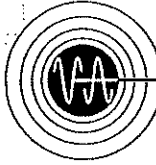


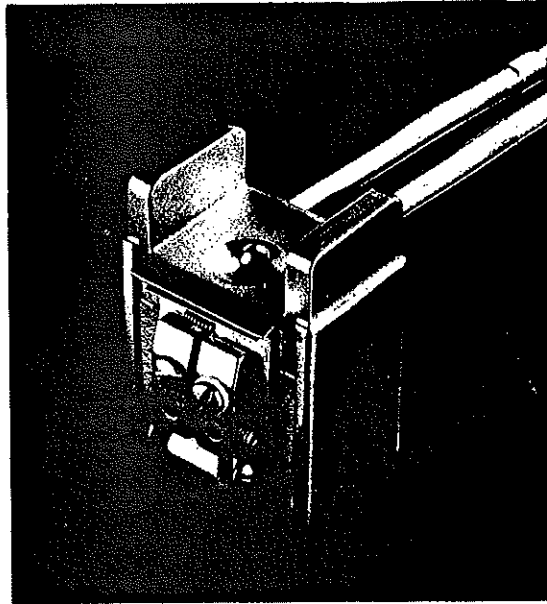
Vacuum Products  
Division



**VARIAN**  
associates

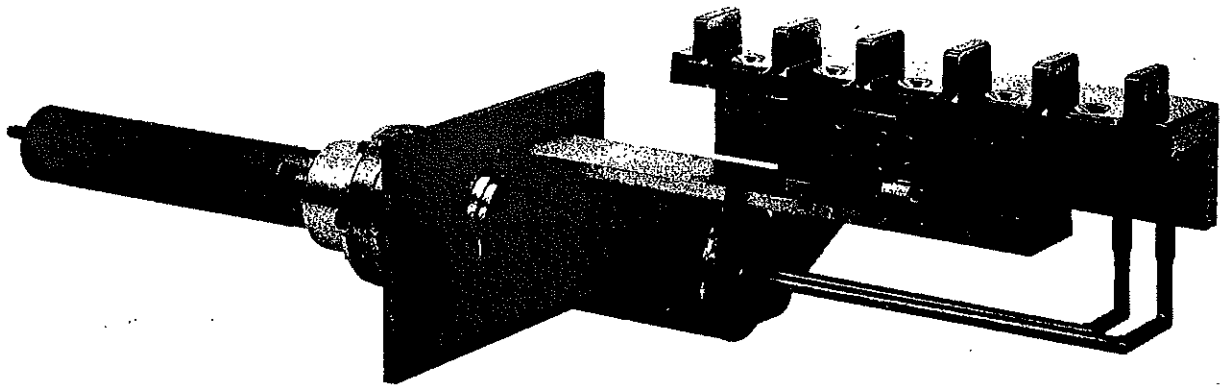
e-GUN\*  
EVAPORATION SOURCE

INSTRUCTION  
MANUAL



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**Single Crucible e-Gun Evaporation Source,  
Model No. 980-0001**



**Multiple Crucible e-Gun Evaporation Source,  
Model Nos. 980-0003, 980-0005**

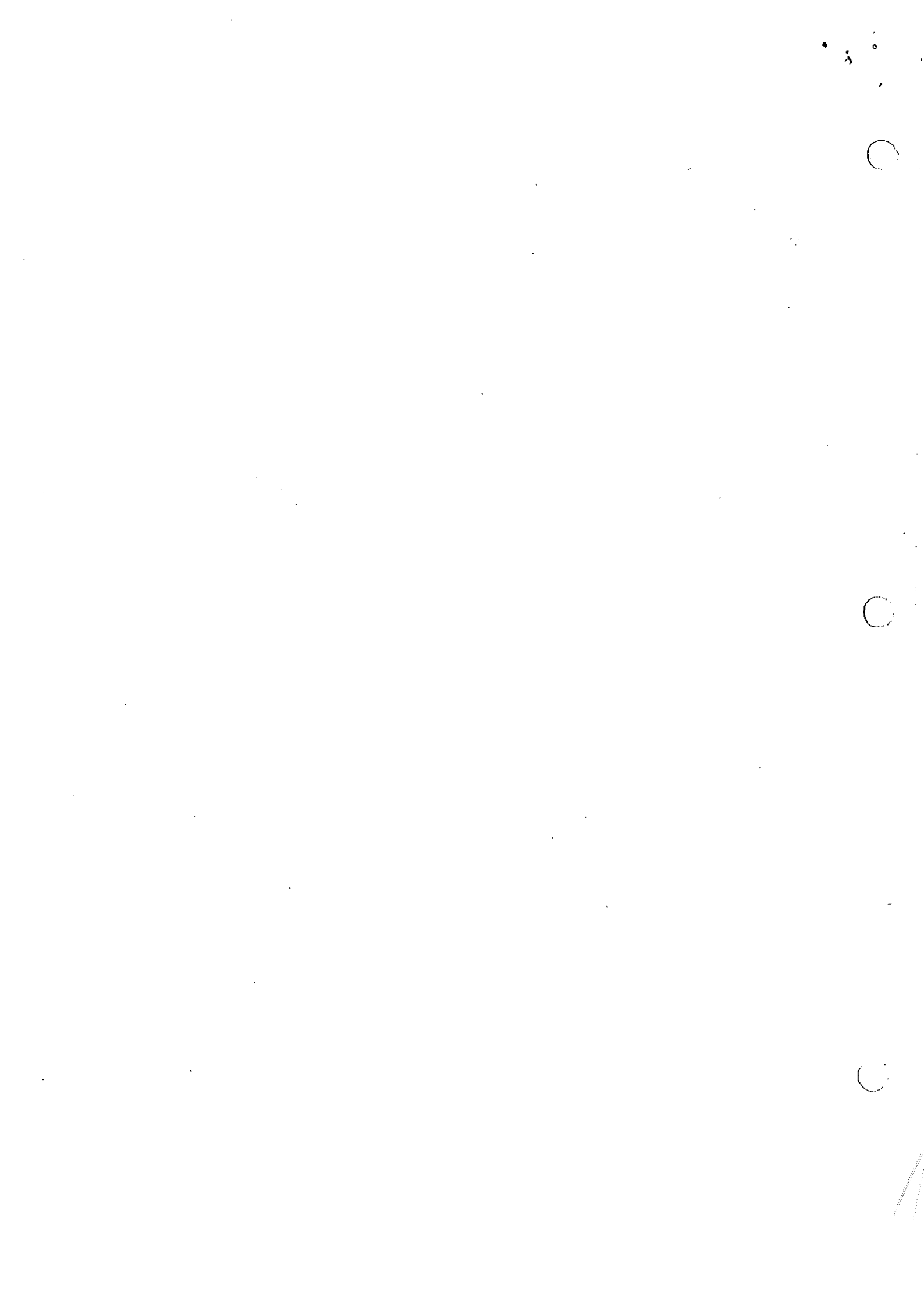
\*Trademark

VAC 2175

MAY, 1964

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## INTRODUCTION

The Varian Associates e-Gun (electron beam evaporation source) Models 980-0001, 980-0003, and 980-0005 provide uniform, high purity films and optical coatings. The compact design and ease of maintenance make it useful in practically all vacuum systems and for many applications. It has been used to evaporate refractory and dielectric materials as well as the more common conductive and semiconductor materials. The cleanliness and reliability of the e-Gun Evaporation Source make it ideal for research, and its simplicity of operation makes it equally suitable for regular production evaporation.

## OPERATION

### Crucible Preparation

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 the previous evaporation if maximum cleanliness is to be maintained.

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 deposit should break loose and enter the melt.

Fine emery paper is recommended for cleaning; stainless steel wool can also be used. Heavy deposits can easily be scraped or chipped loose with a 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 is ideal for final clean-up.

### Loading the Crucible

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 causing shorting. Powders can usually be compressed into pellets of the desired size.

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.

When evaporating materials with high thermal conductivity (e.g. - aluminum), it often is advantageous to place a thermal isolation 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 melt should not be evaporated to completion if high evaporation rates are desired. When the melt becomes very small in size, the evaporation rate decreases rapidly and much of the evaporant vapor is condensed onto the crucible surface and will not readily re-evaporate. A 1/4" to 3/8" diameter melt should be maintained for evaporation rates to be high and fairly uniform.

### Source Operation

1. Turn on crucible cooling water.
2. When ready to begin coating turn on the main circuit breaker and check to see that all interlocks are engaged. After the main breaker has been turned on, the time delay light will come on in about 90

seconds. When the light comes on, the high voltage is ready and the system is set to operate.

NOTE: Do not operate at pressures above  $1 \times 10^{-4}$  torr as a glow discharge will develop. The discharge will not harm the gun but will prevent operation of the gun until extinguished.

3. Check to see that the powerstat is off before pressing the "on" button.

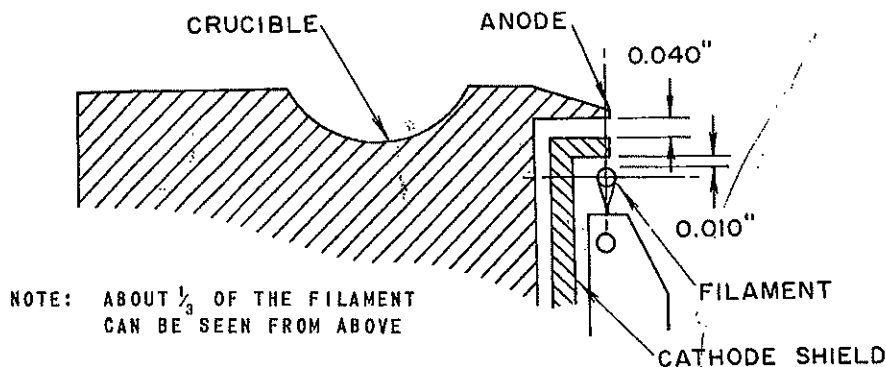
NOTE: The high voltage cannot be turned on unless the powerstat is on zero. High voltage of 4000 volts is applied at the zero setting.

4. Slowly increase the powerstat until a slight rise in emission current is noted.
5. The evaporant is beginning to heat at this point and the power should be held steady as it warms up. Different materials require various power levels, but in general the power can be increased until evaporation begins. Once the evaporant has stabilized the power may be increased to the desired power level for efficient evaporation. Do not exceed 500 ma during evaporation.

#### Shut Down

1. Turn the powerstat to zero. Press the "off" button.
2. Adequate time should be allowed for the evaporant to cool before letting in air to prevent oxidation.

## Filament and Cathode Adjustment



For the most efficient operation, follow the sketch dimensions above when adjusting or changing 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 1/4" wide gauge should be used between the anode and the cathode shield when adjusting clearance and a .010" sheet between the filament and cathode shield when installing the filament.

The anode edge and cathode shield edge should be in vertical alignment. The filament center line should be slightly toward the cathode shield side of this vertical line (see sketch). Looking directly down from the top of the source, approximately one-third 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.

## Magnetic Field Adjustment

If uniform coating is desired, it is important to have the electron beam spot striking directly on the top center of the molten area. Slight changes in the beam

striking area can be made by adjusting the magnetic field. This is done by adjusting the copper shim thickness between the magnet and the pole pieces. All e-Gun evaporation sources are delivered with a pre-set magnetic field which corresponds to the 115-120 volt line voltage normally found in Palo Alto. Because of voltage variations at different customer installations, the shim thickness may have to be slightly adjusted.

If after setting up and running the source, the beam is seen to be hitting on the far side (cooling line side) of the melt, the shims are too thick. If the beam is hitting on the near side (filament side) of the melt, the shims are too thin. Increases or decreases of shims should be made in 0.010 inch steps until the proper focus is obtained.

### Gun Maintenance

The magnet and filament assembly are easily removed for cleaning or repair.

#### Magnet Removal

Use long nose pliers and grip magnet between hole and edge. Pull straight out. The air gap shims will fall out upon magnet removal and must be replaced when the magnet is installed.

NOTE: When replacing the magnet, be certain the polarity is not changed. Reversal of polarity will cause the electrons to spiral away from the crucible and render the e-Gun source inoperative.

#### Filament Assembly Removal

To remove the complete filament assembly, the magnet must first be removed. Then loosen the two 6-32 set screws in the block which was between the magnet pole pieces; the gun assembly will slide out.

#### Filament Installation

Remove the two screws (980-1011) holding the filament legs to the two 3/8" diameter insulators. Loosen the filament set

screws (980-1009) and install the new filament. Do not tighten the filament set screws until the filament legs are re-installed and then adjust the gun and filament as described in Filament and Cathode Adjustment. Tighten the filament and filament legs only to a snug fit. A new filament may be bent gently to get proper alignment, but once used it becomes brittle and will break easily.

The magnet used in the e-Gun source is supplied with a magnetic strength of 350 gauss (oersteds) and care should be taken to see that it retains this strength. It should not be heated to temperatures over 250°C and - when disassembled - should not be left for long periods without a keeper over the pole pieces.

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

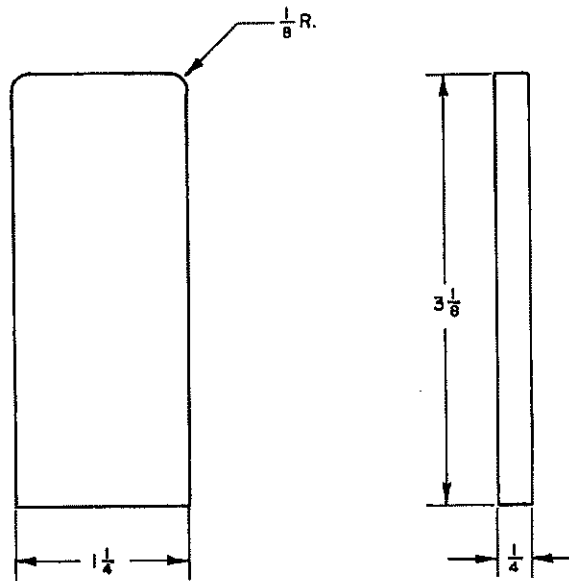
Magnetic Field in Gauss (Oersteds)

<u>Distance (inches)</u>	<u>Vertically Upward</u>	<u>Vertically Downward</u>	<u>Horizontally to Front and Rear</u>
0	340	340	340
1	170	---	110
2	38	80	30
3	12	34	11
4	5	13	5
5	3	6	2
15	1	1	1

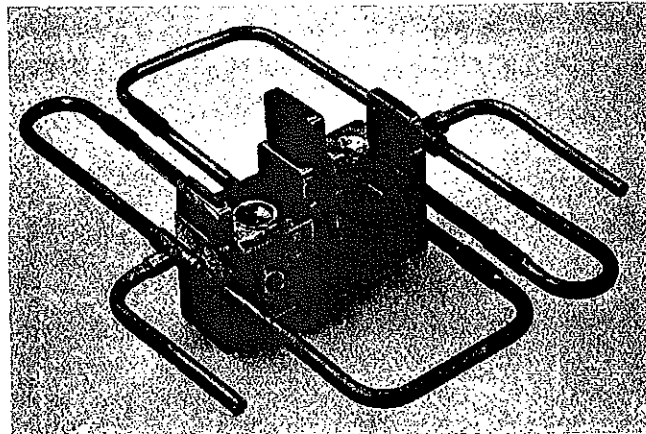
Accuracy of the above measurements is about  $\pm 10\%$  or  $\pm 0.5$  gauss, whichever is greater.



## Installation of Two Single-Crucible e-Guns in a Vacuum System



If it is desired to operate two single-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. A typical installation is shown in the photo below.



## MULTIPLE CRUCIBLE e-GUN EVAPORATION SOURCE

The three and five 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 below an index hole in the positioning handle (index holes vertically positioned).

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

### Installation Instructions

1. Mount the compression port flange on the ConFlat<sup>®</sup> flange on your system.
2. Place copper gasket (part 606563) on compression port seat and insert through feedthrough port. (Use a new gasket each time a seal is made.)
3. Tighten the compression port with the 1-1/2" nut until the vacuum seal is made - until you encounter a firm resistance to further tightening.
4. Screw the positioning handle onto the drive shaft. The positioning handle has a left-hand thread.
5. Mount the aluminum cover plate over the positioning handle and screw to the ConFlat flange.

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

PARTS LIST - e-GUN

Model 980-0001

<u>Part No.</u>	<u>Description</u>	<u>Quantity</u>
980-1001	Crucible assembly	1
980-1002	Molybdenum cathode shield	1
980-1003	Filament leg - neutral	1
980-1004	Filament leg - insulated	1
980-1005	Ceramic 3/8" x 3/4"	2
980-1006	Ceramic 1/4" x 1/2"	1
980-1007	Ceramic washer (Filament Leg Isolation	2
980-1008	6-32 stud	2
980-1009	4-40 x 3/16 set screw	2
980-1010	6-32 x 1/4 set screw	4
980-1011	6-32 x 1/2 binding head	2
980-1012	6-32 x 1/4 round head	2
980-1014	Filament .020 tungsten*	1
980-1015	Magnet - Thermionics Laboratory Inc. Spec. 1068	1
606563	Compression Port Gasket	1

When ordering parts for the e-Gun, be certain to specify the product name and model number as well as the part number.

\*See Accessories and Replacement Parts

ACCESSORIES AND REPLACEMENT PARTS

<u>Description</u>		<u>Model Number</u>
Spare filaments for e-Gun source		980-1014
5 filaments per package		
Spare Parts Kit		980-1000
Part	No. in Kit	No. on e-Gun
Ceramic 980-1005	3	2
Ceramic 980-1006	2	1
Ceramic 980-1007	3	2
Filament 980-1004	5	1
Compression Port Gasket 606563	10	1

This kit consists of the more vulnerable and expendable items used in the e-Gun source. The items are offered only in kit form.