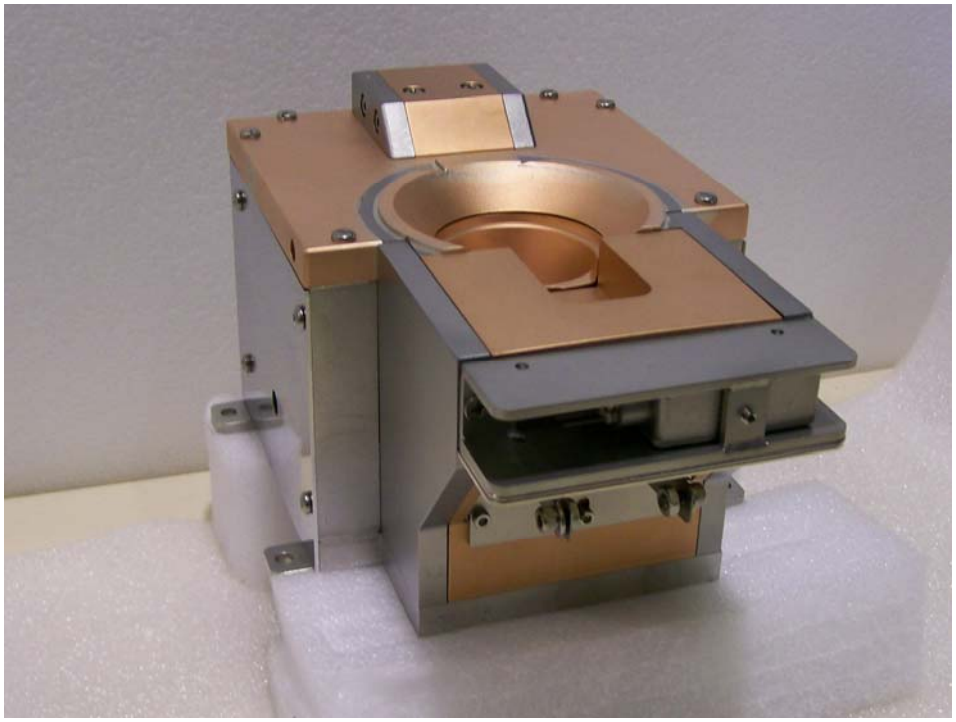
Model HCR
ROTARY e-Gun™
Evaporation Source Manual



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Safety Instructions

DANGER: HIGH VOLTAGE

A. Before servicing or operating this equipment, read this manual and the associated e-Gun power supply manual paying special attention to **ALL SAFETY PRECAUTIONS**.
B. The high voltage used by these evaporation sources can be **INSTANTLY FATAL**. Furthermore, due to internal capacitance in the power supply, **THIS LETHAL VOLTAGE CAN PERSIST EVEN AFTER THE POWER SUPPLY HAS BEEN TURNED OFF**. Before entering the chamber make sure that the power supply is off and then use a grounding hook on the high voltage leads from the e-gun. Do not touch the high voltage leads unless the power supply is turned off and the grounding hook is attached to the part to be serviced. All grounding hooks are supplied with Thermionics brand power supplies.
C. E-gun systems must be clean. Use lint free gloves when handling vacuum components. As the e-gun source is operated coating will build up in the vacuum system and in time create particulates ("flaking of the coating"). A periodic cleaning procedure should be employed to prevent shorting and/or contamination of the e-gun source. Aluminum foil is a popular way of shielding the vacuum system from unwanted coating build up with an inexpensive, disposable material.
D. Operation of an e-gun source without proper water-cooling **WILL** result in failure of the source. A water flow interlock switch should always be used to assure proper water flow.

THEORY OF OPERATION

An electron beam evaporation source uses a beam of focused electrons to vaporize material in a high vacuum environment. The vaporized material then condenses on an object (called a substrate) in the same high vacuum chamber to form a thin film of material. The material, which is evaporated to create the film, can be anything that is solid in the vacuum environment, such as gold, silicon dioxide, or some mixture of substances, depending on the specific application. The vapor emitted from an e-gun source can be roughly calculated using cosine distribution as a model. Small deviations do exist from this model due to the e-guns magnetic field and the ability of many materials to become ionized during the evaporation process.

To evaporate a material with an e-gun source, a load (or "charge") of material is placed in a water-cooled copper crucible inside a vacuum chamber. Then a substrate is placed above the crucible to receive the vapor (normally 18 to 24 inches for a 10kW source). The chamber is evacuated. A filament, held in a cathode assembly is given a high negative potential relative to the grounded crucible. The filament is heated to the point of thermionic emission by an electric current. The liberated electrons are then accelerated away from the filament by a grounded anode plate placed just outside of the cathode assembly. The accelerated electrons are injected into a permanent magnetic field that directs and focuses the electrons to the water-cooled crucible. The accelerated electrons kinetic energy is transformed to thermal energy as they impact the evaporant material placed in the crucible. Temperature in excess of 3500 degrees Celsius can be easily achieved allowing the direct evaporation of virtually any material.

INSTALLATION

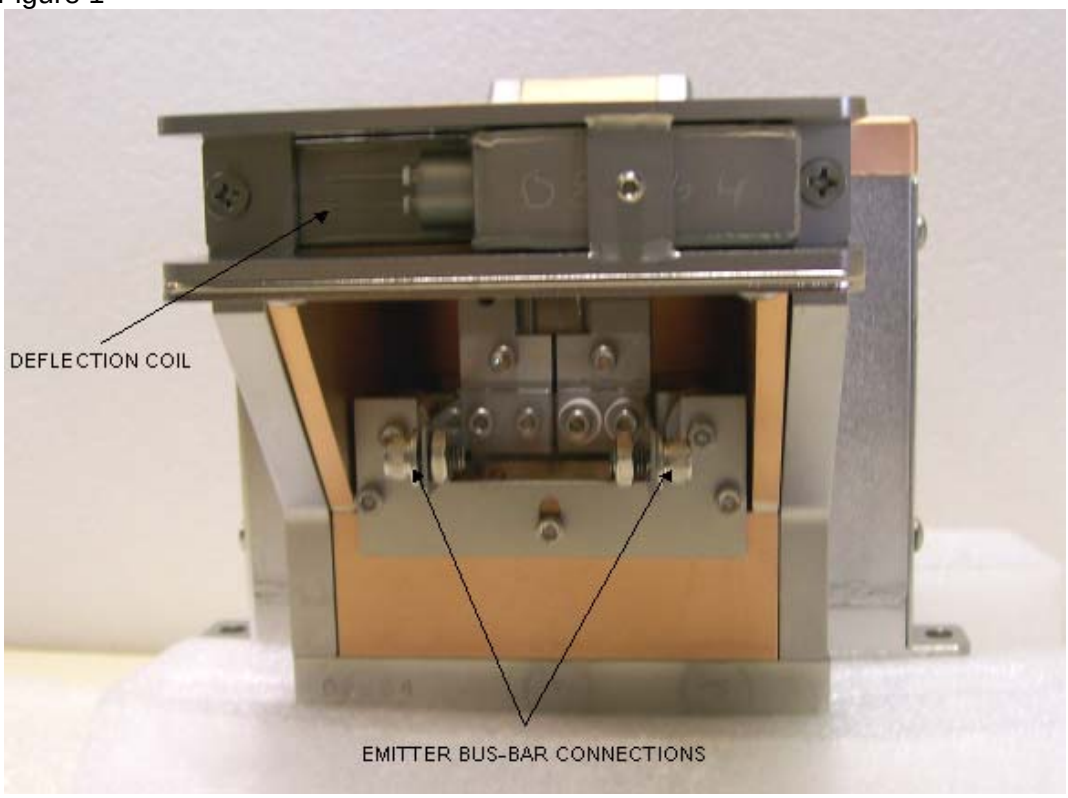
The following components are required for customer installed fixed e-gun systems:

A. Water feedthrough and tubing (3/8" (o.d.), type 304 stainless steel).
B. High Voltage feedthrough. TLI model B111136-12 or equivalent (check flange type for specific installation).
C. High Voltage hookup strap, Oxygen free copper.
D. High Voltage shielding (type 304 stainless steel). Shielding should be made to cover high Voltage leads. These shields should maintain approximately .50" spacing from the high voltage surfaces. Do not place shielding closer than .25". You can place the shielding further away although you will loose the dark space shielding effects (prevents unwanted arcing/discharges).
E. Interlock switches: water, vacuum and high voltage access.
F. Filtered water at 4 gpm at 50 psi.
G. High Voltage power supply. TLI model SEB-15 or equivalent.
    a. Four pin instrument feedthrough (optional) for connecting sweep coils. TLI model 111139-04 or equivalent (check flange type for specific installation).

TO INSTALL THE E-GUN SYSTEM

1. Mount the e-gun in the chamber. Make sure that the source is grounded to the chamber (bolting the source to the baseplate is recommended)
2. Form the water lines from the feedthrough to the e-gun making sure to leave at least .50" from the VCO connections to any bends.
3. Join the lines by heliarc welding. (See figure 1)
4. Connect high voltage strap. A length of copper strap is provided. Make a small hole at the end of the wire for bolting to the emitter buss bars and high Voltage feedthrough clamps. (See figure 2)
5. Attach the sweep coil leads to the instrumentation feedthrough (optional) following the wiring diagram in Appendix A. (See figure 2)
6. Install high Voltage shielding.
7. Connect all interlocks.
8. Connect external grounds (mandatory power supply ground and independent earth ground); high Voltage cables and sweep cables per power supply manual(s).
9. Assure a minimum water flow of 2.5 gpm with a pressure of 50 psi or above.

Figure 1



HCR Connections

Figure 2

OPERATION

CRUCIBLE PREPERATION

Cleanliness is critical for high quality films and trouble free operation. CLEAN the crucible thoroughly before each new material is used. Heavy buildup of the previous material on the crucible can cause contamination of the melt. The crucible should be cleaned with an abrasive pad ("scotch bright") and then vacuumed out. It should then be wiped out with acetone and alcohol. Cleaning by glass bead blasting is another alternative. When using a glass bead blaster make sure to keep the air pressure at 40psi. The source should be disassembled prior to glass bead blasting and special attention should be given to removal of all glass from the parts after cleaning (glass is a dielectric material and will cause severe arcing if left on the source).

CHOSSING EVAPORATION MATERIAL

Material for evaporation comes in a variety of forms and purities. Typically the process will determine purity. Thermionics typically recommends using 3 to 6mm granule material. This material form is readily available and allows you to add material as it is depleted from the crucible. Starter charges are also available from many manufactures. Although they provide a dense original charge of material they can contain impurities that might otherwise be "degassed" during the melt down of a granule type material. Powders can be used but are not recommended. Powders can "splash/spit" during initial heating making them difficult to melt.

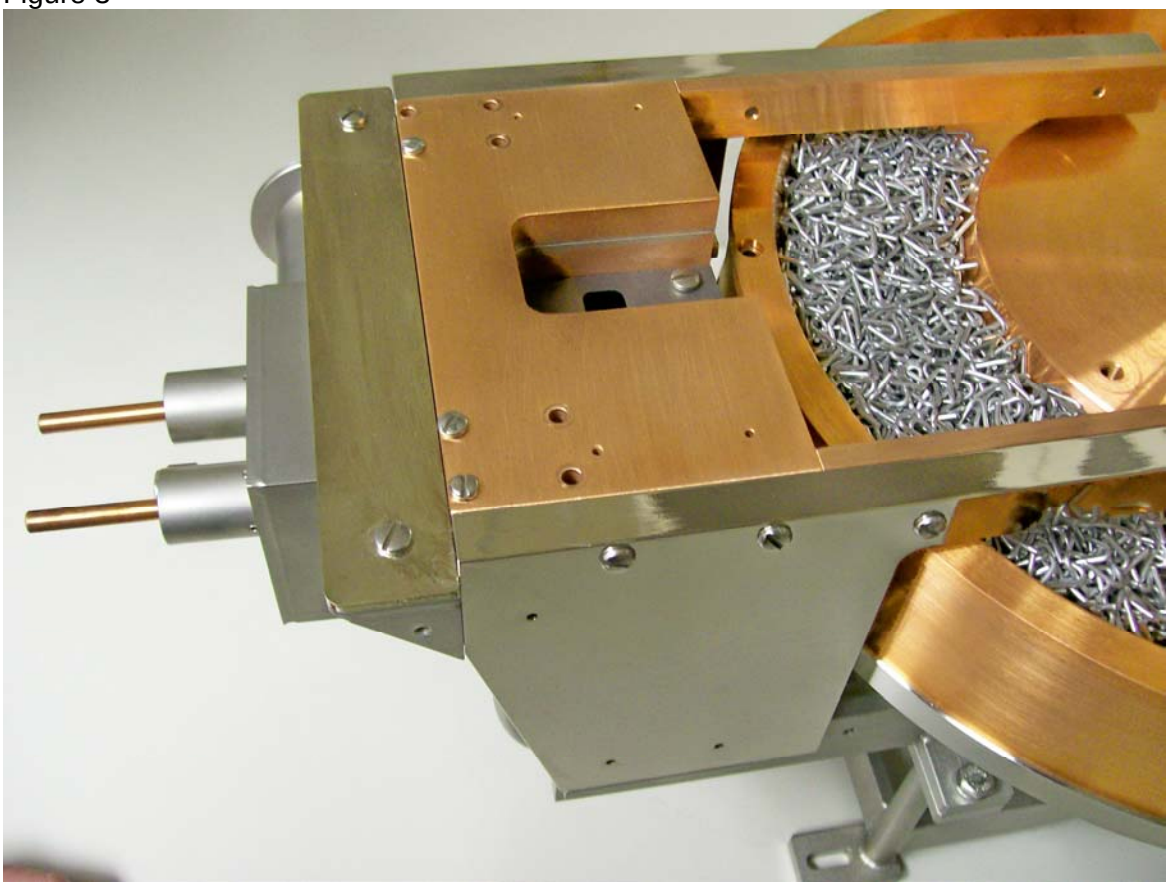
FILLING THE CRUCIBLE

Running the e-Gun with **an empty crucible will destroy the source**. Fill the crucible with evaporant material. If you are using granules, pack the crucible and form a "slight" dome (see figure 3). As the granules melt they will fill in the voids and you should have a full crucible. Make sure not to overfill the crucible, the top plate must have clearance to turn. It is best to operate the source with the crucible filled between 20% and 100% (for liners see below).

FILLING A CRUCIBLE LINER

Crucible liners add a thermal barrier between the evaporant material and the water-cooled crucible. Liners also prevent build up of coating on the e-gun and reduce the need for cleaning. **Overfilling a crucible liner is the number one cause of failure** (cracking). Fill liners between 20% (minimum) and 80% (maximum) unless evaporating Aluminum (70% maximum fill). Make sure that all material is carefully stacked into the liner (see figures 4a and 4b). If **material "spills**" over the top of the liner and touches the water-cooled copper it **will destroy the liner**.

Figure 3

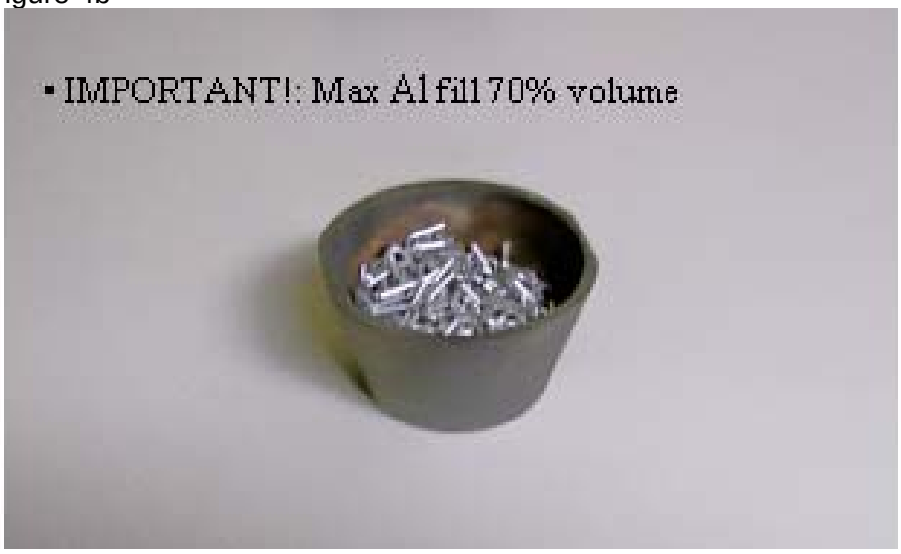


Properly filled carousel (leave clearance for rotation)

Figure 4a

Properly filled liners with SiO_2

Figure 4b



Properly filled Graphite liner with Al

FINAL CHECK PRIOR TO PUMPDOWN

1. Turn on the water and check visually for leaks.
2. Make sure the crucible is loaded with material.
3. Visually check the high voltage and sweep leads making sure you have ½ inch clearance around all high voltage leads. Make sure the sweep leads do no pass directly behind the source (if they must make sure to install a grounded shield around them).

At this point you are ready to pump down the system.

WARNING: e-GUN SYSTEMS REQUIRE AN INDEPENDENT EARTH GROUND IN ADDITION TO POWER SUPPLY RETURN AND SAFETY GROUND. SEE APPENDIX B FOR DETAILS.

e-GUN OPERATION

1. Make sure the vacuum chamber is operating at a pressure less than 5x10^-4 Torr.
2. Make certain all interlocks are operating properly. All grounds must be secure.
3. Turn on the e-GUN cooling water (this should be interlocked to the high voltage power supply).
4. Assure desired crucible is selected and properly located.
5. Set the power supply emission current potentiometer to zero.
6. Turn on the power supply and check to see that all interlocks are satisfied.
7. Turn on the high voltage. If using a variable voltage power supply, slowly bring up voltage to negative 10,000 volts DC.
8. Turn on the emission current and slowly increase the potentiometer until you see a slight glow on the crucible. This will normally appear as a blue glow at an emission current of about 20 to 30 milliamperes. Slowly increase the power to 50 milliamperes, or until you can clearly see the beam spot.

Note: The e-gun is factory set to locate the beam just off the center of the crucible. If the crucible is not close to center you must make adjustments. If you have a variable voltage power supply, adjust the voltage to center the beam or use the x-y sweep position controls to center the beam. If you do not have variable voltage or a sweep controller you will need to make magnetic adjustments to the e-gun. Contact the factory for adjustment procedures.

DEPOSITING MATERIALS THAT MELT

After following the above procedure (steps 1 through 8), continue to slowly increase power in 20 to 30 milliamp increments. If the material appears unstable (flickering light or waves in the melt) stop and let it set until it re-stabilizes (you may have to reduce power if stability cannot be restored). Arcing will occur and is normal in e-Gun evaporation. Stop increasing power when arcing is observed and let the source soak until arcing stops (on melting materials arcing is normally caused by outgassing). Continue to increase power until reaching the desired rate.

Note: Oxide formation can prevent an evaporant charge from melting in some cases. Some metals (aluminum and copper are examples) will form an oxide that prevents melting and causes the beam to appear unfocused. When this occurs you can invert the melted slug and re-melt it to remove the oxide -or- replace the charge with fresh material.

DEPOSITING MATERIALS THAT DO NOT MELT (SUBLIME OR SEMI-SUBLIME)

Subliming materials require beam sweep. All HC e-Guns are equipped with electro-magnetic coils for this purpose, XYS and programmable sweep generators are available as optional items and are required to perform beam sweep functions.

After following the above procedure (steps 1 through 8). Turn on the sweep controller and center the e-beam in the pocket. Set the frequency of both X and Y channels (lateral and longitudinal) to about 10 hertz (1/4 turn on potentiometer models). Increase the amplitude controls until the beam covers 80% to 90% of the crucible. It is best to avoid striking the edge of the crucible as this can cause contamination of the film. Increase the frequency until the desired temperature distribution is achieved. This will vary by material and process. Most dielectric materials prefer a medium to high frequency setting (~40 to ~100 hertz) while chrome and some high temperature oxides prefer a lower setting (~10 to ~30 hertz). The optimum settings must be developed through trial and error. Once the sweep frequency and amplitude are set, continue to slowly increase power until achieving the desire rate.

Note: some subliming materials will not support electrical current until heated. This causes surface charging on the material that results in arcing. The surface charging effects can also cause the beam to be “scattered” behind the crucible and onto the top plate of the e-gun. This is normal with some materials. The e-gun top plate is designed to dissipate this energy. To evaporate materials that have surface charging effects you must increase the “soak” times of the electron beam as you increase power. If you allow the source to set at a power level of ~50 to ~75 milliamperes for an extended time (make sure arcing is not severe) the material will eventually be heated sufficiently to “fire” and the beam will stop scattering beyond the crucible. You will in many cases still see some hazing on the e-gun source (this is normal) during evaporation. As the e-gun becomes coated with these materials hazing may increase.

e-GUN SHUT DOWN

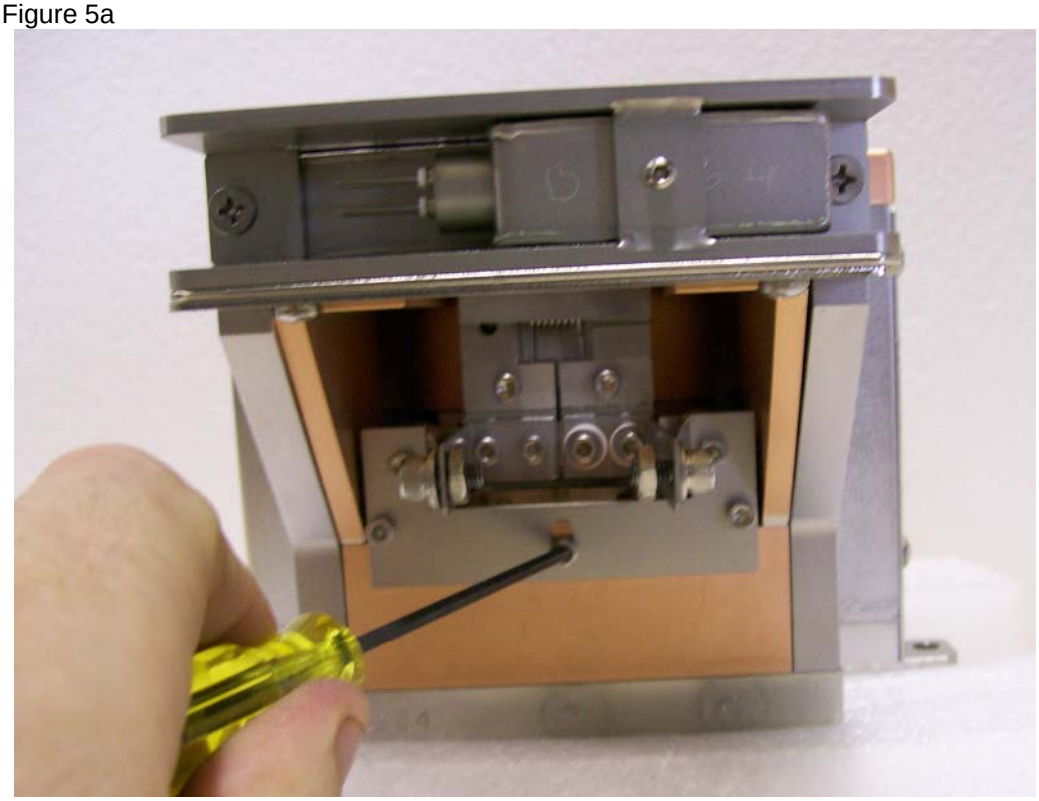
Once the desired rate is achieve; close shutter (if so equipped) or reduce emission current to zero. Turn off high voltage. Allow adequate cooling time prior to venting the system. The e-Gun must be allowed to cool of for at least 5 minutes unless venting to an inert gas to protect the filament. Most metals will cool down quickly ~5 minutes unless they are used in a crucible liner. Subliming and dielectric materials or metals used in insulating liners require additional cool down time. Normally 20 minutes will be adequate although conditions can vary.

CHANGING THE FILAMENT

Filament life is greatly affected by the vacuum level and the types of gas present in the vacuum system (example: Oxygen partial pressures will reduce filament life). Normally filaments will last between 200 and 800 hours. To change a filament follow the procedure listed below (also see Appendix C):

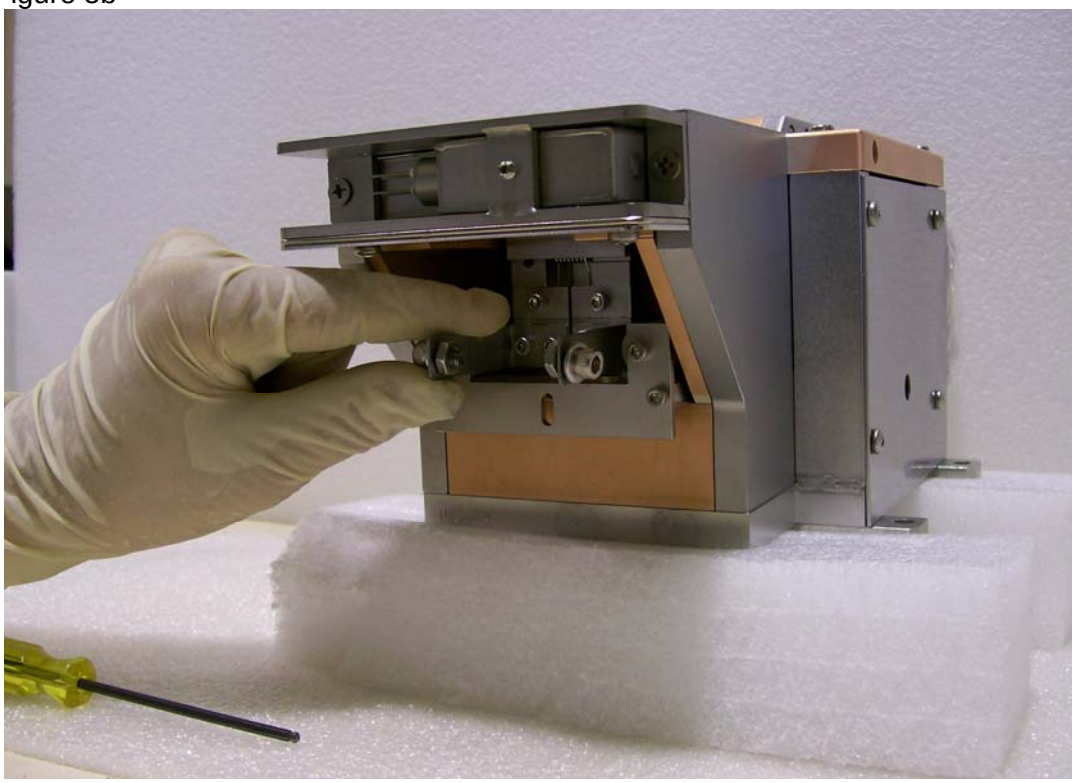
1. Remove the emitter assembly by disconnecting the high voltage leads from the emitter buss bars and then removing the one 6-32 mounting screw.
2. Remove the filament clamps (item 16 App. C)
3. Remove the old filament and clean the surface where the filament contacted the clamps and cathode blocks (use a clean abrasive pad)
4. Install a new filament and replace the filament clamps. Snug the filament clamp screws (item 15 App. C) to allow the filament to be located but still move. Adjust the filament so you have a even gap of .010 inches between the filament and the beam former (see App. C). Tighten the filament clamp screws.
5. The gap between the beam former and the anode should be checked to assure a spacing of .040 inches.
6. When looking down on the filament you should see ~1/3rd of the filament exposed. The filament, beam former and anode should all be parallel to each other. This spacing is very important to assure proper focusing of the electron beam.
7. Replace the emitter assembly and reconnect the high voltage leads. (See figures 5a-5f)

Figure 5a



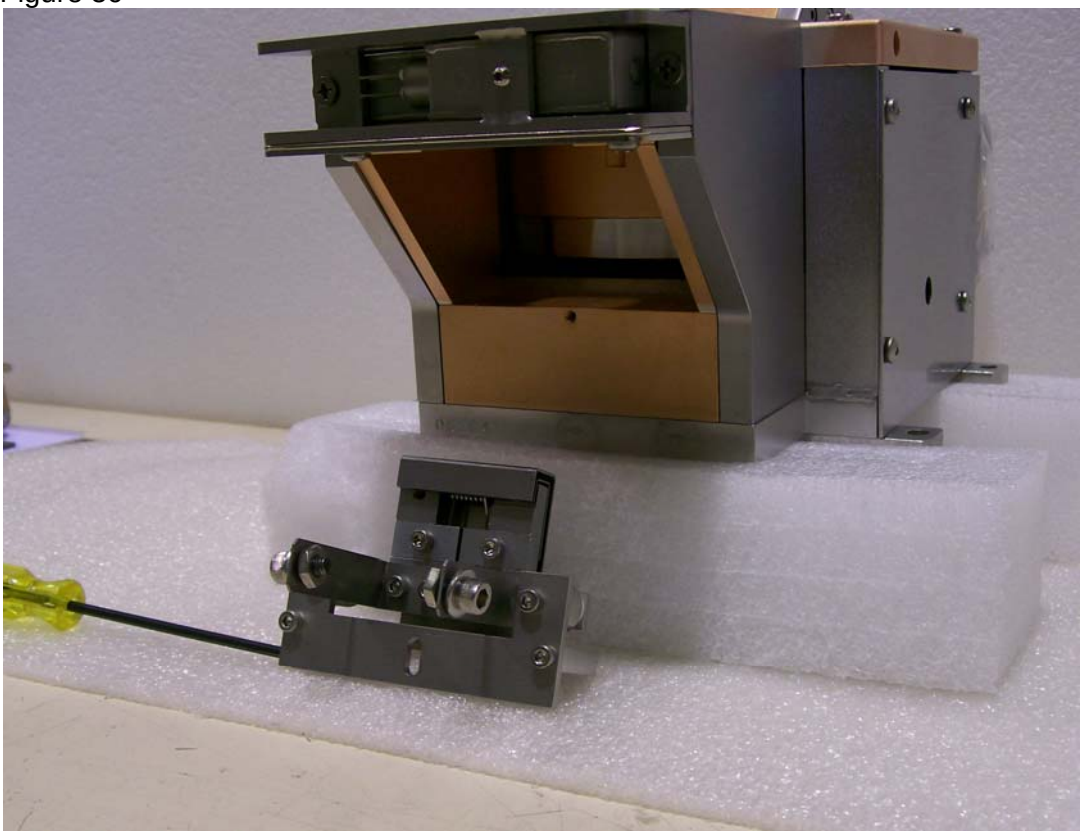
Remove 1, 6-32 screw to remove Emitter Assembly

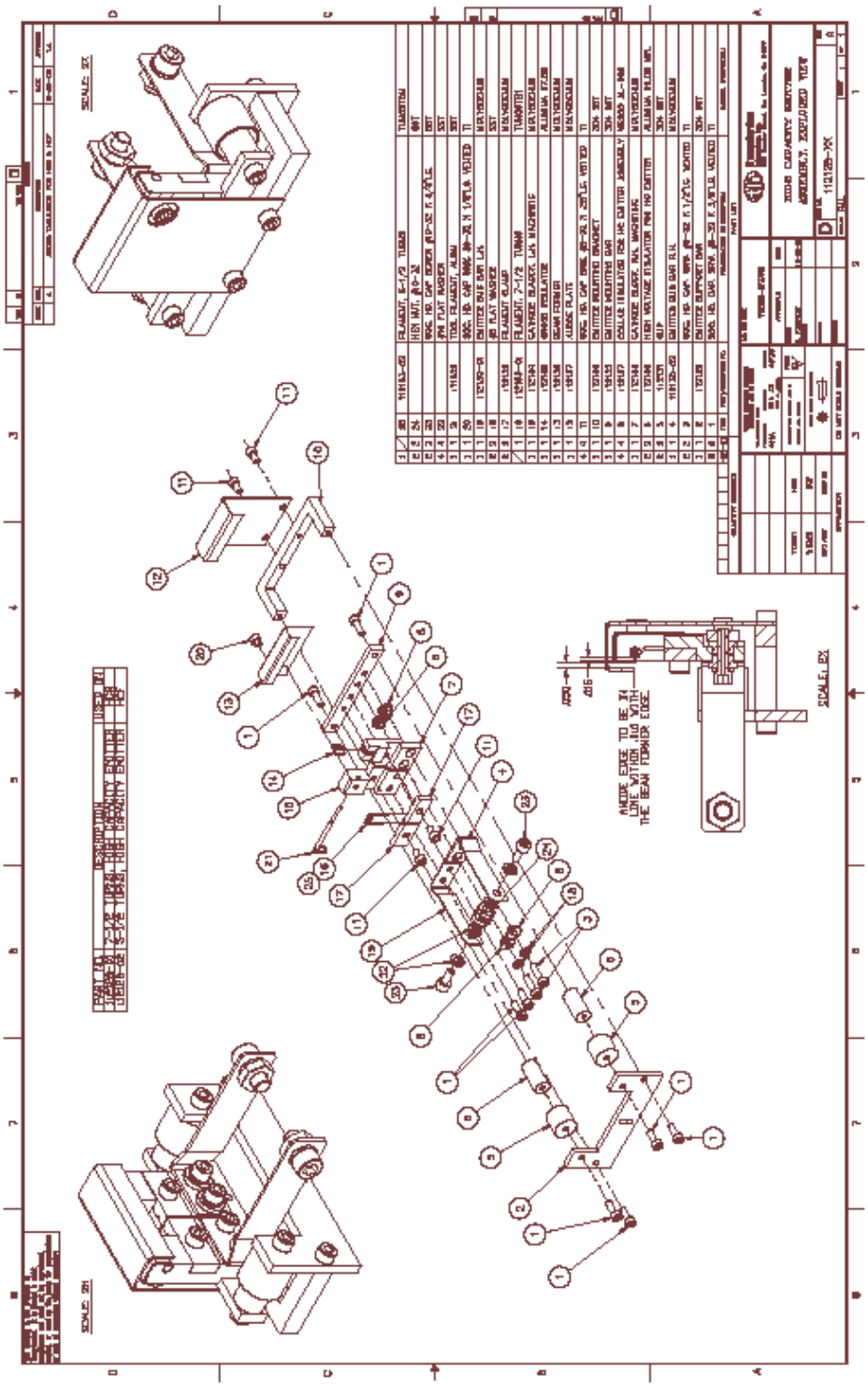
Figure 5b



Remove Assembly

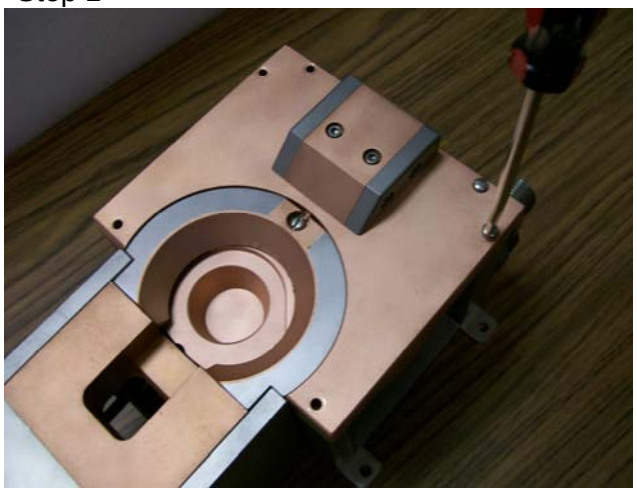
Figure 5c





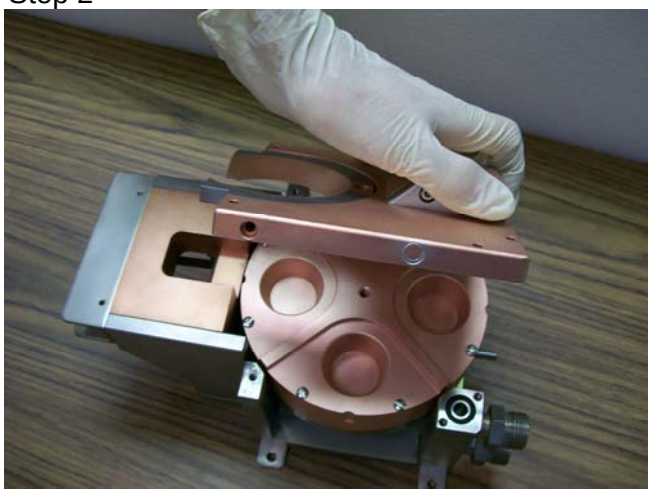
CHANGING THE QUAD SEAL

Step 1



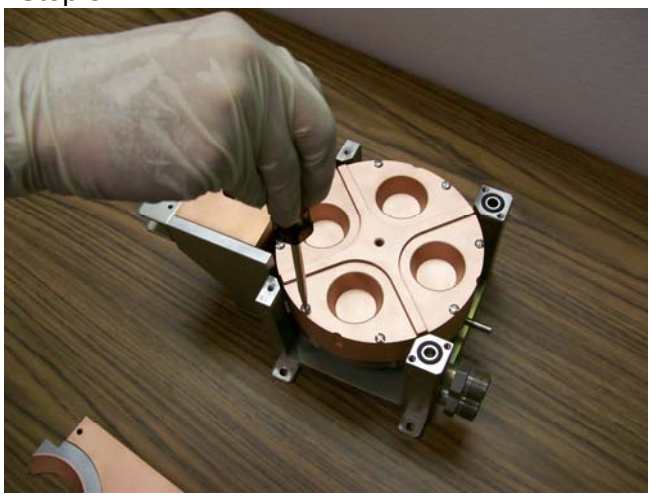
Remove 6 each 8-32 x 3¼ Slot Head Binding screws

Step 2



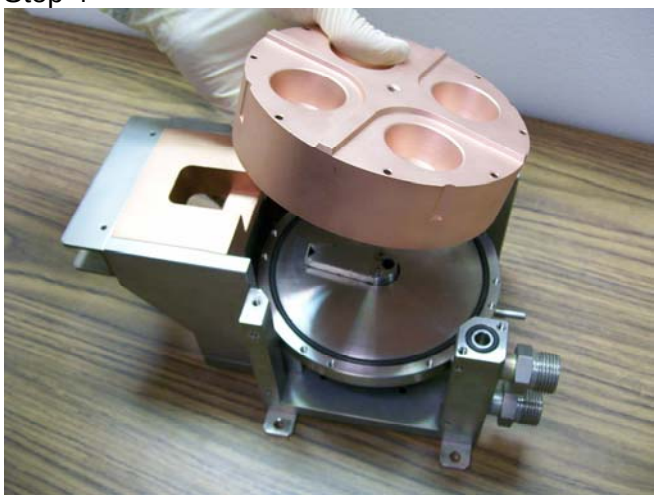
Remove Top Cover

Step 3



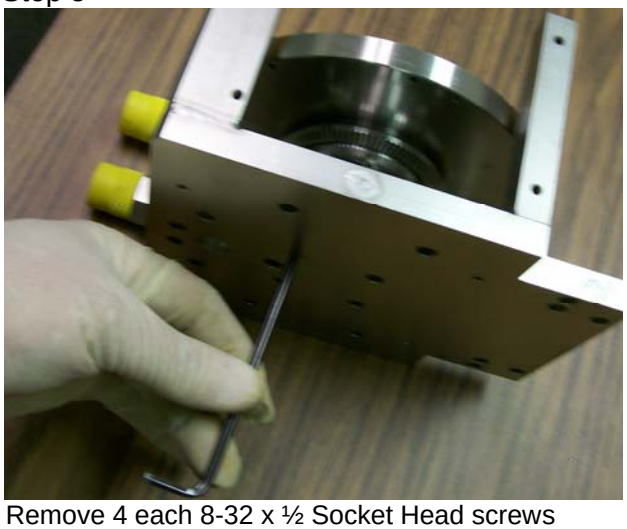
Remove 8 each 6-32 x 2 Slot Head Binding screws

Step 4



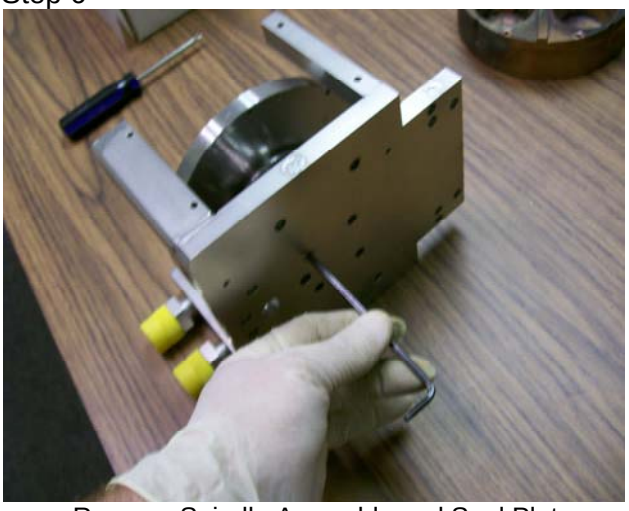
Remove Crucible

Step 5



Remove 4 each 8-32 x ½ Socket Head screws

Step 6



Remove Spindle Assembly and Seal Plate

Step 7

Remove 2 each 8-32 x ¼ Flat Head Philips screws

Step 8

Remove Water Duct

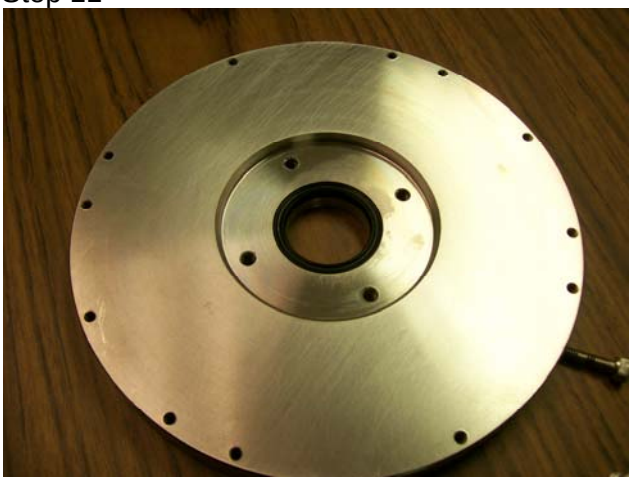
Step 9

Remove 4 each 8-32 x 5/8 Socket Head screws

Step 10

Remove Spindle Assembly

Step 11



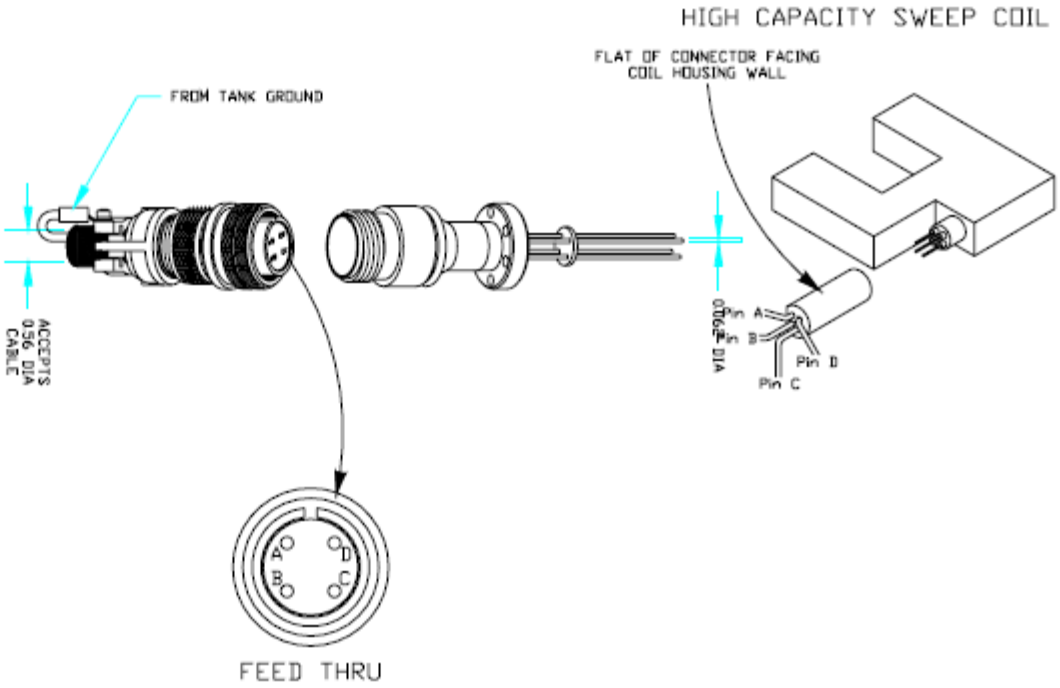
Step 12

Remove Quad Seal
(112/28-OR O-Ring Kits available from factory)

Reverse order to re-assemble

XYS CONTROLLER REAR PANEL

HORIZONTAL	GROUND	1	A
	HOT	2	B
TANK GROUND		3	
LATERAL	GROUND	4	C
	HOT	5	D



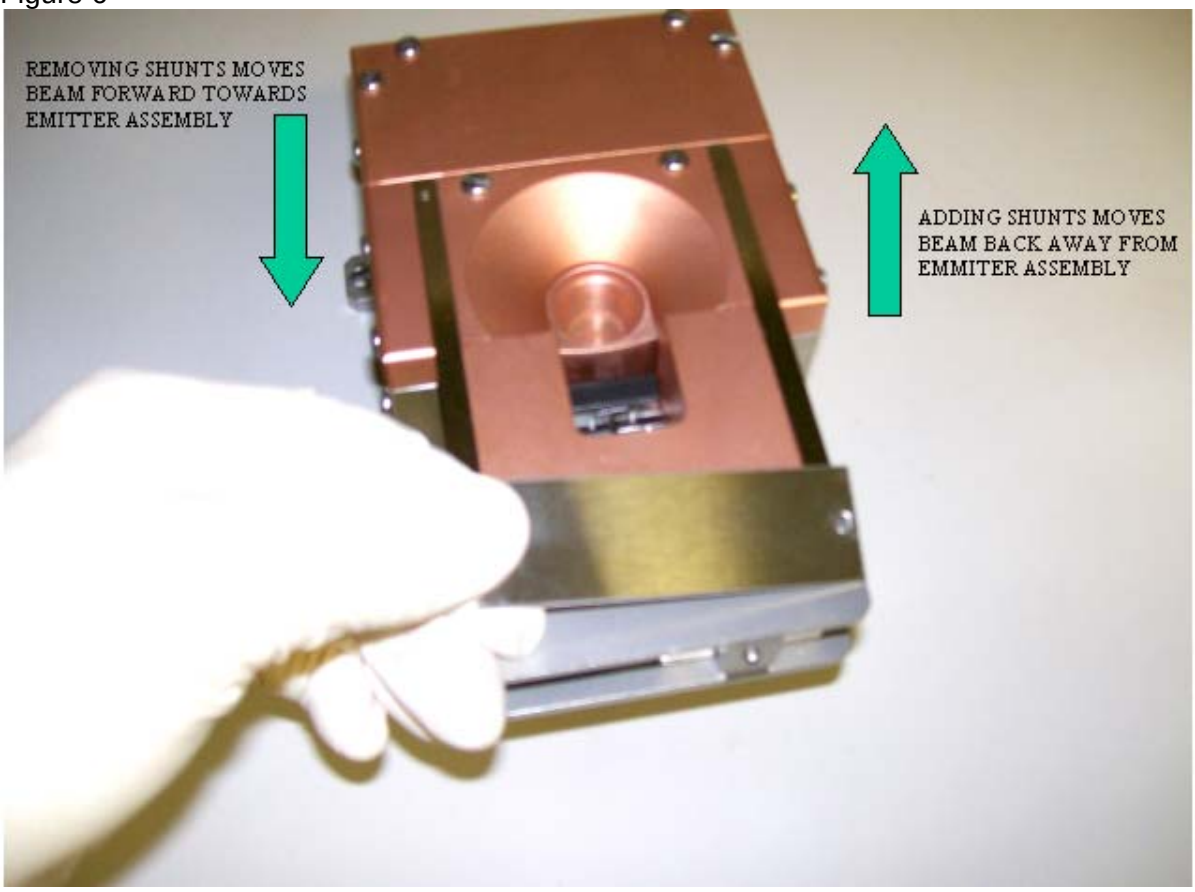
ADJUSTING BEAM POSITION

The RC e-Guns are designed for use with TLI model ISO-0040 high voltage power supply. This power supply is a fixed voltage unit. Although the e-Gun is matched at the factory it may be necessary to make minor adjustments to the e-Gun after installation.

If the beam is not centered in the pocket you can add or remove magnetic shunts to the e-Gun (see figure 6).

You may also use the x-y sweep to position the beam in the center (optional item).

Figure 6



Adding a magnetic shunt

WARRANTY STATEMENT

Thermionics warrants each item it manufactures to be free from defects in workmanship and material for a period of one year from date of shipment. HM2 e-Gun evaporation sources are warranted for a period of five years from date of shipment. Minor deviations that do not affect the performance of the equipment shall not be deemed to constitute defects of workmanship or materials, or failure to comply with the specifications.

Not withstanding the foregoing, Thermionics shall have no warranty responsibility for expendable items such as vacuum tubes, diodes, transistors, batteries, lamps, mechanical pump shaft seals and oil, diffusion pump oil, gaskets, of filaments. In addition, all vacuum gauge sensing devices such as thermocouple tubes, Pirani tubes, ionization gauge tubes, etc. are warranted against defects in manufacture in normal use, as determined be sellers inspection, for a period of ninety (90) days from date of shipment, provided the defective gauge tube is returned to the seller's plant for inspection.

Equipment made or modified to Purchaser's specifications on special orders shall carry the above warranties with respect to material and workmanship, but shall be specifically excluded from any other warranties, express or implied, including those related to performance specifications, and any special components manufactured by others shall carry only the original manufacturer's warranties.

This warranty does not extend to Thermionics products that have been subject to misuse, neglect, accident, or improper application, nor shall it extend to units that have been substantially altered outside the seller's plant except by Thermionics service engineers.

This warranty is expressly in lieu of all other obligations or liabilities on the part of Thermionics unless such additional warranty is either agreed to in writing, appears in a separate warranty statement provided to the customer, or appears in a warranty statement accompanying the product shipped to the customer. Under no circumstance will Thermionics be liable for consequential or resulting loss or damage, neither of nor due to causes covered by Thermionics' warranty. Thermionics neither assumes nor authorizes any other person to make any other representation or warranty on its behalf, or assume for it any liability in connect with the sale of its products.

WARRANTY REPAIR

Notice of any claim that a product is in any way defective shall be given to Thermionics immediately upon discovery. Before any items are returned for repair and/or adjustment, the customer must obtain Thermionics' approval. Written authorization for the return and instructions as to how these times should be shipped will be provided. If any Thermionics products must be returned to the factory, they must be sent prepaid via the means of transportation indicated as being acceptable in the written authorization. Thermionics reserves the right to reject and warranty claim on any product that has been shipped by a non-acceptable means of transportation.

When Thermionics products are returned for examination and inspection, it is important that they be properly packed for shipment. Use the original packing material or equivalent. The sender and the shipping agency must assume the responsibility for damage resulting from improper packing, handling, or loss of transit.

When products are returned, it is very important that the customer provide Thermionics with the data on the operating conditions and any other pertinent information, which will enable us to determine the cause of failure. In all cases, Thermionics has sole responsibility for determining the cause of failure, and sole discretion in determining the nature and extent of adjustment, if any, to which a customer may be entitled.

If it is found that our product has been returned without cause and is still serviceable, the customer will be notified and the product be returned. All shipping costs on products returned for warranty repair shall be the customer's responsibility. Thermionics' sole liability hereunder shall be the correction and/or replacement of defective materials and workmanship.

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