Hummer VI Operations Manual

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INTRODUCTION

The HUMMER™ sputter coaters were introduced in 1971 as a more convenient and efficient method of coating samples for SEM. Using the sputter coating technique, samples of all types can be coated uniformly.

The chamber is evacuated to a pressure of approximately 20 mt.

An inert gas (usually argon) is admitted to the chamber.

A negative 2700-3000 volts is applied to the top plate. This voltage ionizes the gas and forms the plasma. The ions in this plasma are propelled toward the target where they remove material which is deposited in the chamber and on the specimen.

Use of the planar magnetron triode configuration allows those samples to be coated without the damaging effects of electron bombardment typical of diode systems. The design of the planar magnetron system was developed to eliminate effects of high temperatures during plating operations. A high magnetic flux crosses the flow of electrons accelerated toward the anode sample electrode (pedestal). The electrons present in the plasma are sent into a spiral path away from the specimen due to the magnetic field created by the magnet in the top plate. In addition to this magnet, a biased dark space shield surrounds the pedestal. This biased ring serves to attract electrons which may have escaped through the magnetic field. The electrons are, therefore, retarded and diverted toward a biased dark space shield. The result is a cool pedestal and sample.

Please read this manual thoroughly. If you have any questions about the manual or your Hummer VI, please feel free to contact our Customer Service Department.

APPENDIX

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SETTING UP YOUR NEW HUMMER VI

Unpacking the Hummer VI Sputter Coater:

Remove all internal bracing and packing materials from around the instrument; remove any small cartons which may be present and set them aside, as they contain the various accessories. The main portion of the instrument can now be lifted clear of its container. All protective coverings can be easily removed, but care should be taken not to contaminate the protected areas. The accessories and parts should be carefully unpacked and set aside. Check to see that packing material does not contain any parts that would otherwise be overlooked or thrown away.

CHECKLIST:

1. Deposition Chamber
2. 2 Bottles (250cc) Pump Oil
3. Instruction Manual
4. Chamber Gaskets
5. Magnet
6. Cathode Target
7. Cathode Extractor

INSTALLATION

Place the Hummer console on a table or countertop which provides ample working area, approximately 10 square feet, near an electrical outlet. Seat the chamber gaskets around the edges of the chamber. Set the vacuum chamber in the groove provided in the baseplate, and set the top plate in position on the chamber top. Ensure that the contact areas of the chamber and gaskets are free from dirt or dust or other contamination. When needed, chamber rim and gaskets can be wiped clean and regreased with a very light film of silicone vacuum grease.

TABLE 1: HUMMER VI CONTROLS

Fine Gas Control Valve: - FIGURE 4 - used to introduce air or inert gases into the high vacuum chamber and to regulate the pressure within the chamber. Only light two finger pressure is required to close this valve. Excessive force will damage this valve.

Main Power Switch: - FIGURE 2 - used to turn on the vacuum pump, vacuum gauge, and power supply. The amber light indicates the power is on.

Hi-Voltage Switch: - FIGURE 2 - used to turn on hi-voltage supply which generates plasma. A red light indicates that hi-voltage is on.

Hi Voltage Control: - FIGURE 2 - used to adjust the amount of hi-voltage required.

Auto Manual Switch: - FIGURE 2 - used to select either manual operation or automatically timed operation. NOTE: High voltage light will not come on if switch is in automatic position and time is set at zero.

Mode Switch Plate-Etch-Plasma: - FIGURE 2 - used to select mode of operation for either D. C. plating, D. C. cleaning or etching, or plasma processing.

Pulse Switch: - FIGURE 2 - used for intermittent pulsing of the plasma to provide smaller coating crystal nucleation and lowest rise of the specimen temperature. After turning on the pulse mode, it takes 30 seconds for warmup, after which an on-off interval of 5 seconds will continue. Pulse can be selected in either automatic or manual mode.

Pressure Switch: - FIGURE 2 - used as a safety device to cut off high voltage whenever chamber is at atmosphere.

Pedestal Height Adjust Knob: loosen this knob to adjust pedestal height. Adjust pedestal to desired position. Tighten knob. Use only light pressure. Excessive tightening can damage this fixture and cause vacuum leaks. ALWAYS DISCONNECT HUMMER FROM ELECTRICAL SUPPLY BEFORE REMOVING BACK PANEL.

CHECKING OIL LEVEL

All units are equipped with a vacuum pump which must be filled with oil prior to operating the unit. Do not plug main power cord in until ready to run machine.

1. FIGURE 4 - Remove six Phillips screws on back panel and two lower screws on chamber support. Check that all electrical wiring is secure.

2. FIGURE 4: - Remove pump exhaust cap.

3. Add oil thru exhaust port until oil is visible in view port. Fill to the center of the circle. Replace pump exhaust cap.

4. Adjust stage height. Pedestal height should be adjusted to 1.5-2 inches from top plate electrode. Loosen black plastic nut located at base of pedestal rod (inside main cabinet, under base plate). Raise or lower pedestal as required and retighten knob.

5. Replace rear panel. Plug in power cord. Position top plate in place on top of deposition chamber. Turn on main power switch. Resulting vacuum will hold top plate in correct position while rear panel is re-attached.

VACUUM PUMP OIL SPECIFICATIONS

Ultimate pressure at 25°C	8.5×10^{-5}
Boiling point at .01 torr	112°C
Pour Point	5°F
Flash point	415°F
Fire point	472°F
Viscosity, SUS at 100°F	248
Viscosity, SUS at 130°F	101
Viscosity, SUS at 210°F	51
Color	Pale Yellow

GAS INLET

A gas inlet is provided for the introduction of pure gases, such as argon, for quicker, more uniform and oxygen free depositions. A two stage regulated tank pressure of 5-15 psi can be applied at the gas inlet. We recommend the use of argon for higher quality coatings.

1. Attach argon tank to gas inlet fixture in rear of unit.

2. Adjust tank pressure 5-15 psi.

3. If an inert gas is not available or the user does not wish to use it, it may be omitted, and the unit can be operated with laboratory air.

ELECTRICAL CONNECTION

1. Plug the power cord of your Hummer into an electrical supply of 110-115vc, 7 amp, 60 Hz or 220-230v AC, 7-1/2 amp, 50 Hz, as specified on the serial number plate.

NOTE: Before placing your Hummer into operation become familiar with the instrumentation and controls detailed in the following sections.

Make sure the target - FIGURE 5 - is in place and that the tygon tubing is placed on the nipple located in rear of top plate. (Argon Gas Inlet) Always use lint free gloves to handle target to avoid contamination.

OPERATION

First Pump Down:

Check that all switches are off and all valves are closed before commencing operation of your Hummer. To place the Hummer in operation, first set all controls as follows:

CONTROL:	FIGURE:	SETTING:
Main Power Switch	2	OFF
High Voltage Switch	2	OFF
Voltage Control	2	0
Process Control	2	MANUAL
Fine Gas Control	1	Closed (clockwise)
Mode Selector	2	D.C. PLATE/ETCH or PLASMA

Open chamber by lifting top plate and removing glass cylinder and placing specimens on pedestal. Pedestal height should be adjusted to place specimen approximately 1.5-2" from top plate electrode. Raise or lower pedestal as required. Retighten nut with thumb and forefinger only. (See Page 2)

Install Appropriate Target: (FIGURE 5)

The target is held in place by banana plugs. Remove with target extractor provided by pulling at 3 positions 120 degrees apart. Target is installed by pushing the target into place on the banana plugs. Never touch the target; always use lint free gloves to prevent contamination.

After installing the desired electrode, place top plate on the chamber and turn on the main power switch. Initial pump down will take 15 to 20 minutes; thereafter, 2 to 5 minutes should be sufficient.

During pump down, flush chamber with inert gas, if used, by increasing fine gas control to fully open (pressure will rise), then close. Do this 3 times. Allow unit to pump.

When 30 millitorr or less is achieved pump down is complete.

The system is now ready to PLATE or ETCH.

PLATING

1. Place specimens in chamber

2. Close lid gently - power ON.

3. Flush chamber with argon 2 to 3 times using fine gas control knob.

4. Increase gas pressure with fine gas control knob to approximately 55 - 70 millitorr.

5. When gas pressure stabilizes turn hi-voltage switch to ON.

6. Turn high voltage control knob clockwise to achieve approximately 10 milliamps.

7. Alternately adjust gas pressure and high voltage knob until a reading of approximately 10 milliamperes is achieved on current meter at 55-70 millitor.

NOTE: The initial appearance of plasma will cause chamber pressure to rise and fall due to molecular adhesion of water vapor, atmospheric gases and solvents. Adjust fine gas control until pressure and current stabilize.

If automatic timing is to be used:

8. Set timer to desired coating time.

9. Switch to AUTO - plasma will terminate automatically after time set has expired.

10. Switch pulse to ON position if pulse is desired. Time which is set on timer will be actual plating time during on cyle of pulse mode.

11. When specimen is coated:
    - reduce hi-voltage control to ZERO
    - turn hi-voltage switch OFF
    - CLOSE gas valve
    - switch to MANUAL
    - main power OFF
    - vent - Hummer VI vents automatically when main power is switched off

11. Remove specimens.

Typical operating conditions:

Gold or Gold/Palladium Deposition

Voltage Control	Position 7-9
Pressure	40-80 Millitorr (Argon)
Current	10 Milliamperes
Approximate Plate Time	2 Minutes

Curves of typical plating times for various materials are shown in.

ETCH - TYPICAL OPERATING CONDITIONS

1. Place mode selector switch to ETCH. It is advisable to remove precious metal target and replace with aluminum etch ring to avoid contamination of plating target.
2. Place specimens in chamber.
3. Close lid gently.
4. Power ON.
5. When 30 mt or less is achieved turn high voltage switch ON.
6. Increase hi-voltage knob to position 5-6.
7. OPEN fine gas control valve until plasma appears.
8. After plasma appears, adjust current by using this valve to 10 milliamperes or less for biological or organic samples and from 10-20 milliamperes for inorganic samples.
9. When specimen is etched follow directions for shut down as in plating.

Typical operating conditions for etching function:

Metallurgical Specimen

Voltage Control	Position 6
Pressure	50-100 Millitorr (Argon) (Variable)
Etch Time	6-10 Minutes

Biological Specimen

Voltage Control	Position 4-5
Pressure	40-60 Millitorr (Argon) (Variable)
Current	10 Milliamperes
Etch Time	2-5 Minutes

PLASMA PROCESSING

The Plasma Processing is utilized for ashing, cleaning and etching of metals, ceramics, glasses, organics and composites. This is a chemical-physical variation as opposed to the D. C. Etching (Sputter Etching) which is a physical reaction by ion bombardment. The specimens are reacted with active specie of oxygen, carbon tetrafluoride or other reactive gas. In addition, organic and inorganic coating can be deposited by Plasma chemical vapor deposition (CVD). WARNING: When using plasma processing which is corrosive or with oxygen, or with a corrosive reactive gas, an oxygen resistant oil must be used in the vacuum pump or damage to the pump or explosion may result.

To Plasma Process:

1. Place the MODE SELECTOR switch to PLASMA ESC.
2. Turn ON MAIN POWER SWITCH and evacuate the system to 20 millitorr.
3. Place Hi VOLTAGE SWITCH to 0.
4. Increase GAS VALVE to read a pressure of 1 torr.
5. Increase VOLTAGE CONTROL to produce a current of 20 milliamperes on the current meter.
6. Process for desired time with desired gas; oxygen for cleaning, ashing, and etching of organics, carbon tetrafluoride* for etching of metals, ceramics and glasses, ethylene for deposition of ethylene coatings and argon or nitrogen for cross-linking of organic surfaces such as TEM and SEM specimens to improve stability to electron beam exposure.

*Vent toxic exhaust fumes from room.

Typical Plasma conditions for several processes follows:

1. Ashing - Cleaning - Etching of Organic and Carbon

Voltage Control	Position 5
Pressure	1 torr oxygen
Current	20 Milliamperes
Time	10 Minutes

2. Etching of Metals, Ceramics and Glasses

Voltage Control	Position 4
Pressure	500 Millitorr (CF_4)*
Current	20 Milliamperes
Time	5 Minutes

3. Deposition of Ethylene Polymers

Voltage Control	Position 4
Pressure	50 Millitorr (Ethylene)
Current	20 Milliamperes
Time	15 Minutes

4. Cross Linking of Organics (A_2 or N_2)

Voltage Control	Position 4-5
Pressure	100 Millitorr
Current	10 Milliamperes
Time	10 Minutes

MAINTENANCE

Occasional cleaning is necessary as component parts become coated with material. The chamber should be cleaned with water and metal cleanser. The pedestal and shields surrounding the pedestal and electrode can be removed and scrubbed with #0000 steel wool and then washed with detergent and water. Metallic electrodes can be cleaned with acetone or perchloroethylene. Carbon electrodes should be cleaned with steel wool or emery paper. Keep steel wool out of contact with magnet. Be sure all metal filings are removed before replacing in unit.

Seals should be kept coated with a very light film of silicone vacuum grease. Electrodes are actually consumed during the coating process and will take on a matte appearance, usually after 1000 to 1200 depositions. Ring type electrodes are held by three banana plugs and are removed with the extractor supplied. All Hummers are equipped with a pressure interlock or software safeguard sequence to prevent the high voltage from operating unless the chamber is under vacuum. The pressure interlock switch is suspended vertically beneath the base plate and can be seen from the rear of the cabinet The switch is an important safety feature and has been adjusted so that the hi-voltage is off when the chamber is vented and is on when the chamber is evacuated. A small adjusting screw is provided for this adjustment. Backing the screw out will allow the hi-voltage to come on at a high pressure, and advancing the screw will have the opposite effect.

The Hummer VI vents automatically through a solenoid valve. Vacuum pumps normally require no attention other than to check the oil, which should be maintained at a level near the center of the circle in the sight glass located at the side of the pump. The oil should be drained and refilled with a good quality mechanical vacuum pump oil when pressures below 30 mt. cannot be achieved. Refill as described in checking oil level section.

The chamber glass, stage and target area should be cleaned regularly. A buildup of coating material can prevent the unit from pumping down properly. These parts can be cleaned with "Scotch-brite" pads or fine steel wool.

The exterior of the instrument should be kept clean by wiping it with a damp cloth and spray cleaner, such as "Formula 409" or "Fantastic". Avoid excessive scrubbing of the front panels and controls.

REMOVAL OF TARGET ELECTRODE

Insert electrode extractor between outer circumference of target electrode and dark space shield, pull slightly, move extractor 120 degrees around circumference and pull, move one more time about 120 degrees and pull again. Electrode should now be extracted, if not, repeat procedure.

OPTIONAL ACCESSORIES

QUARTZ CRYSTAL DIGITAL THICKNESS MONITOR

A quartz crystal digital thickness monitor (DTM-Q) is available to provide an accurate monitoring of thickness of the deposited material. The unit is easily installed on any Hummer.

CARBON EVAPORATION ACCESSORY - FIGURE 8

It is often desirable to coat specimens with carbon. Since carbon sputtering at high pressure is a complicated and difficult process, an accessory which allows carbon evaporation in the Hummer chamber is available.

This unit uses the vacuum from the Hummer and the gas inlet at the top. It has a separate 10 volt power supply and a separate top plate assembly which holds the evaporation jigging. The Carbon Evaporation Accessory can be used with all Hummer I - VI, X and XP models.

APPENDIX A

TROUBLE SHOOTING GUIDE

A general guide to assist the operator in solving most simple failures:

NO POWER WHEN MAIN SWITCH IS ON:

1. Check that line cord is properly connected both at the power supply and at the wall receptacle.
2. Check that circuit breakers are not thrown. Push button to reset. FIGURE 2
3. Check that on/off switch on pump is in ON position.

POWER LIGHT COMES ON BUT PUMP WILL NOT RUN:

1. Check that circuit breakers are not thrown. Push button to reset. FIGURE 2
2. Check power connection between pump and rear of power supply. FIGURE 2
3. Check that remote switch on extreme right side of pump is in ON position.

PUMP OPERATES BUT NO VACUUM CAN BE ACHIEVED:

1. Check to see that seals on top and bottom of chamber are free from dirt, dust, hair, etc.
2. Make certain that pedestal adjustment nut is tight.
3. Be sure gas valves closed and argon hose fitting is in place on top plate.
4. Check all hoses and clamps for tightness.
5. Be certain that proper oil and volume of oil is in pump.

SYSTEM PUMPS DOWN WELL BUT HI-VOLTAGE LIGHT WILL NOT COME ON:

1. Make certain that auto operation has not been selected with time set to "zero".
2. Check vacuum interlock switch for proper adjustment.
3. Be sure that circuit breaker is not thrown. Push button in to reset.

APPENDIX A (continued)

HI-VOLTAGE IS ON BUT NO PLASMA CAN BE GENERATED IN ANY MODE:

1. Check to see that pressure is in operating range.
2. Check to see that hi-voltage lead from top plate is properly inserted in receptacle provided.
3. Make sure that ceramic hi-voltage connector is attached to bottom of pedestal rod beneath base plate.
4. Be certain that ground connections to top plate and to pedestal are properly made.
5. Check to see that electrodes are properly positioned in top plate.

PLASMA CAN BE GENERATED IN ONE MODE, BUT IN OTHER MODES CURRENT METER IS "PEGGED":

1. Check all causes and remedies in previous section.
2. Check to see that no foreign material is shorting electrode to the dark space shield surrounding the electrode. See that no foreign material is attached to the magnet or pole piece.
3. Make sure that no foreign material is lodged between the pedestal and the surrounding dark space shield.
4. Be sure that pedestal, electrode and space shields are not excessively coated or dirty, especially when selecting etch mode.

PLASMA IS PRESENT BUT NO COATING CAN BE ACHIEVED:

1. Be sure voltage and argon gas is in an operating range.
2. Make certain that electrodes are clean and free of surface contamination.
3. Check to see that the inside of the glass chamber and all fixtures inside the vacuum chamber are clean, to prevent degassing and contamination of the coating.
4. Purge chamber of contaminating gases by continually bleeding in and pumping out chamber with inert gas (argon).
5. Check pedestal height. (1.5-2" from target)

APPENDIX A (continued)

PULSE MODE WILL NOT WORK:

1. Replace delay relay located at right rear inside of power supply.

VACUUM GAUGE WILL NOT WORK:

1. Check power connection between vacuum gauge and rear of power supply.

2. Check connection between vacuum gauge tube.

3. Replace gauge and tube as a matched set.

CHAMBER WILL NOT VENT TO ATMOSPHERE:

1. Check gas supply pressure.

FINE GAS CONTROL VALVE FEELS LOOSE (PACKING WORN) MAY CAUSE LEAK:

1. Tightness can be restored by tightening the chrome compressor directly behind the large control knob.

This section is only a guide to help solve the most commonly encountered problems. For unusual or difficult problems, do not hesitate to call on us for assistance. Direct your queries to the Service Department, where our qualified staff of service personnel is always available to help.

APPENDIX B

INSTRUCTIONS FOR REPAIR, SERVICE, AND RETURN SHIPMENTS

Should repairs or service be necessary, our qualified staff of service personnel is as near as your telephone. When corresponding by mail or phone, ALWAYS be ready to provide the serial and model number of the instrument in question. Before shipping any instrument to our plant, you MUST first get an authorization number for return and packing instructions from the Service Department.

Please direct all questions concerning service, repairs, warranty or operating procedures to the Service Department.

APPENDIX C

HUMMER VI WARRANTY

Anatech Ltd. hereby warrants each instrument and other articles of equipment used in service calls to be free from defects in material or workmanship under normal use and service for one year. Malfunctions of an instrument or other article of equipments caused by abuse, incorrect installation or use, or neglect of the instrument or equipment are not covered by this warranty. No other express warranty is given, and no affirmation of Anatech or its agents, by words or action, shall constitute a warranty.

Anatech Ltd.'s sole and exclusive obligation to an original purchaser under this warranty shall be to repair at its factory any instrument or other article of equipment which is returned intact to Anatech Ltd. by the original pruchaser, transportation and freight charges prepaid, within 30 days after delivery of such instruments or other article of equipment to the original purchaser, and which in the sole opinion of Anatech Ltd., has malfunctioned due to defects in original materials or workmanship. This remedy shall be the original purchaser's sole and exclusive remedy under this warranty. ANATECH LTD. SHALL NOT BE LIABLE UNDER THIS WARRANTY FOR ANY CONSEQUENTIAL DAMAGES INCLUDING LOSS OF PROFITS, DELAYS, EXPENSE, DAMAGE TO GOOD OR PROPERTY USED IN CONNECTION WITH, OR PROCESS BY OR IN, THE INSTRUMENT OR OTHER ARTICLE OF EQUIPMENT COVERED BY THIS WARRANTY, OR DAMAGE TO SUCH INSTRUMENT OR OTHER ARICLE OF EQUIPMENT, OR FOR DAMAGES SUFFERED AS A RESULT OF PERSONAL INJURY.

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APPENDIX D

TECHNICAL CONSIDERATIONS OF SPUTTER COATING

INTRODUCTION

In electron microscopy an image is produced by electrons which flood over the specimen. Materials examined in this manner are typically poor conductors of electricity and, as such, will accumulate negative charge from the electron flooding. Such charging causes undesirable image distortion. In order to minimize this effect and produce clear clean images the surface conductivity of specimens should be increased. Samples which are somewhat conductive will yield a better image by enhancing their conductivity.

Specimen conductivity may be increased by coating with metal, usually a precious metal such as gold or palladium. If applied correctly the coating will not impair resolution or surface detail. Several acceptable techniques have been developed and employed routinely for electron microscopy. Two such methods are evaporative coating and sputter coating.

EVAPORATIVE COATING

Evaporative coating relies on sublimation of a metal at high temperature and vacuum. The metal vapor "sprays" the target material, adhering to any surfaces exposed to the "spray". Coating in this manner is directional and an irregularly shaped specimen may require tilting and rotation to achieve total coverage. Additionally, the metal released is hot, and can damage some specimens. Finally, since metal particle size and coating thickness are difficult to control, satisfactory results are dependent upon operator skill, technique and care.

SPUTTER COATING

Sputter coating is a cold process whereby metal atoms are liberated from a target by ion impacts. The atoms disperse throughout the process chamber in a manner which provides adequate coating of irregularly shaped specimens, without tilting and rotating them. The atoms are cool; consequently no thermally induced damage results. Sputtering is a microscopic process involving clouds of metal atoms, as opposed to the "spray" of relatively large macroscopic clumps of evaporated metal used in evaporative coating. As a result the uniformity and thickness of the coatings are easily controlled. In general, the quality and repeatability obtained by sputter coating are superior to that obtainable through evaporative means.

APPENDIX D (continued)

ADDITIONAL BENEFITS OF SPUTTER COATING

Several additional benefits are derived from the sputter process. Sputtering is done in a soft vacuum of 50 to 70 millitorr, pressures obtainable by small, reliable and inexpensive mechanical pumps. This eliminates the costly and elaborate high vacuum pump system required in evaporative coating. Sputter coating is specific with regard to the amount of coating material needed to achieve a desired coating thickness. Evaporative coating is much more wasteful of material; consequently the annual cost of the precious metal used is significantly reduced.

HUMMER FUNDAMENTALS

The HUMMER supports several configurations which are useful for specimen preparation. These are the PLATE, ETCH and PLASMA modes. All of these modes of operation have a common means of operation, namely the creation and maintenance of an electrical discharge called a plasma. The means of producing this plasma is discussed below, followed by a description of how a plasma is used in each of the processing configurations.

PLASMA PRODUCTION AND USE

Technically accurate descriptions of gas plasmas can be obtained in numerous references. Rather than burden the reader with undue scientific definitions, a lay description is provided which should enhance understanding and which provides ample basis for working with the plasma.

A gas plasma may form whenever gas is exposed to an electric field. If the field is sufficiently strong, a high percentage of gas atoms will surrender an electron or two and become ionized. The resultant ionized gas and liberated energetic electrons comprise the gas plasma, or plasma. Typically a noble gas is used, and is ionized in an electric field produced by hazardously high voltage.

The ionized gas atoms are heavy but have relatively little kinetic energy unless accelerated through the electric field. When this is done, they will smash into a negatively charged surface, or target, and some of the ions will dislodge a metal atom. Once dislodged, the atom can float around and will eventually adhere to a specimen.

APPENDIX D (continued)

A bothersome byproduct of this ion movement into the target is a movement of energetic electrons in the opposite direction. These can impact the specimen and cause heating. Biological specimens, polymers, or any sample which is heat sensitive may be affected and distorted by this heat, leading to artifacts when observed in the electron microscope. The HUMMERS alleviate electron heating problems by employing a planar magnetron. A magnet is located within the cathode electrode configuration. Electrons moving away from the target toward the specimen will be diverted away from the specimen by the magnetic field provided by the magnet.

The term `sputtering' specifically refers to this process of knocking loose material from the target. The term `sputtering rate' refers to the amount of target material per unit time interval that is removed. Another useful term is `sputter coating rate' which is the rate at which a specimen is covered by sputtered material, usually expressed as angstroms per minute. Naturally, the higher the sputter rate, the higher the sputter coating rate will be, since there will be more atoms of target material floating around.

The term `sputter coating rate' is not commonly used, however, but is often shortened to `sputtering rate'.

Many different gasses are useful for sputtering. Argon is most frequently used, because it is reasonably priced. Nitrogen is sometimes used. However, it has a lower sputter rate, and hence the sputter coating rate is decreased. Nitrogen gas will result in reductions of sputter coating rate of about twice from that of argon.

PLATE MODE

The HUMMERS produce plasma in a chamber which has a target cathode at the top, a stage anode (upon which the specimen rests) at the bottom. The chamber is evacuated by a vacuum pump, and the operating gas is introduced through an adjustable leak valve. A high potential is applied between the anode and cathode which results in the plasma formation. The ions are accelerated toward the top plate with an energy proportional to the voltage applied. In general, higher voltage will result in larger numbers of energetic ions, which in turn increase the sputter rate and the sputter coating rate.

APPENDIX D (continued)

ETCH MODE

In the etch mode the polarity of the stage and the cathode are reversed. In this mode a sample previously plated in a HUMMER can be etched in a manner similar to the target in the plate mode. The material will be etched at substantially lower rates than those achieved in plate mode. The etch mode does, however, produce considerable heating of the specimen.

In the event of sustained etching (over two minutes), the threat of contamination of the target by back-sputtered material from the specimen exists. The precious metal target should be removed and replaced with an aluminum etch target during prolonged etchings.

PLASMA MODE

The plasma process mode uses an alternating current, as opposed to the plate and etch modes which use direct current. The resultant plasma is sufficiently energetic to remove small amounts of organic or volatile contaminants from specimen surfaces. Customers have found that an exposure of two minutes to plasma in this mode prior to plating enhances subsequent SEM viewing results. In particular, accumulation of contamination caused by the electron beam is retarded.

TEM grids processed in the plasma mode are more hydrophilic.

PULSE MODE

Any of the three modes discussed above can be operated in a repeated on-off-on pattern, known as pulse mode.

During sputter coating, the deposited material displays a tendency to aggregate into discrete areas, or islands. The most useful application of the pulse mode is reducing the size of these islands.

A collateral benefit derived from pulse mode operation is decreased heating of the specimen. Naturally, while heating is reduced, overall plating time will be increased for a given thickness.

APPENDIX E

BIBLIOGRAPHY

A very short bibliography follows for those individuals wishing to learn more about the sputtering process.

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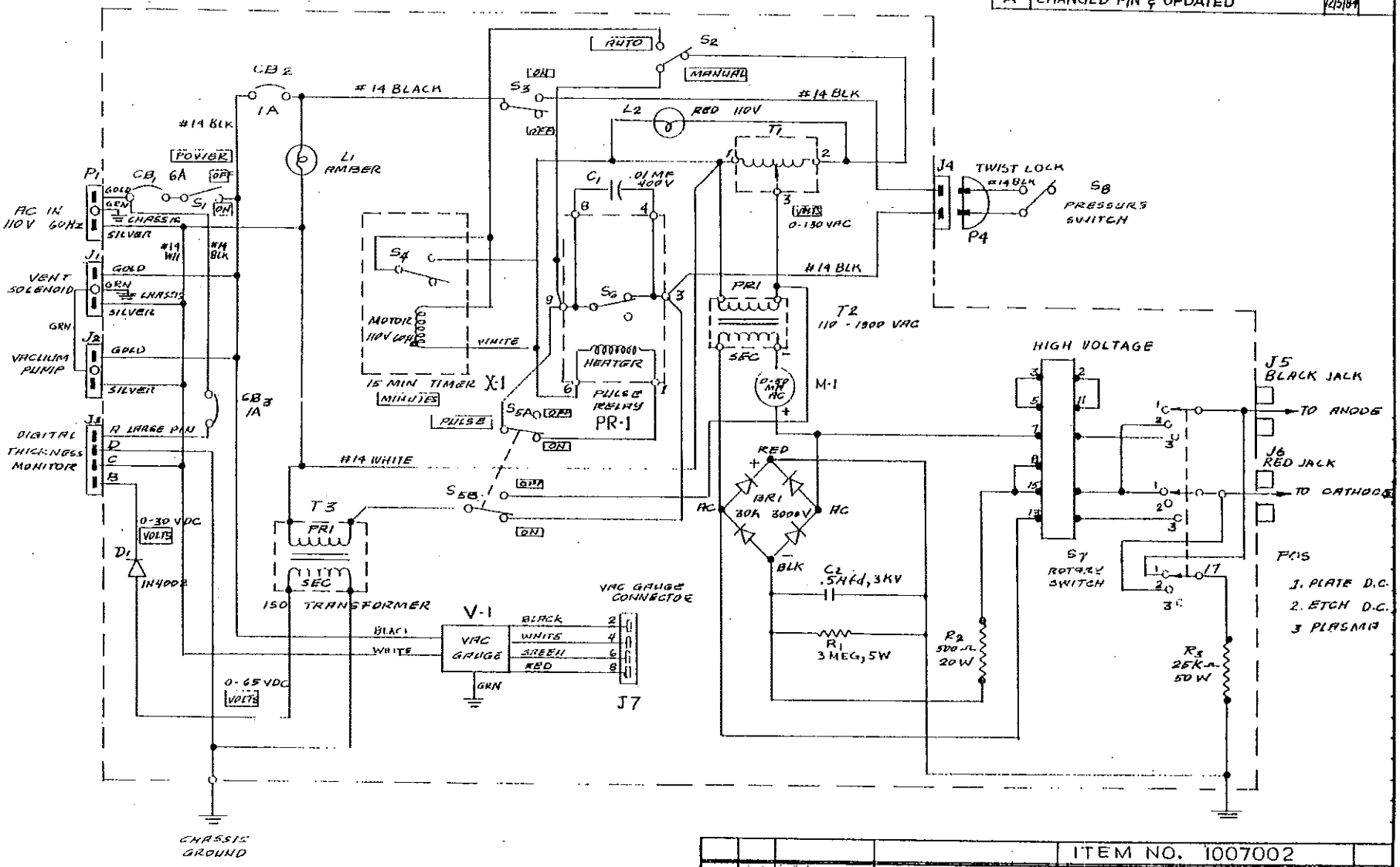
APPENDIX G

DRAWINGS & SCHEMATICS

LTR	REVISION	DATE	APP
A	CHANGED P/N & UPDATED	12/5/84	



NOTE

1 NOMENCLATURE IN BOXES ARE ON FRONT PANEL.

QTY	ITEM	TN PT NO	NOMEMCLATURE
NEXT ASSY	USED ON		
1009000	HUM VI		

UNLESS OTHERWISE NOTED DIMS ARE IN INCHES AFTER PLATING DEBURR & BREAK SHARP EDGES TOL ON DECIMALS
XX ± .010
XXX ± .005
ANGLES ± 0° 30'
SURFACE √ 84

ITEM NO. 1007002

MATL – VENDOR – SPEC | NOTE

ANATECH LTD
ALEXANDRIA VA

TITLE: SCHEMATIC HU VI PWR SUPPLY

DRAWN	CHK	APP
APS	GL	Gwitz 7/1/82

SCALE	DATE	DWG NO	REV
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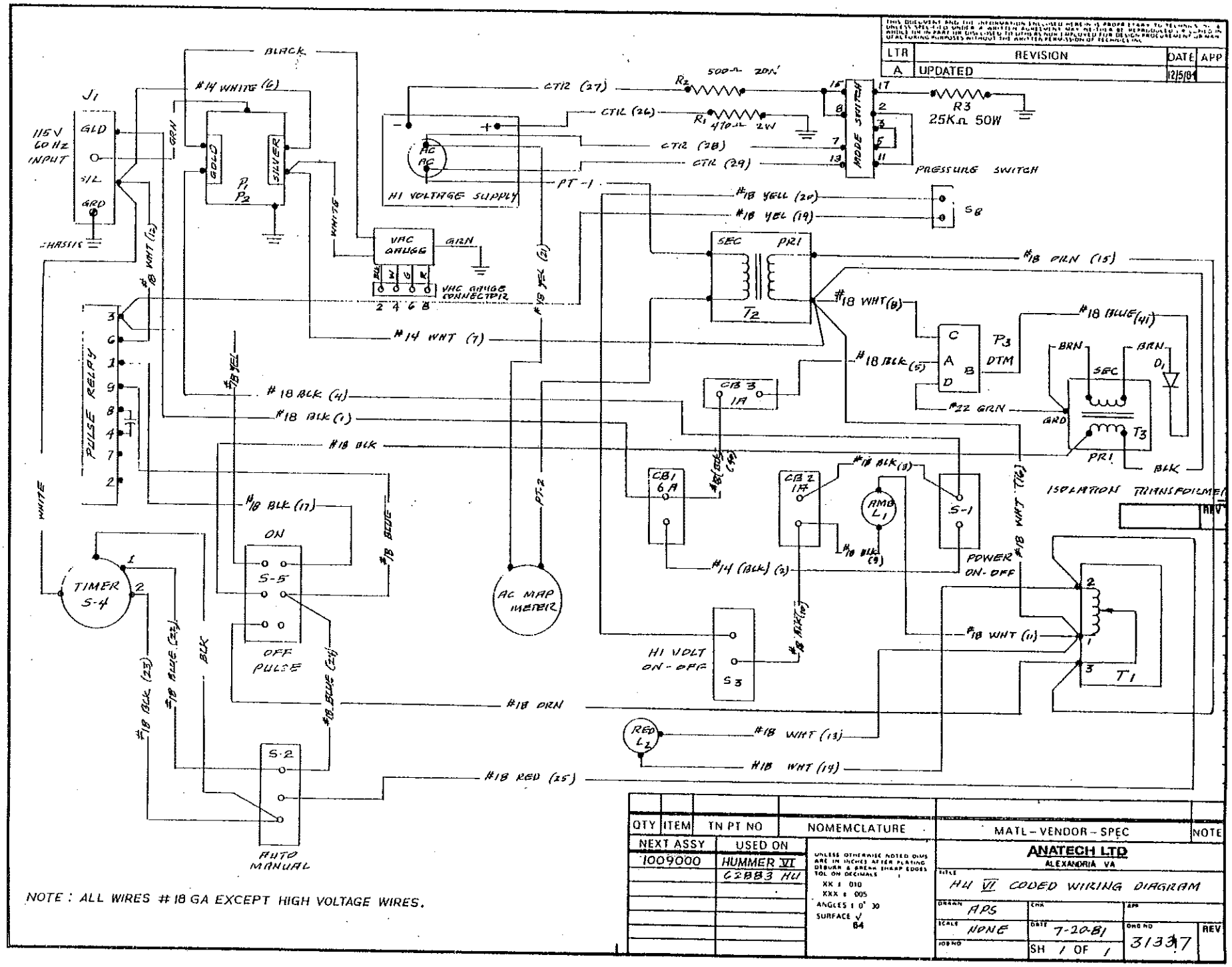
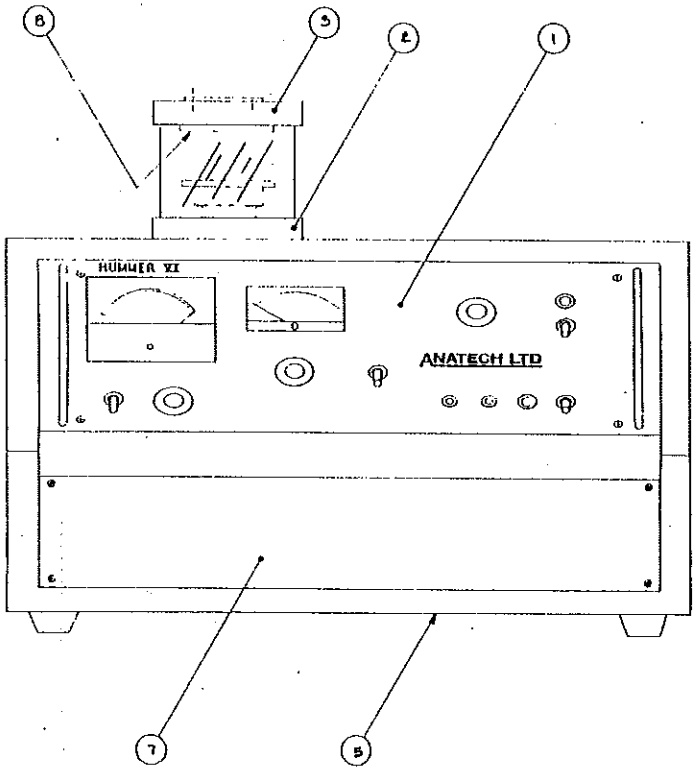
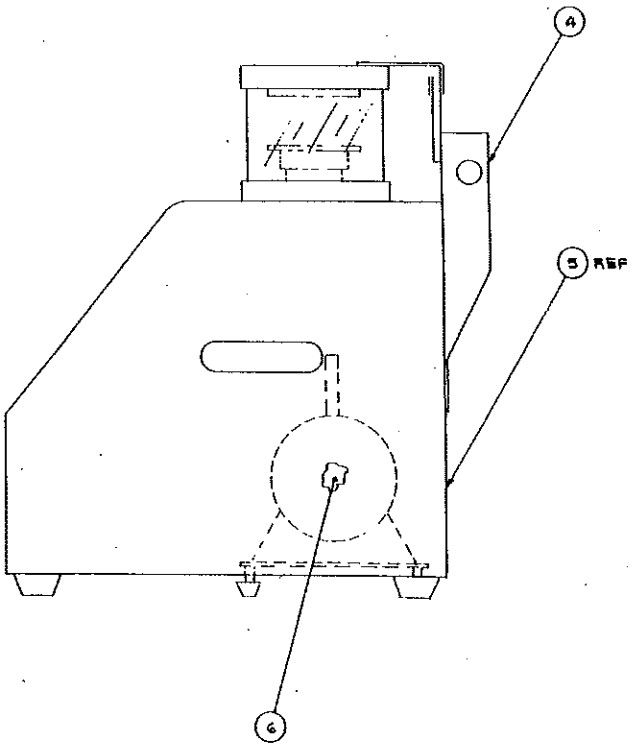
JOB NO | SH 1 OF 1


LTR | REVISION | DATE | APP
A | UPDATED | 12/5/84
J1
115 V 60 Hz INPUT
GLD
S/L
GRD
CHASSIS
#14 WHITE (6)
BLACK
GRN
GOLD
SILVER
P1
P2
WHITE
#18 WHT (12)
VAC GAUGE
GRN
VAC GAUGE CONNECTOR
2 4 6 8
HI VOLTAGE SUPPLY
CTR2 (27)
CTR1 (26)
CTR2 (28)
CTR (29)
PT-1
R2 500Ω 20W
R1 470Ω 2W
MODE SWITCH
R3 25KΩ 50W
PRESSURE SWITCH
#18 YELL (20)
#18 YEL (19)
S8
SEC
PRI
T2
#18 ORN (15)
#18 WHT (8)
#18 BLUE (41)
#18 BLK (5)
C
A
B
D
P3
DTM
BRN
SEC
D1
#22 GRN
GRD
T3
PRI
BLK
ISOLATION TRANSFORMER
REV
#18 YEL (21)
#14 WHT (7)
#18 BLK (4)
#18 BLK (1)
#18 BLK
PULSE RELAY
CB3 1A
CB1 6A
CB2 1A
#18 BLK (3)
AMB L1
S-1
POWER ON-OFF
#18 WHT (11)
#18 BLK (17)
ON
S-5
OFF PULSE
#18 BLUE
TIMER S-4
#18 BLK (23)
#18 BLUE (24)
#18 BLUE (22)
BLK
PT-2
AC MAP METER
#14 (BLK) (2)
#18 BLK (10)
HI VOLT ON-OFF
S3
#18 ORN
RED L2
#18 WHT (13)
#18 WHT (14)
#18 RED (25)
S-2
AUTO MANUAL
T1
NOTE : ALL WIRES #18 GA EXCEPT HIGH VOLTAGE WIRES.
QTY | ITEM | TN PT NO | NOMEMCLATURE | MATL – VENDOR – SPEC | NOTE
NEXT ASSY | USED ON
1009000 | HUMMER VI
62BB3 HU
UNLESS OTHERWISE NOTED DIMS ARE IN INCHES AFTER PLATING DEBURR & BREAK SHARP EDGES TOL ON DECIMALS
XX ± .010
XXX ± .005
ANGLES ± 0° 30'
SURFACE √ 64
ANATECH LTD
ALEXANDRIA VA
TITLE: HU VI CODED WIRING DIAGRAM
DRAWN APS
CHK
APP
SCALE NONE
DATE 7-20-81
DWG NO 31337
REV
JOB NO
SH 1 OF 1

LTR	REVISION	DATE	APP





40923 REV

8	
7	
6	
5	
4	
3	
2	
1	
ASSY.	

QTY	ITEM	IN PT NO	NOMENCLATURE	MATL - VENDOR SIZE	NOTE
NEXT ASSY		USED ON			
		HUMMER VI			
		1			

UNLESS OTHERWISE NOTED DIMS ARE IN INCHES AFTER PLATING TOL ON DECIMALS .XX ± .010 .XXX ± .005 ANGLES ± 0° 30' SURFACE √ 64

ANATECH LTD
ALEXANDRIA VA

TITLE: HUMMER VI ASSY

DRAWN: GK WILEY | CHK'D: SL | APP'D: [illegible] 3/11/82

SCALE: 1/2 | DATE: 3-11-82 | SHEET: SH 1 OF 1

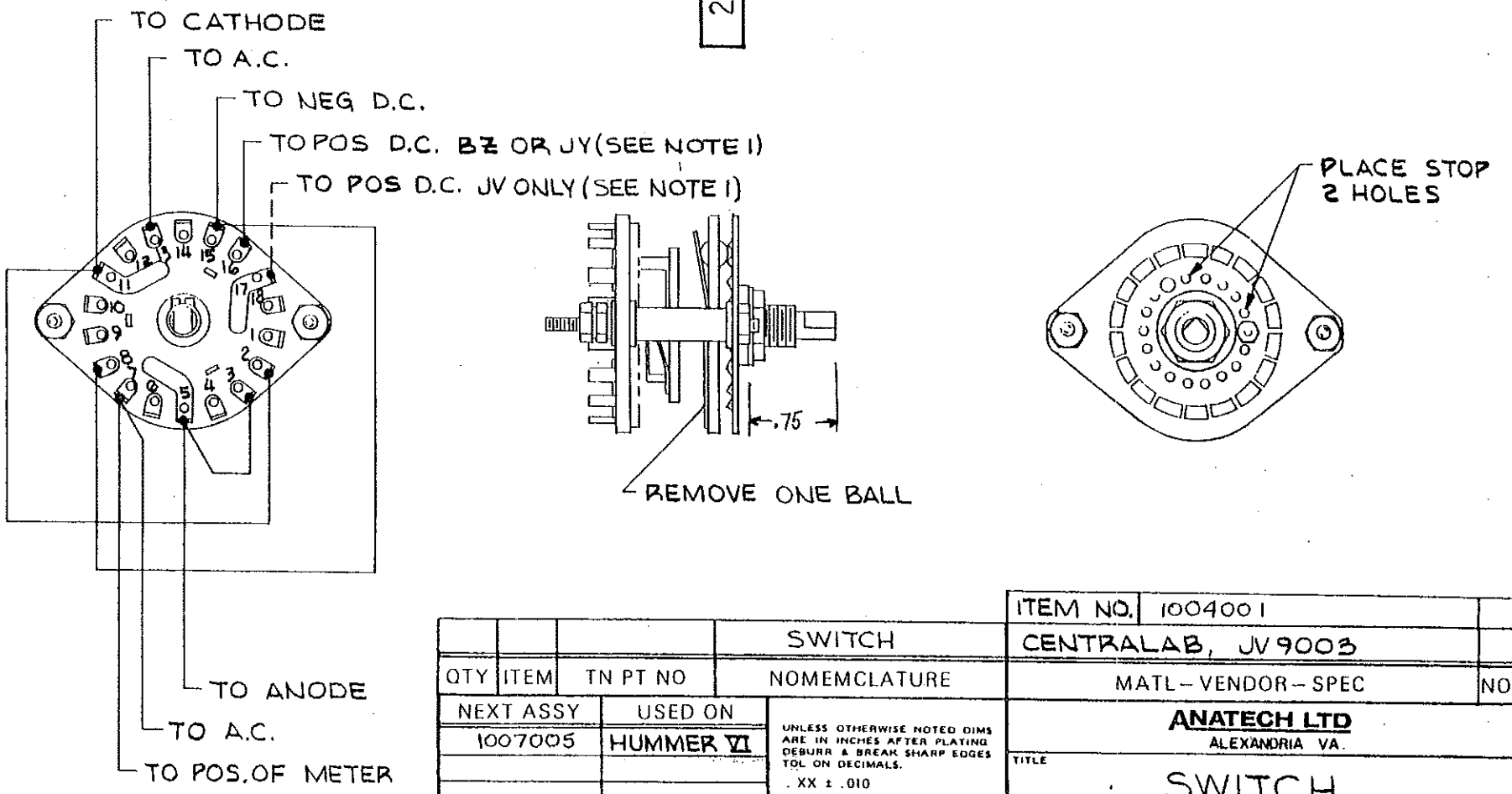
DWG NO: 40923 | REV

NOTES:

1. CHECK SUFFIX ON SWITCH PLATE.
2. NUMBERS ARE FOR HUM VI ONLY.

23110 REV A

LTR	REVISION	DATE	APP
A	CHANGED PART NO.	3-1-85	



QTY	ITEM	TN PT NO	NOMEMCLATURE
			SWITCH

NEXT ASSY	USED ON
1007005	HUMMER VI

UNLESS OTHERWISE NOTED DIMS ARE IN INCHES AFTER PLATING DEBURR & BREAK SHARP EDGES TOL ON DECIMALS.
. XX ± .010
. XXX ± .005
ANGLES ± 0° 30'
SURFACE √ 64

ITEM NO. 1004001
CENTRALAB, JV9003
MATL – VENDOR – SPEC | NOTE

ANATECH LTD
ALEXANDRIA VA.

TITLE: SWITCH

DRAWN	CHK	APP	
G K WILEY	GC	Gwiz 3/9/82	
SCALE 1/1	DATE 3-9-82	DWG NO 23110	REV A
JOB NO.	SH 1 OF 1		

APPENDIX H

FIGURES

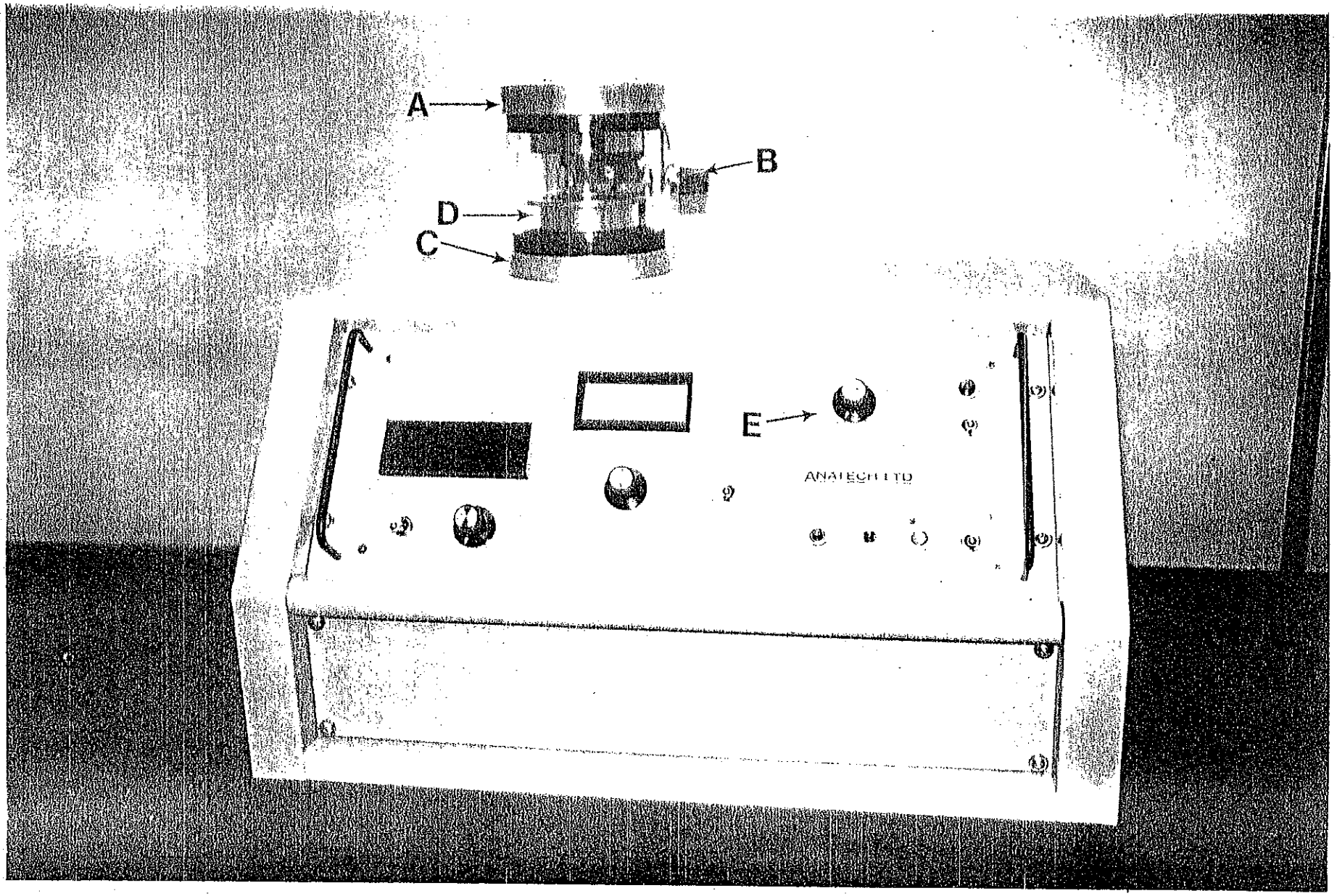


Figure 1

HUMMER VI 1009001

A.) Top Plate, B.) Fine Gas Control Valve, C.) Base Plate,
D.) Anode Pedestal, E.) Power Supply

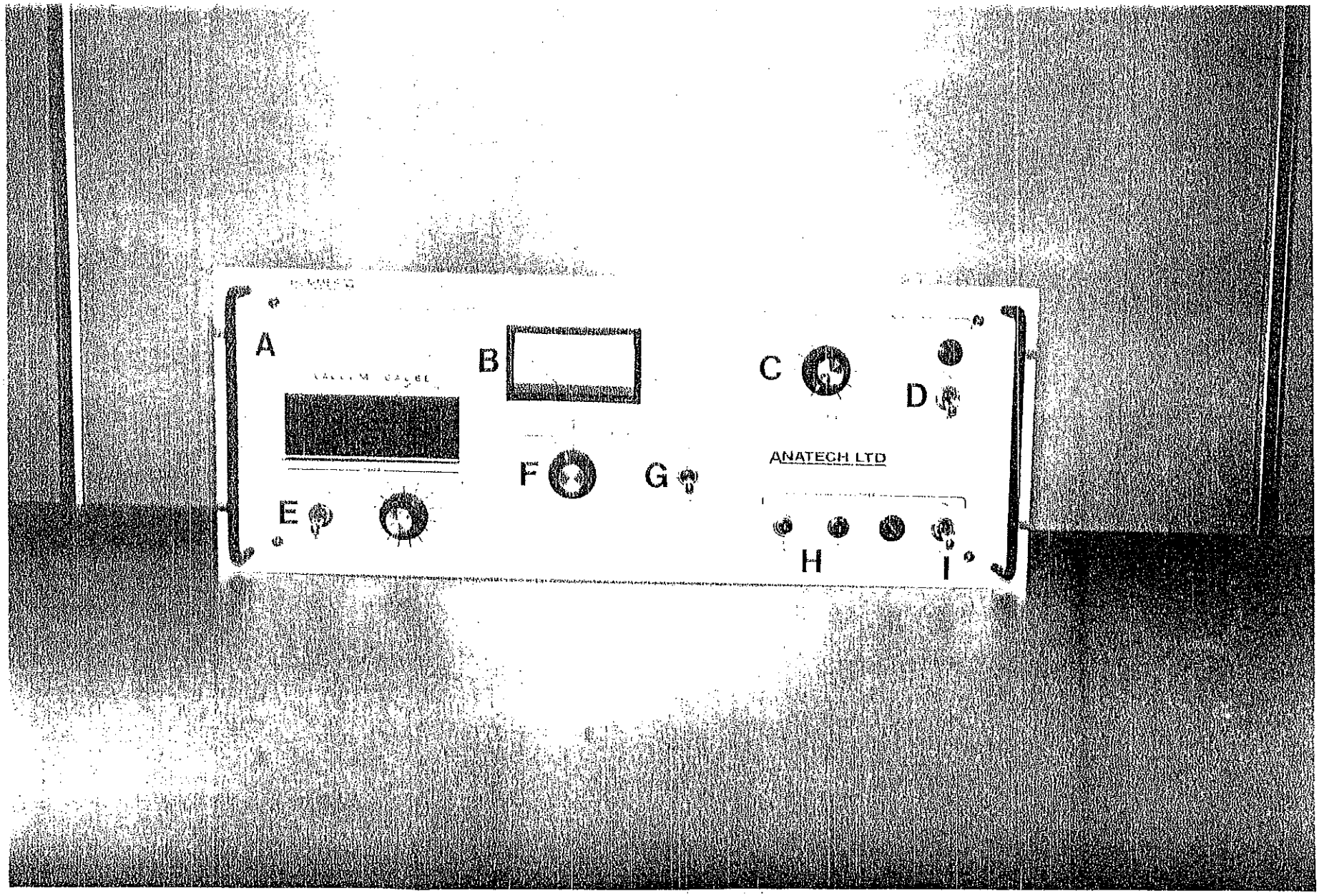


Figure 2

Power Supply Front View

A.) Vacuum Gauge, B.) Current Meter, C.) High Voltage Control,
D.) High Voltage Switch, E.) Auto-Manual Switch,
F.) Process Mode Selector Switch, G.) High Voltage Pulse Switch, H.) Cur-

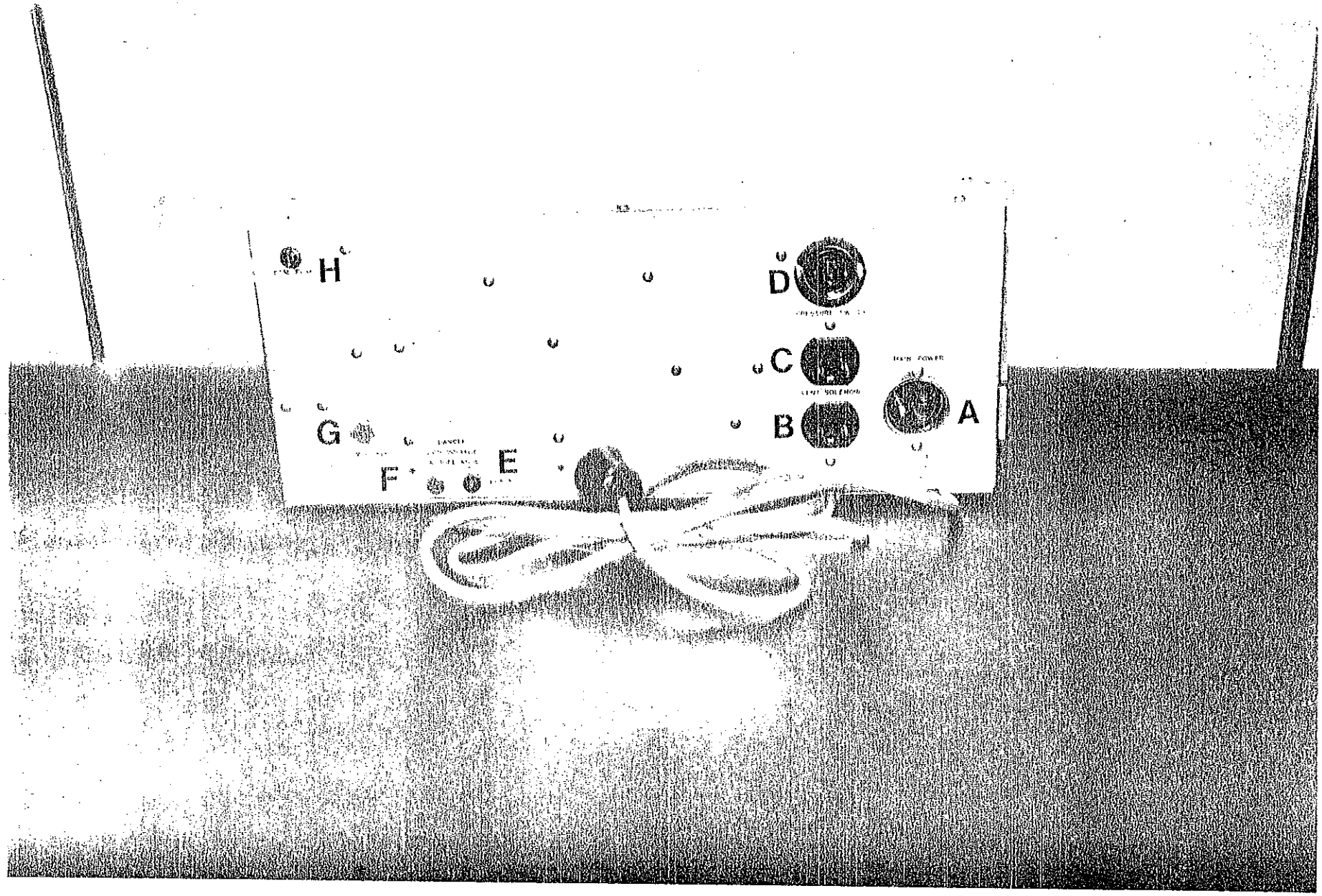


Figure 3
Power Supply Rear View

A.) Main Power Plug, B.) Vacuum Pump Outlet, C.) Vent Valve Outlet,
D.) Pressure Switch Plug, E.) Anode Plug, F.) Cathode Plug,
G.) DTM Plug, H.) DTM Circuit Breaker

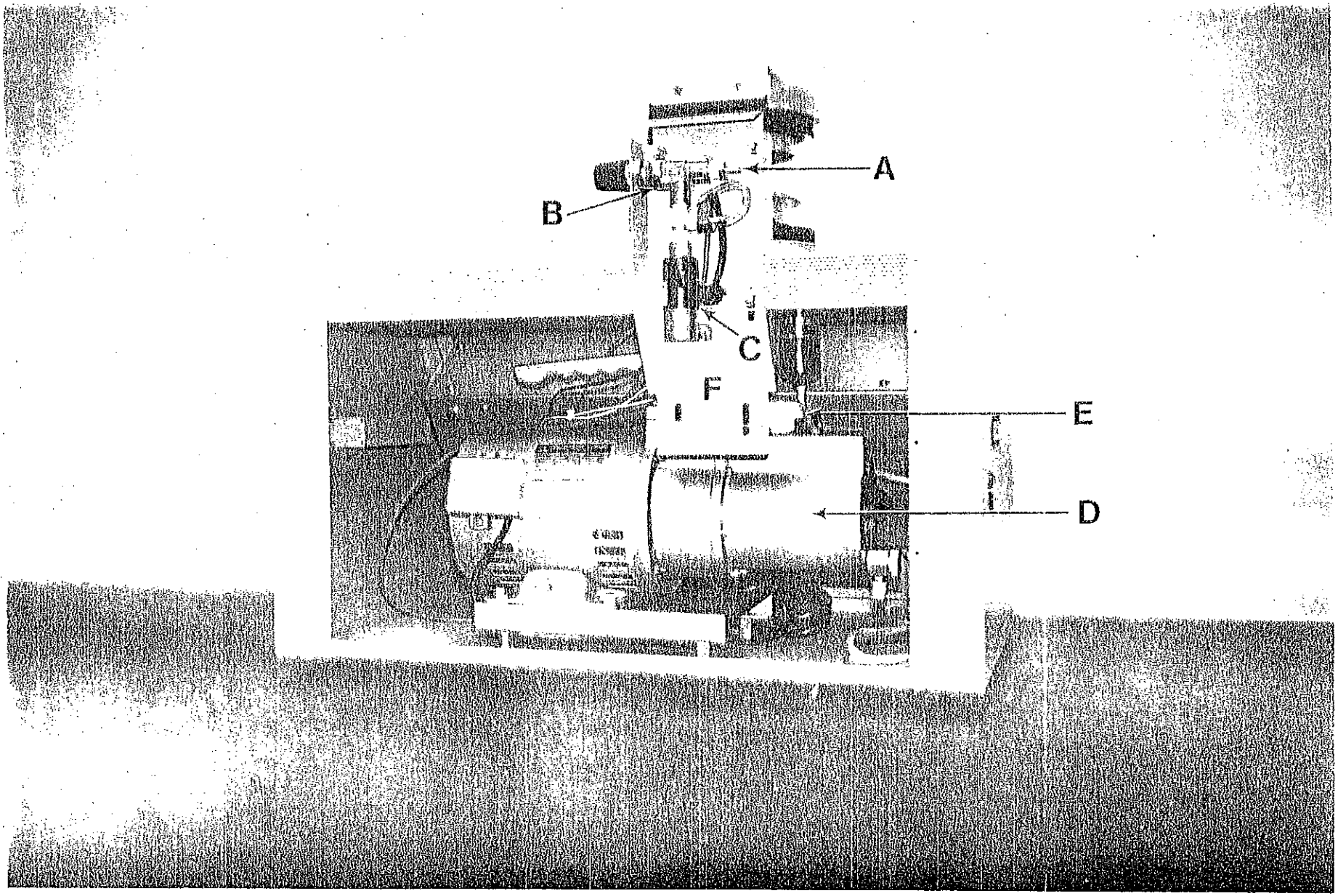


Figure 4
Hummer VI Rear View

A.) Gas Inlet, B.) Fine Metering Valve, C.) Vent Valve, D.) Vacuum Pump,
E.) Vacuum Pump Exhaust Port, F.) Chamber Support

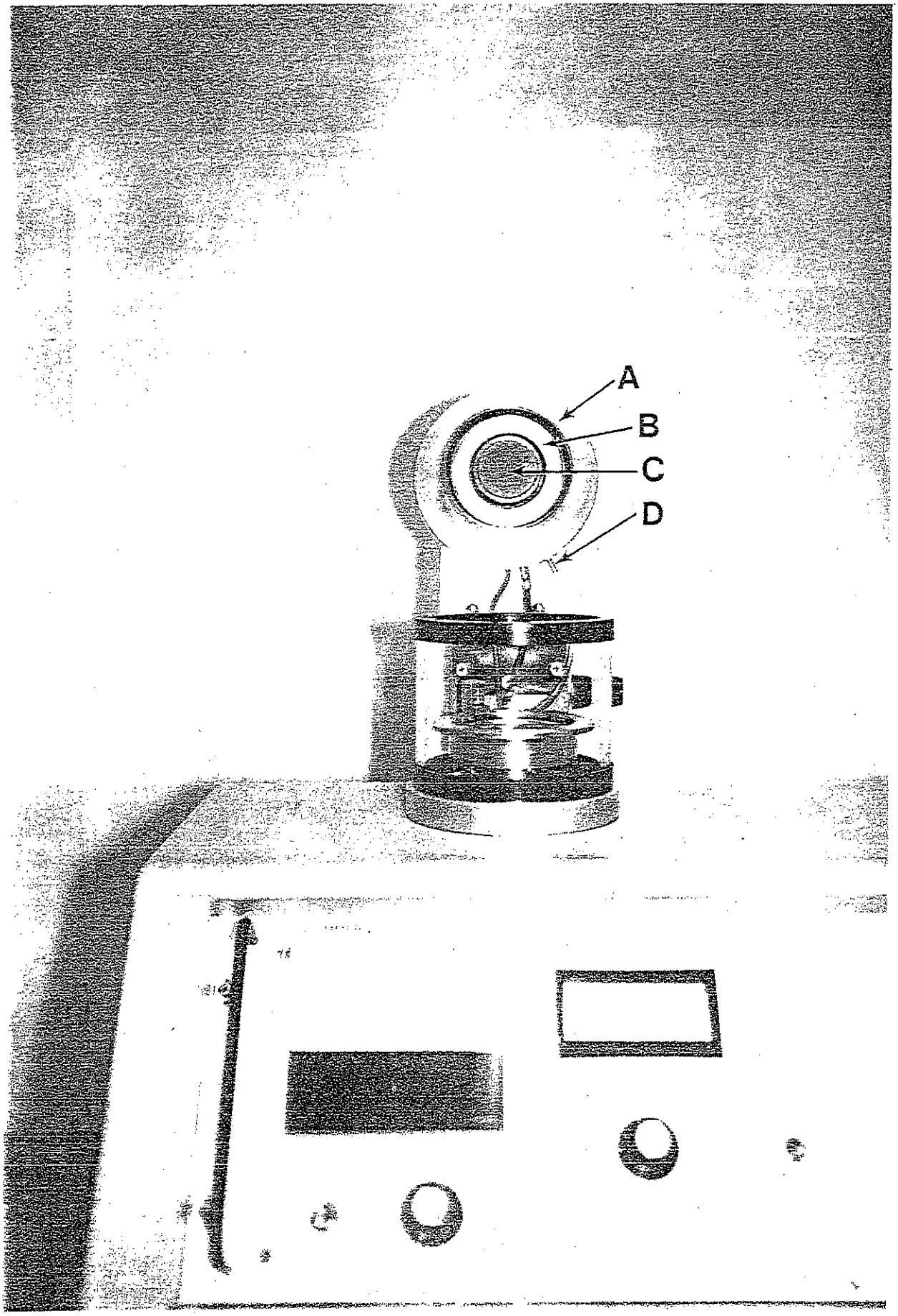
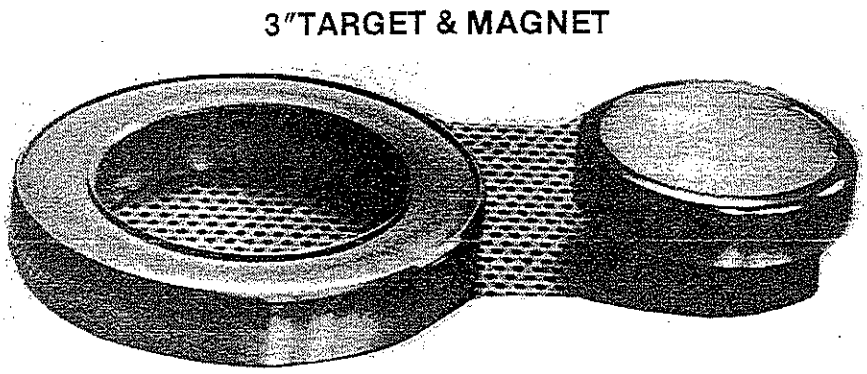
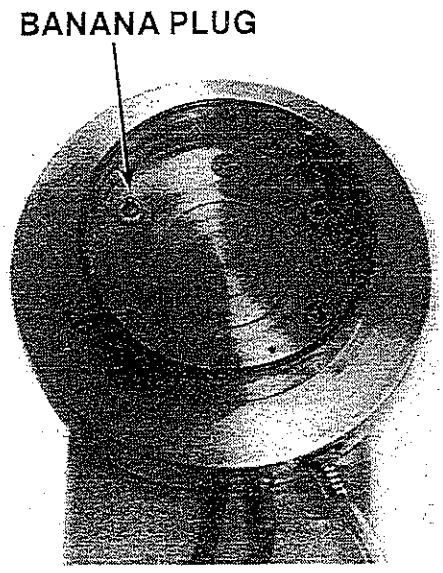


Figure 5
Cathode Assembly
A.) Top Plate, B.) Cathode, C.), Magnet, D.) Argon Gas Inlet





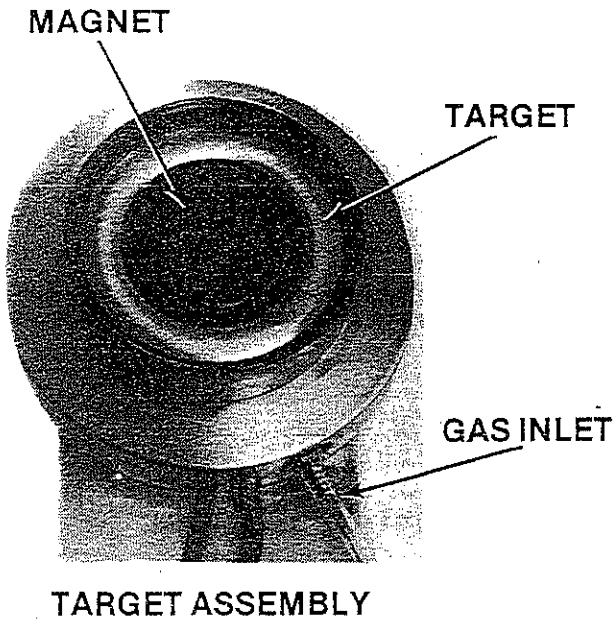


Figure 6

Detailed Cathode Assembly

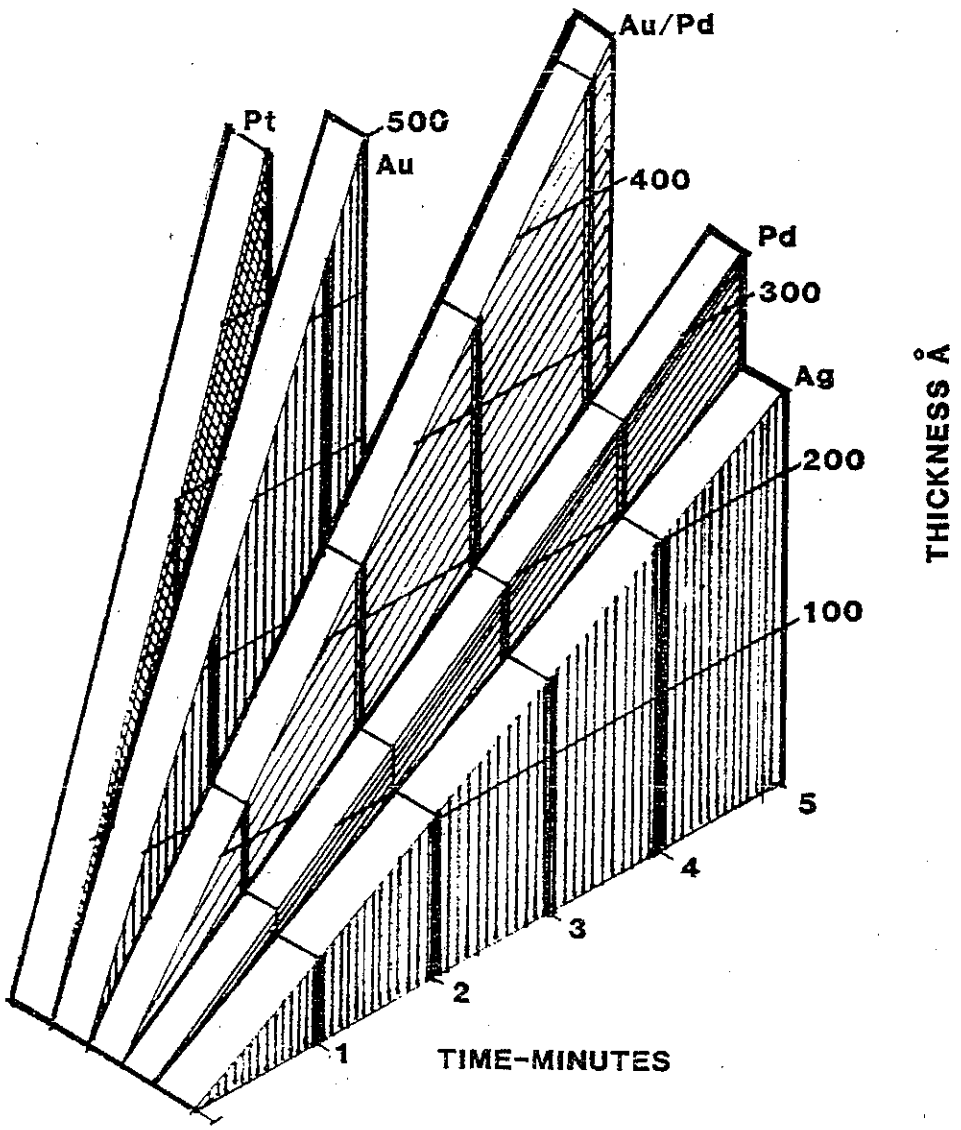


Figure 7

Hummer Deposition Curves

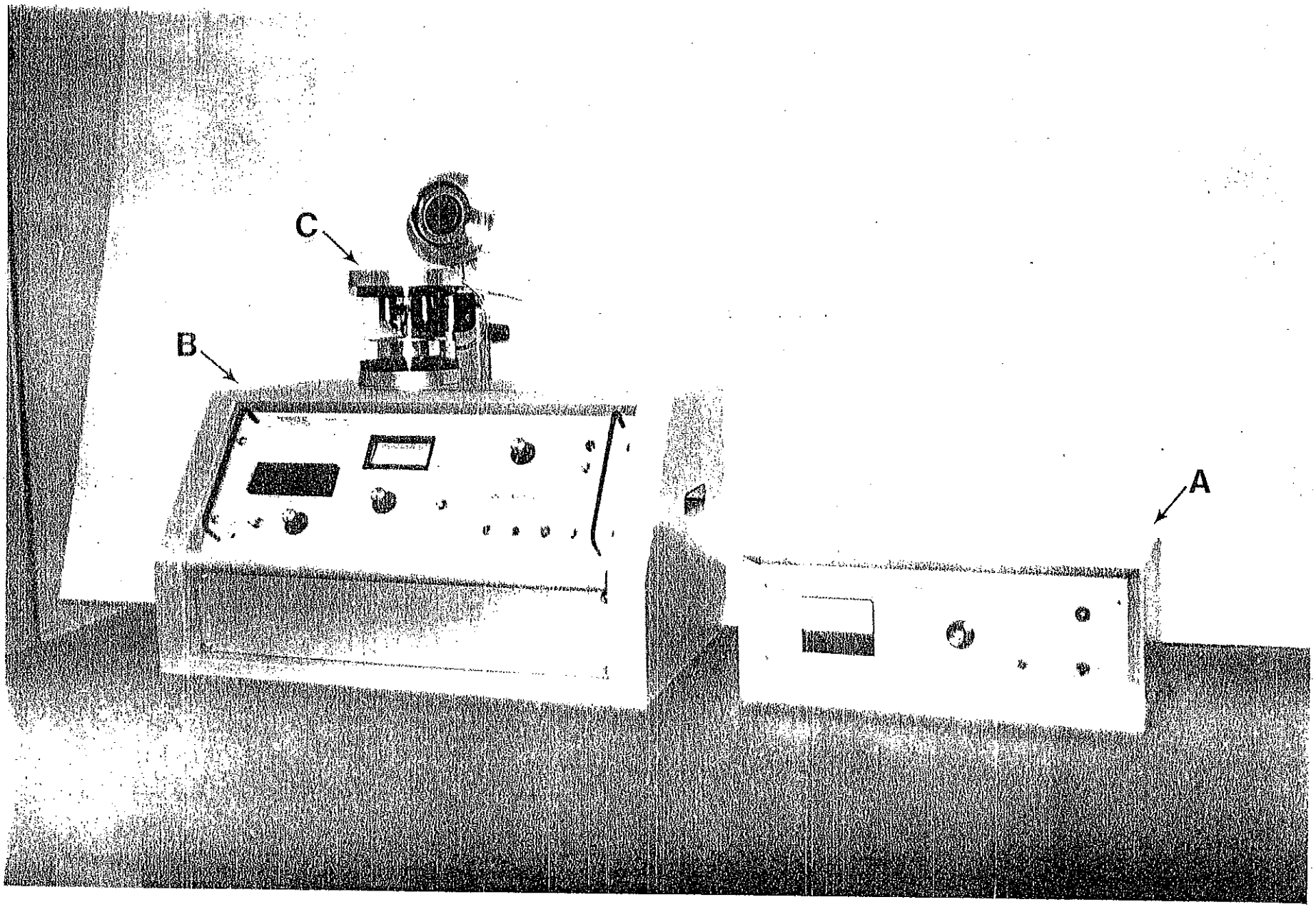


Figure 8
Hummer VI with Carbon Evaporation Accessory

A.) CEA Power Supply, B.) Hummer VI, C.) CEA Top Plate Mounted

Hummer VI - Standard Targets - 3"

UPDATED 1/1/2005

Part Number:	Description:	Unit Price:
1002021	Gold/Palladium Target 3" .004	$ 625.00
1002092	Gold/Palladium Target 3" .010	$ 940.00
1002034	Gold Target 3" .004	$ 625.00
1002090	Gold Target 3" .010	$ 940.00
1002042	Aluminum Etch Target (not for deposition)	$ 68.00

Hummer VI - Non Standard Targets - CALL FOR PRICE & DELIVERY

Part Number:	Description:	Unit Price:
1002036	Silver Target	$ 520.00
1002038	Platinum Target 3" .004	$ 850.00
1002094	Platinum Target 3" .010	$ 1,360.00
1002040	Palladium Target	$ 630.00
1002049	Ag/PD (24%/76%)	
1002051	Copper Target (for EPS only)	$ 475.00
1002053	Nickel Cathode (for EPS only)	$ 625.00
1002055	Chromium Cathode (for EPS only)	$ 1,276.00

Delivery of non-standard targets, if not in stock, is four to six weeks after receipt of order. Price of target may vary depending on current precious metal market value. Please call before ordering to confirm pricing and availability. Other targets available upon request.

NOTE:

Hummer VI does not have an EPS option and CANNOT sputter non-noble metals

Prices subject to change without notice.

Hummer VI - Miscellaneous Parts

Part Number:	Description:	Unit Price:
1001039	Magnet	$ 115.50
1002020	Target Extractor	$ 4.25
1004009	Hi-Voltage Transformer	$ 173.00
1004016	Bridge Rectifier	$ 183.00
1004023	Milliamp Meter	$ 200.00
1004044	Power Cord	$ 31.50
1004049	Thermocouple DV23 (for Analog Meter)	$ 183.00
1004055	Pressure Switch	$ 147.00
1004085	Gauge Tube (for Digital Meter)	$ 157.50
1005003	Deposition Chamber 3.7"	$ 100.00
1005009	Deposition Chamber 6"	$ 115.50
1007013	Hummer VI Operations Manual	$ 78.00
1007053	Banana Plug Assembly	$ 37.00
1007085	O-Ring and Gasket Kit 2 - 1007097 Chamber Gasket Set 2 - 1008009 O-Ring, Anode Assembly 3 - 1008013 O-Ring, Target Assembly 1 - 1008017 O-Ring, Feed Through	$ 126.00
1005005	Vacuum Seal Grease	$ 37.00
1007096	Kel-F Electrode Plug-In Kit 3 - 1002017 Banana plug	$ 236.00

Prices subject to change without notice.

	1 - 1002020 Target Extractor 1 - 1002065 Large Insulator 2 - 1002066 Small Insulator 3 - 1002067 HV Connector 3 - 1008013 O-Ring, HV Insulator 1 - 1101024 Kepnut 4-40 1 - 1101028 Nut 4-40		
1007097	Chamber Gasket Kit - Viton	$	52.50
1008003	Fine Metering Valve	$	236.50
1008006	Vent Valve Solenoid 120 V	$	142.00
1008010	Feed Through, Anode	$	27.00
1008019	Vacuum Pump Oil (1 Litre)	$	27.00
1007013	Operations Manual	$	78.00

Prices subject to change without notice.