HUMMER X MANUAL

Anatech Ltd.
21363 Cabot Blvd.
Hayward, CA 94545
800-390-4449 Fax 510-732-6971

APPENDIX

PAGE NUMBER

APPENDIX (continued)

INDEX

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 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 X, please feel free to contact our Customer Service Department.

SETTING UP YOUR NEW HUMMER X

Unpacking the Hummer X Sputter Coater:

1. After removing the top, remove the filler carton. Do not discard. All accessories are in the two boxes attached to the filler.

2. Carefully remove the Hummer X from the crate.

3. Set the Hummer X on a bench and visually inspect for shipping damage.

4. Open the filler boxes and check all parts.

Please be sure that you have checked for all parts and accessories which are indicated on the checklist. If you should find something missing please contact us immediately.

CHECKLIST:

1. 2 bottles of pump oil
2. 1 target
3. 1 target extractor
4. 1 magnet
5. 1 power cord
6. 1 glass chamber
7. 1 boot gasket set
8. 1 quartz crystal
9. Additional parts purchased, if any.

Once the Hummer X is out of the crate, and you have all of the accessories and parts which were packaged with the unit, place the Hummer X on a suitable bench or tabletop.

WITH THE UNIT UNPLUGGED FROM THE WALL:

1. Open the right rear panel by loosening the screws which secure the panel. (Figure 6)

2. Unscrew the white filler cap on the vacuum pump and set to the side. (Figure 3)

3. Pour the vacuum pump oil into the opening left by the filler cap. At the same time watch the sight glass located on the side of the pump. A small mirror may assist you. Fill the pump until the liquid is seen in the sight glass at the halfway point. DO NOT OVERFILL

SETTING UP YOUR NEW HUMMER X (continued)

4. Replace the filler cap.

5. Close the rear panel and secure the screws.

ONCE THE OIL IS IN THE PUMP YOU ARE ALMOST READY TO START SPUTTERING.

1. Remove from the group of accessories the target which came with the unit. This target fits in the top plate. Use lint free gloves when handling the 3" target; line up the holes in the back of the target with the banana plugs in the top plate. Gently push the target in place over the banana plugs. (Figure 2)

2. Included in the accessory kit is the cathode (target) removal tool. Keep this for changing targets.

3. Install the magnet in the middle of the top plate. (Figure 2)

4. Plug the DTM quartz crystal into the crystal holder mounted on the anode assembly. (Figure 2-F) Always handle the DTM crystal in such a manner that no fingerprints or debris are introduced to the quartz crystal inside the crystal can assembly. ALWAYS remove the DTM crystal prior to using ETCH MODE or PLASMA MODE.

5. Carefully remove the wrapping from the glass chamber and remove the boot gaskets from the package. Place the boot seals on the chamber. (Figure 2) Lightly grease the surface of the boot gasket with vacuum grease where they come into contact with the top and base plates. (Figure 2) Place the chamber on the bottom plate of the Hummer X. Slowly lower the top plate into place over the chamber.

6. Place a tank of laboratory grade Argon gas in close proximity to the Hummer X. Attach a 2 stage regulator to the tank. The output pressure should be 5-8 psi. Higher pressures may give the appearance of a leak and can damage the needle valve.

7. Attach the argon gas line to the outlet on the valve assembly in the cabinet post. (Figure 6-C)

8. Open the main argon valve and adjust 2nd stage to read 5-8 psi.

9. Connect the power cord to the outlet located on the back panel of the Hummer X. Connect the other side to the wall outlet.

NOTE: ALWAYS DISCONNECT THE HUMMER FROM THE ELECTRICAL SUPPLY BEFORE OPENING THE FRONT OR REAR PANEL DOORS.

OPERATING YOUR HUMMER X

This is being written as Phase V of the Hummer X is going into production. You may find that some of the schematics and wiring diagrams do not match your Hummer X.

The five phases can be identified by the following:

Phase I, June 1981:	The front and top panels are not hinged. All of the hi-voltage components are mounted on the front panel. The top and bottom plates for the vacuum system are black, and the control board [PCB] is wire wrapped.
Phase II, Aug 1982:	Hinged front and top panel. The top and bottom plates for the vacuum system are teardrop shaped. The hi-voltage power supply is mounted on the top panel in its own case. Also 5 quick disconnect cables have been added.
February 1984 :	Hummer line acquired by Anatech Ltd.
Phase III, May 1984:	The wire wrapped control board has been changed to a printed circuit board. The PCB power supply has been changed to a regulated power supply.
Phase IV, Sept 1984:	The quick disconnect cables have been reduced from 5 to 2. The DV-23 board has been remounted onto the control PCB.
Phase V, March 1985:	Unitary cabinet shell, hinged top plate.

These are the most noticeable changes in the Hummer X. This information will be helpful in identifying your Hummer X model.

NOTE: Hummer X Phase V
- see Appendix G and Appendix H

Hummer X Phase I, II, III or IV
- see Appendix I and Appendix J

OPERATING CONTROLS

The pushbutton keys are used to control most functions of the Hummer X. In addition to the pushbuttons, there is a process selector rotary switch and a variable hi-voltage control on the front panel, and a gas flow leak valve at the rear of the case top.

The control buttons and numeric displays will be described first. The pushbuttons are divided into two horizontal rows of ten buttons each. The upper row are function keys. The lower row are numeric entry keys, and are used to preset limits for processing time or sputter coating thickness. (The function keys contain lamps which are lit under various conditions; the numeric keys do not have lamps.)

Please read Table 1 for a detailed description of the control buttons and Table 2 for a detailed description of the digital displays.

TABLE 1: HUMMER X CONTROLS

LABEL:	FUNCTION:
1. POWER Figure 1-A	Lighted rocker switch, AC line on/off
2. PROCESS Figure 1-B	5 position rotary switch selecting PLATE, ETCH or PLASMA modes with hi-voltage off between modes.
3. HIGH VOLTAGE Figure 1-C	variable transformer for HV amplitude
4. GAS FLOW Figure 2-D	adjustable leak valve for gas control
5. AUTO Figure 1-D	blue pushbutton that lights starting automatic sequencing
6. VAC Figure 1-E	green pushbutton starts pump in Figure 1-C manual mode. Lit indicates satisfactory vacuum for processing specimens.
7. GAS Figure 1-F	green lighted pushbutton turns gas flow on
8. HV Figure 1-G	green lighted pushbutton enables high voltage
9. PULSE Figure 1-H	blue lighted pushbutton causes 50% HV modulation
10. STOP Figure 1-I	red lighted pushbutton indicates no processing, will stop processing when pressed
11. FAULT Figure 1-J	red pushbutton when lit indicates excess hi-voltage current or vacuum pressure. Push to stop alarm
12. TIME Figure 1-K	orange lighted pushbutton to preset time limit
13. COAT Figure 1-M	yellow lighted pushbutton to preset thickness limit
14. LIMIT Figure 1-L	yellow lighted pushbutton to view or set limits
15. 0-9 Figure 1-N	gray pushbuttons for numeric entry of time or coat limits

TABLE 2: HUMMER X NUMERIC DISPLAYS

LABEL:	FUNCTION:
1. TORR Figure 1-O	three digit display of vacuum pressure range: .001 to 760 torr
2. MILLIAMPS Figure 1-P	two digit display of plasma current range 0 to 30 milliamps
3. SECONDS Figure 1-Q	four digit display of processing time range: 0 to 9999 seconds
4. NANOMETERS Figure 1-R	three digit display of coating thickness range: 0 to 999 nanometers

DETAILED OPERATION

1. Switch the main power to ON using the rocker switch at the lower right of the front panel. (FIGURE) You should hear a high pitched tone which will last for a second or two. The switch will light.

2. The front panel display should appear as follows:

STOP	lamp on, all others off
TORR	-, indicating atmosphere (no vacuum)
MILLIAMPERES	0, indicating no current
SECONDS	0, indicating no elapsed time
NANOMETERS	0, indicating no accumulated thickness
ON/OFF	switch lighted

3. Set the process selector rotary switch (Figure 1-B))to PLATE.

4. Set the variable VOLTAGE TRANSFORMER control (Figure 1-C) to 0.

5. Depress the VACUUM button (Figure 1-E). This will start the vacuum pump and begin to evacuate the chamber.

6. Allow the unit to pump until it has attained a pressure reading of 0.20 torr or less. When the unit is new or has not been used in a long time this may take time. Allow the unit to pump for at least 10 to 15 minutes.

7. Depress the GAS button (Figure 1-F). This will allow argon to flow into the chamber from the tank.

8. In order to adjust the flow of argon into the chamber, adjust the GAS INLET VALVE; the knob is located at the top right of the hinge post. (Figure 2-D)

9. Allow time (approximately 30 seconds) for pressure to stabilize. Increase or decrease this knob so that the millitorr reading is approximately 40-60, clockwise to decrease, counter clockwise to increase. While adjusting the vacuum, allow time for the pressure to stabilize.

10. When this setting is achieved, depress the HV button. (Figure 1-G) This activates the high voltage.

11. Turn the HIGH VOLTAGE CONTROL KNOB (Figure 1-C) until a milliampere reading of 10 is achieved.

DETAILED OPERATION (continued)

12. Adjust the gas and the high voltage settings until a voltage of 2400 volts and 10 milliamperes is reached.

13. Allow the unit to plate for 5-7 minutes during the initial run. This will help to break the unit in properly and to stabilize all operations.

14. Turn off the hivoltage (HV) and GAS buttons. Then press the STOP button. (Figure 1-I)

ONCE THESE STEPS HAVE BEEN COMPLETED THE HUMMER X CAN BE OPERATED IN EITHER MANUAL MODE OR AUTOMATIC MODE.

MANUAL OPERATION

The Hummer X has two different operating modes: MANUAL and AUTOMATIC. The difference between the two is that the unit will automatically sequence through vacuum roughing and backfilling in the AUTO mode, whereas the user must push buttons to accomplish this in MANUAL. The ultimate plasma processing is identical.

The Hummer X is in MANUAL mode whenever the AUTO lamp is off. AUTO or MANUAL may be selected when the unit is in STOP. Once the user has made a choice between the two, the unit will proceed. For a short time the user may change his mind and select the other mode, but after the unit is far enough into the program, this option is removed. Then the only thing the user can do to change modes is to STOP, and start over.

To start the unit into the AUTOMATIC mode, push AUTO. To start it into the MANUAL mode, push VAC, for vacuum. In either case the HUMMER X will turn on the pump and pump down until the pressure falls below 0.100 torr, at which time the VAC lamp will come on. The VAC lamp will be off until this pressure is reached for the first time. Once on, VAC will stay on unless the pressure rises above the FAULT limit, which, generally speaking, is 0.500 torr. (Certain exceptions will be described later.) The program requires the unit to pump below 0.100 torr before turning VAC on, so that basic vacuum integrity is verified. Until the VAC lamp comes on, the user may change modes by pushing AUTO (to go to AUTO from MANUAL) or VAC (to go to MANUAL from AUTO).

Let us assume the user has selected MANUAL mode. The unit pumps below 0.100 torr, and VAC comes on. At this point the GAS and HV keys become operational, and the user may process a specimen.

GAS opens a solenoid valve in series with the variable leak valve between the gas source and the chamber. When the GAS lamp is on, the solenoid valve is open, and vice-versa. Turning the variable leak control clockwise shuts the valve and lets less gas flow. Do not turn the variable leak valve fully clockwise when it is desired to turn off gas flow; use the on/off solenoid valve controlled by the function key to do this. This allows the valve to remain set to a desired flow rate and saves wear on the valve mechanism. Notice this is a separate solenoid valve from the one used to backfill the chamber when the vacuum pump is off. The solenoid valve in series with the variable leak control is normally closed and is closed when power is off. The backfill valve is normally open and is open when power is off. The backfill path is in parallel with the leak valve path between the gas source and the processing chamber.

MANUAL OPERATION (continued)

HV turns on a solid state relay in series with the variable voltage transformer on the front panel. This controls the high voltage applied to the process chamber plates. There are several interlocks in series with the front panel control. The one of most concern to the user is associated with the moveable top plate of the chamber. The top plate must be correctly positioned on top of the bell jar before high voltages can be applied. Other interlocks require all of the internal connectors to be correctly in place.

Once the VAC and HV lamps are on, the Hummer X is in the processing state. All pushbuttons are now active. The elapsed time meter, SECONDS, and the digital thickness monitor, NANOMETERS, are also running. The user will notice that SECONDS increment whenever HV is on, irrespective of whether any plasma is present.

Control of the high voltage amplitude is via the HIGH VOLTAGE variable transformer knob on the front panel. If the pressure is above 0.30 torr, it should be possible to strike a plasma by turning up the high voltage to between 600 and 2000 volts RMS. After the plasma appears, the average current through it can be read on the MILLIAMPERES indicator. The user may notice there appears a short surge in the current value when HV first comes on. This occurs because the plasma current is monitored on the primary of the high voltage transformer (for safety reasons), and the sudden application of voltage to the transformer causes a brief surge of primary current. This does not affect the steady state reading.

The user selects the process mode by the five position front panel rotary PROCESS switch. Three of the positions are used for PLATE (CCW), ETCH, and PLASMA (CW). The two intervening positions are OFF. They prevent the user from switching modes without going through OFF. If HV is on and there appears to be no current as the voltage knob is turned up, check that the selector switch is on an active position. The PROCESS switch determines whether the top or bottom plate receives -DC, GROUND, or AC excitation:

PROCESS:	TOP PLATE:	BOTTOM PLATE:
PLATE	-DC	GROUND
ETCH	GROUND	-DC
PLASMA	AC	AC

MANUAL OPERATION (continued)

The user may select a 50% duty cycle of the HV by pushing PULSE on. PULSE may be selected before HV is enabled, and may be selected or de-selected any time HV is on. Once the vacuum pressure is low enough to enable HV, the user must explicitly push HV on, even though PULSE may already be on. ALL PULSE will do is modulate HV. It will not turn HV on initially.

The operation of GAS is similar, in the sense that it too is enabled by having the VAC lamp on, i.e., having a sufficiently good vacuum initially. Once VAC has come on, GAS and HV are enabled even though the pressure may rise above the threshold necessary to turn VAC on.

If the user allows the pressure to rise excessively (above 0.500 torr in MANUAL), a vacuum fault will be declared. This will cause an annoying alarm to sound, the FAULT lamp to come on, and the VAC lamp to go off. The combination of the FAULT lamp on and the VAC lamp off indicates this is a vacuum fault. To clear the fault and stop the alarm, push GAS off, or do whatever is necessary to lower the pressure below 0.500 torr, and then push the FAULT button. This will cause the FAULT lamp to go off and the VAC lamp to come back on. The purpose of all this is to avoid turning HV on in excessive pressure.

It is also possible to get a current fault by having the plasma current rise above a threshold of approximately 25 milliamperes. If this occurs, HV will go off, FAULT will come on, and the alarm will sound again. The combination of the FAULT lamp on and the HV lamp off indicates this is a current fault. When HV goes off, the elapsed time meter and digital thickness monitor also stop, in the sense they pause. To clear the fault, turn down the HIGH VOLTAGE knob somewhat and push FAULT.

The final pushbuttons to be described are those associated with the process endpoint limits: TIME, COAT, and LIMIT. They are a subject unto themselves, and are discussed in the section following AUTOMATIC operation.

AUTOMATIC OPERATION

THE HUMMER X MUST BE SET UP FOR MANUAL OPERATION BEFORE AUTOMATIC OPERATION CAN BE CORRECTLY APPLIED.

AUTOMATIC operation relieves the user from having to purge the specimen chamber before plasma processing. To activate the AUTOMATIC mode, simply push AUTO, and let the machine do the rest. If the endpoint limits, PROCESS, and HIGH VOLTAGE knobs are all set correctly before beginning, it is possible to place the specimen in the chamber, push AUTO, and go away while the Hummer X does completely automatic processing. At the conclusion, it will turn off HV and GAS and leave the specimen under vacuum, while 'beeping' to indicate it is finished.

The AUTO vacuum sequence will do two rough pump and backfill sequences to 0.100 torr, to approximately 1 torr with processing gas, followed by a final rough to 0.040 torr. If the Hummer cannot reach 0.040 torr within five minutes, it declares a vacuum fault. Assuming 0.040 is reached, it then continues to pump for another minute, or until it reaches 0.020 (whichever comes first), at which time it turns on GAS and waits 30 seconds for gas pressure to stabilize. Then it turns on HV and processing begins.

As indicated before, the coatring process itself is identical in either MANUAL or AUTO mode.

1. Set the TIME and COAT controls as desired.
   See Page 14, Endpoint Limits.

2. Depress the AUTO button.

3. The vacuum pump will start.

4. Once the unit reaches 1 torr the VAC light will come on and the chamber will be evacuated and backfilled 2 times.

5. The unit will pump down to approximately 0.020-0.040 torr.

6. After 2 minutes at approximately 20 millitorr, the GAS button will enable backfilling the chamber to the preset pressure. If the reading does not go below .040 torr within 30 seconds, the FAULT light will come on and the unit will start chirping.

7. After 30 seconds for stabilization, the HV button will become enabled.

8. At this point you should see a plasma in the chamber and a reading of 10 milliamperes on the front panel display.

9. The time and thickness will be monitoring the process.

AUTOMATIC OPERATION (continued)

10. When the preset limit is reached, you will hear a series of beeps, one every 2 seconds. This indicates the process is complete.

11. Depress the red STOP button to vent the chamber and remove your coated samples.

ENDPOINT LIMITS

The user may select between two endpoint limits for automatically terminating processing. Endpoint limits are available irrespective of whether MANUAL or AUTO is selected, since processing is identical in both modes.

The TIME pushbutton enables the elapsed time endpoint limit. Processing will stop when the elapsed time reaches its preset limit.

The COAT pushbutton enables the thickness endpoint limit. Similarly to TIME, processing will stop when the thickness limit is reached.

The user may select one, both, or neither limit. When both are selected, processing stops when the first limit is reached.

When neither is selected, the Hummer X will continue to run indefinitely.

The user may view either TIME or COAT limits by pushing LIMIT while the desired TIME or COAT is on. The Hummer X presets the TIME limit to 60 seconds and the COAT limit to 10 nanometers when it initializes itself. However, the user may easily change a limit at any time by the following simple procedure.

1. View the existing limit by LIMIT and TIME or COAT.

2. Enter a numeric value by pushing 0-9, similar to a calculator. The new limit will appear from the right and shift over on the display.

3. When the desired value is present on the display, transfer the new limit to the program by pushing LIMIT off. Then, and only then, will the endpoint program respond to the new limit.

If the user changes the limit while a process is running and the particular limit is active because TIME or COAT are on, and the new limit is met or exceeded by the current SECONDS or NANOMETERS reading, the process will stop immediately.

The Hummer X will 'pause' when it satisfies an endpoint limit. It turns GAS and HV off and STOP on, but leaves the vacuum pump running. It leaves SECONDS and NANOMETERS reading whatever values were accumulated during processing. And it 'beeps' to call the attention of the user. At this point, the user may return to atmosphere by pushing STOP, or may continue with some other process by pushing VAC, for MANUAL mode, or AUTO, for AUTOMATIC mode. Since the vacuum pressure at this time will most likely be below 0.100 torr, the Hummer X will immediately go into its sequence, without the normal pump down delay necessary when starting from atmosphere.

TO SET THE THICKNESS AND TIME LIMITS

1. The yellow lights on the right hand side of the control panel control the thickness and time limits.

2. To set a thickness at which you wish the unit to cut off depress the COAT button and the LIMIT button. These buttons will light. Using the gray numbered buttons below, set in the number of nanometers you wish your sample to be coated with. Once the numbers appear correctly on the digital display, depress the LIMIT button, turning out the light. This sets the limit. It cannot be changed unless the LIMIT light is relit or the main power is turned off. When the main power is off, the limits revert to 10 nanometers and 60 seconds. Prior to setting the time, turn off the COAT button.

3. The same procedure is followed to set time using the TIME and LIMIT buttons.

4. The Hummer X will be controlled by whichever parameter is lit.

5. If both TIME and COAT buttons are lit the Hummer X will control by the first limit which is reached.

6. If no limit lights are lit, the unit will not cut off.

7. The control features work in both manual and automatic. To start the auto cycle depress the AUTO button (see Page 3).

8. After completing a cycle and the process of sputtering stops, you will hear a series of beeps. These sounds tell you that the process is complete.

9. The unit will remain under vacuum with the vacuum pump running until you vent it by pressing the STOP button.

10. You can at any time stop the processing by pressing the STOP button. This completely disables the functions and vents the unit.

FAULT

If you hear a sharp fast series of high pitched tones, the Hummer X has gone beyond the limits the factory has set for trouble free operation.

The FAULT light will disable the high voltage until the problem is solved. The problem will be one of the following: pressure too high above 500 millitorr; current too high above 30 millitorr. These must be corrected before the unit will function again.

FAULT OPERATION

The internal alarm sounds whenever one of three conditions is true:

FINISH	a short beep every 2 seconds
FAULT	2 1/2 medium beeps per second
FAILURE	steady, uninterrupted alarm

The FINISH sounding occurs when the unit has completed a preset time or coating thickness process run. The fault alarm will be accompanied by the FAULT lamp to indicate either an excessive vacuum pressure or excessive processing current. The failure alarm occurs when the microprocessor is not in proper control. This normally occurs when the unit is turned on, and when it is turned off. It can also occur because of a momentary power failure or transient. It is possible for the pump motor turning on or off to cause such a transient. If the continuous alarm sounds while the unit is running, try turning it off, waiting five seconds, and turning it back on. The alarm should stop. If it persists, there is a hardware failure.

The unit may be stopped and the chamber returned to atmosphere at any time by pushing STOP.

OPTIONAL ACCESSORIES

CARBON EVAPORATION ACCESSORY

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

HUMMER X
TROUBLE SHOOTING GUIDE

Economic and easy checkout of the Hummer X requires several things.

A. Familiarity with microprocessors and debugging circuits containing them.

B. Familiarity with vacuum systems and plasma systems.

1.0 NO POWER WHEN MAIN SWITCH IS TURNED ON

1.1 Check that the line cord is properly connected at the rear panel and at the wall receptacle.

1.2 Check circuit breaker on rear panel. If breaker is open, reset.

1.3 Disconnect cables on the front panel and check for bent pins or for pins pushed out of slots in the covers.

1.4 Open front panel and ensure that cables which plug into the front panel are correctly connected.

2.0 POWER LIGHT COMES ON BUT NOTHING HAPPENS TO THE PCB DISPLAY

2.1 Remove cage on rear of front panel and check the red led on the regulated power supply. If it is lit, see Step 2.3.

2.2 Check for 115VAC at the voltage regulator.

2.3 Check led DSI on the PCB. If it is not lit, see Step 2.4.

2.4 Check cables J1, J2 and J3 on the PCB as in Step 1.3 and Step 1.4.

3.0 DISPLAYS LIGHT BUT BUZZER WILL NOT SHUT OFF; ALL DISPLAYS SHOWS LETTERS OR NUMBERS

3.1 Turn the unit off then on again after waiting 5-10 seconds.

3.2 If Step 3.1 does not work, remove the cage and reset switch 6 on SW21. This is the reset signal to the Z80.

APPENDIX A (continued)

4.0 STOP LIGHT TURNS ON BUT DISPLAYS DO NOT LIGHT

4.1 Check for 2.5VDC on the output of HSK 1. (LM317T voltage regulator)

5.0 CIRCUIT BREAKER POPS OUT WHEN PUMP STARTS UP

5.1 Probable cause: circuit breaker has gone soft.

5.2 Check pump wiring and pins.

5.3 Replace 4 amp circuit breaker.

6.0 WHILE RUNNING UNDER "AUTOMATIC" MODE GAS LIGHT DOES NOT COME ON AND HUMMER X FAULTS OUT

6.1 Probable cause: vacuum leak is not allowing the Hummer X to pump down below 40 millitorr within 120 seconds.

6.2 Try running in manual mode to see how far down the unit will pump (20 millitorr or less).

6.3 Try isolating the leak by pinching off the gas line going to the top plate. If the unit then pumps down, the leak is in the gas valve assembly. To isolate the leak further, close the gas inlet valve. If it pumps down, then the leak is on the gas inlet side of the valve assembly.

6.4 If the leak is on the gas inlet side of the valve assembly, place a short piece of tubing over the inlet where the argon connects and pump down. If the unit pumps down, check for 12VDC at the valve and check transistor Q1 on the PCB - either the valve is bad or the transistor has blown. If the unit does pump down, there is a leak at one of the fittings on the gas valve assembly.

6.5 If Step 6.3 does not have any effect, then check the target insulator on the top plate. There are two o-rings in this assembly. Sometimes changing targets will cause the o-ring seal to break, i.e., pushing up on the banana plugs. Remove o-rings, grease and re-place.

6.6 If no leaks are found, plug a mechanical vacuum gauge into the DV23 vacuum gauge tube on the base plate. If the reading is different that the display reading the unit needs calabration. FOR CALABRATION CALL THE FACTORY.

APPENDIX A (continued)

7.0 UNIT WILL NOT PUMP DOWN AT ALL AND YOU HEAR A GURGLING SOUND FROM THE PUMP

7.1 Check that the top plate is seated.

7.2 Check chamber gaskets.

7.3 Check hose clamps on pump hose to baseplate and pump.

7.4 Ensure that the gas line to the top plate is connected at the top plate and at the gas assembly. (Figure 6-C)

7.5 Follow Step 6.2 and Step 6.3.

7.6 Check the o-ring on the feed thru assembly.

7.7 Check the o-ring in the anode assembly.

7.8 Check that the proper oil is being used, and that the proper volume of oil is in the pump.

8.0 UNIT PUMPS DOWN WELL BUT NO PLASMA CAN BE GENERATED IN ANY MODE. HI-VOLTAGE LIGHT COMES ON.

8.1 Check that the top plate interlock switch is making proper contact.

8.2 Check that the hi-voltage leads are inserted in receptacle provided.

8.3 Make sure that the process mode switch is not in the "OFF" position. (Figure 1-B)

9.0 PLASMA CAN BE GENERATED IN ONE MODE BUT NOT IN OTHER MODES

9.1 Check for foreign material around the dark space shield, pole piece and magnet.

9.2 Make sure that the pedestal, electrode and space shields are not excessively coated or dirty.

9.3 Follow Step 8.2.

APPENDIX A (continued)

10.0 PLASMA IS PRESENT BUT NO COATING CAN BE ACHIEVED

10.1 Check cathode (target) to ensure it is clean and free of surface contamination.

10.2 Check that vacuum chamber and all fixtures are clean to prevent degassing and contamination of the coating.

10.3 Purge the chamber of contaminating gases by continually bleeding in and pumping out the chamber with inert gas (argon).

11.0 DTM DISPLAY JUMPS AROUND OR STAYS AT 0

11.1 Probable cause: crystal is not oscillating.

11.2 Check DTM cable connections.

11.3 Replace crystal.

12.0 Unit pumps down but no vacuum reading is displayed.

12.1 Check that the gauge tube cable is plugged into the DV-23.

12.2 On the 8 pin connector at the DV-23 check for 0.2 volts AC on pins 2 and 4, or pins 6 and 8. If there is no voltage at these pins then check for 115 Volts AC on the vacuum controller on the other end of the gauge tube cable. If there is voltage there, then replace the controller.

12.3 The DV-23 can be checked for damage by removing it from the baseplate and checking for broken couples, etc. Also you can check for continuity between pins 2 and 4, or 6 and 8. DO NOT ATTEMPT TO CHECK FOR CONTINUITY WITH THE GAUGE TUBE EVACUATED OR DAMAGE TO THE TUBE WILL RESULT. There should be about 5 OHMS between the pins. If there is not, then replace the gauge tube.

APPENDIX B

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 equip-ments 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 workman-ship. 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 INCLUD-ING 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.

Anatech Ltd. and the original purchaser of the instrument or other articles of equipment covered by this warranty expressly agree that THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANT-ABILITY OR IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ALL OTHER OBLIGATIONS OR LIABILIES ON THE PARTS OF ANATECH LTD. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF. Anatech Ltd. neither assumes nor authorizes any person to assume for it any other liability or obligation in connection with the sale or service of any of its products.

APPENDIX C

CARE & CLEANING OF YOUR HUMMER X

VACUUM CHAMBER

The chamber should be cleaned after every 10 coatings so that no water vapor or air is allowed to build up in the system which will result in a longer pumping time (some biological and geological samples will outgas for a considerable amount of time). These should be done in the manual mode to prevent fault conditions.

SPUTTER SOURCE (CATHODE)

The cathode should never be handled without gloves since oil and moisture from your hands will crystalize on the surface. Results are that the sample turns blue, or you can see the plasma form but get no coating. To clean the cathode, remove it from the sputtering head and clean with a very fine metal polish and then with acetone to remove all of the residue of the polish. Clean the aluminum holder with Scotch Brite.

DTM CRYSTAL

The digital thickness monitor crystal mounted on the anode space shield should not be cleaned as this would damage the crystal. As the crystal gets plated, the frequency changes. Once the crystal becomes too heavily plated, it stops oscillating or oscillates randomly, which will cause the nanometer display to stay at zero or jump around. At this point the crystal needs replacement.

VACUUM PUMP

The oil in the vacuum pump should be changed every 60 to 90 days depending on use. There are two oils that are recommended for the pump, Ulvac MR-100 or Inland type 19. The 60-90 day time frame is based on running clean samples, three to five times a day.

DV-23 GAUGE TUBE

A contaminated gauge tube can be cleaned by removing it from the base plate and filling it with acetone or Freon 23. Rock the tube (do not shake) to loosen contamination. Rinse the tube in alcohol and bake at 150 degrees F for about 1 hour to de-gas.

APPENDIX D

TECHNICAL CONSIDERATIONS OF SPUTTER COATING

INTRODUCTION

In electron microscopy an image is produced by electrons which flood over the specimen. Typically the materials examined in this manner are 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 gases 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.

ALWAYS remove the DTM crystal before using ETCH MODE. Handle the DTM crystal in such a manner that no fingerprints or debris are introduced to the quartz crystal inside the crystal can assembly.

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.

ALWAYS remove the DTM crystal before using PLASMA MODE. Handle the DTM crystal in such a manner that no fingerprints or debris are introduced to the quartz crystal inside the crystal can assembly.

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.

REFERENCES

Thin Film Processes,
(John L. Vossen and Werner Kern, eds.)
Academic Press, New York, 1978

G. Carter and J. S. Colligon,
Ion Bombardment of Solids,
Am. Elsevier, New York, 1968.

M. Kaminsky,
Atomic and Ionic Impact Phenomena on Metal Surfaces,
Academic Press, New York, 1965.

L. I. Maissel,
in Handbook of Thin Film Technology,
(L. I. Maissel and R. Glang, eds.),
McGraw-Hill, New York, 1970.

P.D. Townsend, J.C. Kelly, and N.E.W. Hartley
Ion Implanatation, Sputtering and Their Applications,
Academic Press, New York, 1976

G. K. Wehner and G. S. Anderson,
in Handbook of Thin Film Technology,
(L. I. Maissel and R. Glang, eds.),
McGraw-Hill, New York, 1970.

APPENDIX H

HUMMER X PHASE V

FIGURES

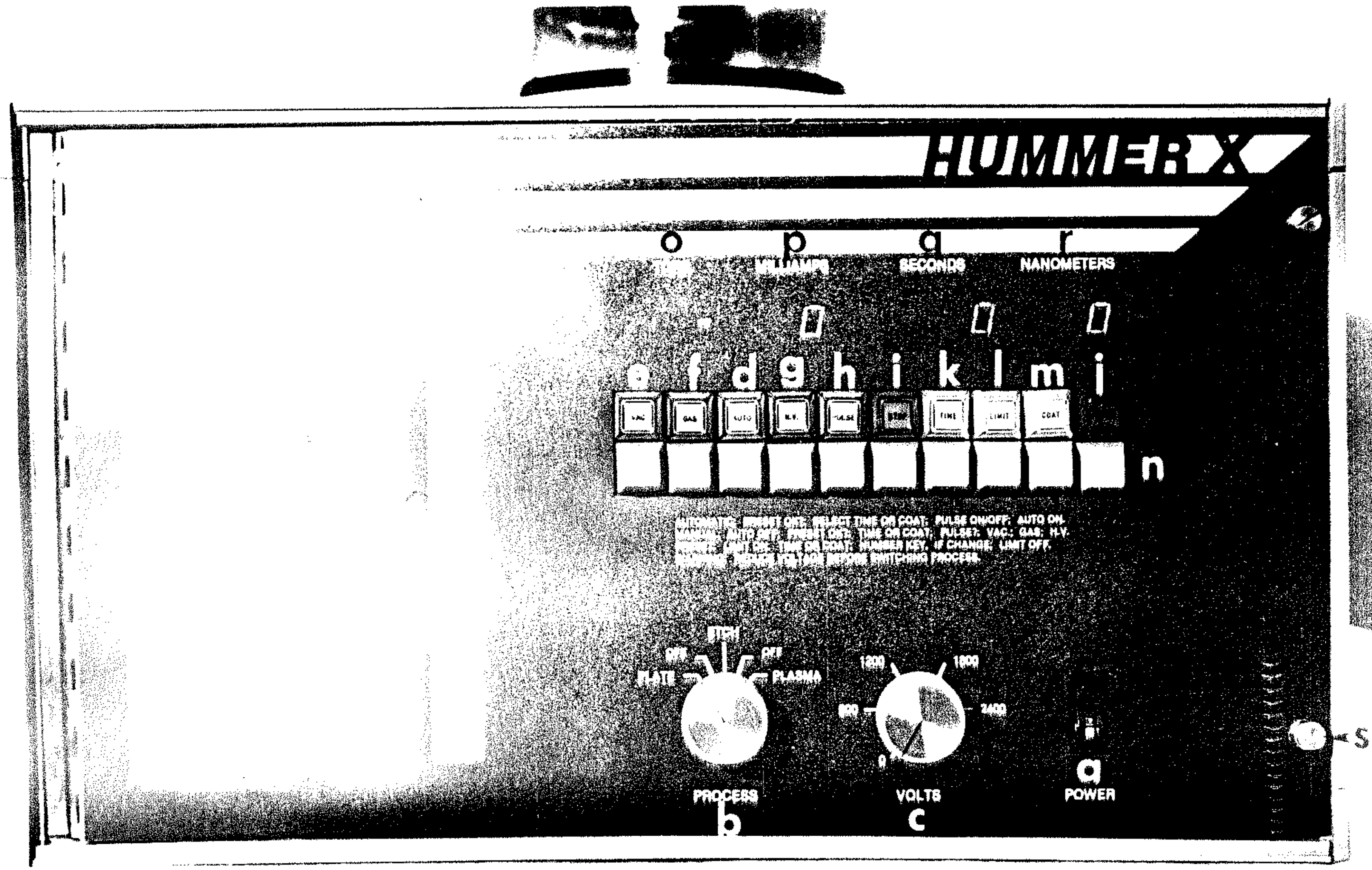


Figure 1 - Front panel controls
(a) power, (b) process, (c) high voltage, (d) auto, (e) vacuum,
(f) gas, (g) HV, (h) pulse, (i) stop, (j) fault, (k) time,
(l) limit, (m) coat, (n) 0-9 numeric entry keys, (o) torr,
(p) milliamps, (q) seconds, (r) nanometers, (s) front panel screws

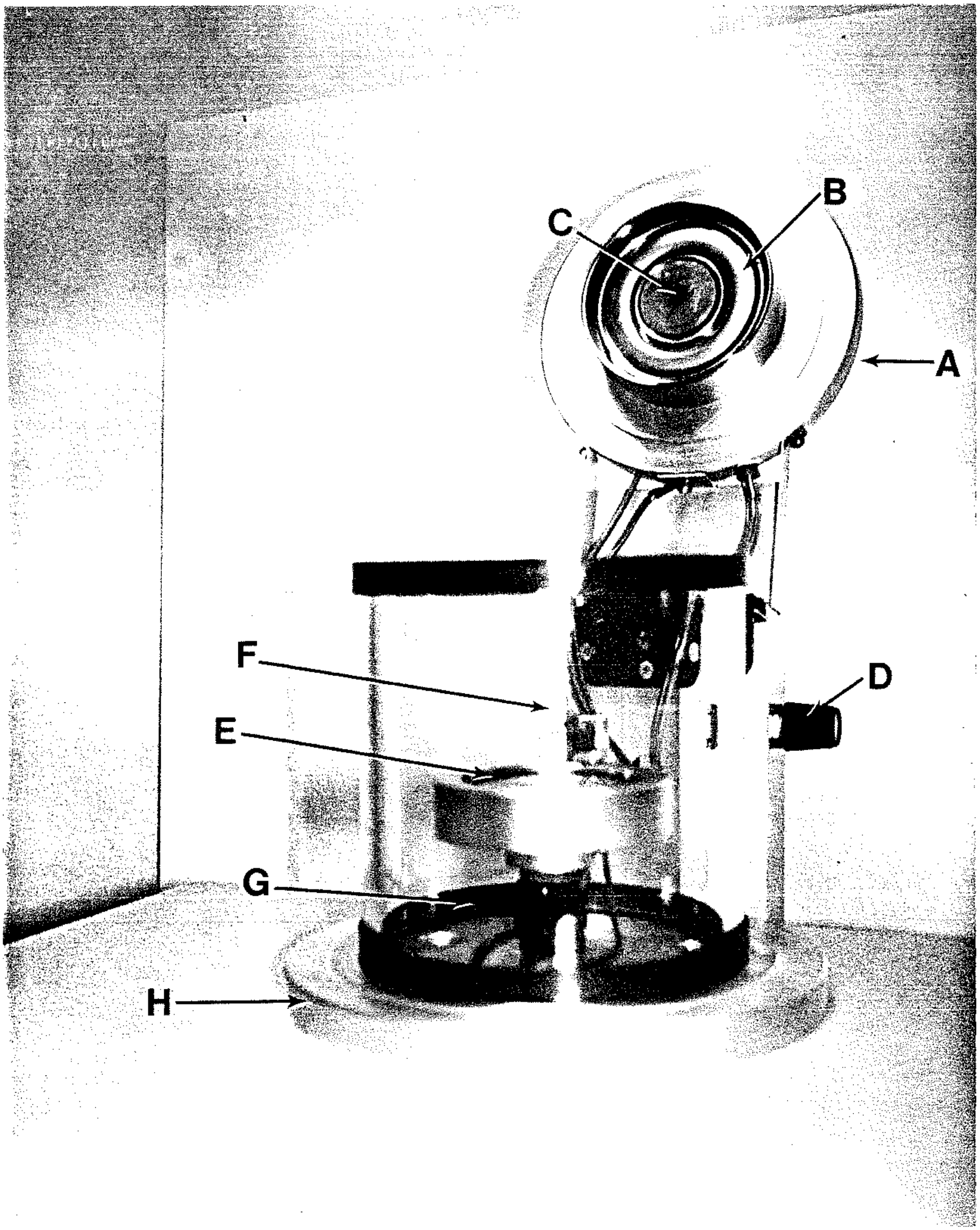


Figure 2
Vacuum Chamber

A.) Top Plate, B.) Cathode, C.) Magnet. D.) Gas Valve,
E.) Pedestal, F.) Crystal Holder, G.) Height Adjustment Nut,
H.) Base Plate

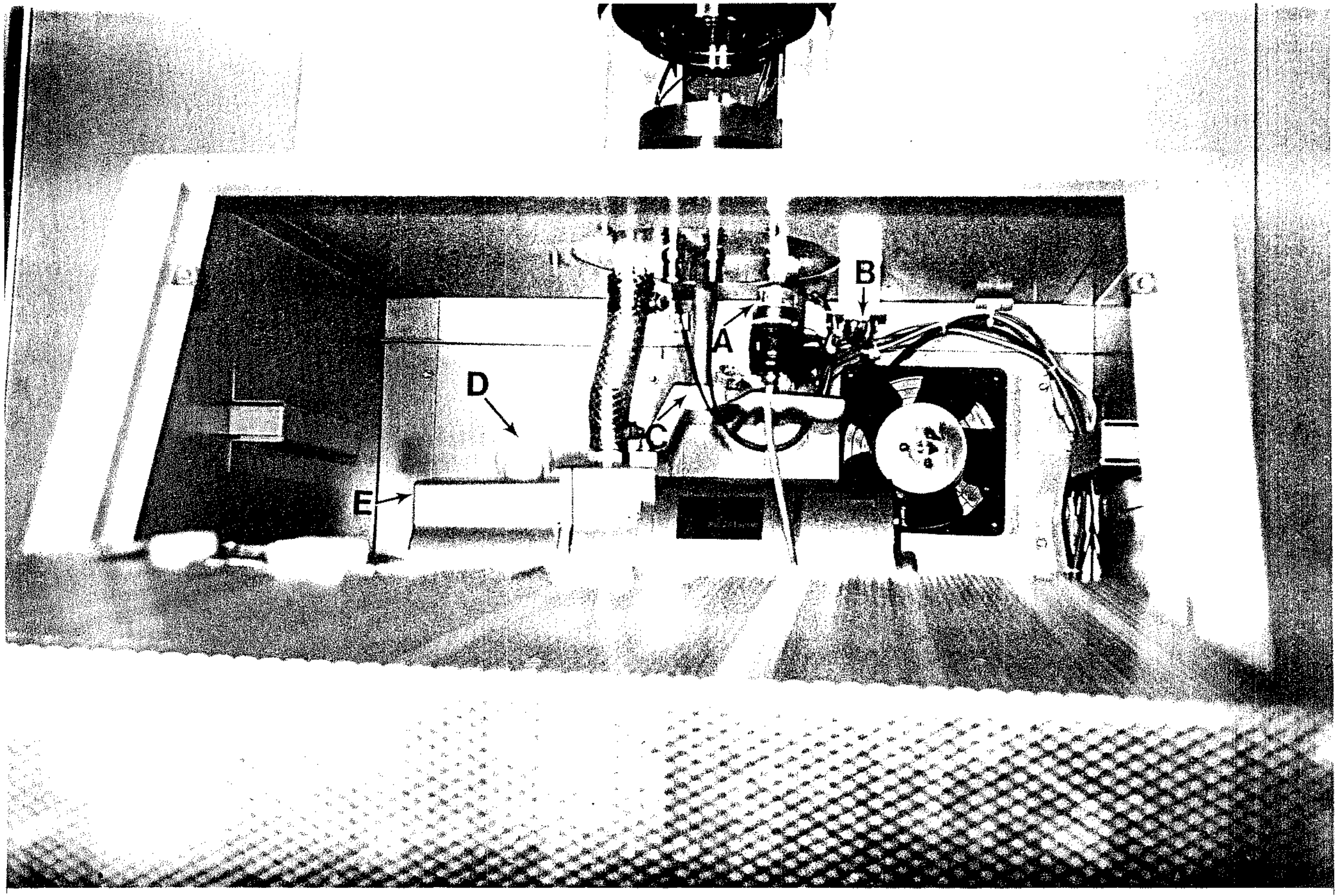


Figure 3
Front Panel Open
A.) Vacuum Gauge Thermocouple, B.) Thickness Monitor Driver Board,
C.) Anode High Voltage Connector, D.) Pump Exhaust Cap,E.) Pump Oil View Port

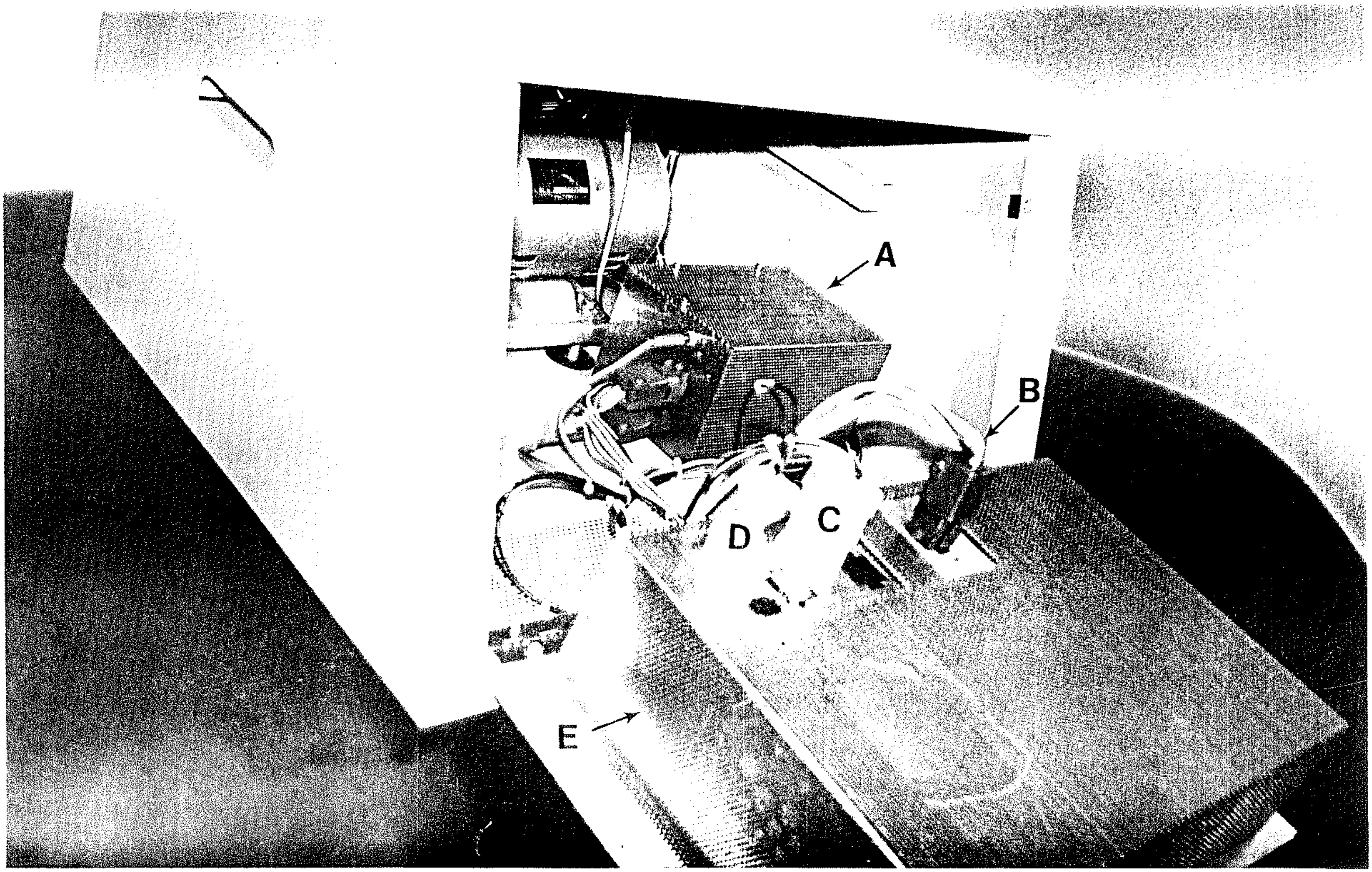


Figure 4
Front Panel Open
A.) High Voltage Power Supply, B). High Voltage Control Cable, C.) Cabinet Wiring Cable, D.) Digital Thickness Control Cable, E.) Front Panel Cover

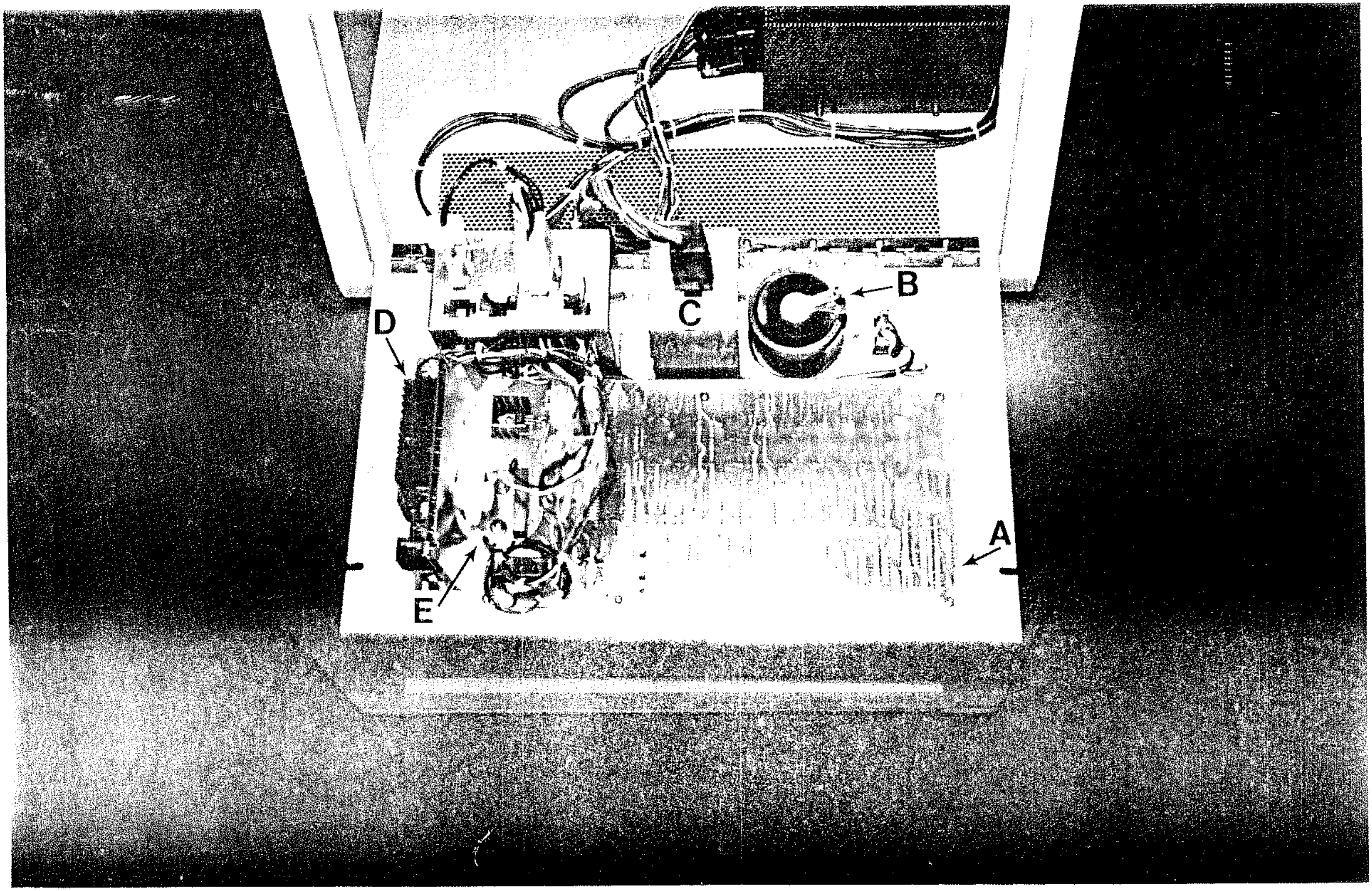


Figure 5
Front Panel with Cover Removed

A.) Micro Processor Control Board, B.) High Voltage Control Variac,
C.) Process Mode Switch Cover, D.) Processor Power Supply,
E.) Vacuum Gauge Driver Board

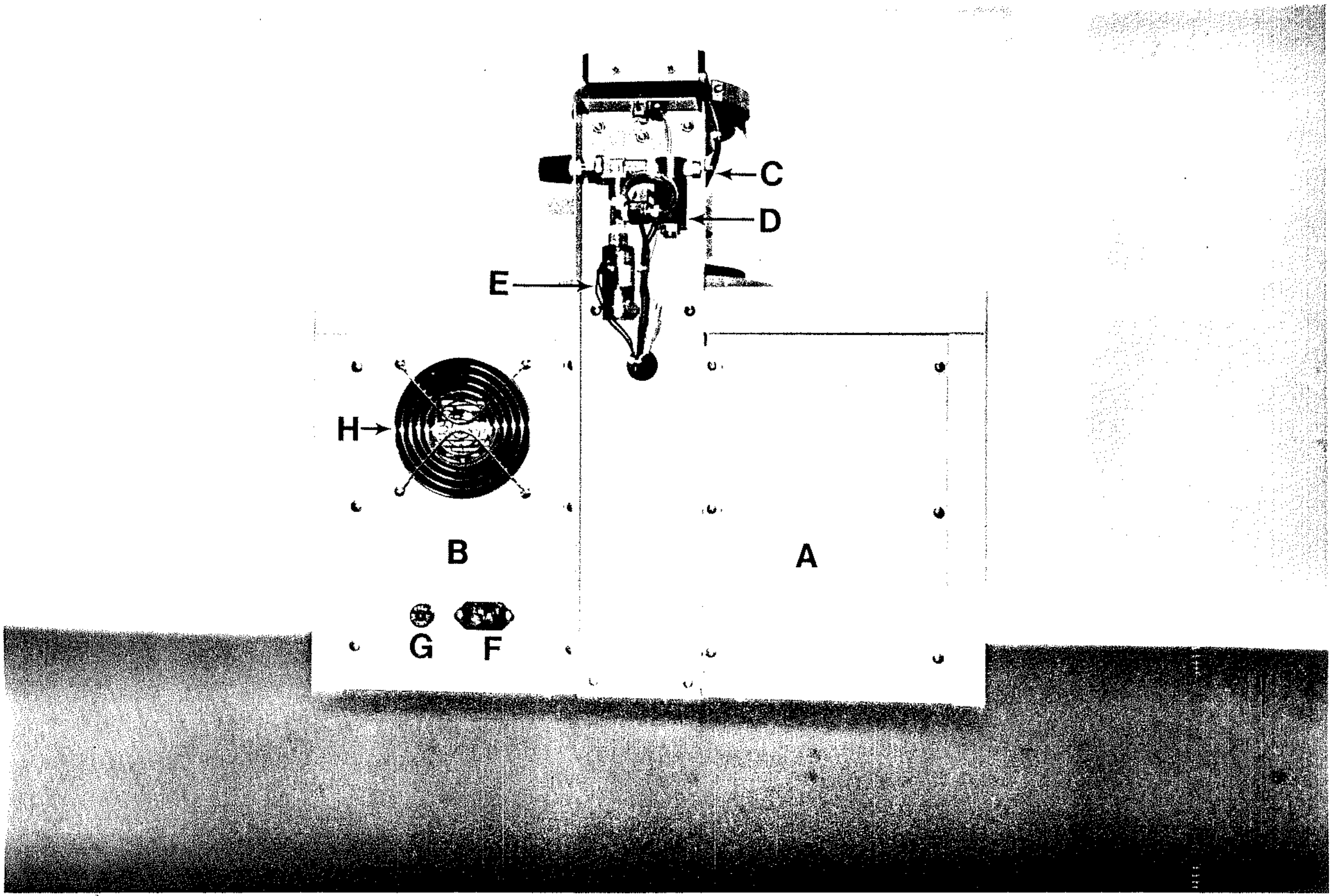


Figure 6
Rear View

A.) Pump Access Panel, B.) Electrical Panel, C.) Process Gas Inlet, D.) Process Gas Solenoid, E.) Vent Solenoid, F.) Power Cord Plug, G.) Circuit Breaker, H.) Cooling Fan

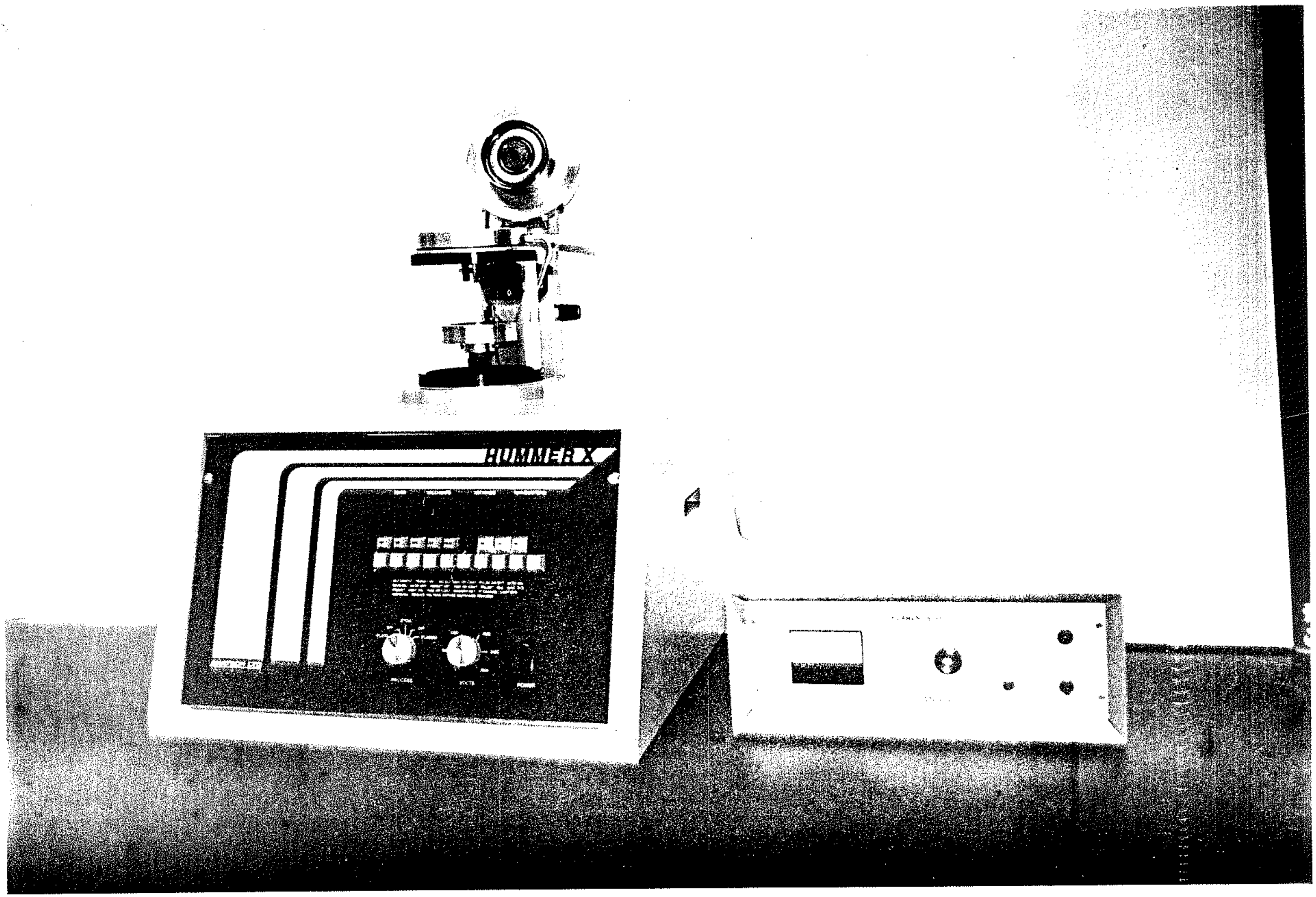


Figure 7

Hummer X with Carbon Evaporation Accessory

APPENDIX J

HUMMER X PHASE I, II, III, IV

FIGURES

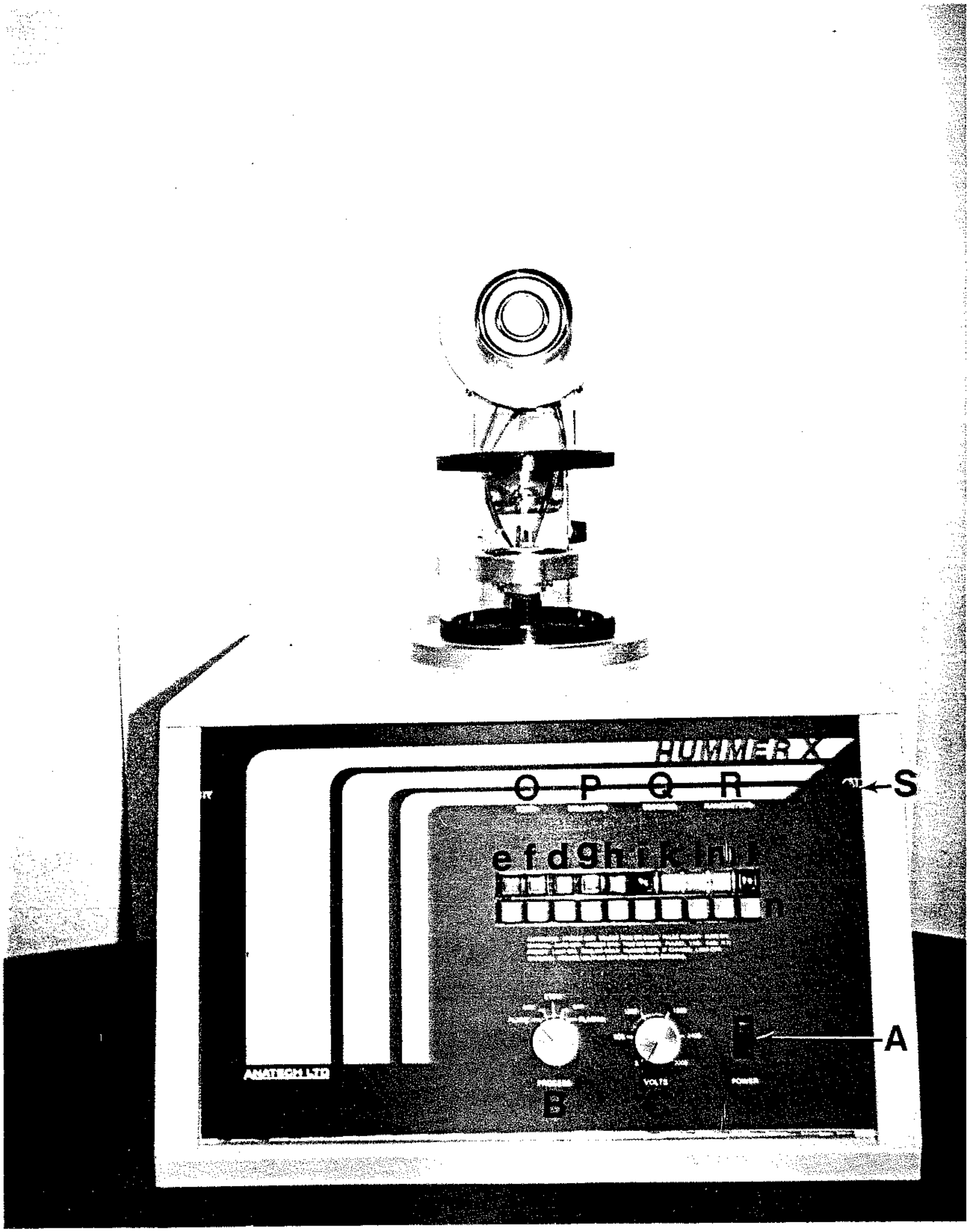


Figure 1
Front Panel Controls

A.) Power, B.) Process, C.) High Voltage Control, D.) Auto, E.) Vacuum, F.) Gas, G.) High Voltage Switch, H.) Pulse, I.) Stop, J.) Fault, K.) Time, L.) Limit, M.) Coat, N.) 0-9 Numeric Entry Keys, O.) Torr, P.) Milliamps, Q.) Seconds, R.) Nanometers, S.) Front Panel Screws

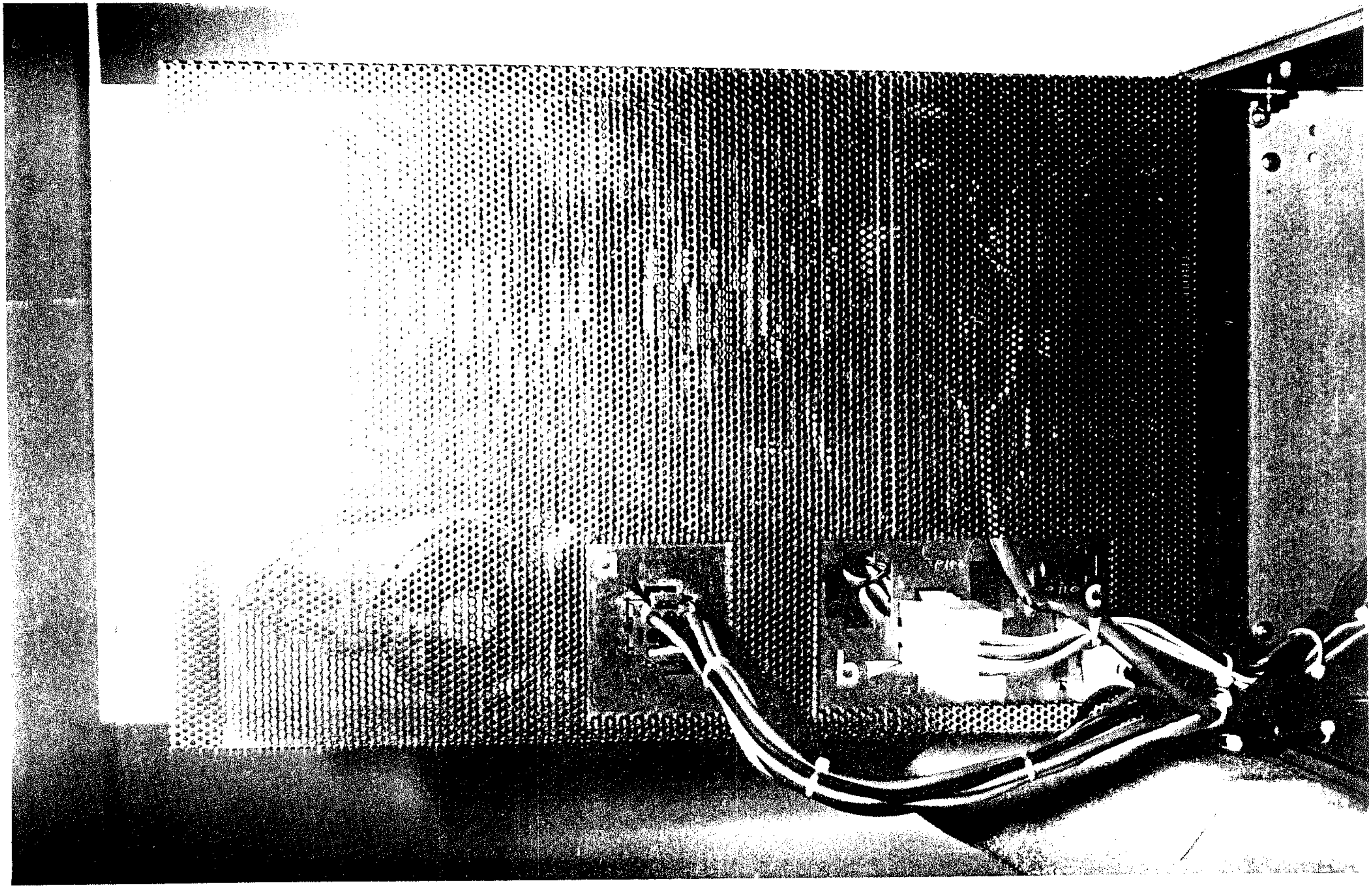


Figure 2 - Internal front panel connectors
(a,b,c) - connectors

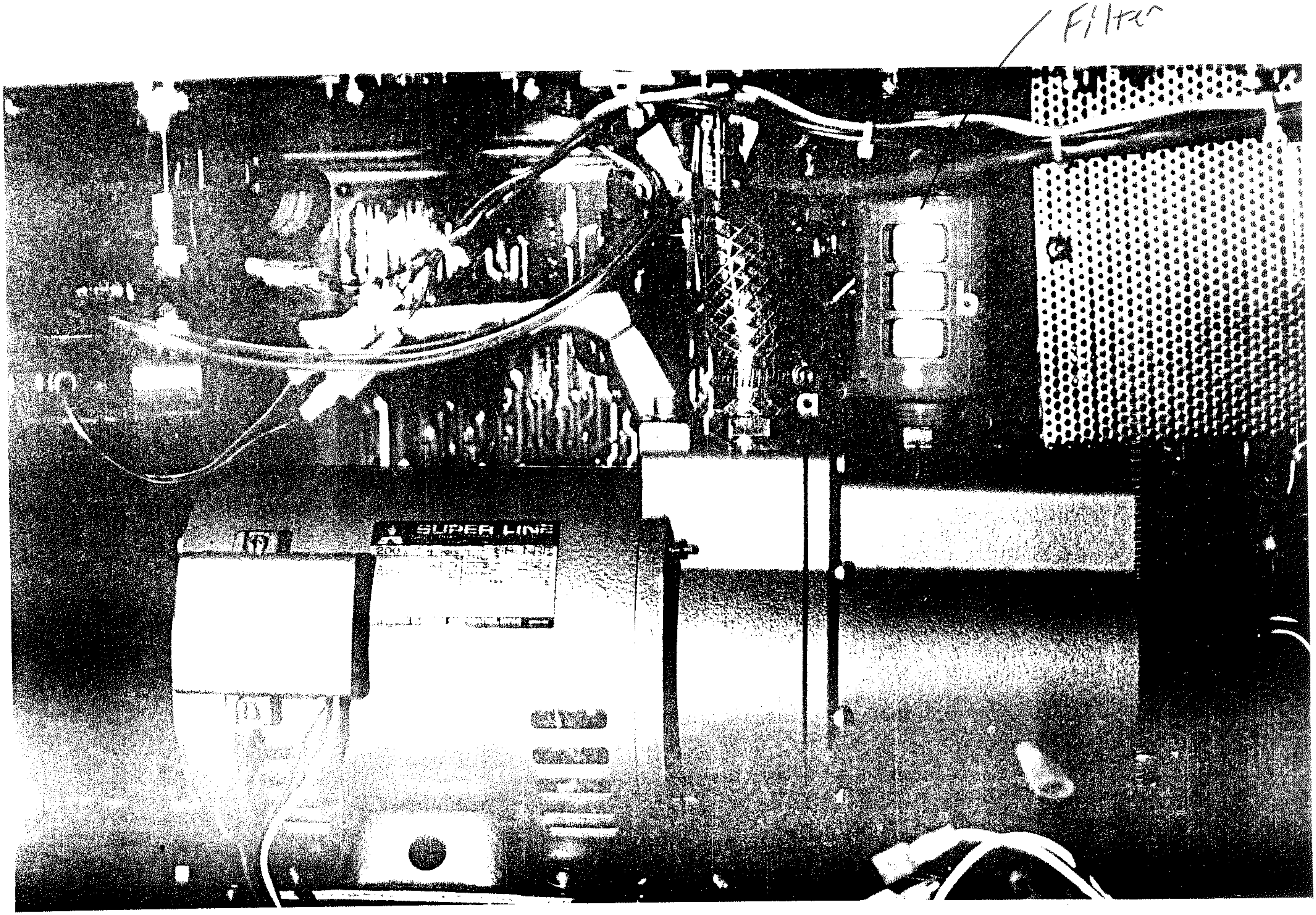


Figure 3 - (a) hose clamp, (b) pump filter

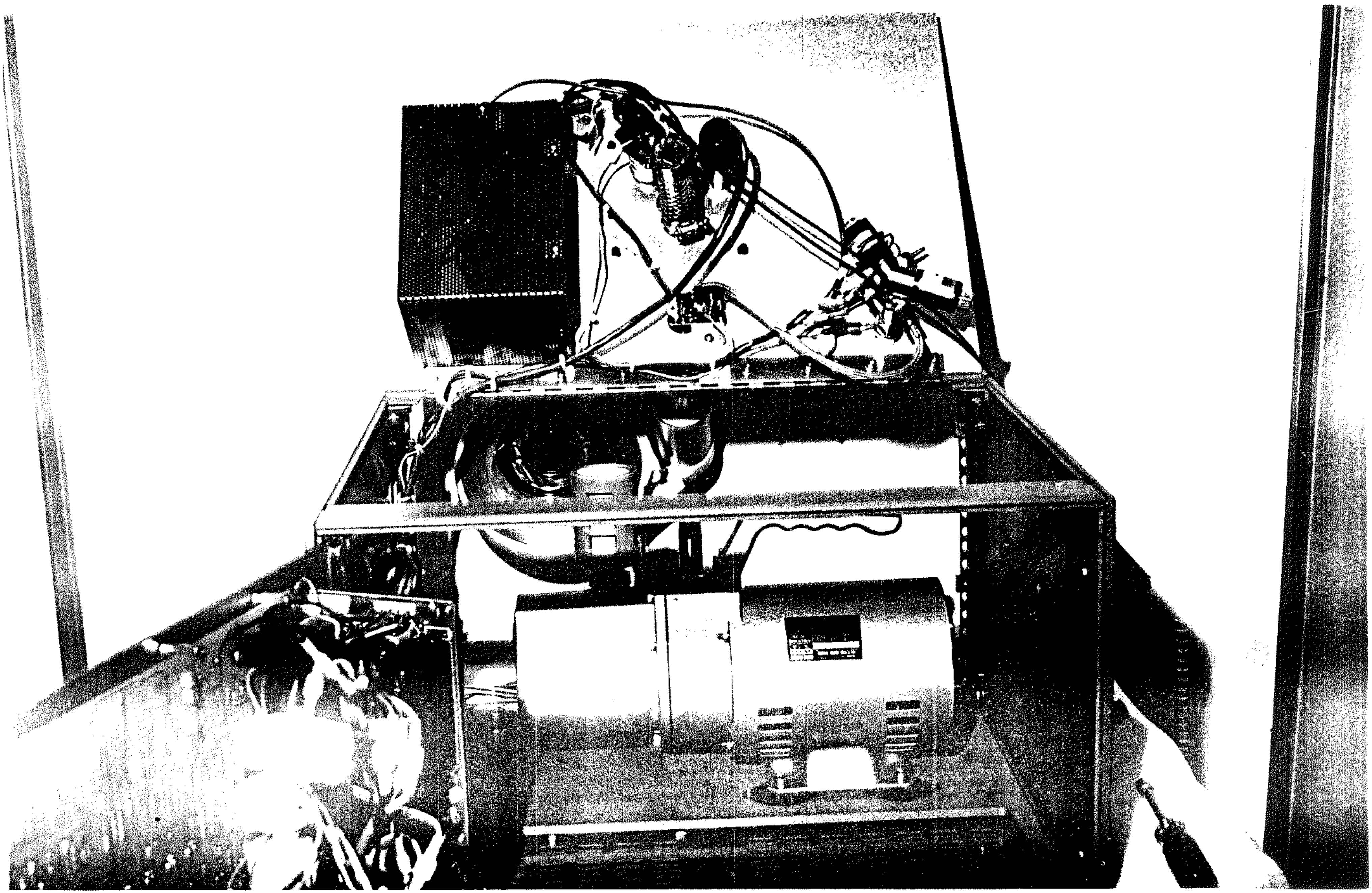


Figure 4 - Hummer X, internal view.

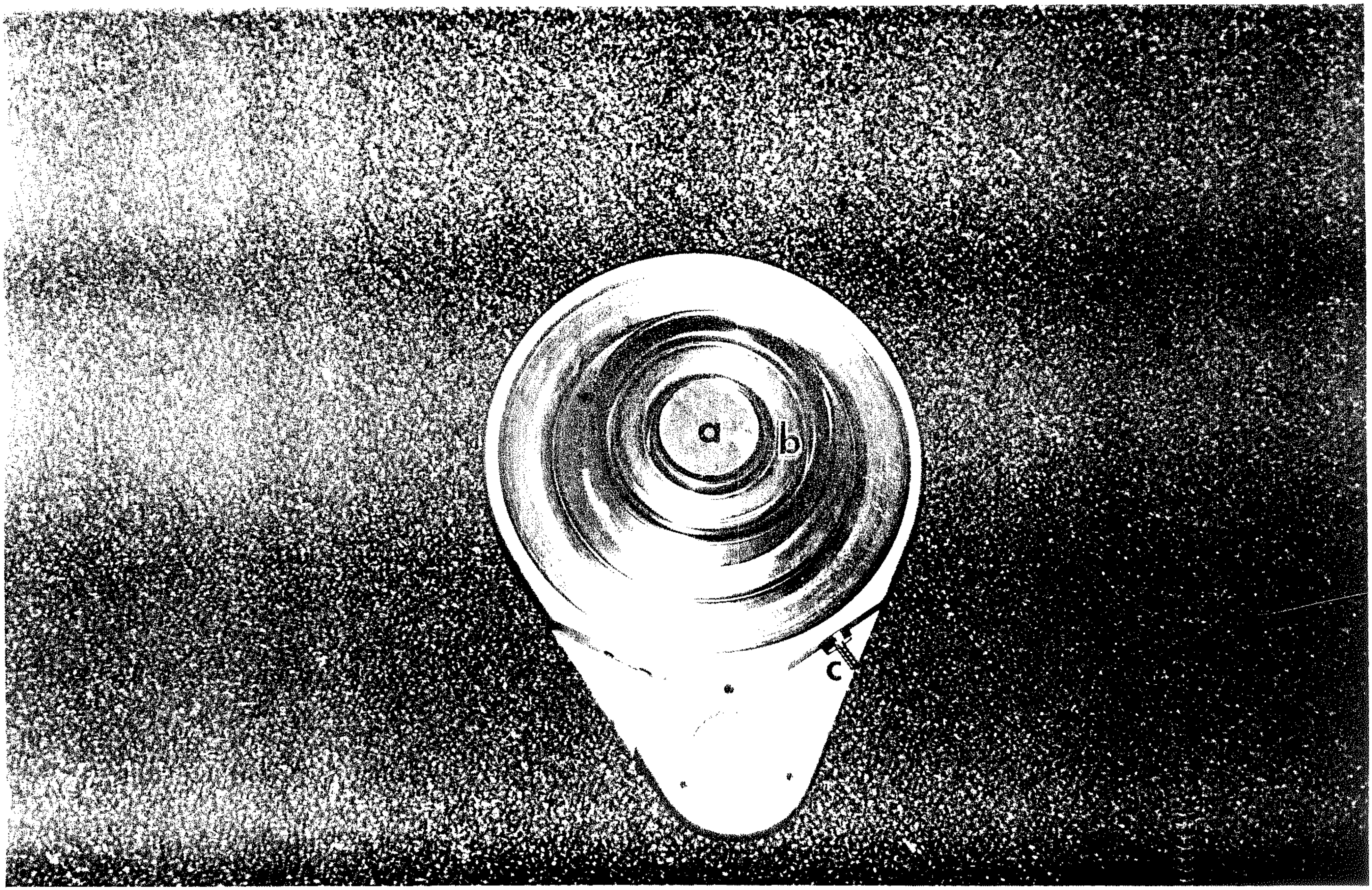


Figure 5 - Top Plate
(a) magnet, (b) target, (c) base plate

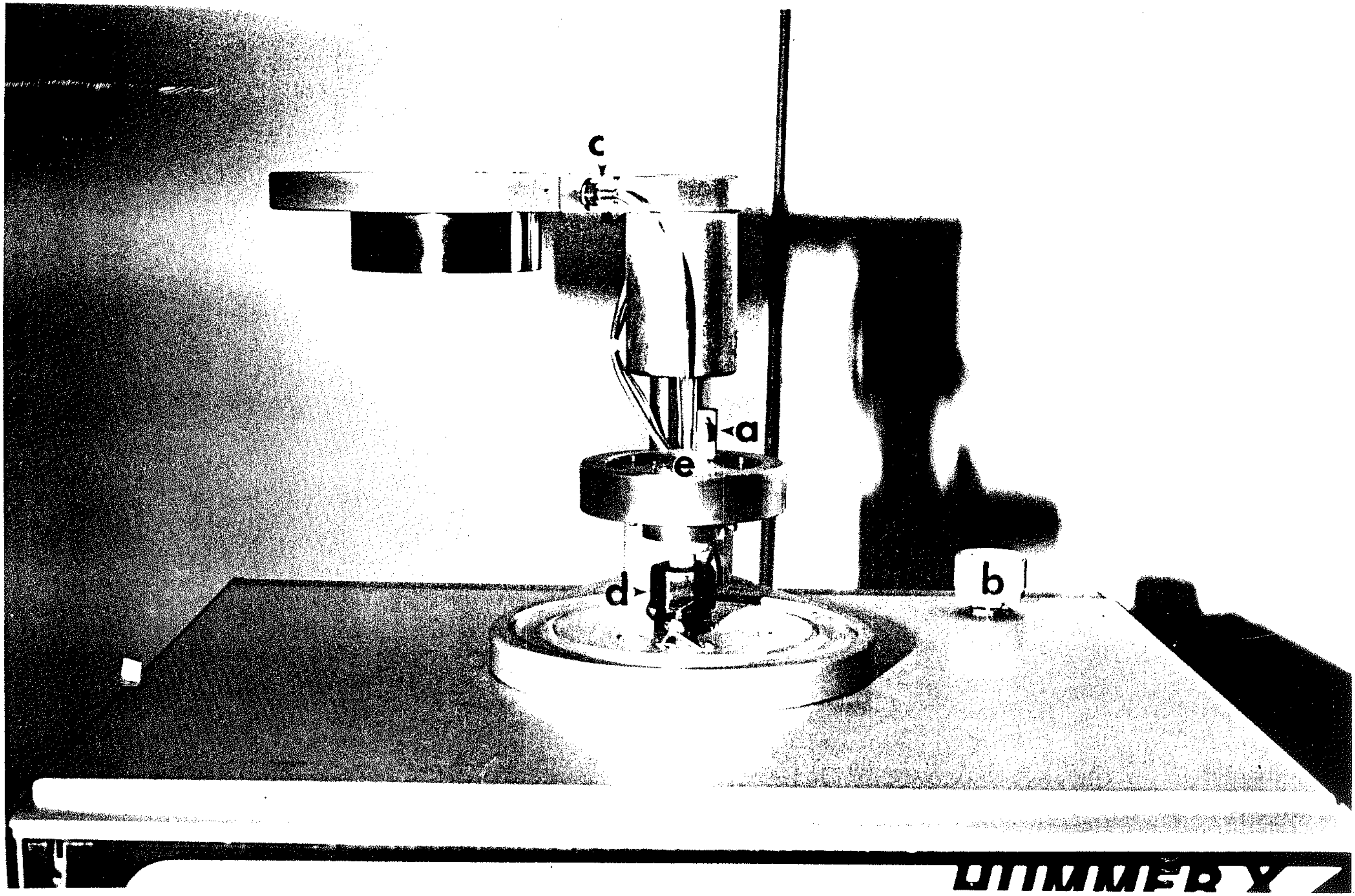


Figure 6 - Chamber
(a) DTM crystal holder assembly, (b) gas inlet valve,
(c) top plate gas inlet, (d) pedestal feedthru, (e) stage (anode)

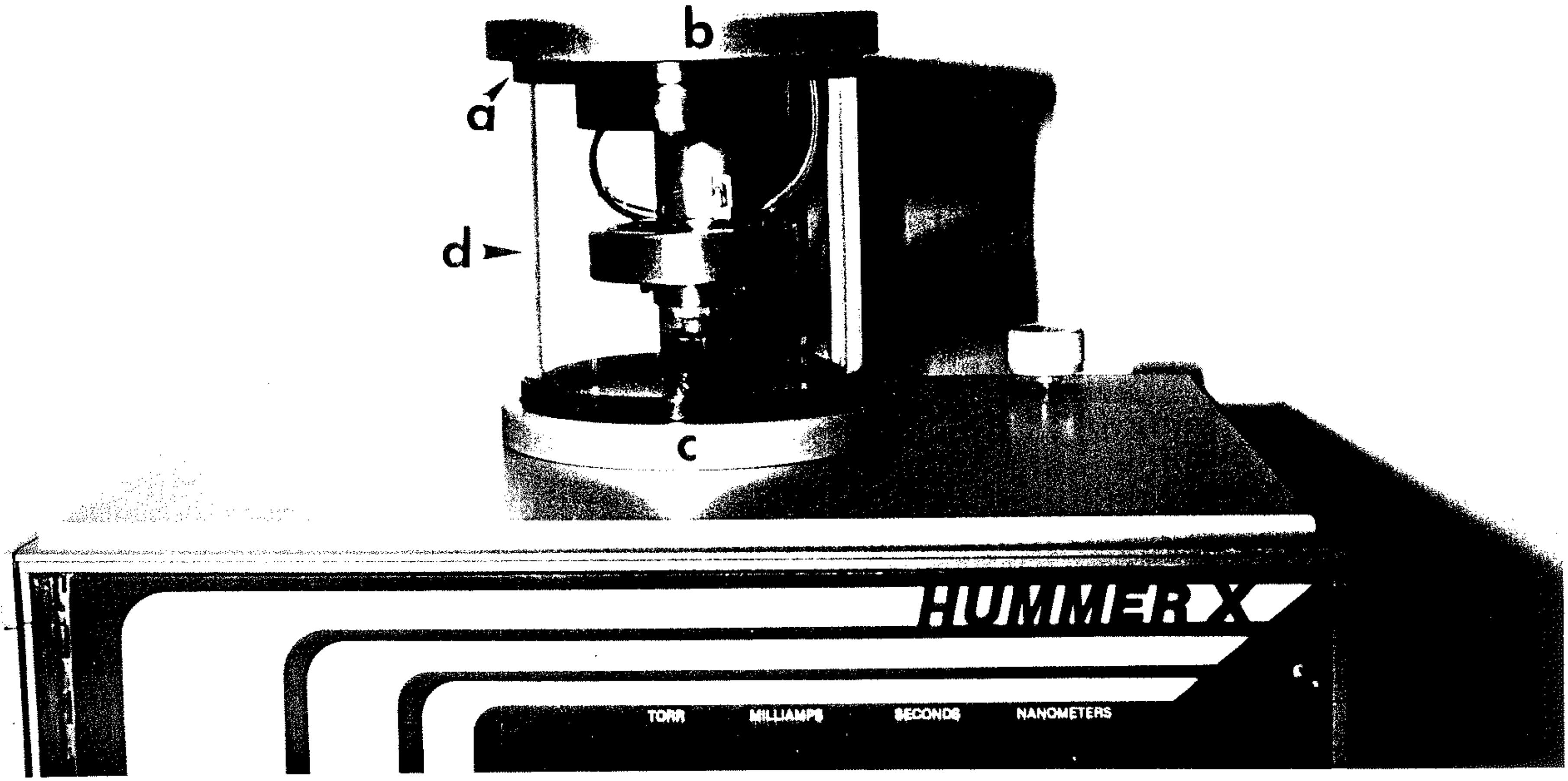


Figure 7 - (a) gaskets, (b) top plate, (c) base plate, (d) deposition chamber

APPENDIX I

HUMMER X PHASE I, II, III, IV

DRAWINGS & SCHEMATICS

Ultimate pressure at 25°	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

Figure 8
Vacuum Pump Oil Specifications

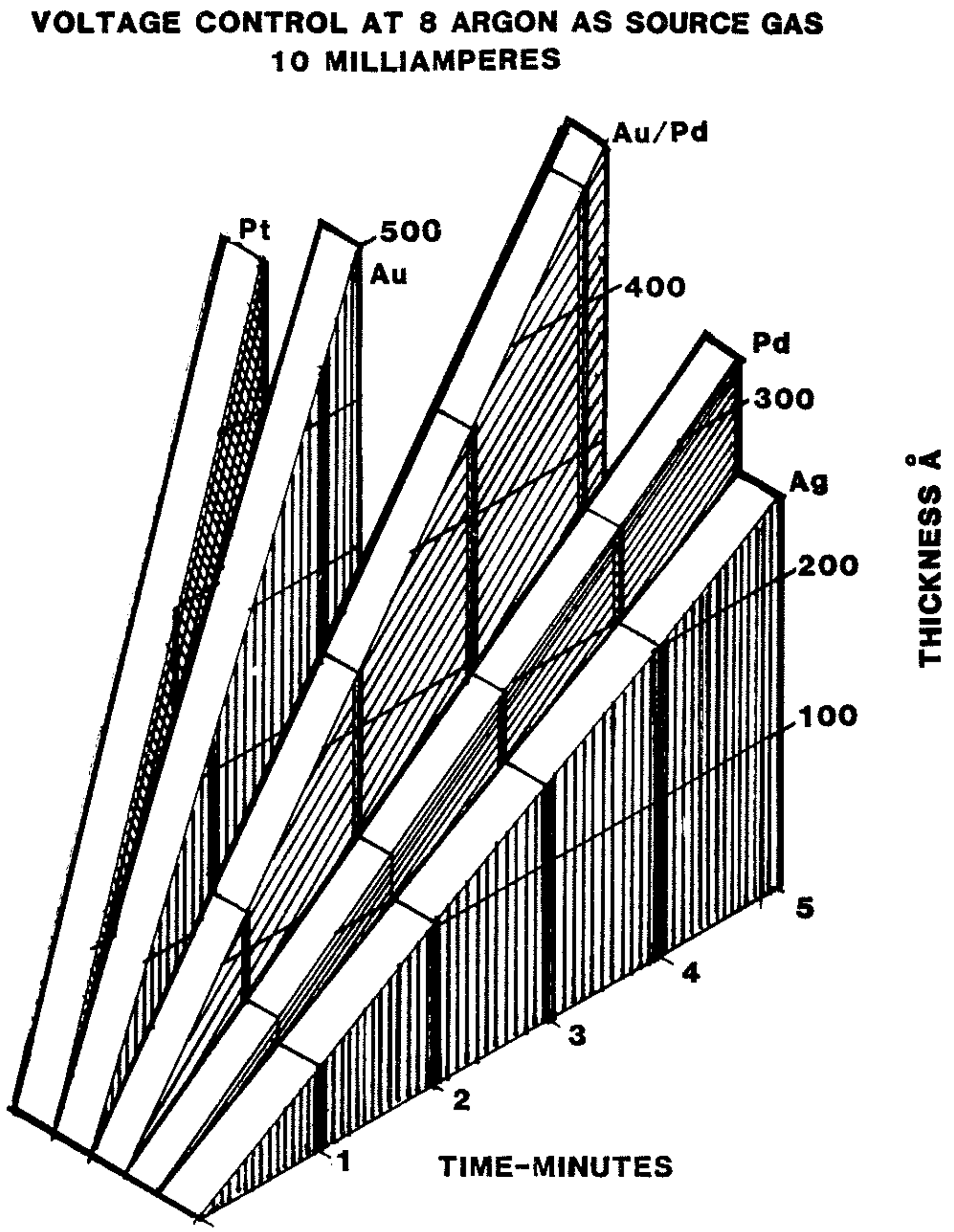


Figure 9

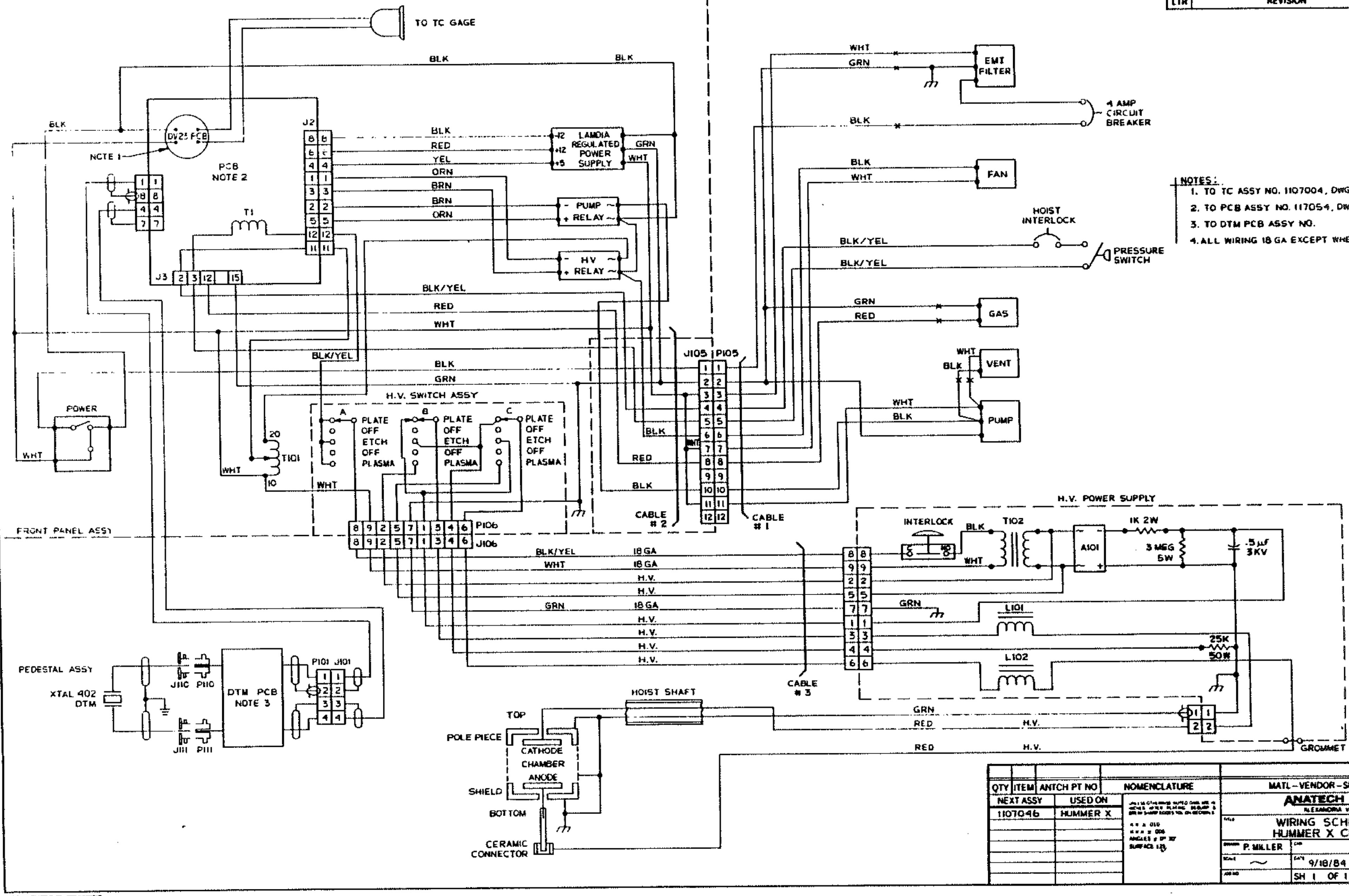
Hummer Deposition Curves

APPENDIX G

HUMMER X PHASE V

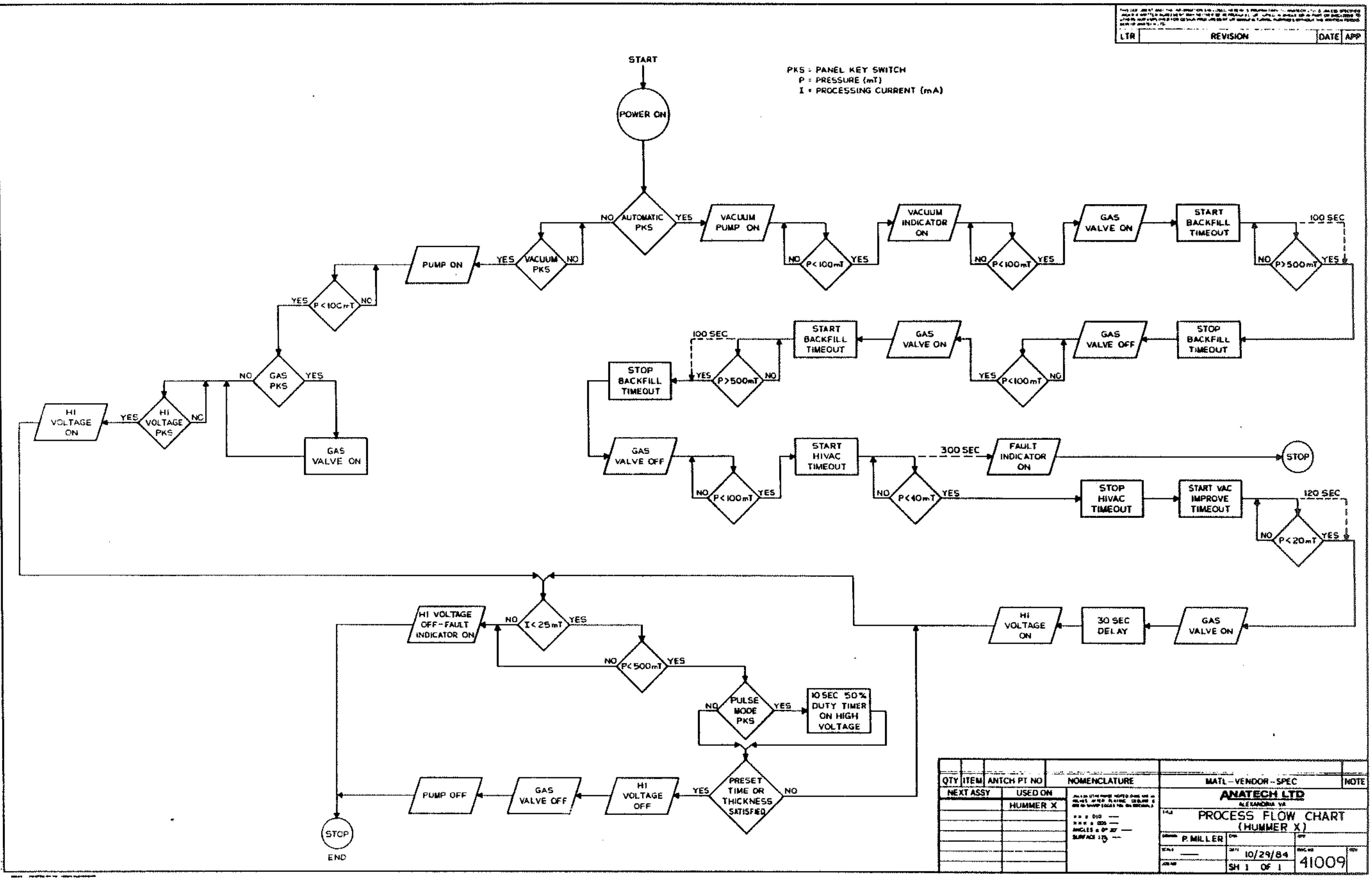
DRAWINGS & SCHEMATICS

LTR	REVISION	DATE	APP

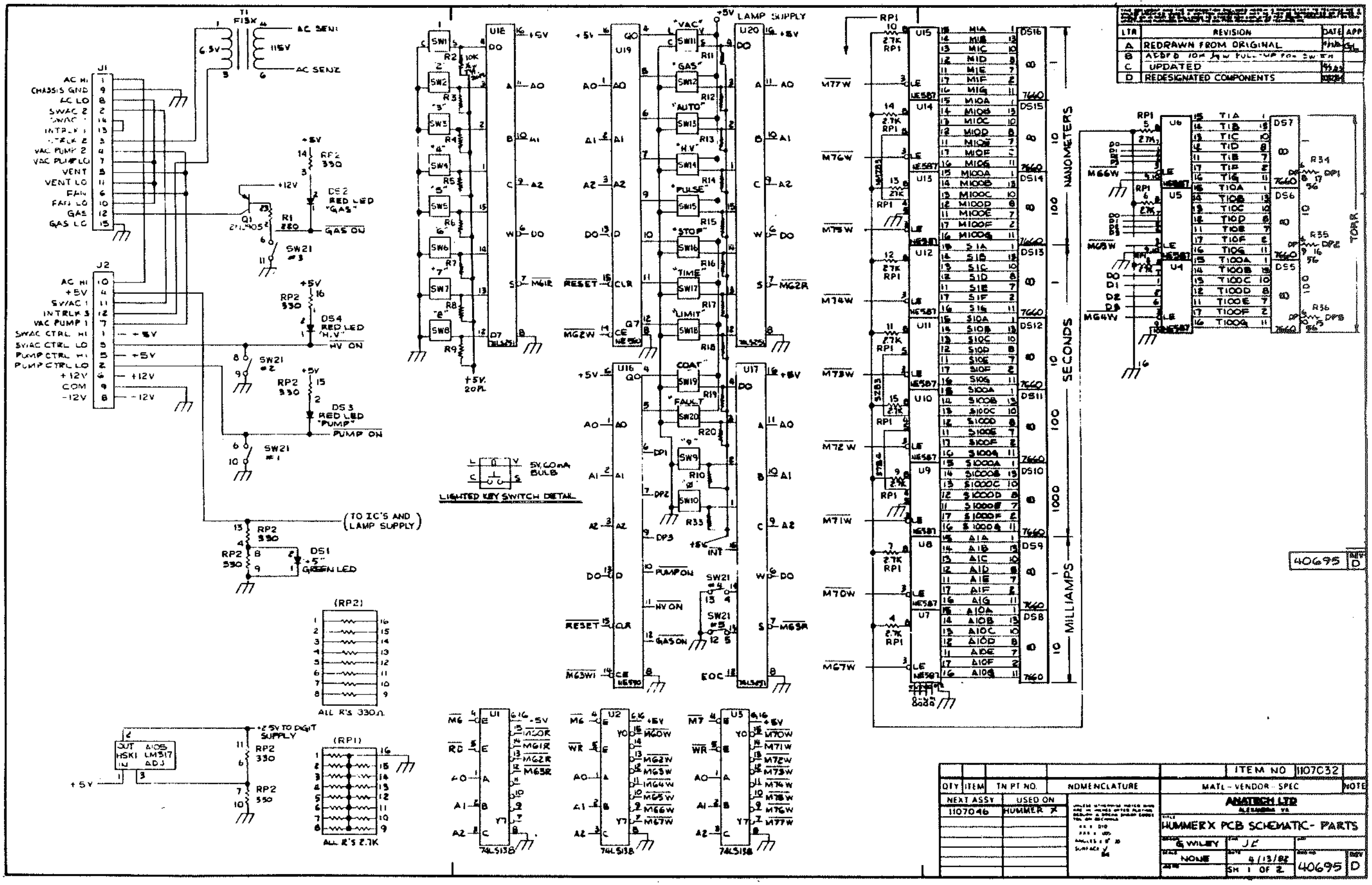


NOTES:
1. TO TC ASSY NO. 1107004, DWG NO.
2. TO PCB ASSY NO. 117054, DWG NO. 40695.
3. TO DTM PCB ASSY NO.
4. ALL WIRING 18 GA EXCEPT WHERE NOTED.

QTY	ITEM	ANTCH PT NO	NOMENCLATURE	MATL-VENDOR-SPEC	NOTE
NEXT ASSY		USED ON		ANATECH LTD ALEXANDRIA VA	
1107046		HUMMER X		WIRING SCHEMATIC, HUMMER X CHASSIS	
				DRAWN P. MILLER; DATE 9/18/84; SH 1 OF 1	41008



LTR
REVISION
DATE
APP
START
POWER ON
PKS : PANEL KEY SWITCH
P : PRESSURE (mT)
I : PROCESSING CURRENT (mA)
AUTOMATIC PKS
VACUUM PUMP ON
P<100mT
VACUUM INDICATOR ON
P<100mT
GAS VALVE ON
START BACKFILL TIMEOUT
100 SEC
P>500mT
STOP BACKFILL TIMEOUT
GAS VALVE OFF
P<100mT
GAS VALVE ON
START BACKFILL TIMEOUT
100 SEC
P>500mT
STOP BACKFILL TIMEOUT
GAS VALVE OFF
P<100mT
START HIVAC TIMEOUT
P<40mT
300 SEC
FAULT INDICATOR ON
STOP
STOP HIVAC TIMEOUT
START VAC IMPROVE TIMEOUT
120 SEC
P<20mT
GAS VALVE ON
30 SEC DELAY
HI VOLTAGE ON
VACUUM PKS
PUMP ON
P<10mT
GAS PKS
GAS VALVE ON
HI VOLTAGE PKS
HI VOLTAGE ON
I<25mT
HI VOLTAGE OFF-FAULT INDICATOR ON
P<500mT
PULSE MODE PKS
10 SEC 50% DUTY TIMER ON HIGH VOLTAGE
PRESET TIME OR THICKNESS SATISFIED
HI VOLTAGE OFF
GAS VALVE OFF
PUMP OFF
STOP
END
YES
NO
QTY
ITEM
ANTCH PT NO
NOMENCLATURE
MATL – VENDOR – SPEC
NOTE
NEXT ASSY
USED ON
HUMMER X
ANATECH LTD
ALEXANDRIA VA
PROCESS FLOW CHART (HUMMER X)
P. MILLER
10/29/84
SH 1 OF 1
41009



LTR	REVISION	DATE	APP
A	REDRAWN FROM ORIGINAL		
B	ADDED 10K ¼W PULL-UP FOR SW		
C	UPDATED		
D	REDESIGNATED COMPONENTS		

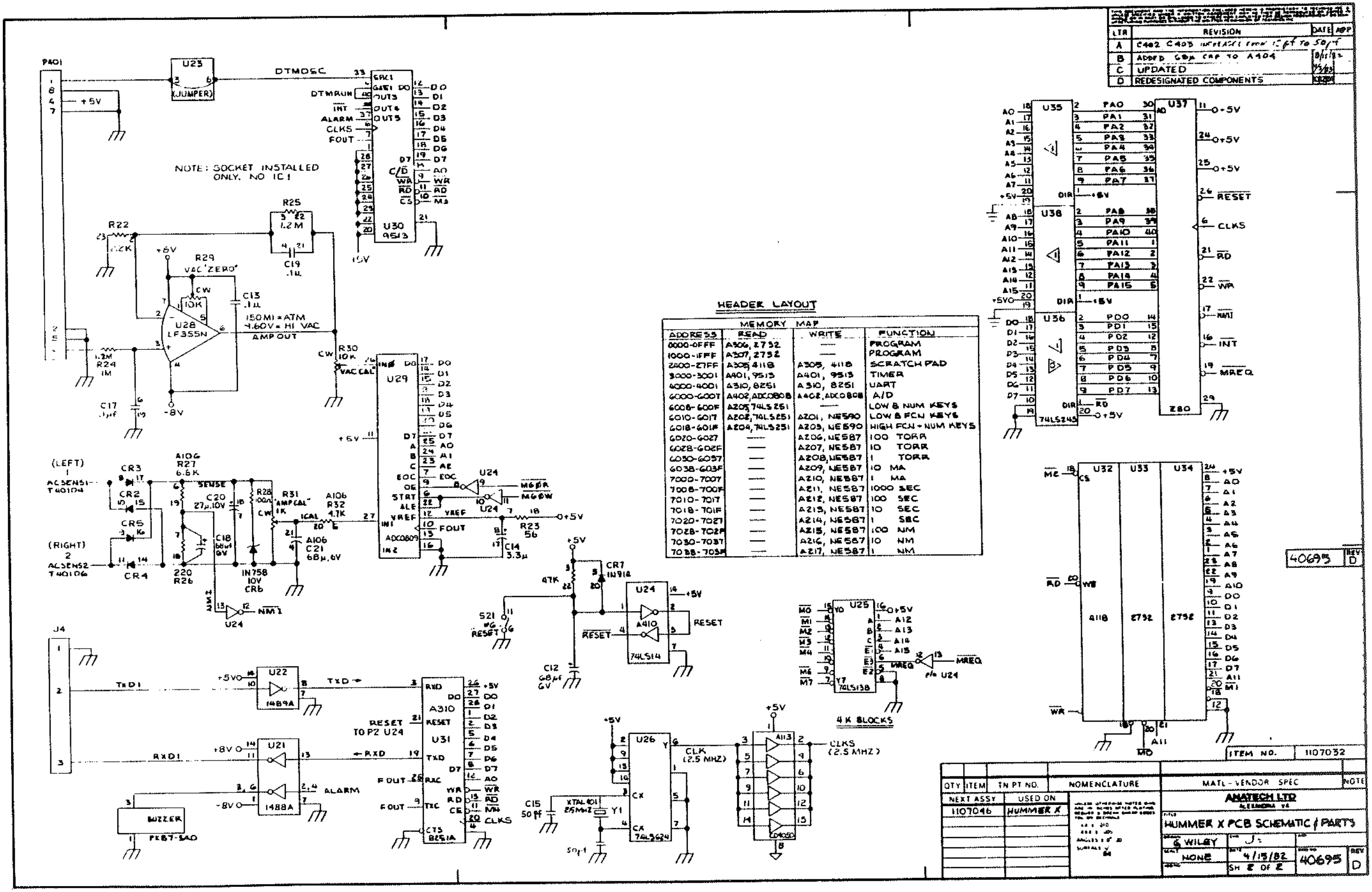
40695 REV D

QTY	ITEM	TN PT NO.	NOMENCLATURE	MATL - VENDOR - SPEC	NOTE
NEXT ASSY	USED ON			ITEM NO 1107C32	
1107046	HUMMER X				

ANATECH LTD

HUMMER X PCB SCHEMATIC - PARTS

G. WILEY — J.E. — SCALE NONE — 4/13/82 — SH 1 OF 2 — 40695 — REV D



HEADER LAYOUT

MEMORY MAP			
ADDRESS	READ	WRITE	FUNCTION
0000-0FFF	A306, 2732	—	PROGRAM
1000-1FFF	A307, 2732	—	PROGRAM
2400-27FF	A305, 4118	A305, 4118	SCRATCH PAD
3000-3001	A401, 9513	A401, 9513	TIMER
4000-4001	A310, 8251	A310, 8251	UART
6000-6007	A402, ADC0808	A402, ADC0808	A/D
6008-600F	A205, 74LS251	—	LOW & NUM KEYS
6010-6017	A202, 74LS251	A201, NE590	LOW & FCN KEYS
6018-601F	A204, 74LS251	A203, NE590	HIGH FCN + NUM KEYS
6020-6027	—	A206, NE587	100 TORR
6028-602F	—	A207, NE587	10 TORR
6030-6037	—	A208, NE587	1 TORR
6038-603F	—	A209, NE587	10 MA
7000-7007	—	A210, NE587	1 MA
7008-700F	—	A211, NE587	1000 SEC
7010-7017	—	A212, NE587	100 SEC
7018-701F	—	A213, NE587	10 SEC
7020-7027	—	A214, NE587	1 SEC
7028-702F	—	A215, NE587	100 NM
7030-7037	—	A216, NE587	10 NM
7038-703F	—	A217, NE587	1 NM

LTR	REVISION	DATE	APP
A	C402 C403 increased from 15pf to 50pf		
B	ADDED 68µ CAP TO A404		
C	UPDATED		
D	REDESIGNATED COMPONENTS		

QTY	ITEM	TN PT NO.	NOMENCLATURE	MATL - VENDOR SPEC	NOTE
NEXT ASSY	USED ON				
1107046	HUMMER X				

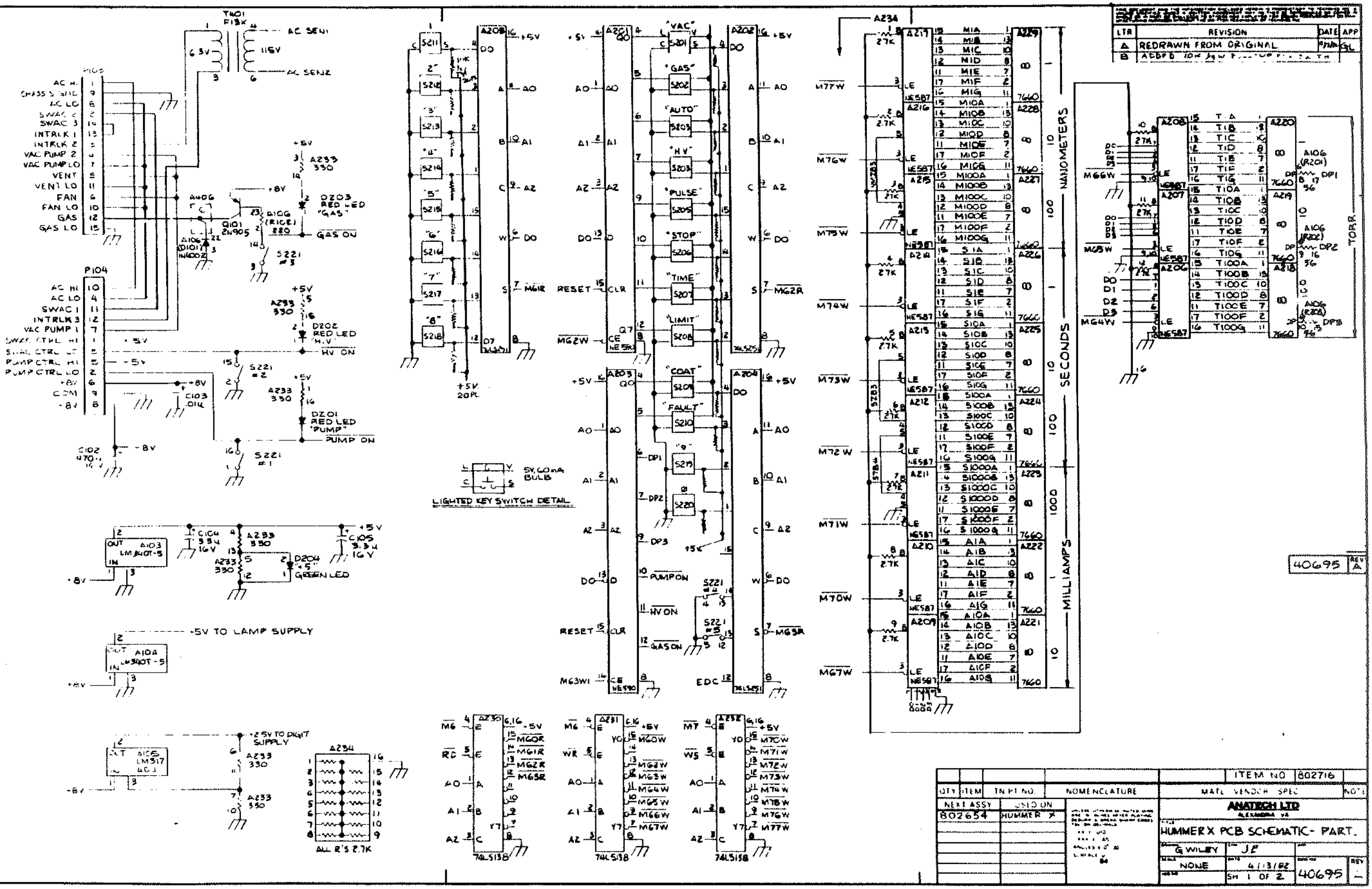
AMATECH LTD
ALEXANDRIA VA

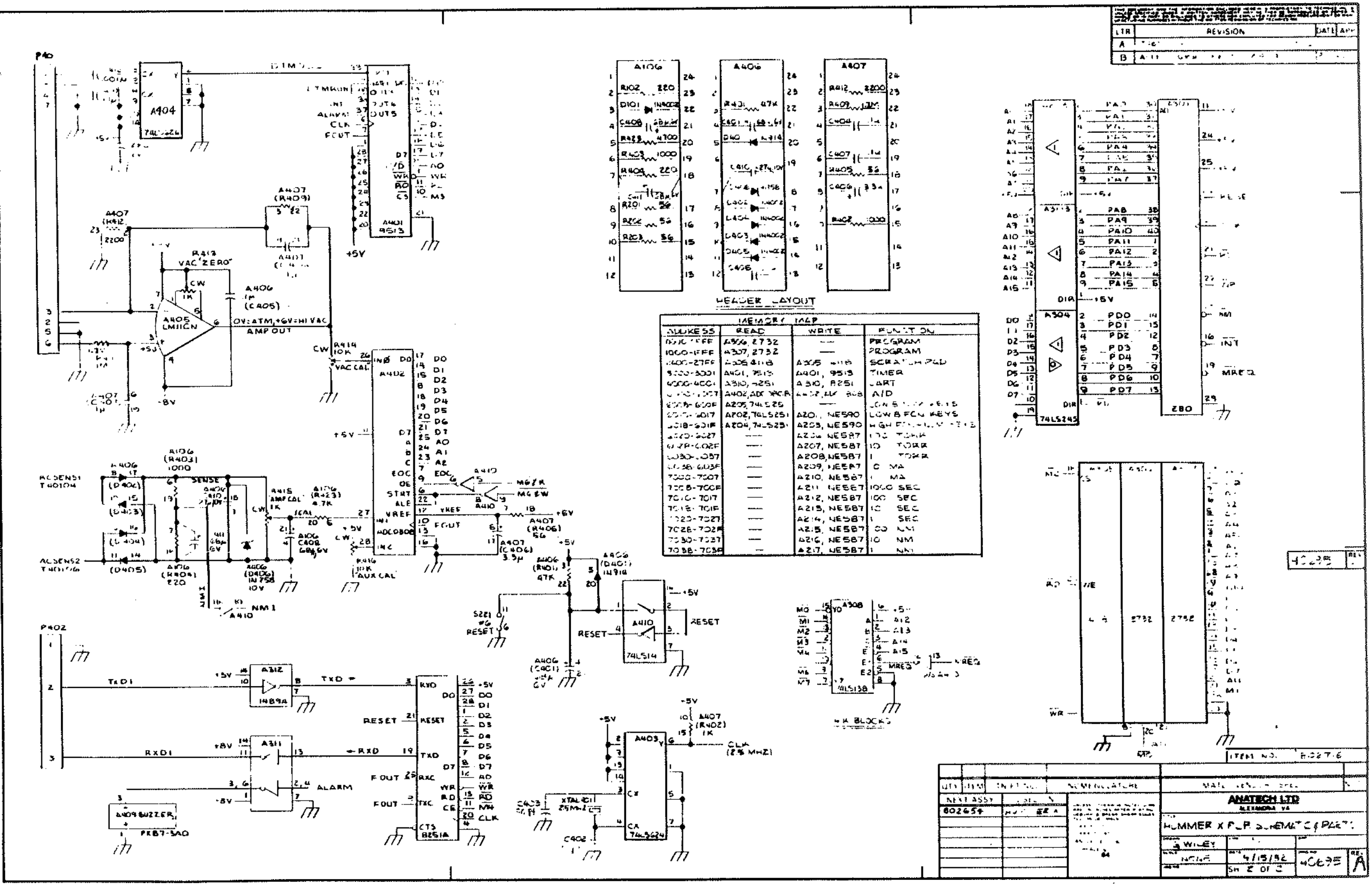
HUMMER X PCB SCHEMATIC / PARTS

G WILEY — NONE — 4/15/82 — SH 2 OF 2

ITEM NO. 1107032

40695 REV D


REVISION
A REDRAWN FROM ORIGINAL
NANOMETERS
SECONDS
MILLIAMPS
TORR
LIGHTED KEY SWITCH DETAIL
5V, 60mA BULB
+5V TO LAMP SUPPLY
+2.5V TO DIGIT SUPPLY
ALL R'S 2.7K
"VAC"
"GAS"
"AUTO"
"H.V"
"PULSE"
"STOP"
"TIME"
"LIMIT"
"COAT"
"FAULT"
GAS ON
HV ON
PUMP ON
RED LED "GAS"
RED LED "H.V"
RED LED "PUMP"
GREEN LED
ITEM NO 802716
NEXT ASSY 802654
USED ON HUMMER X
ANATECH LTD
ALEXANDRIA VA
HUMMER X PCB SCHEMATIC - PART
G WILEY
JF
NONE
4/13/82
SH 1 OF 2
40695
REV A



ADDRESS	READ	WRITE	FUNCTION
[illegible]FFF	A306, 2732	—	PROGRAM
1000-1FFF	A307, 2732	—	PROGRAM
[illegible]-27FF	A305 4118	A305 4118	SCRATCH PAD
3000-3001	A401, 9513	A401, 9513	TIMER
4000-4001	A310, 8251	A310, 8251	UART
[illegible]	A402, ADC 0808	A402, ADC 0808	A/D
[illegible]-600F	A205, 74LS25	—	[illegible]
[illegible]-6017	A202, 74LS251	A201, NE590	LOW B FCN KEYS
6018-601F	A204, 74LS251	A203, NE590	HIGH [illegible]
[illegible]-6027	—	A206, NE587	[illegible] TORR
[illegible]-602F	—	A207, NE587	10 TORR
[illegible]-6037	—	A208, NE587	1 TORR
[illegible]-603F	—	A209, NE587	C MA
7000-7007	—	A210, NE587	[illegible] MA
7008-700F	—	A211 NE587	1000 SEC
7010-7017	—	A212, NE587	100 SEC
7018-701F	—	A213, NE587	10 SEC
[illegible]-7027	—	A214, NE587	1 SEC
7028-702F	—	A215, NE587	[illegible] NM
7030-7037	—	A216, NE587	10 NM
7038-703F	—	A217, NE587	1 NM