INSTRUCTION MANUAL

THERMIONICS e-GUN™ 3kW EVAPORATION SOURCE
[MODELS: RCRF-0325/0338]

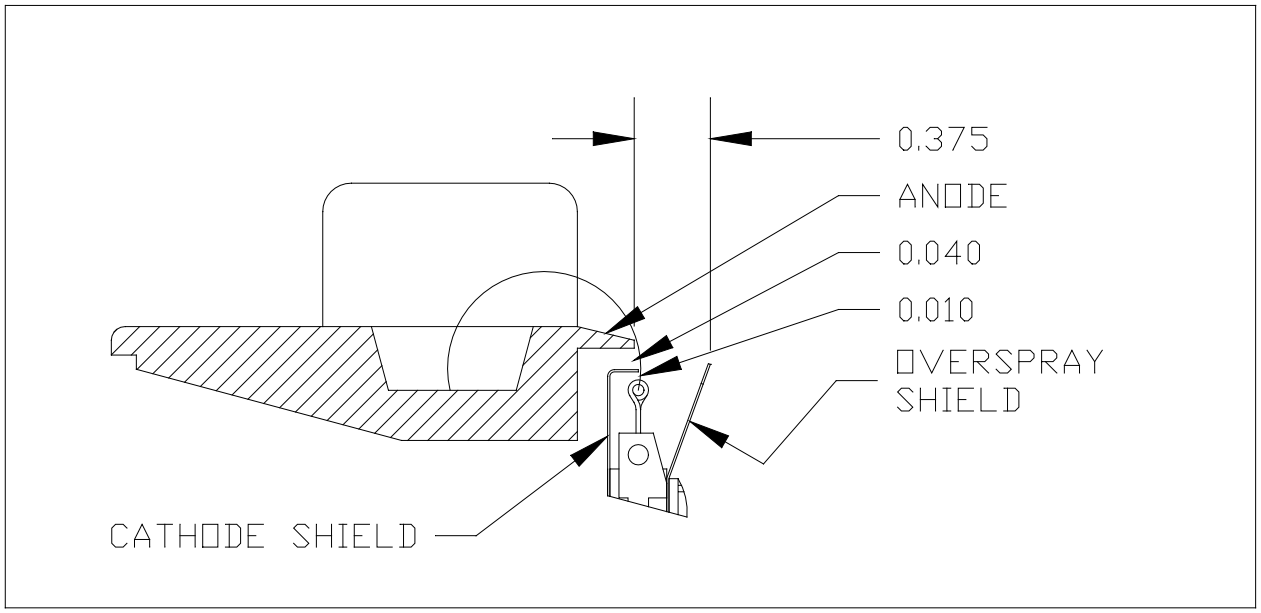
Version 2

SERIAL # _____

12.2023
3118 Depot Rd., Hayward, CA 94545 - Phone: 800-962-2310

IMPORTANT NOTE

DUE TO POSSIBLE SHIPPING DAMAGE THE EMITTER ASSEMBLY ALIGNMENT MUST BE CHECKED OR DAMAGE TO THE e-GUN AND / OR VACUUM SYSTEM MAY RESULT



REF. PAGES 4-1 AND 4-2 IN OPERATING INSTRUCTIONS MANUAL

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.

TABLE OF CONTENTS

Section 1

Introduction

A. Electron beam heating is an efficient and practical way of achieving temperatures in excess of 3500°C (6300°F) for uniform optical coating and metallurgical process. The Thermionics e-Gun™ source, which is bake-able to 250°C, and its control units have been designed to be part of any high or ultra high vacuum system. While the equipment will serve reliability for routine production work, its simplicity and non-contaminating operation makes it equally suitable for extracting research activities.

B. The e-Gun™ source control unit (power supply) provides convenient single-knob control of evaporation. The unit is current regulated (feedback of a solid-state unit to a reactor) and minor changes in line voltage do not affect the beam power. [However, if the input power is connected to the wrong voltage (208 vs. 230) the control unit will not operate properly. The proper input power is marked on the serial number label. If you need to change input power, contact Thermionics Laboratory, Inc.].

C. The source control unit has three safety interlocks that work in conjunction with the e-Gun™ evaporation source. These safety interlocks should be connected as the source control unit instruction book describes.

   1. Water-flow interlock to insure a proper water flow to the unit (at least ½ gallon per minute).

   2. Pressure interlock to make certain the control unit won't operate above 1 x 10^{-5} Torr.

   3. Cabinet interlock to make certain the power is safely disconnected when the rack panel door is opened.

D. The e-Gun™ source control unit is designed to accommodate two very important accessories, which will allow precision application of practically any of the standard evaporates.

   1. A deposit rate controller will monitor the rate of the deposit in angstroms per minute. This is necessary for any precision application of films.

   2. A thickness monitor will indicate the film thickness and is very valuable in the evaporation of precious metals.

E. The maximum output of the e-Gun™ source is 3,000 watts. The output power will be the meter reading in milli-amps multiplied by the

constant output voltage of 4kV (Maximum meter reading of 750 milli-amps x 4kV equals 3kV).

F. Thermionics Lab, Inc. manufactures 3kW e-Gun™ electron beam evaporation sources in five sizes.

1. Single position e-Gun™ unit (Model 100-0010)

2. Three position e-Gun™ unit (Model 100-1030)

3. Four position e-Gun™ unit (Model 100-1040)

4. Five position e-Gun™ unit (Model 100-0050)

5. Rod Fed e-Gun™ unit (Model 100-0011)

6. Rod Fed e-Gun™ unit w/ all mechanical & electrical F/T's mounted on a 4.5" flange (Model 100-001R/SK)

All of these electron beam evaporation source units provide uniform high purity films and optical coatings. The compact design and ease of maintenance make them useful in practically all vacuum systems and for many varied applications. They have been used to evaporate refractory and dielectric materials as well as the more common conductive and semi-conductive materials. The cleanliness and reliability of the e-Gun™ evaporation source makes it ideal for research, and its simplicity of operation makes it equally suitable for regular product evaporation.

G. The crucible of the single position e-Gun™ source will hold approximately 2cc of source material. The crucible of the three and five position e-Gun™ source units will hold approximately 2.5 cc of source material.

H. Several types of accessory liners are available for these e-Gun™ source units. The liners are very useful. With a liner, a smaller amount of source material may be used. A liner will also keep the e-Gun™ crucibles clean. Several different types of source material may be evaporated without cross contamination of the material by simply removing the crucible liner after coating one material and inserting a crucible liner containing the next material.

Liners are made of carbon or vitreous carbon. In some application these liners may introduce some impurities. The amount of contamination appears to be slight.

I. Custom designed e-Gun™ units may be obtained by special order. These offer:

1. Various types of e-Gun™ feedthroughs.

2. Special configuration of water lines for the e-Gun™ units other than vertical.

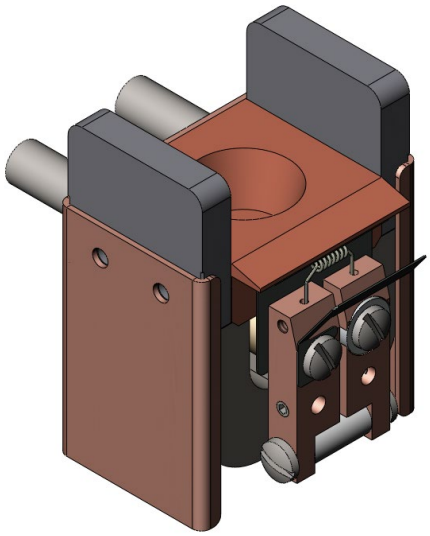
3. Rod fed e-Gun™ units, which allow continuous source material feeding and various tilting angles other than horizontal.

4. Back-to-back e-Gun™ units, single position, allowing single or double evaporation procedures.

Section 2

INSTALLATION

MODEL 100-0010
SINGLE POSITION CRUCIBLE E-GUN™ SOURCE



A. If your e-Gun™ source was ordered for mounting on a feedthrough spool, proceed as follows using figure 1 (above) as a reference.

1. Prepare the 2.75” receiver metal seal flange (1) with the seal flange insert (3) with the GK-275 copper gasket inserted (4). Bolt the two receivers (1 and 2) together vacuum tight.

2. Insert the e-Gun™ assembly (5) with the water feedthrough weldment assembly (6) placed through the flange assembly with the 22008 annealed copper gaskets (7).

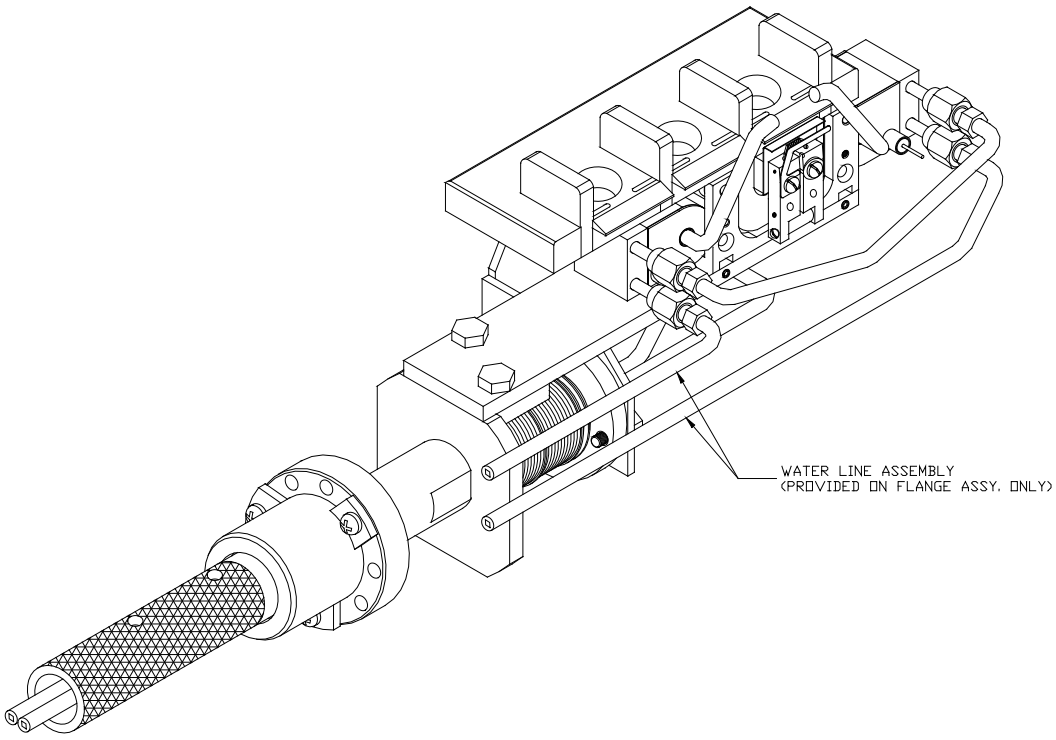
3. Place the washer (8) and screw the 1-1/4 hex nut (9) onto the threaded feedthrough body (10) using a 1-1/4 open end wrench placing a 7/8 open end wrench on the flat side of the treaded feedthrough body (10) to counter while tightening the 1-1/4 hex nut (9), as well as keeping the e-Gun™ system level. When tightened this should create a good vacuum seal

4. Refer to power supply manual for electrical hookups.

MULTIPLE CRUCIBLE E-GUN™

MULTIPLE POSITION CRUCIBLE E-GUN™ EVAPORATION SOURCE

The three and five position crucible e-Gun™ sources are installed and operated like the single crucible source. Indexing of the various crucibles over the fixed position electron beam source is accomplished by turning the positioning handle on the outside of the system. This handle has a series of index holes located along the shaft. The crucibles are properly positioned when the end of the threaded drive shaft is located directly bellow an index hole in the positioning handle (index holes vertically positioned).

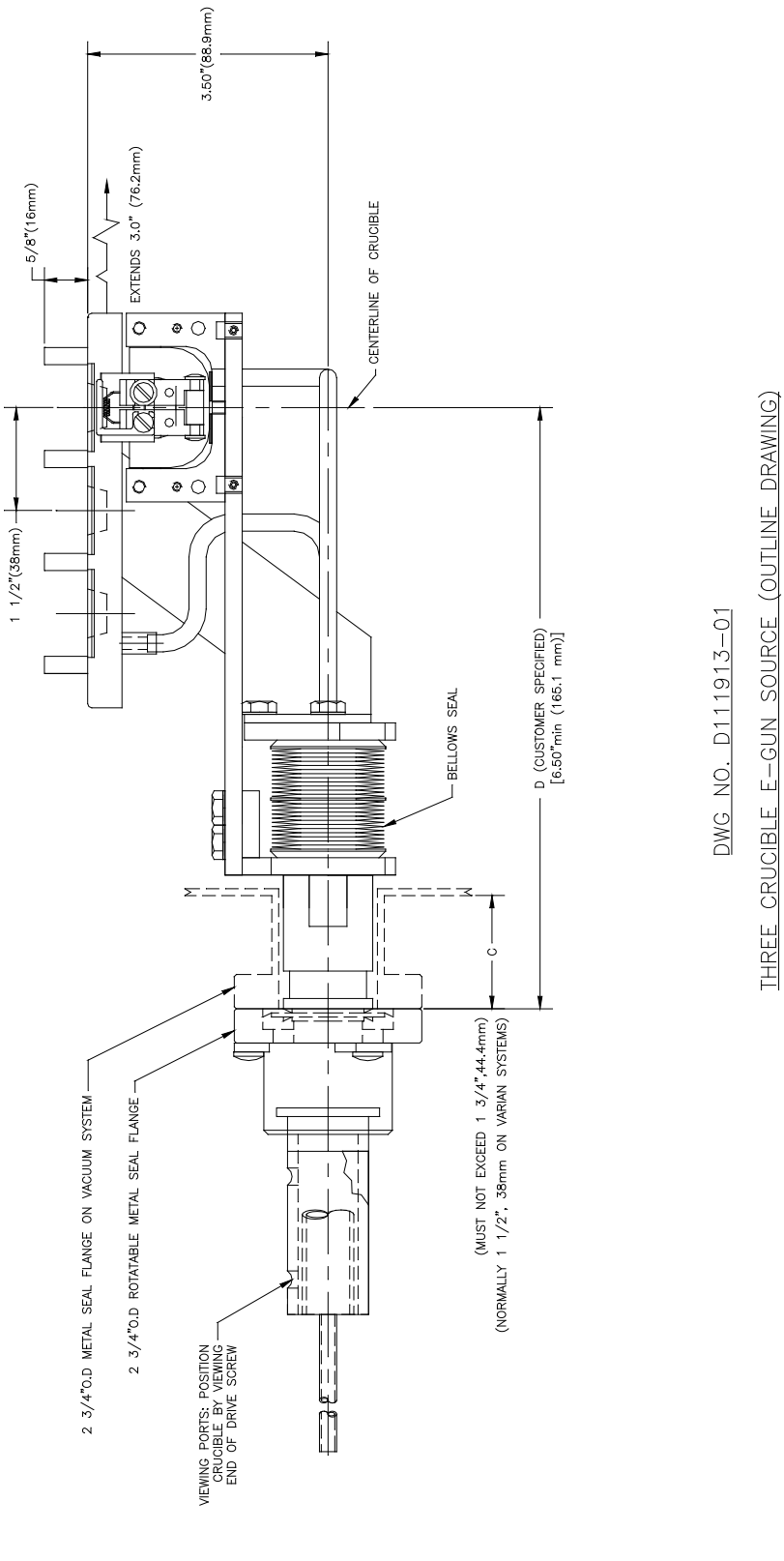


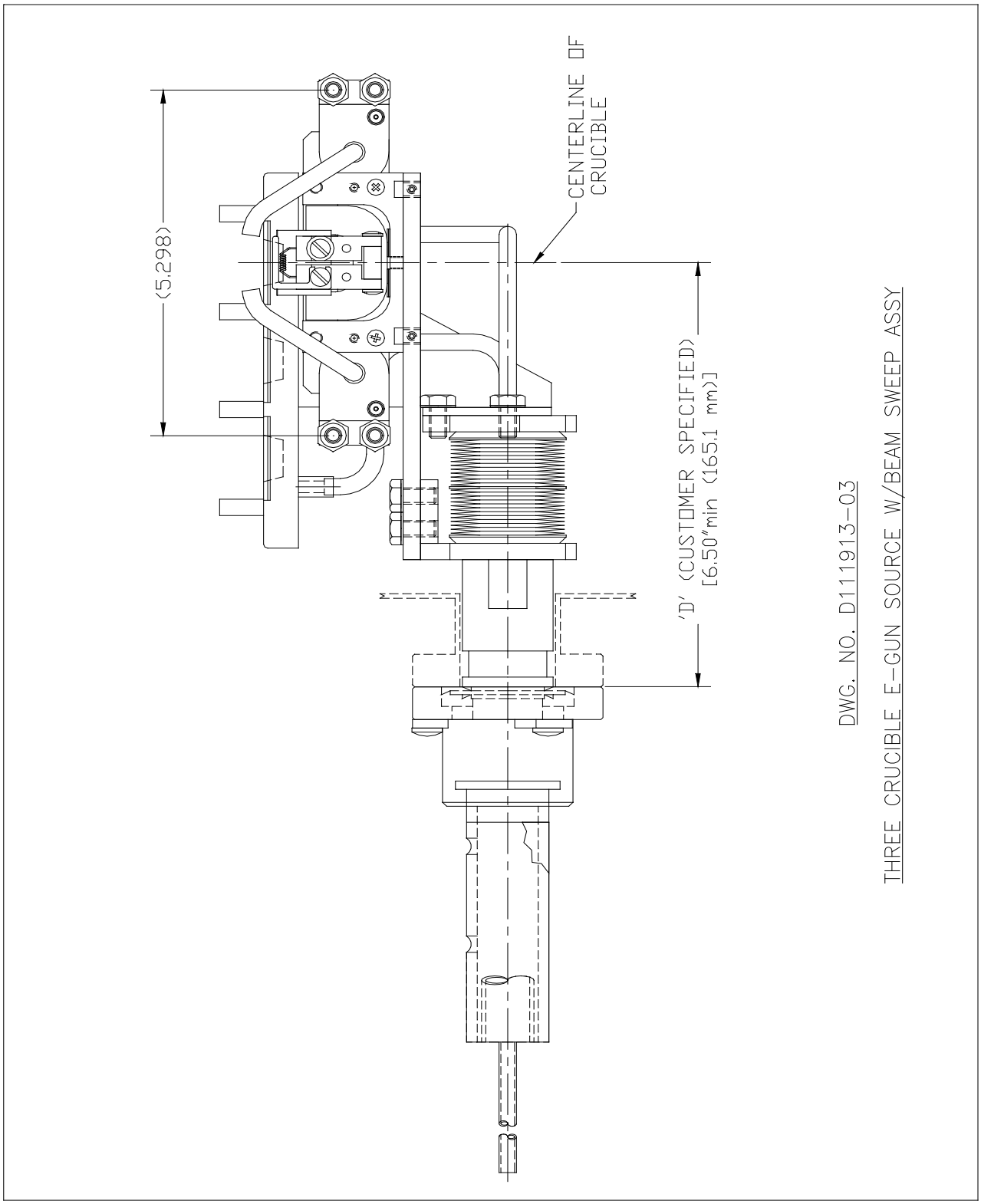
MODEL 100-0030

THREE POSITION CRUCIBLE E-GUN™ SOURCE (SHOWN WITH OPTIONAL SWEEP ASSEMBLY)

3 kW Linear Multi Position e-Guns™

MODEL NO.	DWG. NO.	DESCRIPTION	"D" DIM (MINIMUM)	REMARKS
100-0030 3 POSITION	D111913-01	R/H W/OUT BEAM SWEEP ASSY.	6.500	SHOWN
	D111913-02	L/H W/OUT BEAM SWEEP ASSY.	6.500	
	D111913-03	R/H W/ BEAM SWEEP ASSY.	6.500	SHOWN
	D111913-04	L/H W/ BEAM SWEEP ASSY.	6.500	
100-0040 4 POSITION	D111914-01	R/H W/OUT BEAM SWEEP ASSY.	8.000	SHOWN
	D111914-02	L/H W/OUT BEAM SWEEP ASSY.	8.000	
	D111914-03	R/H W/ BEAM SWEEP ASSY.	8.000	SHOWN
	D111914-04	L/H W/ BEAM SWEEP ASSY.	8.000	
100-0050 5 POSITION	D111915-01	R/H W/OUT BEAM SWEEP ASSY.	9.500	SHOWN
	D111915-02	L/H W/OUT BEAM SWEEP ASSY.	9.500	
	D111915-03	R/H W/ BEAM SWEEP ASSY.	9.500	SHOWN
	D111915-04	L/H W/ BEAM SWEEP ASSY.	9.500	

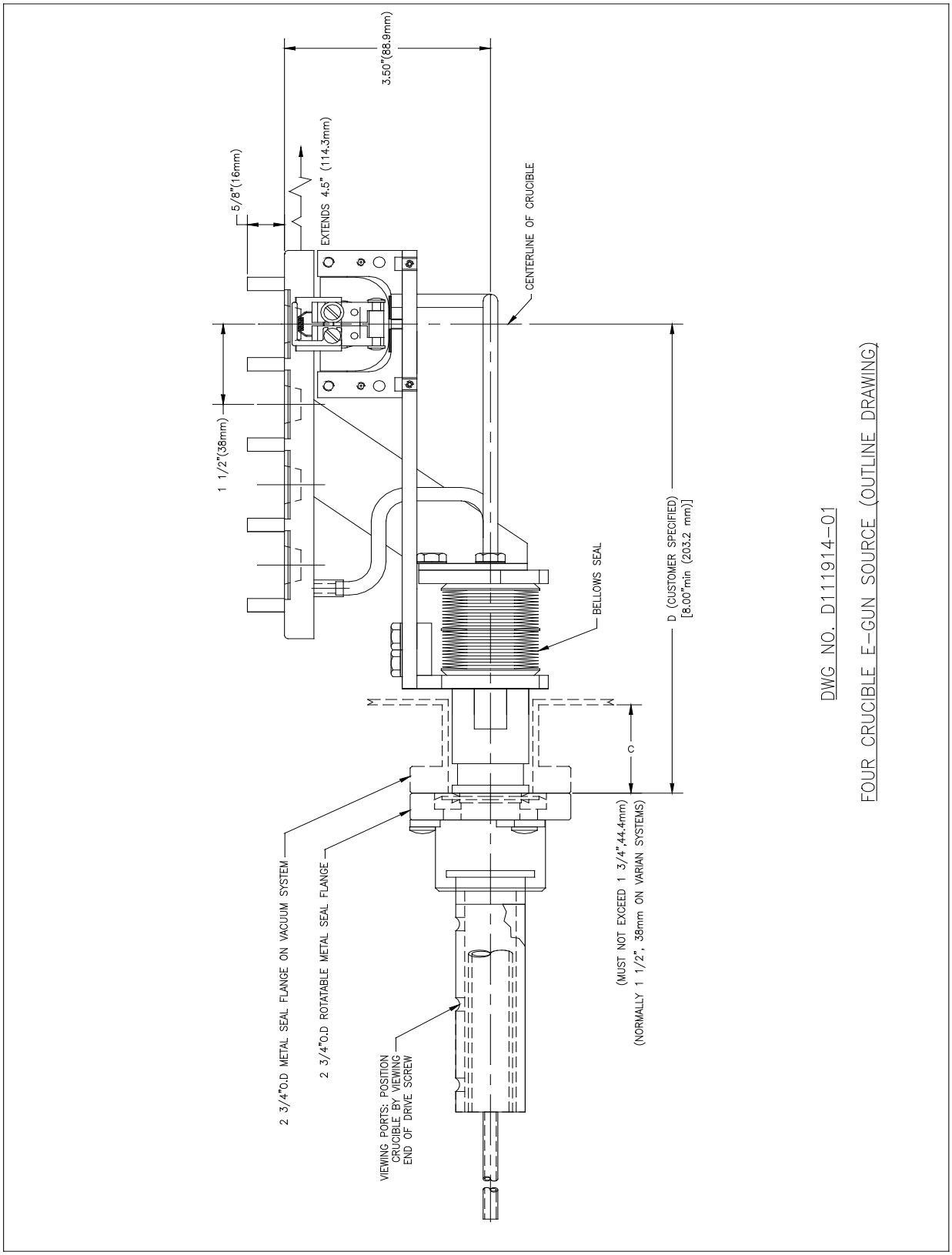

3.50"(88.9mm)
5/8"(16mm)
EXTENDS 3.0" (76.2mm)
CENTERLINE OF CRUCIBLE
1 1/2"(38mm)
BELLOWS SEAL
D (CUSTOMER SPECIFIED)
[6.50"min (165.1 mm)]
C
(MUST NOT EXCEED 1 3/4",44.4mm)
(NORMALLY 1 1/2", 38mm ON VARIAN SYSTEMS)
2 3/4"O.D METAL SEAL FLANGE ON VACUUM SYSTEM
2 3/4"O.D ROTATABLE METAL SEAL FLANGE
VIEWING PORTS: POSITION
CRUCIBLE BY VIEWING
END OF DRIVE SCREW
DWG NO. D111913-01
THREE CRUCIBLE E-GUN SOURCE (OUTLINE DRAWING)

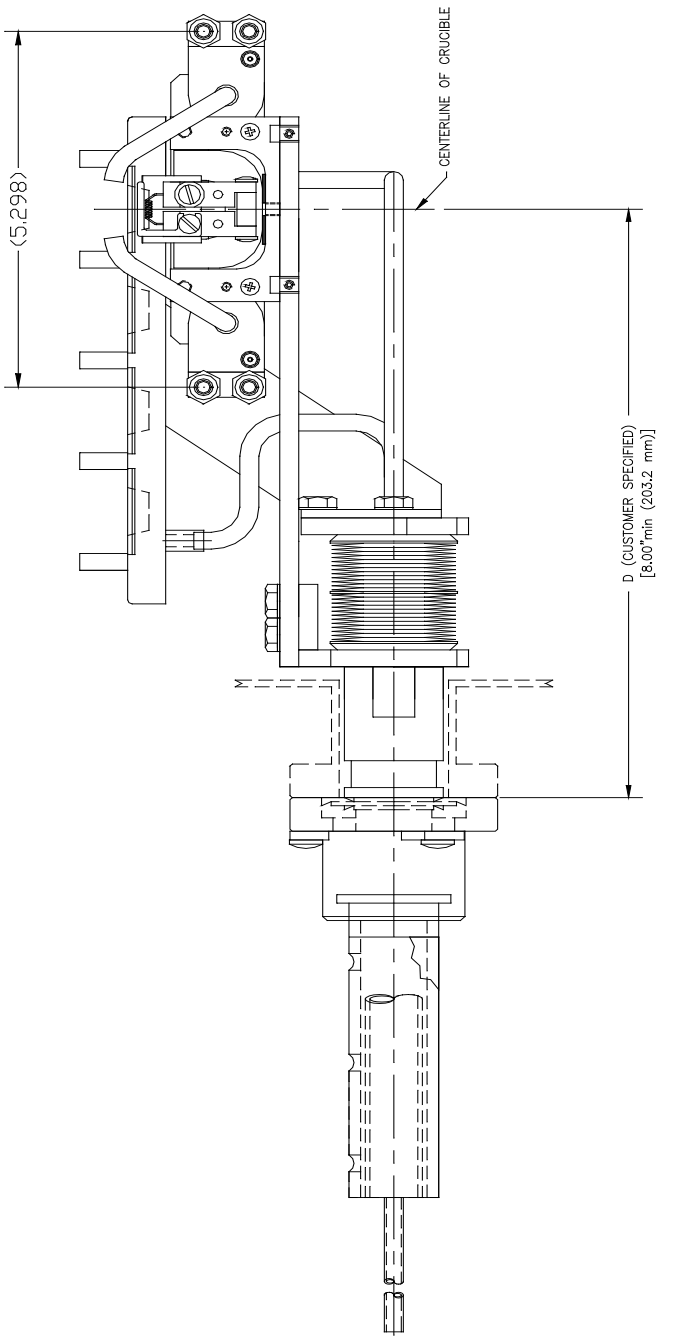


DWG. NO. D111913-03

THREE CRUCIBLE E-GUN SOURCE W/BEAM SWEEP ASSY

2-6

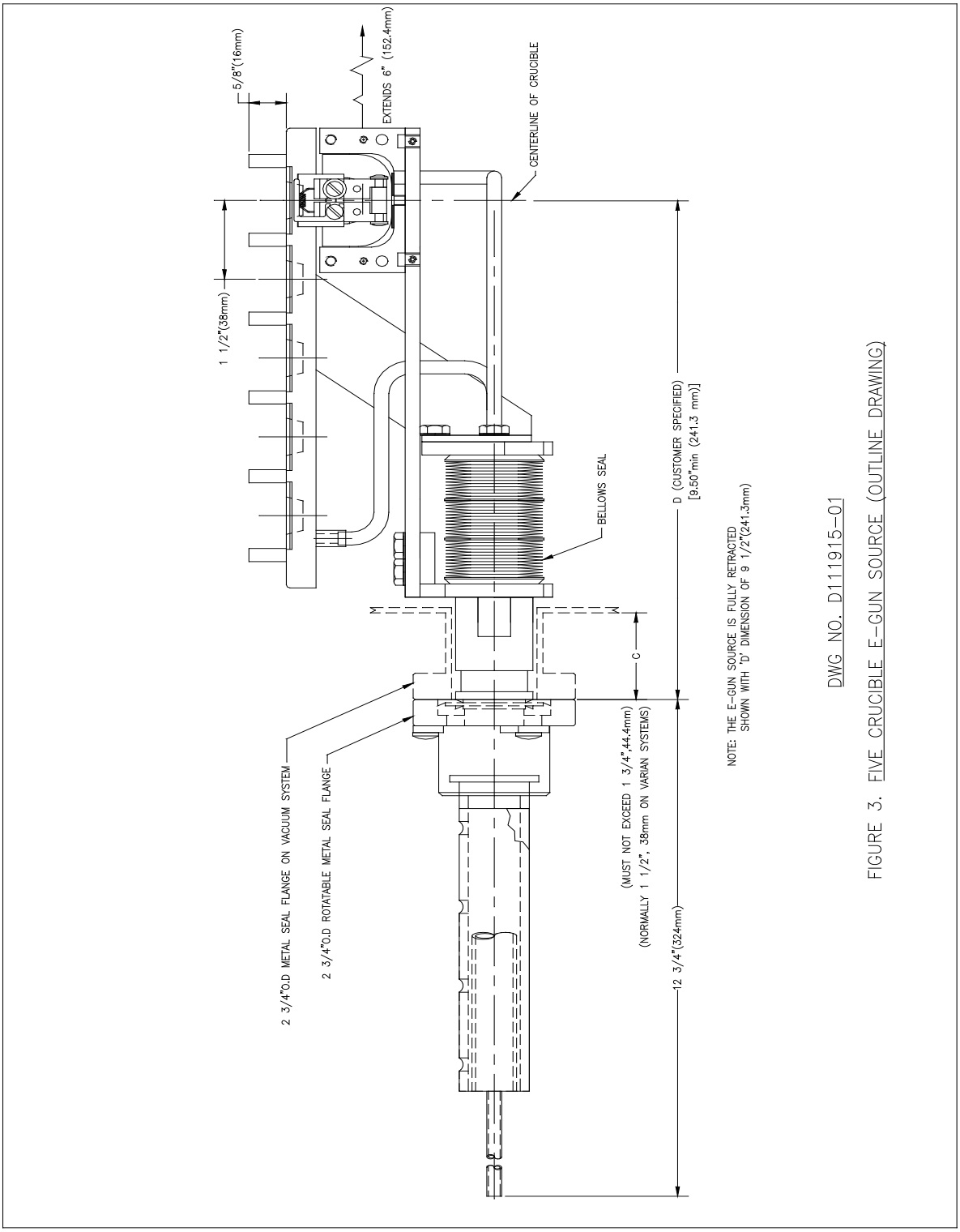

3.50"(88.9mm)
5/8"(16mm)
EXTENDS 4.5" (114.3mm)
CENTERLINE OF CRUCIBLE
1 1/2"(38mm)
BELLOWS SEAL
D (CUSTOMER SPECIFIED)
[8.00"min (203.2 mm)]
C
(MUST NOT EXCEED 1 3/4",44.4mm)
(NORMALLY 1 1/2", 38mm ON VARIAN SYSTEMS)
2 3/4"O.D METAL SEAL FLANGE ON VACUUM SYSTEM
2 3/4"O.D ROTATABLE METAL SEAL FLANGE
VIEWING PORTS: POSITION
CRUCIBLE BY VIEWING
END OF DRIVE SCREW
DWG NO. D111914-01
FOUR CRUCIBLE E-GUN SOURCE (OUTLINE DRAWING)



DWG NO. D111914-03

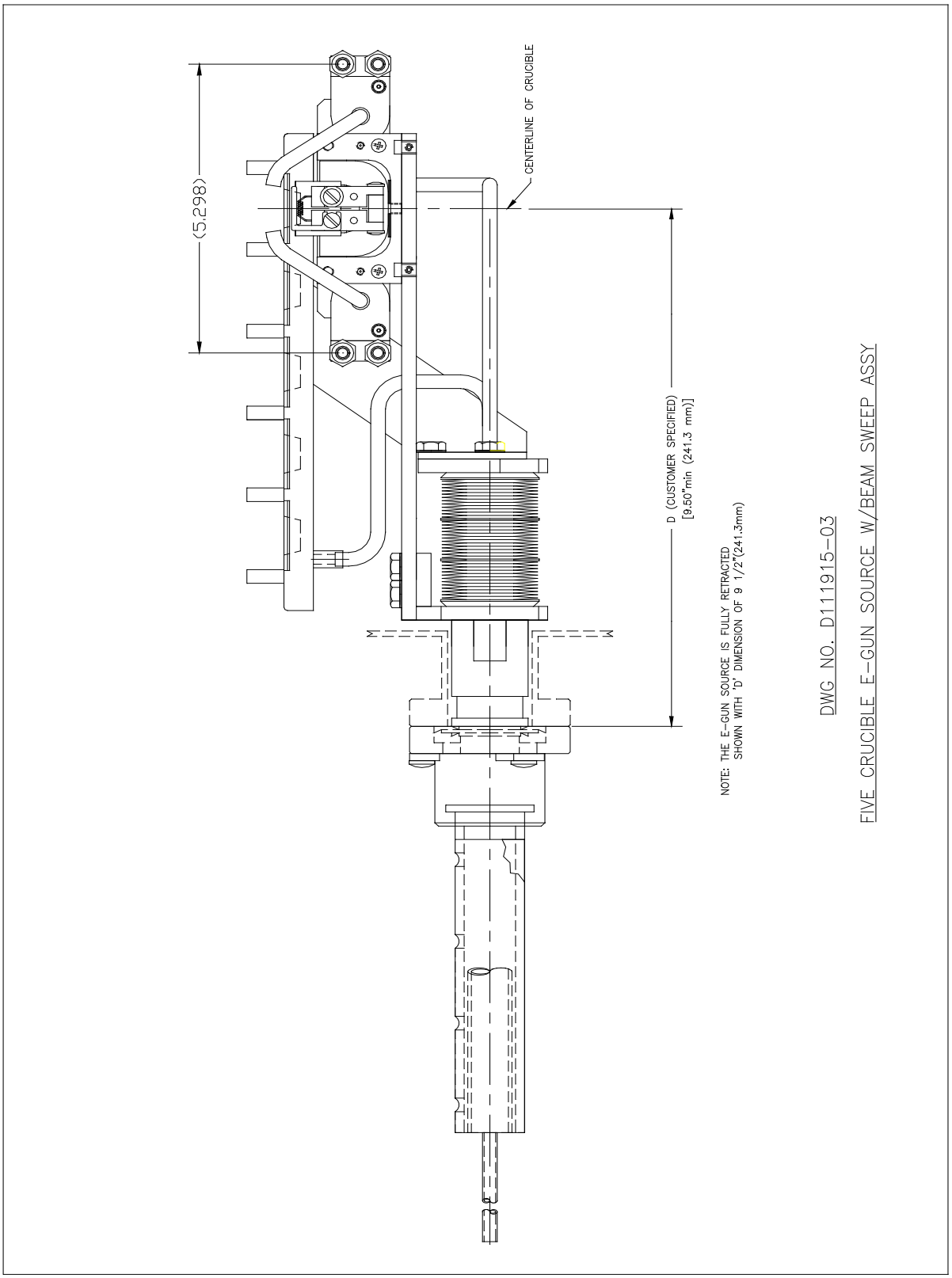
FOUR CRUCIBLE E-GUN SOURCE W/BEAM SWEEP ASSY

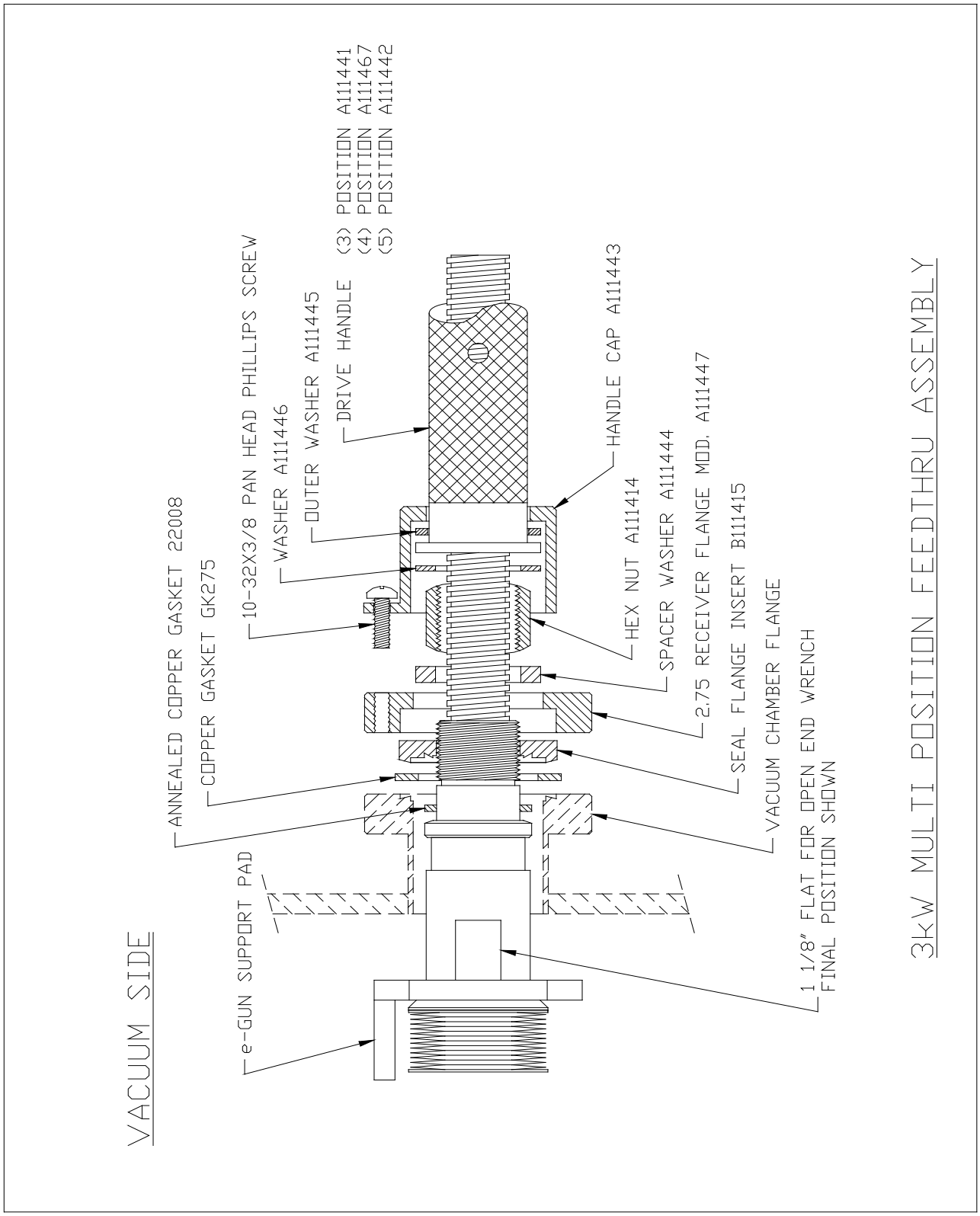
2-8



DWG NO. D111915-01

FIGURE 3. FIVE CRUCIBLE E-GUN SOURCE (OUTLINE DRAWING)

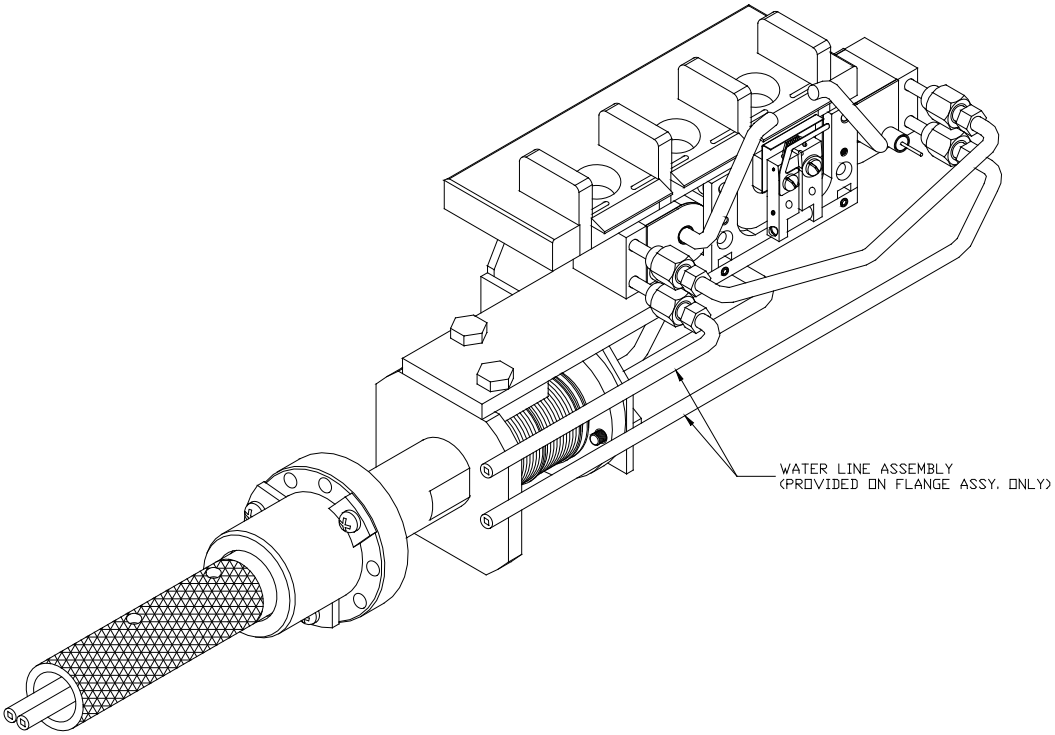

(5.298)
CENTERLINE OF CRUCIBLE
D (CUSTOMER SPECIFIED)
[9.50"min (241.3 mm)]
NOTE: THE E-GUN SOURCE IS FULLY RETRACTED
SHOWN WITH 'D' DIMENSION OF 9 1/2"(241.3mm)
DWG NO. D111915-03
FIVE CRUCIBLE E-GUN SOURCE W/BEAM SWEEP ASSY



2-11

Multiple Crucible e-Gun™

Multiple Position Crucible e-Gun™



Evaporation Source

Model 100-0030

When operating the multiple position crucible e-guns™, the electron beam power should always be turned off while the crucibles are being indexed or the beam may physically damage the pole between the crucibles.

Installation Instructions

A. Mount the compression port flange on the metal seal flange on your system.

B. Place the copper gasket (Part No 606563) on compression port seal and insert through feedthrough port. (Always use a new gasket each time a seal is made).

C. Tighten the compression port with the 1-1/4” nut until the vacuum seal is made.
Tighten until you encounter a firm resistance to further tightening.

D. Screw the positioning handle onto the drive shaft.

E. Mount the aluminum cover plate over the positioning handle and screw the metal seal flange.

To remove the e-Gun™ source, reverse these steps.

Multiple Position Crucible e-Gun™ Source Alignment Procedure

The Thermionics Laboratory, Inc. multiple position e-Gun™ source carriage
slides on roller bearings in a grooved track. It is very critical that the carriage rides on these tracks for proper alignment. If, for some reason, the carriage disengages from the track, alignment is lost. This may cause the beam to distort, or skew. Loss of alignment may even result in loss of emission current. See Figure 4.

First, if the carriage is not nested in the track when the carriage is moved from pocket to pocket, the mounting plate support bracket must be adjusted. Remove the carriage from the mounting plate. The mounting plate is bolted to a bracket, which is welded on one side only. Carefully raise the mounting plate by grabbing one end of the mounting plate and forcing it up until the bracket is 2 to 3 degrees above parallel to the crucible track. When this adjustment is correct, the bracket will push the carriage, and thus the roller bearing, upward, so that a slight load pressure ensures that the carriage stays in the track. After the support bracket is properly adjusted, put the carriage back on the mounting plate so that the roller bearings are in the track.

Second, once the carriage nestles properly in the track, loosen the (2) ¼ -20 socket head cap screw very slightly to move the mounting plate and carriage in parallel to the crucible.

Third, adjust the ¼”-20 socket set screws so that they just touch the bottom of the grooved carriage. Do not tighten beyond this point, otherwise it forces the mounting plate downward.

Once these adjustments have been made, test them by turning the drive handle and moving the carriage from pocket to pocket. If there is free movement without any binding, then the multiple pocket crucible e-Gun™ is properly aligned.

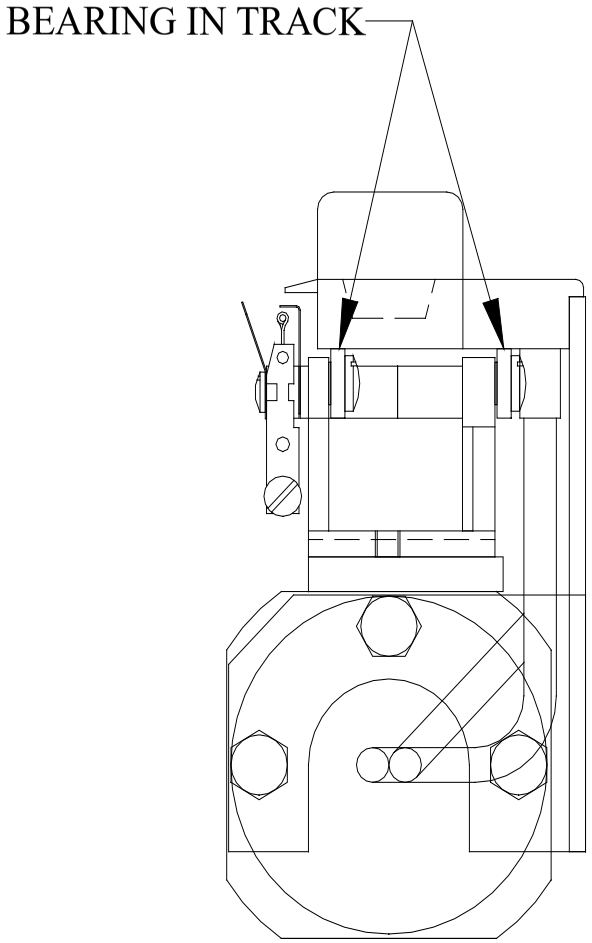


FIGURE 4
MULTI POSITION ALIGNMENT (OUTLINE DRAWING)

Section 3

Operation

A. CRUCIBLE PREPARATION

1. The most important requirement for high quality films and trouble-free operation is source cleanliness. Before every run, the crucible should be cleaned thoroughly to remove coatings built up from previous evaporation, if maximum cleanliness is to be maintained.

2. A heavy build-up of condensed coatings on the crucible surface will cause the melt to flow out rather than “balling up” from surface tension as it should. Heavy deposits in the crucible can also cause eruptions during a run if a piece of the cooled deposits should break loose and enter the melt.

3. Fine emery paper is recommended for cleaning; stainless steel wool can also be used. Heavy deposits can easily be scraped or chipped loosed with small scraper. When using stainless steel wool, caution should be taken to remove all small pieces left on the crucible, as static charges will cause them to jump around during operation and cause shorting. A vacuum cleaner, such as a canister type with extension base and crevise tool is ideal for final clean up.

B. LOADING THE CRUCIBLE

1. Whenever possible the evaporant should be in solid form. Small flakes and loose powders should be avoided if possible because static charges cause them to jump around. Often powders can be compressed into pellets to avoid this problem.

2. Very few materials are pure enough to be melted the first time without some spatter or gaseous outburst. A shutter should be used to protect the substrate during initial melting. It is desirable in some cases to pre-melt the evaporant in a separate pump down cycle. This is especially true in cases where new and unfamiliar materials are to be used. Once the materials are purified, the coating run can be made without fear of erratic operation.

3. When evaporating materials with high thermal conductivity (e.g. aluminum) it is often advantageous to place a thermal barrier between the crucible and the evaporant material. A thin sheet (10 mil) of tantalum or tungsten is suitable for this

purpose. However, some impurities may be introduced by this method.

The crucible liners also act as a good thermal insulator between the hearth and the melt. Following are four advantages to the use of the crucible liners.

a. Lower the beam power to obtain the same deposition rate.

b. Deposition rates higher than those obtainable in a bare hearth.

c. Elimination or reductions of charge splattering.

d. Decreased X-ray damage.

Note that to obtain the benefits of using a crucible liner, the crucible liner must be used properly. The crucible liner should be handled using conventional clean room techniques. The crucible liners have been purified to less than 200 PPM total ash.

When crucible liners are used, then to obtain the same deposit rates, the electron beam power is reduced to 1/3 –1/4 of the power used when bare hearth evaporations are performed. If the same power settings are used, then the deposition rates will be two to four times greater. The exact difference will depend on the material being evaporated.

The surfaces of the hearth cavity should be properly cleaned, and any marred or rough surface be refinished to a smooth surface.

Normally the best amount to load in a crucible liner is between 80% and 30% of the crucible liner. If the amount of the load is over 80% of the capacity of the liner, then spillover may occur. Spillover will cause a thermal short, the crucible will overheat, and the liner will break.

Make sure the electron beam does not strike the crucible liner or breakage may occur.

4. Persons not familiar with the evaporation process should learn that there are several factors involving thermal and electromagnetic phenomena taking place within the area of the crucible and pole pieces. These phenomena result in unusual behavior of the power supply current meter over time.

a. When the source material is of a metallic nature (magnetic or non-magnetic), there appears to be a field retention between the two pole pieces which causes a decrease of field current,

which requires an increase in the current from the e-Gun™ source control unit.

EXAMPLE: The source material is aluminum. The evaporant point is 300 ma. As the material evaporates there is a slight decrease in the current. The control must be increased to 325, 350, or even 375 ma to obtain the same rate of deposition on the substrate.

b. The second phenomena may be noticed in the changing physical characteristic of the source material. As the start of the evaporation cycle there may be a round ball of source material. This is desirable but you must realize that as soon as the ball melts down to a flat mass you no longer have a pinpoint contact between the crucible bottom and the source material. The surface contact is increased several hundred times so that the source material now has a very large cooling area and thus may need more current to obtain the same evaporation rate.

c. SOURCE OPERATION

1. Make sure the vacuum chamber is operating at a pressure lower than 1 X 10-5 Torr. Otherwise a glow discharge may develop. This will not harm the e-Gun™ source but will prevent the e-Gun™ source from operating.

2. Make certain all of the interlocks are operating properly. All the safety grounds must be secure.

3. Turn on the crucible cooling water.

4. Be sure the emission control switch is in the “OFF” position.

5. When ready to begin coating, turn on the main circuit breaker and check to see that the interlock lights are out.

6. Press the “H.V. ON” button. The H.V. LED (red light) should light up. If the light does not go on, check the front and rear circular connector (shorted) plugs. Check the emission control to be sure the normally closed switch is closed. Be sure the main power cords is plugged into a power outlet that actually has power.

7. Slowly turn the emission control clockwise, while watching both the crucible charge and the current meter, until the charge begins to become red-hot. Now hold the current steady for a moment to allow the source material to equalize in temperature. Once the evaporant has stabilized, the power may be slowly increased to any desired power level less than 750 ma. However,

too strong a beam may drill through the charge. The best level to use depends on the material; most evaporate 100% at 700 ma or less.

d. SHUT DOWN

1. Slowly turn the emission control counterclockwise until it points to “start”. Only in emergency should you press the “OFF” button while the power supply is emitting current to the e-Gun™ source.
2. Allow the e-Gun™source to become “COLD” before venting chamber to air.

Section 4

e-Gun™ Maintenance and Adjustments

A. Filament and Cathode Adjustment

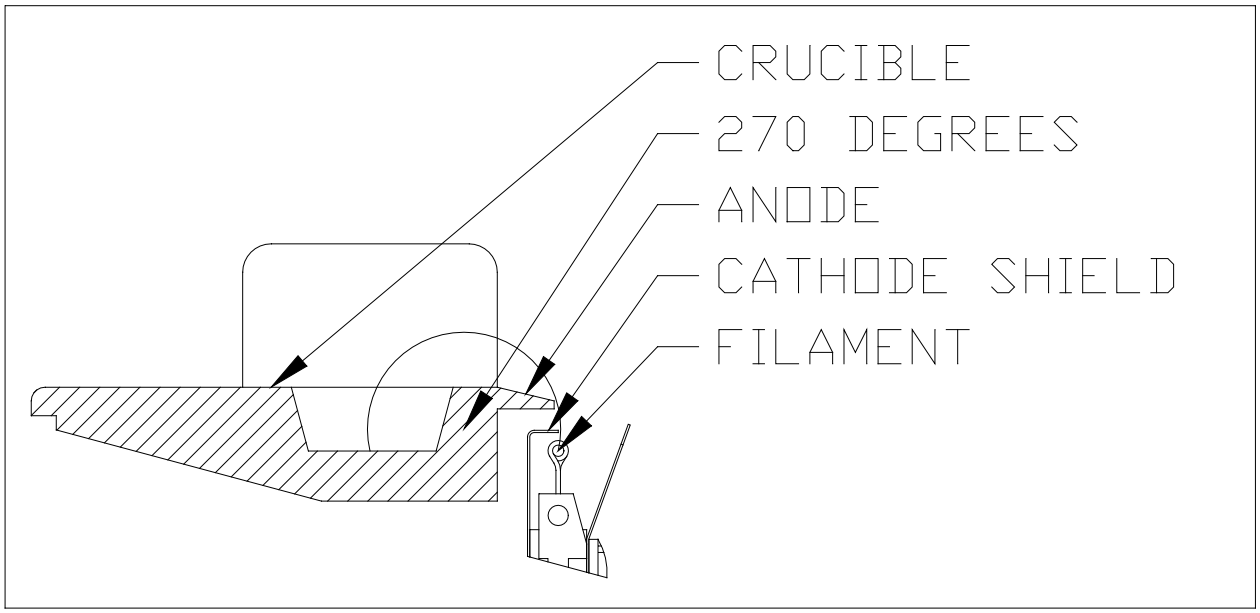


FIGURE 5 FILAMENT AND CATHODE ADJUSTMENT
NOTE: About 1/3 of the Filament can be seen from above

1. For the most efficient operation, follow the sketch dimensions above when adjusting or charging the filament. If too much of the filament is exposed, the anode will be bombarded decreasing the power to the crucible. If however, too much of the filament is hidden, the space charge will increase and the filament will have to be excessively heated for sufficient emission.

A .040” X ¼” wide gauge should be used between the cathode shield when adjusting clearance and a .010” sheet between the filament and cathode shield when installing the filament.

2. The anode edge and cathode shield edge should be in vertical alignment. The filament center should be slightly toward the cathode shield side of the vertical line (see sketch). Looking directly down from the top of the source, approximately 1/3 of the filament should be exposed. It should be centered between the poles. If it favors one side over the other, the beam spot will be off-center on the opposite side.

B. MAINTENANCE

1. One of the most important maintenance procedures is cleanliness. All of the items within the vacuum system must be as clean as possible. Clean all items according to “Clean Room” procedures and remember that one small fingerprint can cause very serious coating and vacuum problems.

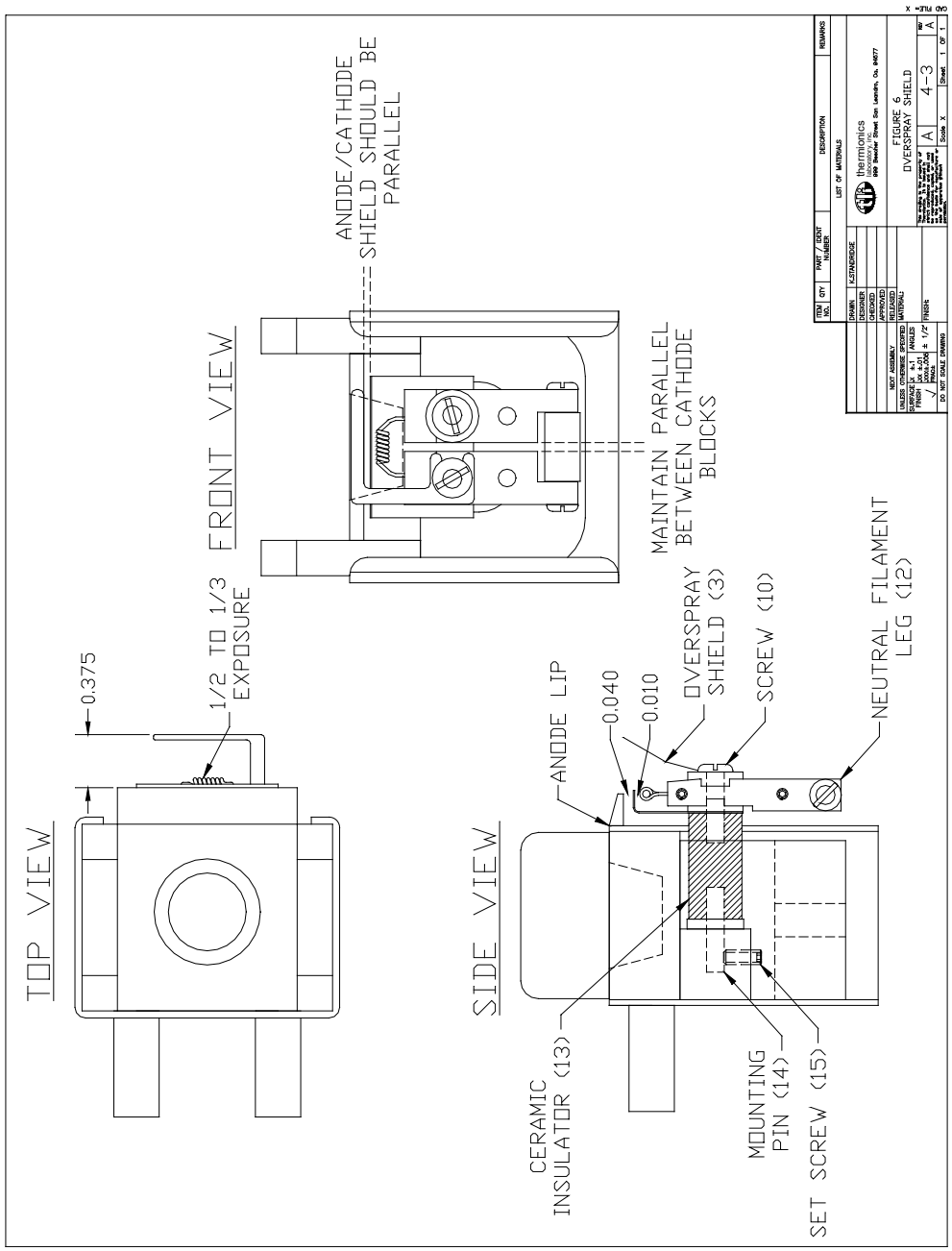
2. Make certain the e-Gun™ crucible, pole pieces, filament, and all related parts are completely free of small particles and overspray. Scrape the surfaces clean then vacuum clean completely.

C. OVERSPRAY SHIELD MODEL #21013

1. The overspray shield shown in figure 6 is supplied to all current models of e-Gun™ sources and can be added to earlier models to increase their efficiency. Without the shield roughly 79% of all electrons leaving the filament strike the crucible. With the shield, this vale is increased to over 99%. Be sure that the shield is properly adjusted, as described below.

D. INSTALLING THE OVERSPRAY SHIELD

1. Attach the overspray shield (3) to the neutral filament leg (12). Using the screw (10) already on the source head. Bend the overspray shield, so that its main arm is parallel to and 3/8” (9MM) away from the anode lip.



The e-Gun™ HEAD and OVERSPRAY SHIELD combination is now ready to mount.

IMPORTANT NOTICE:

It is difficult to install a filament and make necessary adjustment with the overspray shield in place. The most effective procedure is to remove the overspray shield, make the complete adjustment, then reinstall the overspray shield. However, this procedure involves one delicate aspect. When you loosen and re-tighten the left-hand screw (part No. 10), you must be very careful not to change the filament assembly alignment. The two filament leg screws, (part No. 10) must be tight, but over tightening will put the filament assembly out of alignment. After the overspray shield has been installed check the filament assembly very carefully to be sure you have not changed any of the adjustments.

E. MAGNETIC FIELD ADJUSTMENT

1. If uniform coating is desired, it is important to have the electron beam spot striking directly on the top center of the molten area. Some slight changes in the beam striking area can be made by adjusting the magnetic field. This is done by adjusting the aluminum shim thickness between the magnet and pole pieces. All e-Gun™ evaporation sources are delivered with a pre-set magnetic field between 250-280 gauss measured at the center of the bottom of the crucible.

2. FOR SINGLE POSITION e-Gun™ UNITS ONLY

The e-Gun™ source units should be set up and the beam spot observed. If a pair of welding goggles is used to overcome the brightness, then it is easy to observe the beam spot at the point where the beam strikes the source material. If the beam is seen to be hitting on the far side (cooling line side) of the melt, the magnetic field is too weak. If the beam is hitting on the near side (filament side) of the melt, then the magnetic field is too strong. Use Aluminum shims (provided by factory) to increase or decrease the magnet gap until proper focus is obtained (see Fig. 7, item #6, shims must be equal in thickness on both sides.

3. FOR MULTI-POSITION e-Gun™ UNITS ONLY

In order to make magnetic field adjustments on the multi-position e-Gun™ unit, begin by removing the slide carriage from the mounting bar. Once the carriage is removed, loosen the screw holding the permanent magnet in place. If you want to pull the beam forward toward the emitter, place more shims under the magnet to strengthen the magnetic field. If you want to push the beam away from the emitter, remove shims to weaken the magnetic field. Once shims have been added or removed, tighten the magnet holding screw and install the carriage back on the mounting plate.

F. Gun Maintenance

IMPORTANT NOTE:

The installation and adjustment of the e-Gun™ filament assembly is outlined above. This is not a difficult procedure to follow. In approximately 90% of those cases where the power supply output will not excess 400-500 ma at 100% power, the problem may be traced to alignment errors.

1. In order to remove the filament assembly, you must first remove the magnet. As you do, MAKE SURE you count the number of magnet shims under the magnet so you can put back the same number. Use a pair on long nose pliers and grip the magnet between the center hole and edge of the magnet. Pull straight out. You will have to pull hard, since the magnetic pull will cause considerate resistance. Be careful to catch the shims in the air gap. These shims will have to be reused when the magnet is reassembled.

2. Remove the filament assembly by removing the two set screws (Item No. 15 Figure 7). The gun assembly will now slide out.

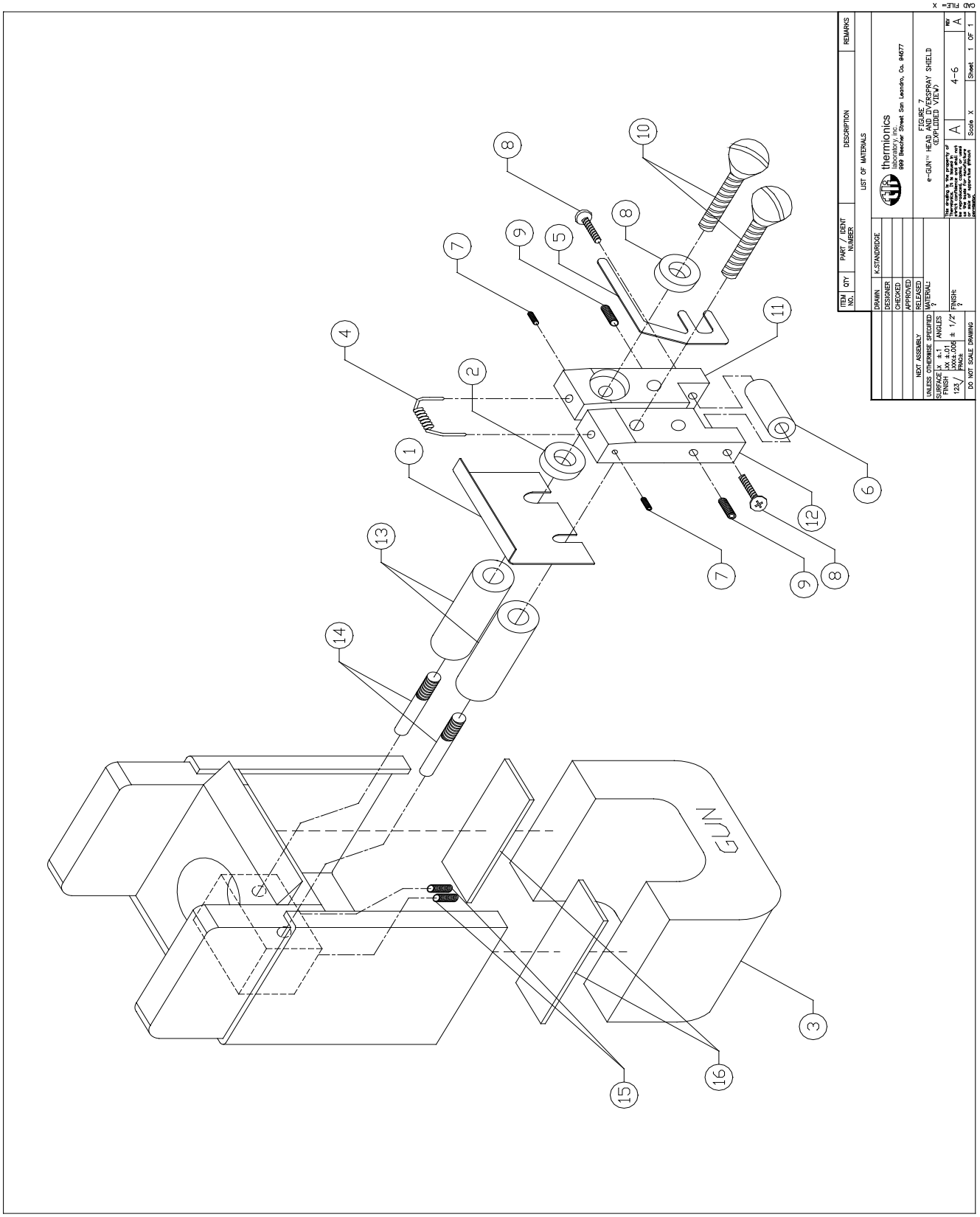
3. Loosen the two 6-32 X ½" binding head screws (Item 10 Figure 7)

4. Loosen the two-dog point Allen head screws (Item No. 7 Figure 7) and remove the old filament from the filament legs. Install the new filament and retighten the two set screws (Item No. 7).

AFTER THE FILAMENT ASSEMBLY IS REINSTALLED IN THE E-GUN™

5. Recalibrate the e-Gun™ source assembly as per the instructions on page 4-1. During the normal installation of filaments there is no need to replace the cathode shield or the overspray shield. Just inspect them for breaks or coatings.

6. Replace the magnet being careful to install it so that the word "GUN" is facing out and is under the filament assembly. The e-Gun™ source will not function if the magnet is in backwards.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APPROVED
RELEASED
NEXT ASSEMBLY
UNLESS OTHERWISE SPECIFIED
SURFACE FINISH
MATERIAL?
ANGLES ± 1/2°
FINISH: ?
DO NOT SCALE DRAWING
thermionics
laboratory, inc.
999 Beecher Street San Leandro, Ca. 94577
FIGURE 7
e-GUN™ HEAD AND OVERSPRAY SHIELD
(EXPLODED VIEW)
Scale X
Sheet 1 OF 1
GUN

Parts List

Fig. 7 3kW Single Position e-Gun Head and Overspray Shield (Exploded View)

ITEM	PAGE	DESCRIPTION	SPECIFICATION	PART NO.
1	4-5	Cathode Shield	Molybdenum	A21011
2	4-5	Ceramic Washers (2 req.)	Milk Ceramic	A22009
3	4-2 & 4-5	Magnet	Alnico	A21005
4	4-5	Filament	.020 Tungsten	A21015
5	4-5	Overspray Shield	Molybdenum	A21013
6	4-5	Ceramic Insulator	6-32 x ¼", ½" Long	A22001-2
7	4-5	Set Screws (2 req.)	4-40 x 3/16" (Cup Pt.)	A22013-3
8	4-5	Vented Screws (2 req.)	6-32 x 5/16" Rnd. Head	A22013-2
9	4-5	Set Screws (2 req.)	6-32 x 3/16"	A22013-5
10	4-2 & 4-5	Vented Screws (2 req.)	6-32 x ½ Bndg. Hd.	A22013-1
11	4-5	Insulated Filament Leg	O.F.H.C. Copper	A21007-2
12	4-2 & 4-5	Neutral Filament Leg	O.F.H.C. Copper	A21007-1
13	4-2 & 4-5	Ceramic Insulators (2 req.)	6-32 x 3/8", ¾" Long	A22001-1
14	4-2 & 4-5	Mounting Pin: Single Position e-Gun™ Multiposition e-Gun™ Rod Fed e-Gun™ 6 kW e-Gun™	 6-32 x .600" 6-32 x .937" 6-32 x .480" 6-32 x .812	 A21008-a A21008-b A21008-c A21088-d
15	4-2 & 4-5	Set Screws (2 req.)	6-32 x 3/16 S.S. (Cup Pt.)	A-22013-3A
16	4-5	Aluminum Shim Set Aluminum Shim Set Aluminum Shim Set Aluminum Shim Set Aluminum Shim Set	1.130 x .450 x .010 1.130 x .450 x .020 1.130 x .450 x .030 1.130 x .450 x .040 1.130 x .450 x .050	A111416-01 A111416-02 A111416-03 A111416-04 A111416-05

DIAGNOSTIC TROUBLESHOOTING GUIDE

The symptoms are simply numbered for reference. There is no implication of an ordered sequence.

NO.	SYMPTOM	PROBABLE CAUSE	CORRECTION
1	Beam power voltage is normal but there is no beam power current and no filament current. (Power supply nominal operating values are listed in the appropriate power supply instruction manual.)	(1) Filament is broken, loose or high resistance due to oxide buildup on filament clamps. (2) Break in filament circuit or power supply	(1) Ensure that the filament is good and the filament clamp screw is clean and tight. (Apply molybdenum disulfide to all threads whenever a fastener is removed and reinserted.) (2) Check the filament circuit and power supply.
2	There is no beam power voltage. Emission current will be fully pegged, with zero high voltage.*	(1) There is a high-resistance ground in the source or system. (2) There is a high voltage breakdown.	(1 & 2) Check system for shorted emitter, filament leads, and/or feedthroughs, broken insulators.
3	Emission voltage and current move up and down and there is visible arcing or heating at the high voltage insulators.	(1) The high voltage insulators are fouled or have failed. (2) The filament current lead is dirty and is making intermittent contact.	(1) If fouled by conductive deposits, clean by glass-bead honing. If they are physically damaged, replace them. (2) Clean lead by glass-bead honing.
4	Beam power voltage and current are normal; filament current is high.*	(1) Filament winding is shorted	(1) Replace the filament. Do not repair it.
5	Beam power voltage and current are normal; filament current is normal* but longitudinal current is excessive.	(1) The main field permanent magnet is weak. (2) The focus coil is partially shorted. (3) The filament is warped.	(1) Re-magnetize the permanent magnet** or replace it. (2) Replace the focus coil. (3) Replace the filament.
6	Beam voltage and current are normal; filament current is normal.* The beam is not centered in	(1) Coil current improperly adjusted. (2) The permanent magnet is weak.	(1) Adjust the focus current.** (2) Re-magnetize the magnet.

	the longitudinal direction.		
7	Beam voltage and current are normal; filament current is normal.* Beam spot is not centered in the lateral direction or the spot tails on one side of the spot.	(1) Parts are not correctly aligned. The center line of the emitter filament is not aligned exactly between the pole pieces. (2) Pole pieces or other parts are damaged. (3) Interference from another source. (4) Air gap between permanent magnet and pole pieces.	(1) Ensure that all parts fit snugly, that ** the filament is positioned correctly and is not warped or sagging. (2) Repair or replace damaged parts. (3) Install magnetic shield between the two magnetic fields. (4) Readjust pole pieces
8	Beam voltage and current are normal; filament current normal.* There is melt wetting or eroding in the crucible.	(1) Beam is off center and/or focus is too close to the edge of the crucible. (2) There is insufficient water flow. (3) The emitter is out of adjustment. The filament may be out of alignment.	(1) Readjust the focus current so that the beam is centered in the crucible. (2) Ensure that the cooling water is flowing through the crucible at required rate. See installation (3) Ensure that the emitter is adjusted correctly.

9	Water boiling	(1) Inadequate flow. (2) High inlet temperature. (3) Weak permanent magnet. (4) Distorted filament. (5) Aluminum alloyed with copper crucible.	(1) Increase flow. (2) Chill water. (3) Check beam position with zero longitudinal coil current. Re-magnetize or replace permanent. (4) See following symptom. (5) See following symptom.
10	Aluminum alloying (wetting) with crucible. The alloying crucible cannot be reused until it has been glass-bead honed.	(1) Inadequate cooling (flow)) or badly warped filament. (2) Beam spot position is too far in or out, too far right or left, at high power operation.	(1) Check flow rate and water temperature. Replace warped filament. (2) Center beam in longitudinal or lateral direction as indicated.
11	Warped beam former and/or gun emission is limited.	(1) Beam former is shorted to right hand cathode block. (2) Filament emission is limited because the: (2a) filament is installed backwards, or (2b) not enough filament is exposed, or (2c) there are short turns on filament, or (2d) filament is badly warped, or	(1) Clean or replace locating insulator **. (2) Replace the beam former if the warp is extreme. If filament is warped or has shorted turns, replace it. If it is installed incorrectly, reposition filament.

		(2e) the anode is too far from the filament. (3) Badly coated flanged insulator. (4) Loose connection or oxidized surfaces at connections. (5) Low filament voltage.	(3) Clean or replace insulator. (4) Clean and reconnect. (5) Check for proper transformer connections. Check output of gun controller.
12	Short filament life.	(1) Filament emission limited because the: (1a) filament is installed backwards, or (1b) not enough filament is exposed, or (1c) there are short turns on filament, or (1d) filament is badly warped, or (1e) the anode is too far from the filament. (2) Improper use of rate control. Poor vacuum pressure in gun area (above 5 X 10^{-4} Torr).	(1) Call for reference to make proper adjustments of the emitter assembly. (2) Refer to the power supply manual to adjust the rate range.
13	There is a rapid loss of field strength in permanent magnet.	(1) There are strong ac fields coming from an external source.	(1) Reroute ac leads away from permanent magnet. CAUTION DO NOT SLIDE MAGNET ON MAGNETIC MATERIAL.
14	There is no lateral or longitudinal movement of the beam.	(1) No coil current. (2) Shorted leads to focus coils.	(1) Coil leads disconnected (2) Check resistance of lateral and longitudinal coils for shorts.
15	There is a pronounced loss of evaporation rate.	(1) Beam density may be too high, causing cavitation of molten pool. (2) The permanent magnet is too weak. The beam is not centered laterally. (3) There is interference by other electron beam source magnets or other magnetic fields. (4) The filament may be warped.	(1) Expose more filament or vary the distance between the pole extensions.** (2) Use zero coil current to determine the beam spot position at low power. (3) Install magnetic shield between the two magnetic fields. (4) Replace filament.

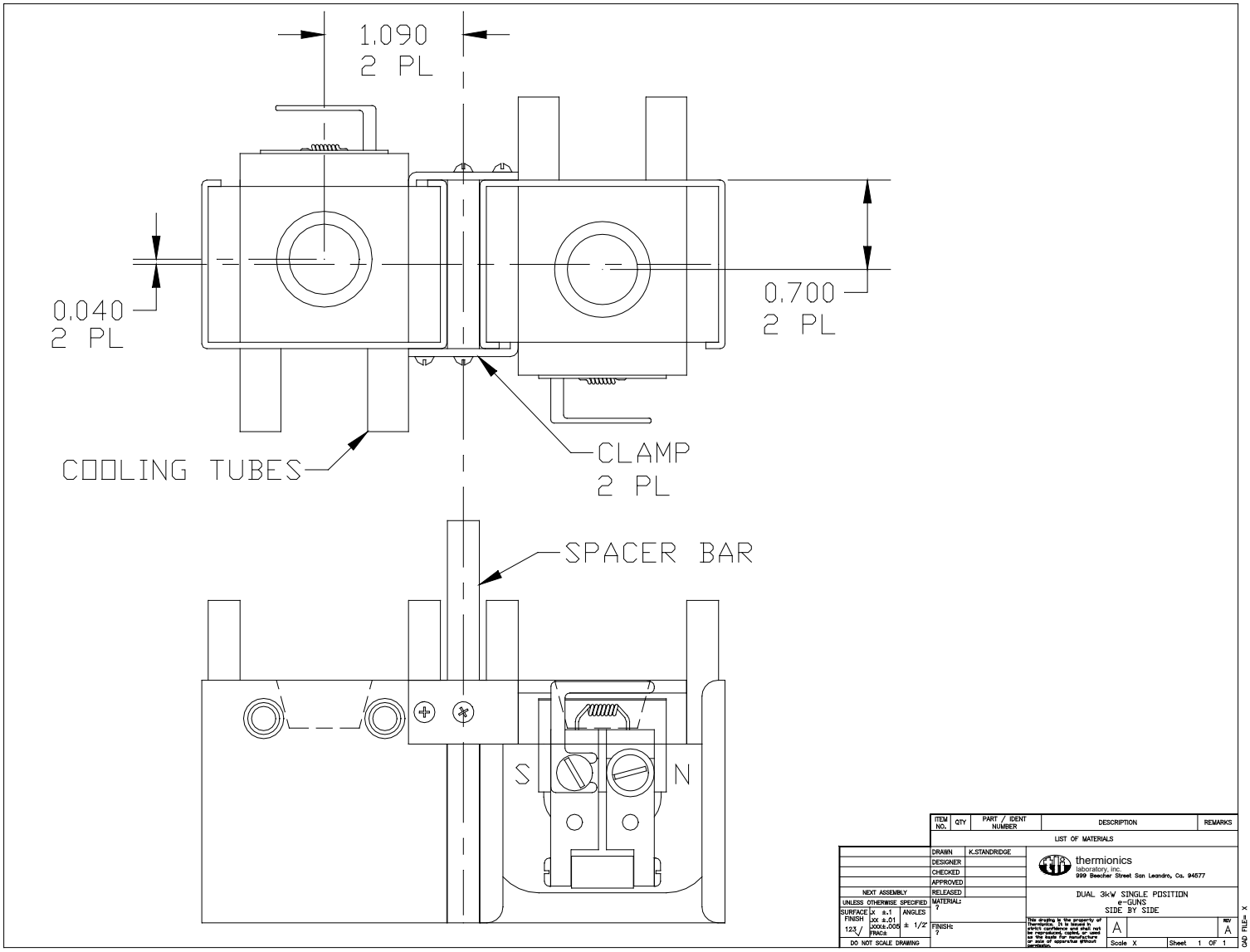
NO.	SYMPTOM	PROBABLE CAUSE	CORRECTION
16	There is loss of all lateral and longitudinal beam control.		(1) Check voltages on electromagnet. If there is voltage then check coil resistance. Longitudinal: 2.2 to 2.4 ohms Lateral: 3.0 to 2.1 ohms Change coil assembly.
17	Electron beam spot changes position as source is heated.	(1) The evaporant may be magnetic material such as Ni or Fe which when heated passes the curie point becoming nonmagnetic.	(1) For automatic cycling, heat evaporant at low power levels with beam spot in such a position that when the evaporant is through the curie point, the beam spot is centered in the crucible.
18	Electron beam spot shifts position as relatively large quantities of the material is evaporated.	(1) The evaporant is magnetic material, which builds up around the hopper causing a magnetic shunt.	(1) Remove deposit from around the hopper.
19	Electron beam spot cannot be moved out along the longitudinal axis	(1) The source is being operated at lower than 10kV.	(1) Use appropriate permanent magnet shunts.
20	Anode plate burned through.	(1) Anode plate directly exposed to the filament. (2) Power supply voltage not remaining constant.	(1) a. Adjust height of anode plate.** (1) b. Beam former shorted to cathode causing beam former to emit electrons and burn hole through anode. (2) a. Check power supply manual for proper rate control adjustments. (2) b. Check power supply for proper voltage regulation.
21	No filament current.	(1) Oxide buildup on the filament clamp blocks.	(1) Remove oxide.**
22	The maximum beam power attainable is 5 kW.	(1) The filament is installed backwards causing space charging. (2) The anode is positioned too far from the filament	(1) Reverse filament. (2) Realign filament.
23	Emission current drifts after a long period of operation.	(1) Pancake insulator has become cracked.	(1) Replace the insulator.

24	Cannot sweep complete area using tight beam.	(1) The permanent magnetic field is too strong.	(1) Use a shunt bar or bars as needed.
25	Filament burns out when energized.	(1)Possible 12 volts is being applied to the filament indicating a transistor or SCR (s) is burned out on the gun controller.	(1) Replace the SCR (s) or transistor (s) and the filament
26	After long usage there is a loss of evaporation rate; there is a slight space charging and sometimes the cooling water boils when operating above 12 kW beam power.	Filament has become warped.	Clean the emitter assembly. Replace the filament and adjust (filament 1/3 of the filament winding diameter is exposed below beam former).** NOTE ALIGNMENT OF THE EMITTER ASSEMBLY IS CRITICAL.

* Power Supply operation values are listed in the appropriate power supply instruction manual.

** Apply molybdenum disulfide to all threads whenever a fastener is removed and reinserted.

Appendix



If it is desired to operate two single position crucible e-Gun™ sources next to each other, either simultaneously or individually, the guns must be placed side by side with the cooling tubes pointing in opposite directions (repelling each other). A mild steel spacer bar as shown above must then be placed between the two guns or the bucking fields will change the magnetic flux lines, causing the beams to focus off center.

EVAPORATION CHARACTERISTICS

Material	Angstroms Per Minute
Aluminum	1260
Copper	1220
Gold	1550
Tantalum	435
Molybdenum	2290
Nickel	2250
Tungsten	590
Palladium	750
Silver	3000

All measurements were taken with a substrate 10 inches (25.4 cm) directly above the crucible in a vacuum of about 10-6 Torr. Power varies according to material, e.g. around 400 ma for aluminum, 650 ma for tungsten. This chart is for reference only. Several factors will affect actual deposition rates, including the chamber vacuum pressure, the amount of source material in the crucible, the condition of the filament, and whether or not a crucible liner is used.

SPECIAL INFORMATION AND DATA

A. A new filament may be bent greatly o get proper alignment, but once used it becomes brittle and will break easily.

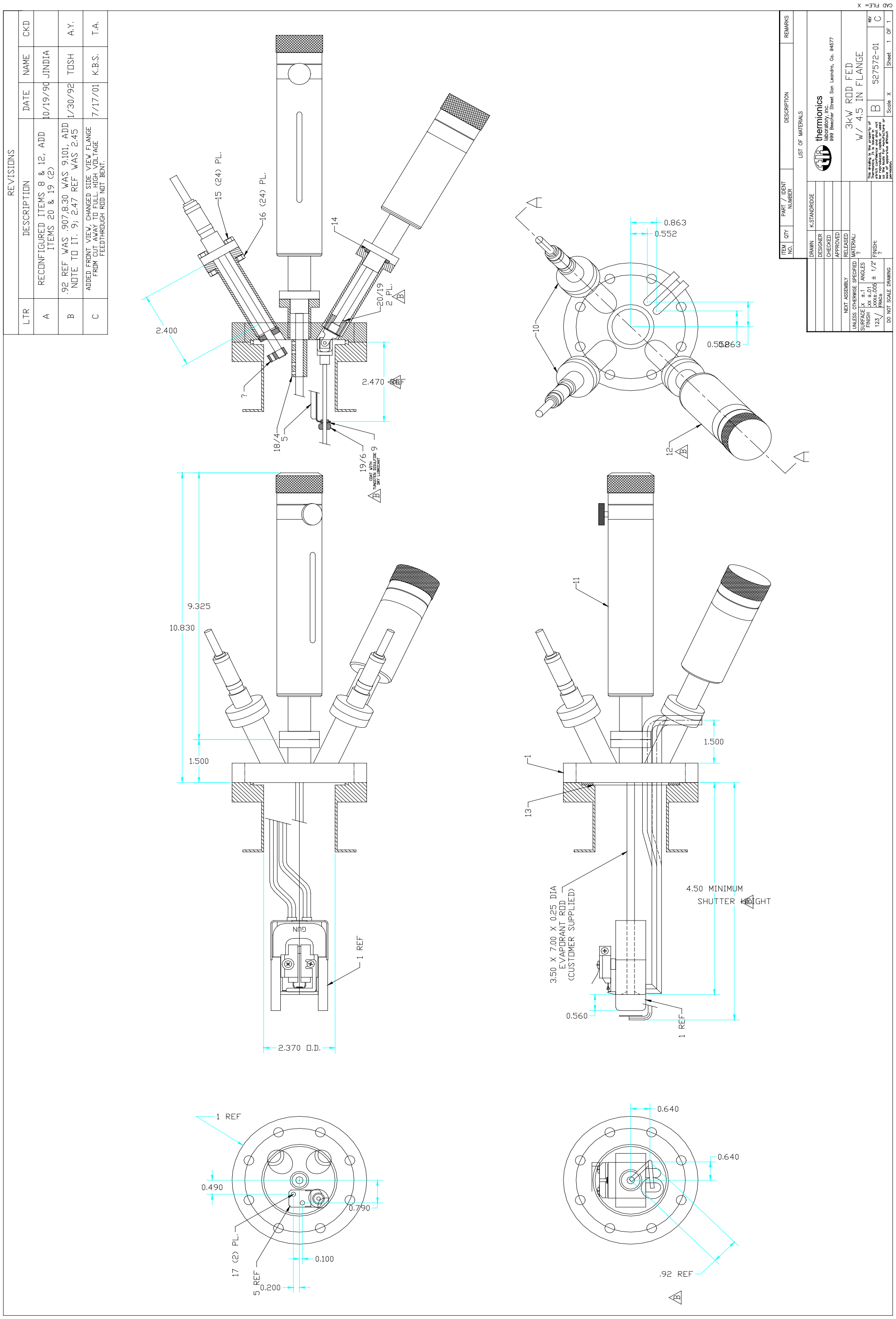
B. The magnet used in the e-Gun™ source is supplied with magnetic strength of 300-320 gauss (Oersteds) and care should be taken to see that it retains this strength. It should not be heated to temperatures over 250° Celsius and when disassembled should not be left for long periods without a keeper over the pole pieces.

C. With the magnet mounted in the e-Gun™ source the stray magnetic field around the gun has been measured and is tabulated in the following chart.

Magnetic Field in Gauss (Oersteds)

Distance (Inches)	Vertically Upward	Vertically Downward	Horizontally To Front and Rear
0	340	340	340
1	170	-	110
2	3	80	30
3	12	34	11
4	5	13	5
5	3	6	2
15	1	1	1

Accuracy of the above measurement is about +/- 10% or *0.5 Gauss, whichever is larger.



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1/30/92
TOSH
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C
ADDED FRONT VIEW, CHANGED SIDE VIEW FLANGE FROM CUT AWAY TO FULL, HIGH VOLTAGE FEEDTHROUGH ROD NOT BENT.
7/17/01
K.B.S.
T.A.
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16 (24) PL.
14
20/19 2 PL.
2.400
2.470 REF
18/4
5
19/6
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0.552
0.552
0.863
10
12
9.325
10.830
1.500
11
1
13
1.500
4.50 MINIMUM SHUTTER HEIGHT
3.50 X 7.00 X 0.25 DIA EVAPORANT ROD (CUSTOMER SUPPLIED)
GUN
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0.560
1 REF
0.490
0.790
17 (2) PL.
5 REF
0.100
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thermionics
3kW ROD FED W/ 4.5 IN FLANGE
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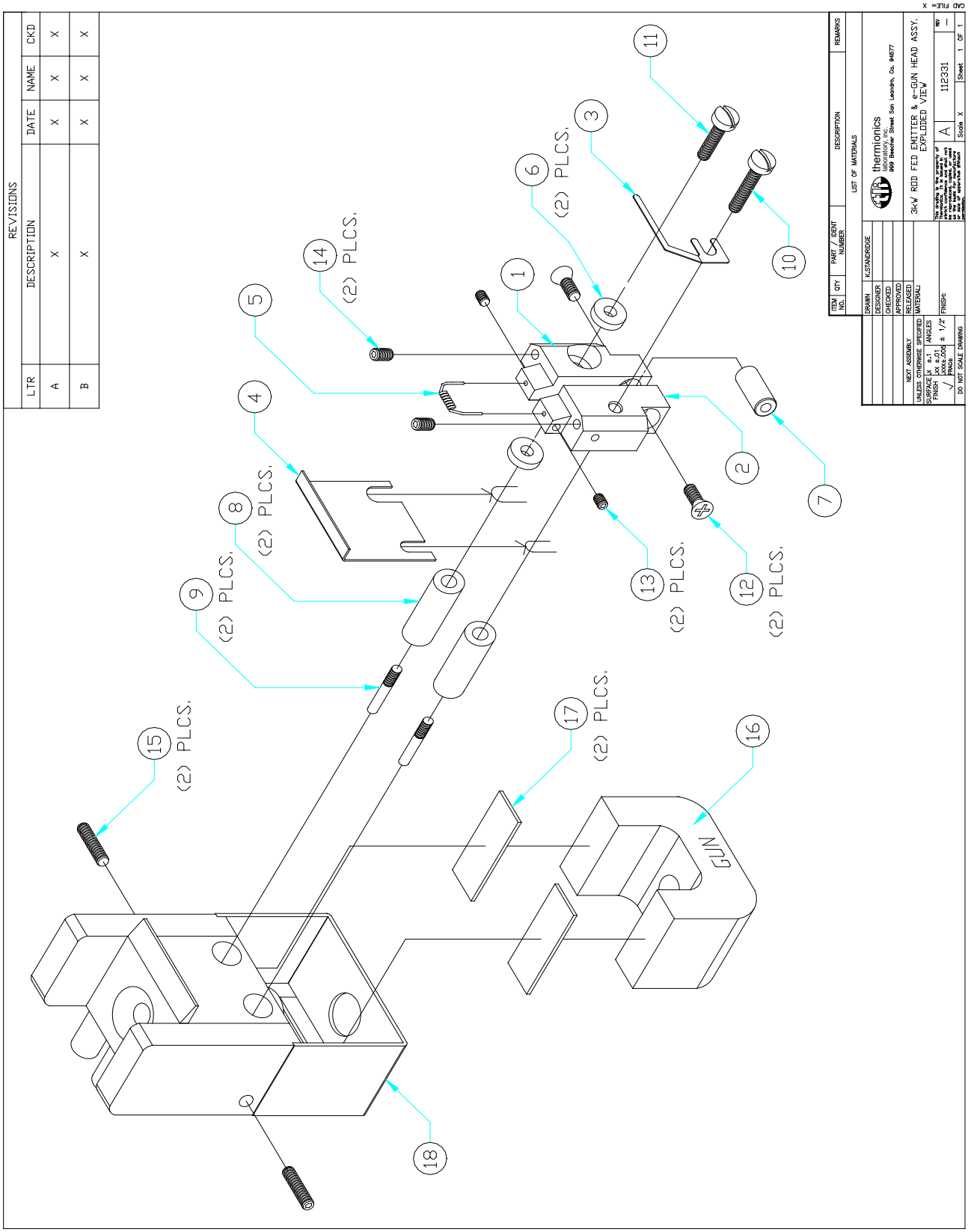
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DO NOT SCALE DRAWING
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laboratory, inc.
3kW ROD FED EMITTER & e-GUN HEAD ASSY.
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Scale X
Sheet 1 OF 1
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(2) PLCS.
GUN

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X					A524783-13	2		FILAMENT LEG, NEUTRAL	1	
X					A524783-15	3		OVERSPRAY SHIELD	1	
X					A524783-14	4		CATHODE SHIELD	1	
X					A111407	5		FILAMENT, 3kW e-GUN	1	
X					A111418-01	6		CERAMIC WASHER	2	
X					22001-2	7		CERAMIC INSULATOR, 6-32 X ¼ DIA X ½	1	
X					22001-1	8		CERAMIC INSULATOR, 6-32 X 3/8 DIA X ¾	2	
X					A111604	9		MOUNTING PIN	2	
X						10		6-32 X 5/8 PAN HD. SLOT SST.	1	
X						11		6-32 X ½ PAN HD SLOT SST.	1	
X						12		6-32 X 5/16 FLAT HD PHILLIPS SST.	2	
X						13		4-40 X 1/8 SET SCREW SOC. DOG POINT SST.	2	
X						14		6-32 X 3/16 SET SCREW SOC. DOG POINT SST.	2	
X						15		6-32 X ½ SET SCREW SOC. SST	2	
X					A523957-09	16		MODIFIED MAGNET	1	
X					A111416-XX	17		SHIM SET 1.125 X 0.437 X 0.010 THK	VARIES	
X						18		3kW ROD FED e-GUN HEAD	1	
						19				
						20				
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						22				
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						24				
						25				
						26				
						27				

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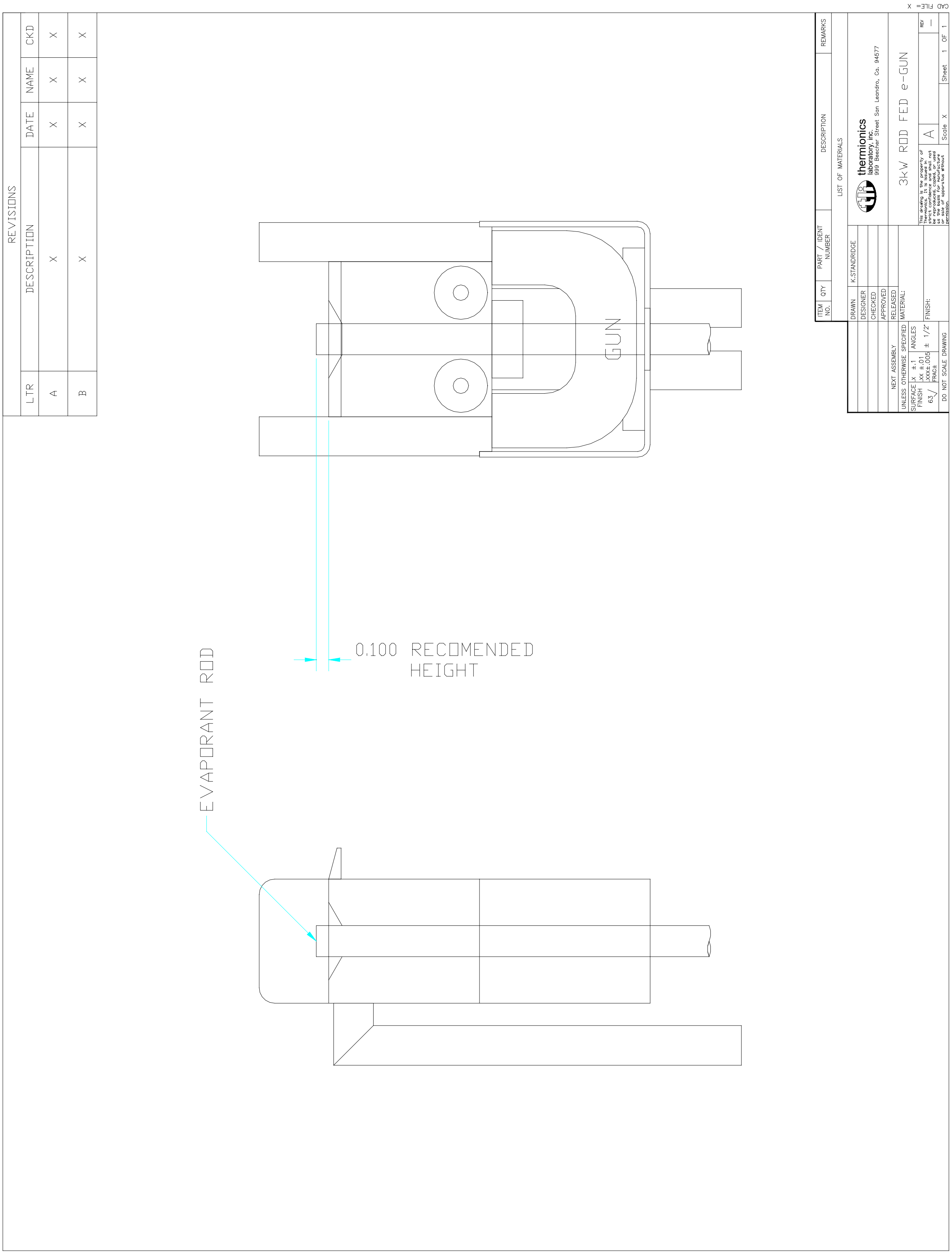
DATE REV						SHT 1 OF 1	A112331-01 REV -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RELEASED
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NEXT ASSEMBLY
UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
thermionics
laboratory, inc.
999 Beecher Street San Leandro, Ca. 94577
3kW ROD FED e-GUN
A
Sheet 1 OF 1
CAD FILE= X

Beam Sweep Coil Connections