thermionics laboratory, inc.

INSTRUCTION MANUAL

EPS-500 SAMPLE POWER SUPPLY

Version 2

FAILURE TO CONNECT AND OPERATE CORRECTLY CAN CAUSE DANGEROUS SITUATIONS, INCLUDING POTENTIALLY LETHAL CONSEQUENCES.

SEE WARNINGS ON PAGE 1 & 2

SERIAL # _____

9.2024
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WARNING

POWER SUPPLIES FOR ELECTRON BOMBARDMENT HEATING EMPLOY LETHAL VOLTAGES.

PLEASE READ THE MANUAL AND UNDERSTAND IT. DO NOT HESITATE TO CALL US AND ASK QUESTIONS ABOUT THE DEVICE AND PROCEDURES IF REQUIRED.

THIS DEVICE SHOULD BE INSTALLED AND OPERATED ONLY BY PROPERLY QUALIFIED PERSONNEL.

We at Thermionics want you alive and well, using our equipment to achieve your goals. With appropriate care this unit will operate safely and effectively. There is no risk that is worth your life.

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I. Preface

Congratulations! You have purchased a quality vacuum positioning device from Thermionics. This unit is capable of many years of use with minimal care and maintenance. This manual is a tool to aid you in obtaining this service.

We at Thermionics encourage your comments and suggestions on this manual.

II. Product Description

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WARNING WARNING WARNING WARNING

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This power supply can generate ample voltage and current to kill. All personnel involved in its installation and operation must be qualified to work on and with such equipment. All users must first be familiar with this manual, its safety warnings, and high voltage procedures in general.

Do not take short cuts. Please do not be in a hurry.

EACH and EVERY item in the following list must be strictly followed.

1. DO NOT partially connect this power supply to your equipment.
All connections to the manipulator must be made because they provide the return path for the e-beam electrons.
FAILURE to do this may cause unsafe situations, including lethal consequences.

1b. The rear panel of the power supply has a two conductor with ground, twist lock connector.

- This interlock enables the high voltage and filament power to be turned on.
- This must be connected to an SPST set of contacts that close when the chamber containing the electron gun is under vacuum. Depending on application, this may be:

1. a diaphragm switch
2. a filament relay on a controller for a hot cathode ion gauge
3. or other suitable contacts.
   - It is imperative the contacts stay open unless vacuum is established in the chamber, and thus preclude human entry.

1c. Unplug this supply from the wall and wait at least 1 minute prior to working on the gun or sample area of the manipulator. This will allow the High Voltage capacitor to bleed down inside the power supply.

- Check for zero potential with a voltmeter before working on the sample holder.
- Attach a safety-grounding strap to the exposed high voltage lines at the base of the heater assembly.
- Do not remove the strap until all work has been completed.

2. There is a grounding cable attached to the rear of the panel.
   - This must be hard wired to the chamber, which will house the electron gun.
   - This connection must be made prior to connecting the HV connector to the HV vacuum feedthrough.
   - Verify the ground connection with a VOM.

3. The power supply operates on 220 VAC, using a 3-prong plug (grounding type).
   - This must be connected to a correctly wired receptacle.
   - IF one is not available, one must be installed.

4. DO NOT SWITCH ON the high voltage with the connector(s) disconnected from the vacuum feedthrough.
   - This should only be done by a qualified technician under appropriate conditions for test purposes.

5. Protect the high voltage cable and connector from moisture.
   - Bag and tape the connector when not in use. Either dirt or moisture can cause a HV leakage path.

NOTE: Care is especially important around liquid nitrogen.
- Condensation due to LN2 boil-off can cause leakage paths.
- Thoroughly insulate LN2 lines when they are near the cable or at the connector at the base of the manipulator or at the chamber wall.
- Do not run the cable on the floor. Mechanical damage or freezing by LN2 may cause failure of the insulation and thus produce a severe safety hazard.

- Replace any equipment showing damage or misuse.

6. The gun assembly can emit small stray streams of energetic electrons.
   - To avoid a buildup of high voltage electrical charge, be sure all insulated conductors passing through the chamber wall are grounded.

7. The high voltage is exposed in the vacuum chamber.
   - Be certain to constrain all conductors in the chamber in such a manner as to not allow them to reach the high voltage lines under any condition.
   - It is common to break or melt thermocouples off of samples. If the broken TC lines make contact with the HV, significant electrical damage would result to equipment as well as create a PERSONNEL SAFETY HAZARD.

8. Understand the limits of travel of your device and calibrate the range of operation.
   - Do not do this by "feel".
   - Visually watch the operation through a viewport.
   - Forcing the system beyond its capabilities will cause mechanical & electrical damage and may endanger the operator's life.
   - Do not change position of the electron bombardment heater assembly while the high voltage is on.

9. The sample plate must be at ground potential.
   - This must be a secure connection.
   - Do not operate the system in any other manner.
   - If there is any doubt, verify electrical path to ground with an ohm meter.

10. WARNING
This electron gun assembly is capable of melting a molybdenum sample holder if operated at high output levels. Assuming a case where the sample would also be melted, an electron gun with an "acceleration orifice" would remain. This could spray energetic electrons out roughly in a direction normal to the sample face. Other equipment in the chamber should be prepared therefore for this eventuality by having grounded face surfaces.

11. Replace any items that may be damaged or worn.

12. /LO OPTION WARNING
The intrinsic heating cable must be attached to provide a return path for the e-beam electrons. Although similar to the HV connector, it has different keying. This prevents the HV cable from being inadvertently connected to

the intrinsic heating connector.

If the intrinsic cable were not attached, and the e-beam heater were operated, lethal high voltage would appear on the intrinsic connector pins. This would be a serious safety hazard.

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IIII. Features

The EPS-500 substrate power supply is especially designed to give the researcher exceptional operational control of the sample temperature while maximizing the life of the heater filament. Depending on the options selected, this is accomplished by providing:

- Maximum output:
  15 A at 20 VAC filament
  0-3,000 VDC bias
  0.50 A emission
- Input: 220 V 50/60 Hz AC
- True phase fired proportional control of heater element or high voltage bias
- Filament and high voltage current meters
- Adjustable minimum and maximum current limits
- Adjustable high voltage bias output for e-beam heating
- PID microprocessor based automatic temperature controller
- Auto-tuning
- Digital temperature read-out
- Single programmable ramp rate and dwell time
- Two programmable setpoints
- Up to three alarm relays
- Computer interface via RS 232
- Includes power cable, output cable and thermocouple cable
- Requires system thermocouple, type “K” or “C”

IV. Unpacking

All shipment containers should be visually inspected upon arrival for physical damage. Visual inspection of the product should also be done immediately. Shipping companies often require claims for damage is established upon arrival of goods.

All EPS models are shipped with custom foam-in-place packing. This is the only system we have found to provide adequate protection for shipment. The foam is separated approximately halfway inside the box with thin plastic. We recommend the packing box with packing be saved for possible future shipment or equipment storage.

V. Mounting

The EPS-500 power supply is manufactured in a relay rack mountable chassis.

VI. Controls, Fuses, Meters and Adjustments

CONTROLS:

AC POWER:

- Rocker switch (on/off) on front panel with integral circuit breaker
- Controls all power to the chassis.

TEMPERATURE CONTROLLER:
Refer to controller manual (attached).

Function Switch- 3 modes:

- E-Beam Heater
- Bias
- Intrinsic Heater

e-beam:

- Allows e-beam heating of the sample.
- Intrinsic sample heating is disabled.
- Biasing of the sample or reading e-beam current from the sample is also disconnected.

Bias:

- Allows the application of a sample bias voltage to the sample through the BNC (up to 500 volts) fitting on the face panel.
- Intrinsic heating and e-beam heating are disabled.

Intrinsic:

- Allows intrinsic heating of the sample up to 20 amps maximum.
- This setting disables e-beam heating and sample biasing.

NOTE:
Cooling must be used during intrinsic heating

When switching between e-beam operation and either bias or intrinsic operation:

- Power down the e-beam filament
- Turn off the high voltage
- Wait at lease 2 minutes to allow the power supplies to bleed down
- Switch to the intrinsic or bias position

Sample Bias Connector:

- BNC-female
- Connection for external sample bias power supply
- Supplies voltage to the BNC output connector on the back of the LPS-500

Filament On/Off:

- Rocker switch with pilot light

Filament Output Bias:

- Ten turn potentiometer
- The output bias setting establishes a minimum power setting. This will keep some current passing through the filament whenever the supply is on and the limit is set above "0". This is done to minimize the temperature swings in the filament and thus prolong filament life. If the user prefers, this can be left at "0".
- This adjustment also supplies manual operation when the temperature controller is in manual mode with 0.00% output.

Filament Limit/Maximum:

- Ten turn potentiometer
- Adjusts maximum power output of the PID controller "Filament Automatic" mode or “Manual operation”. This must be set correctly as not to burn out filament assembly or over-heat sample.

High voltage on/off (e-beam voltage):

- Rocker switch with pilot light
- Applies or disconnects power to the e-beam High Voltage power supply

High Voltage Adjust:

- Manually adjusts e-beam bias high voltage level
- 0 to 500 volts

Meters:

1. Filament Output: 0-10 Amps
2. Bias Current: 0-500 ma

VII. Installation

Connections:

The following connections are made on the back panel and must be attached to the appropriate circuits prior to operation.

THESE ARE CRITICAL SAFETY ITEMS.

High Voltage Interlock:

- connect to vacuum switch,
- connector only supplied

The rear panel of the power supply has a two conductor with ground, twist lock connector. This interlock enables the high voltage to be turned on. This must be connected to an SPST set of contacts that close when the chamber containing the electron gun is under vacuum. Depending on application, this may be a diaphragm switch, a filament relay on a controller for a hot cathode ion gauge, or other contacts. It is imperative the contacts stay open unless vacuum is established in the chamber, and thus preclude human entry.

- The ratings on the cable and switch need to be greater than 2 amp at 24 VAC.

Grounding cable:

- with eyelet,
- supplied, hard wire to chamber body

There is a grounding cable attached to the rear of the panel.

- This must be hard wired to the chamber, which will house the electron gun.
- This connection must be made prior to connecting the High Voltage connector to the High Voltage vacuum feedthrough.
- Verify the integrity of this connection between the power supply chassis and the chamber body with an ohm meter.

Output:

- 15 feet Output cable, attached

Protect the high voltage cable and connector from moisture.

- Bag and tape the connector when not in use. Either dirt or moisture can cause a HV leakage path.

Care is especially important around liquid nitrogen.

- Condensation due to LN2 boil-off can cause leakage paths.
- Thoroughly insulate LN2 lines when they are near the cable or at the connector at the base of the manipulator or at the chamber wall.
- Do not run the cable on the floor. Mechanical damage or freezing by LN2 may cause failure of the insulation and thus a severe safety hazard.
- Replace any equipment showing damage or misuse.

The output cable will be terminated differently, depending on what is ordered with the unit.

- When ordered with our FHV3-133-2 UHV electrical feedthrough, the connector will be attached to the end of the cable.
- If the power supply is ordered without a feedthrough, the output cable arrives without termination.

Warning:

IT IS THE CUSTOMER'S RESPONSIBILITY TO CORRECTLY TERMINATE THE OUTPUT CABLE, SUPPLYING APPROPRIATE PERSONNEL PROTECTION.

FAILURE TO TERMINATE THE OUTPUT CABLE CORRECTLY MAY CAUSE DAMAGE TO THE EQUIPMENT AND HUMAN INJURY OR DEATH.

Thermocouple:

- 15 feet Type K thermocouple cable, included

AC input:

- power cord supplied
- 220 VAC, < 6 amps, 3 prong (grounding type),

******* BE SURE THE MAIN AC POWER SWITCH IS OFF BEFORE CONNECTING THE POWER CORD TO THE 220 VAC SUPPLY OUTLET. *****

NOTE:

If your unit includes the /LO Interlock Option, refer to page 11 for additional cabling which must be connected.

Sample Grounding (electrical return path):

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

This is an e-beam type heater. An electrical return path from the sample to the power supply must be maintained. This means the sample and platen must be electrically grounded whenever the heater is in operation. If an electrically isolated sample is needed, safety interlocks must be used to protect the equipment and the user.

Note for: STLC Transferable thermocouple platen users heating with E-gun heaters

RE: Platen grounding through thermocouple

SAFETY WARNING

A customer has had a damaging operational situation occur with potentially lethal consequences. We feel you need to be aware of the possibility and take action to avoid possible problems.

The customer was depositing insulating films in the chamber. Apparently the dock became coated. (The dock/platen interface provides the electron return path.) As he operated the E-gun, the electrons did not have a suitable path to ground. The transferable thermocouple was electrically connected to the sample. The thermocouple wires rose in potential, eventually burning out the temperature controller. A safety hazard was created, as the TC lines and feedthroughs are not suitable for high voltage.

It is conceivable to have the platen, and thus the TC lines, float up to 3,000 VDC.

This would be an extremely dangerous and potentially lethal situation.

It is critical for safe operation that a good electrical ground be maintained between the sample platen and the dock (ground). We recommend the following steps be taken:

Maintain good electrical contact between the dock and the platen. Depending upon your circumstances, this may mean opening up to clean the dock on a regular basis. Clean the back of the sample platen at each use.

Use one of the fingers (finger "C") as a secondary ground path. Connect a ground wire to the finger and a wire between the platen and the "C" platen insert. The wiping action of the finger will help assure this connection.

Route and protect all TC wires and feedthroughs in such a manner as to preclude human contact. This may mean using shielding braid over the TC wires. Safety cans over the TC feedthrough may be required.
/LO Interlock Option

The /LO Bias & intrinsic heating option to the power supply allows multiple use of the heating stage. This option protects the user from inadvertently attempting to e-beam heat the sample when a safe electron return path from the sample is not available.

TWO additional cables are attached to the rear of the power supply chassis and must be attached to the appropriate connectors before powering or operation.

Intrinsic sample heating power to chamber:
Attach to mating connector on chamber or manipulator.

**********/LO OPTION WARNING**********

The intrinsic heating cable must be attached to provide a return path for the e-beam electrons. Although similar to the HV connector, it has different keying. This prevents the HV cable from being inadvertently connected to the intrinsic heating connector.
If the intrinsic cable were not attached, and the e-beam heater were operated, lethal high voltage would appear on the intrinsic connector pins. This would be a serious safety hazard

Intrinsic sample heating power to supply:

This cable is supplied without termination. Terminate it correctly and attach cable to intrinsic heating power source. DO NOT pass over 20 amps through this circuit.

VIII Operation: (EPS-500 with temperature controller)

This EPS-500 consists of two separate power supplies in one unit. The filament supply is a conventional transformer type, controlled through a true proportioning output module. The final output has special HV isolation. The second power supply is a HV unit capable of high currents (up to 1/4 amp). The HV output is tied to one line of the filament output. The filament power alone can heat small samples with good thermal mounting to approximately 800 degrees C. To obtain higher temperatures, an e-beam bias voltage must be applied to the filament. The temperature controller varies the power to the filament. The e-beam bias voltage is controlled manually by the "High Voltage Adjust". The effective power delivered to the sample back changes greatly with variation of filament temperature.

With the power off, select the power supply mode of operation. This choice is made via the "Function" switch on the face panel of the EPS-500 power supply.

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

Secure attachment of the sample thermocouple to the sample or sample plate is imperative. If the thermocouple becomes disconnected, incorrect heating will occur. With this unit, that may cause meltdown of the sample, and possible hazardous situations. The thermocouple wires must be properly constrained to avoid contact with the High Voltage wires inside the chamber.

Function Settings: Options are:

- e-beam Heater

Allows e-beam heating of the sample:

1. Manual control of Filament supply
   Manual control of the e-beam High Voltage supply
   or
2. Auto control of Filament supply via the PID Controller
   Manual control of the e-beam High Voltage supply

Note: In both modes: Intrinsic sample heating is disabled and Biasing of the sample is disconnected.

- Bias
  Allows the application of a bias to the sample through the BNC (up to 500 volts) fitting on the face panel located below the "Function" switch.
  Note: Intrinsic heating and e-beam heating are disabled

- Intrinsic Heat
  Allows intrinsic heating of the sample up to 20 amps maximum.
  Auto control of Filament supply
  Manual control of HV supply
  Note: This setting disables e-beam heating and sample biasing.
  Note: Sample cooling must be used during intrinsic heating.

A. MANUAL OPERATION
In manual operation, the "Manual" ten-turn potentiometer controls the filament current output and e-beam High voltage is set manually as described below.

Initial Operation Procedure:

1. Verify all cables are attached correctly.
2. Verify the chamber is at vacuum better than 1 x 10^{-6} Torr.
3. Verify that any cooling is operating properly.
4. Turn "Power", "Filament" and "High Voltage" switches to "Off".
5. Turn "Maximum" and "High Voltage Adjust" adjustment knobs to "0"(Fully counterclockwise).
6. Turn "Manual" adjustment knob fully clockwise.
7. Turn on AC power. The PID controller display will indicate actual temperature.
8. Select manual mode on the PID controller (see PID operation manual page 1-8).
9. Adjust PID controller manual output for 00.0 output (see PID operation manual page1-9).
10. Turn the "Filament" switch on. The switch will illuminate.
11. Apply power to the filament by slowly turning the "Maximum" knob clockwise. Observe the filament current on the front panel. Note the following guidelines while making this adjustment: Maximum current setting varies depending upon the filament of your gun. Start at a current less than 6 amps. Most filaments should not be run at currents greater than 8.5 amps.
12. Lock the "Maximum" control knob in place. (This adjustment knob limits the maximum output power of the filament control.)
13. Turn the manual control knob until the desired operating filament current is displayed on the front panel meter (in manual mode this adjustment knob sets the output power delivered to the filament).
14. Turn on the e-beam "High Voltage" switch. The switch will illuminate.
15. Slowly turn up the e-beam "High Voltage Adjust" knob. Observe the emission current on the DC Milliamp meter.

16. Operate unit to obtain the desired heating temperature.

To turn off the heater

17. Turn down the e-beam “High Voltage Adjust” to "0" and then turn off HV with the “High Voltage” switch.
18. Turn the “Manual” control knob fully to 0 (fully counterclockwise).
19. Turn off the “filament” switch.
20. Turn off the “Power” to the EPS-500 power supply.

Normal Operation Procedure:

1. Verify all cables are attached correctly.
2. Verify the chamber is at vacuum better than 1 x 10^{-6} Torr.
3. Verify that any cooling is operating properly.
4. Turn “Power”, “Filament” and “High Voltage” switches to “Off”.
5. Turn “Manual” and “High Voltage Adjust” adjustment knobs to "0"(Fully counterclockwise).
6. Turn on AC power. The PID controller display will indicate actual temperature.
7. Select manual mode on the PID controller (see PID operation manual page 1-8).
8. Adjust PID controller manual output for 00.0 output (see PID operation manual page1-9).
9. Turn the “Filament” switch on. The switch will illuminate.
10. Turn the manual control knob until the desired operating filament current is displayed on the front panel meter.
11. Turn on the e-beam “High Voltage” switch. The switch will illuminate.
12. Slowly turn up the e-beam “High Voltage Adjust” knob. Observe the emission current on the DC Milliamp meter.
13. Operate unit to obtain the desired heating temperature.

To turn off the heater

14. Turn down the e-beam “High Voltage Adjust” to "0" and then turn off HV with the “High Voltage” switch.
15. Turn the “Manual” control knob fully to 0 (fully counterclockwise).
16. Turn off the “filament” switch.
17. Turn off the “Power” to the EPS-500 power supply.

AUTOMATIC CONTROL Filament... switch to right

In filament automatic control, the PID temperature controller varies the power to the filament. The High voltage is set manually as in MANUAL operation.

Operation Procedure:

1. Follow the procedures 1 thru 10 listed above in Normal Operation Procedure.
2. Turn on the e-beam “High Voltage” switch. The HV red light will illuminate.
3. Slowly turn up the e-beam “High Voltage Adjust” knob. Observe the emission current on the DC Milliamp meter. This may need to be adjusted to obtain adequate heating.
4. Select auto operation mode on the PID controller (see PID operation manual page 1-8).
5. Set the target heater operating temperature on the PID controller (see PID operation manual page 1-4).
6. Turn the “Manual” control knob fully to 0 (fully counterclockwise).
7. Operate unit to obtain the desired heating temperature.
   To turn off the heater
8. Turn down the e-beam “High Voltage Adjust” to "0" and then turn off HV with the “High Voltage” switch.
9. Turn off the “filament” switch.
10. Turn off the “Power” to the EPS-500 power supply.

Tuning the PID temperature controller:

The temperature controller can be fine-tuned to meet the specific characteristics of your heater and sample.
Please refer to chapter 4 of the PID operation manual for an explanation and procedures.

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

Never allow electron bombardment sample heating equipment to operate un-attended, due to the large number of failure scenarios and their possible consequences. Catastrophic failure may result.

We at Thermionics have a large stake in your new equipment operating up to your expectations. If you experience difficulty with this unit or any other aspect of your endeavor where our experience might be of value, we want to hear from you. We want to be part of your success.