INSTRUCTION MANUAL FOR

MODEL ES-6A-110/210
ELECTRON BEAM POWER SUPPLY

SERIAL NOS. 6-788 AND ABOVE
1.1 MODEL DESIGNATION AND DOCUMENTS

Serial Nos. 6-783 and above:

Model ES-6A-110 for 1 gun in 1 tank
Model ES-6A-210 for 2 guns in 1 tank

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1.2 GENERAL DESCRIPTION

The Airco Temescal ES-6A Power Supplies are 10KV, 6KW Power Supplies, designed for use as a source for one or two electron guns, operating in the same chamber.

The guns may be operated independently of each other and may be used simultaneously or singly. The output power is split between the two guns; should both be utilized together, the total power is not to exceed 6KW.

The power supply is comprised of the following functional stages: Series 100 - Front Panel Mounted Equipment; Series 200 - Chassis and rear panel mounted equipment; Series 300 - the overload sensing and control circuit; Series 400 - focus supply; Series 500 and 600 - gun filament controllers for gun 1 and gun 2 respectively; and Series 700 - transductor boards.

The versatility of this power supply is demonstrated by its ability to operate either or both guns separately or simultaneously, that internal or external (rate) control of emission current can be utilized for either or both guns, and that the supply possesses the capability of remote manual control of emission current, beam position and beam dither.
1.3.1 Input Requirements. 208 or 220 to 240V ac, three-phase, 50/60Hz, four-wire (three-phase wires and equipment ground - NO NEUTRAL), capable of 25 amps. A 30A, 3-pole circuit breaker on the supply line is recommended.

1.3.2 Output Specifications.

A. High voltage output:

1. -10KV (fixed) at 600ma maximum.

   NOTE: A companion variable voltage control unit, Model VVC-6, is available for the ES-6A which will allow the voltage to be adjusted over a 5 to 10KV range.

2. Overload current limited by automatic shut off circuit, when 600ma current limit is exceeded.

3. Regulation: voltage unregulated.

4. High voltage ripple: 14% at full load.

B. Filament control output: 6V ac, 40 amps maximum from each of two gun controllers. Closed-loop regulation of emission current.

C. Focus magnet supplies:

1. -20V dc, -2.5 amps maximum from each of two focus supplies, current regulated against load and line changes.

2. Output current is front panel adjustable from 0 to maximum.

3. A 1 cps dither is independently front panel adjustable from 0 to 50% of the maximum dc output as set in 2 above.

4. Minimum load resistance is 2 ohms.
1.3.3 **Gun Cooling Water.** When two guns are used on the ES-6A-210, the water cooling circuits should be connected in series.

**Inlet Water**

- Flow Rate - 1.5 gallons per minute
- Pressure - 100 PSI maximum
- Temperature - 50°C (122°F) maximum
SECTION 2

DESCRIPTION OF CONTROLS AND INDICATORS

Descriptions of all controls and indicators are given in the following paragraphs.

2.1 FRONT PANEL

The front panel contains the main circuit breaker, the interlock indicators, the keylock, the high voltage off and on switch the emission controls and meters, the focus controls, the REMOTE/LOCAL switch and the remote plug.

2.1.1 Input Circuit Breaker CB101. This circuit breaker supplies utility power to the entire power supply. Should the input current exceed 25 amps, the handle will trip on the OFF position. The condition causing excessive input current should be corrected before returning the handle to the ON position.

2.1.2 Interlock Indicators. The interlock indicators monitor the status of circuits and implements which must be operable prior to the application of power to the various parts of the supply. There are seven indicators in this row. Each must be lit prior to the lighting of the one on the right (facing the panel), in series. Should any condition cause the associated indicator to extinguish, all indicators to the right extinguish also. The functions of each indicator in the sequence of lighting are discussed in the steps below.

(2) POWER ON LT101 - This indicator lights when the input circuit breaker is thrown in the ON position and utility power is applied to the power supply.

(3) TEMPERATURE LT102 - Several components in the ES-6A are cooled by forced air. Should the air flow become inadequate or the air temperature excessive, a switch opens, deenergizing the entire ES-6A (except for the power on light and the flow switch heater). When this indicator is lit, the internal 115V control power and tube control circuitry (overload sensing and control) are energized.
(4) VAC TANK LT103 - This indicator monitors the continuity between terminal 1 and 2 of TB204. These terminals must be connected to an interlock switch, which closes when all access ports to the vacuum tank are closed.

(5) VAC GAUGE LT104 - This indicator monitors the continuity between terminals 2 and 3 of TB204. These terminals must be connected to the interlock contacts of a vacuum gauge which closes these contacts when the pressure in the tank is low enough to permit operation of the gauge.

(6) GUN WATER LT105 - This indicator monitors the continuity between terminals 3 and 4 of TB204. These terminals must be connected to a water flow switch which closes when sufficient water flows through the gun to adequately cool it.

(7) AUXILIARY LT106 - This indicator monitors the continuity between terminals 4 and 5 of TB204. There must be continuity before the gun filament, focus supplies, or high voltage can be energized. This interlock is provided for use with a rate monitor or controller. If the rate monitor has no interlock, or is not used, these terminals must be jumpered prior to the operation of the ES-6A.

(8) FOCUS LT108 - This indicator monitors the gun focus current and interrupts the interlock line if gun focus current drops below .4 amps.

(9) KEY LT107 - This indicator lights when the keylock is closed by turning the key.

2.1.3 Keylock S101. This switch must be closed prior to the lighting of the HIGH VOLTAGE OFF light on PB102. When all prior indicators are lit, closing the keylock will cause the KEYLOCK and HIGH VOLTAGE OFF indicators to light.

2.1.4 High Voltage OFF/ON. When all seven interlock indicators are lit, the HIGH VOLTAGE OFF (PB102) and HIGH VOLTAGE ON (PB101)
switches are enabled. The high voltage output may then be turned on and off by pressing the appropriate button, and the associated indicator will light to show the status of the high voltage output.

2.1.5 Emission Controls R101, 102 And Meters M101, 102. The EMISSION CURRENT controls set the emission current for each gun, from 0 to 600ma. The emission current meters indicate the dc electron beam current of each gun. For an ES-6A-210 the sum of currents to both guns must not exceed 600ma.

2.1.6 Beam Position R103, 107 And Dither Controls R105, 109. The BEAM POSITION controls vary the position of the electron beam on the crucible, and the DITHER controls allow the beam to be swept back and forth longitudinally across the crucible. The sawtooth dither waveform is superimposed on the quiescent dc beam position setting.

2.1.7 Remote/Local Switch S102 And Remote Jack J101. A remote control box may be attached to the remote jack. The REMOTE/LOCAL switch will then select between front panel and remote control of emission, beam position, and dither for both guns.

2.2 REAR PANEL

The rear panel mounts the cooling fan, the power input cord, the fuses, the tank interlock cable connector, the RATE/MANUAL switches, the rate input connectors, the gun filament leads and the low impedance ground connector.

2.2.1 Cooling Fan B201. This fan provides air to cool the overload switch tube, the bias resistors for this tube, and the focus supply output transistors. It must not be obstructed.

2.2.2 Power Input Cord W201. This 4-conductor #10 cable carries utility power into the power supply.

2.2.3 Fuses F201 Through F206. These fuses provide individual overload protection for the internal circuits of the power supply.
2.2.4 Interlock Cable Receptacle J201. This receptacle and interlock cable assembly, A201, connects the ES-6A interlock string to the interlock on the tank. They also carry focus power to the guns. Standard length is 10/ft. but 20/ft. is available on special order.

2.2.5 Rate/Manual Switches S202, S203. These switches allow the selection between manual (front panel or remote) or external rate control of the emission current of either or both guns.

2.2.6 Rate Input Jacks J202, J203. These BNC connectors accept an external rate control signal to control the emission current of either or both guns. The BNC connector shell is grounded internally to the ES-6A chassis. The rate input may be positive, negative or floating with respect to ground. A jumper link in a transistor socket on gun control P.C. card assemblies A501 and A601 is used to select the desired rate input polarity with respect to ground. 9 volts at 3.7ma is required for full control at J202 or J203.

2.2.7 Gun Filament leads. These 10-foot long, RG-14A/U leads, carry both the filament power and the high voltage to the guns. The connections of the center conductors to the high voltage feed-throughs (which must be rated at 40 amps, 10,000 volts minimum) must be clean and tight. The shield pigtails should be grounded to the tank. 20-foot leads may be obtained on special order.

2.2.8 Low Impedance Grounds.

A. Control Console/Vacuum Chamber Low Impedance (Z) Neutral/Ground Wire -

--- EXTREMELY IMPORTANT ---

Connect the #6 wire low impedance Neutral/Ground lead from the Neutral/Ground bussbar, terminal #5 on the ES-6A to the control console/vacuum chamber. **INDUCTANCE, RATHER THAN RESISTANCE, IS THE CRITICAL PARAMETER IN THIS GROUNDING SYSTEM.** The low z ground lead should be as short as possible and NOT coiled up or installed in metallic conduit. If conduit must be used, use PVC plastic conduit.

During operation, arcing may occur in low-voltage control cables or connectors. This indicates an inadequately installed low impedance grounding system, and the inductance must be lowered; shorten the low impedance ground, run it directly to the tank, away from the control cables, and use a larger conductor. Under the most severe conditions,
a 2-inch wide x .060 thick copper strap (or other conductor of large surface area) may be required. One method of assuring good connections is the removal of paint, inside and out, from a 2-inch diameter circle centered on the power supply frame. Weld the copper strap to this point and run a similar strap from the inside of the frame directly to the neutral/ground busbar. Weld the other end of the strap to the bottom of the vacuum tank.

B. Crucible Assembly Grounding - The crucible assembly must be securely mounted to the vacuum tank to ensure that it has a low impedance ground. If the crucible assembly is suspended in space, by small support members, a 2" wide x .060 thick or 4" wide x .030 thick copper strap should be securely connected to the bottom of the crucible assembly and its other end securely grounded to the vacuum tank as closely as possible to the ground stud on the outside of the tank that terminates the low z ground lead.

C. System Earth Ground - The vacuum tank should be connected to a good earth ground such as a ground rod or a ground grid in the floor. DO NOT USE WATER PIPES. This can be accomplished on a steel framed building by welding directly to one of the steel girders.

It is usually best to connect the system to earth ground (neglecting the power ground green wire in power cable assembly) ONLY at the vacuum tank.

2.2.9 Model VVC-6 Variable Voltage Control Jack J209. Optional Model VVC-6 is available to manually adjust the emission voltage between 5 and 10KV. Jumper Plug P209, which is supplied as standard, must be removed from J209. Then the plug on the VVC-6 cord can be connected to J209.

2.3 INTERNAL

*2.3.1 Focus Interlock Gun Selector Switch S1. A switch on the focus control P.C. board can be set to one of three positions to interlock either Gun 1, Gun 2 or both guns in the high voltage interlock circuit. The switch is to be placed on the appropriate Gun 1 or Gun 2 position when a single gun focus coil is connected on the ES-6A. If two guns are connected to an ES-6A-210 the switch should then be placed in the BOTH position so as to assure protection for both gun positions.

*See Addendum
The internal circuitry of the ES-6A is divided into different symbol series to identify sub-assemblies on the schematic and wiring diagrams. The first digit of the three-digit number in the symbol identifies the sub-assembly and the last two numbers are used to identify the component on that sub-assembly. Schematic diagrams for P.C. boards will show symbols with only the last two digits.

The ES-6A Power Supply schematic may be used as reference for all discussions in this section. The schematic and wiring diagram for your Model ES-6A are included in the envelope in the back of this manual. Refer to Section 1.1 for schematic drawing numbers.

3.1 INPUT POWER CONTROL NETWORK

3.1.1 Preparation For Power Application. The ES-6A will be shipped connected for 208V or 230V operation as specified by the customer. If the operating voltage is changed, the plate transformer (T201) the tube control transformer (T202), the focus supply transformer (T203) and the gun filament transformers (T204 and T205), must have their tap connections changed to the appropriate voltage.

3.1.2 Initial Power Application. Input circuit breaker CB101 controls the utility power input to the ES-6A. Closing CB101 connects utility power to the following points:

A. MC201 and MC202.
B. Power ON indicator LT101 and Air Flow Heater switch.
C. T202 through S201.
D. RE201-1 relay contact.

Upon application of source power to the above listed points, the following functions are performed:

E. The air and temperature switch heater are energized. If the internal temperature is not excessive, T202 is energized through the normally closed S201. If the fan fails to run, S201 quickly heats up and de-energizes T202. The heater remains energized and
keeps S201 open until the ES-6A is shut off and the heater is allowed to cool.

F. Transformer (T202) supplies the power for the tube control circuitry and provides 120V ac control power from winding 4-5. This causes the TEMP interlock indicator to light.

G. If the tank access ports are closed and the tank interlock switch is therefore closed, the VAC TANK indicator lights.

H. If the tank is pumped down to operating pressure and the vacuum gauge interlock switch is therefore closed, the VAC GAUGE indicator lights.

J. If the flow of water through the gun is adequate and the water flow switch is therefore closed, the GUN WATER indicator lights.

K. If there is an accessory used (usually a rate monitor), and it is connected between terminals 4 and 5 of TB204, and its interlock circuit is closed (indicating operational status); or if terminals 4 and 5 of TB204 are jumpered (no accessory used); the AUX indicator will light, power will be applied to the normally open keylock switch and RE201 will be energized.

L. Contact RE201-1 energizes the primary to T203 which applies power to the focus supplies. At the same time power is applied through F205 and F206 to the SCR packages in the gun control circuits, and to the gun filament transformers.

M. The gun filament controllers allow the gun filament temperature to rise to a point just below emission capability.

N. Closing the keylock switch applies power to the KEY indicator, lighting it, and applies power to the normally open contacts of PB101, the HIGH VOLTAGE ON switch, through the normally closed contacts of PB102, the HIGH VOLTAGE OFF switch. The HIGH VOLTAGE OFF indicator lights, finding a ground path through the coils of TD201 and MC102.
O. Pressing and releasing PB101 applies power to TD201, MC202 and the HIGH VOLTAGE ON indicator which then lights. Contacts MC202-1, MC202-2 and MC202-3 apply utility power to the high voltage transformer T201 through resistors R201-R203. R201-R203 suppress high inrush currents. Contact MC202-4 provides a path around normally open PB101, after this momentary push-button is released.

P. After approximately 0.2 second, TD201 has ended its time delay period, and its contacts close. Contact TD201-1 energizes MC201, whose contacts bypass resistors R201-R203, connecting T201 directly to the utility power.

Q. Pressing and releasing PB102 removes power from PB101 and its indicator, TD201, MC201 and MC202, returning the power supply to the same status as in N above.

3.2 HIGH VOLTAGE DC SUPPLY

Transformer T201 converts the 208V or 220-240V input power to 8150V ac, three-phase power, which is then rectified to 10,500V dc by high voltage rectifiers CR201-CR206.

The positive terminal of the 10KV supply is connected to the plate of V201, the overload switch tube on the ES-6A-210. The negative end is connected, after passing through the current-sensing transductors L701, 702, to one side of the secondary of T204 and T205, the gun filament transformers, for respectively, Gun #1 and Gun #2. On the ES-6A-110, the negative end is connected directly to the Gun #1 filament transformer secondary.

3.3 LOW VOLTAGE POWER SUPPLIES

Transformer T202 and associated components supply the switch tube bias and operating voltages for the tube control P.C. board (+115V dc and +310V dc); 120V ac for the cooling fan, relays,
transducers and indicator lights; switch tube 5V filament power; 20V ac for the tube control P.C. board.

Transformer T203 and associated components supply 33V dc to the focus coil circuitry and 40V ac to the focus and gun control P.C. boards.

3.4 OVERLOAD SENSING AND CONTROL

The function of this circuit is to protect the high voltage supply from overloads or short circuits, caused by gun arc-downs, or shorts. This function is performed by sensing an overcurrent condition and turning off series switch tube V201 for a predetermined length of time, during which no output current can flow. The switch tube is then turned on and the cycle repeats as long as the overload persists.

This circuit may be divided into four sections: power supply, sensing and control circuit, bias and drive circuit, and series switch tube. The functions of each will be discussed in the steps below. The most common failure modes and their consequences will also be discussed.

3.4.1 Power Supply. The P.C. board accepts the +310V grid drive power through a 200-ohm collector resistor (R210) and a 2K ohm base resistor (R211). The P.C. board also accepts 20V ac power from T202 and converts this to +28V dc and +10V dc regulated from its control electronics. Note all of the above dc voltages are referenced to the common of the tube control P.C. board (pins S, T, Y and Z), not to chassis ground.

3.4.2 Sensing And Control Circuit. Current sense resistors R210-R219 develop a voltage proportional to the emission current. This voltage is stored by C304 of the tube control PC board, which is prevented by diode CR309 from discharging through R214-R219.

Q303 and Q304 form a Schmitt trigger, whose input is taken from a voltage divider between the +10V supply and the negative polarity current sense signal. Under normal conditions, Q303 is on and
Q304-Q306 are off. (Q305 and Q306 are used to amplify the output state of Q304.) When an overload occurs, Q303 is turned off and Q304-Q306 are turned on. This ultimately results in V201 being turned off, which shuts off the load current. The driving signal is then removed from C304, which discharges through R307 and part of R306. In approximately 50 milliseconds C304 has discharged sufficiently far to allow Q303 to turn on and Q304-Q306 to turn off, ultimately turning on V201. This cycle continues as long as the overload condition persists.

3.4.3 Bias And Drive Circuit. The purpose of this circuit is to control V201 in response to signals from Q306, turning V201 off when Q306 is on and vice-versa.

The +155V supply is connected to the cathode of V201 and to R212. This establishes a cathode voltage of +155V, to allow the grid to be driven both positive and negative with respect to the cathode.

Under normal conditions (no overload, Q306 off); Q302 is off and Q301 is on. The grid of V201, is biased to approximately +60V (ref. to cathode) by the +310V supply, through R210, R211 and Q301. When an overload occurs and Q306 is turned on, Q302 is turned on. Q302 deprives Q301 of base current from R211, causing Q301 to turn off and bring the grid of V201 to common (approximately -150V ref. to cathode). Q301 blocks current flow through R210, preventing an intolerably high dissipation in this resistor. When Q306 turns off again, Q302 turns off. Current flows through R211 into Q301 and from there into the grid of V201, biasing the grid to approximately +20V (ref. to cathode). When Q301 reaches approximately 0.7 volts, Q301 turns on and the grid of V201 is biased through R210 to approximately +60V, ref. to cathode.

3.4.4 Switch Tube. V201, the series overload switch tube, is connected between the positive end of the 10KV dc supply and ground, such that the output current must flow through V201. When an overload occurs and the control circuit turns V201 off, the output circuit is opened and no output current can flow; thus, the high voltage supply is protected against destructive overload currents.

3.4.5 Failure Modes. The overload control circuit is failsafe concerning most of the probably common failure modes. A failure in
3.4.5 (cont.)

Q302 (normally a collector-base or collector-emitter short) will turn off V201. A failure in Q301 (normally same modes as Q302) will have no effect until a sustained overload occurs. Then, R210 will be overloaded, but F207 will blow before R210 can be damaged. This removes all grid drive from V201, which is then biased off by the +150V dc cathode bias. These two failure modes result in a "safe" condition which causes no further damage. All other components are conservatively rated and well protected against transients, so that failure is very unlikely.

3.5 FOCUS SUPPLY

Focus Control P.C. Board Assembly A401.

This module provides power to the beam deflection and focus magnets of two electron beam guns. A beam sweeping capability (dither) is provided for each gun. Circuitry in the module may be divided into four sections: power supply, sweep generator, current regulator and undercurrent sensor. The operation of each section is described in the following paragraphs.

3.5.1 Power Supply. T203 and associated components provide operating power for the focus supply. A rectifier bridge and filter capacitor external to the printed circuit module develop the -28 volts used as an input to the focus regulator. A second winding is rectified on the circuit card and regulated to +15 volts with zener diodes. This supply provides excitation for the position controls and powers the sweep generator.

3.5.2 Dither Generator. This circuit provides a signal which drives the electron beam slowly across the crucible from outside to inside in approximately one second, after which the beam returns rapidly to the outside and repeats the sweep.

Q416 and Q417 generate a 1 cps sawtooth wave which is amplified by Q418. Diodes CR411-CR414 provide an offset which interrupts the sawtooth, giving the focus coil current time to decay to the value established by the beam position setting each time the dither function resets to zero at the end of its cycle. This is necessary
to avoid an inward position shift of the beam position with increasing dither due to the high inductance of the focus coil, which resists any attempt to rapidly change the focus coil current.

3.5.3 Current Regulator. Drive to the focus coil assemblies is provided from a high gain current regulating loop which assures that the focus coil current will be independent of focus coil resistance, and also makes the supply short circuit proof. The command signal from the beam position and dither controls are compared at the emitter of Q403 with a feedback signal derived from the output current. A very small difference or error signal is used to drive a current amplifier (Q404, Q405, Q201) which provides the output current. Q403 provides no current amplification but is needed as a voltage level translator to permit comparison at ground potential and amplifier reference at -28 volts. Output current is sensed in a one-ohm resistance located between the current amplifier and the -28V supply. Q401 and Q402, in conjunction with the 1000-ohm resistor in the emitter circuit of Q401, provide a feedback current of one-milliampere per ampere of load current which is returned to the summing point at the emitter of Q403 for comparison with the command signal. Load current is delivered through a low pass filter section which protects the supply from rapid transients and bursts of RF energy which arise from arcing in the vacuum chamber.

3.5.4 Undercurrent Sensor. A second current proportional to load is created in Q411 and amplified in Q413 after a short deadband established by the low resistance shunting the Q413 base-emitter junction. This current is used to operate a relay with contacts in the primary high voltage interlock chain. The contacts will not close and high voltage cannot be generated until focus current exceeds 0.4 amperes in both focus circuits or in one circuit with the other bypassed if this is desired. The signal from each focus circuit is combined in a series "and" gate configuration to drive the relay. Both focus circuits must be operable to generate high voltage. A center-off double-throw switch is provided for use when only one gun of a two-gun unit is to be used. This switch bypasses the unused element in the "and" gate so that the undercurrent relay may be controlled by either gun focus supply independently, as well as by both together.

NOTE: This circuit is current regulated and is, therefore, capable of delivering its preset current into any load impedance shown to and including a short circuit. However, because all available power must be dissipated by the current amplifier transistors when

*See Addendum
operating into a zero impedance load, this mode of operation should not be sustained with over 2 amperes of load current. To operate at currents above 2 amperes the load should have a total resistance of at least 2 ohms. Focus coils of lesser resistance should be used in series with additional resistance providing a total resistance of at least 2 ohms and preferably about 5 ohms.

3.6 GUN CONTROLLERS

Gun control PC board assemblies (A501 and A601) are identical and only A501 is discussed below.

The function of this module is to supply heating power to the gun filaments and to regulate this power according to the desired emission current. This function is performed by comparing an emission current feedback signal with a reference signal, the resultant signal controlling the power applied to the primary of the gun filament transformer. Capability is provided for manual remote control and automatic rate control, as is circuitry for internal biasing of filament power to just below the emission range and circuitry for shutting off all except this bias level during an arc-down of the gun.

This module may be divided into six sections: power supply, summing amplifier, emission current feedback, the SCR firing circuit, the SCR's arc-down control circuit, and rate inverter circuit. The functions of each will be discussed in the steps below.

3.6.1 Power Supply. T203 supplies 40V ac C.T., which the PC board converts into +28V filtered, -28V unfiltered, -28V filtered, and -10V regulated. The +28V output supplies the summing amplifier, firing circuit and arc-down control circuit. The -28V unfiltered output is used in the firing circuits, the -28V filtered output supplies the rate inverters, and the -10V regulated output supplies the reference input to the summing amplifiers.

3.6.2 Summing Amplifier. This amplifier (Q504 and Q505) accepts a (negative polarity) reference signal and compares against it a (positive polarity) emission current feedback signal. Q505 delivers the difference (for reference greater than feedback) to Q504 which amplifies it and drives the firing circuit.
HIGH VOLTAGE IS PRESENT WITHIN THIS EQUIPMENT. GREAT CARE SHOULD BE EXERCISED AT ALL TIMES WHEN WORKING WITH THIS EQUIPMENT.

Human contact with this voltage can be fatal. Make sure to turn off high voltage, keylock, circuit breaker and remove input power connector before removing any covers. Short all capacitors with a grounding hook.

Standard safety practice dictates the utilization of grounding hooks in conjunction with the electron guns to ground any inadvertent high voltage application when human contact with these units is anticipated.

Avoid testing live circuits. Use an ohmmeter whenever possible.

If, in the process of troubleshooting, it becomes necessary to energize portions of the circuitry, extreme caution should be observed. All test meter connections should be made with the power off. Test leads should be in good repair and have insulation rated for the test voltage. Test meters should be securely mounted and not touched after power is turned on. Stand clear of clip leads which may become disconnected and other energized parts. Do not work in cramped spaces or areas that are cluttered. Do not work in a manner that will allow energized equipment to fall on you or you to fall into the equipment. Troubleshooting of this nature should be carried out only by highly experienced personnel utilizing standard, approved, safety procedures.
The reference for the summing amplifier is derived from the -10V supply, and is manually adjustable from the front panel (emission current control) or by a control on the remote control box. The reference signal may be derived from a rate controller, through the rate inverter circuit.

3.6.3 Emission Current Feedback. The feedback signal for the summing amplifier is derived from the emission current of the gun which the summing amplifier is controlling.

In two gun models, this signal is taken from the transducer PC board assembly A701 (See section 3.7).

In single gun models, the feedback and metering signals are derived from the current sense resistor (R214-R219) through meter and feedback PC board assembly Q801 which is inserted in place of A701.

3.6.4 Firing Circuit And SCR's. The firing circuit (Q501, Q502 and associated components) accepts the signal from the summing amplifier and fires the SCR’s (CR501 and CR502), which determine the amount of power delivered to the primary of T204, the gun filament transformer.

The signal from the summing amplifier is integrated in C506 until its voltage is sufficient to trigger UJT Q502. The pulse from Q502 is amplified by Q501 and triggers whichever SCR (CR501 or CR502) is forward biased at the time. Q503 resets C506 to zero at the end of each half-cycle, so that its voltage at the beginning of each half-cycle is independent of the point in the previous half-cycle that Q502 was triggered.

R508 and R509 provide a bias signal into C506 which may be adjusted such that the filament is just below its emission range with no reference input into the summing amplifier.

3.6.5 Arc-Down Control Circuit. This circuit (Q506 and associated components) shuts off the summing amplifier when there is no high voltage at the output. This is necessary to protect the filament against sustained operation at excessive power levels, and to prevent lockup during an arc-down, since the high gain of the filament controller will turn the filament fully on with very little reference, if there is no emission current feedback.
Prior to operating the ES-6A, the preparations and precautions given in Section 4.1 MUST BE STRICTLY adhered to.

The design of the ES-6A allows either gun to operate alone, or both guns to operate together.

4.1 PREPARATION FOR OPERATION

4.1.1 Input Power. Ensure that the utility power to be supplied to the ES-6A meets the requirements of Section 1.3.1. The green wire in the power cable MUST be grounded at the power source. Also ensure that the taps on T201-T205 are connected according to the utility power to be used.

4.1.2 Output Connections.

A. Ensure that the gun filament leads are securely connected to the high voltage feedthroughs at the tank, and that the shield pigtails are grounded to the tank.

IF, ON A TWO GUN MODEL, ONLY ONE GUN IS TO BE CONNECTED, THE UNUSED GUN FILAMENT LEADS MUST BE DISCONNECTED FROM THE ES-6A AND REMOVED FROM THE CABINET. Also, the filament fuse (F205 or F206) should be removed.

B. Ensure that a low impedance ground is connected from the tank to the terminal stud provided on the ES-6A.

THIS GROUND CONNECTION IS ESSENTIAL FOR THE SAFETY OF BOTH THE POWER SUPPLY AND THE PERSONNEL OPERATING IT.

This low impedance ground connection must be at least #6 copper, and MUST BE RUN IN A SHORT AND DIRECT PATH BETWEEN THE ES-6A AND THE CHAMBER. Also, the shields on the high voltage cables must be connected securely to the tank near where the guns are
mounted to the tank. If during operation, arcing in low-voltage control cables or connectors, this is an indication that the low impedance ground is inadequate. Increasing the conductor size, making the path shorter or more direct, avoiding running this ground wire next to control cables, and avoiding passing this ground wire through holes in metal panels, are all steps which will tend to alleviate this condition. In extreme cases a copper foil strap about one-to-one-half inches wide may be necessary. Impedance at high frequencies, rather than dc resistance, is the critical parameter to be minimized.

C. Ensure that the gun is securely grounded to the tank.

D. Ensure that the tank interlock cable is connected between J201 and the tank interlocks. Ensure that the focus output for each gun is connected to the focus electromagnet on the corresponding gun.

E. Interlock Connections:

1. Ensure that terminals 1 and 2 of TB204 are connected to series interlock switches which will close only when all access ports to the vacuum tank are closed.

2. Ensure that terminals 2 and 3 of TB204 are connected to the vacuum gauge interlocks, which will close only when the proper operating pressure is attained in the tank.

3. Ensure that terminals 3 and 4 of TB204 are connected to a water flow interlock switch which will close only when there is sufficient water flowing to cool the gun.

4. Ensure that terminals 4 and 5 of TB204 are connected to the interlock contacts on a rate monitor (or other interlock device as desired), or are jumpered if no additional interlocks are desired.
5. Ensure that the ES-6A is properly adjusted according to Section 5. (Internal adjustments need not and should not be altered unless the filament or focus coil is changed to a different type.)

4.2 OPERATION

When all conditions of Section 4.1 have been satisfied, and power is applied to the ES-6A, all interlock indicators, except KEY, should light. If any remain unlit the unsafe condition responsible must be ascertained and corrected before further operation is attempted.

When the first six indicators are lighted, turning on the keylock should light the KEY and HIGH VOLTAGE OFF indicators.

Two operating procedures are suggested: an INITIAL OPERATION procedure, for use when the focus coil or filament have been changed, or the operating characteristics of the gun are otherwise unfamiliar to the operator, and a NORMAL OPERATION procedure for use when the operator has become familiar with the operating characteristics of the gun in use.

4.2.1 Initial Operation. This procedure enables an operator, unfamiliar with the characteristics of the gun, to obtain emission and place the beam into the crucible without damage to the tank or gun. It is assumed the ES-6A is operable as in above.

A. Turn EMISSION and DITHER controls fully counterclockwise.

B. Meter the focus current with an external meter. Adjust the position control until a focus current is obtained which is approximately correct for the gun being used. Try 1.2 amps, if correct current is unknown.

IMPORTANT: ES-6 Power Supplies with Serial Nos. 6-546 through 6-729 do not have focus current interlocks. Make certain the beam is on the
crucible before increasing emission above 10ma or the tank, water lines or gun may be damaged.

C. Press and release the HIGH VOLTAGE ON button. It should light and the HIGH VOLTAGE OFF indicator extinguish.

D. While watching for the electron beam, very slowly rotate the emission control slightly clockwise until emission (do not exceed 10ma) is obtained. The impact of the beam should be visible; it should be somewhere near the crucible.

E. Rotate the position control until the beam is in the crucible.

F. Increase emission to approximately 50ma and position the beam in the center of the crucible.

G. Increase emission power to the level desired for the vacuum deposition to be performed.

H. If dither is desired, move the beam to the outside (farthest from the filament) of the area to be swept by the beam. The beam will return to this point at the end of each sweep cycle.

J. Slowly rotate the DITHER control clockwise until the beam sweeps the desired area.

K. When the desired vacuum deposition is complete, rotate the EMISSION control fully counterclockwise. Emission will cease. If the other gun is not in use, press and release the HIGH VOLTAGE OFF button; it will light and the HIGH VOLTAGE ON indicator will extinguish.

4.2.2 Normal Operation. This procedure is for use only when the operator has become familiar with the characteristics of the gun in use.

A. Set the position (and dither) controls to a position known to place the beam in the crucible. Set the emission control to a low value.
B. Turn on the high voltage and observe that the beam is in the desired position, making whatever corrections are necessary.

C. Raise the emission power to the desired level.

4.2.3 Rate Controlled Operation. Connect the rate controller to the rate input and set the RATE/LOCAL switch to RATE. The emission level is now set by the rate controller.

4.2.4 Remote Control Operation. To use the manual remote control connect its cable to the front panel REMOTE plug, and set the REMOTE/LOCAL switch to REMOTE. The EMISSION, POSITION and DITHER functions for both guns will then be controlled from the remote control box.
INTERNAL ADJUSTMENTS

Internal adjustments are provided on each P.C. board of the ES-6A to match its characteristics to the external accessories used. These adjustments should not be disturbed unless the focus coil or filament is changed. If both are changed, the focus adjustment (Section 5.1) MUST be performed first.

IMPORTANT SAFETY CAUTION

All internal ES-6A adjustments are to be made with the high voltage off and the high voltage keylock in the off position. If it is found that the proper adjustment has not been attained after turning the high voltage back on, turn high voltage off and readjust until proper operating conditions are attained.

*5.1 FOCUS ADJUSTMENTS

No internal adjustments are provided or required on Focus P.C. Board A401. However, Gun Selector Switch S401 must be in the Gun 1, Both, or Gun 2 position depending on the guns that are to be operated. Refer to schematic or Figures 1 and 2 for switch positions.

5.2 GUN CONTROL ADJUSTMENTS

There are three adjustments for each gun; BIAS, RANGE and RATE. The adjustment of each will be included in the steps below.

NOTE: If 620ma emission current cannot be achieved prior to step 5.5 due to the switch tube triggering as noted by a rapid fluctuation of emission current it will be necessary to adjust trimpot R306 on tube control PC board A301 further clockwise until it is adjusted in step 5.5.

*See Addendum
5.2.1 SCR Bias R508 Or R608 (R8 on A501 or A601). It may become necessary due to aging or replacement of the gun filament to readjust the SCR bias.

Adjust R8 to the threshold of emission with the front panel emission control set to the 10% mark. This provides a small "dead-band" at the full counterclockwise position to allow for good gun control and assume there is zero emission when the control is at zero.

5.2.2 Current Range R520 And R620 (R20 on A501 and A601) ES-6A-210 ONLY. Adjust the current range trimpot (R20) for about 610ma as indicated on the front panel meter for the desired gun when the emission control is raised to 100% emission.

5.2.3 Current Range R520 (R20 on A501) ES-6A-110 ONLY. The current range trimpot R20 on the ES-6A-110 only, is adjusted to its midpoint and the current range adjusted with the feedback pot (R802) on the meter and feedback adjustment PC card A801 as described in Section 5.4.2. NOTE: R20 is a 20-turn trimpot and, therefore, must be adjusted 10 full turns from either end for this step.

5.2.4 Rate Adjustment R529 And R629 (R29 on A501 and A601). A jumper on the gun control PC board can be connected for either a plus or minus rate input signal voltage to control the emission. Trimpot R29 is adjusted for the full emission desired with the full rate input voltage applied at the rate input connector J202 for Gun #1 and J203 for Gun #2.

The ES-6A has been factory adjusted to supply 600ma emission current with a positive 10 volts rate input for both the ES-6A-110 and ES-6A-210.

5.3 METER AND TRANSUDCTOR ADJUSTMENTS ON TRANSUDCTOR AMPLIFIER P.C. BOARD ASSEMBLIES A702 AND A703 - ES-6A-210 ONLY

Before attempting to adjust meters electrically turn off the main circuit breaker and mechanically zero the meters from the meter face with a non-magnetic screwdriver.
5.3.1 Transducer Meter Zero (R4 on A702 or A703). With the main circuit breaker on and the high voltage off, adjust the R4 trimpots on the transducer boards for a zero meter indication on their respective meters.

5.3.2 Transducer, Meter Full Scale Adjustment (R13 on A702 and A703).

A. Remove the high voltage keylock key so as the high voltage CANNOT BE TURNED ON.

B. Obtain a current regulated dc power supply capable of delivering .6 amps into 25 ohms. A voltage regulated power supply that has at least a 15-volt, .6-amp output will also work.

C. Connect the positive output lead of the test power supply to the X2 terminal of the Gun 1 filament transformer T204.

D. Connect the negative output lead of the test power supply to the ES-6A electrical ground buss (chassis).

E. On the ES-6A, with a jumper clip lead, connect the negative terminal of the high voltage capacitor C201 to the junction of resistors R214 and R213. R213 is the third power resistor (100-ohm, 100W) down from the top on the left side panel near the back of the supply. The R214 end of R213 is the terminal nearest the front panel.

F. Turn on and adjust the test power supply for .6 amps on its meter or on an external standard ammeter.

G. Turn "meter full scale" trimpot R13 on Gun 1 transducer board A702 fully counterclockwise.

H. Turn the ES-6A main circuit breaker on and adjust the "meter full scale" trimpot R13 for a full scale, 600mA, reading on the ES-6A front panel Gun 1 emission meter.

I. Turn the ES-6A main circuit breaker off.
J. Turn the test power supply off.

K. Remove the positive external power lead from the X2 terminal of T204 and connect to the X2 terminal of Gun 2 filament transformer T205.

L. Turn on the test power supply and adjust for .6 amps current flow.

M. Turn "meter full scale" trimpot R13 on Gun 2 transducer board A703 fully counterclockwise.

N. Turn the ES-6A main circuit breaker on and adjust the "meter full scale" trimpot R13 for a full scale, 600ma, reading on the ES-6A front panel Gun 2 emission meter.

O. Turn off the ES-6A main circuit breaker.

P. Turn off and disconnect the external test power supply.

Q. Remove the cliplead jumper from C201 to the junction of R213 and R214.

5.4 METER AND FEEDBACK ADJUSTMENTS ON P.C. CARD A801 - ES-6A-110 ONLY

Before making any electrical adjustments, turn off main circuit breaker and mechanically zero Gun 1 meter with a non-magnetic screwdriver.

5.4.1 Meter Adjustment (R801).

A. Remove the high voltage keylock key so as the high voltage CANNOT BE TURNED ON.

B. Connect an external dc power supply to the ES-6A as described in steps 5.3.2 A through E.
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C. Turn the "meter" trimpot R801 fully counterclockwise.

D. Turn on and adjust the test power supply for .6 amps on its meter or on an external standard ammeter.

E. Turn the ES-6A main circuit breaker on and adjust the meter trimpot R801 for a full scale, 600ma, reading on the ES-6A front panel Gun 1 emission meter.

F. Turn the ES-6A main circuit breaker off.

G. Turn off and disconnect the external test power supply.

H. Remove the cliplead jumper from C201 to the junction of R213 and R214.

5.4.2 Feedback Adjustment (R802). Adjust trimpot R802 on the meter and feedback adjustment PC card for about 610ma front panel indicated emission current when the emission control is set at 100% emission. See Section 5.2.3. NOTE: If R802 is open, no feedback will be present to gun control PC board A501 and the emission current will come up rapidly as the emission control (R101) is advanced and will reach 600ma when R101 is about 10% of full scale.

5.5 OVERCURRENT TRIP ADJUST R6 ON PC BOARD A301

The overcurrent trip adjust trimpot R6 on tube control board A301 is adjusted so that when 620ma emission current is exceeded the switch tube circuit will trigger and cut off the emission current for approximately 50 milliseconds and then turn back on. The current trip point is easily recognized by a rapid fluctuation of the emission current.

NOTE: With an ES-6A-210 the total emission current from both guns must not exceed 620ma. Therefore, Gun 1 emission can be set for 300ma and when Gun 2 emission is brought to 320ma the supply will go into the over-
current trigger mode. On the ES-6A-110 it will be necessary to temporarily extend the current rate adjustment on the Gun 1 control card so as 620ma emission can be reached. The 620ma reading must be approximated because M101 needle will be off scale.
6.1 PREVENTIVE MAINTENANCE

Preventive maintenance on the power supply electrical components requires only that the enclosure be kept clean. The power supply should be checked at least every thirty days. If visual inspection discloses any accumulation of dust, dirt or grease anywhere within the power supply, power should be shut off, the power switch at the wall source disabled, and the dust, dirt, or grease removed by vacuuming or cleaning with a solvent.

6.2 TROUBLESHOOTING

In the electrical system a study of the functional analysis will isolate a malfunction to the appropriate section. Associated circuits can then be investigated using normal electrical troubleshooting procedures.
# SPARE PARTS LIST

**MODEL ES-6A-110/210 POWER SUPPLY**

It is recommended that the spare parts listed below be kept on-hand to reduce down-time of the system in the event that excessive loading or aging causes failure.

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* When replacing a light or pushbutton, the original engraved lens can still be used.

** International Rectifier (I-R) #10DB, 1A, 800PRV may be substituted for SD-2 or SD-8.
Subject: The changing of switch on printed circuit card assembly A401.

Reason: To bypass focus current interlock feature when external sweeps such as the XYS-R-1 or VWS-R-1 are used. Also to allow the bypassing of focus current interlock if operating at reduced voltage and the focus current low limit of 400mA is being exceeded.

Effectivity: Serial numbers 6-788 through 6-1039, which have an external sweep supply. After 6-1039 all units will incorporate this feature.

WARNING: Extreme caution should be observed when using external sweep units. With focus current interlock bypassed, it is possible to lose focus current and cause damage in the vacuum system if the beam is still on.

Changes: Delete paragraph 2.3.1 and add the following paragraph.

2.3.1 Gun Focus Current Source Interlock Selector Switch S1. A switch on the focus control printed circuit board can be set to one of four positions to interlock either Gun 1, Gun 2, both guns internally or bypass the interlock circuit for external sweeps. This circuit controls the focus current interlock relay contacts which are in the high voltage interlock circuit. The switch is to be placed in the appropriate position. Position #1 is for Gun #1 internal focus control for ES-6-110 or an ES-6-210 when Gun #2 has an external sweep. Position #2 is for Gun #2 internal focus control for an ES6-110 or an ES6-210 when Gun #1 has an external sweep. Position #3 is the internal focus control of both guns for an ES6-210 only. Position #4 is for external control of both guns for an ES6-210 or ES6-110 when only external sweepers are used. Position #4 also can be used to bypass the focus current interlock feature. In position #4, if focus current is lost in one or both guns, damage could result to the vacuum system, therefore, EXTREME CARE must be taken while operating in position #4 and should be done only when absolutely necessary.

3.5.4 Change line 10 from "a center-off double-throw switch" to "a four-position, two-pole rotary switch....".

Delete paragraph 5.1 and add the following.

5.1 FOCUS ADJUSTMENTS

No internal adjustments are provided or required on Focus Printed Circuit Board A401. However, gun focus current source interlock switch S401 must be in the Gun 1, Gun 2 position (both guns internal, or both guns external position) depending on the guns that are to be operated. Refer to schematic No. 306-3163 "D" revision or to Figure below for switch positions.
GUN FOCUS CURRENT SOURCE  TOP OF CARD

(POS = 4) BOTH GUNS [EXT]
(POS = 3) BOTH GUNS [INT]

GUN1 (POS = 1)
GUN2 (POS = 2)

Switch shown in position #1, slotted shaft is indexed to show position.

Figures 1 and 2: Disregard switch shown on A401 Focus Printed Circuit Assembly No. 306-3192.

NOTE: This only affects ES-6 units which use an external sweep and have serial numbers 6-788 through 6-1039. Above serial number 6-1039 this addendum will affect all units.

Use schematic No. 306-3163 "C" revision for ES-6 units which do not have an external sweep with serial numbers 6-788 through 6-1039.

DO: 10/70
See Addendum

(FIGURE 1)  ES6A-110

SERVICE ADJUSTMENT LOCATION
CAUTION: SHAD ED AREAS ARE OPERATING AT 10KV.

See Addendum

(FIGURE 2) ESSA-210

SERVICE ADJUSTMENT LOCATION
INPUT POWER JUMPER LINK CONNECTIONS

208V ~ INDICATED BY DOTTED LINES.
220-240V ~ INDICATED BY SOLID LINES.

TERMINAL BOARD ON H.V. XFRMR. T201

TB202 & TB203
LOCATED UNDER FOCUS PC BOARD, A401
(SHOWN WITH BOARD REMOVED)

TB202

TB203

REAR OF CHASSIS