

OPERATION - MAINTENANCE MANUAL  
FOR

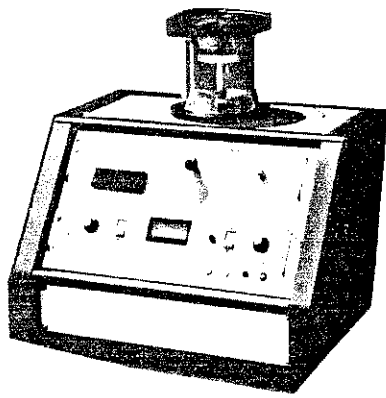
HUMMER JR

HUMMER I

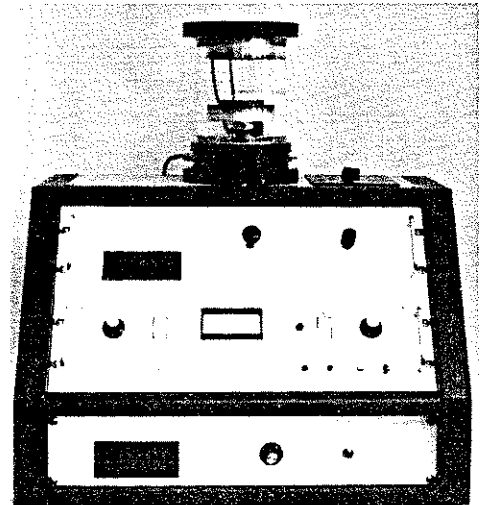
HUMMER II

HUMMER III

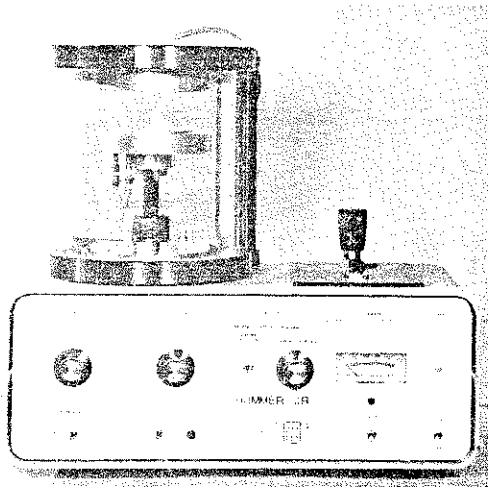
HUMMER V



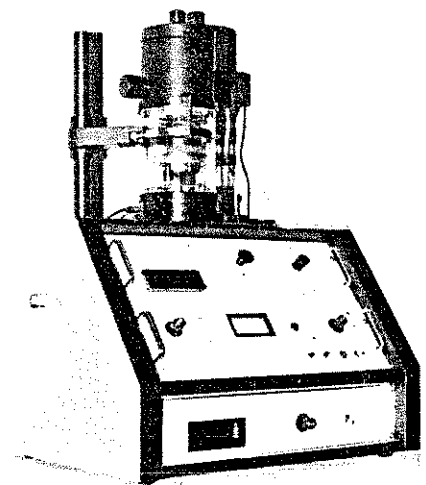
HUMMER I



HUMMER II, V



HUMMER JR.



HUMMER III

HUMMER

DESIGNED AND BUILT ESPECIALLY  
FOR

JOB NO \_\_\_\_\_ DATE \_\_\_\_\_

TECHNICS



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## 1.0 WARRANTY

The Hummer is warranted as specified and limited herein to be free from defective parts or workmanship for a period of 90 days from the purchase date, assuming the system is installed properly and operated in accordance with the sellers instructions. Within this period, any failure determined by the seller to be the result of defective parts or workmanship will be remedied by repair or replacement (at our option) free of charge at our plant. The following are excepted:

1. Transportation, shipping, and travel costs incurred in the performance of service or repairs.
2. Normal wear of parts, normal maintenance, or the result of misuse, accident, or abuse.
3. Cathodes, insulators, gaskets, o-rings and other expendables.
4. Machines which have been repaired, modified, or tampered with by anyone other than the sellers' authorized personnel.

Liability either remote or consequential damage are limited to sums not in excess of the original purchase price of the instrument covered thereby. There is no warranty representation or condition of any kind, expressed or implied, including no warranty of merchantability or fitness for any purpose, except that specified in the paragraphs above, none shall be implied by law. Any description of the goods sold hereunder, or any affirmation of fact or promise, shall not be regarded as part of the basis of the bargain and shall not be deemed to create an express warranty that the whole of the goods sold hereunder shall conform to the sample or model. The sellers performance under this warranty as herein limited shall be the buyer's sole remedy for any and all losses arising from the sale or use of the instrument.

## 2.0 INSTRUCTIONS FOR REPAIR, SERVICE, AND RETURN SHIPMENTS

Should repairs or service be necessary, our qualified staff of service personnel are 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 authorization for return and packing instructions from the Sales Department.

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

### 3.0 UNPACKING YOUR NEW HUMMER

After removing the lid of the crate, 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. Some accessories might still be connected electrically. Care should be taken not to allow them to fall or hang by the wiring. The main portion of the instrument can now be lifted clear of its container, complete with its plastic covering. 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, only to be replaced at your expense.



## 4.0 INSTALLATION

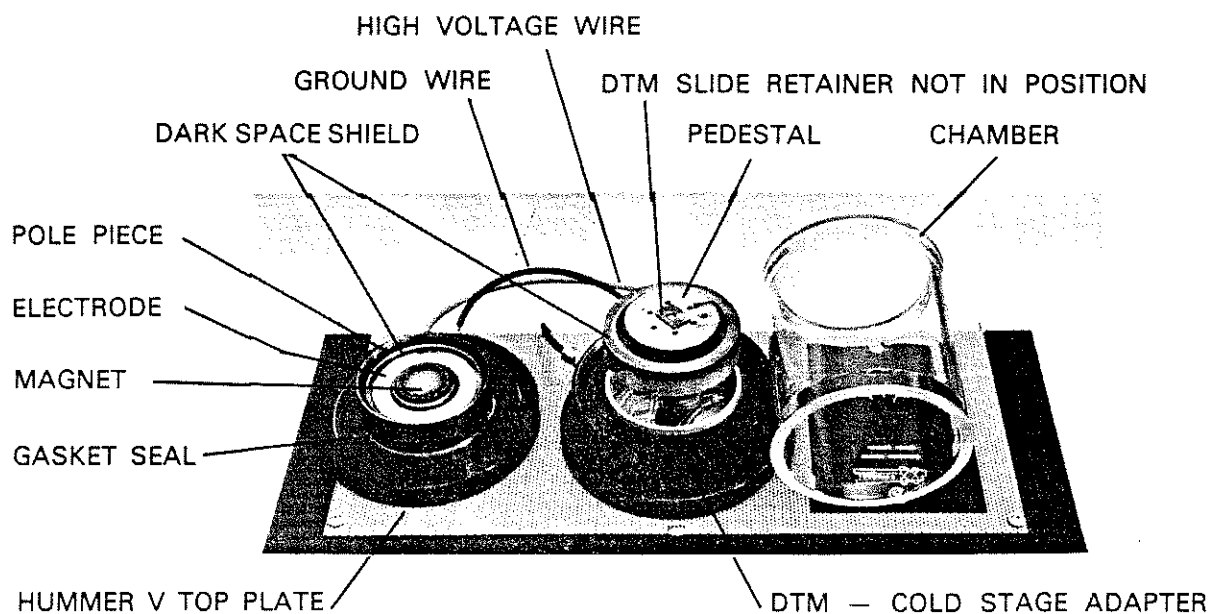
Place the Hummer console on a table or counter-top which provides ample working area, approximately 10 square feet, near an electrical outlet. Set the glass vacuum chamber in the groove provided in the baseplate, and set the top plate in position on the chamber top. (Figure 1) Insure that the contact 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.

### 4.1 Checking Oil Level and Gas Inlet

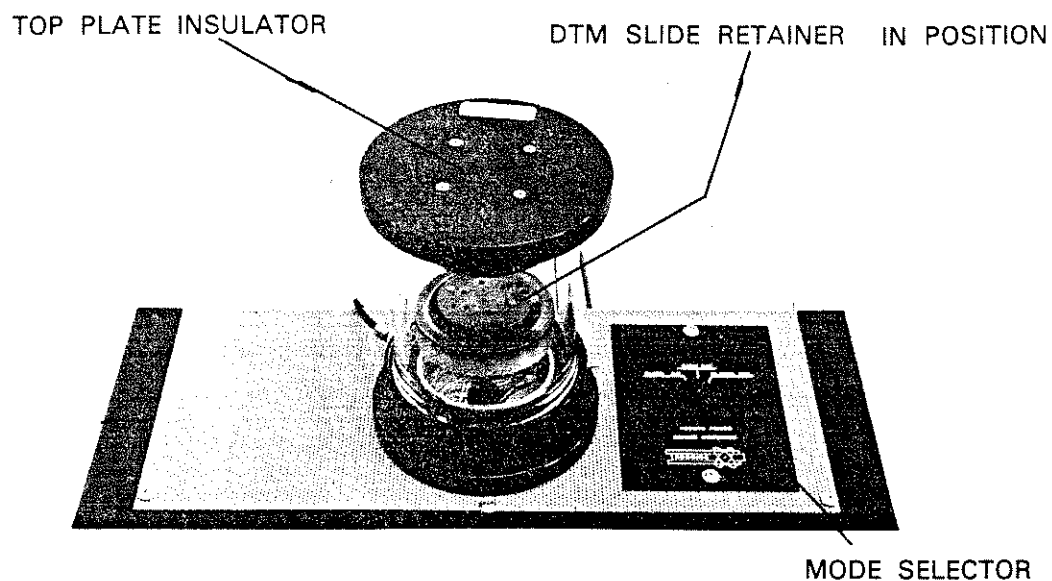
All units except the Hummer Jr. are equipped with a vacuum pump which must be filled with oil prior to placing the unit in operation, 1 1/4 quarts of supplied mechanical vacuum pump oil is required. Oil is to be added through the rear oval opening of the cabinet by means of the exhaust port, after removing the copper elbow marked oil filling port in Figure 2 and using the small funnel and hose included with the accessories. Several inches below the oval opening is a small oil view port. Oil should be added until the level is halfway up the oil view port. When this level is obtained, refit the elbow to the exhaust port. A gas inlet is provided for the introduction of pure gases such as argon or dry nitrogen for more uniform and oxygen free depositions. A regulated tank pressure of 5 - 15 psi must be applied at the gas inlet. However, if deposition conditions are not critical for the sample, then the air inlet should be left free for the introduction of laboratory air. Figure 2 also shows connections to accessories such as cold stage and DTM.

### 4.2 Hummer Jr. Vacuum Pump Connection

The Hummer Jr. requires an auxiliary vacuum pump, attached in the rear, with a pumping rate of at least 2 cfm and an ultimate pressure of 10 millitorr. If the vacuum pump requires current at a rate equal to or less than the amperage listed on the serial number plate of the Hummer, it can be connected directly to the receptacle on the rear of the console. If the pump is left with its switch in the on position, it can be fully controlled by the main power switch of the Hummer Jr. Pumps with amperage ratings higher than listed on the Hummer will require separate electrical service. Attach the intake port of the vacuum pump to the vacuum port at the rear of the Hummer Jr. console with a suitable vacuum hose. Plug the



DISASSEMBLED



ASSEMBLED

FIGURE 1. HUMMER V

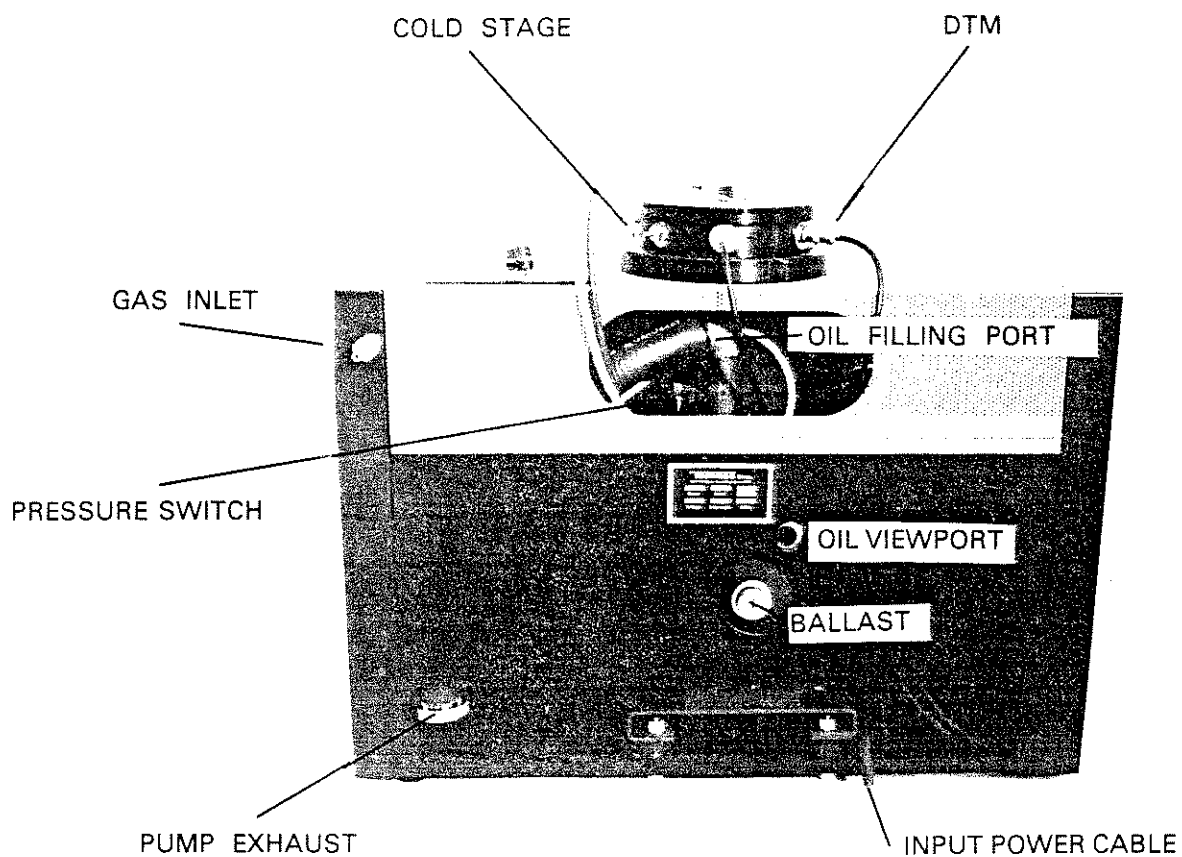


FIGURE 2. REAR VIEW

power cord of your Hummer unit to an electrical supply of 110-115 V AC, 15 amps, 60 hz or 220-230 V, 7 1/2 amps, 50 hz, as specified on the serial number plate.

Before placing your Hummer instrument into operation, familiarize yourself with the instrumentation and controls detailed in the following sections.

## 5.0 CONTROLS - DESCRIPTION AND EXPLANATIONS (Figures 2, 3 and 4)

Vent Valve - used to vent the chamber to atmospheric pressure, allowing removal or replacement of specimens within the chamber. Leave the vent valve open when the pump is not in operation.

Gas Valve - used to introduce air or inert gases into the vacuum chamber and to regulate the pressure within the chamber. Vent valve must be closed in order for this valve to function. Only light two finger pressure is required to close this valve. Excessive force will damage this valve.

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

Hi-voltage Switch - used to turn on hi-voltage supply which generates plasma. A red light indicates readiness.

Hi-voltage Control - used to adjust the amount of hi-voltage required.

Auto-manual Switch - 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 timer is set at zero.

Mode Switch Plate-Etch-Plasma - used to select mode of operation for either D.C. plating, D.C. cleaning or etching, or plasma processing. The Hummer I, for plating only does not have a mode switch.

Test Switch - Hummer Jr. only) vacuum sensor to determine sufficient vacuum in the chamber to begin operation; indicated by a deflection of 5 milliamps or less on the milliamp meter when the test switch is activated.

Pulse Switch - (All Hummers except Hummer Jr.) used for intermittent pulsing of the plasma to provide smallest coating crystal nucleation and lowest rise of the specimen temperature. After turning on the pulse mode, it takes 30 seconds for warm up after which an on-off interval of 5 seconds will continue. Pulse can be selected in either automatic or manual mode.

Vacuum Pump Gas Ballast Valve - the gas ballast valve is operated by means of a knurled knob at the rear of the cabinet. Its use is to purge the vacuum pump oil of water and other volatile contamination. Normally, this valve is fully closed, (turned clockwise to stop), approximately 1 time per month turn the knurled knob 3/4 turn counter clockwise and run the vacuum pump under vacuum approximately 1 hour to vent all volatile contaminants. Regitthen valve to original position. (See included manual for additional information on the vacuum pump.)

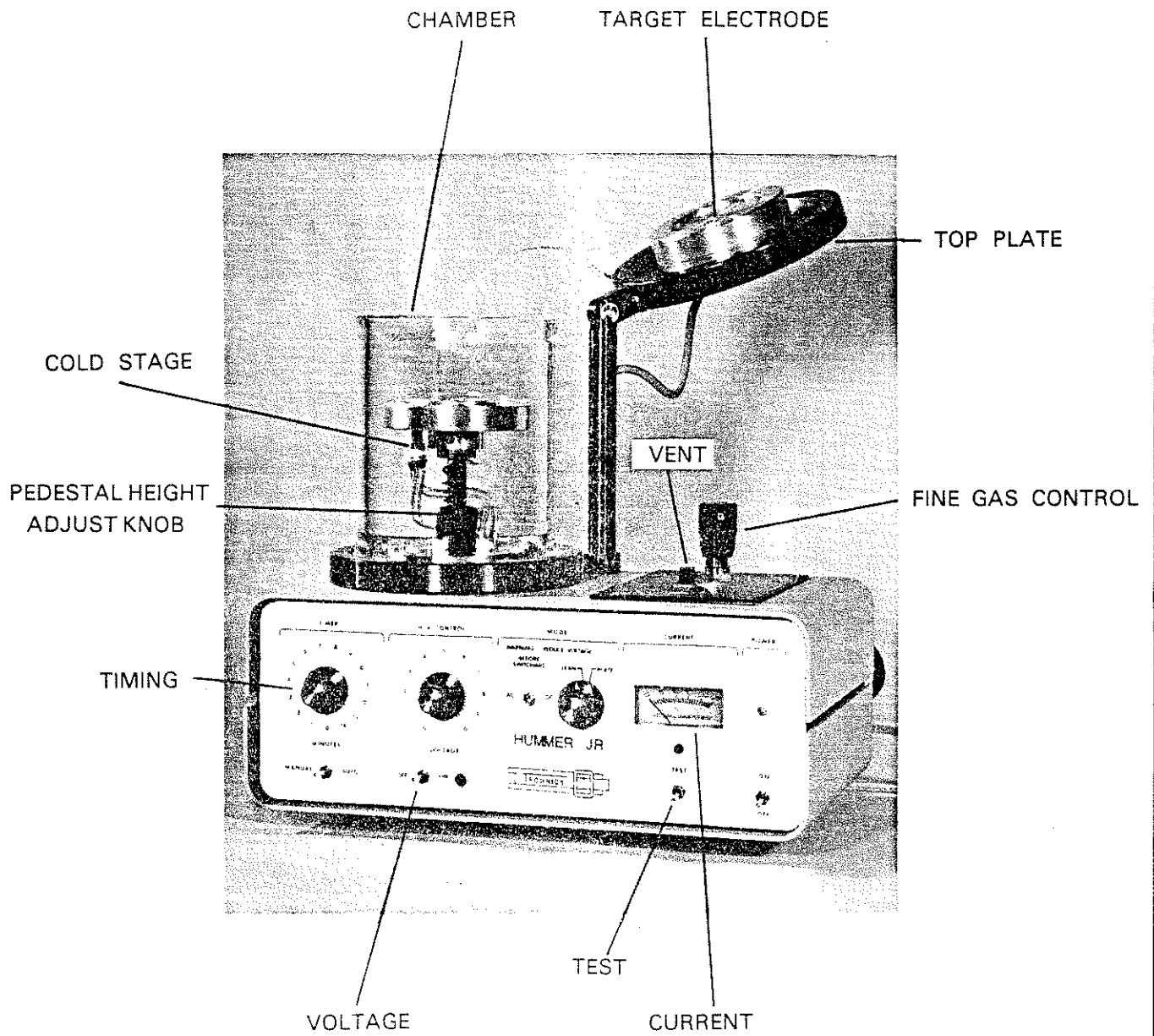


FIGURE 3. HUMMER JR.

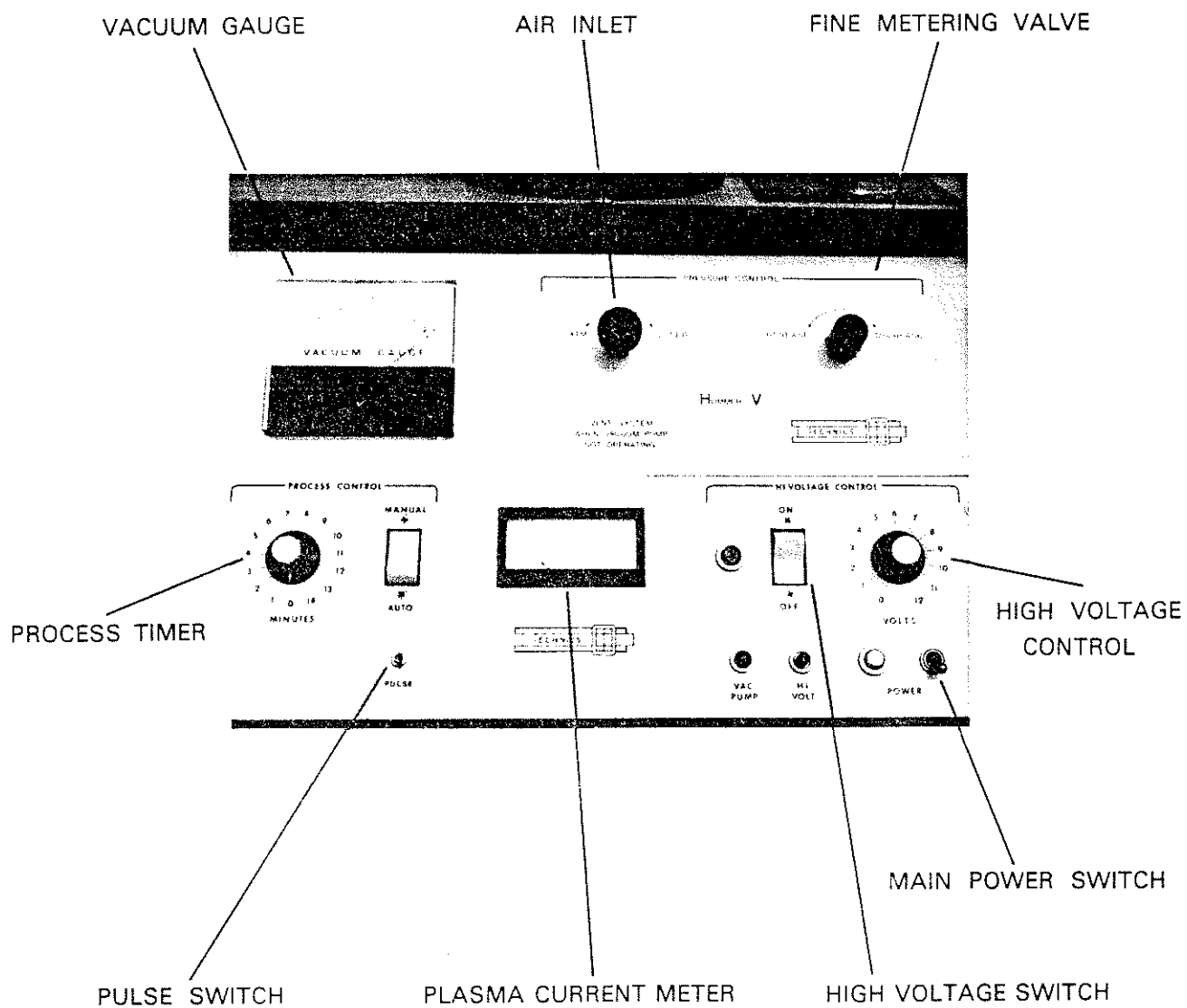


FIGURE 4. CONTROL PANELS

Target Selector - (Hummer III only) depress target selector on the top of the Rotary Electrode Selector and rotate target selector knob to select target 1, 2, 3, or E (etch) Electrode desired.

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



## 6.0 OPERATION - HUMMER JR, I, II, III

### 6.1 First Pump Down

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

Main Power Switch	OFF
High Voltage Switch	OFF
Voltage Control	O
Process Control	MANUAL
Vent Valve	CLOSED
Pressure Control	DECREASE
Mode Selector	D.C. PLATE

Open chamber by lifting top plate or glass cylinder and place specimens on pedestal. Pedestal height should be adjusted to place specimen approximately  $3/4 - 2$ " from top plate electrode. Loosen pedestal height adjust knob (Figure 3) (black plastic nut at base of pedestal rod). Raise or lower pedestal as required. Retighten nut with thumb and forefinger only. Install desired electrode (electrodes in Hummer III) in top plate by turning clockwise until tight (Hummer Jr, I, II, and III). On the Hummer V, the ring-shaped electrode is held in place by three screws exposed by removing the black top plate insulator (Figure 1) from top plate. These screws are sealed by o-rings, and should be loosened or tightened evenly and with care when changing electrodes. Hummer II and V top plates are shown with and without electrodes in place in Figures 6 and 7. After installing the desired electrode, place top plate on the chamber and turn on the main power switch. Initial pump-down should take 15 to 20 minutes; thereafter, 2 to 5 minutes should be sufficient. Pump-down is complete when a vacuum reading of 20 millitorr or less is obtained. On the Hummer Jr., a test deflection of 5 milliamps indicates sufficient vacuum to continue to the next step.

For best operation, especially with carbon electrodes, an inert gas, such as argon should be attached via vacuum hose to the hose connector at the rear of cabinet, and regulated to a pressure of 5 - 15 psi, Figure 2.

## 6.2 Hummer V

The design of a Plasma 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 are, therefore, retarded and diverted toward a biased dark space shield. The result is a cool pedestal and sample.

## 6.3 Plate - General Operating Conditions

To plate specimens, place mode switch to plate position, turn hi-voltage switch to ON and turn hi-voltage knob to II. Open gas valve until vacuum reading is 80-100 millitorr. It should be noted that the initial appearance of the plasma will cause the pressure in the chamber to rise and fall due to molecular adhesion of water vapor and atmospheric gases. Adjustment of the gas valve is necessary to compensate for these fluctuations until the pressure stabilizes. Plasma will appear with a purple-blue glow. Vary pressure in chamber with the fine metering valve to achieve reading of 5-15 milliamperes. Set timer to desired number of minutes and turn switch to auto setting. Plasma will terminate automatically after the number of minutes selected have expired. If pulse mode is selected, timer totalizes only the ON cycle. When specimen has been coated to desired thickness, reduce hi-voltage control to zero, turn off hi-voltage switch, close gas valve, and turn main power switch off. Open vent valve, lift chamber top and remove specimen from chamber.

Typical operating conditions for Hummer I, II, III, and Jr.:

### Gold or Gold/Palladium Deposition

Pressure	40-80 Millitorr (Argon)
Current	10 Milliamperes
Voltage Control	Position 9 or 11
Plate Time	2 minutes

### Carbon Deposition (Except Hummer Jr.)

Pressure	40-80 Millitorr (Argon)
Current	10 Milliamperes
Voltage Control	Position 11 or 12
Plate Time	10 minutes

Typical for Hummer V:

Gold or Gold/Palladium Deposition

Pressure	30-50 Millitorr (Argon)
Current	5-10 Milliampères
Voltage Control	Position 9 or 11
Plate Time	1 minute

Carbon Deposition

Pressure	20-40 Millitorr (Argon)
Current	5 Milliampères
Voltage Control	Position 11 or 12
Plate Time	10 minutes

Curves are shown for each in Figures 8, 9 and 10.

6.4 Etch - Typical Operating Conditions

To clean or etch specimens, place mode selector switch to Etch or clean position, turn on hi-voltage and increase hi-voltage knob to position 6. Open fine metering valve until vacuum reading is 50-70 millitorr. After plasma appears, adjust current to 10 milliampères or less by using this valve for biological or organic samples and from 10-30 for inorganic samples.

Typical operating conditions for etching or cleaning functions:

Metallurgical Specimen

Pressure	50-100 Millitorr (Argon)
Current	20 Milliampères
Voltage Control	Position 8 - 10
Etch Time	6 - 10 minutes

### Biological Specimen

Pressure	50-80 Millitorrs (Argon)
Current	10 Milliampere
Voltage Control	Position 9
Etch Time	2 - 5 minutes

### 6.5 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).

To Plasma Process, place the mode selector switch to Plasma Exc. on Hummers II, III and V and to A/C and clean on Hummer Jrs. Next, turn on Main Power Switch and evacuate the system to 20 millitorr, increase gas valve to read a pressure of 1 torr, place high voltage switch to on and increase voltage control to produce a current of 20 ma. on the current meter. 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.

Typical Plasma conditions for several processes follow:

#### 1. Ashing - Cleaning - Etching of Organic and Carbon

Pressure	1 torr (oxygen)
Current	20 Milliampere
Voltage Control	Position 6
Time	10 minutes

\*Vent toxic fumes

2. Etching of Metals, Ceramics and Glasses

Pressure	500 Millitorr (CF <sub>4</sub> )*
Current	20 Milliampères
Voltage Control	Position 4
Time	5 minutes

3. Deposition of Ethylene Polymers

Pressure	500 Millitorr (Ethylene)
Current	20 Milliampères
Voltage Control	Position 5
Time	15 minutes

4. Cross Linking of Organics (A or N<sub>2</sub>)

Pressure	100 Millitorr
Current	10 Milliampères
Voltage Control	Position 6
Time	10 minutes

\*Vent exhaust from room

## 7.0 MAINTENANCE

Occasional cleaning is necessary as component parts become coated with material. Chambers should be cleaned with water and Bon-Ami cleanser. Pedestal and shields surrounding the pedestal and electrode can be removed and scrubbed with steel wool, or Scotchbrite<sup>R</sup> 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.

Seals should be kept coated with a very light film of silicone vacuum grease. Electrodes are actually consumed during coating process and will take on a matte appearance when worn, usually after 1000 to 1200 depositions. Disc type electrodes i.e., Hummer Jr., I, II, and III, are easily removed by unscrewing directly from beneath the top plate. Ring type electrodes i.e., Hummer V, are fastened by three screws exposed by first removing the circular black plastic insulator from the top plate (Figure 1). All Hummers (except Hummer Jr.) are equipped with a pressure interlock to prevent the high voltage from operating unless the chamber is under vacuum. This interlock switch is suspended vertically beneath the base plate and can be seen through the oval opening at the cabinet rear (Figure 2). This switch is an important safety feature and has been adjusted so that the hi-voltage is off when the chamber is vented, and 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 higher pressure and advancing the screw will have the opposite effect.

Occasionally after long periods of use, the packing around the vent valve may become worn and the valve will feel loose. This tightness can be restored by first loosening the jam nut on the valve body located just behind the panel, and then tightening the chrome compression nut located just in front of the panel. This valve should then be repositioned and held in place by retightening the jam nut against rear of the panel. Some machines are equipped with a lift type vent valve which is not adjustable and requires no attention. Vacuum pumps normally require no attention other than to check the oil, which should be maintained at a level midway in the sight glass, located at the rear of the cabinet (Figure 2). The oil should be drained and refilled when pressures below 30 mt cannot be achieved with a good quality mechanical vacuum pump oil, a drain cock for this purpose is provided at the front-left corner of the pump. The lower panel in Figure 5 should be removed first. Oil capacity is 1 1/4 quarts, overfilling should be avoided. Refill as described in Section 4.1.

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

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## 8.0 ACCESSORIES

### 8.1 Water Cooled Pedestal

A water cooled pedestal, fitted as standard on the Hummer Jr. (Figure 3) is available as an option (Figures 1 and 2) for all other Hummer Models. This pedestal is used to keep the specimens below ambient temperatures when the heat generated during sputtering is objectionable.

To install, simply remove the standard pedestal and rod assembly and replace with the special water cooled assembly complete with adapter collar, which is placed between the base-plate and glass chamber. Using 1/8" PVD hose, connect the hose connection to a water supply of approximately 1/10 gallon per minute flow rate. The return hose should be directed to an appropriate drain, and the system should be checked for proper flow. Do not restrict drain or excessive pressure could cause rupture of hoses. The Hummer Cold Stages are designated HCS I, HCS II, HCS III, or HCS V for use with the Hummer I, II, III, V respectively.

### 8.2 Rotary Electrode Selector

The Rotary Electrode Selector, RES (Figure 5) is fitted as standard on the Hummer III, and can be ordered as an option for the other models. Usually fitted with a hoist to help support its weight, the RES is used to supply a compliment of four different electrodes, which can be selected for use without venting the vacuum chamber or interrupting the vacuum pump operation. This is especially useful in saving time when several coatings are desired on the same specimen. Electrodes are selected by depressing the top "target selector lock" and indexing the target selector to the desired position, numbered 1 - 3 for plating electrodes, or "E" for etching electrode. Electrodes are removed and replaced by using the same procedure as with the standard top-plate.

The Hummer hoist shaft is attached to the rear of the cabinet with two bolts. The carriage which rides up and down is keyed in a slot and holds the glass chamber with a band clamp. Two clips are provided to hold the RES firmly to the chamber by clamping to the band.

To operate, raise the hoist to the top of the hoist shaft and swing to the rear. The hoist will remain suspended until its again raised, moved forward, and then lowered until the chamber rests on the base plate. During initial installation, the band clamp should be left loose until the chamber is evacuated, when the clamp and top plate clips can be positioned and tightened in place. On subsequent pump downs, make certain that the hoist does not prevent the chamber from seating fully on the base plate, causing leakage. The RES and Hoist are not available for the Hummer Jr. The hoist can be used with conventional top plates and is available as a separate accessory.

### 8.3 Digital Thickness Monitor (All Hummers except Hummer Jr.)

#### 8.3.1 Installation and Operation

The Digital Thickness Monitor, DTM, is used to provide a means of measuring the thickness of coating, and reads directly in angstrom units. To install, remove the standard pedestal and rod assembly and replace with special DTM pedestal assembly complete with adaptor collar, which is placed on the base plate (Figure 5). The DTM panel replaces the blank panel at the lower front of the Hummer cabinet, and is connected to the rear of the power supply with the special four pin connector and cable provided. The coaxial cables are then passed through the opening at the bottom rear of the cabinet and connected to the adaptor collar, maintaining polarity by observing the color-coded connector.

To operate, place coverslip in the recess provided in the pedestal, and place the metal DTM slide retainer directly over the coverslip. Turn on the DTM switch (Figure 5) and operate the Hummer in the regular manner, using argon gas and 10 ma current. The digital reading at this time is of no consequence because the photo cell resistance is reducing from its high dark current value toward its illuminated value of 10-20 K ohms. When sputtering begins, the DTM will begin counting backwards toward zero again for the reasons just explained, but will reverse and advance when the coating thickness and digital reading coincide. The values will continue to increase as the coating progresses, indicating the exact thickness of the coating on the control slide which is very nearly directly proportional to the thickness on the specimen being coated. The slide must be removed after each coating process. Always use a new



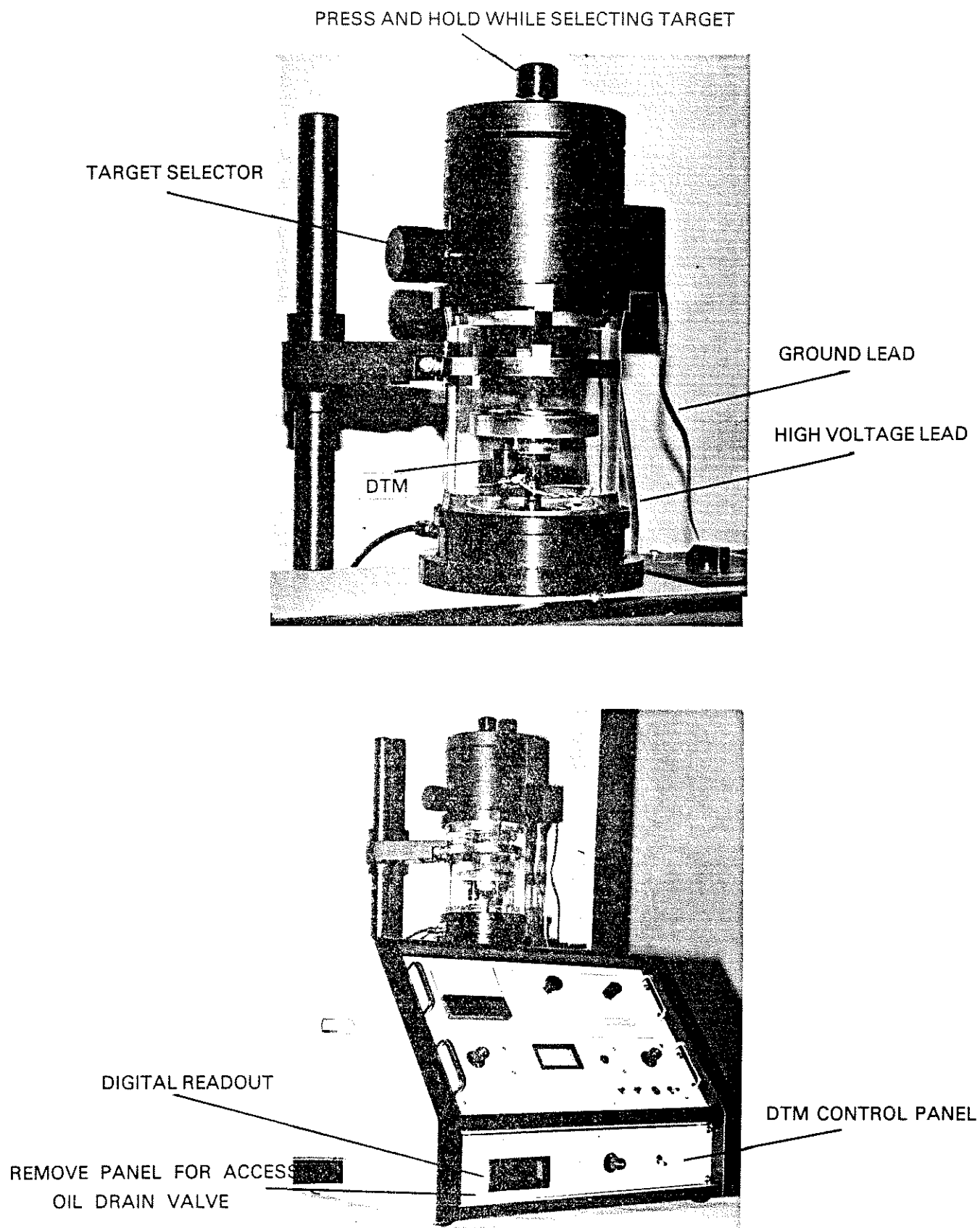


FIGURE 5. ROTARY ELECTRODE SELECTOR

coverslip for each run, and leave a coverslip in position even if the DTM is not being used.

### 8.3.2 Zero Calibration

To check the zero calibration, position the zero adjust knob on the front panel to its central position. The potentiometer is a 10 turn pot. Position to one end and count back 5 turns.

Remove the slide and leave the retainer on the pedestal. Operate Hummer at voltage setting of 9 and 10 ma. The digital readout should read approximately -13. The reading can be adjusted within a few turns of the potentiometer and should be so adjusted. Replace slide and sample and operate.

The DTM is adjusted thoroughly before leaving the factory and should need no attention. Because this device is based on a photo-conductive principle of operation, extra bright or variable light conditions in the room can cause improper readings. Any further adjustment, if needed, should be carried out at the factory. The DTM is available on all Hummers except the Hummer Jr.

The DTM is also available in combination with the Cold Stage attachment.

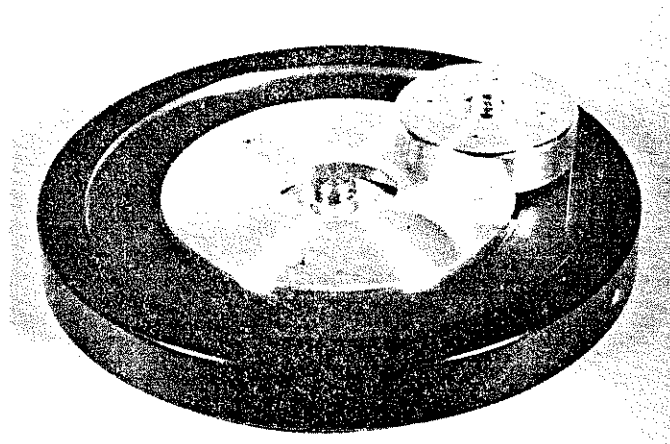
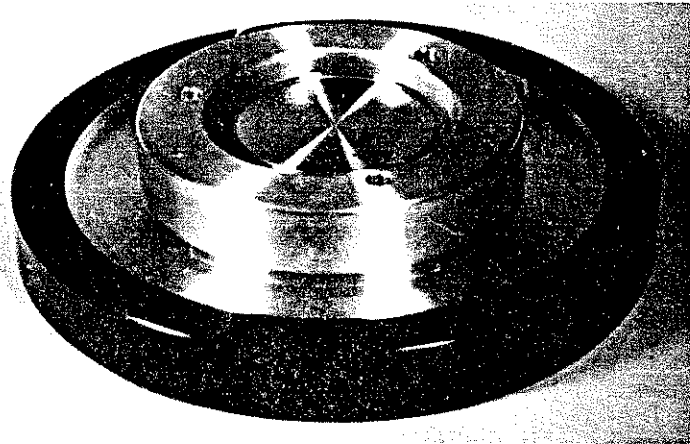


FIGURE 6. HUMMER II TOP

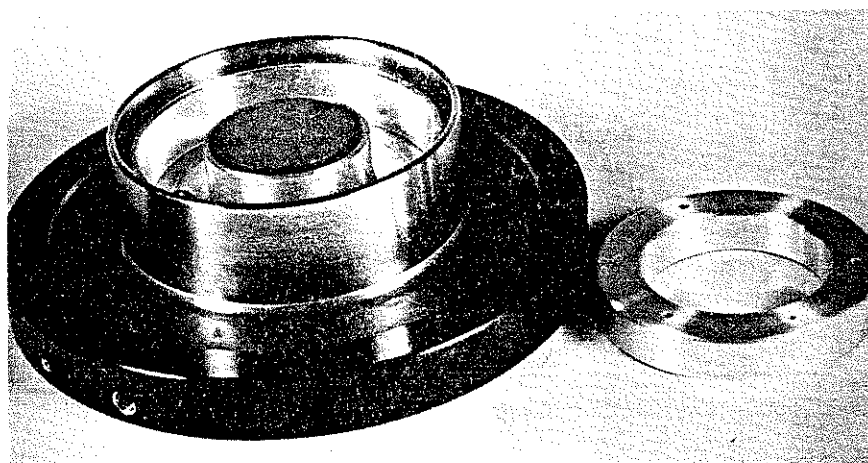
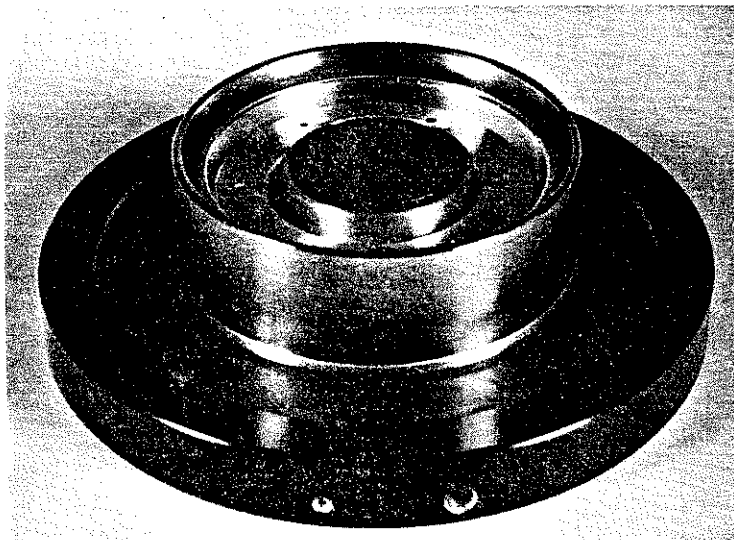


FIGURE 7. HUMMER V TOP ASSEMBLY

VOLTAGE CONTROL AT 12  
ARGON AS SOURCE GAS

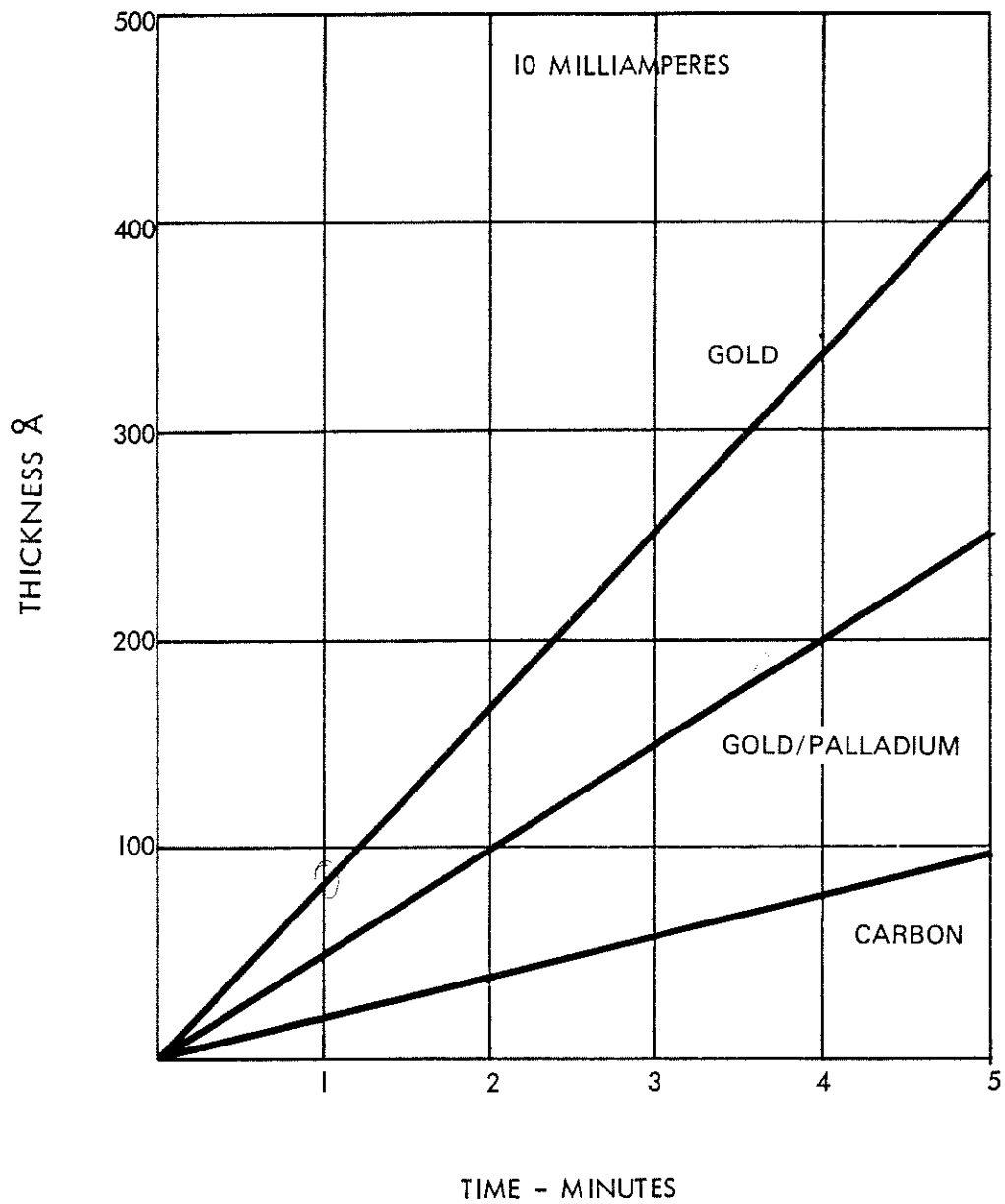


FIGURE 8. HUMMER V DEPOSITION CURVES

VOLTAGE CONTROL AT 12  
ARGON AS SOURCE GAS

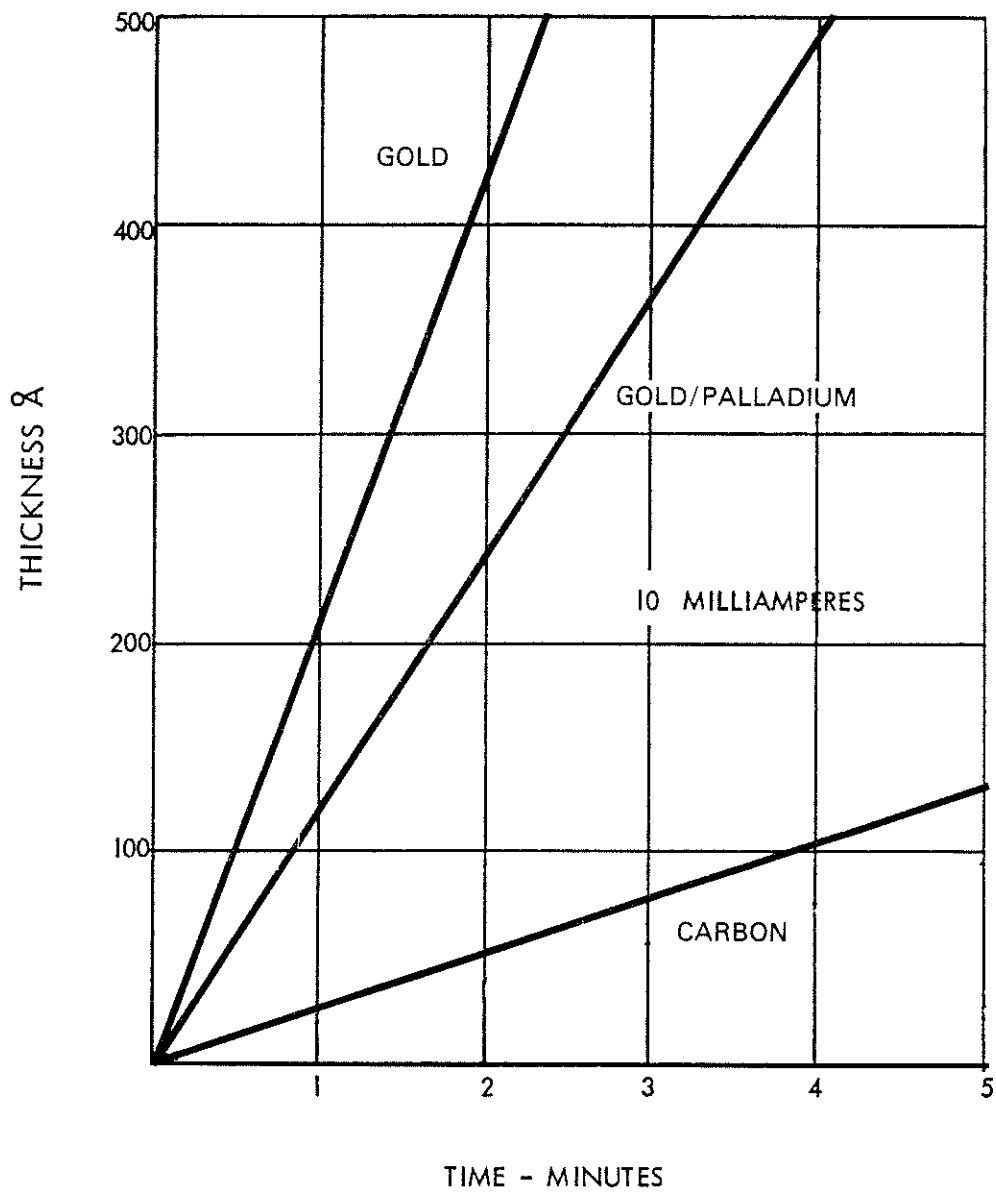


FIGURE 9. HUMMER II, III DEPOSITION CURVES

GOLD  
VOLTAGE CONTROL AT 9  
AIR AS SOURCE GAS

CARBON  
VOLTAGE CONTROL AT 12  
ARGON AS SOURCE GAS

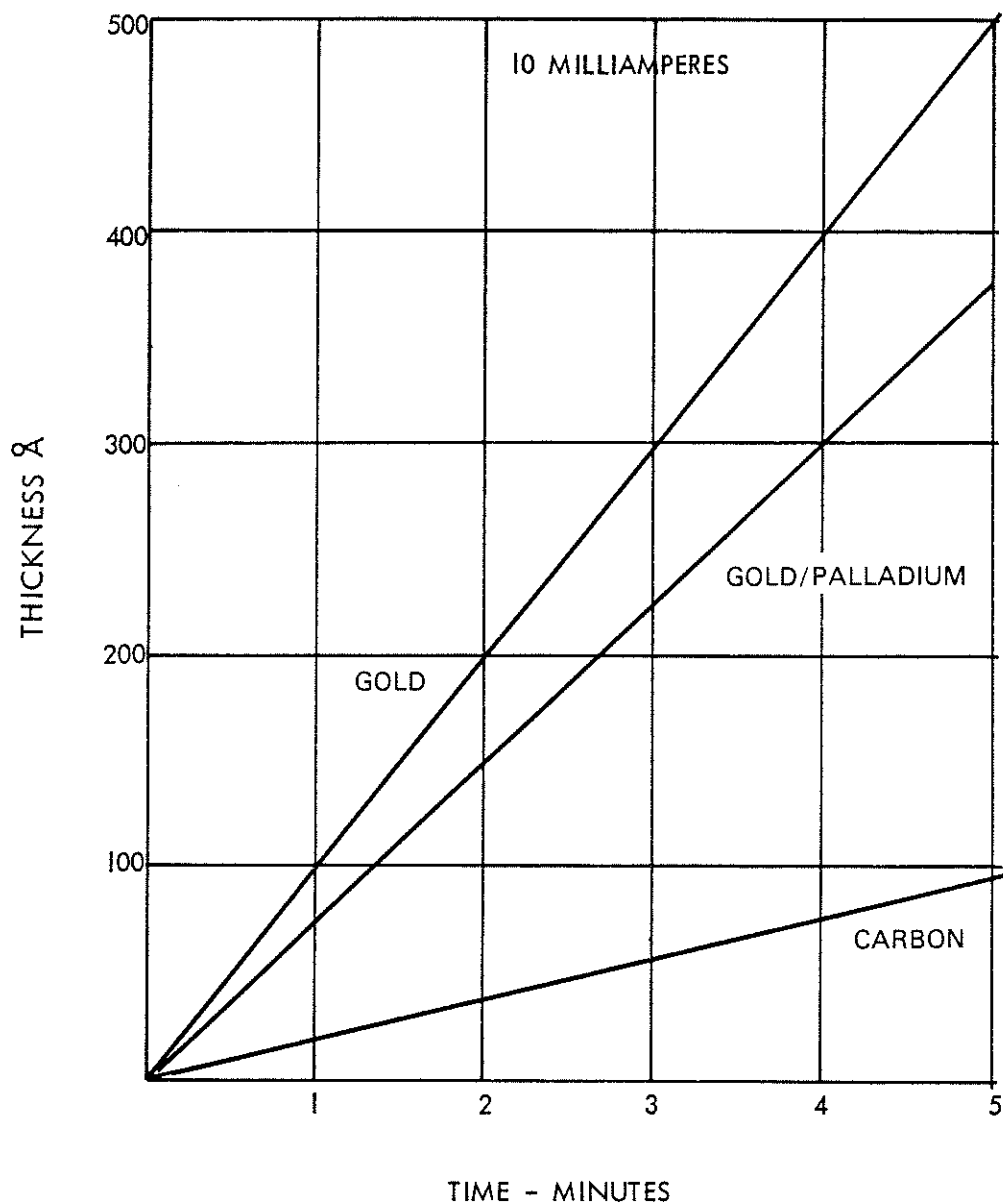


FIGURE 10. HUMMER JR., I DEPOSITION CURVES

## 10.0 TROUBLE-SHOOTING GUIDE

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

<u>PROBLEM</u>	<u>POSSIBLE CAUSE AND REMEDY</u>
No power when main switch is on	<ol style="list-style-type: none"><li>1. Check that line cord is properly connected both at the power supply and at the wall receptacle.</li><li>2. Check that circuit breakers are not thrown. Push button in to reset.</li></ol>
Power light comes on but pump will not run	<ol style="list-style-type: none"><li>1. Check that circuit breakers are not thrown. Push button in to reset.</li><li>2. Check power connection between pump and rear of power supply.</li><li>3. Check that remote switch on extreme right side of pump is in on position.</li></ol>
Pump operates but no vacuum can be achieved	<ol style="list-style-type: none"><li>1. Check to see that seals on top and bottom of chamber are free from dirt, dust, hair, etc.</li><li>2. Make certain that pedestal adjustment nut is tight.</li><li>3. Be sure both gas and vent valves are closed.</li><li>4. Check all hoses and clamps for tightness including pump ballast valve and knurled lock-ring just below main pumping port hose.</li><li>5. Be certain that proper volume of oil is in pump.</li></ol>





## PROBLEM

System pumps down well but hi-voltage light will not come on

## POSSIBLE CAUSE AND REMEDY

1. Make certain that auto operation has not been selected with timer 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.
4. Check 6-pin hi-voltage connector at rear of power supply

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 connection to top plate and to pedestal are properly made.
5. Check to see that electrodes are properly positioned in top plate, especially with Hummer V units.
6. Check 6-pin hi-voltage connector at rear of power supply

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 annular space shield surrounding the electrode. On Hummer V, see that no foreign material is attached to the magnet or pole piece.

## PROBLEM

## POSSIBLE CAUSE AND REMEDY

Plasma is present, but no coating can be achieved

3. Make sure that no foreign material is lodged between the pedestal and the surrounding annular space shield.
4. Be sure that pedestal, electrode, and space shields are not excessively coated or dirty, especially when selecting etch mode.
1. Be sure voltage is in operating range
2. Make certain that electrodes are serviceable by insuring that they 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).

Pulse mode will not work

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.

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 are always anxious to help.