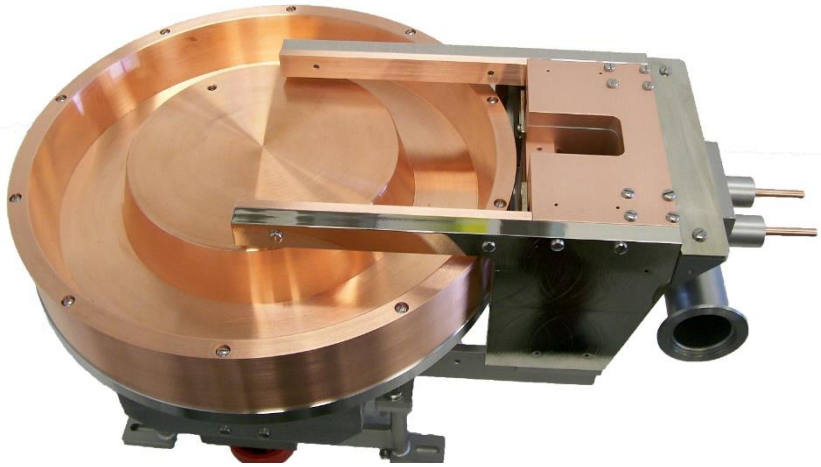
thermionics laboratory, inc.

INSTRUCTION MANUAL

ICR Rotary e-Gun™ Evaporation Source
Version 2



SERIAL # _____

04.2024
3118 DEPOT RD., HAYWARD, CA 94545 - PHONE: 800-962-2310

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 3,500 degrees Celsius can be easily achieved allowing the direct evaporation of virtually any material.

Installation

A. The following components are required for customer installed fixed e-gun systems:
B. Water feedthrough and tubing (3/8” (o.d.), type 304 stainless steel).
C. High Voltage feedthrough. TLI model #111136-12 or equivalent (check flange type for specific installation).
D. High Voltage hookup strap, Oxygen free copper.
E. 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 lose the dark space shielding effects (prevents unwanted arcing/discharges).
F. Interlock switches: water, vacuum and high voltage access.
G. Filtered water at 4 gpm at 50 psi.
H. High Voltage power supply. TLI model SVA-12 or equivalent.
I. Four pin instrument feedthrough (optional) for connecting sweep coils. TLI model #111139-04 or equivalent (check flange type for specific installation).

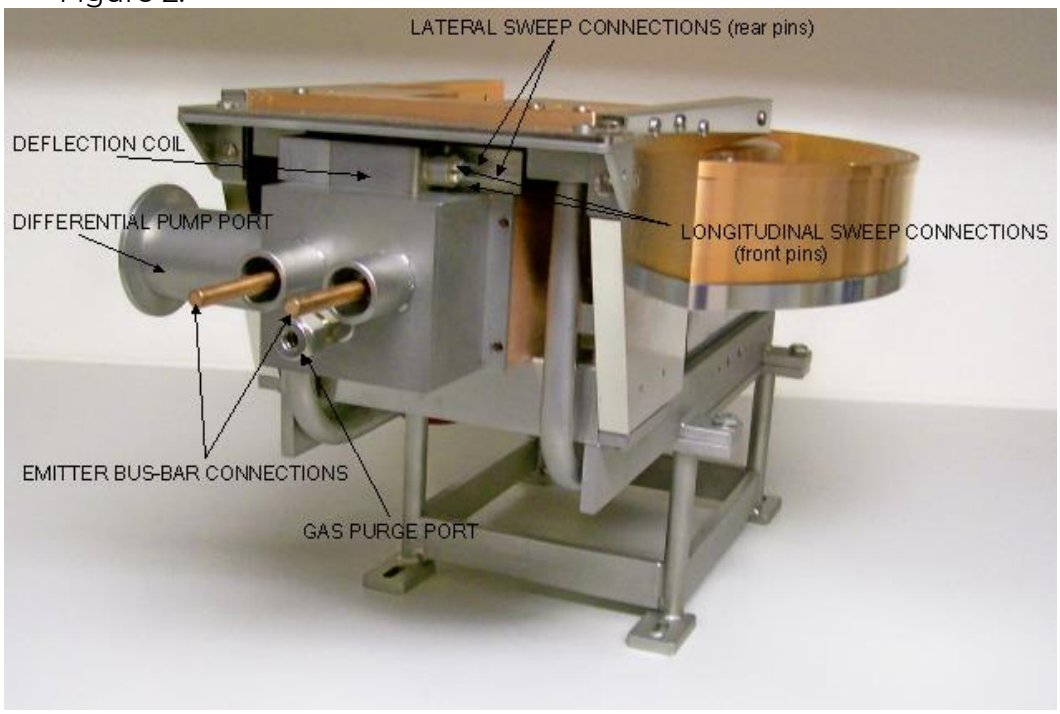
TO INSTALL THE E-GUN SYSTEM

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 water flow of 4 gpm with a pressure of 50 psi or above.

Figure 1:

Model ICR water-cooling connections

Figure 2:



Sweep (top) and high voltage (emitter) power connections

Operation

CRUCIBLE PREPARATION

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).

CHOOSING 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

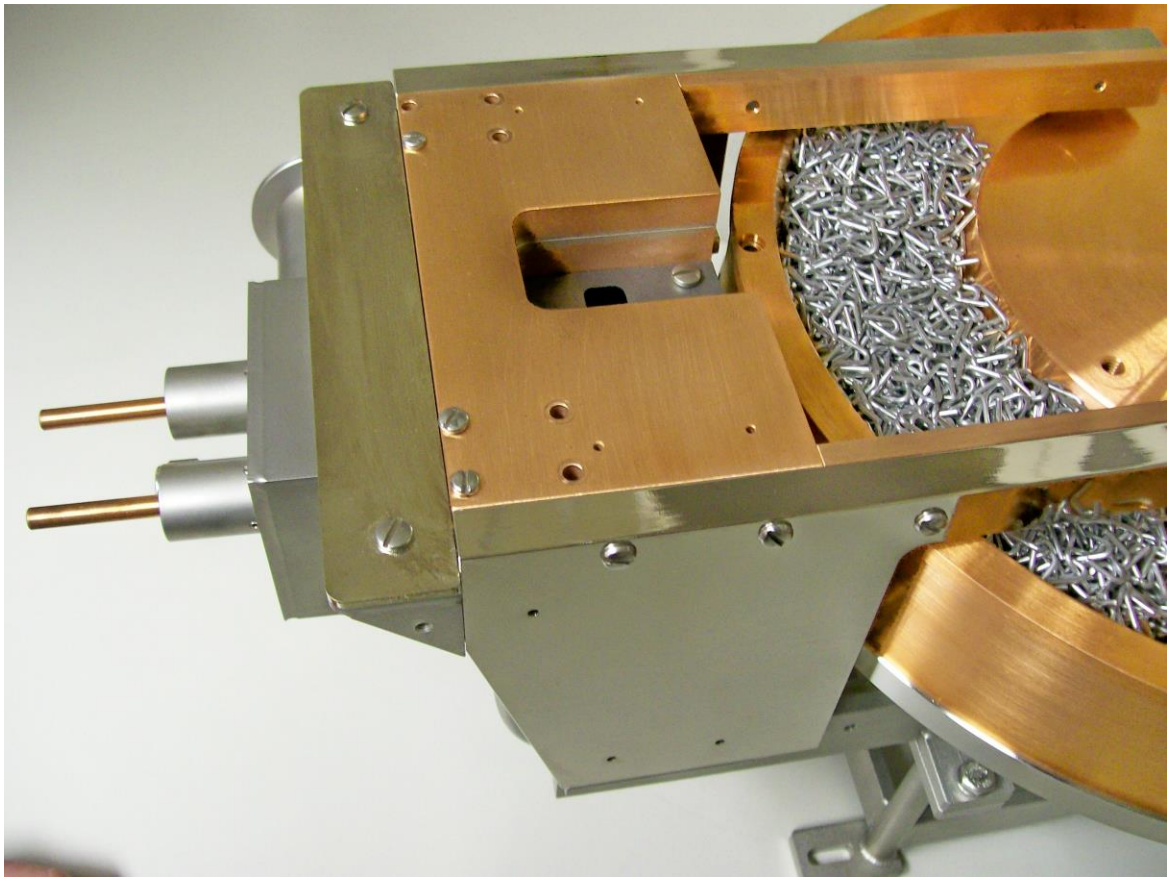
Running the e-Gun with **an empty crucible will destroy the source.** Fill the crucible with evaporant material. If you are using granules, pack the crucible and form a "slight" dome (see figure 3). As the granules melt, they will fill in the voids and you should have a full crucible. Make sure not to 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 buildup 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 4B and 4B). **If material "spills"** over the top of the liner and touches the water-cooled copper**, it will destroy the liner.**

Figure 3:

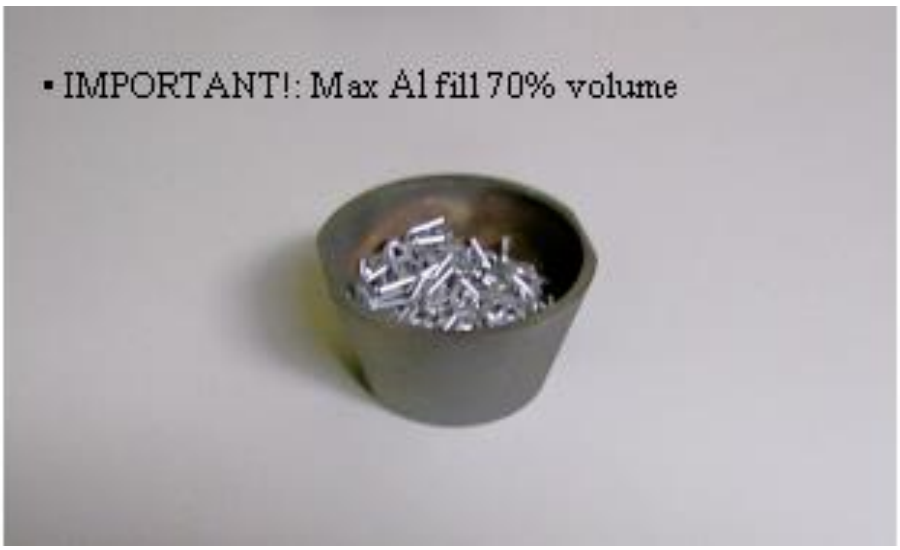


Properly filled crucible (leave clearance for rotation)

Figure 4A:

Properly filled liners with SiO_2

Figure 4B:



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 not 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 ICR e-Guns are equipped with UHV 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

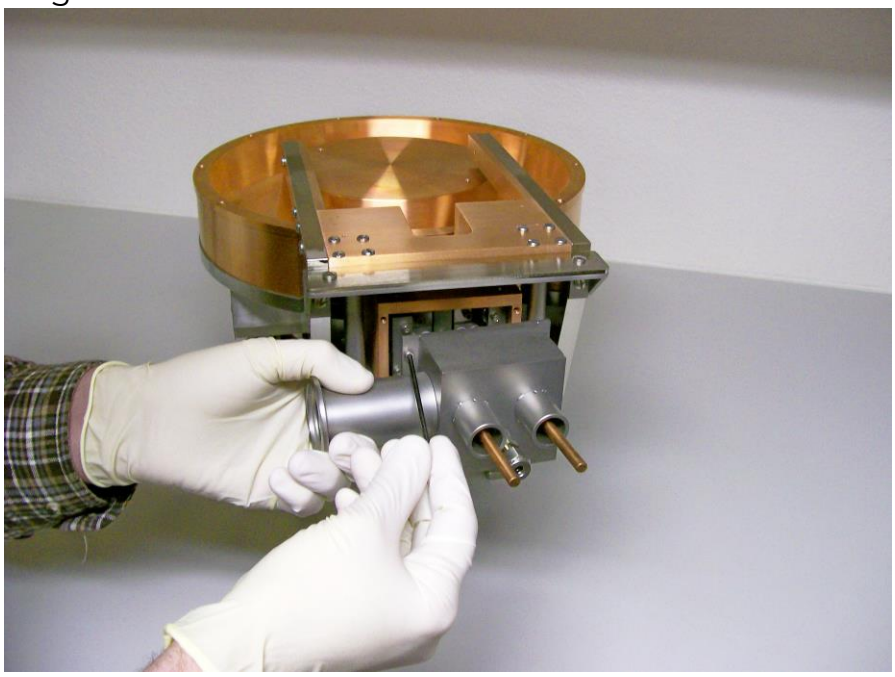
Once the desired rate is achieved; close shutter (if so equipped) or reduce emission current to zero. Turn off high voltage. Allow adequate cooling time prior to venting the system. The e-Gun must be allowed to cool off for at least 5 minutes unless venting to an inert gas to protect the filament. Most 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):

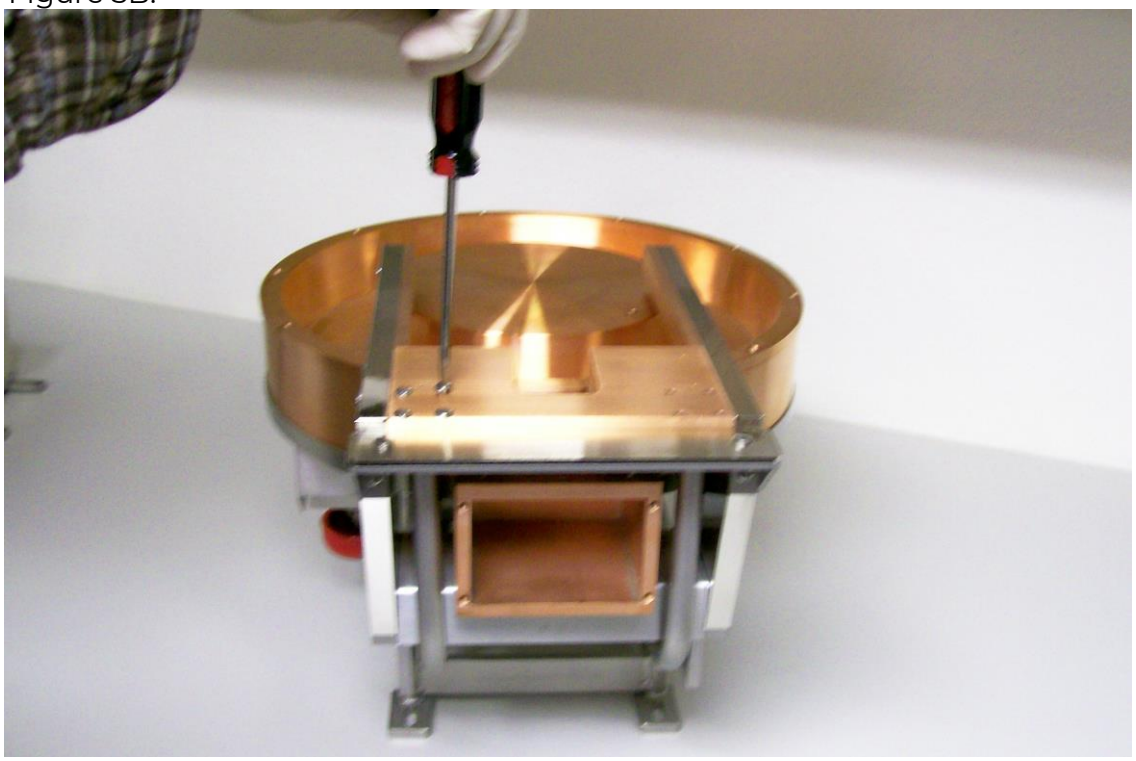
1. Remove the emitter assembly by disconnecting the high voltage leads from the emitter buss bars and then removing the one #6-32 mounting screw.
2. Remove the filament clamps (item 16 App. C)
3. Remove the old filament and clean the surface where the filament contacted the clamps and cathode blocks (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 an 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:



Unscrew the 4, #8-32 socket cap screws and pull out the emitter assembly

Figure 5B:

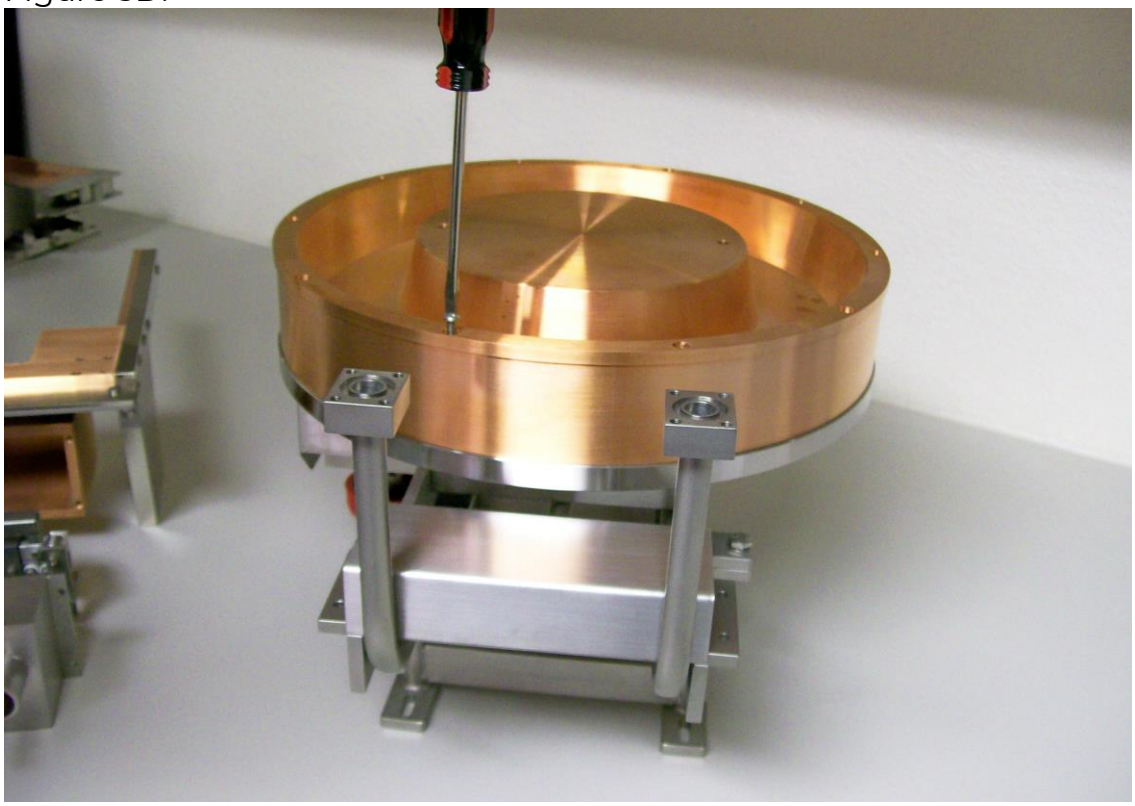


Remove all 8 slotted screws

Figure 5C:

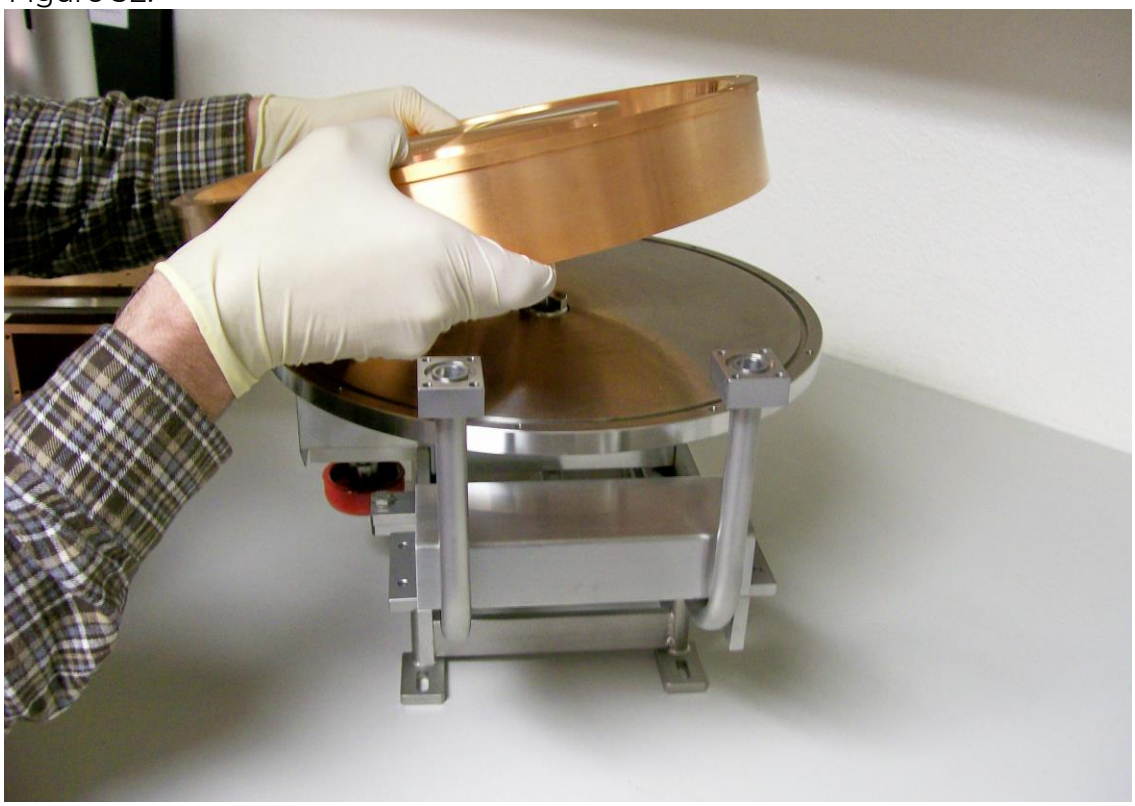
Remove the 4 socket cap pole screws (2 on each side)

Figure 5D:



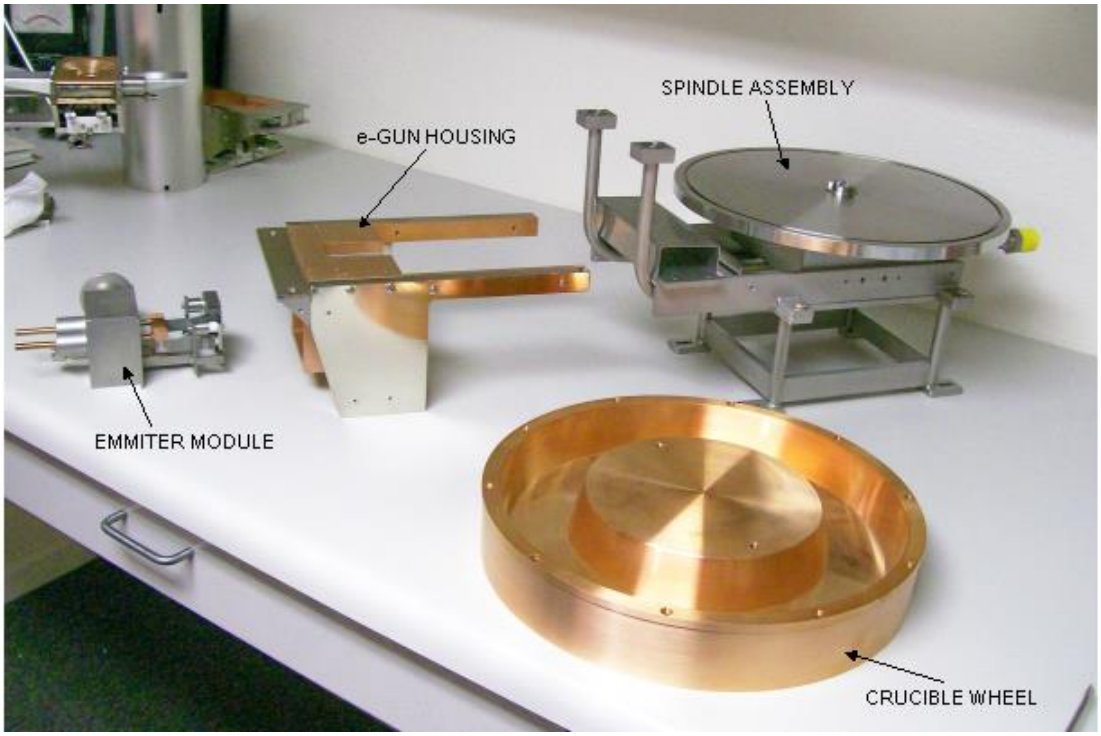
Remove the 10 slotted screws

Figure 5E:

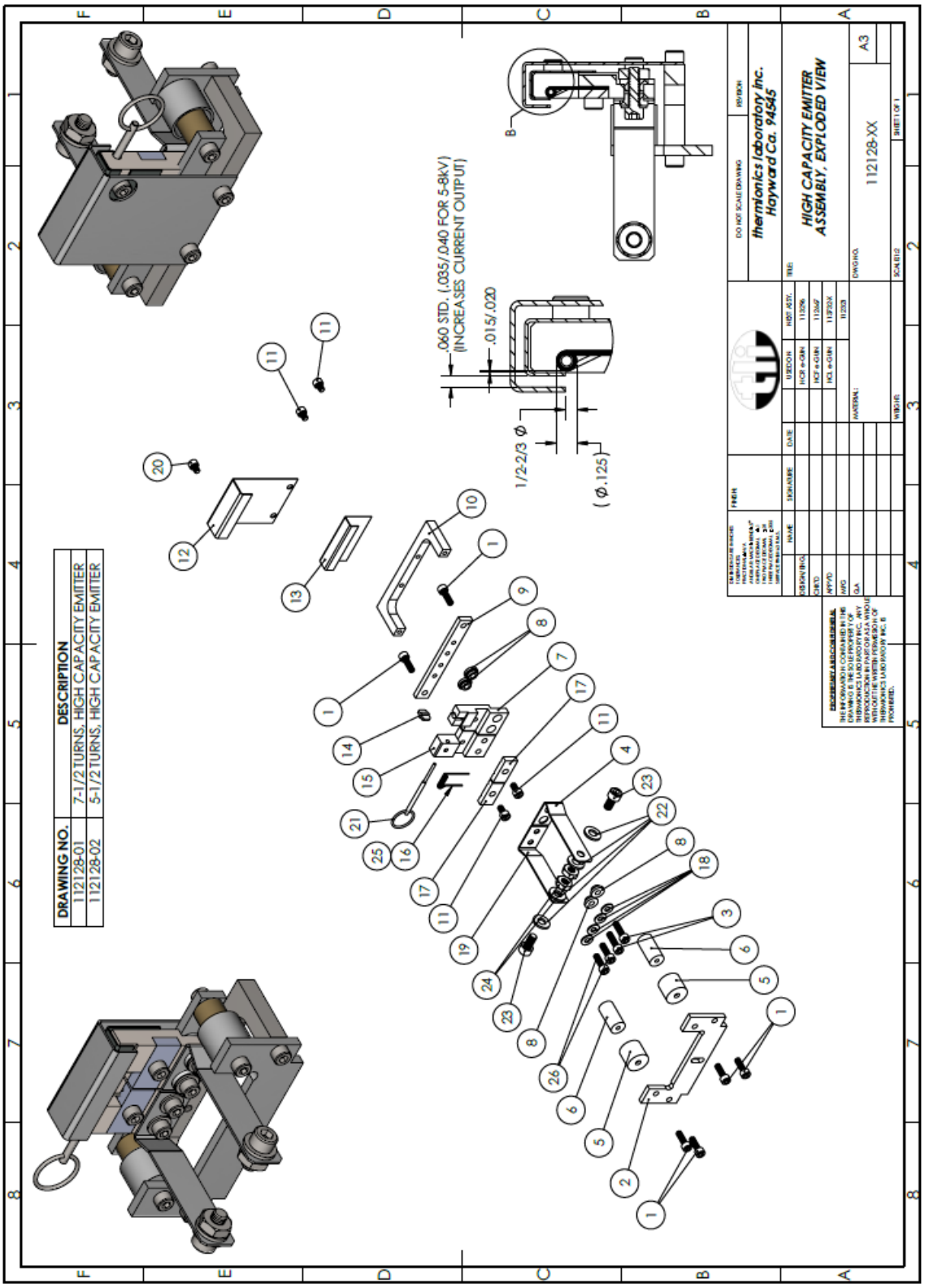


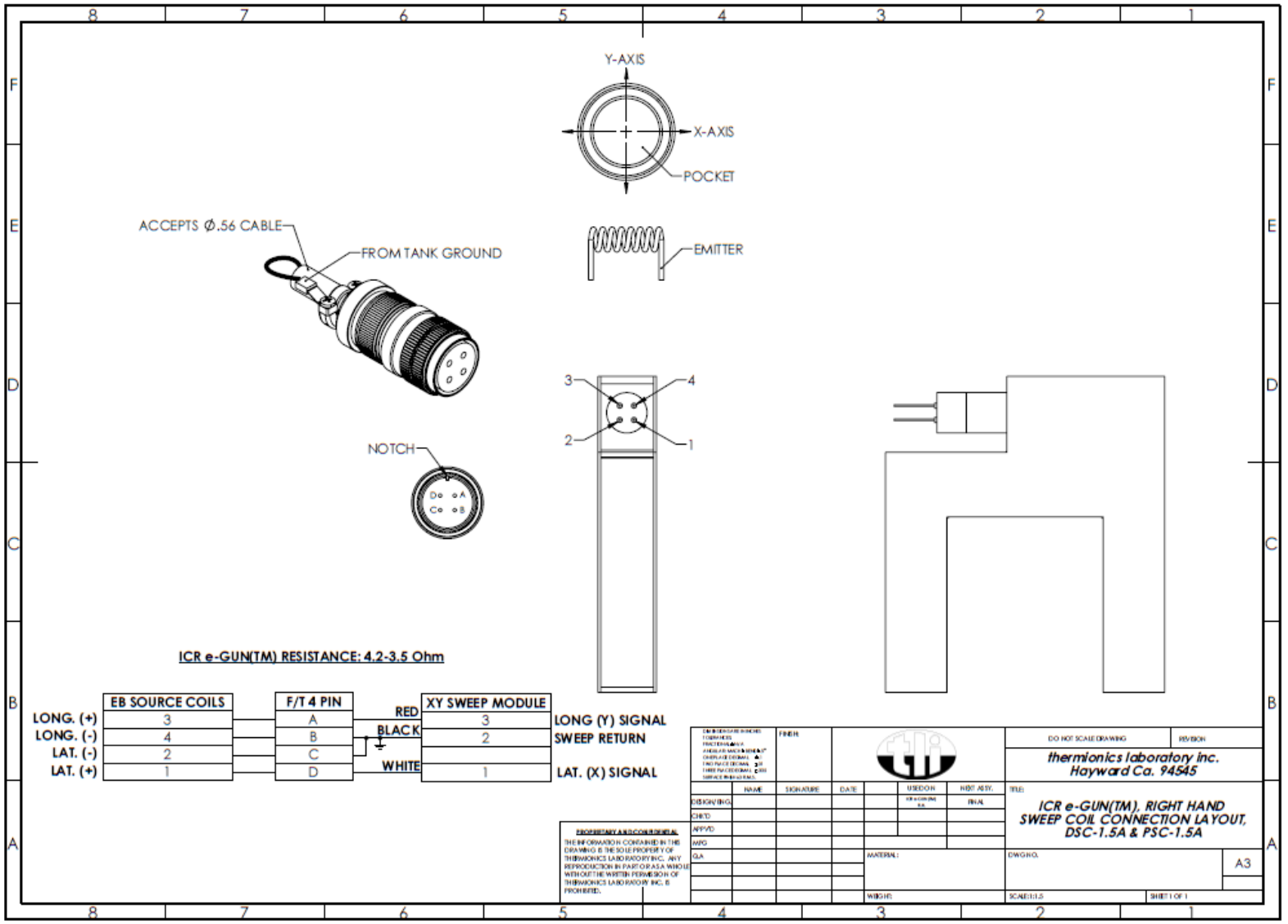
Remove crucible

Figure 5F:



Disassembled source


DRAWING NO.
DESCRIPTION
112128-01
7-1/2 TURNS, HIGH CAPACITY EMITTER
112128-02
5-1/2 TURNS, HIGH CAPACITY EMITTER
.060 STD. (.035/.040 FOR 5-8kV)
(INCREASES CURRENT OUTPUT)
.015/.020
1/2-2/3 Ø
(Ø.125)
thermionics laboratory inc.
Hayward Ca. 94545
HIGH CAPACITY EMITTER
ASSEMBLY, EXPLODED VIEW
112128-XX
A3


Y-AXIS
X-AXIS
POCKET
EMITTER
ACCEPTS Ø.56 CABLE
FROM TANK GROUND
NOTCH
3
4
2
1
ICR e-GUN(TM) RESISTANCE: 4.2-3.5 Ohm
EB SOURCE COILS
F/T 4 PIN
XY SWEEP MODULE
LONG. (+) 3 A RED 3 LONG (Y) SIGNAL
LONG. (-) 4 B BLACK 2 SWEEP RETURN
LAT. (-) 2 C
LAT. (+) 1 D WHITE 1 LAT. (X) SIGNAL
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thermionics laboratory inc.
Hayward Ca. 94545
TITLE:
ICR e-GUN(TM), RIGHT HAND
SWEEP COIL CONNECTION LAYOUT,
DSC-1.5A & PSC-1.5A
DWG NO.
A3
SCALE:1:1.5
SHEET 1 OF 1

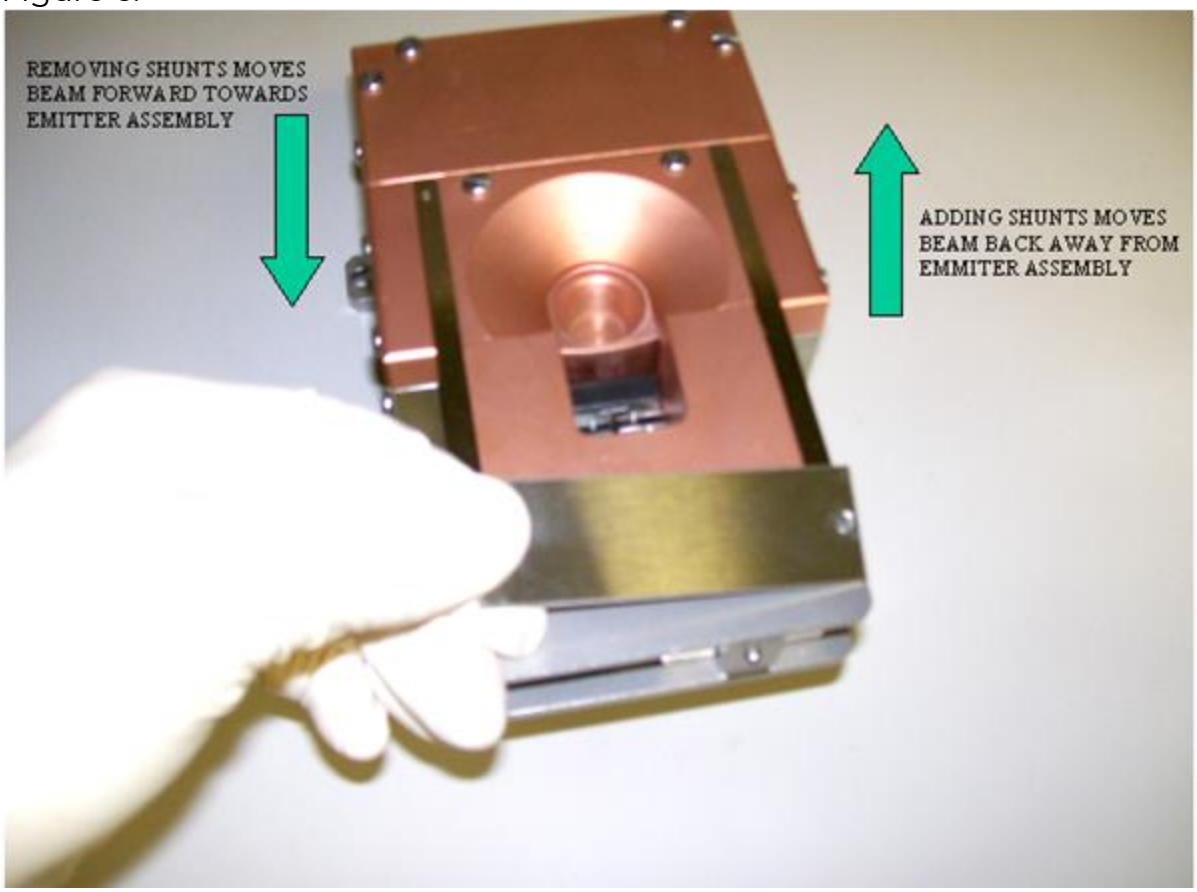
ADJUSTING BEAM POSITION

The ICR e-Guns are designed for use with TLI model SVA-12 high voltage power supply. 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

Standard Warranty

Revision A.01 | 2020

Standard and Tailored Products are guaranteed to be free of material and workmanship defects for a period of one (1) year. Custom Projects and electronic components are guaranteed for a period of one (1) year. Expendable component parts are guaranteed for their expected service life. If, for any reason, you are not completely satisfied with our products, let us know. We want to address your concerns.
Our relationship with the user does not end with the delivery of the equipment. We have a large stake in your equipment operating up to your expectations. Our goal is to be part of your success.

WARRANTY

1.0. THERMIONICS VACUUM PRODUCTS (HEREIN CALLED THERMIONICS) WARRANTS TO THE ORIGINAL PURCHASER:
1.1. Standard catalog products manufactured by Thermionics against defects in workmanship for a period of one (1) year from the date goods are received at the customer's facility.
1.2. Special products and electronic components are covered for one (1) year from the date goods are received at the customer's facility.

2.0. SCOPE
2.1. Liability under this warranty is expressly limited to repair or replacement of defective parts. THERMIONICS, at its sole option, may at any time discharge its warranty as to any of its products by refunding the purchase price and taking back the product(s).
2.2. This warranty applies only to parts manufactured and labor provided by THERMIONICS.
2.3. Valid warranty claims must be received by THERMIONICS within the warranty period and are subject to the terms and conditions hereon.
2.4. All warranty replacement or repair of parts shall be limited to equipment malfunctions, which, at the sole discretion of THERMIONICS, are due or traceable to defects in original materials or workmanship.
2.5. Malfunctions, which in the sole opinion of THERMIONICS, are caused by abnormal wear and tear, lack of maintenance, abuse, operation, maintenance or care inconsistent with the product manual, accident, or neglect of equipment are expressly not covered by this warranty. It is the responsibility of the user to operate the equipment in a reasonable and prudent manner, consistent with the stated intended use.
2.6. In-warranty repaired or replaceable parts are warranted only for the remaining portion of the original warranty period, applicable to the parts which have been repaired or replaced, and the total equipment is warranted for the balance of the five (5) year period. After expiration of

the applicable warranty period, the buyer shall be charged at THERMIONICS' current prices for parts and labor, plus freight and per diem, when applicable.
2.7. Expendable component parts, including, but not limited to, pump elements, cold cathode gauges, bellows, thermocouple gauges, hot cathode gauges, sublimator filaments, emissive filaments, heater, elastomers, bearings, and gaskets, etc., are guaranteed for their expected service life. If the expendable component parts fail to give reasonable service, as determined solely by THERMIONICS, they will be repaired or replaced at our discretion.
2.8. CONDITIONS
2.9. THERMIONICS expressly disclaims responsibility for any loss or damage caused by the use of its products, when not used in accordance with proper operating and safety procedures in accordance with specifications, or if the equipment is used without the proper recommended maintenance. Reasonable care must be taken by the user to avoid hazards.

3.0. Except as stated herein, THERMIONICS makes no warranty, express or implied, either in fact or by operation of law; and, as stated herein, THERMIONICS shall have no liability under any warranty, express or implied, either in fact or by operation of law.
3.1. THERMIONICS shall have no liability for special or consequential damages of any kind, or from any cause arising out of the sale, installation, or use of any of its products. Statements made by any person, including representatives of THERMIONICS, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon THERMIONICS unless reduced to writing and approved by an authorized officer of THERMIONICS.
3.2. This warranty does not cover normal maintenance requirements, which are the customer's responsibility.
3.3. This warranty does not extend to equipment that (1) someone other than Thermionics approved personnel have disassembled or attempted to repair, (2) has been modified or altered, or (3) has been contaminated with hazardous material or induced activation.
3.4. PROCEDURES
3.5. If you wish to return equipment for repair, contact the THERMIONICS DIVISION which sold you the product in question. You will be given an RMA Authorization Number and instructions on how and by what means to ship the product to the factory. NO SHIPMENT WILL BE ACCEPTED WITHOUT PRIOR APPROVAL and completed RMA Authorization Form.
3.6. In the first year, goods must be returned, freight prepaid, to the factory and will be returned prepaid, to the customer. After the first year, the customer must pay all freight costs.