise ratio set by the operator.

Scan speed is also a critical issue. Once the pre-amp (AC) gain and post-amp (DC) gain are set for a desired signal level, the damping constant must be set for the desired signal-to-noise ratio. If a long damping constant is used (3sec), the scan speed must be slowed so that the Auger signal has time to change before the pass energy has increased. The correct scan speed is set by trial and error, although a rule of thumb is that the scan rate should be slower than $V_{mod}/3\tau$, where τ is the time constant.

2. Auger Operation: Manual Control

With all power off, connect the G23 cable and COL cable to the upper pair of connectors on the back panel. Begin by setting the LOCAL/REMOTE Switch to LOCAL and the AUGER/5kV Switch to AUGER.

a) Scanning the pass energy: The pass energy can be scanned in two modes: manual and by a computer. Computer operation of the pass energy is discussed in section 4. For manual scanning, set the LOCAL/REMOTE Switch to LOCAL. In this mode, the pass energy can be changed by adjusting the AUGER E pot within the limit set by the MAX E pot.

b) Setting the Modulator Amplitude: The Modulator Amplitude is set by first selecting MODULATOR AMPLITUDE on SWITCH M1 . The meter will then display the modulation amplitude as a peak-to-peak voltage. Remember that the Auger energy resolution is decreased linearly with the modulation amplitude, while the signal is increased as the square of the amplitude.

3. Auger Operation: Lock-In Control

The Lock-In Amplifier has five controls: PHASE, FINE PHASE, AC GAIN, DC GAIN, and DAMPING. Some optimization of the Auger signal can be made by adjusting the phase relation between the modulation voltage and the collected current.

The electron current from the sample is collected on the phosphor screen and is first passed through a preamp before entering the Lock-In Amplifier. This signal is passed both to the PREAMP BNC (for an optional external Lock-In) and to the Lock-In pre-amp. The AC GAIN is used to amplify this signal before going into the Lock-In. For best signal to noise ratio the AC GAIN should be set as low as possible.

After passing through the Lock-In, the demodulated signal is passed through a post-amplifier and low pass filter pair. The post-amp gain is adjusted by the front panel DC GAIN to condition the Lock-In output for a chart recorder or a computer A/D converter. The low pass filter demodulates the Auger signal with a pass frequency set by the DAMPING control. Longer damping times reduce the AC ripple on the output at the expense of slower scanning times.

a) Lock-In and pass energy output : The demodulated Auger signal is displayed on the front panel meter by selecting AUGER INT on SWITCH M1 . For either chart recorder or computer monitoring, two outputs are provided on the rear panel. The E MON BNC is the x-axis output that presents a 0 to -3V output proportional to the 0 to -3kV Auger pass energy. The INTENSITY BNC is the y-axis output that presents a -10 to +10V output proportional to the demodulated Lock-In output voltage.

b) Setting Lock-In parameters: To tune the Lock-In, it is best to first calibrate on the incident Energy or elastic peak. This is best accomplished by setting the gun ENERGY to 500 eV. Turn on the electron gun as outlined in the LEED operation section (IV). Focus settings for Auger mode are very different from LEED mode and must be adjusted to optimize Auger signal as outlined below. Begin by adjusting the MAX E limit to 600 eV (Set AUGER E fully cw, then adjust MAX E for –600 V.) Set the MODULATION AMPLITUDE to 10 V_{pp} and the PHASE to 45°. The Lock-In AC GAIN should be 10^2 and DC GAIN should be 5 with the DAMPING set to 0.3 sec. Set SWITCH M1 to monitor AUGER INT.

Using the LOCAL mode, adjust the AUGER E pot through 500 eV until a signal is found, as noted by the Auger Int reading. Then adjust the the AUGER E pot to coincide with one of the two peaks (usually the peak at the higher energy). If the signal is too large (front panel meter exceeds 13.0 V), adjust the AC and DC GAIN to prevent saturation of the Lock-In. Alternatively, the modulation voltage can be lowered to improve energy resolution and thereby reduce the peak intensity. Next adjust the FOCUS and CAN voltage controls to maximize the peak intensity. Usually the CAN voltage is much higher in the Auger mode than in the LEED mode. Finally adjust the PHASE to maximize the peak intensity. (If monitoring the second peak, adjust PHASE for maximum Negative intensity.)

c) Measuring an Auger signal: Once the Lock-In has been calibrated, an Auger scan can be made. Both the Auger cross-section and gun current are a strong function of primary beam energy. Typically the gun energy should be run at 2.5kV although lower energies can be used when electron beam desorption effects are important. Scan speed must be kept slow enough so that the Auger peak profiles are not "slewed". It is best to try different scan speeds while scanning a peak to determine the fastest setting for minimum "slewing" at a given DAMPING time.

d) Energy calibration and sample-optics distance: The intensity of the Auger signal and the energy position of the peak are functions of the sample-to-optics distance. Unlike in a CMA, the functional dependence is not very strong. However, a significant improvement in Auger signal can be made by adjusting the sample-optics distance. This must be done in mind of the fact that moving the optics will also require a change in gun focus so that both distance and focus settings must be alternately adjusted for optimum performance.

The Auger peak positions are also a slight function of sample-optics distance. It is usually more convenient, however, to calibrate either the computer or chart recorder to a known Auger peak rather than adjusting the sample distance.

4. Auger Operation: Computer Control

Computer control of the AUGER MODE is accomplished using an IBM compatible computer, Keithley KPCI3107 card, and the AES Windows-compatible program.

a) HARDWARE AND SOFTWARE INSTALLATION:

1) Install the KPCI3107 card into a PCI slot.

2) Insert and Run the KPCI3107 INSTALL CD. (The pertinent pages of the Installation Instructions are included in this manual.)

3) The control program is "AESx.EXE," where "x" is the version number. Run SETUP.BAT from the diskette. This will copy the files to c:\AES and create an icon on the desktop.

4) Hook up DIN COMPUTER cable and INTENSITY BNC cable from the rear panel to the Keithley card. The DIN COMPUTER cable attaches to the DIGITAL input and the INTENSITY BNC cable attaches to the pigtail, which then attaches to the ANALOG input. In case of a problem, it is a good idea to check the card with the program provided by Keithley, "AIO Panel". Place a 0 to 10 V signal into the pigtail (ANALOG INPUT) and see if CH #7 responds.

5) Place the REMOTE/LOCAL switch in REMOTE. Turn on the control electronics and run the AES program.

b) <u>PROGRAM DETAILS</u>

1) START SCAN
   Use slider bars to choose START VOLTS, STOP VOLTS, VOLTS per CHANNEL, and TIME per CHANNEL.

2) STOP SCAN
   This is a way to abort the current SCAN

3) SAVE
   Saves data to a file. See note below on data format.

4) READ
   Reads a file saved previously.

5) CLEAR
   Clears all data. All SCAN points in memory are erased.

6) AUTO SCALE
   Displays all data points in memory, from 0 to -2600 Volts, scaled to fit the screen. Click and Drag the mouse to pick out a region of interest. To access another region, click AUTO SCALE, then select the desired region.

7) DATA FORMAT
   SCAN DATA is mapped into 32000 values of the Auger Energy from 0 to –2600 Volts. The data files are ascii and have the format " AES voltage ; AES signal ; AES dac/2; scan number ." The first line for the file is a comment with the file name.

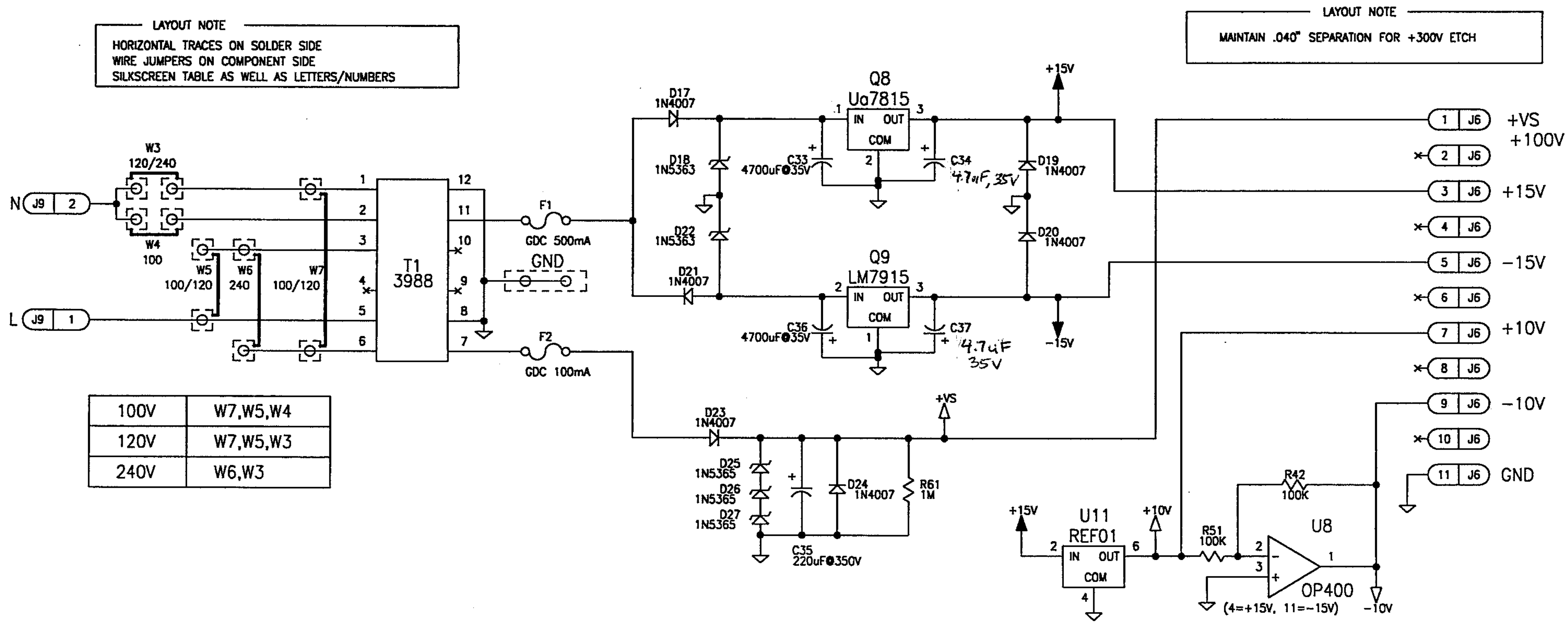
Multiple scans are possible. The software distinguishes scan sets by color.

c) External Lock-In: The internal Lock-In in the LEED Auger controller can be bypassed if desired. The 2.5 kHz BNC on the rear panel may be used to drive an external Lock-In, while the PREAMP BNC is the Auger signal after passing through the preamp. This signal can then be sent to the external Lock-In input.

VI. PROBLEM SOLVING

All repairs and calibrations of the LEED control unit should be performed at LK Technologies laboratories. Some problems may, however, be traced in the field to speed up the repair process. Before sending the unit back, go back and perform the Initial Installation checks. If these checks turn out OK, then the source of trouble is most likely in the LEED optics. Note that even if external shorts exist, the front panel meters will may show voltage readings.

LEED/AES SCHEMATICS / Table of Contents



100V	W7,W5,W4
120V	W7,W5,W3
240V	W6,W3

ALL RESISTORS 1/4W MF UNLESS NOTED.
ALL CAPACITORS ARE 50V UNLESS NOTED.

6/1/06 Change C34, C37 to 4.7uF@35V (LD-1B)

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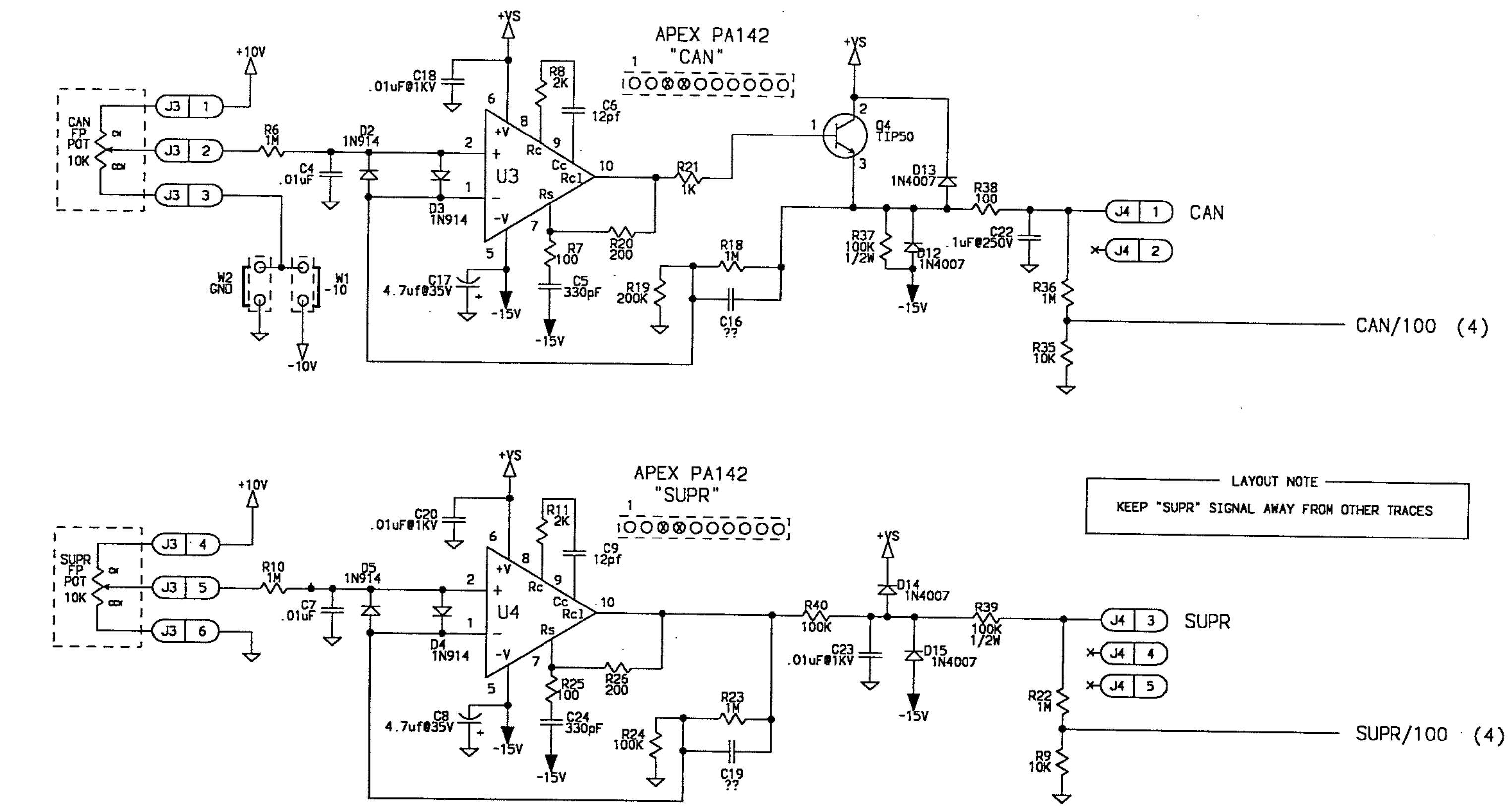
DATE: 8/29/01	
DRAWN BY: CD	
APPR BY:	LEED Filament Car[illegible] A
SHEET: 01 OF 04	

For PA241: omit R7, C5; R25, C24
R20, R26 = 47.5Ω
R8, R11 = Φ Ω



ALL RESISTORS 1/4W MF UNLESS NOTED.
ALL CAPACITORS ARE 50V UNLESS NOTED.

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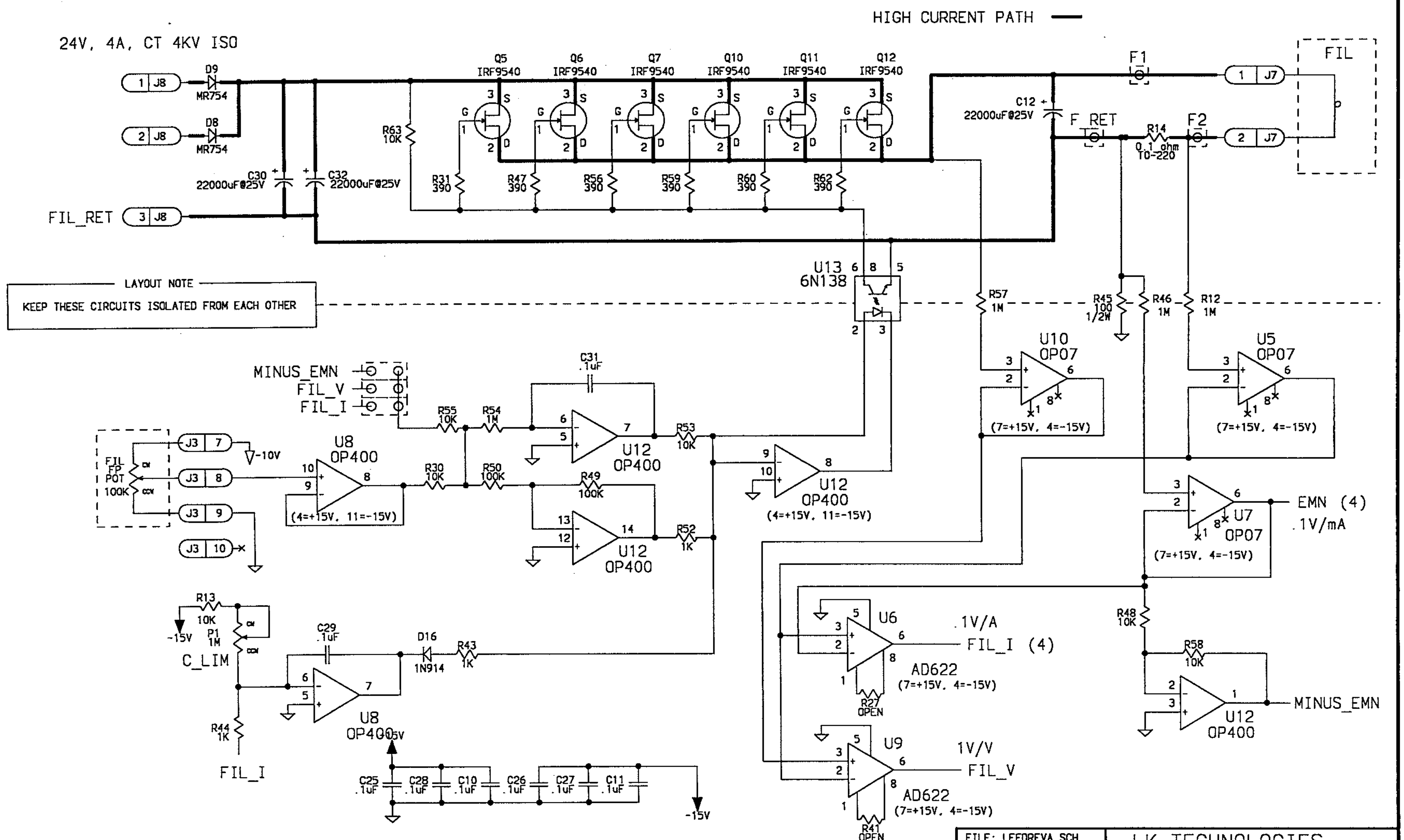

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ALL CAPACITORS ARE 50V UNLESS NOTED.

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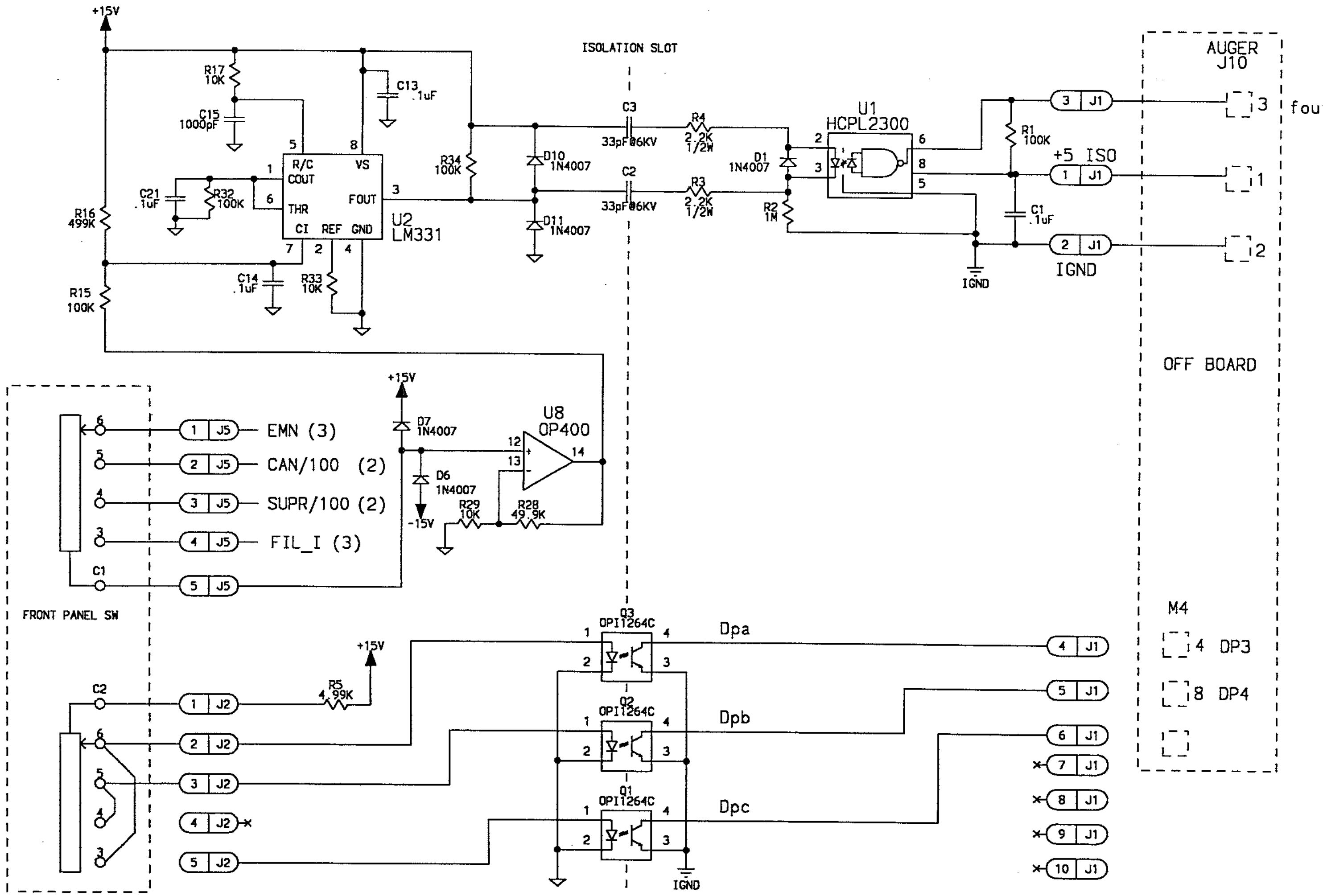
SHEET: 03 OF 04	



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ALL CAPACITORS ARE 50V UNLESS NOTED.

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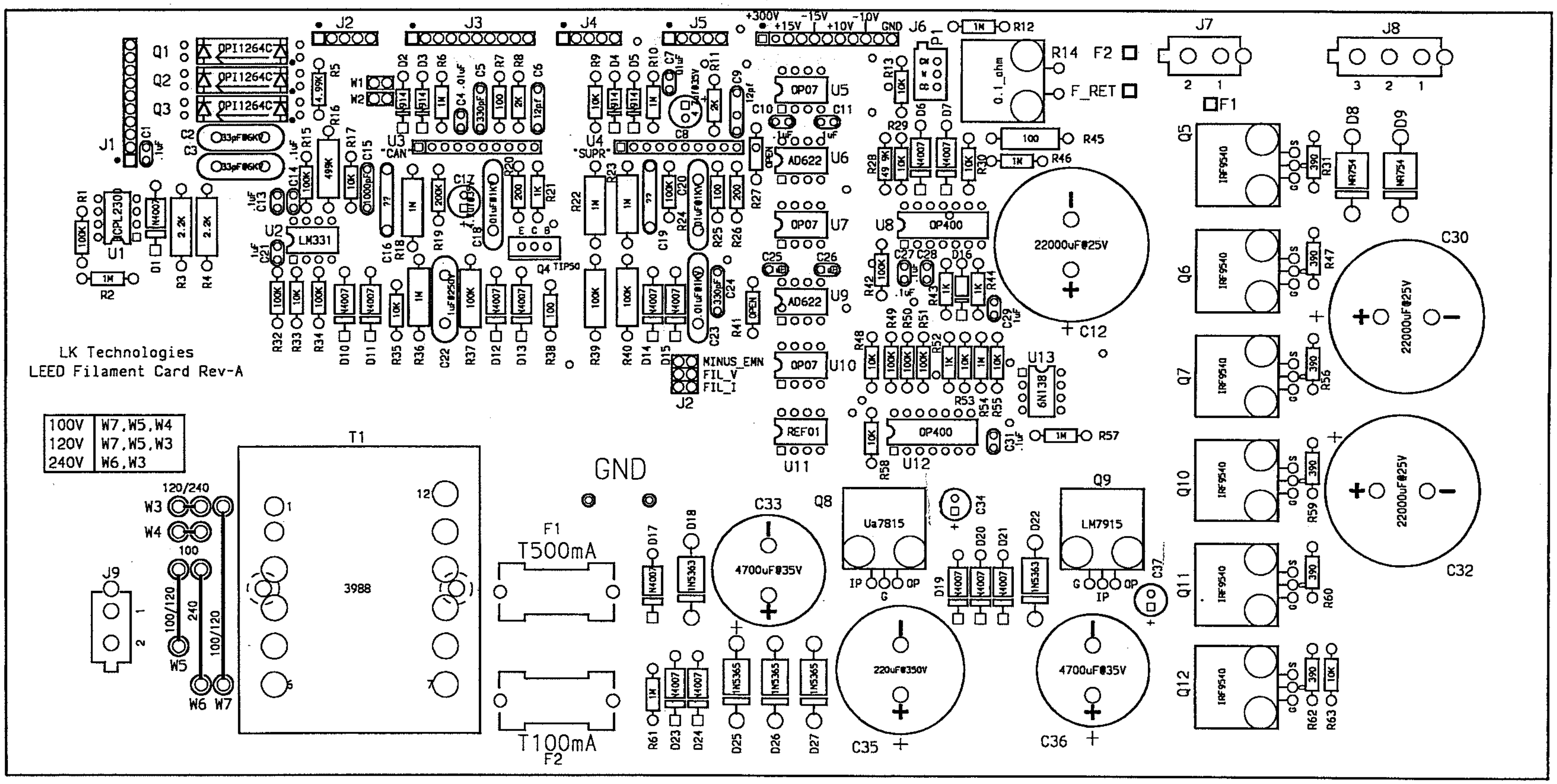
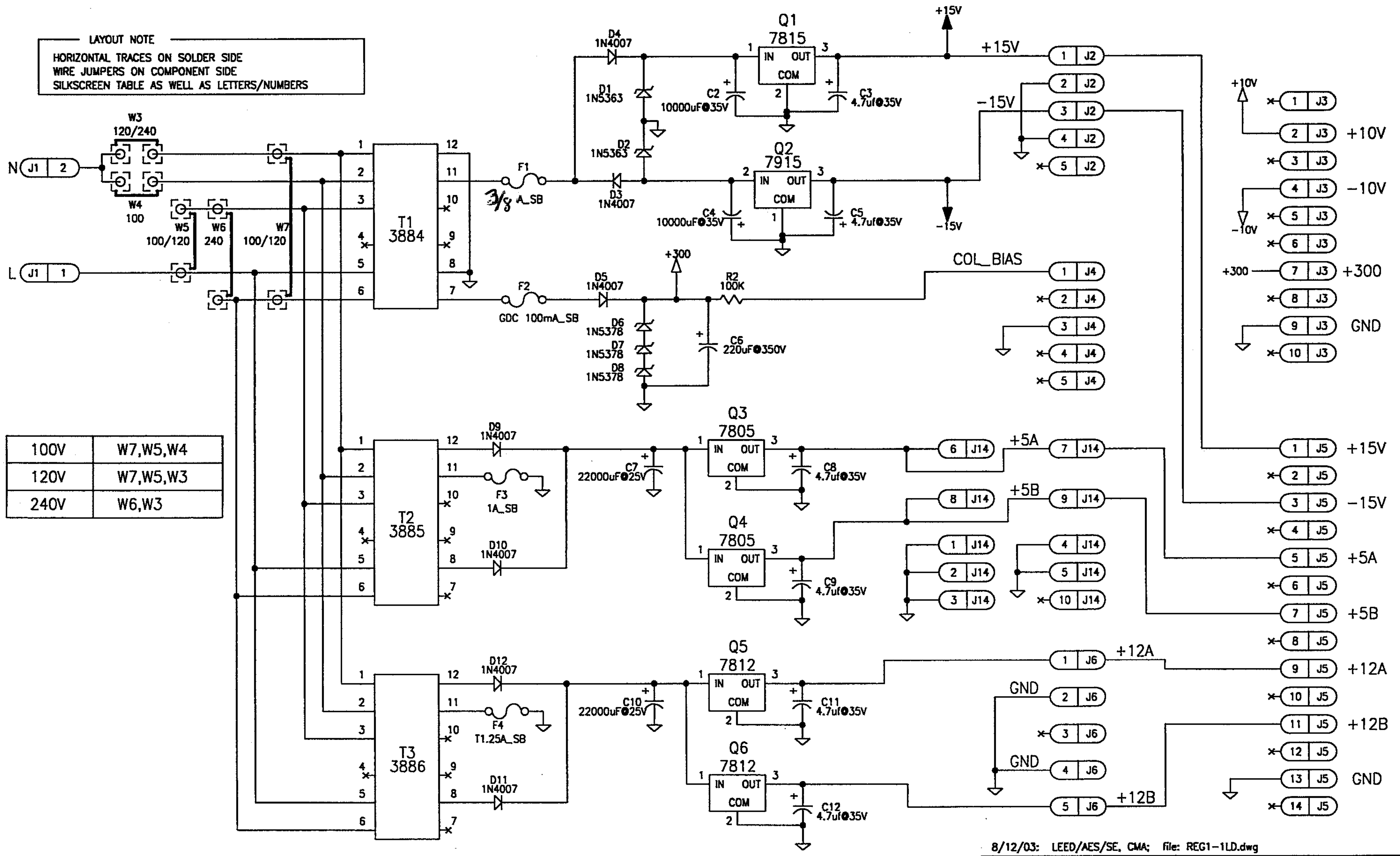


SILKSCREEN

LEED Filament Card Rev A - Assembly			LK TECHNOLOGIES 3910 W. Roll Ave. Bloomington, IN 47403
TOLERANCES 3 PLACE DECIMALS +/- .010 2 PLACE DECIMALS +/-	DRN BY: CD	DATE: 29 AUG 01	
	SCALE: NA	SHEET 1 OF 1	FILE NAME: LEEDREVA.PCB

LAYOUT NOTE

HORIZONTAL TRACES ON SOLDER SIDE
WIRE JUMPERS ON COMPONENT SIDE
SILKSCREEN TABLE AS WELL AS LETTERS/NUMBERS



100V	W7,W5,W4
120V	W7,W5,W3
240V	W6,W3

ALL RESISTORS 1/4W MF UNLESS NOTED.
ALL CAPACITORS ARE 50V UNLESS NOTED.

8/12/03: LEED/AES/SE, CMA; file: REG1-1LD.dwg

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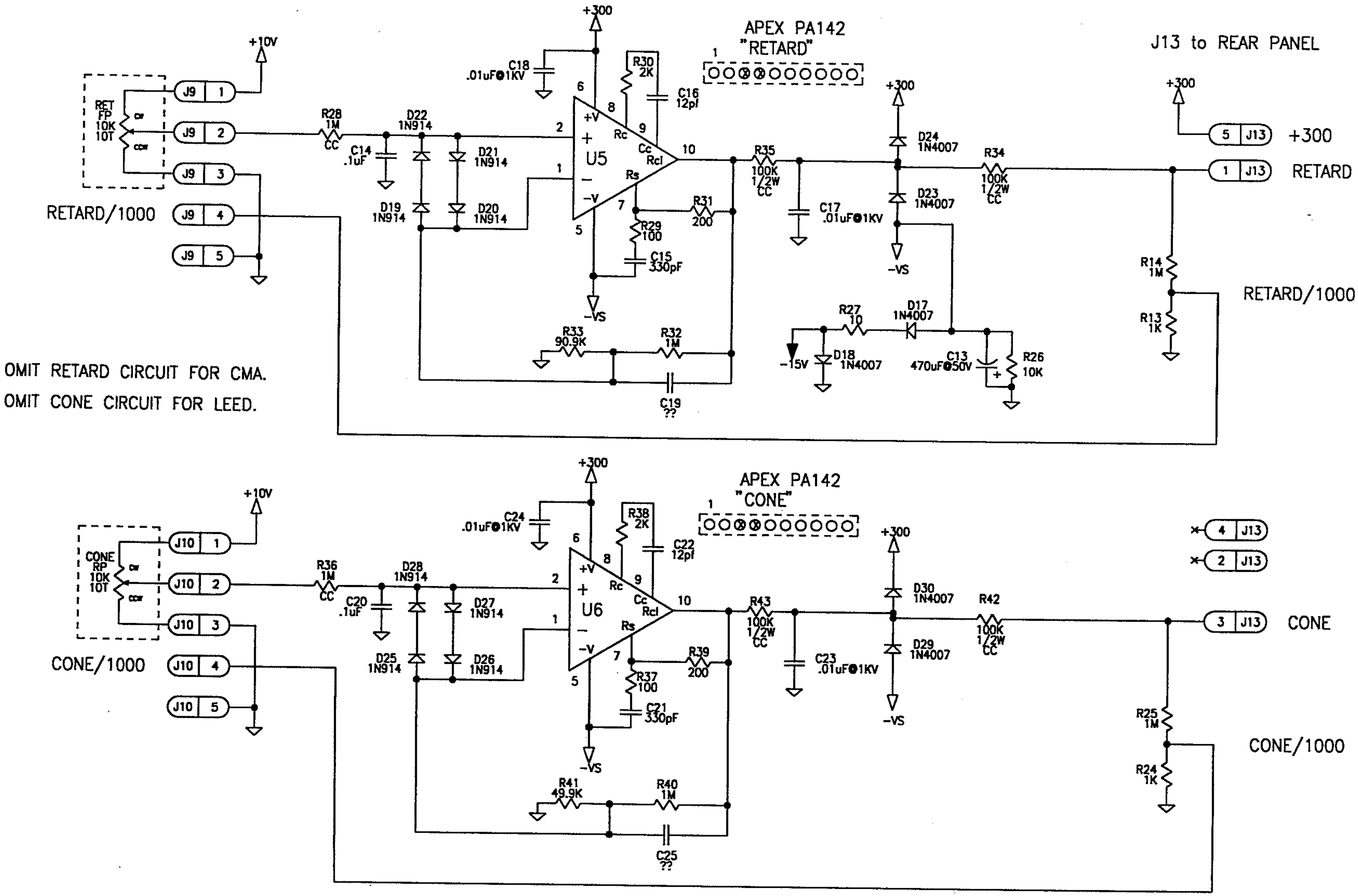
DATE: 2/13/02	
DRAWN BY: CD	
APPR BY:	LEED REG I Card F
SHEET: 01 OF 03	

For PA241: omit R29, C15; R37, C21
R30, R38 = ∅Ω
R31, R39 = 47.5Ω



OMIT RETARD CIRCUIT FOR CMA.
OMIT CONE CIRCUIT FOR LEED.

ALL RESISTORS 1/4W MF UNLESS NOTED.
ALL CAPACITORS ARE 50V UNLESS NOTED.

8/12/03: LEED/AES/SE, CMA; file: REG1-2LD.DWG

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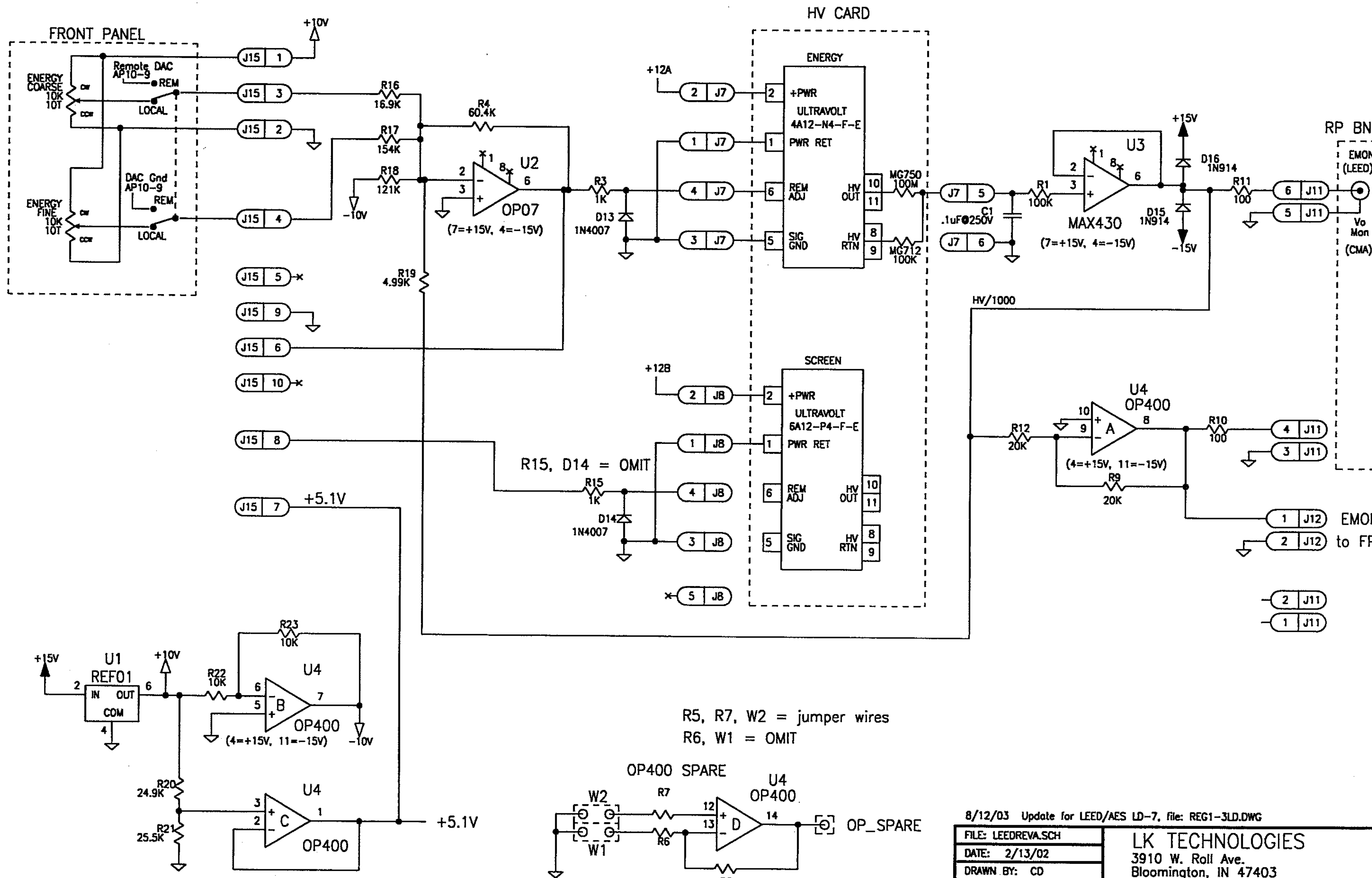

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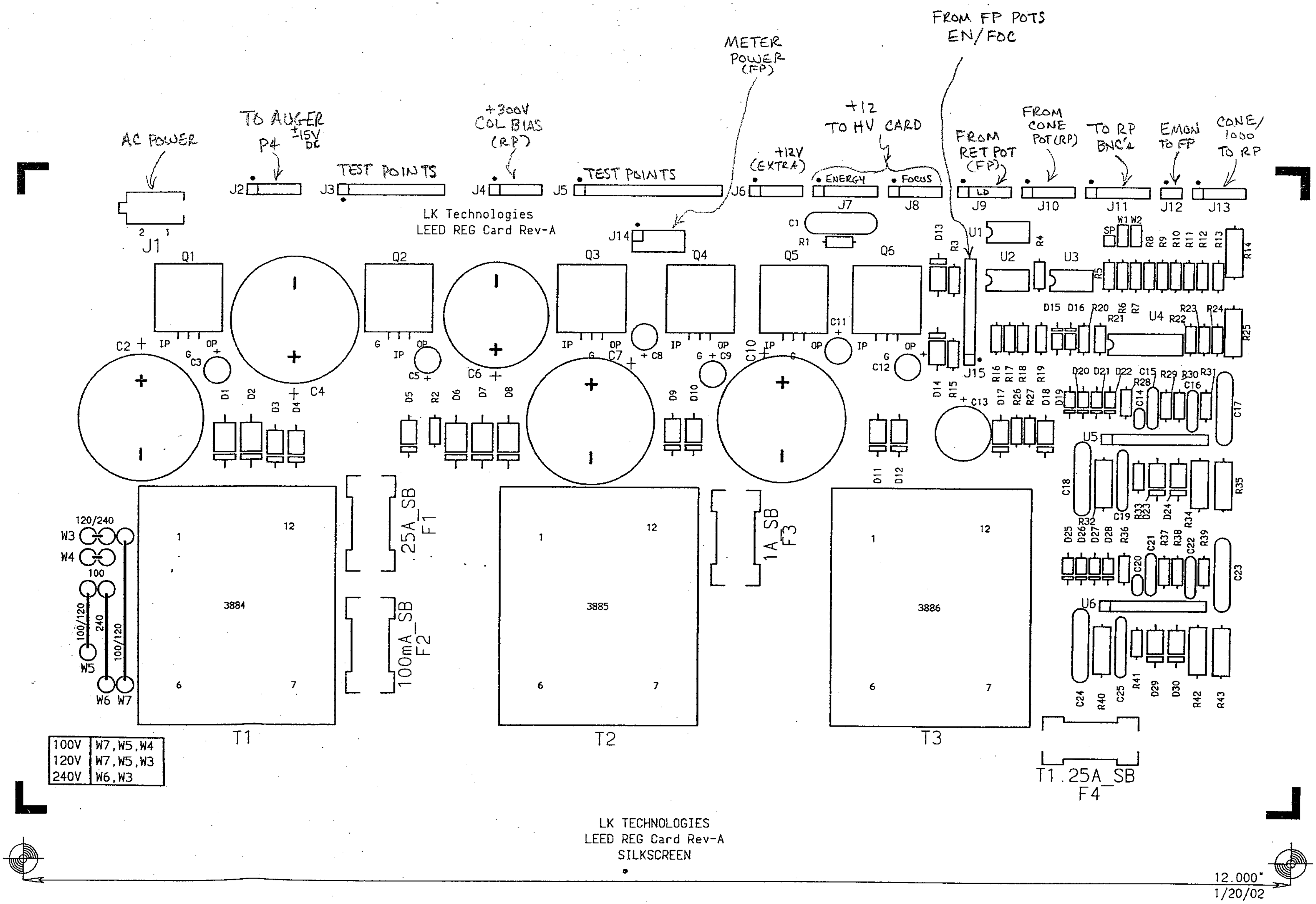
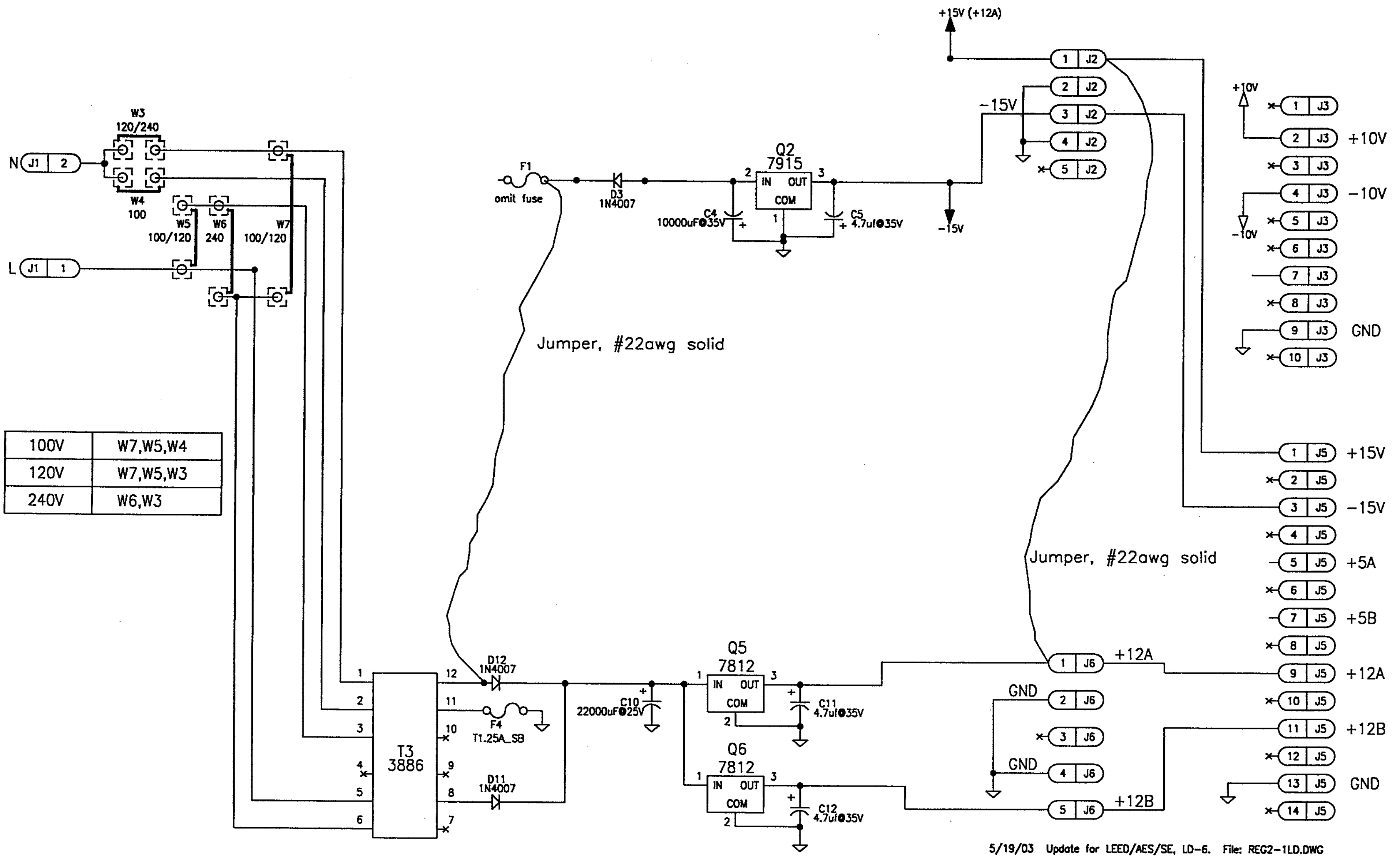


AC POWER
TO AUGER P4 ±15V DC
TEST POINTS
+300V COL BIAS (RP)
TEST POINTS
METER POWER (FP)
+12V (EXTRA)
+12 TO HV CARD
ENERGY
FOCUS
FROM FP POTS EN/FOC
FROM RET POT (FP)
LD
FROM CONE POT (RP)
TO RP BNC's
EMON TO FP
CONE/1000 TO RP
LK Technologies
LEED REG Card Rev-A
.25A_SB F1
100mA_SB F2
1A_SB F3
T1.25A_SB F4
3884
3885
3886
T1
T2
T3
120/240
100/120
240
100V W7,W5,W4
120V W7,W5,W3
240V W6,W3
LK TECHNOLOGIES
LEED REG Card Rev-A
SILKSCREEN
12.000"
1/20/02

JAN 2 8 2002

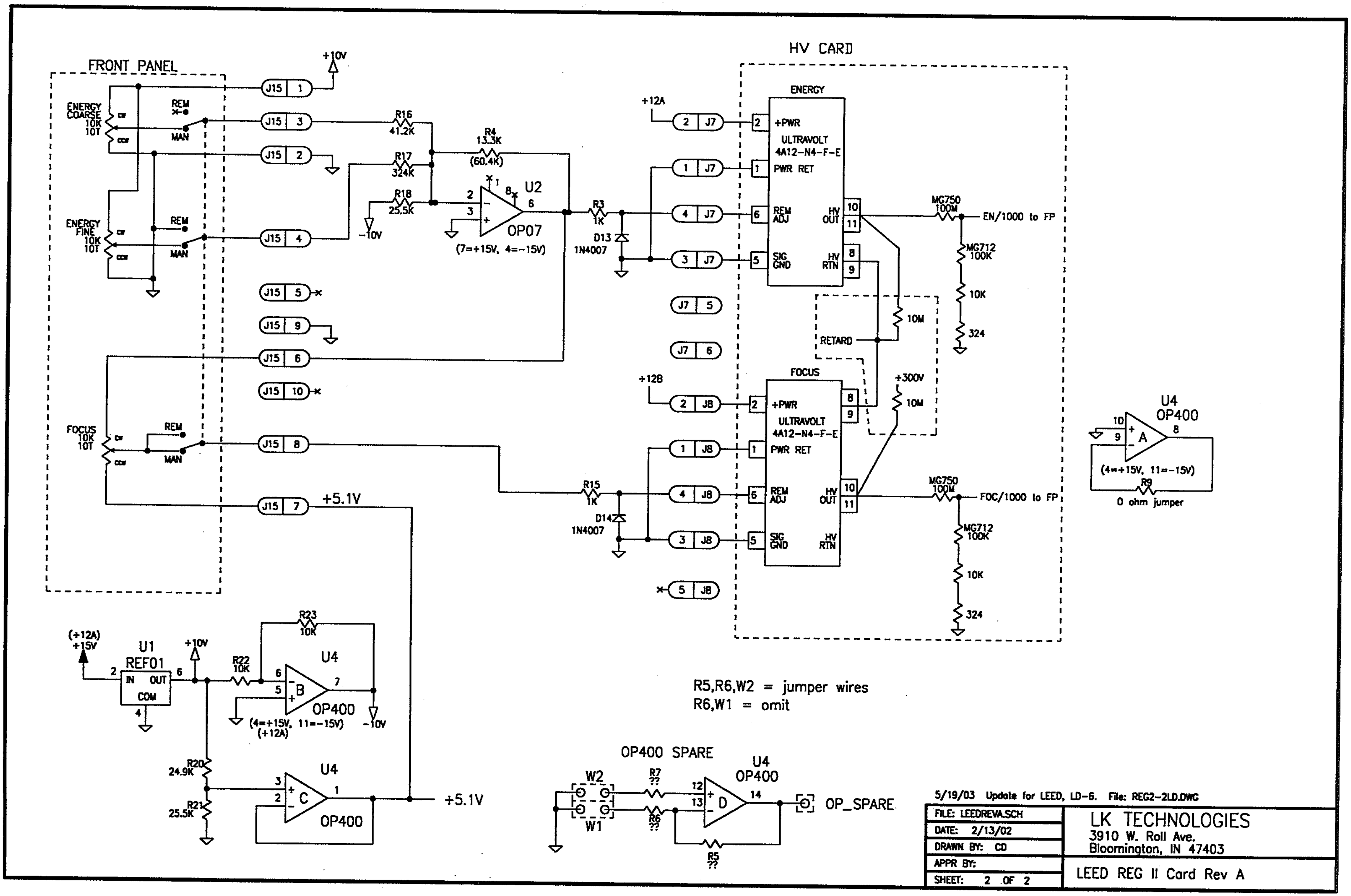


100V	W7,W5,W4
120V	W7,W5,W3
240V	W6,W3

ALL RESISTORS 1/4W MF UNLESS NOTED.
ALL CAPACITORS ARE 50V UNLESS NOTED.

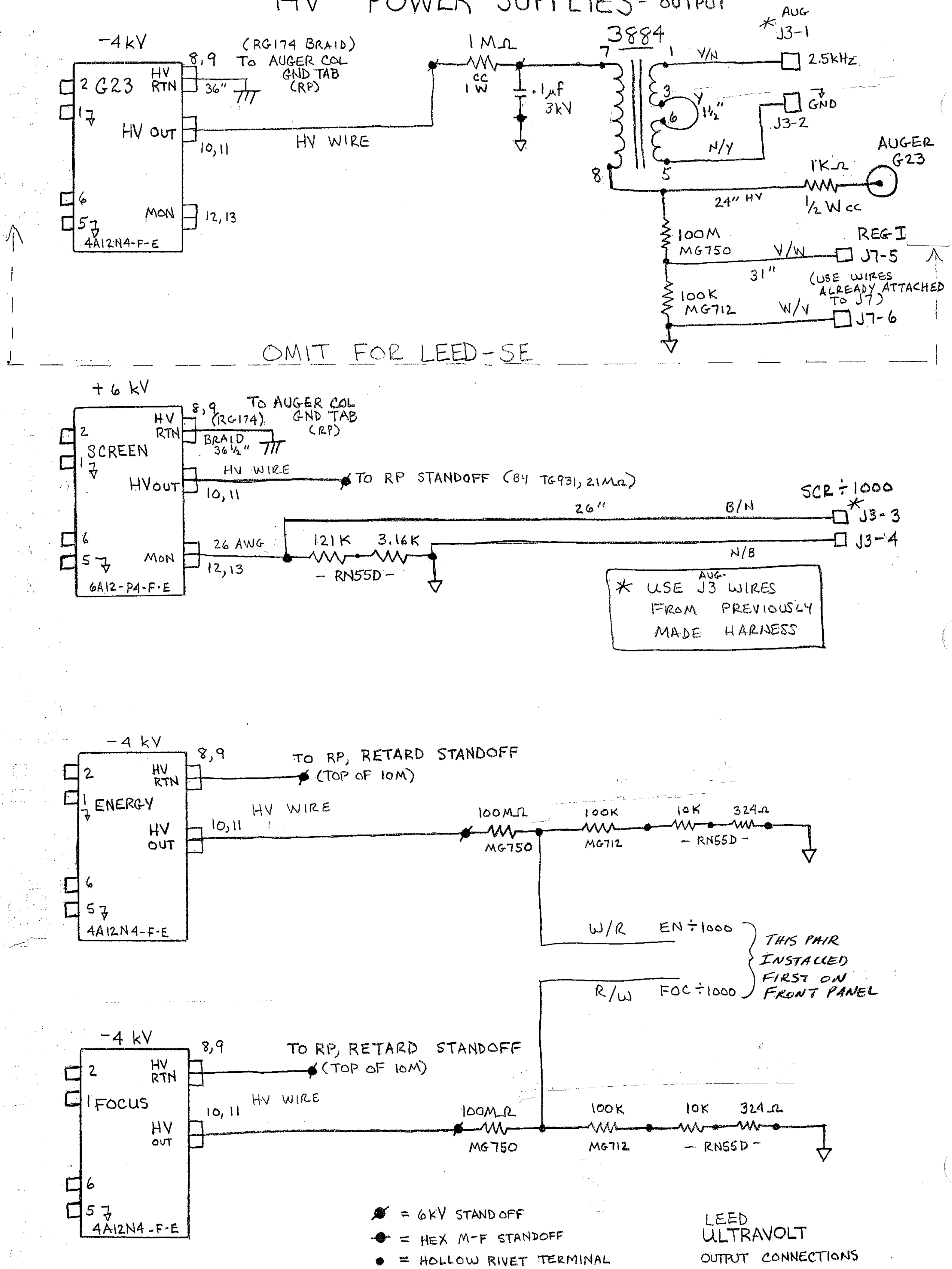
5/19/03 Update for LEED/AES/SE, LD-6. File: REG2-1LD.DWG

FILE: LEEDREVA.SCH	LK TECHNOLOGIES 3910 W. Roll Ave. Bloomington, IN 47403
DATE: 2/13/02	
DRAWN BY: CD	
APPR BY:	LEED REG II Card
SHEET: 1 OF 2	



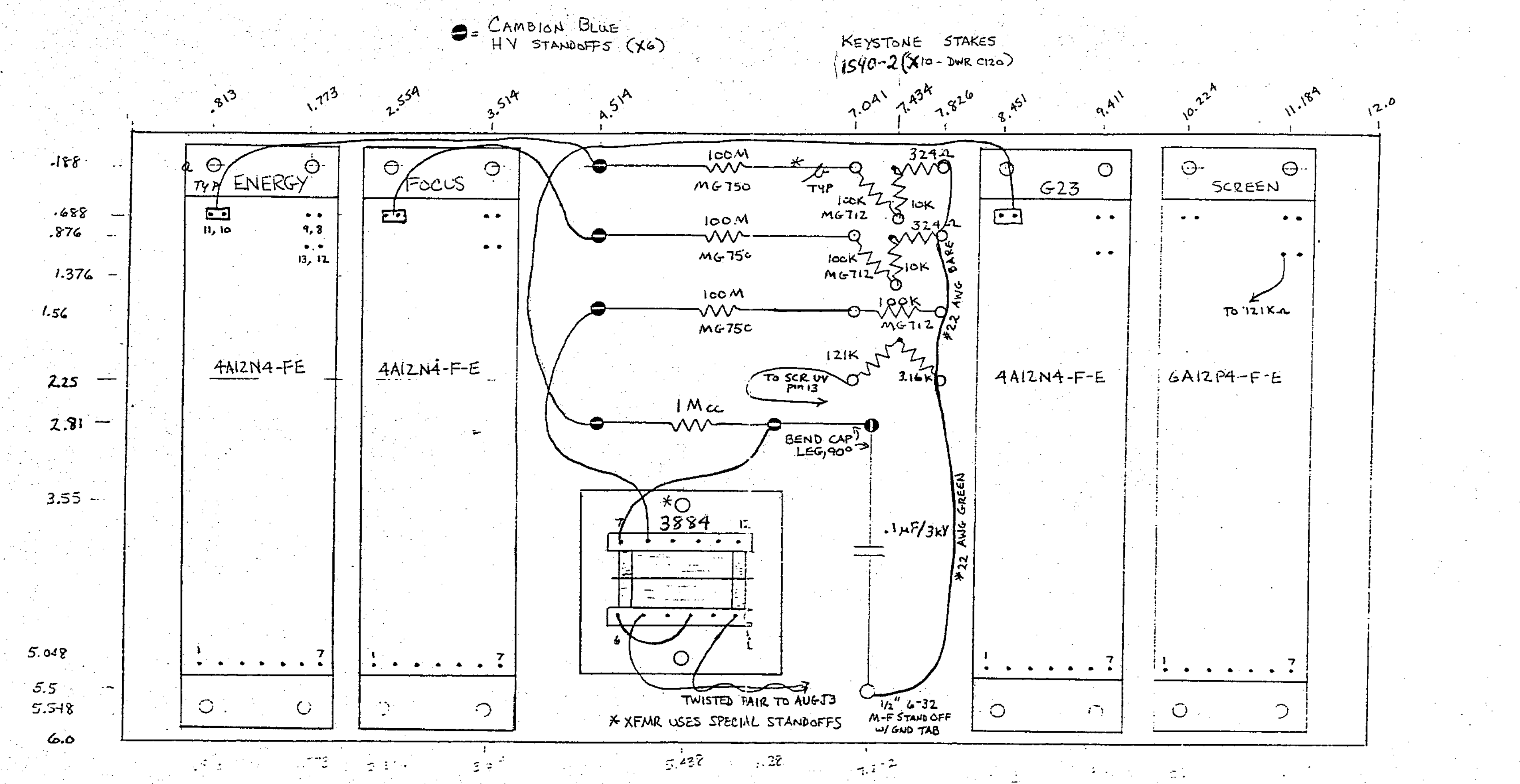
FRONT PANEL
HV CARD
ENERGY COARSE 10K 10T
ENERGY FINE 10K 10T
FOCUS 10K 10T
REM
MAN
R16 41.2K
R17 324K
R18 25.5K
R4 13.3K (60.4K)
U2 OP07
(7=+15V, 4=-15V)
R3 1K
D13 1N4007
R15 1K
D14 1N4007
ENERGY
FOCUS
ULTRAVOLT 4A12-N4-F-E
+PWR
PWR RET
REM ADJ
SIG GND
HV OUT
HV RTN
RETARD
+300V
10M
MG750 100M
MG712 100K
10K
324
EN/1000 to FP
FOC/1000 to FP
+12A
+12B
+10V
-10V
+5.1V
U4 OP400
(4=+15V, 11=-15V)
R9 0 ohm jumper
U1 REF01
(+12A) +15V
R22 10K
R23 10K
(4=+15V, 11=-15V) (+12A)
R20 24.9K
R21 25.5K
R5,R6,W2 = jumper wires
R6,W1 = omit
OP400 SPARE
W2
W1
R7 ??
R6 ??
R5 ??
OP_SPARE
5/19/03 Update for LEED, LD-6. File: REG2-2LD.DWG
FILE: LEEDREVA.SCH
DATE: 2/13/02
DRAWN BY: CD
APPR BY:
SHEET: 2 OF 2
LK TECHNOLOGIES
3910 W. Roll Ave.
Bloomington, IN 47403
LEED REG II Card Rev A

HV POWER SUPPLIES - OUTPUT



LEED
ULTRAVOLT
OUTPUT CONNECTIONS
12-12-00
UPDATED 6-28-01

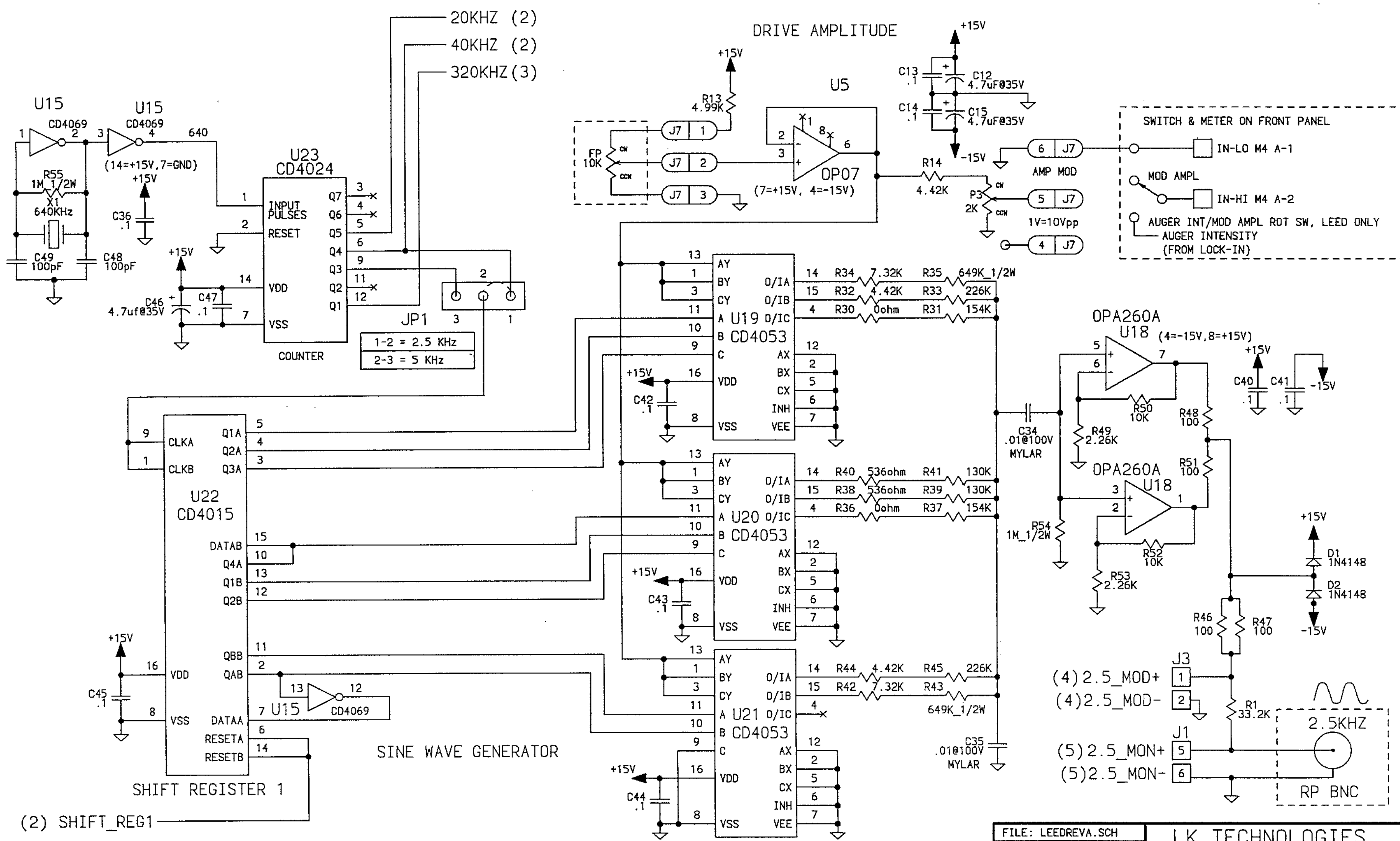
1/2



HOLE SIZES:
ALL HOLES = #26 UNLESS OTHERWISE NOTED
= #41 (10 PLCS.)

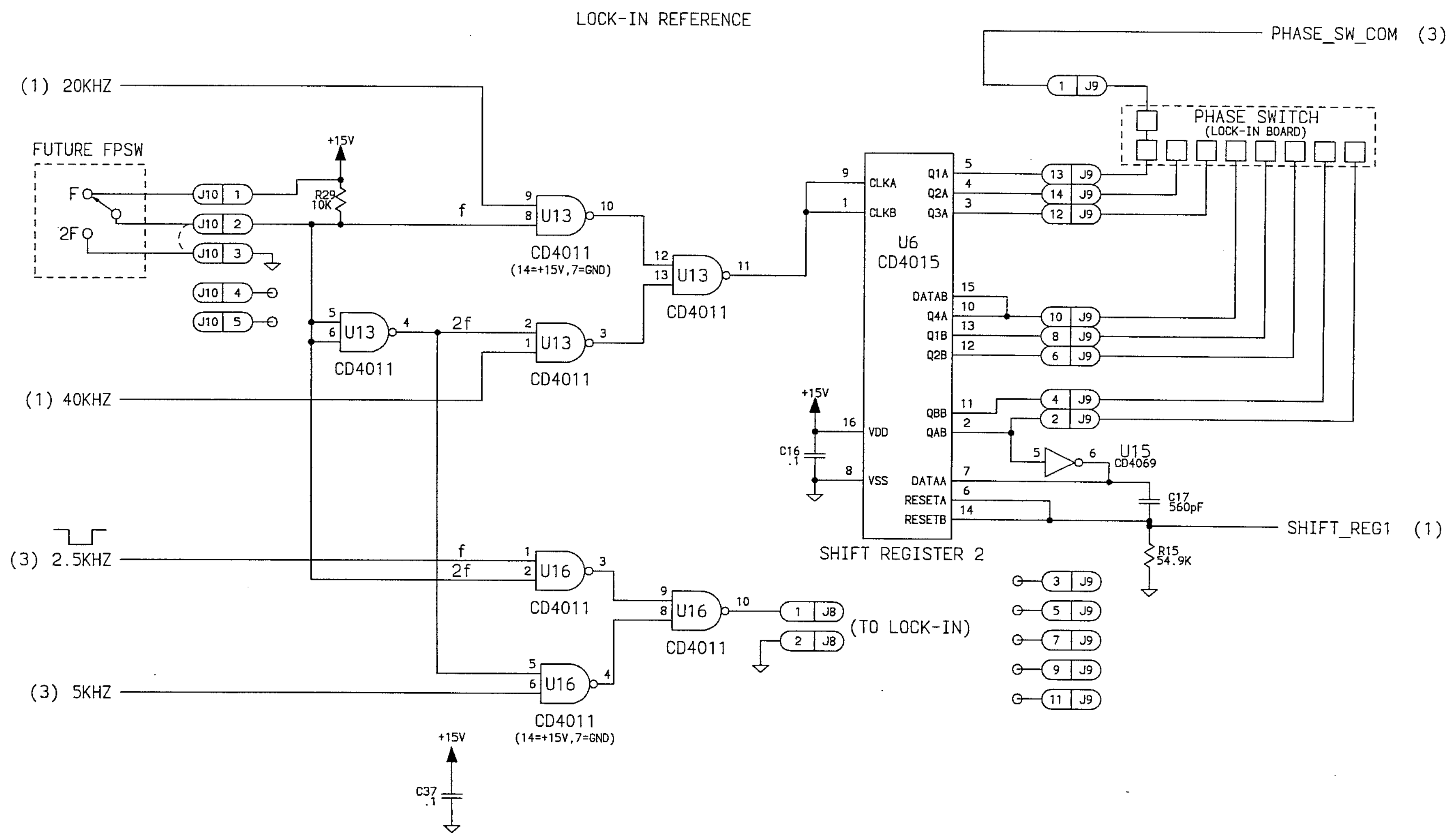
LEED HV BOARD
MAT'L: 6 X 12 G-10 (1/16" THICKNESS)
QTY: 1 PER UNIT
6-29-99 CAW
2-13-02 CMA-2, LD-6
8-14-03 LD-9, CMA-4

CONSTRUCTION ORG

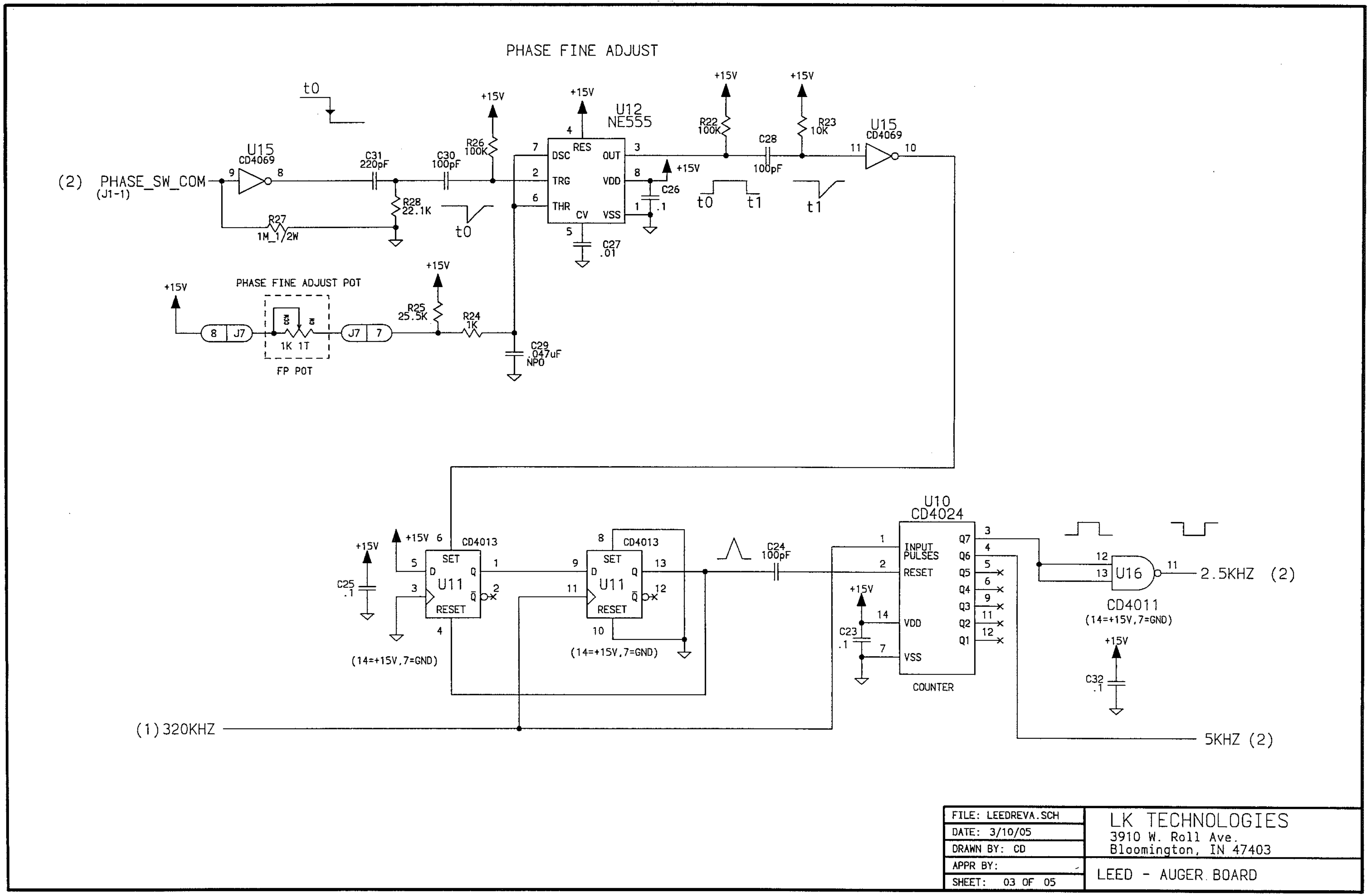


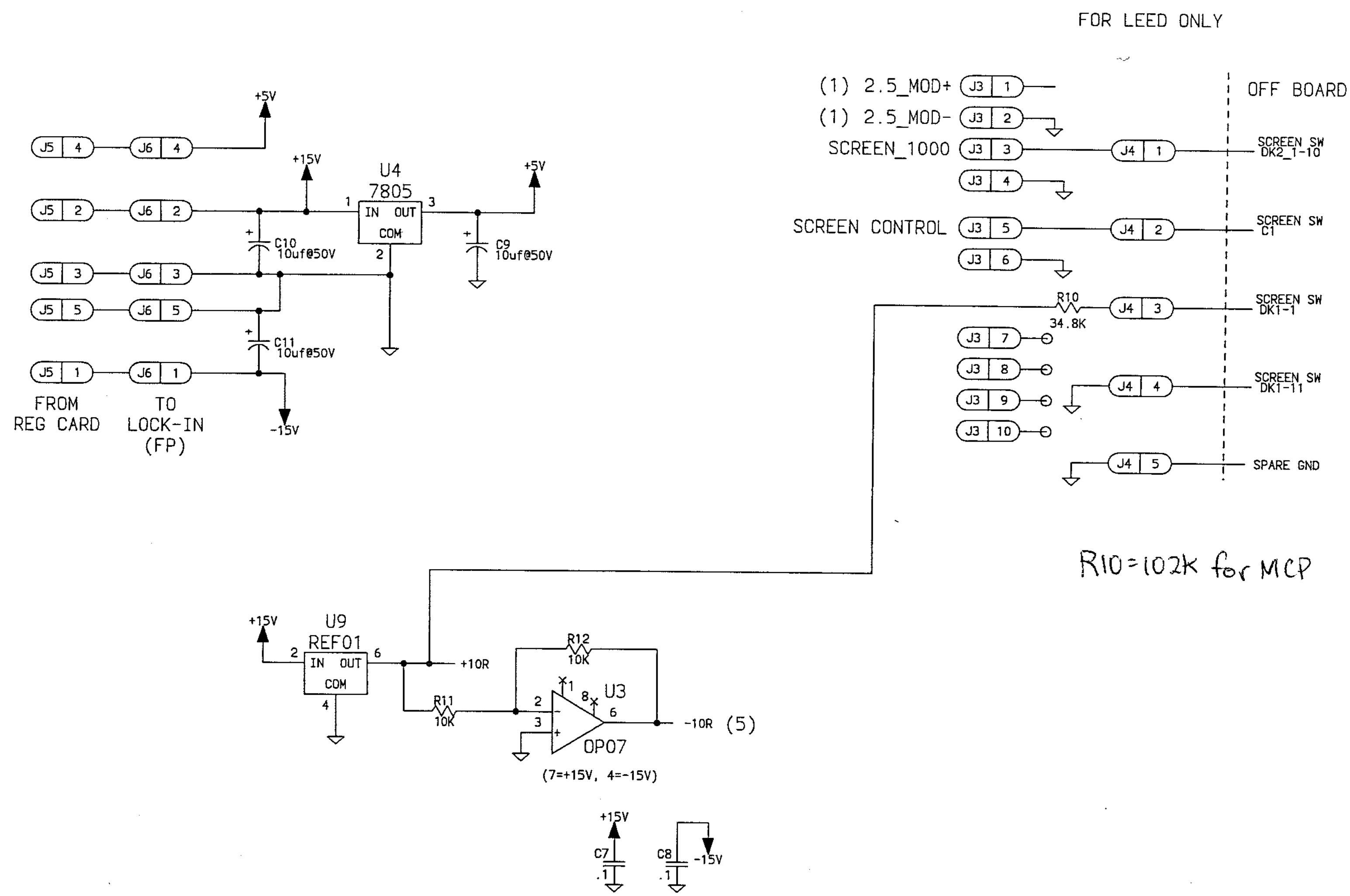
ALL RESISTORS 1/4W MF UNLESS NOTED.
ALL CAPACITORS ARE 50V UNLESS NOTED.

FILE: LEEDREVA.SCH	LK TECHNOLOGIES 3910 W. Roll Ave. Bloomington, IN 47403
DATE: 3/10/05	
DRAWN BY: CD	
APPR BY:	LEED - AUGER BOARD
SHEET: 01 OF 05	

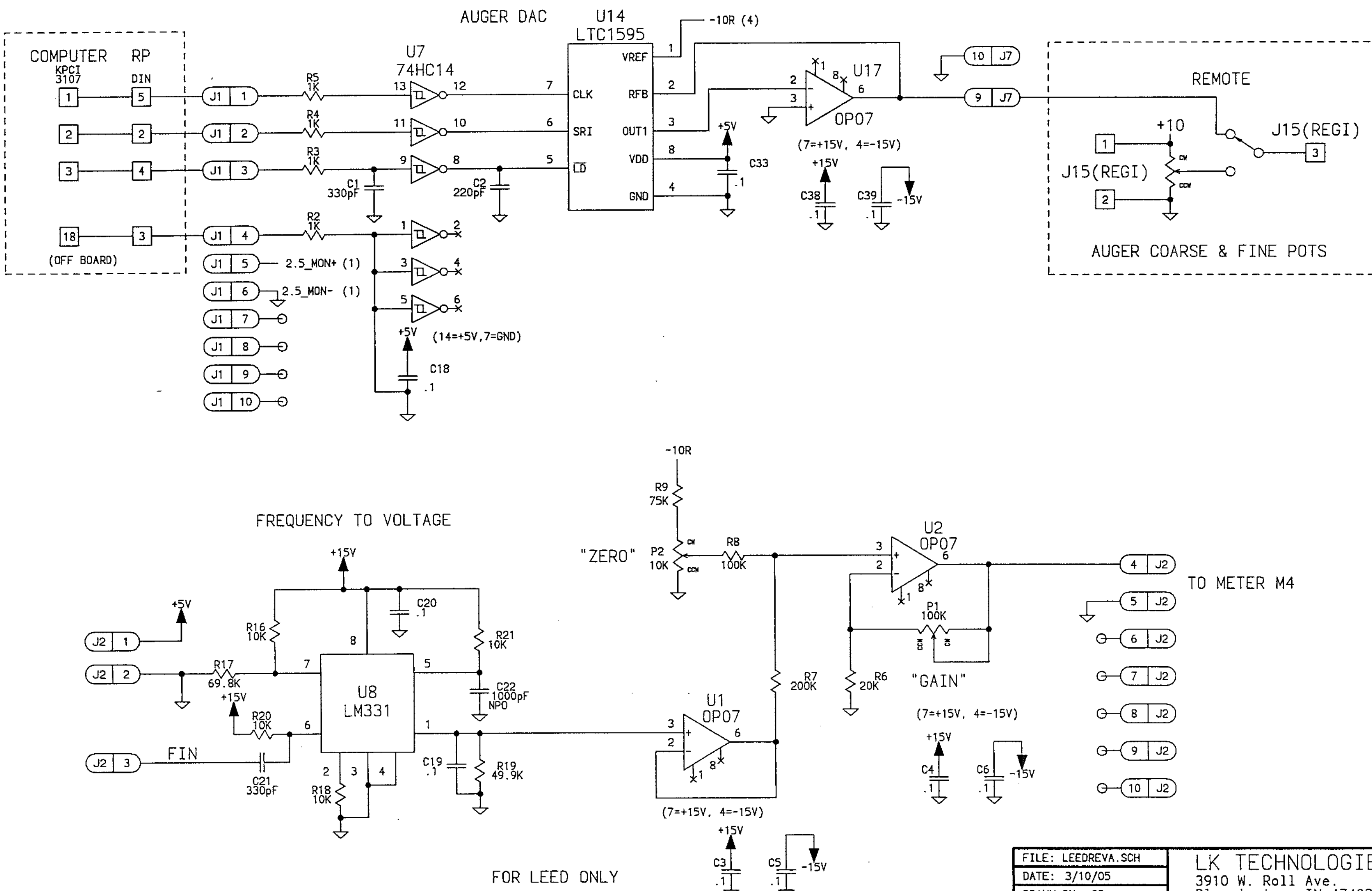


FILE: LEEDREVA.SCH	LK TECHNOLOGIES 3910 W. Roll Ave. Bloomington, IN 47403
DATE: 3/10/05	
DRAWN BY: CD	
APPR BY:	LEED - AUGER BOARD
SHEET: 02 OF 05	


PHASE FINE ADJUST
t0
U15
CD4069
(2) PHASE_SW_COM
(J1-1)
C31
220pF
C30
100pF
R26
100K
R28
22.1K
R27
1M_1/2W
t0
U12
NE555
RES
DSC
TRG
THR
CV
OUT
VDD
VSS
C26
.1
C27
.01
R22
100K
C28
100pF
R23
10K
t0
t1
t1
U15
CD4069
+15V
PHASE FINE ADJUST POT
J7
1K 1T
FP POT
R25
25.5K
R24
1K
C29
.047uF
NPO
CD4013
U11
SET
RESET
C25
.1
(14=+15V,7=GND)
C24
100pF
U10
CD4024
INPUT
PULSES
RESET
VDD
VSS
COUNTER
C23
.1
U16
CD4011
(14=+15V,7=GND)
C32
.1
2.5KHZ (2)
5KHZ (2)
(1) 320KHZ
FILE: LEEDREVA.SCH
DATE: 3/10/05
DRAWN BY: CD
APPR BY:
SHEET: 03 OF 05
LK TECHNOLOGIES
3910 W. Roll Ave.
Bloomington, IN 47403
LEED - AUGER BOARD



FILE: LEEDREVA.SCH	LK TECHNOLOGIES 3910 W. Roll Ave. Bloomington, IN 47403
DATE: 3/10/05	
DRAWN BY: CD	
APPR BY:	LEED - AUGER BOARD
SHEET: 04 OF 05	



FILE: LEEDREVA.SCH	LK TECHNOLOGIES 3910 W. Roll Ave. Bloomington, IN 47403
DATE: 3/10/05	
DRAWN BY: CD	
APPR BY:	LEED - AUGER BOARD
SHEET: 05 OF 05	

AUGER CONNECTOR PIN ASSIGNMENTS 12-26-00

J9
- 1 PHASE SW COM
- 2 PHASE SETTINGS
- 4
- 6
- 8
- 10
- 12
- 13
- 14

J3
- 1 2.5 kHz before R_Z
- 2 ⏚
- 3 SCR ÷ 1000
- 4 ⏚
- 5 SCR CTL
- 6 ⏚
- 7
- 8
- 9
- 10

J4 (CMA / LEED ONLY)
- 1 CMA: OPEN — LEED ONLY: SCR ÷ 1000
- 2 CMA: OPEN — LEED ONLY: SCR CTL
- 3 CMA: OPEN — LEED ONLY: R_F + 10R
- 4 CMA: OPEN — LEED ONLY: SCR SW ⏚, DK1-11
- 5 CMA: OPEN — LEED ONLY: OPEN

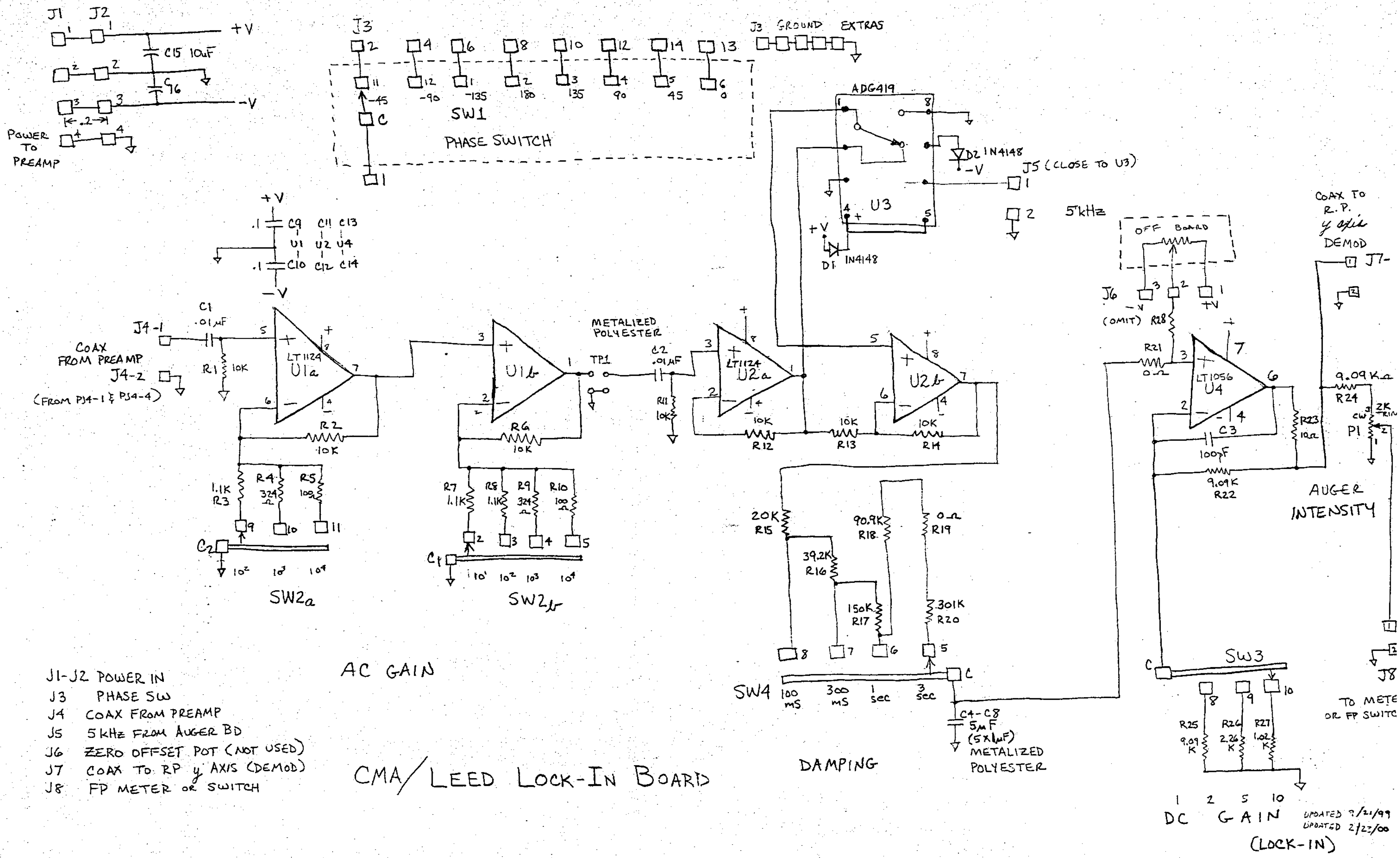
J5/6 (FROM REF. I. / TO LOCK-IN)
- 1 −15
- 2 +15
- 3 ⏚
- 4 +5
- 5 ⏚

J8
- 1 LOCK-IN (5 kHz)
- 2 ⏚ " " (5 kHz)

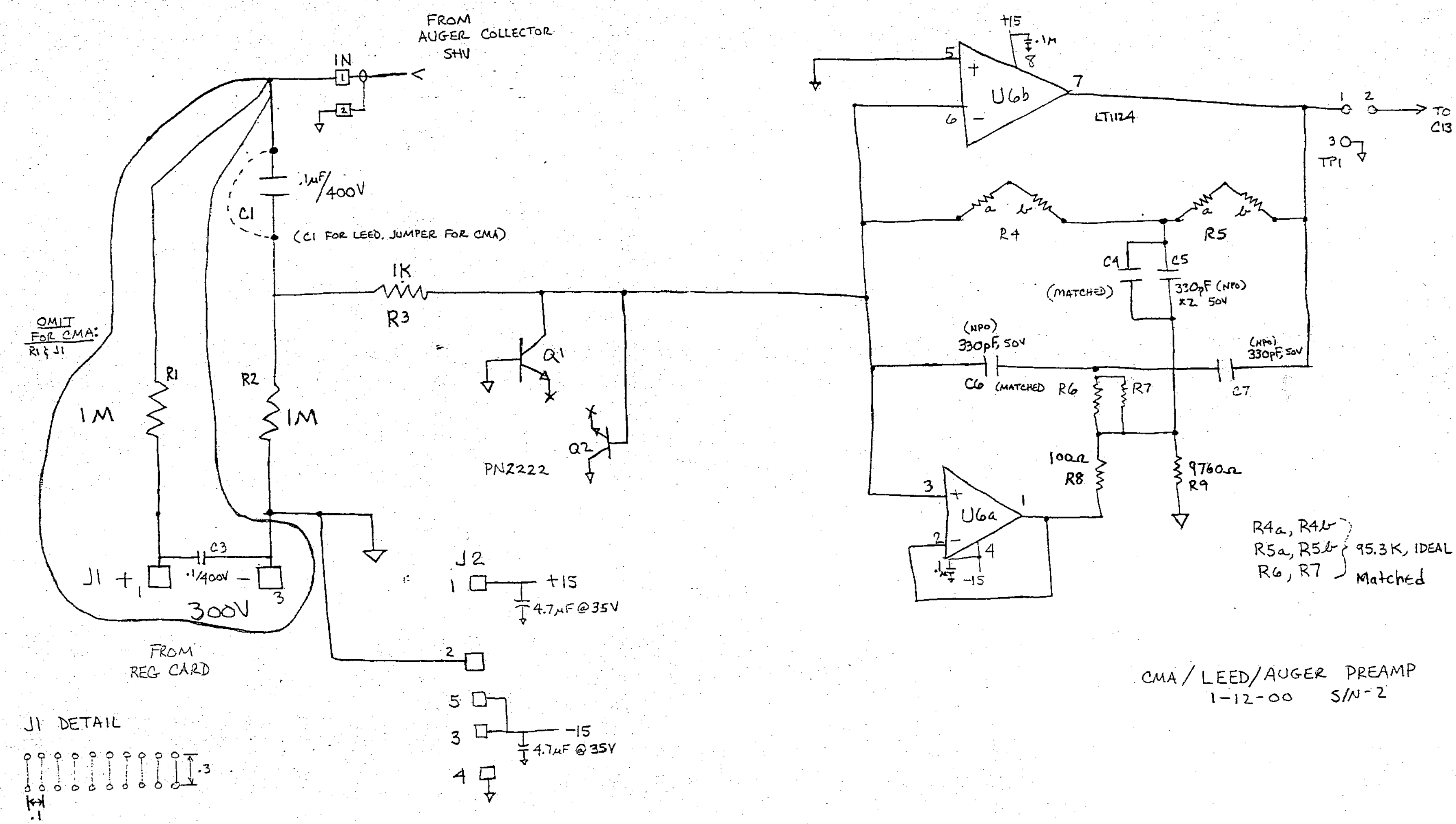
J7
- 1 TO FP-POT CW AMPMOD +15
- 2 POT WIPER
- 3 AMPL MOD CCW ⏚ (K/V)
- 4 V/K HEAT SHRINKED TO K/V; M4A-2 "IN-HI" (CMA ONLY)
- 5 AMP MOD ROT SW (LEED ONLY); M4A-1 "IN-LO" (CMA ONLY)
- 6 AMP. MOD ROT SW ⏚ (LEED ONLY)
- 7 PHASE FINE ADJ CW
- 8 PHASE FINE ADJ +15
- 9 AUGER DAC OUT
- 10 AUG DAC GND

J2 LEED ONLY
- 1 +5
- 2 ⏚
- 3 f IN (C291)
- 4 M4 IN (V_{OUT})
- 5 M4 SIG ⏚
- 6 ⏚ (for f)
- 7
- 8
- 9
- 10

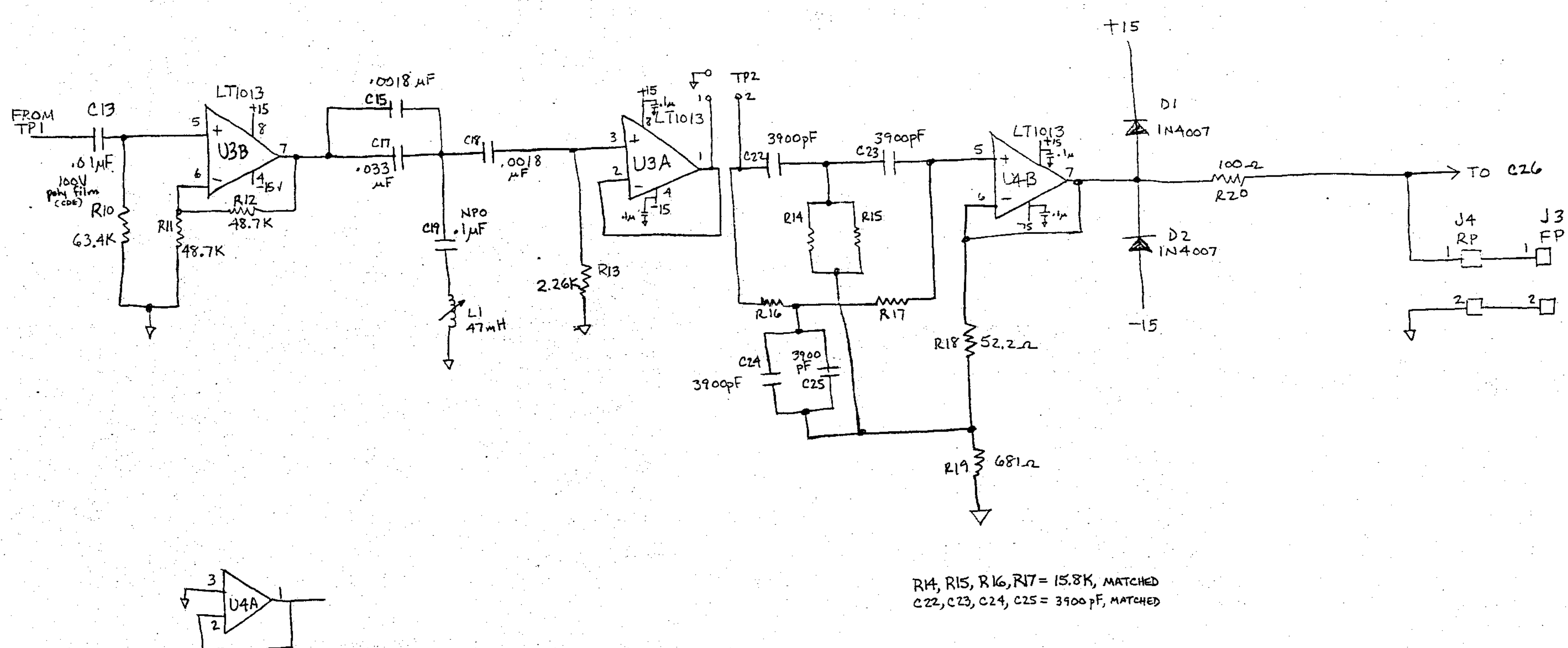
J1
- 1 CLK
- 2 DATA
- 3 LOAD
- 4 GND
- 5 2.5 kHz
- 6 ⏚
- 7
- 8
- 9
- 10



CMA/LEED LOCK-IN BOARD



CMA / LEED/AUGER PREAMP
1-12-00 S/N-2



RI4, RI5, RI6, RI7 = 15.8K, MATCHED
C22, C23, C24, C25 = 3900 pF, MATCHED

CMA/LEED/AUGER PREAMP
1-12-00 S/N-2

FIL BD - TO - FP WIRING

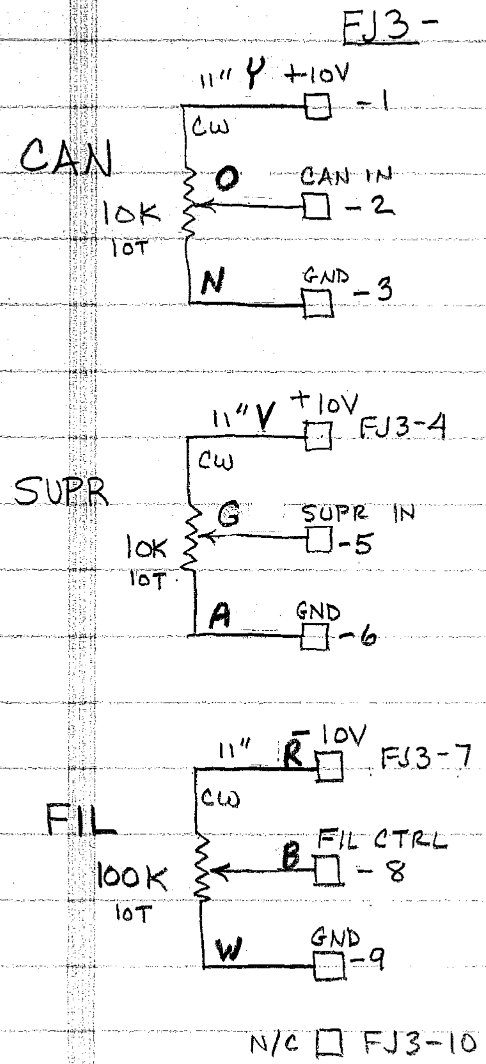
9/01
LD-5

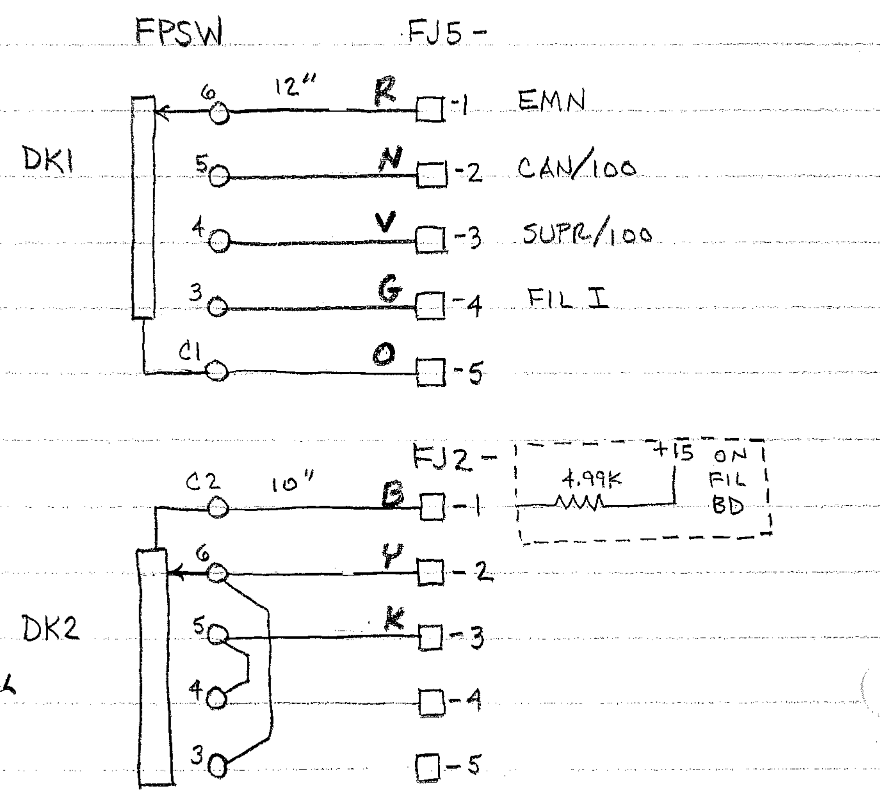
ALL WIRES = ROWE WHT HV WIRE

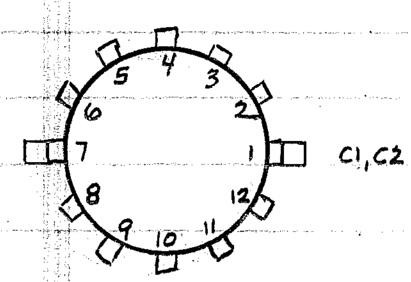
FJ3 = 10-pin MOD IV (FP-to-FIL BD)

FJ2, FJ5 = 5-pin MOD IV (FP-to-FIL BD)

FPSW = 44D30-02-2-AJN







Deck 1 is outer deck

Rear View of Can Rotary Switch

Fasten to front panel in this orientation.

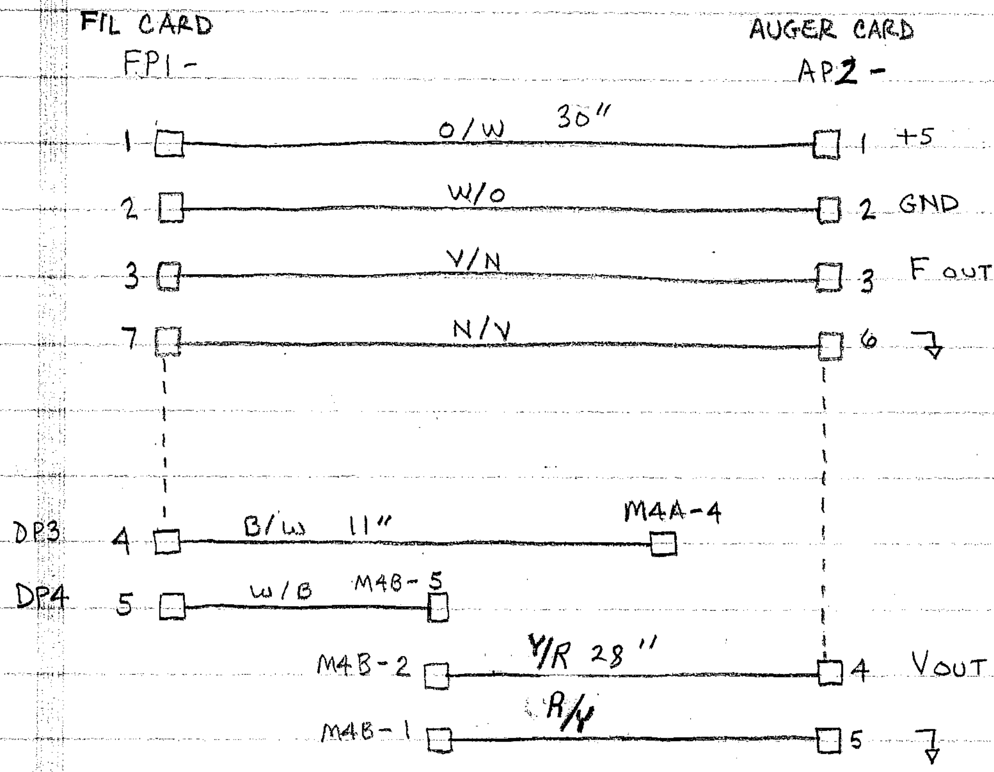
LEEDS 19-14-01
LD-6 2-8-02

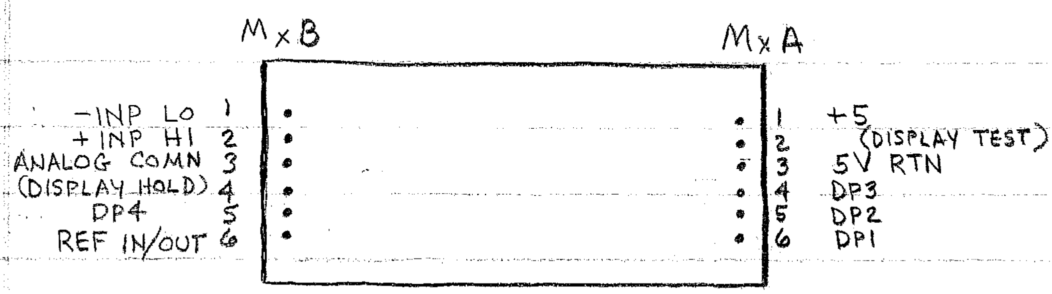
LEED FP WIRING

FP1, AP2 = 10pin MOD IV

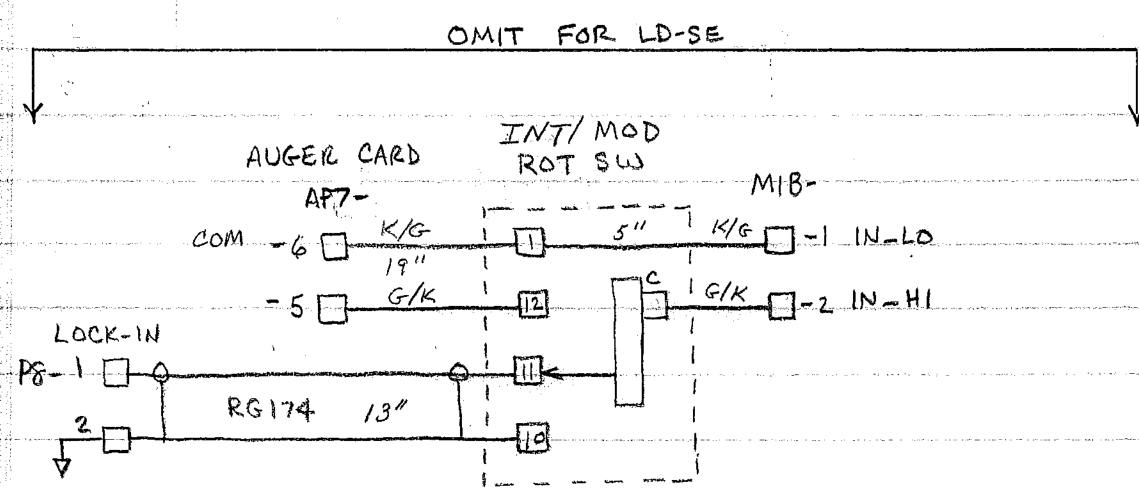
M4A, M4B = 6 pin MOD IV

LP8 = 2 pin MOD IV





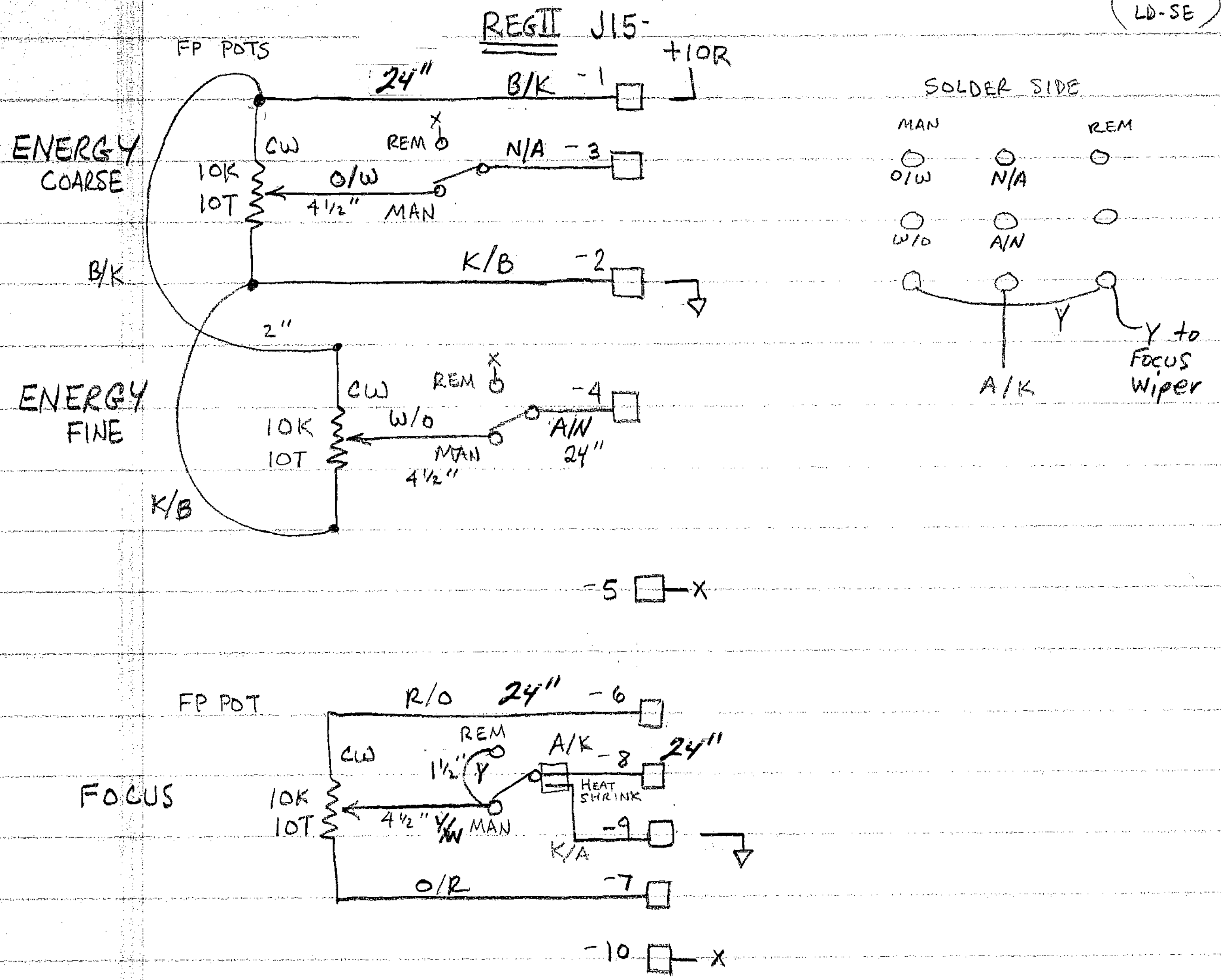
FRONT PANEL METER
(REAR VIEW)

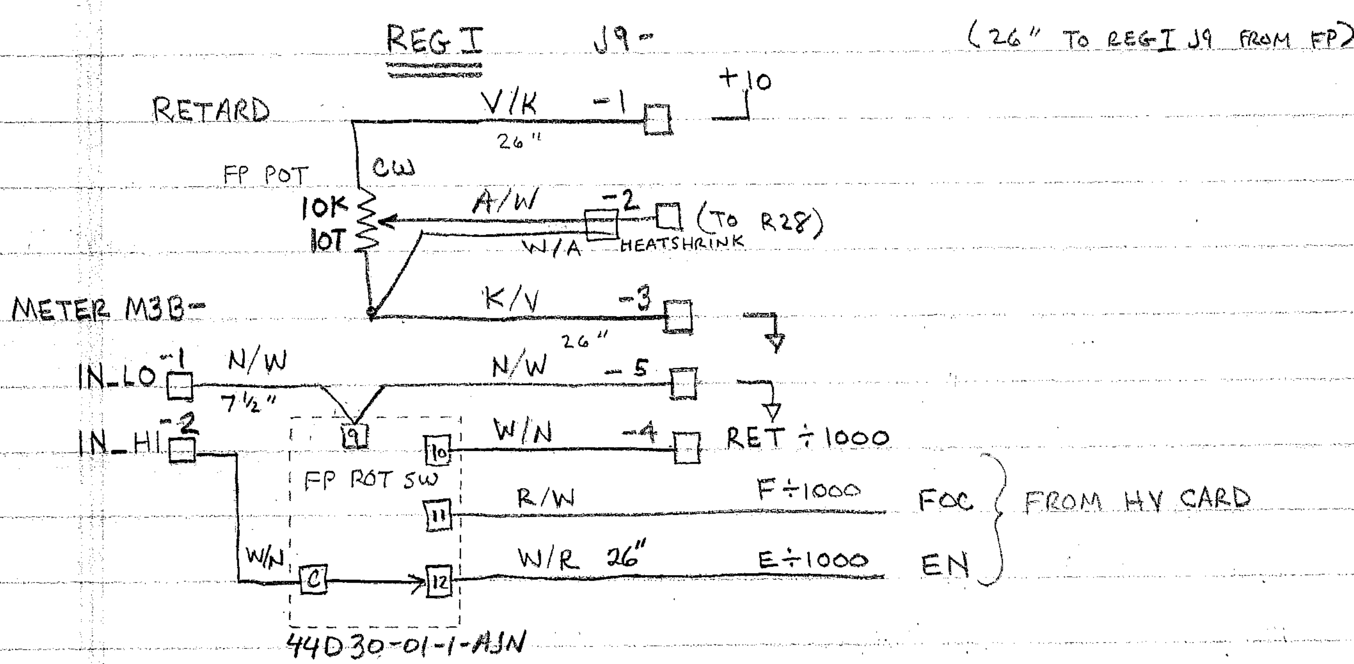


9/02

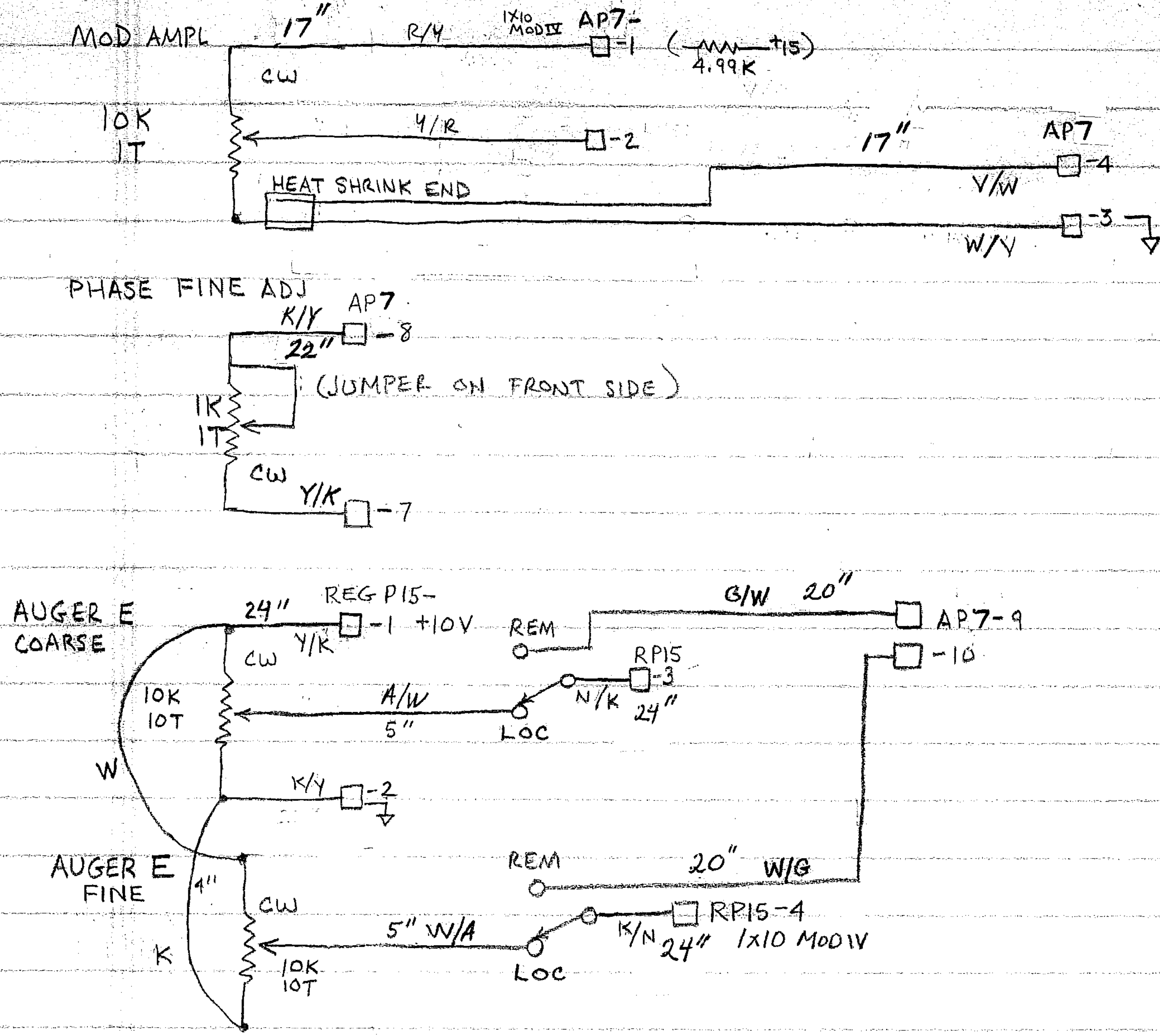
ENERGY, FOCUS, RETARD FP POT WIRING

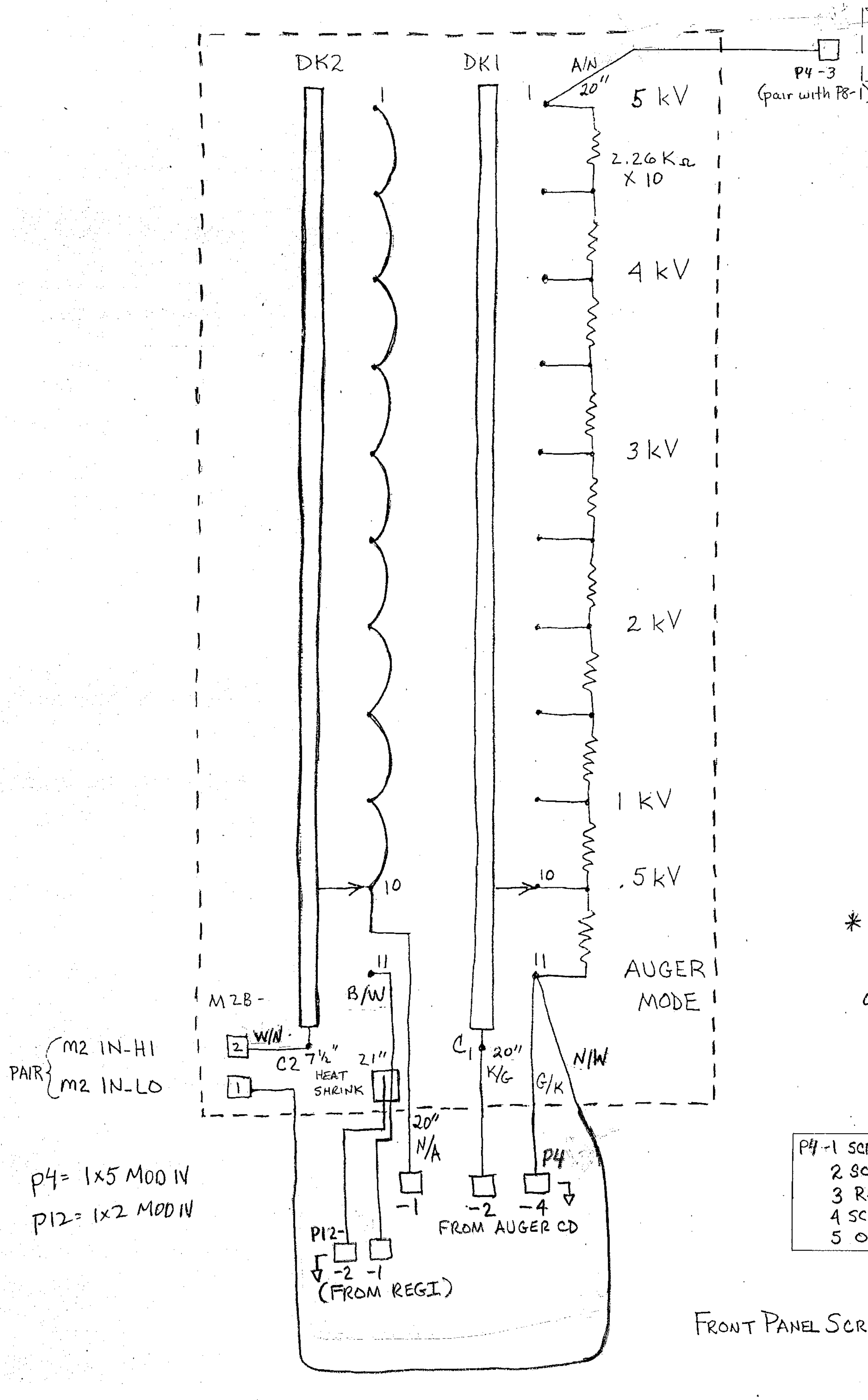
(LD-6
LD-SE)



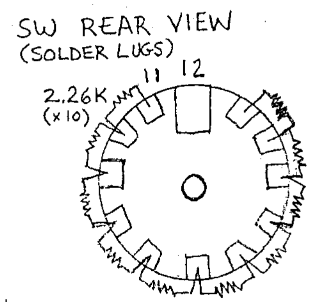


LEED/CMA FP WIRING





P4 = 1x5 MOD IV
P12 = 1x2 MOD IV



* *Bend down all tabs except the one between pins 9 & 10*

P4-1	SCR ÷ 1000
2	SCR CTL
3	Rf +10R
4	SCR SW ⏚ DK1-11
5	OPEN

FRONT PANEL SCREEN SWITCH

Cut Belden 8340 35" to Start

11/5/99 LD-2
9/10/01 LD

BELDEN 8340 #24 awg

Auger P5 → REG P2- (29")

1x5 MOD IV – MOD IV

X5 10D IV

	Auger P5		REG P2-
−15	1	O/W	3
+15	2	R/N	1
GND	3	W/O	2
+5	4		
GND	5	N/R	4
		X	5

Auger P6 → Lock-IN P1 (23")

1 X5 MOD IV (X2)

	Auger P6		Lock-IN P1
−15	1	W/N	3
+15	2	B/W	1
GND	3	W/B	2
+5	4		
GND	5	N/W	4

LockIN P2 → Preamp P2 (35")

1 X5 MOD IV (X2)

	LockIN P2		Preamp P2
+15	1	R/O	1
GND	2	O/R	2
−15	3	W/A	3
GND	4	A/W	4

LEED ONLY

REG1 P4 → Preamp P1 (NQP 26awg, 44")

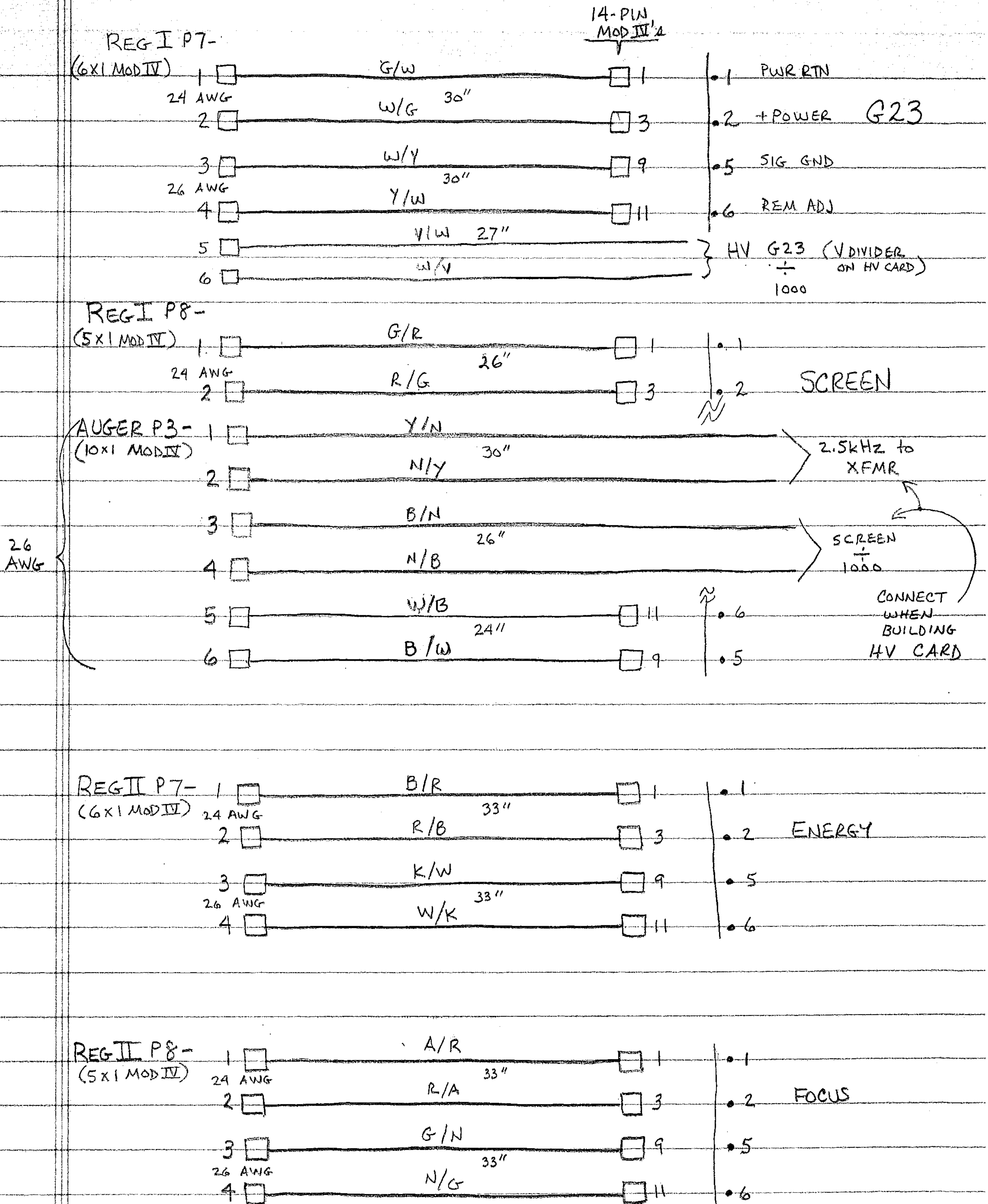
1 X3 MOD IV

	REG1 P4		Preamp P1
+300	1	R/N	1
GND	3	N/R	3

5X1

9/03

HIGH VOLTAGE CARD INPUT WIRING HARNESS



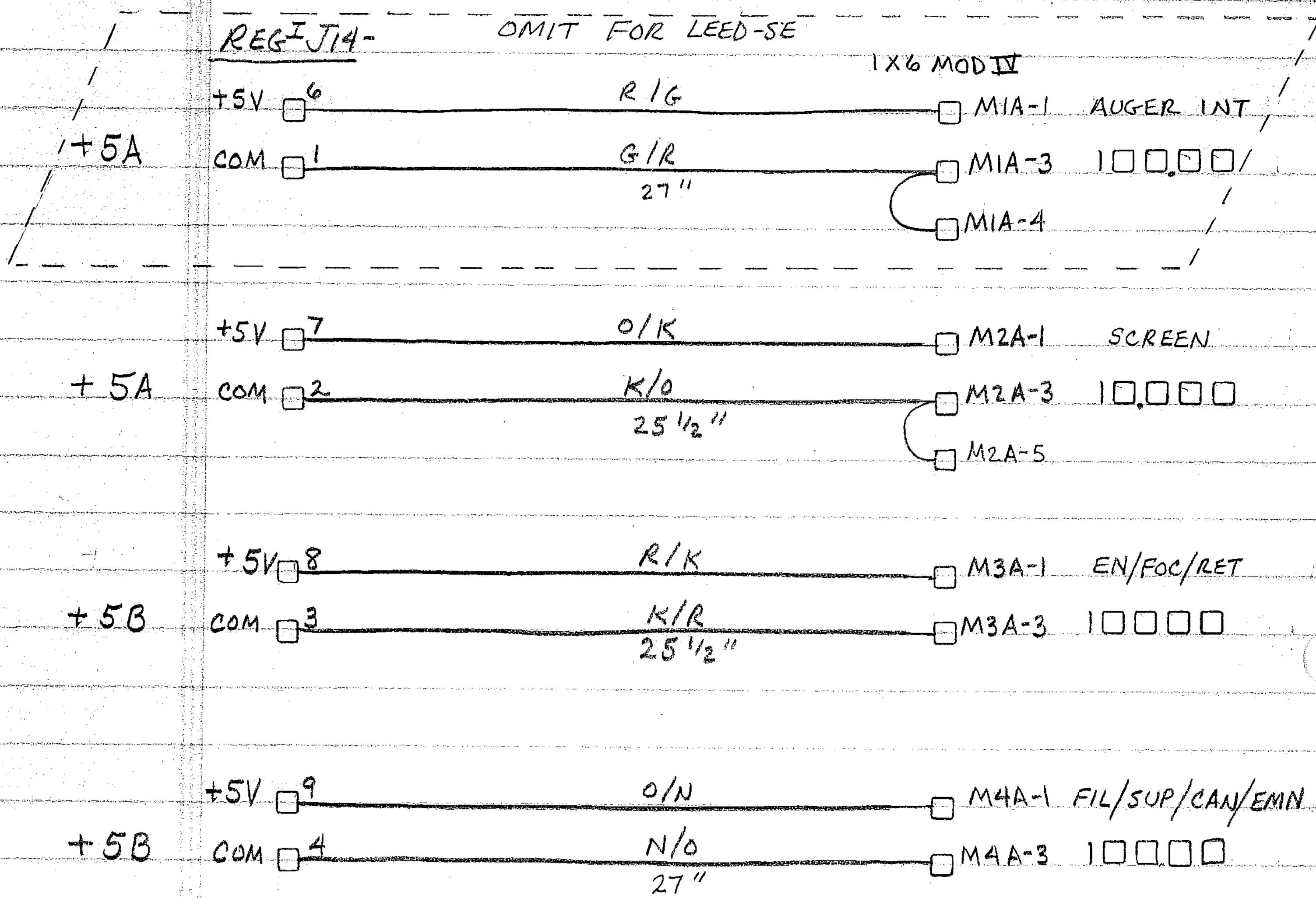
Start with 48" NQP cable

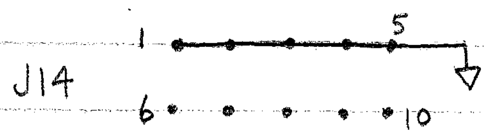
8/02

LEED METER POWER

(FOR LD-SE)

4 TWISTED PAIRS - 26 AWG

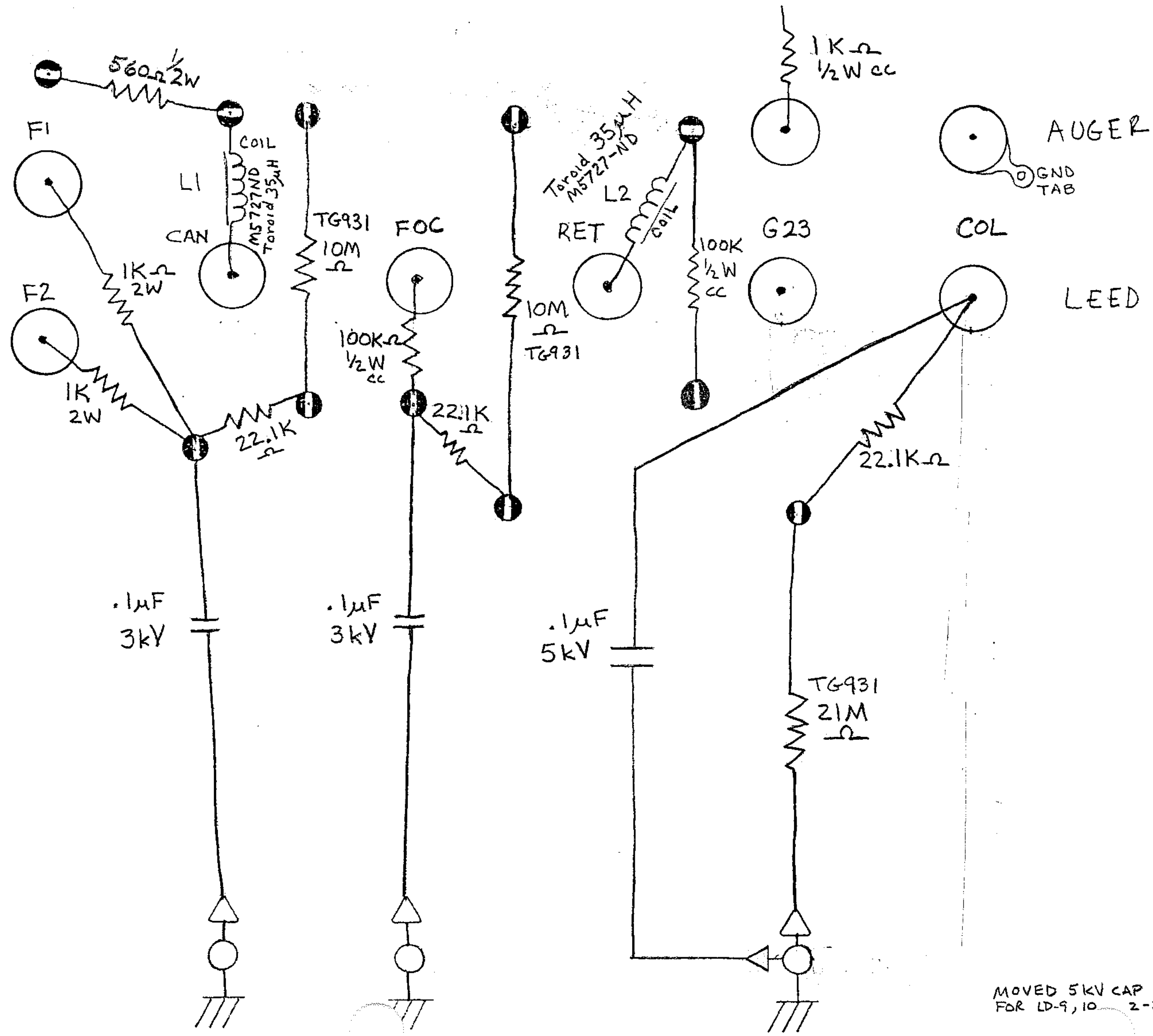




VIEW FROM INSERTION SIDE

5x2 MOD IV

7-25-00 LD-4
Pg 1/2
RP COMPONENT LAYOUT



= SHV

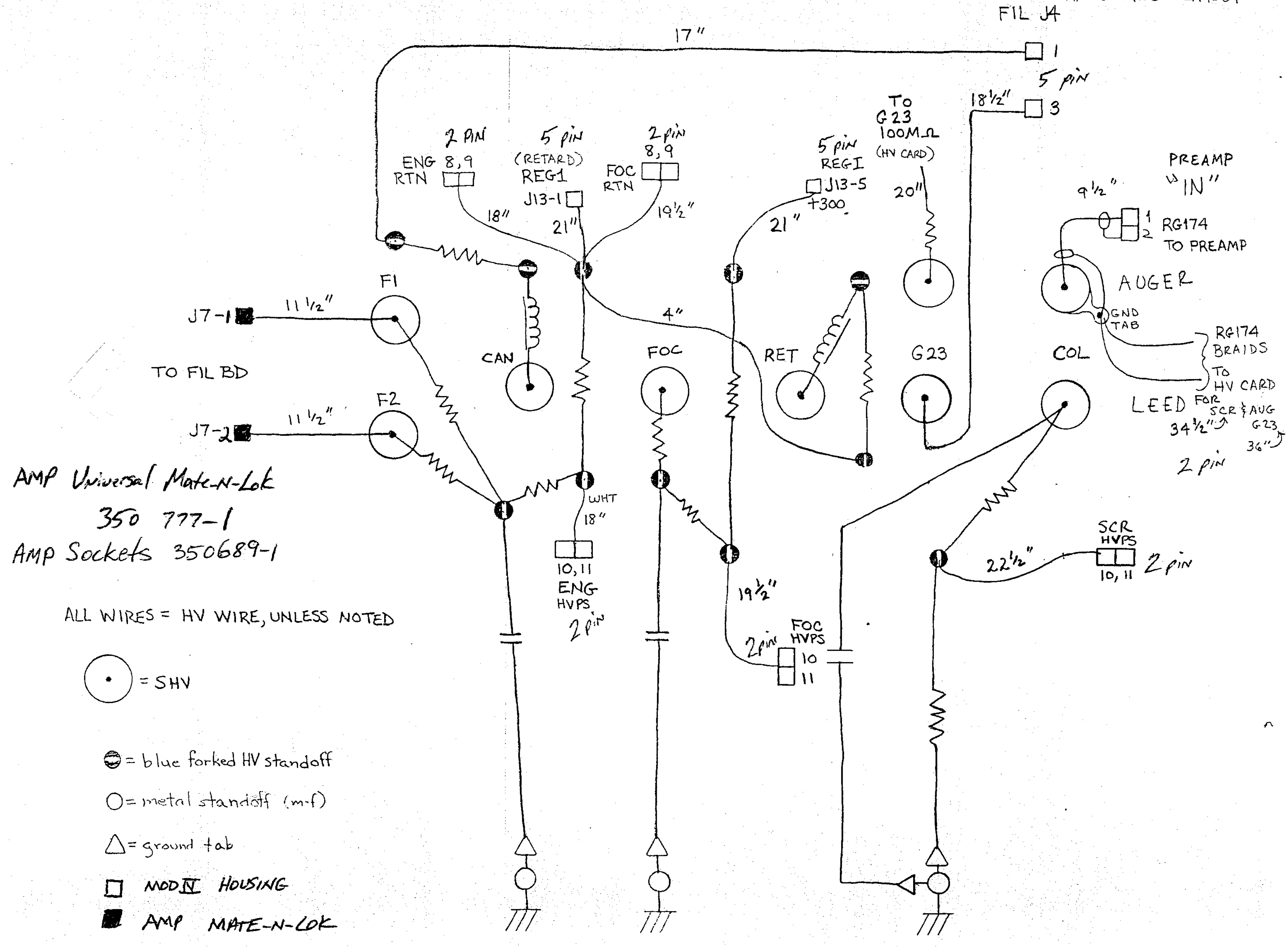
= blue forked HV standoff

= metal standoff (m-f) 1/2"

△ = ground tab

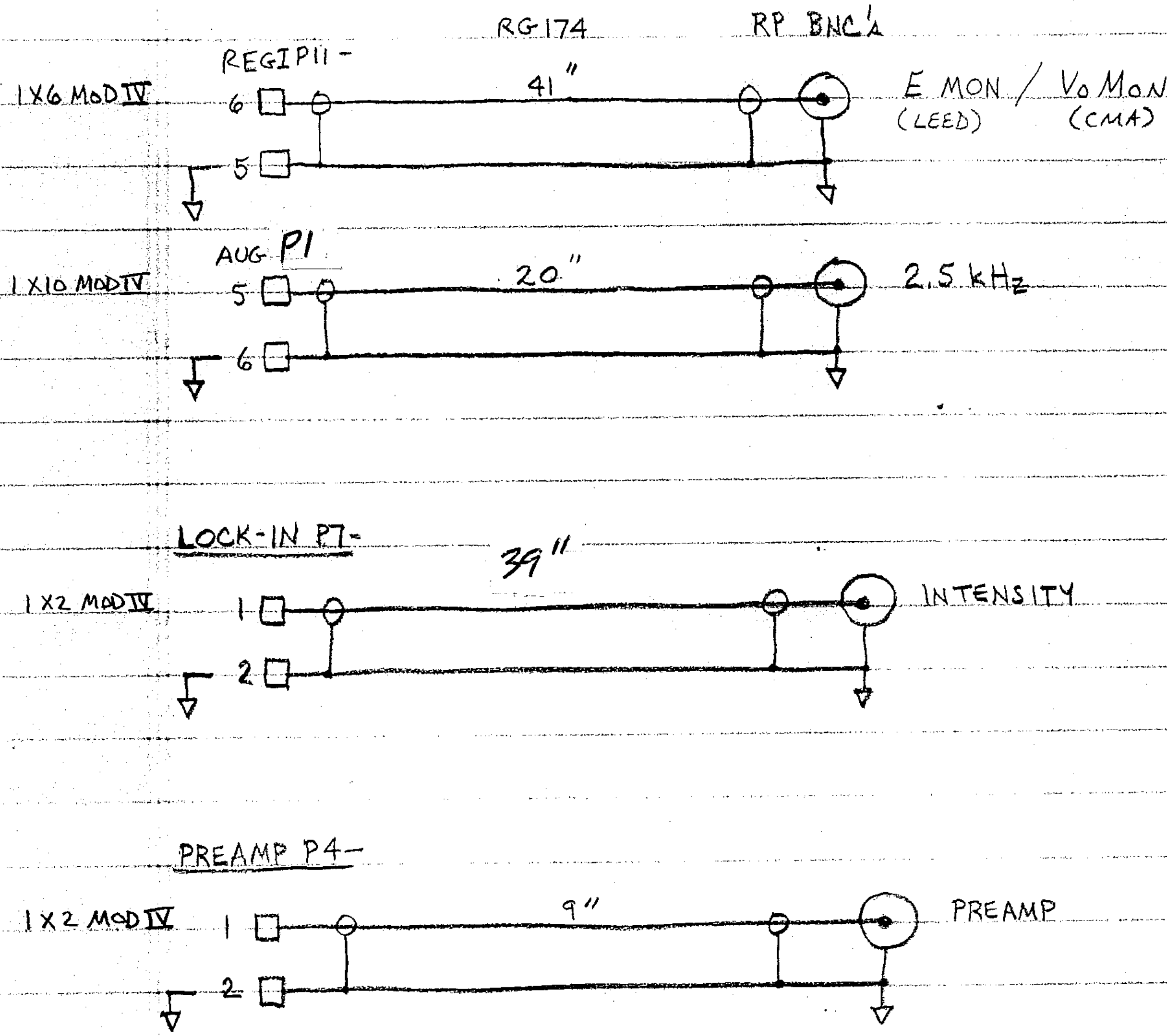
MOVED 5kV CAP
FOR LD-9, 10 2-24-04

7-25
Pg 2/2
RP WIRING LAYOUT

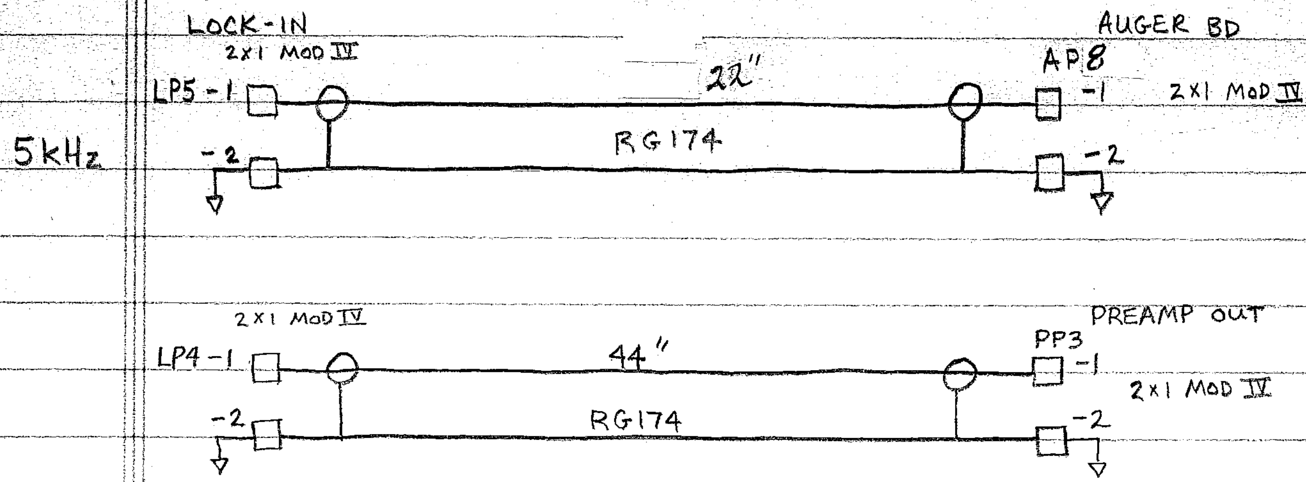


LEED / CMA RP BNC CONNECTIONS

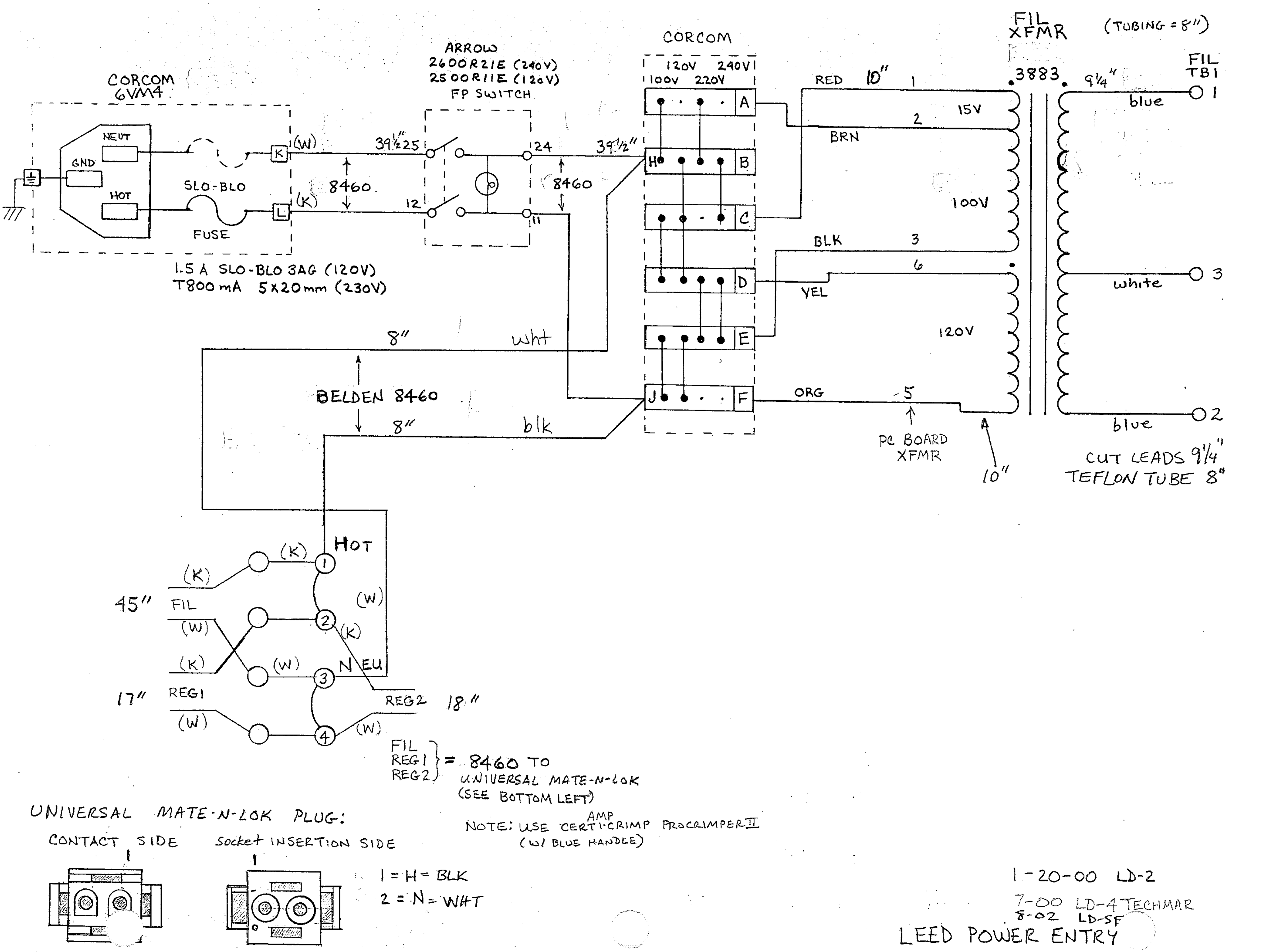
1-4-01



LEED/CMA COAX CABLES



CMA-2 LD-6 2/02
REDRAWN 8/03

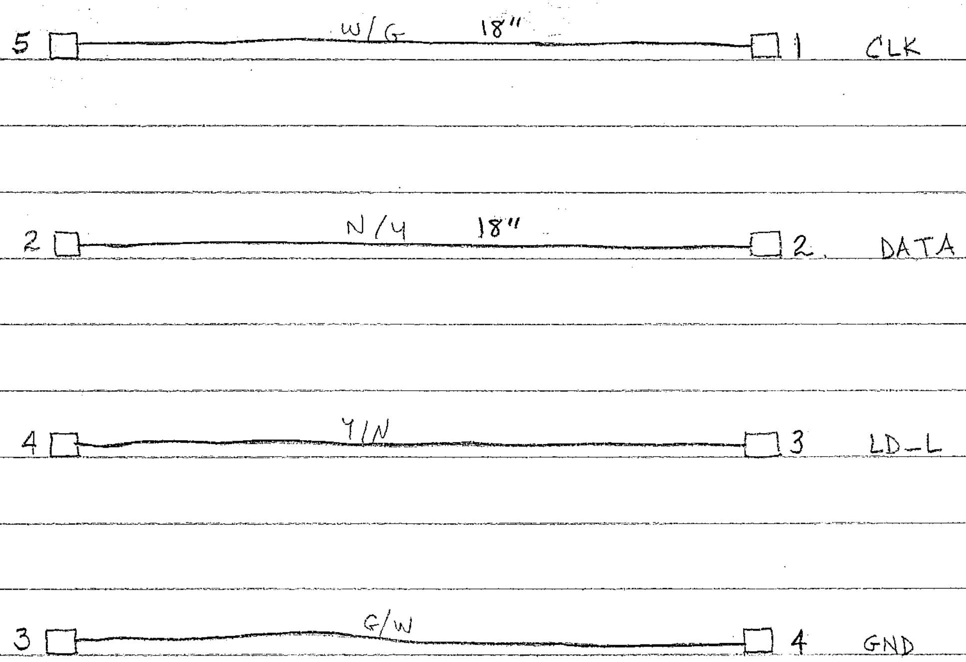

CORCOM
6VM4
NEUT
GND
HOT
SLO-BLO
FUSE
1.5 A SLO-BLO 3AG (120V)
T800 mA 5x20mm (230V)
K
L
(W)
(K)
8460
39½" 25
12
ARROW
2600R21E (240V)
2500R11E (120V)
FP SWITCH
24
11
39½"
CORCOM
100V 120V 220V 240V
A
B
C
D
E
F
H
J
RED
BRN
BLK
YEL
ORG
10"
1
2
3
6
5
15V
100V
120V
PC BOARD XFMR
10"
FIL XFMR
3883
(TUBING = 8")
9¼"
blue
white
blue
FIL TB1
1
3
2
CUT LEADS 9¼"
TEFLON TUBE 8"
8"
wht
BELDEN 8460
8"
blk
HOT
N EU
(K)
(W)
45"
FIL
17"
REG1
REG2
18"
FIL
REG1
REG2
= 8460 TO
UNIVERSAL MATE-N-LOK
(SEE BOTTOM LEFT)
NOTE: USE AMP CERTI-CRIMP PROCRIMPER II
(W/ BLUE HANDLE)
UNIVERSAL MATE-N-LOK PLUG:
CONTACT SIDE
Socket INSERTION SIDE
1 = H = BLK
2 = N = WHT
1-20-00 LD-2
7-00 LD-4 TECHMAR
8-02 LD-SF
LEED POWER ENTRY

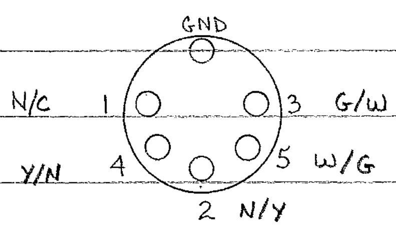
9-12-00

DP-DIN - TO - AUGER J1

INTERNAL COMPUTER SIGNAL WIRING

RP DIN — AUGER J1 (10-PIN MOD IV)





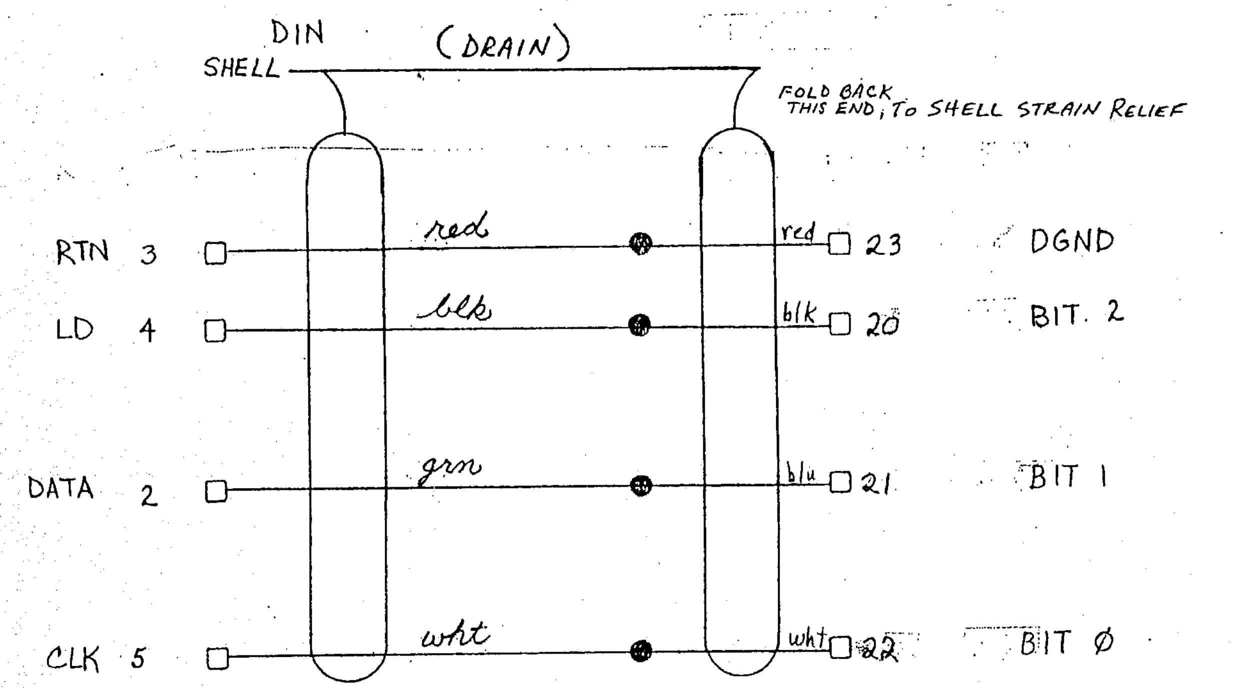
DIN SOLDER SIDE

CMA/LEED COMPUTER CABLE

12-2-99 S/N-2
2-8-08 -11

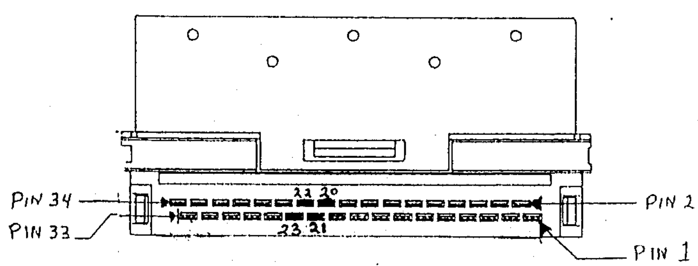
Cabling: 15' Belden 9534 OR Equivalent

● = splice to #30 awg ww wire
to: KCPI-3116



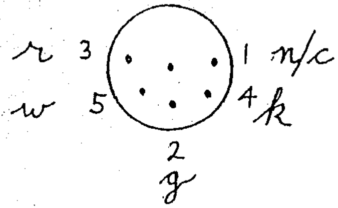
P1 = Φ5BL5M
5-pin Male DIN Plug

P2 = Molex 7145-3001 68 pin VHDCI



VHDCI 68 PIN LAYOUT

Molex # 71425-3001

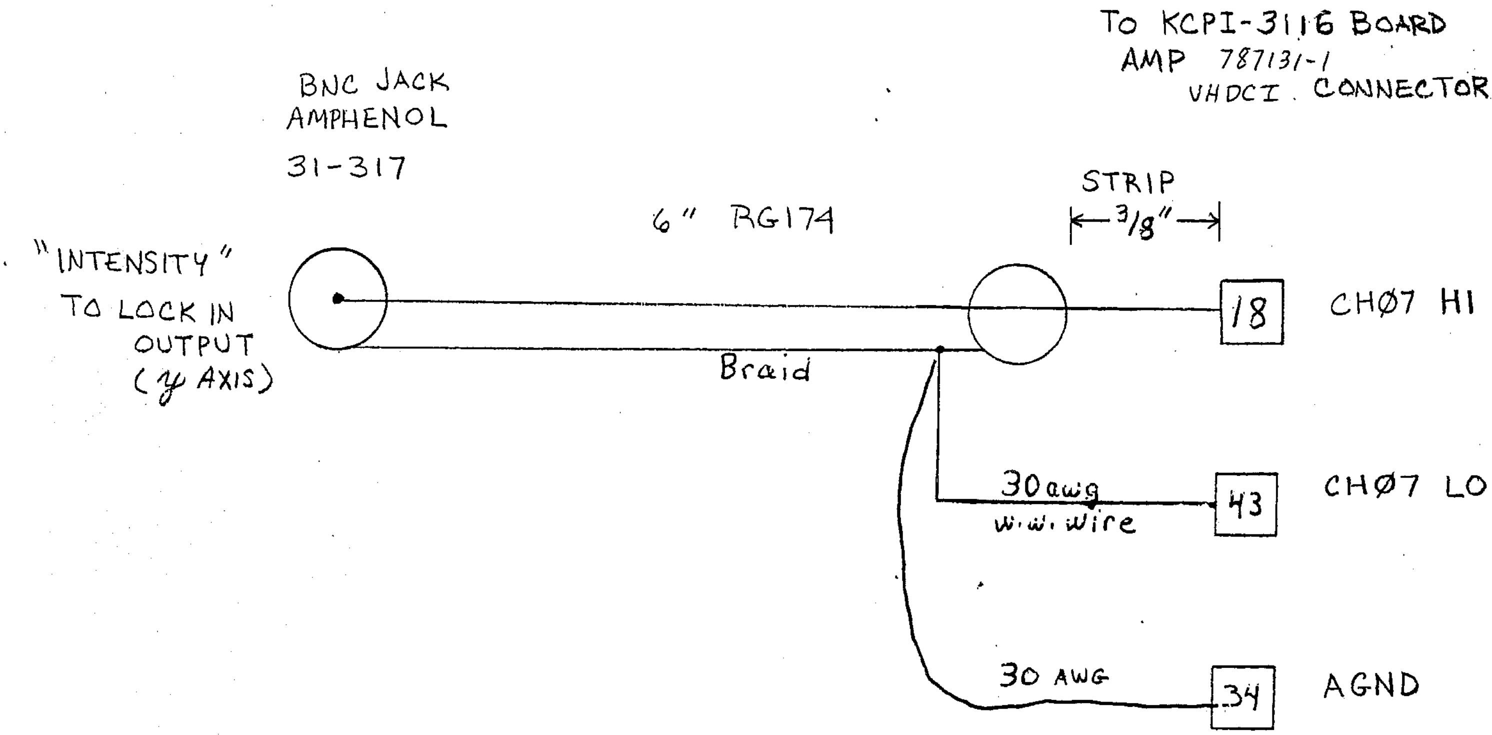


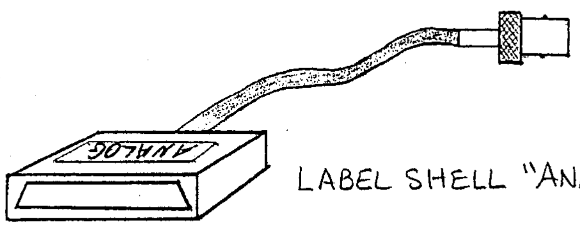
DIN Solder Side

DRAWN BMR 1-13-94
REVISED SAW 12-16-94
REV II SAW 9-12-96
REV III SAW 2-2-98 ELS3-15, ELS5-1
REV IV SAW 1-25-00 LD-2
REV V SAW 8-11-03 LD7 & 8

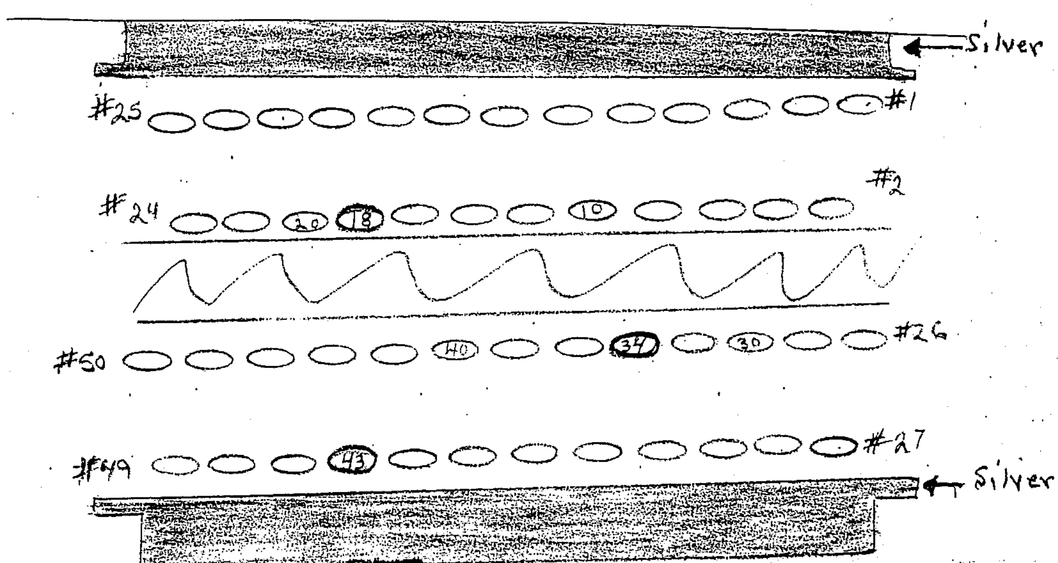
LEED/CMA ANALOG INPUT CABLE

2-8-08 CMA-11, LD-22





LABEL SHELL "ANALOG"



VHDCI 50 pos. crimp side