OPERATIONS AND MAINTENANCE MANUAL

Jupiter III

Reactive Ion Etcher

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INTRODUCTION

This manual is broken down into sections dealing with all issues related to the Jupiter III Reactive Ion Etcher.

This includes detailed installation instructions, specifications, and a full description of the equipment and all controls and indicators on the equipment components.

A safety hazards and precautions section points out any risks involved with equipment operation along with recommendations for safely operating and maintaining the system. The safety features included with the system are also outlined.

A section on theory of operation explains the principals behind plasma generation and the variables that are under operator control during process development and optimization. The goal is to give the beginning plasma process engineer a starting point for developing plasma treatments for various applications using the Jupiter III equipment. The user should contact March Instruments if more detailed process development assistance is required for a specific application.

Another section gives the step by step details for system operation.

The service information section contains the information on warranties, trouble shooting, equipment repair, and parts replacement.

The appendix lists a detailed explanation of the effect of changing the variables in the plasma process and a characterization of some aspects of the system.

A glossary defines the terms used in the manual.

Textural conventions used in the manual are as follows:
In the Installation Instructions section, parts that the installer needs to attach to the main unit are listed in all capital letters. In operating procedures, call-outs for buttons the operator is instructed to actuate are listed in all capital letters. References to other sections of the manual are given with section heading title and page number. Section headings are in bold print and underlined.

Nomenclature for data entry in this manual uses millitorr (mTorr or mT) in reference to pressure, watts (w) for power, and seconds (secs) or minutes (mins) for time.

This manual can be ordered under March Instruments part number 021-1004.

EQUIPMENT OPTIONS

This is a list of all non-standard system accessories. Equipment can be upgraded to include these options. For additional information, contact March Instruments.

PUMP OIL MIST ELIMINATOR

Collects and condenses the oil mist generated during pump operation. This leads to lower pump oil consumption and a cleaner operation.

If the system is to be run with a fluorine based process gas, a special mist eliminator is required.

PUMP OIL FILTRATION UNIT

Pump oil gets dirty during the course of normal operation. Certain plasma processes will cause the oil to accumulate contaminants at an accelerated rate. The pump oil filtration unit is a device that attaches to the vacuum pump and keeps the pump oil clean. This cuts down on pump maintenance and increases the life of the pump.

BOTTOM ELECTRODE OPTIONS

The bottom electrode (where the sample is placed) can be supplied in three different configurations depending on the plasma application and composition/geometry of the sample to be processed. The chamber gas flow pattern is different for each configuration.

The standard electrode is solid. The other two available options are perforated and slotted.

TEMPERATURE CONTROLLER

A temperature controller is available for regulating the chamber temperature. This optional unit recirculates and controls the temperature of the system cooling water in the range from 0 to 100 C.

SAFETY

This section covers the safety issues associated with the Jupiter III. It describes the system safety features. Any inherent equipment hazards are outlined. Details on necessary precautions for safe operation are provided.

Alert boxes containing the words "NOTE", "CAUTION", and "WARNING" are used in various advisories in this manual. "CAUTION" implies that the action could possibly cause damage to equipment or injury to personnel if the proper procedures are not followed. Use of the word "WARNING" implies that the action places the operator in a situation that has a possibility of serious injury or death if the proper procedures are not followed. "NOTE" alert boxes are advisories that point out important information that is not obvious to the reader but will not lead to any hazardous situations or immediate equipment damage if not followed.

SAFETY FEATURES

The following is a description of the safety features designed into the system. Schematics are in the back of the manual.

SAFETY INTERLOCKS

A push button RF (Radio Frequency) interlock is mounted on the chamber lid hinge. This prevents activation of the RF power unless the lid is closed.

Another RF interlock is linked to the VACUUM switch. If the vacuum has not been activated, RF power cannot be turned on.

There is also an interlock to prevent RF hazard built into the system's right side panel. If the side panel is removed, a triggering mechanism opens the RF power interlock line and prevents actuation of the RF generator. Once the mechanism is triggered, the interlock must be manually reset by replacing the panel.

AC SWITCH

Pressing this front panel switch shuts down all power to the system.

WARNINGS AND PRECAUTIONS

When used properly, your Jupiter III system is very safe. The purpose of this advisory is simply to point out possible hazards resulting from misuse of the equipment and to suggest ways of operating the equipment as safely as possible.

ELECTRICAL

As with all electrical equipment, caution is warranted whenever any external panels are removed and/or electrical wiring is exposed. Only qualified technicians should perform maintenance, repair or installation on the equipment. Per OSHA 29 CFR 1910.147 (Control of Hazardous Energies, Lockout/Tagout), if possible the equipment should be disconnected from the power source and a lockout device attached to the electrical disconnect before beginning any work. The lockout device prevents re-energization of the equipment while the maintenance/repair is occurring.

RADIO FREQUENCY (RF) EXPOSURE

A potential hazard from RF exposure exists if the system is operated without the side panels in place. This is not recommended. This system runs at an RF frequency of 13.56 MHz and a maximum power of 300 watts.

CHAMBER TEMPERATURE

The plasma chamber can become quite hot during some processes. Exercise caution to prevent burns.

CHEMICAL HAZARDS

The fluorinated pump oil (Krytox) is a skin and eye irritant. Gloves and eye protection should be used when changing or adding pump oil.

The Material Safety Data Sheet for Krytox is included for reference at the back of the manual.

PROCESS GASES

Certain process gases selected for use with this equipment may be hazardous. Some may require special precautions. These precautions vary depending on the gas. Consult with your safety officer to ensure proper precautionary steps are taken before bringing any new gas into your facility. Take care to insure that gas lines containing toxic or flammable gases do not leak.

Gas line integrity can be confirmed simply by opening the valve on the gas cylinder then quickly closing it again. If the pressure reading on the regulator drops within one minute, there is a substantial leak that could be dangerous.

UNPACKING

CAUTION: COMPONENTS OF THE JUPITER III RIE SYSTEM ARE HEAVY. USE PROPER LIFTING PROCEDURES TO AVOID INJURY TO PERSONNEL.

The Jupiter III Plasma System is completely tested and inspected at the factory before shipping. Inspect all shipping cartons before unpacking. If there is any reason to suspect damage to the cartons or their contents, make note of the damage and report it to the shipping company immediately.

Using the included packing list, check to ensure that all listed components have arrived at your facility. Unpack the shipping cartons carefully and inspect the main plasma unit and all other system components for any damaged or missing items.

If any component is damaged or missing, notify the shipper and notify the March Instruments Customer Service Department by telephone(510 827 1240) or FAX (510 827 1189) immediately. Claims based on late notification of shipping damage will be denied.

Keep all shipping containers and materials in case it should be necessary to return any item to March.

Place the system components on the selected work surfaces. Remove all packing materials including any that might be present in the chamber of the system.

LONG TERM STORAGE

If the plasma system and vacuum pump are to be placed in long term storage, take the following precautions in order to keep the equipment in good working condition.

All system components should be placed in protective packaging. A dessicant should be placed in the packaging to minimize moisture exposure. Storage should be in a room with humidity less than eighty percent.

Before packaging and storing the vacuum pump, fill the pump reservoir with oil to the proper level and run the pump for five minutes to lubricate the seals. During the time the pump is stored, you will also need to run the pump for five minutes every three months in order to keep the seals lubricated.

INSTALLATION

The following section outlines the requirements for system installation, recommended working area allowance, step by step instructions for assembly, and initial startup procedure. The installer should refer to Safety Warnings and Precautions and Unpacking sections on pages 7 and 8 before beginning installation.

FACILITIES REQUIREMENTS:

The specifications and requirements for the system and applicable options are listed in the following table. All power cords are supplied by March Instruments.

ETCHER:

Power Supply:.....	Single Phase 110VAC or 220VAC +/-10% (Specified at time of order). 50-60 Hz @ 10 Amps. 12 AWG, 3 wire.
Process Gases:.....	Regulated to 10-15 PSIG. Connections made by either .25" O.D. Stainless Steel or Teflon tubing (Supplied by purchaser).
Purge Gas:.....	Nitrogen or Compressed Dry Air regulated to 45 PSIG (Gas, regulators and .25" tubing supplied by purchaser).
External Gas Fittings:.....	Swagelok compression fittings, .25" O.D.
Power Output:.....	300 watts +/-5% @ full load output into 50 Ohm impedance @ 13.56 MHz.
Dimensions, Door Closed....	13"(33 cm) W x 16"(40.5 cm) H x 18"(46 cm)D.
Chamber Cooling:.....	Distilled water only.

VACUUM PUMP

Capacity:.....	2015CP, 11 CFM or 2033CP, 27 CFM (11 CFM minimum recommended).
Power Supply:.....	2015CP - Single Phase 110VAC or 220VAC +/-10% @ 50-60 Hz and 15 Amps. 14 AWG, 3 wire. 2033CP - Single Phase 110VAC or 220VAC +/-10% @ 50-60 Hz and 15 Amps. 14 AWG, 3 wire.
Lubricant:.....	Charged with either Perfluorinated Krytox or Fomblin oil.
Exhaust:.....	2015CP - NW-25 connection (1" exhaust tubing supplied by purchaser) 2033CP - NW-40 connection (1.5" exhaust tubing supplied by purchaser).
Dimensions:.....	2015CP - 22"L x 11"H x 5.5"W 2033CP - 30" L x 14"H x 8"W.

Optional Equipment

PUMP OIL FILTRATION UNIT:

Power Supply:.....	Single Phase 110VAC or 220VAC +/-10%. 50-60 Hz @ 8 Amps. 14 AWG, 3 wire.
Dimensions:.....	13"W x 14.5"H x 17.5"L.

CHILLER:

Power Supply:.....	Single Phase 110VAC* +/-10%. 50-60 Hz @15 Amps. 14 AWG, 3 wire.
Output:.....	2 GPM @ 6 PSI. Distilled water only.
Connections:.....	Swagelok fittings, .25" O.D. (Either .25" Stainless Steel or Teflon tubing supplied by purchaser).
Dimensions:.....	25.5"W x 12"H x 25"L.
Temperature:.....	50-60 Degrees F.

CONTACT ANGLE MEASURING SYSTEM:

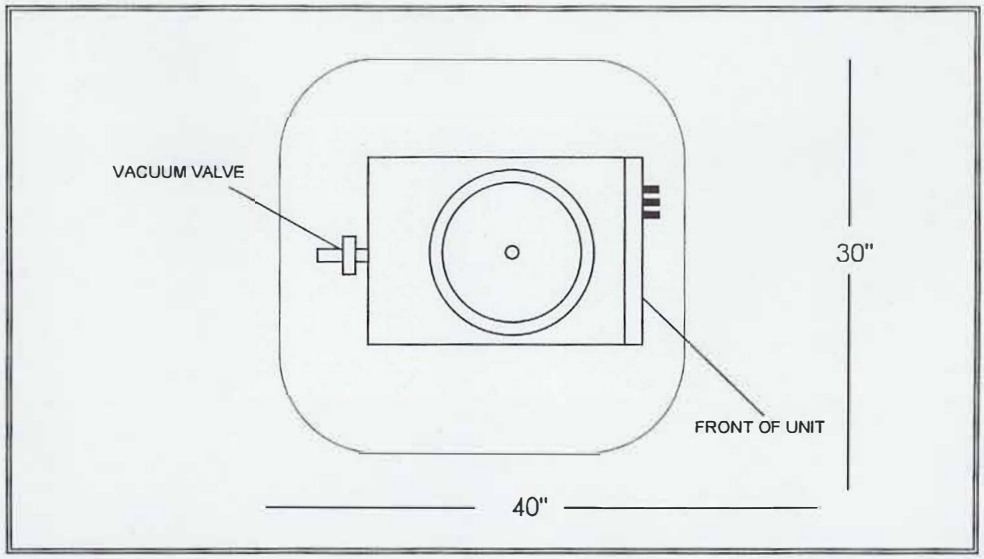
Power Supply:.....	Single Phase 110VAC or 220VAC +/-10%. 50-60 Hz @ 2 Amps. 3 wire, 14 AWG.*
Dimensions:.....	11"W x 16"H x 22.5"L.

NOTE: ALL CONNECTIONS FOR PROCESS GAS BETWEEN GAS BOTTLES AND JUPITER III MUST BE MADE USING CORROSION RESISTANT MATERIALS SUCH AS TEFLON OR STAINLESS STEEL. OTHER MATERIALS CAN CORRODE GENERATING PARTICULATE MATTER WHICH WILL CLOG GAS SHUTOFF VALVES.

* 220VAC with external transformer supplied with system.

RECOMMENDED WORKING AREA ALLOWANCE

The following diagram outlines the minimum recommended working space recommended for the Jupiter III system.



SYSTEM ASSEMBLY

To facilitize the system, please complete the following steps in the order listed:

1. Connect the vacuum pump to the VACUUM port on the back of the system using the 1" ID flexible tubing provided.

2. Connect a 1/4" water line from the chiller outlet to the port labeled "H_2O IN" on the rear of the unit.

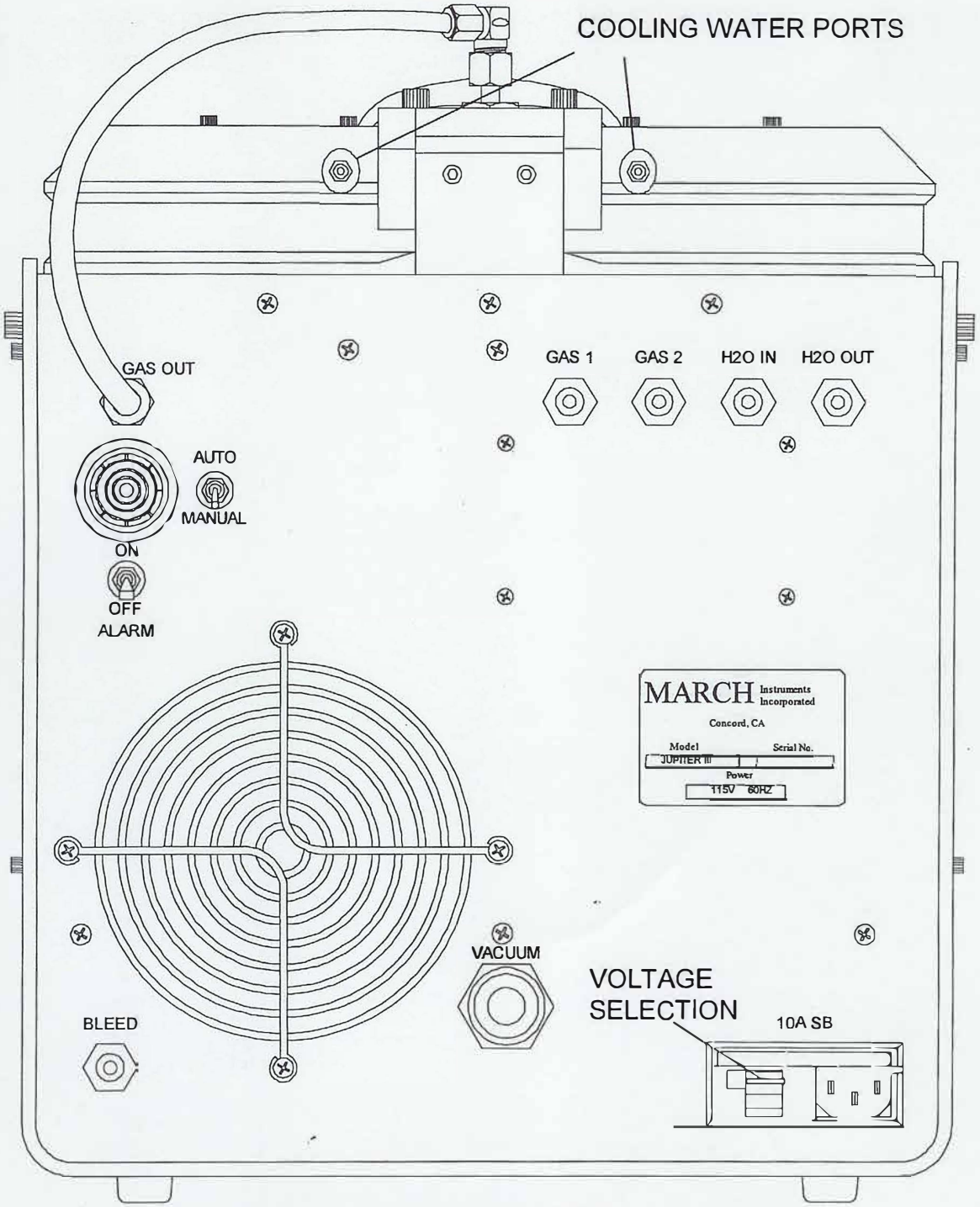
3. Connect a 1/4" line between the port labeled "H_2O OUT" and one of the brass fittings (COOLING WATER PORT) on the chamber lid.

4. Connect a 1/4" line from the other brass fitting on the chamber lid (2D) to the chiller inlet.

NOTE: USE DISTILLED WATER ONLY. TAP OR DEIONIZED WATER MAY CAUSE CORROSION OR BUILD-UP IN THE CIRCULATION LINES.

5. Connect the port labeled "GAS OUT" on the rear of the system to the fitting located on the top of the plasma chamber using the 1/4" line supplied.

6. Connect desired process gases to the ports labeled "GAS 1" and "GAS 2" (The process gases should be regulated to 10-15 PSI).



REAR VIEW OF JUPITER III SYSTEM **FIGURE 5.**

7. If a Nitrogen bleed is desired, connect a regulated Nitrogen supply line (10-15 PSI) to the port labeled "BLEED".

8. Make sure that the system is configured for the proper voltage:

With the power cord and fuse removed, read the voltage as indicated by the writing to the left (when facing the back of the unit) on the side of the VOLTAGE SELECTION board facing upward. If it is necessary to change the voltage, extract the board and reinstall it so that the desired voltage rating is oriented to the left on the side of the board facing upward.

9. Connect the vacuum pump exhaust line so that the exhaust is vented to the outside of the building or to some other well ventilated area.

INITIAL STARTUP

After the machine has been properly installed, you can begin operation by following the steps detailed below:

1. Be sure that the system is correctly installed as specified in this manual and that all fittings are leak tight.
2. Make sure that the VACUUM, RF, and GAS buttons on the system front panel are off.
3. Turn on the AC switch on the system front panel. Check that the switches and displays light up.
4. Close the reactor chamber lid.
5. Plug in the vacuum pump.
6. Plug in and turn on the chiller.
7. Ensure that the AUTO/MANUAL switch on the rear of the system is in the manual position.
8. Ensure that the ALARM switch on the rear of the system is in the on position.
9. Depress the Auto/Man switch on the front of the unit until the portion under the "AUTO" is lit. This places the unit in the automatic RF tuning mode which internally minimizes the reflected power.
10. Leak check gas lines by opening the valve on the gas cylinder then quickly closing it again. If the pressure reading on the regulator drops within one minute, there is a substantial leak in the line.

CAUTION: CERTAIN PROCESS GASES SELECTED FOR USE WITH THIS EQUIPMENT MAY BE HAZARDOUS. CONSULT WITH YOUR FACILITIES SAFETY OFFICER TO ENSURE PROPER PRECAUTIONARY STEPS ARE TAKEN BEFORE THESE GASES ARE CONNECTED OR USED.

11. Turn on process and purge gases at their sources and adjust the regulators to 10-15 psi.

Vacuum Check

When first starting a vacuum system it is advisable to check the vacuum integrity of the system. To do so:

1. Toggle the AUTO/MANUAL switch on the rear of the system to select manual mode.
2. Depress the VACUUM switch on the front panel to commence pumping down the chamber. Start timer.

3. Record the time required to reach a pressure of .15 Torr. The pressure should fall below .15 Torr less than 5 minutes after pressing the VACUUM switch.
4. Wait 20 minutes to allow any residual moisture to exit the system and record the ultimate pressure shown on the display.
5. Save the vacuum check data for future reference and comparison purposes. This same procedure should be run periodically in order to recheck the vacuum integrity. The following form is included for this purpose:

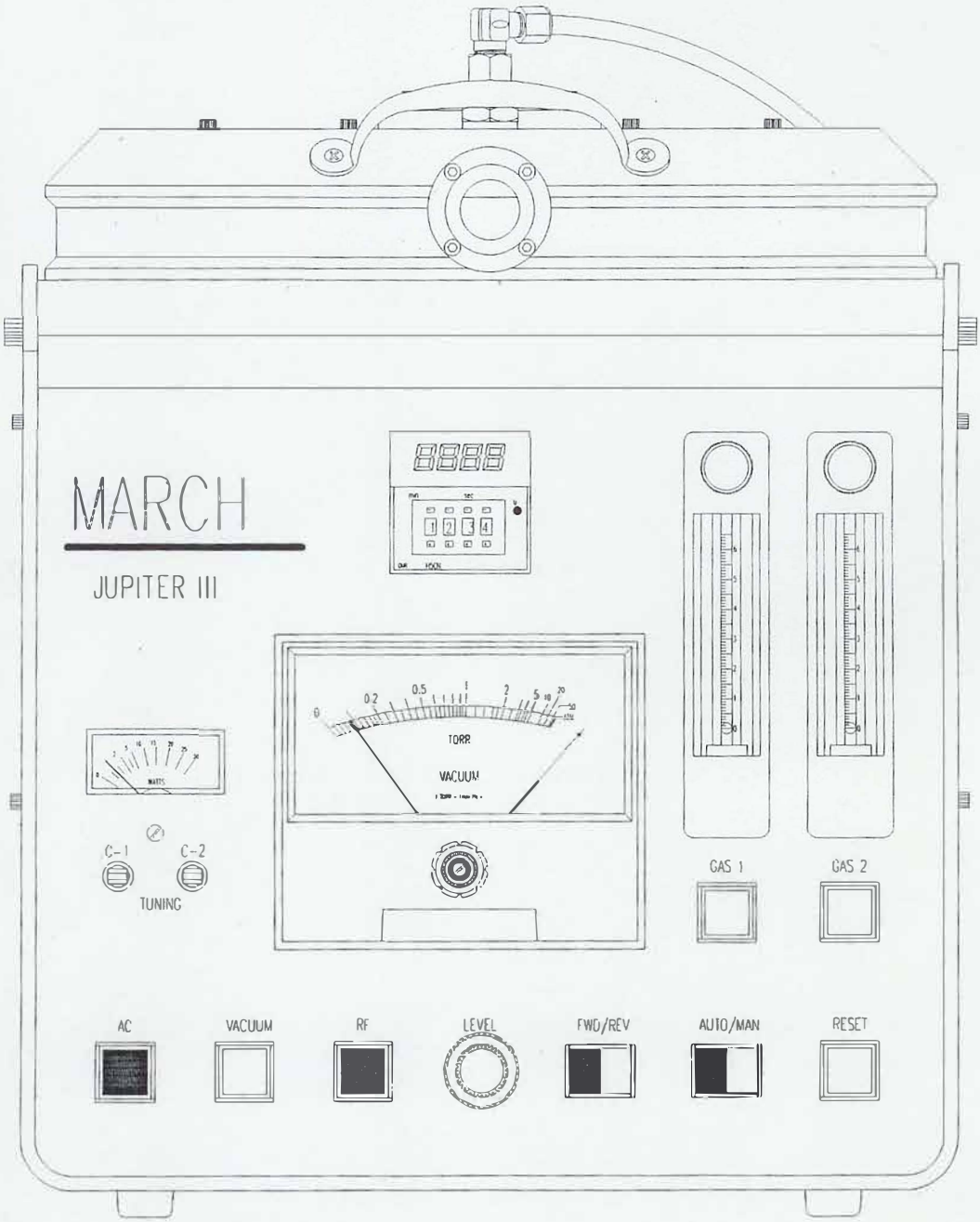
VACUUM INTEGRITY CHECKLIST

DATE:	PRESSURE AFTER 15 SECONDS (Torr):	TIME TO .15 TORR:	PRESSURE AFTER 20 MINUTES (Torr):

EQUIPMENT ORIENTATION

This section includes a general description of the overall plasma system as well as a more detailed description of the controls and indicators on the front and rear panels.

GENERAL EQUIPMENT DESCRIPTION



The Jupiter III plasma system is a parallel plate reactive ion etcher designed to meet the needs of today's failure analysis and research and development applications. It offers fast, uniform, and selective anisotropic etching. It consists of a single module which contains a vacuum control system, gas delivery system, and an RF generator.

Designed for maximum performance and flexibility, March Instrument's Jupiter III Reactive Ion Etching systems are tabletop etchers used primarily in failure analysis and small scale production plasma etching applications.

PROCESS CONTROL

The variable parameters of the plasma process, including chamber pressure, process duration and gas flow rates are monitored and regulated through the Process Control panel on the front of the unit. The Jupiter III houses two Flowrators for regulation of process gas flow, and the system is equipped with a Convectron convection device for pressure determination.

The unit can be operated in either an automatic or manual mode. In automatic mode built-in sequencing will:

- Vacuum down the chamber to the preset base pressure level.
- Turn on the selected gases to the preset flow rate.
- Turn on the RF power to the preset level when the gas flow has stabilized.
- Maintain these parameters until desired processing time has elapsed.

The Process Controller will then shut off the RF power and perform a complete evacuation of process gases. The chamber will vent to atmospheric pressure and the end-of-process alarm will sound. Manual mode provides the same control over process parameters but requires that each sequence step be initiated by the operator.

Process Control Elements

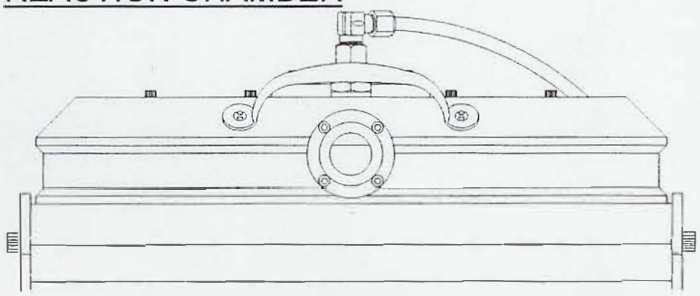
- Two rotary process gas flow meters (solenoid controlled)
- Convectron pressure gauge with base pressure set point
- Automated process sequencing with manual override and process timer
- Tuning Mismatch Alarm
- Automatic RF tuning

RADIO FREQUENCY POWER GENERATOR AND MATCHING NETWORK

The Jupiter III is equipped with a solid state RF (Radio Frequency) generator with a fixed frequency of 13.56 MHz and a maximum power output of 300 watts. Impedance matching is achieved through the employment of an Inductive-Capacitive tuning network. The tuning network functions by adjusting the forward to reflected power ratio during processing in order to achieve the best power transfer to the plasma. The forward power is the total power output from the generator at a given setting. Reflected power is undesirable and should be minimized during operation. It is the portion of the forward power that is lost from the plasma and reflected back towards the generator.

When the tuning network is operated manually, reflected power must be continuously monitored in order to keep it at a minimum. In auto mode, the tuning is automated for hands-off operation and convenience.

REACTION CHAMBER



The top-loading chamber is designed to ensure anisotropic etching and maximize selectivity, uniformity, and speed. A ceramic ring focuses the plasma on the bottom electrode where the sample is placed, thus optimizing power utilization to increase anisotropy and etch rate. Both electrodes are water cooled to maintain the chamber at a low temperature during processing. The size difference between the top and bottom electrodes produces a DC bias which enhances ion bombardment and anisotropy.

The chamber is equipped with a circular quartz viewing window for observation of the plasma process. The primary chamber material is anodized aluminum; other components are manufactured from ceramic and quartz. No plastic components are used in the construction of the chamber.

JUPITER III SPECIFICATIONS

The following are the specifications for the Jupiter III system:

Exterior Dimensions

- 18" (46 cm) D x 13" (33 cm) W x 16" (40.5 cm) H.

Weight

- 80 lbs. (36.4 kg)

Chamber Material

- Anodized Aluminum

Chamber Interior Dimensions

- 10" Diameter x 1.5" High

Installation Working Surface

- Designed for use on table top or counter.

RF Power Generator

- 0-300 watt RF Power Generator.
- 13.56 MHz operating frequency.
- Solid state circuitry.
- Automatic or Manual impedance matching.

CONTROLS AND INDICATORS

This section describes the controls and indicators on the Jupiter III system. Each control and indicator is numbered on Figures 7 and 8 for reference.

Front Panel Controls

1. **AC**. The AC power switch is a push-button lamp switch which activates and deactivates the main power. The button is lit when the power is on.

2. **AUTO/MAN**. Selection of Manual (user controlled) or Automatic (system controlled) Tuning Mode is accomplished by placing the switch in the AUTO or MAN position.

3. **GAS 1/GAS 2**. A button for each flowrator that turns the process gas flow on and off. When the button is lit, gas flow is activated via a solenoid. During automated operation, the vacuum set point must be reached before gas will flow. In manual operation, gas flow begins when the button is pressed, regardless of chamber pressure.

4. **Flowrators**. Each flowrator consists of a gas flow meter and a knob for adjusting the gas flow rate.

5. **Digital Timer**. Consists of a digital time display and plunger switches for changing the process time setting. The timer can be set to any desired process time up to 99 minutes and 99 seconds. The timer begins counting at the moment the RF power is activated. When running in Auto mode, the elapsed time (following application of RF power) is indicated on the display and processing stops when the timer reaches zero. In Manual operation mode, the timer is inactive.

6. **VACUUM**. Push button lamp switch which opens and closes the vacuum valve between the pump and chamber, allowing the chamber to be evacuated or bled back to atmospheric pressure. In the "on" position the vacuum solenoid valve is open and the bleed solenoid valve is closed (chamber under vacuum). When the switch is "off", the vacuum solenoid valve is closed and the bleed solenoid valve is open (chamber at atmospheric pressure).

7. **RESET**. When in automatic operation mode, pressing this button will reset the internal timers and RF relay so that the process sequence can be run automatically.

8. **Vacuum Meter**. Provides a digital display of chamber pressure in Torr. It has a logarithmic scale with a readable range from about 0.01 Torr to 50 Torr.

The meter is equipped with a threshold pressure set point mechanism, consisting of a red needle that is positioned by rotating the dial centered on the face of the meter. This allows operator control of the pressure at which the process sequence begins. In automatic operation mode, when the chamber pressure reaches the set point, any gas flow solenoids that are enabled will open to allow the process gas to pass through the flowmeters and into the chamber. Internal timing cycles also begin. During manual operation the threshold pressure set point is inactive.

9. **RF**. The RF power switch is a push-button lamp switch which lights when the RF power is on.

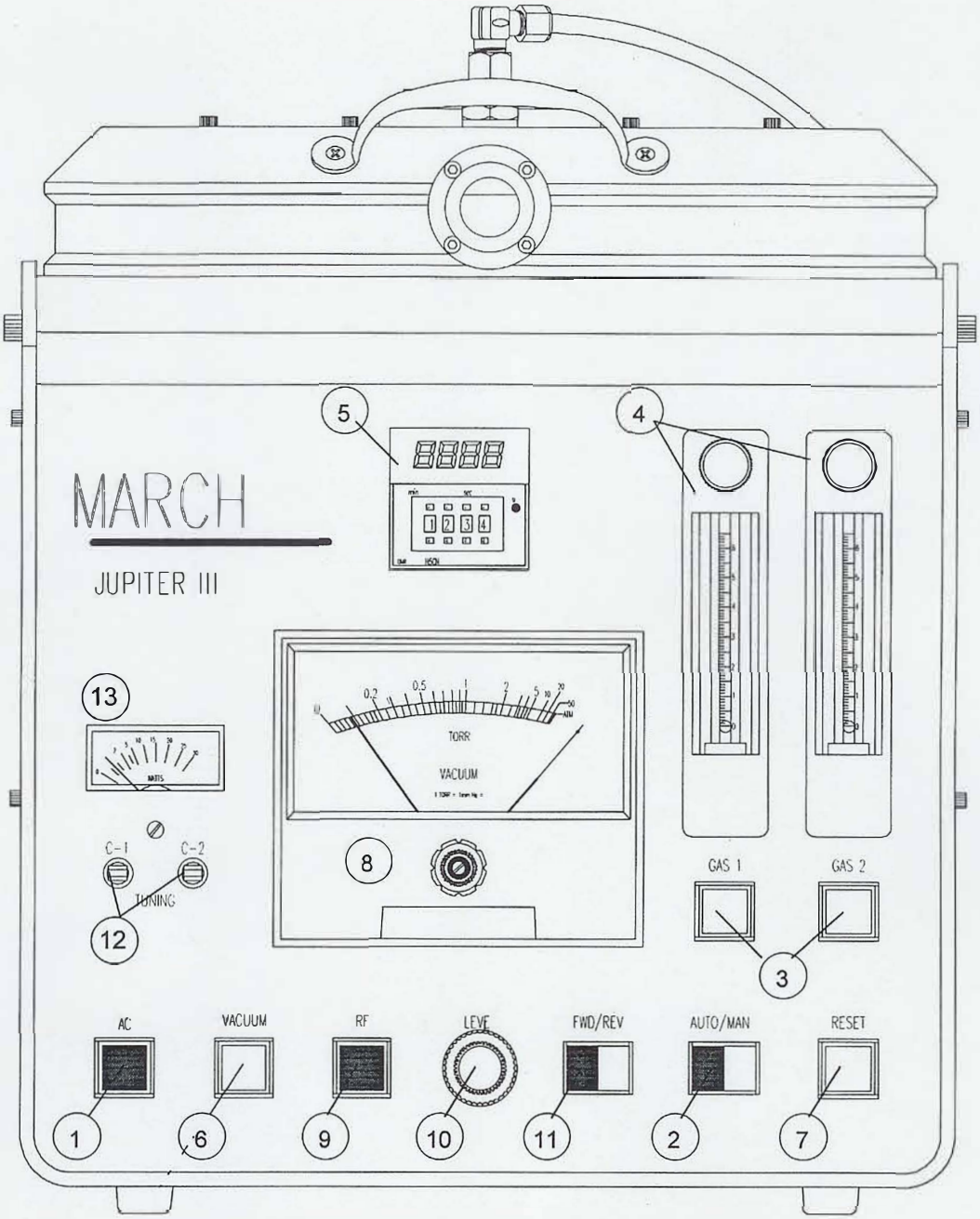


FIGURE 7.- Front Panel Controls and Indicators

10. **LEVEL**. The level control knob is a potentiometer which controls the power level.

11. **FWD/REV**. Toggles the RF meter display to indicate either forward RF power (FWD) or reflected RF power (REV) in watts.

12. **C1 & C2**. If the Manual tuning mode has been selected, toggling these switches controls the positioning of the air capacitors of the impedance matching network. Used to minimize reflected power by matching the impedance of the RF generator and the chamber.

13. **RF Power Meter**. Indicates forward or reflected RF power in watts. The FWD/REV switch determines which parameter is monitored.

Rear Panel Controls

14. **AUTO-MANUAL**. Toggles the machine between automatic and manual process operation modes.

15. **ALARM SPEAKER**. Audio alarm that sounds to indicate RF tuning mismatch.

16. **ALARM ON/OFF**. Switch used to activate/deactivate the tuning mismatch alarm. In the "ON" position, the alarm will sound when the RF power is out of tune. In the "OFF" position, the alarm is disabled.

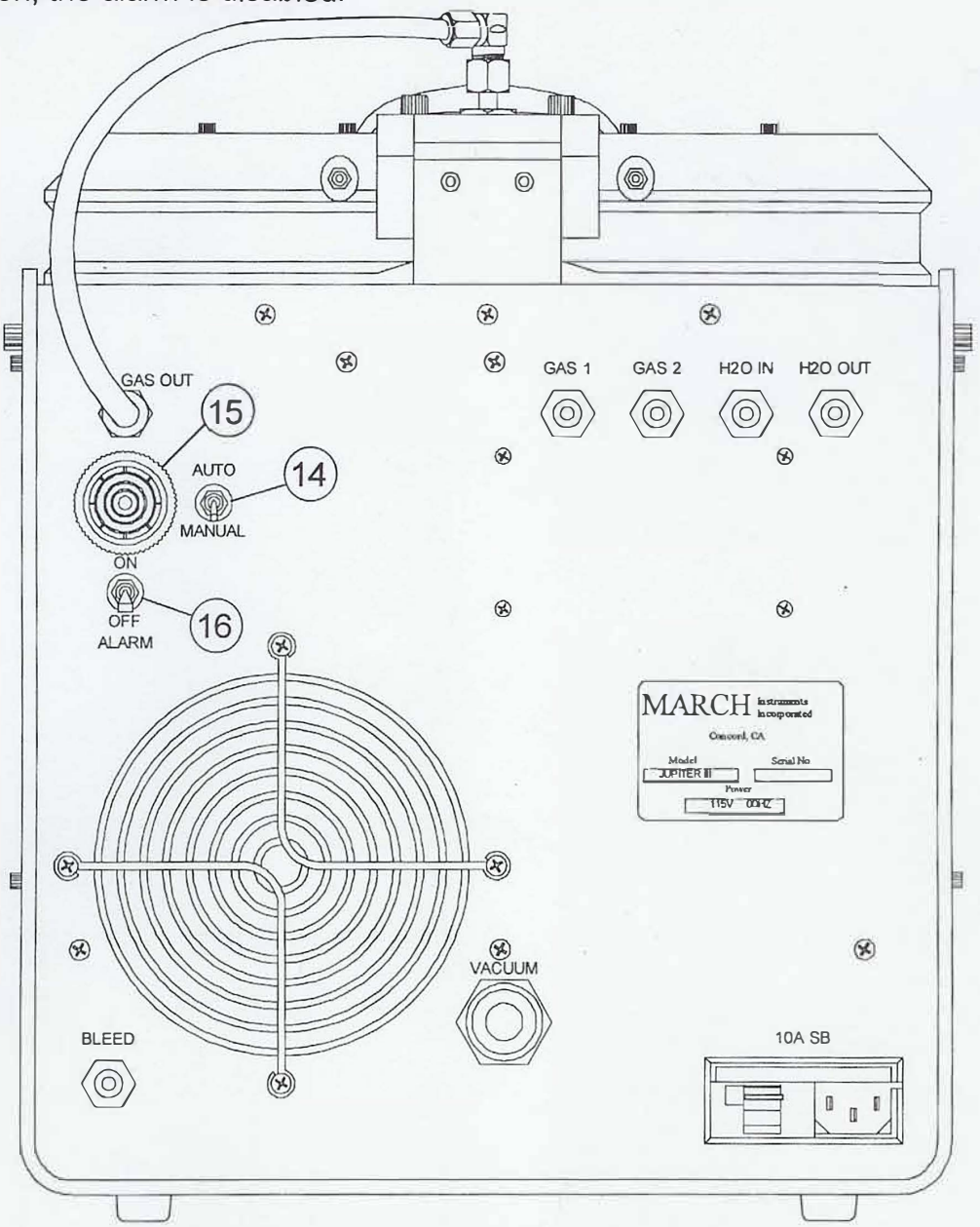


FIGURE 8.- Rear Panel Controls and Indicators

THEORY OF OPERATION

This chapter gives an overview of plasma and plasma processes. It outlines the basic requirements to create a plasma and what variables are under operator control.

THE PLASMA PROCESS: AN OVERVIEW

A gas plasma consists of a collection of ions, free radicals, and electrons produced when a gas is transformed to a high energy, excited state by exposure to an energy source under the right physical conditions. Natural plasma examples include lightning, fire, and the Aurora.

Plasma treatment is a process by which the surface of a material is modified in some way through the actions of the dissociated molecular components of a gas. Because these components are in such a high energy state, they are very chemically reactive and can easily affect changes to the surface of materials. The changes that occur are complex and dependent on many variables including gas chemistry, process pressure, and the surface chemistry of the material being processed. A key advantage to plasma treatment is that only the surface (first several molecular layers) of the material is altered; the characteristics of the bulk material remain the same.

In etching and cleaning processes, unwanted material is removed from the surface of the substrate using a relatively high energy plasma. The process breaks the contaminant molecules into smaller pieces which volatilise and are then swept out of the chamber by the vacuum pump.

Surface activation processes work by altering the first several molecular layers of the bulk material through incorporation of chemical functional groups that increase the surface energy of the material. This leads to improvements in the adhesion and wettability of the treated material.

BASIC ELEMENTS OF PLASMA TREATMENT

To plasma treat a sample in the Jupiter III, the basic steps are:

1. Place the material to be treated into the chamber.
2. Seal the vacuum chamber by closing the lid.
3. Pump the vacuum chamber down to a low, preset pressure level.
4. Introduce a process gas or gases into the chamber.
5. Apply RF energy to the low pressure gas in the chamber to light the plasma.

To end the process:

1. Stop applying RF energy to the chamber.
2. Stop the flow of process gases.
3. Bleed the chamber back to atmospheric pressure.
4. Open the vacuum chamber.
5. Remove the treated material from the chamber.

These steps are flow charted on the next page.

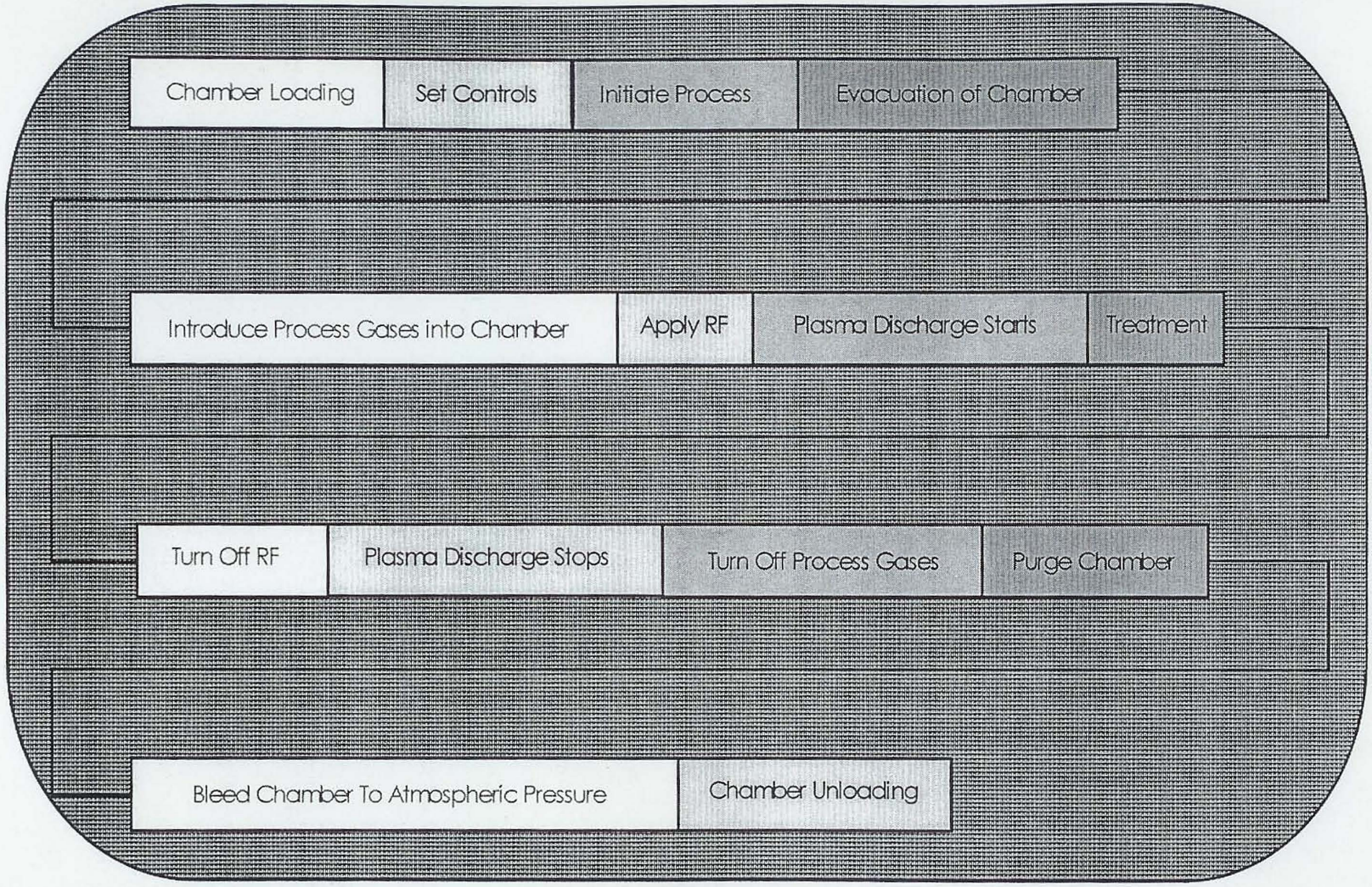
CAUTION: THE CHAMBER CAN BECOME VERY HOT DURING SOME PROCESSES. EXERCISE CAUTION TO PREVENT BURNS.

In order to develop and optimize a plasma process for a given material, the operator has the ability to alter the following parameters:

- Process gas(es) selected for use.
- Flow rate/pressure of selected gas(es).
- Amount of RF energy applied to the vacuum chamber.
- Amount of time material is exposed to the plasma.
- Vacuum chamber threshold pressure (the pressure setting that must be achieved before the process can start).

Process pressure, RF power, and treatment time are the primary factors that affect the intensity of the treatment. For example, a high energy treatment would be run under conditions of relatively low pressure, high power, and long treatment time. Conversely, a low energy treatment would be run under conditions of relatively high pressure, low power, and a short treatment time.

Since every material has different treatment requirements and many factors need to be taken into account, it is difficult to say what type of treatment will give the desired results. A general rule would be that energetic processes are better for cleaning and etching applications; more moderate processes are better for surface activation applications.


Chamber Loading
Set Controls
Initiate Process
Evacuation of Chamber
Introduce Process Gases into Chamber
Apply RF
Plasma Discharge Starts
Treatment
Turn Off RF
Plasma Discharge Stops
Turn Off Process Gases
Purge Chamber
Bleed Chamber To Atmospheric Pressure
Chamber Unloading

SETUP

This section illustrates the proper use of various equipment and process options.

ADJUSTING GAS FLOW

The operator can control the flow rate of each individual gas and mix two gases entering the plasma chamber. The scaling on the flowmeter ranges from 0 to 65 mm and the gas flow is linear within mid-range. The standard flowrators can each regulate up to 50 cc/min of air at standard temperature and pressure.

It is important to note that each type of process gas has a different flowrate at a given flowrator setting. The flowrates for the most common process gases at various flowrator settings are listed under Gas Flow Settings, page 50.

When running two process gases at once, the operator should know the ratio of the two gases flowing into the chamber for future reference. Simple chamber pressure ratios (rather than flowrate ratios) are sufficient for most applications:

Example:
You want to process the sample with 300 mTorr of process gas at a ratio of 90% CF_4 and 10% O_2. Oxygen is Gas 1 and CF_4 is Gas 2.
90% of the total process gas pressure is due to CF_4- .90 x 300 = 270 mTorr
10% of total process gas pressure is due O_2- .10 x 300 = 30 mTorr

1. Press the VACUUM button and allow the chamber to evacuate for five minutes to ultimate vacuum.
2. Adjust the flow of the gas contributing the most pressure first. In this case, turn on GAS 2 and adjust the flow until the pressure reads .27 Torr over the ultimate pressure from step 1.
3. Turn on GAS 1 and adjust the flow until the pressure reads .03 Torr above the pressure value determined from step 2.
4. The flow meters are now set and you are ready to begin processing samples.

TUNING THE RF MATCHING NETWORK

The Jupiter III Plasma System utilizes an L-C tuning network to ensure maximum transfer of energy into the chamber. The unit is equipped with a manual tuning system comprised of motor driven air capacitors which, when the system is operated in manual tuning mode, are positioned by the operator to achieve minimum reflected power during processing. This positioning is accomplished through front panel mounted switches (C1 and C2). When running in Auto tuning mode, circuitry automatically monitors the forward-to-reverse power ratio on a continuous basis during processing and positions the air capacitors for optimum power transfer to the chamber. This is the preferred mode of operation.

CAUTION: REFLECTED POWER LEVELS THAT BECOME EXCESSIVE CAN CAUSE DAMAGE TO, OR FAILURE OF, THE RF POWER GENERATOR. IT IS VITAL THAT REFLECTED POWER BE MONITORED AND KEPT TO A MINIMUM LEVEL DURING OPERATION.

Manual Tuning

- Toggle the AUTO/MAN tuning mode switch to MAN position.
- Toggle C1 and C2 switches to minimize reflected power.
- Reflected power value is displayed on the RF Power Meter.

Automatic Tuning

- Toggle the AUTO/MAN tuning mode switch to the AUTO position.
- Reflected power value is displayed on the RF Power Meter.
- Monitor reflected power during the plasma process to ensure proper operation of Auto tuning.

PROCESS PROGRAMMING

This section describes the programming steps necessary for running processes in both the Manual and Automatic operational modes. The procedure for shutting down the system is also included. Before turning on the system, refer to the Initial Start Up, page 13.

MANUAL OPERATION

When developing a process, the Manual mode is used to determine gas setting versus pressure relationships and to set the RF power level for future runs in Auto mode.

1. Close the chamber lid.

2. Toggle the AUTO/MANUAL switch on the rear of the system to enable manual operation.

3. Ensure that the AUTO/MAN button on the front panel is set to AUTO (for automatic RF tuning).

4. Press the VACUUM button on the front panel to begin evacuating the chamber.

5. When the Pressure Display on the front panel reads less than 200 mTorr, press the GAS button corresponding to the desired process gas.

6. Turn the gas flow rate knob on the flowrator until the desired chamber pressure is achieved.

Ensure Cooling Water is ON

7. Press the RF button on the front panel so that the button is lit.

8. Ensure that the FWD/REV button on the front panel is set to FWD, then turn the power level knob on the front panel until the desired power level is observed on the power meter. A plasma should be visible in the chamber.

9. Monitor the reflected power on the power meter by pressing the FWD/REV button so that REV is selected. Reflected power should not be any higher than 5% of the forward power setting.

10. Press the RF button to shut down the RF power.

11. Deactivate the GAS buttons.

12. Press the VACUUM button to bleed the chamber back to atmospheric pressure.

AUTOMATIC OPERATION

Now that the desired settings for gas flow and RF power have been established in manual mode, the operator can run the process in Automatic mode:

1. Enter the desired amount of process time into the process timer by pressing the plunger switches (labeled + and -).

2. Place sample of material to be treated into the chamber and close the lid.

3. Toggle the AUTO/MANUAL button on the rear of the system to enable Automatic operation.

4. Turn the red Threshold Pressure Setpoint needle on the Pressure Meter to the desired threshold pressure for beginning the process.

5. Press the GAS buttons to enable the desired gas channels.

6. Press the RF button to enable RF power.

7. Press the RESET button to reset the system internal timers.

8. Press VACUUM button. The system will now run through all the steps necessary to complete the process.

9. When the process is complete, press the VACUUM button again to vent the chamber to atmospheric pressure. The sample can now be removed from the chamber.

10. For future runs under the same conditions, press the RESET button followed by the VACUUM button.

SYSTEM SHUT DOWN

Procedure for complete system shutdown:

1. Press the RF button to shut off RF power.

2. Turn off the gases by pressing the GAS buttons.

3. Press the VACUUM button to vent the chamber.

4. Press the AC button to shut off the system main power.

5. Unplug vacuum pump.

6. Turn off the chiller.

SERVICE AND MAINTENANCE

This section gives information on the warranty and details on servicing the equipment. Recommended maintenance and part replacement procedures are outlined. A trouble shooting guide is also included.

WARRANTY

1. This March system is guaranteed to be free of defects in workmanship and components. This warranty covers labor for a period of ninety (90) days and parts for a period of one (1) year, with the exception of ceramics, glass, seals, lubricants, and consumable parts such as rollers, bearings etc.

2. The exclusive remedy for any breech of this warranty is as follows: March Instruments, Inc. will furnish without charge, repairs to or replacement of those parts proven to be defective in material or workmanship. March Instruments, Inc. will issue a Return Authorization number for the defective parts. The customer will give March Instruments, Inc. a Purchase Order number of a dollar amount to cover the cost of these parts. Once the system is operational the customer will return all defective and/or unused parts back to March Instruments, Inc. with the Return Authorization number on the outside of all packages. Once these parts are received a credit will be given minus any shipping or transportation costs. No claim may be made for any incidental or consequential damages.

3. All transportation and shipping charges shall be borne by the customer.

4. March Instruments, Inc. will inspect the equipment and decide upon such repairs or replacement as are necessary. The customer will be notified of any charges incurred that are not covered by this warranty prior to undertaking those repairs.

5. Any customer modification of this equipment, or any repairs undertaken without prior written consent of March Instruments, Inc. shall render this warranty void.

6. This warranty is expressly in lieu of all warranties, expressed or implied, including implied warranty of merchantability or fitness for a particular purpose unless otherwise agreed to in signed correspondence from March Instruments, Inc. March Instruments, Inc. shall not be responsible for any damage caused by improper installation, use, servicing or testing of equipment.

NOTE: PLEASE COMPLETE AND RETURN ALL WARRANTY REGISTRATIONS RECEIVED WITH THIS SYSTEM. WARRANTY CLAIMS FOR SYSTEMS COMPONENTS SOLD BUT NOT MANUFACTURED BY MARCH INSTRUMENTS, INC. SHOULD BE PURSUED THROUGH THE DEFECTIVE EQUIPMENT'S MANUFACTURER.

SERVICING

If a March Instruments, Inc. product requires service or if technical assistance is desired, contact the Customer Service Department at 510 827 1240 (or by fax at 510 827 1189). Be prepared to provide:

- The serial number of Plasma System and all associated components.
- A detailed description of process parameters, including material being etched, gas or gases used, chamber pressure during process, RF power levels applied and duration of process.
- A detailed description of the problems encountered.

If a unit is to be returned to March Instruments for service or for any other reason, the following procedures must be followed:

- Obtain a Return Authorization number (RA) through the March Customer Service Department. Display this number on your shipping label. A unit received without an RA number visible will be rejected.
- Re-pack the system in its original shipping container. If this is no longer available, take special precautions to avoid damage to any glass chamber sections and other fragile components. An approved shipping container may be purchased from March Instruments.
- If the system is under warranty, you will be charged only for travel expenses and/or shipping costs. If the system is out of warranty, a purchase order will be required and you will be billed for all parts, service, shipping costs and/or travel expenses.

RECOMMENDED SPARE PARTS

The following is a list of recommended spare parts for the Jupiter III system. The location of the parts on the system is shown on the following pages.

Part Number	Quantity	Description
004-7004	1	O'ring 345 viton
004-7005	1	O'ring 259 viton
004-7006	1	O'ring 240 viton
004-7013	1	O'ring 449 viton
004-7015	1	O'ring 262 viton
004-7014	1	O'ring 023 viton
004-7023	1 Ft	Tubing, Teflon, .5" OD x .068"
008-1032	4	Lamp, Incandescent
008-1066	2	Fuse, 10A, 250V
009-1011	1	Gauge Tube, Teledyne DV24
009-1021	1	Solenoid Valve, B2DX288 110V
009-1023	1	Valve, Vacuum, 8272C90V
011-2006	1	Centering Ring, K100-CR
002-5006	1	Window, Quartz

Above parts available in a single kit.

USER MAINTENANCE

User-performed maintenance required for Jupiter III System is minimal. However, regular attention to the suggested maintenance tasks listed below will help to ensure proper operation and maximum availability of the system. To ensure maximum performance and process repeatability, the following items should be checked at regular intervals, the frequency of which is dependent upon the level of use of the system.

CLEANING THE CHAMBER

Depending on the process, the inside of the reaction chamber may need to be cleaned regularly with isopropanol or another suitable cleaning agent. It should be noted that isopropanol is listed as a volatile organic compound and its use, even as a maintenance chemical, may be restricted by local government agencies. Use of an abrasive pad (like 3M) in conjunction with the cleaning agent is recommended except on the quartz viewport.

CAUTION: ISOPROPANOL IS A MILD SKIN AND EYE IRRITANT. USE GLOVES AND EYE PROTECTION WHEN CLEANING THE CHAMBER.

If CF4 is used as a process gas, the recommended cleaning method is to scrub the chamber with hot, soapy water and then rinse, first with DI water, then with alcohol.

After cleaning the chamber, always generate an argon or oxygen plasma for at least ten minutes at high power to remove any residual contamination.

One means of ensuring chamber cleanliness in the absence of visual indications is to:

1. Pump the chamber down to it's minimum achievable base pressure and record that value.
2. Generate an argon or oxygen plasma for fifteen minutes at high power and 400 mTorr.
3. Pump the chamber down to it's minimum achievable base pressure a second time and record that value. Compare this value to the first value. If there has been a notable decrease from the first pump-down to the second it is an indication that cleaning of the chamber has occurred while running the plasma.
4. Repeat this process until no discernible difference is noted in minimum base pressure from one test to the next.

NOTE: USE OF CF_4 OR SIMILAR GASES CAN CAUSE A COATING OF THE REACTION CHAMBER AND IT'S COMPONENTS WITH BYPRODUCTS OF THESE GASES (TEFLONS). WHEN USING THESE TYPES OF GASES IN PLASMA PROCESSES, THE CLEANING REGIMEN MUST BE REPEATED VERY FREQUENTLY TO REMOVE THE BYPRODUCTS AS THEY WILL EASILY REDEPOSIT ONTO CLEAN SURFACES OF MATERIALS THAT YOU ARE TRYING TO TREAT.

As a general rule, the chamber should be cleaned at least once a month but the frequency is very process dependent. A dirty chamber is usually obvious on visual inspection. The time to solvent clean the chamber and run a cleaning plasma should be about 30 minutes.

VACUUM INTEGRITY

It is necessary to periodically check the vacuum integrity of the system. This check should be performed only after thoroughly cleaning the chamber to avoid confusing contaminant out-gassing with vacuum leaks. The test is accomplished by completing the following steps:

1. Toggle the AUTO/MANUAL switch on the rear of the system to select manual mode.
2. Depress the VACUUM switch on the front panel to commence pumping down the chamber. Start timer.
3. Record the time required to reach a pressure of .15 Torr. The pressure should fall below .15 Torr less than 5 minutes after the pressing the VACUUM switch.
4. Wait 20 minutes to allow any residual moisture to exit the system and record the ultimate pressure shown on the display.

Save the vacuum check data for future reference and comparison purposes. This same procedure should be run periodically in order to recheck the vacuum integrity.

Successful operation of the vacuum system ensures optimum performance and repeatability of this system. If any discrepancies were noted compared to prior vacuum checks, inspect the chamber gasket (plastic strip around the rim of the chamber). Dirt and contaminants can sometimes build up on the gasket, compromising vacuum integrity. Also check the gas line connections on the inside and outside of the Process Controller for obvious damage or leakage.

Vacuum integrity should be checked once a month. A competent technician should be able to accomplish this task in 25 minutes.

VACUUM PUMP OIL

Many of the problems with the vacuum system are associated with the vacuum pump oil. It is important that the oil condition be checked periodically to verify that it is at the proper level and free of contaminants. Dirty or insufficient oil can result in poor vacuum pump performance. Dirty oil can also lead to possible chamber contamination due to the increased vapor pressure backstreaming into the chamber from the contaminated oil.

To change the pump oil:

1. Allow 15 minutes for the pump oil to cool slightly before beginning the operation. The pump oil should not be cold as this makes it difficult to remove from the system.
2. Vent the oil case to atmospheric pressure.
3. Disconnect the pump from the system.
4. Flush the pump with dry nitrogen to clear out any residual toxic or corrosive gases.
5. Tilt pump in the direction of the drain plug.

CAUTION: THE PUMP OIL IS A SKIN AND EYE IRRITANT. ALWAYS USE EYE PROTECTION AND APPROVED PERSONAL PROTECTIVE EQUIPMENT WHEN CHANGING THE PUMP OIL.

6. Unscrew the drain plug and drain the oil.

7. Replace the plug and run the pump for about ten seconds, leaving the inlet port open. This removes the oil from the pumping module.
8. Drain this oil by removing the plug again.
9. Replace plug and fill with fresh oil to the middle of the oil sight glass by dumping the oil into the oil fill port.

Refer to the pump manual for explicit instructions on this and all other pump procedures.

Some plasma processes may create a larger degree of pump oil contamination than others. Additional personal protective equipment may be necessary in some cases. The end user of this equipment should conduct industrial hygiene sampling in accordance with NIOSH, or other nationally recognized standards or test procedures, during the changing of the pump oil. Do not allow this pump oil to flow down the sewer drain.

Pump oil should be changed at least once a year. If the system is getting a lot of use and the process being used creates a large amount of contamination, the oil may need to be changed as often as every two months. If the pump oil appears visually dirty, it needs to be changed. Check the pump oil at least once a month. A competent technician should be able to change the pump oil in about one hour.

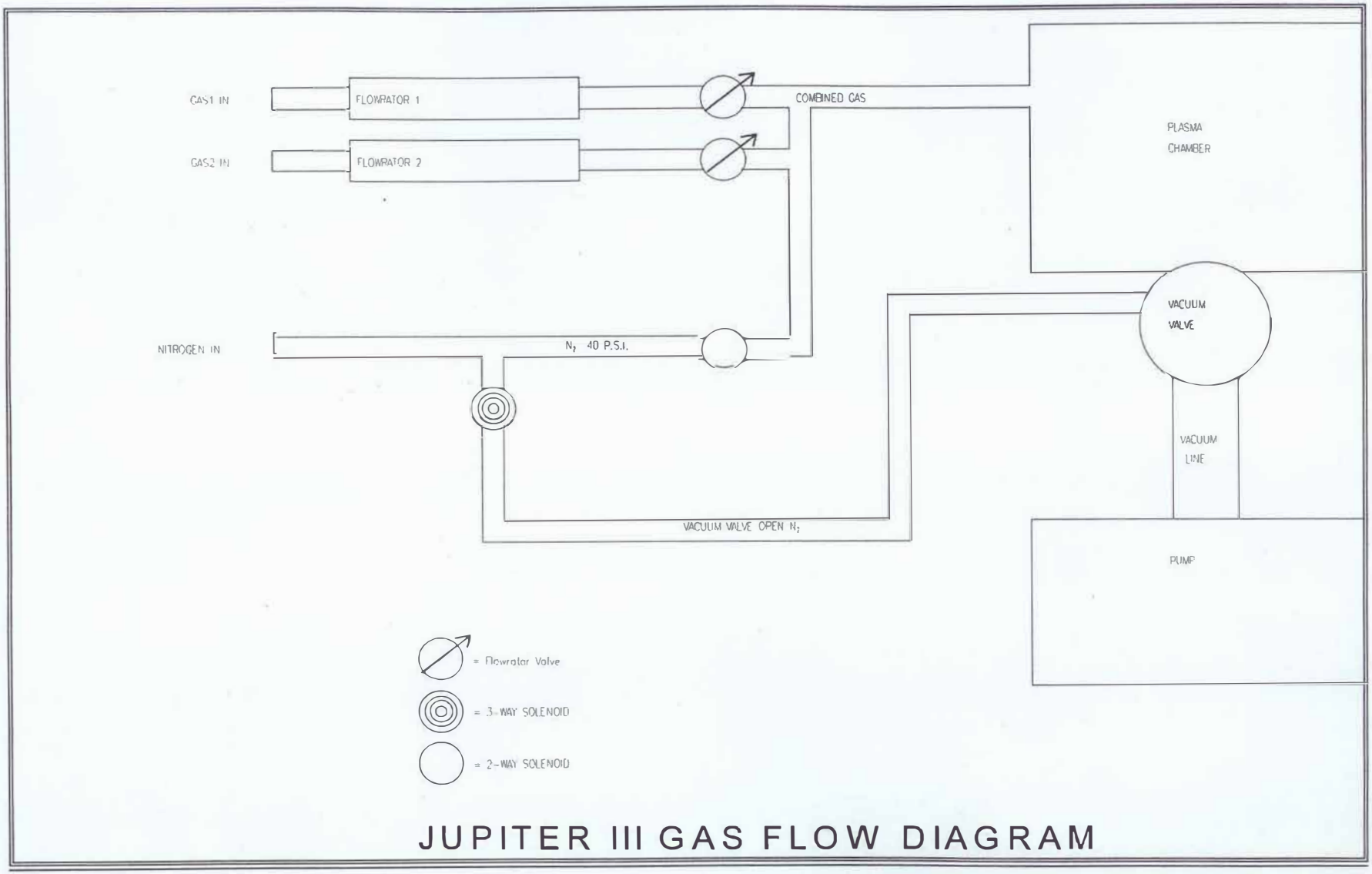
VACUUM LEAK DETECTION

A vacuum leak can often be detected by using isopropyl alcohol. By bathing the suspected component in the volatile liquid, a vacuum leak will suck in the vapors and cause a rise in pressure on the display panel. A rise of 10 mTorr or more would indicate a faulty vacuum component or connection. To detect small leaks, it is necessary to keep the flow of alcohol on the component or connection for approximately 10 seconds. Small leaks will not show up with a quick wetting. The flow of alcohol should cover the entire connection or component associated with the vacuum. When using the alcohol, avoid contact with the connection lettering on the back of the system as this will cause the surface to turn white and the lettering will disappear.

If the system will not pump down below 1500 mTorr, this method of leak detection may not be useful. The user will do best by following the troubleshooting chart on the following pages to locate and fix the leak.

JUPITER III MAINTENANCE CHECKLIST

DATE:									
CHAMBER CLEANING									
VACUUM CHECK									
PUMP OIL CHECK									
PUMP OIL CHANGE									



JUPITER III GAS FLOW DIAGRAM

SYSTEM TROUBLESHOOTING

This section is a troubleshooting guide for the various components in the system along with a listing of the necessary tools. The SEMI S2-93 level of hot work is also given for any maintenance procedure that must be performed with the system electrically energized.

WARNING: BEFORE BEGINNING ANY REPAIR OR MAINTENANCE RELATED PROCEDURE THAT REQUIRES REMOVAL OF EXTERNAL PANELS, DISCONNECT THE POWER AND APPLY THE APPROPRIATE LOCKOUT DEVICE TO THE POWER PLUG IN ORDER TO PREVENT RE-ENERGIZATION OF THE EQUIPMENT.

TOOL REQUIREMENTS

The following tools will be required at one time or another to perform the troubleshooting procedures in this section. Some tools can be used in place of others, i.e. adjustable wrench in place of a 9/16 wrench.

1.) Digital Voltmeter capable of reading 0-230VDC, 0-230VAC, Continuity, and Resistance from 0-2M OHM.
2.) Watt meter capable of reading 0-1000 Watts at 13.56Mhz.
3.) Open end wrenches consisting of the following:
3/16", 1/4", 5/16", 3/8", 7/16", 1/2", 9/16", 5/8", 11/16", 3/4".
4.) Allen wrench set consisting of the following:
.050", 1/16", 5/64", 3/32", 7/64", 1/8", 9/64", 5/32", 3/16", 7/32", 1/4", 5/16".
5.) Slotted screwdriver set consisting of the following:
1/8" X 2" blade, 3/16" W X 1 1/4" L blade, 5/32" W X 4" L blade, 1/4" W X 4" L blade, 3/16" W X 6" L blade, 5/16" W X 6" L blade.
6.) Phillips screwdriver set consisting of the following:
#0 X 2" blade, #1 X 2 3/4" blade, #2 X 3 3/4" blade, #1 X 10" blade, #2 X 10" blade, #1 X 1 1/4" blade, #2 X 1 3/8" blade.
7.) 4" and 6" pair of wire cutters.
8.) 5" and 6 3/4" pair of needlenose pliers.
9.) 1 pair of 10" tongue and groove pliers.
10.) Nut driver set consisting of the following:
3/16", 7/32", 1/4", 9/32", 5/16", 11/32", 3/8", 7/16", 1/2", 9/16".
11.) 4" adjustable wrench.
12.) 10" adjustable wrench.
13.) 1 pair of slip joint pliers.
14.) 1 pair of wire strippers capable of stripping from AWG 24 to AWG10 wire sizes.
15.) 1/4" Swagelok fitting caps, 4 ea.

DEFINITION OF HOT WORK LEVELS

These definitions apply to Hot Work Levels referred to in the following Troubleshooting and Replacement Procedures sections.

LEVEL 3: Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are less than 30 volts RMS, 42.2 volts peak, 240 volt-amps, and 20 Joules.

LEVEL 4: Equipment is energized. Live circuits are exposed and accidental contact is possible. Voltage potentials are greater than 30 volts RMS, 42.2 volts peak, 240 volt-amps, and 20 Joules or RF is present.

Table 4-1. Power/Display System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) Front panel displays do not light up when AC power switch is on.	1.) Power cord disconnected.	Reconnect power cord.	****
	2.) DC Power supply inoperative.		
	3.) Power supply electrically shorted.		

Table 4-2. Vacuum System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) Chamber will not evacuate (needle on pressure gauge does not move).	1.) Pump not running.	Ensure pump is plugged in and has power to it.	****
	2.) Pump oil dirty or not at correct level.	Check and replace oil as necessary.	****
	3.) Oil filter clogged.	Clean/replace oil filter.	****
	4.) Vacuum line kinked or blocked.	Remove blockage and ensure a free path from pump to system.	****
	5.) Faulty vacuum valve.	Repair/replace vacuum valve.	****
	6.) Faulty vacuum gauge.	Repair/replace vacuum gauge.	****

Table 4-2. (Continued) Vacuum System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
B.) Chamber evacuates partially but does not go all the way down to normal base pressure.	1.) Chamber Dirty.	Clean chamber per instructions on page 30 and perform leakback check.	****
	2.) Pump oil dirty or not at correct level.	Check and replace oil as necessary.	****
	3.) Oil filter clogged.	Clean/replace oil filter.	****
	4.) Vacuum line kinked or blocked.	Remove blockage and ensure a free path from pump to system.	****
	5.) Chamber gasket faulty.	Lid gasket should be clean and free of debris, cracks, or pitting. Separate inside and check for cracks. Replace gasket if any abnormality is detected.	****
	6.) Leaking vacuum valve.	Repair/replace vacuum valve.	****
	7.) Leaking vacuum component or connection.	Remove system side covers. Check all connections and components associated with the chamber vacuum using the procedure outlined on page 32. Check around all feedthroughs. Replace components as needed.	LEVEL 3
	8.) Faulty pump.	Replace pump.	****
	9.) Leak between system and vacuum pump.	Tighten all connections from system to pump.	****
	10.) Faulty vacuum gauge.	Repair/replace vacuum gauge.	****

Table 4.3 Gas System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) Process gas does not appear to flow into chamber, as indicated by increase in chamber pressure (If in Auto mode, try checking gas flow in Manual mode of operation).	1.) Gas bottle empty.	Replace gas bottle.	****
	2.) Gas turned off.	Turn gas on.	****
	3.) Process gas not regulated to 10-15 psi.	Regulate gases properly.	****

Table 4.4 RF System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) RF power does not turn on.	1.) Faulty RF generator.	Repair/replace RF generator.	****
	2.) No time value set on process timer (automatic operation mode only).	Set a time value on the timer.	****
B.) System not Autotuning (If system will not Autotune, try Manual tuning).	1.) Loose or broken motor couplers.	Remove system external covers. Turn on main power to the system. Place the AUTO/MAN tuning switch in the MAN position. While observing the tuning network capacitors inside of the system enclosure, hold the C1 switch in the down position. The top capacitor should rotate one direction.	****

Table 4.4 (Continued) RF System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
B.) (Continued)		Hold the C1 switch in the up position. The top capacitor should rotate in the opposite direction. Do the same check using the C2 switch while observing the lower capacitor. If either capacitor does not rotate both ways, check motor couplers for tightness at the shaft of the capacitor and shaft of the motor. Also check for broken coupler. Replace as necessary.	
	2.) Phase/Magnitude module (located within system external enclosure) is not securely connected to the wiring harness.	Tighten the connection.	****
	3.) Phase/Mag module needs adjustment/alignment.	Follow procedure outlined in Tuning and Replacement Procedures, page 45.	LEVEL 4
	4.) Chamber pressure is not between 300 and 1200 mTorr.	Bring chamber pressure within acceptable limits.	****

Table 4-5. Bleed System Troubleshooting

Problem	Possible Cause	Solution	Hot Work
A.) System will not bleed back to atmospheric pressure when the VACUUM switch is pressed.	1.) Bleed valve failure.	Replace bleed valve.	****
	2.) Vacuum valve failure.	Replace vacuum valve.	****

TUNING AND REPLACEMENT PROCEDURES

The following section describes the tuning and replacement procedures that may be necessary for the Jupiter III system.

CAUTION: THESE CAUTIONS ARE APPLICABLE TO THE ACTIONS DETAILED ON THE FOLLOWING PAGES:

- **LINE VOLTAGE HAZARD EXISTS WHEN THE EXTERNAL PANELS ARE REMOVED.**
- **RADIO FREQUENCY VOLTAGE AND EXPOSURE HAZARD EXISTS WHEN THE EXTERNAL PANELS ARE REMOVED.**
- **HIGH TEMPERATURE BUILDUP WILL OCCUR ON SOME ELECTRONIC COMPONENTS AND HEAT SINKS INSIDE THE EXTERNAL PANELS DURING OPERATION.**

THE RF SYSTEM

This portion of the manual provides information necessary to perform Maintenance, Fault Isolation, and Removal and Replacement of subject assemblies in the RF system. It also details Adjustments required for proper operation.

Fundamentals of Operation

Autotuning circuitry consists of an RF Phase and Magnitude sensing device, a Tuning Controller and associated wiring. The RF Phase and Magnitude sensing device measures forward and reverse power magnitudes and phase relationships of the RF as it is applied to the tuning network. Phase of the RF power is measured at two points; magnitude is similarly measured. The measurement at one point is compared to that at the other point. If any difference exists, it is output as a voltage to the amplifiers on the tuning controller printed circuit board. Here it is amplified to a level sufficient to drive the tuning motors which control the positioning of the variable capacitors of the tuning network. When these capacitors are properly positioned, there will be minimal standing waves in the RF transmission lines which will result in little or no difference in the value of the phase or magnitude of the RF when measured at the two sensing points. This, in turn, results in a zero volt difference between these points. No drive voltage for the tuning motors is created and the tuning capacitors will retain their position until the tuning degrades. When this occurs, the phase/magnitude sensor will detect the difference, and express it as a voltage, which will be amplified by the tuning controller amplifiers for application to the tuning capacitor motors and drive the tuning capacitors to values capable of most effectively coupling the RF power to the plasma.

When the Automatic/Manual Tuning switch on the control panel of the unit is placed in the AUTO position, the output of the amplifiers on the tuning controller PCB are applied to the tuning capacitor positioning motors. When the same switch is placed in the MANUAL mode, the operator controls tuning by applying a drive voltage of + or - 15V to the individual drive motors through switches C1 & C2. By monitoring reverse (or reflected) power via the RF Meter on the control panel of the unit the operator can manually tune for a minimum reverse power level.

Maintenance
No regular maintenance is required.

Fault Isolation
The following procedure is to be used in determining the cause of problems with the components in the RF system.

Hot Work Level 4

Required Materials:
- Multimeter
- Standard assortment of hand tools (See list on page 35)

Procedure

1. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
2. Observe forward power indication on RF Level meter. It should be possible to obtain an indication of the maximum level that the RF generator installed in the system is capable of achieving. The unit should be manually tuned for minimum reverse power as indicated on the RF Level meter. If it is not possible to manually tune the unit for a reverse power level of 5 watts or less, proceed no further. Contact March Instruments to arrange for factory reconfiguration of the tuning network.
3. Once unit is manually tuned properly, place the control panel mounted tuning mode selection switch in the AUTO position. The system should maintain approximately the same low value of reverse power as indicated on the RF level meter. The unit may temporarily go out of tune when switching from Manual to Automatic tuning but will return to a tuned condition after a few seconds. This is normal and expected. If the unit remains out of tune for more than 30 seconds, return to manual tuning and tune unit or turn off RF to prevent damage to the power amplifier.
4. Increase and decrease chamber pressure by adjusting gas flow. The unit should maintain approximately the same low value of reverse power as indicated on the RF level meter.
5. Increase and decrease RF power level by RF generator output. The system should maintain approximately the same low value of reverse power as indicated on the RF level meter.
6. Place the control panel mounted tuning mode selection switch in the MAN position. Actuate C1 & C2 to de-tune the unit. This is indicated by a dimming or extinguishing of the plasma glow and an increase in the value of reverse power as indicated on the RF level meter or a sounding of the tuning alarm.
7. Once unit is de-tuned, place the control panel mounted tuning mode selection switch in the AUTO position. The system should tune to and maintain the original low value of reverse power as indicated on the RF level meter.
8. If the unit passes all of the steps detailed above, it is operational. If it fails any of those steps, continue with steps listed below.
9. Ensure unit power has been turned off. Remove AC Line power cord if possible.

10. Remove system external panels.
11. Visually inspect RF Tuning Controller PCB for evidence of burning, shorting or damaged components. If any evidence of damage is noted, repair or replace the printed circuit board or failed components on that board. Inspect all wiring and connections for mechanical and electrical integrity. Repair as necessary.
12. To determine proper output from Phase/Mag module, disconnect wiring harness from Phase/Mag module and connect test equipment as shown in Diagram 1. Set meter to 2 volt scale (or closest setting).

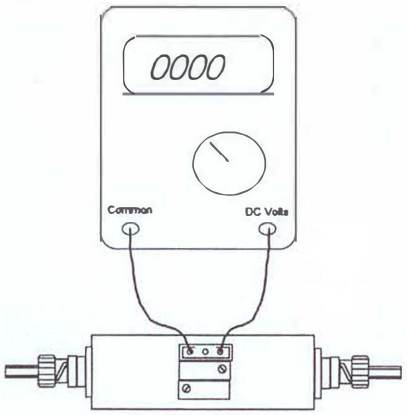


Diagram 1.

NOTE: IT IS NECESSARY TO DETERMINE WHICH PIN ON THE PHASE/MAG MODULE IS AT GROUND POTENTIAL. WHILE IT WILL ALWAYS BE ONE OF THE TWO OUTSIDE PINS, A SMALL PERCENTAGE OF PHASE/MAG MODULES WERE CONSTRUCTED WITH THE NORMAL PIN ASSIGNMENT(AS ILLUSTRATED IN THE ABOVE AND FOLLOWING DIAGRAMS) REVERSED. TO DETERMINE GROUND PIN ASSIGNMENT, CHECK FOR CONTINUITY BETWEEN ETCHER CHASSIS AND OUTSIDE PINS. IF PIN ASSIGNMENT IS REVERSE OF THAT ILLUSTRATED, THEN REVERSE MULTIMETER CONNECTIONS TO MATCH.

13. Reconnect AC power cord if removed.
14. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
15. Allow unit to warm up for at least one minute before taking readings.
16. Multimeter should indicate a -.5 volt to +.5 volt swing when adjusting lower potentiometer from one end of it's travel to the other. If this range cannot be obtained, replace the Phase Magnitude module. See Adjustment procedures (page 45) for proper setting of potentiometers.
17. Turn off RF power.

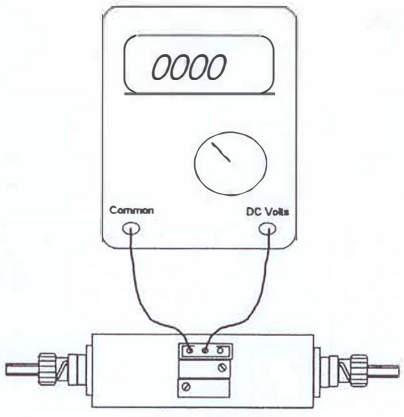


Diagram 2.

18. Connect test equipment as shown in Diagram 2. Set meter to 50 millivolts scale (or closest setting).
19. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
20. Multimeter should indicate a -.5 volt to +.5 volt swing when adjusting upper potentiometer from one end of it's travel to the other. If this range cannot be obtained, replace the Phase Magnitude module. See Adjustment procedure (page 45) for proper setting of potentiometers.
21. If output of Phase/Magnitude Module is correct, check inputs to and outputs from Tuning controller PCB. Inputs on J1-7 & J1-8 should be equivalent to outputs from Phase Magnitude module. Outputs of Tuning Controller, measured at IC1, pins 1 & 7, should be equivalent to outputs from Phase Magnitude module amplified by up to a factor of 50. Other Tuning Controller inputs to test include:

Location	Voltage
Connector J1 Pin 3	GROUND
Connector J1 Pin 6	GROUND
Connector J2 Pin 1	-12 VDC
Connector J2 Pin 2	+12 VDC

22. If inputs to the Tuning Controller PCB are correct, yet outputs are incorrect, replace Tuning Controller PCB.
23. If unit will tune in one mode but not the other, and outputs are correct from both Phase/Magnitude module and Tuning Controller PCB, check tuning mode selection switch (marked AUTO MAN) for continuity.

Removal and Replacement of the Phase Magnitude Module

The following lists the steps necessary for the removal and replacement of the Phase Magnitude module.

Required Materials:

- Standard assortment of hand tools (See page 35)

Procedure

1. Ensure unit power has been turned off and the power cord disconnected.
2. Remove system external panels.
3. To remove Phase Magnitude module, disconnect wiring harness from Phase/Magnitude module by removing connector plug from socket.
4. Disconnect RF cable from both sides of Phase/Magnitude module by removing BNC connector plugs from connector sockets.
5. Loosen screws securing Phase/Magnitude module to chassis of unit.
6. To reinstall, reverse steps 2 through 5 above.

Adjustment of the Phase/Magnitude Module

The following lists the steps required to adjust the Phase/Magnitude module.

Hot Work Level 4

Required Materials:

- Multimeter
- Standard assortment of hand tools (See page 35)

Procedure

1. Remove system external panels.
2. Using standard operational procedures and process parameters, run plasma system through normal operational cycle.
3. Observe forward power indication on RF Level meter. It should be possible to obtain an indication of the maximum level that the RF generator installed in the system is capable of achieving. The unit should be manually tuned for minimum reverse power as indicated on the RF Level meter. If it is not possible to manually tune the system for a reverse power level of 5 watts or less, proceed no further. Contact March Instruments to arrange for factory reconfiguration of the tuning network.

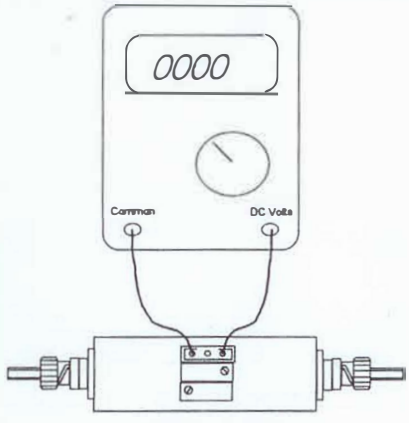


Diagram 3.

NOTE: THE RF GENERATORS USED WITH MARCH PLASMA SYSTEMS ARE EQUIPPED WITH CUTBACK CIRCUITRY TO PREVENT DAMAGE IN CASE OF SEVERE IMPEDANCE MISMATCHES. AS THE MISMATCH BECOMES MORE SEVERE, FORWARD POWER IS CUT BACK TO PREVENT DANGEROUS CURRENT AND VOLTAGE LEVELS (WHICH COULD CAUSE FAILURE OF THE POWER AMPLIFIER) FROM BUILDING UP.

4. Turn off RF power.
5. To adjust output from Phase/Mag module, disconnect wiring harness from Phase/Mag module and connect test equipment as shown in Diagram 3. Take care to avoid physical contact. Set meter to 2 volt scale (or closest setting).
6. Turn on RF power.
7. Taking care not to come into contact with any RF transmission line, tuning network component, or chamber electrode, adjust the lower potentiometer on the Phase/Mag module so that the Multimeter indicates zero volts (+/- 5 millivolts).
8. Turn off RF power.
9. Connect test equipment as shown in Diagram 4. Set meter to 2 volt scale (or closest setting).

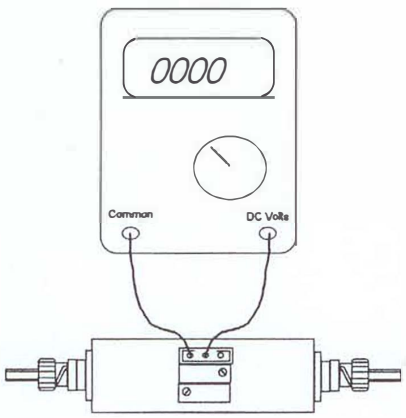


Diagram 4.

10. Turn RF on.
11. Adjust the upper potentiometer on the Phase/Mag module so that the Multimeter indicates as closely as possible to zero volts (+/- 5 millivolts).
12. Turn off RF power.
13. Repeat steps 6-11 above until both pins on the Phase/Mag module indicate as closely as possible to zero volts (+/- 5 millivolts).
14. Turn off unit power.
15. Disconnect Multimeter and reattach wiring harness to Phase/Mag module.
16. Test unit for proper operation as detailed in Fault Isolation, page 42, steps 1 through 8. If unit does not pass these tests, recheck adjustment and repeat if necessary.
17. When adjustment is complete, replace external panels.

CONSUMABLES

The only consumable is used in the system is the fluorinated pump oil (Krytox). This pump oil can become corrosive after being exposed to certain process gases. Always wear approved personal protection equipment (eye protection and rubber gloves) when changing the pump oil. Waste oil and any dirty rags generated during maintenance should be considered hazardous waste. It should never be dumped down the drain. Instead, place the oil in a corrosion proof waste container and dispose of the waste container at an EPA certified waste disposal company when full.

The Material Safety Data Sheet has been included in the back of the manual for reference.

APPENDIX

The appendix contains information on various elements of plasma processing with the Jupiter III equipment. Instructions on process development for etching applications and optimizing pump down speed are included.

PUMP-DOWN SPEED

Additional vacuum hose length, greater inner diameter, and increased number of bends will all contribute to an increase in pump-down times. For best results, position the vacuum pump as close to the chamber as possible and use flexible tubing to minimize effect of sharp bends.

PROCESS DEVELOPMENT-ETCHING

Etching processes can be controlled by the operator of the equipment to achieve desired characteristics including:

- Etch Rate.
- Uniformity.
- Anisotropy.
- Selectivity.

Associated characteristics can be controlled as well, including:

- Process Heat.
- Ion Exposure.

Control is achieved through selection of:

- Process Gas Type.
- Process Gas Flow.
- RF Power Level.
- Chamber Pressure.
- Process Cycle Time.
- Process Threshold Pressure.

The matrix on the following page is intended as a general guideline to help the operator develop an etching process by manipulating the system variables. It must be noted that the plasma etching process is extremely complex and is not easily characterized. In offering this information, March Instruments makes no claim as to it's applicability in tailoring operator controllable parameters to achieve specific etch characteristics. It is offered only to illustrate how altering an operator controllable parameter might effect an etch characteristic.

	Gas Choice	Gas Flow	RF Power	Process Time	Process Threshold Pressure	Process Pressure	Chamber Loading
Etching Characteristics:							
Uniformity Increased	Yes	+/-	+/-	No Effect	No Effect	+/-	-
Uniformity Decreased	Yes	+/-	+/-	No Effect	No Effect	+/-	+
Etch Rate Increased	Yes	+/-	+	+	No Effect	+/-	-
Etch Rate Decreased	Yes	+/-	-	-	No Effect	+/-	+
Anisotropy Increased	Yes	+/-	+	-	No Effect	-	Unknown
Anisotropy Decreased	Yes	+/-	-	+	No Effect	+	Unknown
Selectivity Increased	Yes	+/-	+/-	No Effect	+	+/-	Unknown
Selectivity Decreased	Yes	+/-	+/-	No Effect	-	+/-	Unknown
Heat Build-up Increased	Yes	-	+	+	No Effect	-	+
Heat Build-up Decreased	Yes	+	-	-	No Effect	+	-
Ion Exposure Increased	Yes	+/-	+	+	No Effect	+	Unknown
Ion Exposure Decreased	Yes	+/-	-	-	No Effect	-	Unknown
Process Cycle Time Increased	Yes	+/-	-	+	-	+/-	+
Process Cycle Time Decreased	Yes	+/-	+	-	+	+/-	-

(+) =Increase value of parameter for desired change (+ / -) = Value of parameter can be increased or decreased for desired change

(-)=Decrease value of parameter for desired change

GAS FLOW SETTINGS

Each process gas has a different flow rate for a given flowmeter setting. The tables on the following pages list the flowrates in standard cubic centimeters per minute (sccm) for Argon, Oxygen, CF_4, and SF_6 at various flowmeter settings.

Be advised that these flowrates were calculated for an input gas pressure of 15 psig and a temperature of 70 degrees F. These flowrates will not change significantly as long as the temperature is between 65 and 75 degrees F, but a difference in input pressure of +/-5 psig will make a significant difference in the flowrate value.

Tables are provided for three sizes of flowrator/glass tube. The flowrator size is stamped on one of the flats of the nut located behind the gas flow adjustment knob. The glass tube number is printed on the glass tube (flowmeter gauge).

ARGON				OXYGEN				CF4				SF6			
Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow
5	1.85	36	18.13	5	4.10	36	26.80	5	1.53	36	17.06	5	1.03	36	16.12
6	2.26	37	18.96	6	4.64	37	27.83	6	1.93	37	17.86	6	1.42	37	16.88
7	2.67	38	19.82	7	5.17	38	28.90	7	2.31	38	18.68	7	1.80	38	17.65
8	3.08	39	20.70	8	5.68	39	30.00	8	2.69	39	19.53	8	2.18	39	18.43
9	3.48	40	21.60	9	6.19	40	31.14	9	3.07	40	20.41	9	2.56	40	19.22
10	3.88	41	22.51	10	6.69	41	32.30	10	3.45	41	21.30	10	2.94	41	20.01
11	4.28	42	23.45	11	7.19	42	33.51	11	3.83	42	22.22	11	3.32	42	20.82
12	4.68	43	24.41	12	7.70	43	34.78	12	4.21	43	23.17	12	3.70	43	21.63
13	5.09	44	25.40	13	8.21	44	36.10	13	4.59	44	24.14	13	4.08	44	22.47
14	5.50	45	26.41	14	8.74	45	37.47	14	4.98	45	25.14	14	4.47	45	23.32
15	5.91	46	27.45	15	9.28	46	38.90	15	5.37	46	26.16	15	4.86	46	24.19
16	6.34	47	28.53	16	9.84	47	40.40	16	5.77	47	27.21	16	5.25	47	25.09
17	6.76	48	29.64	17	10.43	48	41.96	17	6.18	48	28.29	17	5.65	48	26.01
18	7.20	49	30.78	18	11.05	49	43.59	18	6.60	49	29.39	18	6.06	49	26.96
19	7.65	50	31.96	19	11.70	50	45.29	19	7.03	50	30.52	19	6.48	50	27.94
20	8.11	51	33.19	20	12.39	51	47.05	20	7.47	51	31.68	20	6.91	51	28.96
21	8.58	52	34.46	21	13.14	52	48.87	21	7.92	52	32.86	21	7.34	52	30.02
22	9.07	53	35.75	22	13.92	53	50.75	22	8.39	53	34.07	22	7.79	53	31.09
23	9.57	54	37.07	23	14.74	54	52.68	23	8.88	54	35.29	23	8.25	54	32.20
24	10.09	55	38.41	24	15.59	55	54.65	24	9.38	55	36.52	24	8.72	55	33.32
25	10.62	56	39.77	25	16.46	56	56.66	25	9.90	56	37.77	25	9.22	56	34.45
26	11.18	57	41.14	26	17.36	57	58.70	26	10.44	57	39.02	26	9.73	57	35.60
27	11.76	58	42.53	27	18.27	58	60.76	27	11.00	58	40.29	27	10.26	58	36.75
28	12.36	59	43.91	28	19.19	59	62.83	28	11.58	59	41.55	28	10.81	59	37.91
29	12.99	60	45.30	29	20.12	60	64.92	29	12.18	60	42.82	29	11.39	60	39.07
30	13.64	61	46.69	30	21.05	61	67.00	30	12.81	61	44.09	30	11.99	61	40.23
31	14.32	62	48.07	31	21.98	62	69.07	31	13.45	62	45.35	31	12.62	62	41.39
32	15.03	63	49.45	32	22.92	63	71.13	32	14.13	63	46.62	32	13.28	63	42.54
33	15.77	64	50.84	33	23.86	64	73.17	33	14.82	64	47.88	33	13.96	64	43.70
34	16.53	65	52.22	34	24.82	65	75.18	34	15.54	65	49.15	34	14.66	65	44.85
35	17.32			35	25.80			35	16.29			35	15.39		

FLOW SETTINGS- FLOWRATOR #0, GLASS TUBE #A-125-3

ARGON				OXYGEN				CF4				SF6			
Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow
5	4.64	36	93.41	5	1.97	36	83.87	5	5.35	36	67.80	5	3.44	36	61.97
6	6.83	37	97.85	6	3.83	37	88.46	6	6.73	37	71.19	6	4.87	37	64.98
7	8.99	38	102.32	7	5.65	38	93.21	7	8.07	38	74.70	7	6.28	38	68.08
8	11.11	39	106.82	8	7.43	39	98.12	8	9.38	39	78.30	8	7.68	39	71.27
9	13.22	40	111.32	9	9.18	40	103.19	9	10.66	40	82.02	9	9.05	40	74.55
10	15.32	41	115.65	10	10.93	41	108.34	10	11.94	41	85.80	10	10.43	41	77.89
11	17.42	42	120.01	11	12.68	42	113.65	11	13.21	42	89.70	11	11.80	42	81.31
12	19.53	43	124.43	12	14.43	43	119.15	12	14.50	43	93.70	12	13.17	43	84.83
13	21.66	44	128.95	13	16.21	44	124.85	13	15.81	44	97.81	13	14.57	44	88.43
14	23.81	45	133.61	14	18.03	45	130.74	14	17.15	45	102.02	14	15.98	45	92.12
15	26.01	46	138.44	15	19.89	46	136.85	15	18.53	46	106.34	15	17.41	46	95.90
16	28.24	47	143.48	16	21.81	47	143.19	16	19.96	47	110.77	16	18.88	47	99.78
17	30.54	48	148.76	17	23.79	48	149.75	17	21.46	48	115.29	17	20.39	48	103.74
18	32.89	49	154.33	18	25.86	49	156.55	18	23.03	49	119.92	18	21.95	49	107.79
19	35.32	50	160.21	19	28.02	50	163.60	19	24.69	50	124.66	19	23.55	50	111.93
20	37.84	51	166.37	20	30.28	51	170.88	20	26.44	51	129.48	20	25.22	51	116.16
21	40.40	52	172.85	21	32.64	52	178.39	21	28.29	52	134.40	21	26.94	52	120.47
22	43.05	53	179.62	22	35.12	53	186.11	22	30.25	53	139.40	22	28.73	53	124.84
23	45.81	54	186.63	23	37.72	54	194.01	23	32.20	54	144.47	23	30.58	54	129.29
24	48.68	55	193.85	24	40.45	55	202.07	24	34.46	55	149.60	24	32.51	55	133.79
25	51.66	56	201.25	25	43.30	56	210.25	25	36.72	56	154.79	25	34.52	56	138.33
26	54.76	57	208.79	26	46.28	57	218.54	26	39.08	57	160.01	26	36.60	57	142.91
27	57.99	58	216.44	27	49.39	58	226.91	27	41.54	58	165.27	27	38.76	58	147.52
28	61.34	59	224.15	28	52.64	59	235.33	28	44.09	59	170.54	28	41.00	59	152.14
29	64.84	60	231.90	29	56.03	60	243.77	29	46.73	60	175.83	29	43.32	60	156.78
30	68.47	61	239.65	30	59.56	61	252.22	30	49.47	61	181.11	30	45.73	61	161.41
31	72.35	62	247.37	31	63.23	62	260.63	31	52.28	62	186.39	31	48.21	62	166.04
32	76.36	63	255.02	32	67.06	63	269.00	32	55.19	63	191.64	32	50.79	63	170.64
33	80.49	64	262.56	33	71.03	64	277.29	33	58.20	64	196.87	33	53.45	64	175.22
34	84.71	65	269.95	34	75.16	65	285.47	34	61.30	65	202.05	34	56.20	65	179.77
35	89.03			35	79.43			35	64.50			35	59.04		

FLOWRATOR #2, GLASS TUBE #A-125-5

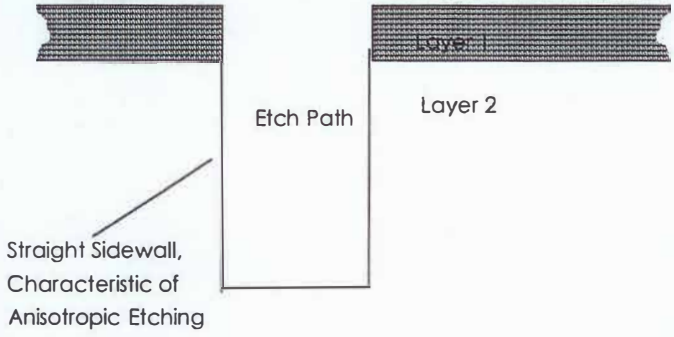
ARGON				OXYGEN				CF4				SF6			
Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow	Scale	Flow
5	6.02	36	374.21	5		36	555.20	5		36	252.60	5		36	195.07
6	12.80	37	394.18	6	9.24	37	586.26	6	1.40	37	268.19	6	1.08	37	207.11
7	19.13	38	414.77	7	19.78	38	615.44	7	6.31	38	284.16	7	4.88	38	219.45
8	25.15	39	436.03	8	29.94	39	645.61	8	11.08	39	300.48	8	8.56	39	232.05
9	30.94	40	458.02	9	39.84	40	675.67	9	15.76	40	317.11	9	12.17	40	244.89
10	36.63	41	480.95	10	49.62	41	705.40	10	20.39	41	334.18	10	15.74	41	258.08
11	42.32	42	504.58	11	59.40	42	734.95	11	25.01	42	351.50	11	19.32	42	271.46
12	48.11	43	528.84	12	69.30	43	764.35	12	29.69	43	369.04	12	22.93	43	285.00
13	54.12	44	553.64	13	79.46	44	793.63	13	34.46	44	386.76	13	26.61	44	298.69
14	60.46	45	578.89	14	90.00	45	822.83	14	39.37	45	404.64	14	30.41	45	312.49
15	67.23	46	604.52	15	101.04	46	851.97	15	44.48	46	422.64	15	34.35	46	326.39
16	74.55	47	630.43	16	112.72	47	881.09	16	49.82	47	440.72	16	38.47	47	340.36
17	82.51	48	656.54	17	125.15	48	910.23	17	55.44	48	458.87	17	42.82	48	354.37
18	91.23	49	682.77	18	138.48	49	939.42	18	61.40	49	477.05	18	47.42	49	368.41
19	100.82	50	709.03	19	152.81	50	968.68	19	67.74	50	495.22	19	52.31	50	382.44
20	111.38	51	735.32	20	168.29	51	998.37	20	74.50	51	513.21	20	57.54	51	396.34
21	123.23	52	761.56	21	184.74	52	1028.0	21	81.57	52	531.20	21	63.00	52	410.23
22	136.06	53	787.76	22	202.41	53	1057.7	22	89.13	53	549.23	22	68.83	53	424.16
23	149.81	54	813.93	23	221.27	54	1087.3	23	97.19	54	567.34	23	75.06	54	438.14
24	164.37	55	840.06	24	241.27	55	1116.8	24	105.77	55	585.55	24	81.68	55	452.21
25	179.66	56	866.16	25	262.38	56	1146.0	25	114.88	56	603.92	25	88.72	56	466.39
26	195.59	57	892.25	26	284.55	57	1174.8	26	124.54	57	622.46	26	96.18	57	480.71
27	212.07	58	918.32	27	307.73	58	1203.3	27	134.76	58	641.23	27	104.07	58	495.20
28	229.01	59	944.37	28	331.90	59	1231.4	28	145.55	59	660.25	28	112.41	59	509.89
29	246.33	60	970.42	29	357.01	60	1258.9	29	156.94	60	679.56	29	121.20	60	524.80
30	263.93	61	996.48	30	383.01	61	1285.9	30	168.93	61	699.14	30	130.46	61	539.93
31	281.47	62	1022.5	31	410.19	62	1312.5	31	181.52	62	718.98	31	140.19	62	555.25
32	299.27	63	1048.6	32	438.12	63	1338.7	32	194.74	63	739.02	32	150.37	63	570.73
33	317.38	64	1074.6	33	466.70	64	1364.6	33	208.44	64	759.19	33	160.97	64	586.30
34	335.87	65	1100.7	34	495.80	65	1390.4	34	222.69	65	779.43	34	171.98	65	601.93
35	354.79			35	525.34			35	237.42			35	183.35		

FLOWRATOR #3, GLASS TUBE #A-157-1

GLOSSARY

The following lists definitions of commonly used terms in this manual.

Anisotropic: Etching that is directional in it's action with characteristic etch path side walls that are perpendicular to the electrode plates of the etcher. Characteristic of etching applications where the preservation of underlying material is desirable. Typical of reactive ion etchers(RIE).



Autotuning System: The system that automatically tunes the RF matching network for minimal reflected power so that there is optimal power transfer to the chamber.

Base Pressure: The preset pressure, factory programmed, at which the plasma process begins. The lower the Base Pressure level, the less impurities will be present in the chamber when the process gas is introduced. By evacuating the chamber for a longer or shorter period of time at the commencement of the process cycle, more or less of the room air and water vapor present in the chamber will be pumped out before the process gas is introduced. Also referred to as **Process Threshold Pressure**.

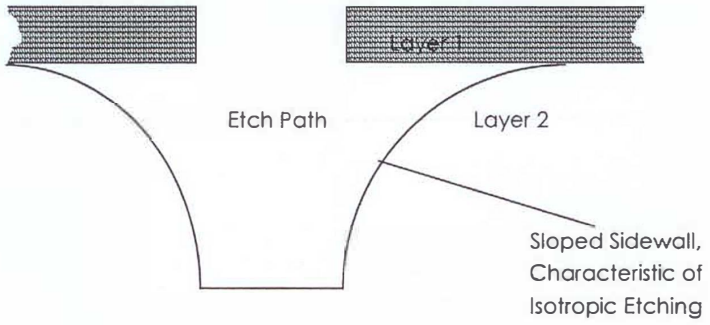
Clippard Valve: A brand of solenoid valve used in the Jupiter III system.

Endpoint: The point at which a material has received satisfactory treatment. Most commonly used in reference to cleaning processes.

Etch Rate: The rate at which material is removed during exposure to plasma. Often given as a value of Angstroms per minute.

Forward Power: The amount of RF energy applied to the plasma. This value is measured in watts.

Isotropic: Etching that is not directional in it's effect. Characteristic of most cleaning applications where it is desirable to remove material from all surfaces. Typical of barrel type etchers.



Impedance Matching: The matching of the fixed output impedance of the RF Power Generator to the constantly varying input impedance characteristic of a plasma. This is done to attain maximum transfer of available RF energy to the plasma and keep the plasma uniform.

Matching Network: The module in the plasma system that accomplishes the matching of the fixed output impedance of the RF Power Generator to the constantly varying input impedance characteristic of a plasma.

Parameter: A variable in the plasma process that can be changed by the operator. A value chosen for the specific parameter is passed to a controlling device in the plasma system which will then regulate the plasma generation process accordingly. For example, RF Power Level is a parameter; a typical value assigned to this parameter would be 300 watts.

Plasma: A highly energetic state of matter produced when a gas is introduced into a chamber at low pressure and is excited by the application of RF energy. This results in a disassociation of the gas molecules into ions, free radicals and other reactive species which interact physically and chemically with exposed surfaces of materials.

Process: The plasma cycle. The complete sequence of steps a material is subjected to in order to attain desired results. A process can consist of single or multiple programs.

Process Recipe: A sequential listing of the total set of conditions which make up a process. This includes gas type and process parameters as well as sample loading and positioning in the treatment chamber.

Process Threshold Pressure: The preset pressure, factory programmed, at which the plasma process begins. The lower the Process Threshold Pressure level, the less impurities will be present in the chamber when the process gas is introduced. By evacuating the chamber for a longer or shorter period of time at the commencement of the process cycle, more or less of the room air and water vapor present in the chamber will be pumped out before the process gas is introduced. Also referred to as **Base Pressure**.

Pump-down Speed: The amount of time required to reach Base (Threshold) Pressure once the chamber is placed under vacuum.

Radio Frequency (RF): The frequency range of the power generators used to create the plasma in the Jupiter III equipment. The specific frequency is 13.56 MHz.

Reactive Ion Etching (RIE): A high energy plasma process used to remove relatively large quantities of material. Due to high energy ion bombardment, material to be etched can be removed quickly.

Read point: Actual value of a parameter at any given time as monitored by that parameter control device's sensors and reported for the operator's information on the appropriate panel display.

Reflected Power: The amount of RF power that is not successfully transferred to the plasma, due to an impedance mismatch. This power is reflected back towards the RF generator. May also be referred to as **Reverse Power**.

Reverse Power: The amount of RF power that is not successfully transferred to the plasma, due to an impedance mismatch. This power is reflected back towards the RF generator. May also be referred to as **Reflected Power**.

Selectivity: Different materials have different etch rates when exposed to the same plasma. This phenomenon can be manipulated to control, through process parameter selection, the etch rate of separate components of a multiple substance device to preserve one material while removing another.

Set point: The value of a parameter set into the Process controller. Once set, the Process Controller will keep the parameter at the set point throughout the course of the process.

Threshold Pressure: The preset pressure, factory programmed, at which the plasma process begins. The lower the Process Threshold Pressure level, the less impurities will be present in the chamber when the process gas is introduced. By evacuating the chamber for a longer or shorter period of time at the commencement of the process cycle, more or less of the room air and water vapor present in the chamber will be pumped out before the process gas is introduced. Also referred to as **Base Pressure**.

Tuning: The process of controlling the settings of the tuning network components to effect best possible impedance matching. This can be performed through manual input from the operator or through an automatic function, whereby forward and reverse power levels are compared and a feedback is generated from that comparison which is used to set the value of the variable components.

Tuning network: A coupling network by which impedance matching is controlled and optimized by varying the phase and amplitude of the RF waves entering the treatment chamber. Alteration of these values compensates for any mismatch in impedance as the network couples the RF power to the chamber.

Ultimate Pressure: The highest chamber vacuum level achievable, as indicated by observation of the chamber pressure after it has been subjected to vacuum for a period of time sufficient for the pressure reading to completely stabilize. The capacity of the vacuum pump, the dimensions of the connecting line between the vacuum pump and the chamber, and the overall vacuum integrity of these components all affect the ability to reach Ultimate Pressure.

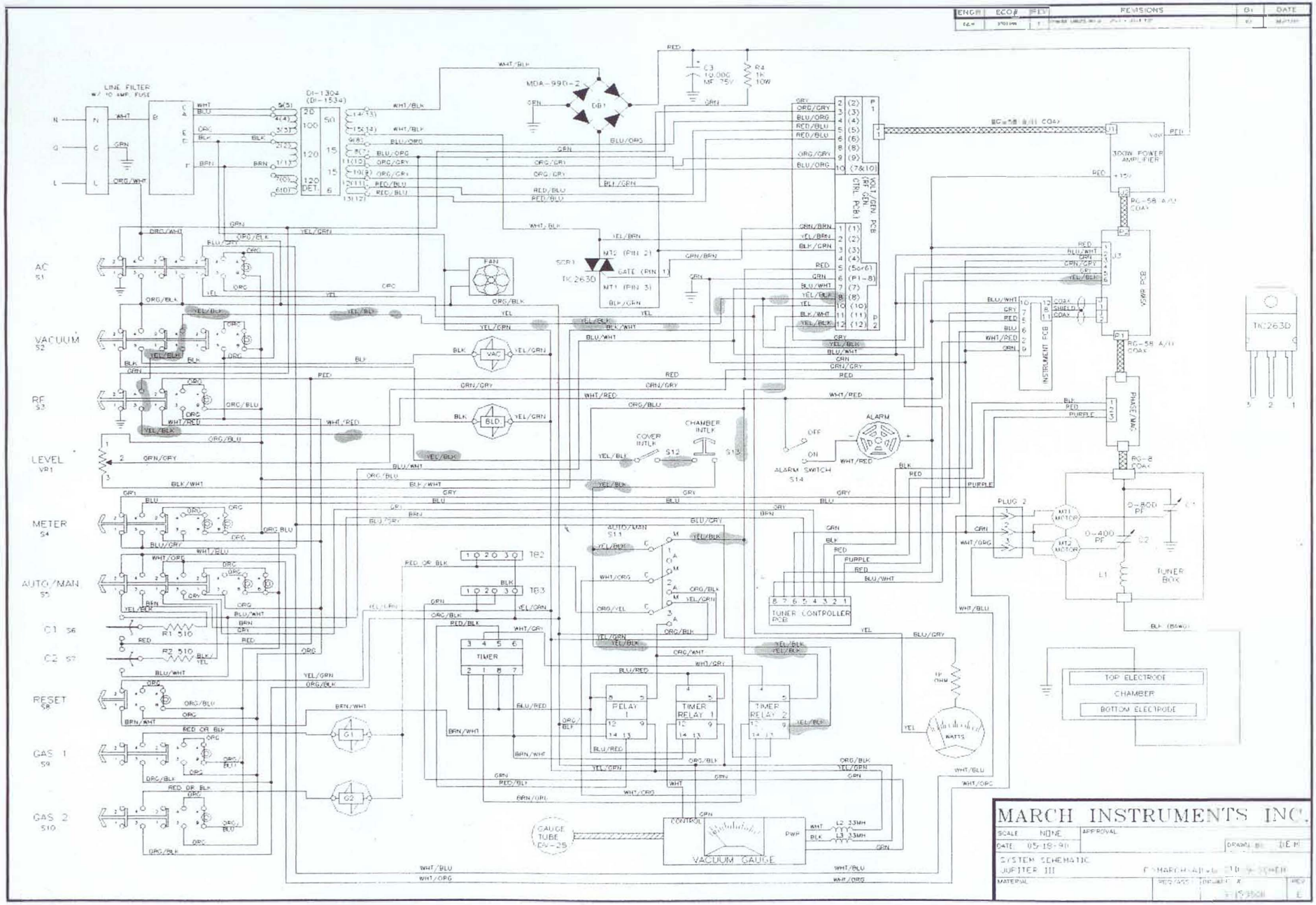
Ultraviolet (UV) Light: The region of the electromagnetic spectrum just beyond the visible wavelengths. The plasma environment is rich in UV light and this is one of the elements contributing to the surface modifications created by plasma.

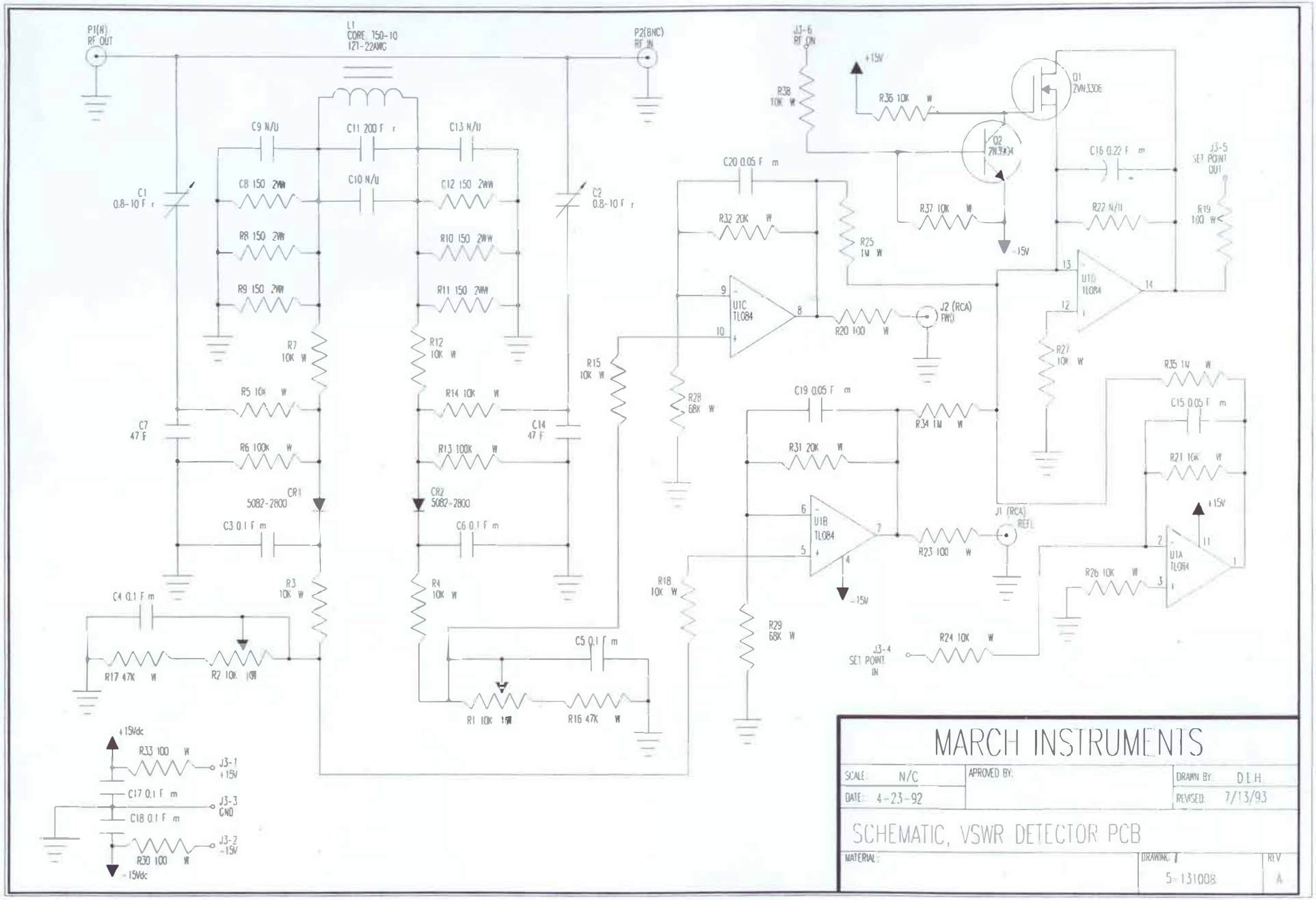
Uniformity: The degree to which the plasma process gives a uniform treatment across a materials surface. Also can refer to the degree plasma uniformity inside the chamber.

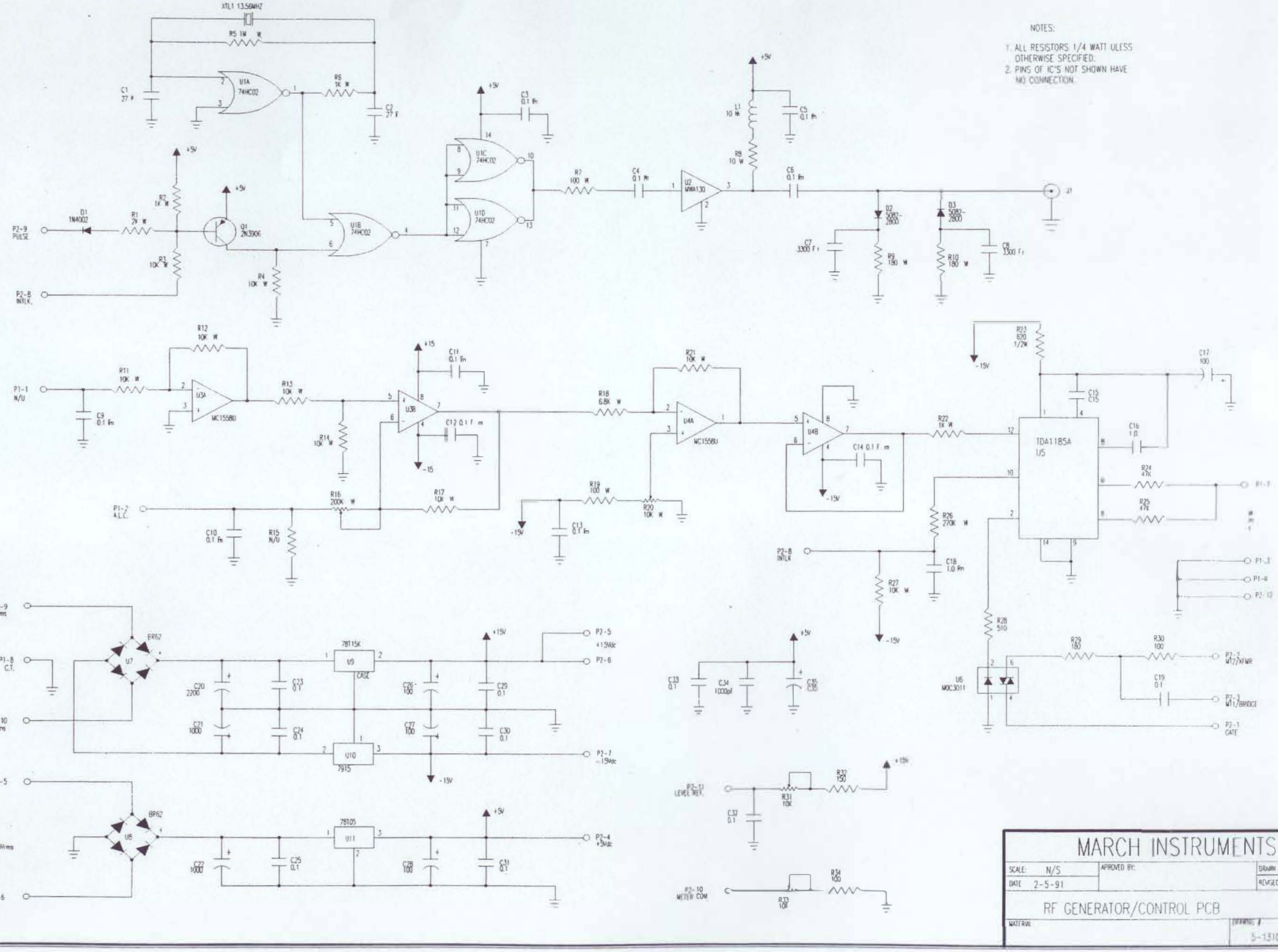
NOTES

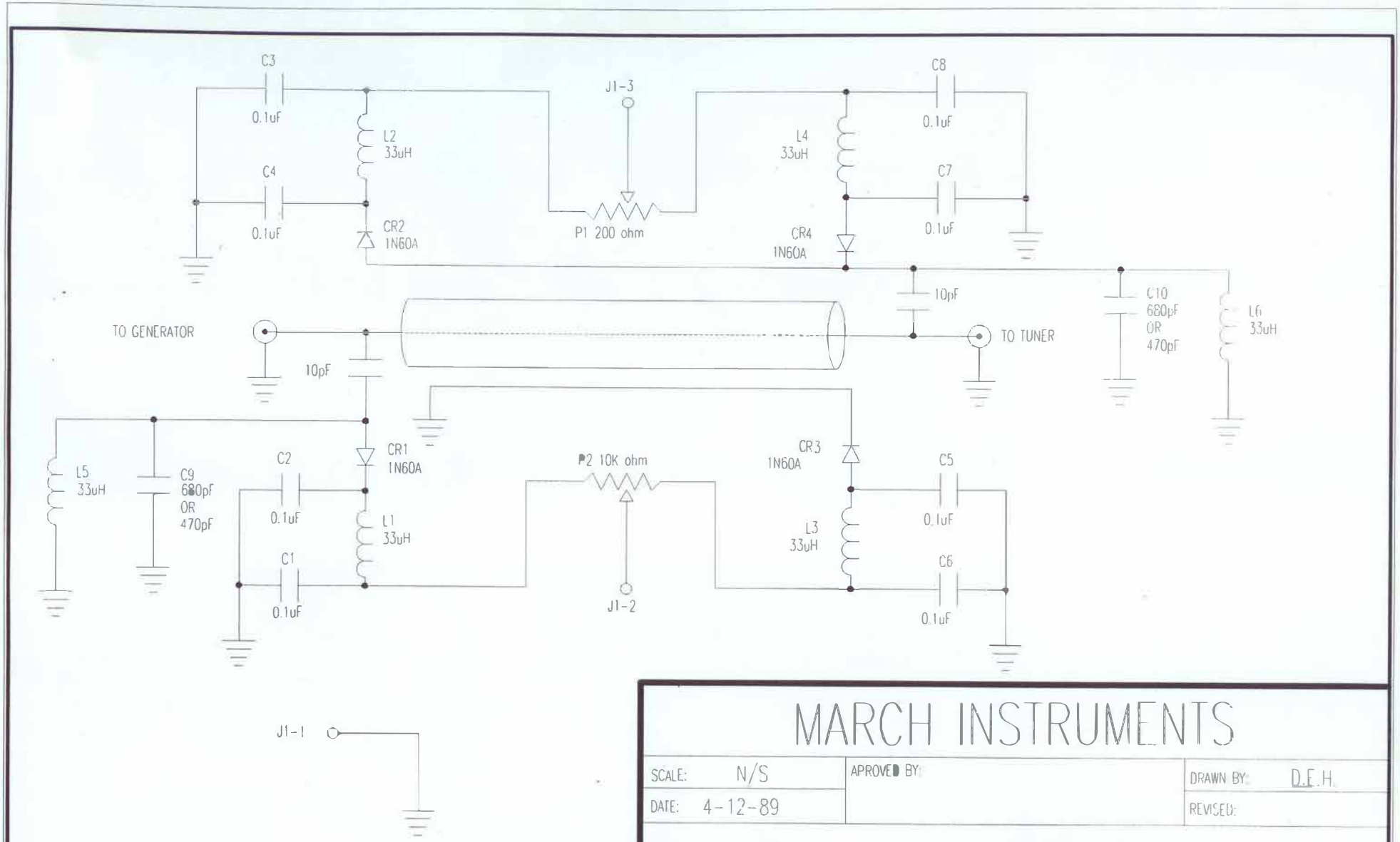
SCHEMATICS

The following pages are the schematics for components of the Jupiter III system. Included are schematics for the 300w Instrument PCB, Tuning Controller PCB, 300w P.A. PCB, RF Generator Control PCB, Phase/Mag. PCB, VSWR Detector PCB, and overall system.


MARCH INSTRUMENTS INC.
SYSTEM SCHEMATIC
JUPITER III
LINE FILTER
W/ 10 AMP. FUSE
MDA-990-2
DB1
C3
10,000
MF 75V
R4
1K
10W
DI-1304
(DI-1534)
300W POWER
AMPLIFIER
MT2 (PIN 2)
GATE (PIN 1)
MT1 (PIN 3)
SCR1
TIC263D
FAN
AC
S1
VACUUM
S2
RF
S3
LEVEL
VR1
METER
S4
AUTO/MAN
S5
C1 S6
C2 S7
RESET
S8
GAS 1
S9
GAS 2
S10
R1 510
R2 510
VAC
BLD
COVER
INTLK
S12
CHAMBER
INTLK
S13
ALARM
ALARM SWITCH
S14
AUTO/MAN
S11
TIMER
RELAY
1
TIMER
RELAY 1
TIMER
RELAY 2
TUNER CONTROLLER
PCB
PLUG 2
MT1
MOTOR
MT2
MOTOR
0-800
PF
0-400
PF
C1
C2
L1
TUNER
BOX
TOP ELECTRODE
CHAMBER
BOTTOM ELECTRODE
1K
OHM
WATTS
GAUGE
TUBE
DV-25
CONTROL
VACUUM GAUGE
L2 33MH
L3 33MH
VOLT/CURR
CTRL PCB
INSTRUMENT PCB
PCB AMP
PHASE/MAG
RG-58 A/U
COAX
RG-8
COAX
TIC263D
SCALE NONE
DATE 05-19-90
APPROVAL
DRAWN BY
MATERIAL


P1(N)
RF OUT
L1
CORE 150-10
12T-22AWG
P2(BNC)
RF IN
J3-6
RF IN
+15V
R38
10K W
R36 10K W
Q1
2VN3306
Q2
2N3904
C16 0.22 F m
J3-5
SET POINT
OUT
C9 N/U
C11 200 F r
C13 N/U
C1
0.8-10 F r
C8 150 2WW
C10 N/U
C12 150 2WW
C2
0.8-10 F r
C20 0.05 F m
R32 20K W
R25
1W W
R37 10K W
R22 N/U
R19
100 W
R8 150 2WW
R10 150 2WW
R9 150 2WW
R11 150 2WW
U1C
TL084
J2 (RCA)
FWD
R20 100 W
U1D
TL084
R7
10K W
R12
10K W
R15
10K W
R28
68K W
R27
10K W
R35 1W W
R5 10K W
R14 10K W
C19 0.05 F m
C15 0.05 F m
C7
47 F
C14
47 F
R6 100K W
R13 100K W
R34 1W W
R21 10K W
R31 20K W
CR1
5082-2800
CR2
5082-2800
U1B
TL084
J1 (RCA)
REFL
+15V
C3 0.1 F m
C6 0.1 F m
R23 100 W
U1A
TL084
R3
10K W
R4
10K W
R18
10K W
R26 10K W
C4 0.1 F m
C5 0.1 F m
R29
68K W
R17 47K W
R2 10K TRIM
R1 10K TRIM
R16 47K W
J3-4
SET POINT
IN
R24 10K W
+15Vdc
R33 100 W
J3-1
+15V
C17 0.1 F m
J3-3
GND
C18 0.1 F m
J3-2
-15V
R30 100 W
-15Vdc
MARCH INSTRUMENTS
SCALE: N/C
APPROVED BY:
DRAWN BY: D.E.H
DATE: 4-23-92
REVISED: 7/13/93
SCHEMATIC, VSWR DETECTOR PCB
MATERIAL:
DRAWING #
5-131008
REV
A


NOTES:
1. ALL RESISTORS 1/4 WATT ULESS OTHERWISE SPECIFIED.
2. PINS OF IC'S NOT SHOWN HAVE NO CONNECTION.
XTL1 13.56MHZ
U1A 74HC02
U1C 74HC02
U1D 74HC02
U1B 74HC02
Q1 2N3906
D1 1N4002
D2 5082-2800
D3 5082-2800
U2 MMA130
L1 10 M
P2-9 PULSE
P2-8 INTLK.
P1-1 M/U
P1-2 A.L.C.
U3A MC1558U
U3B
U4A MC1558U
U4B
TDA1185A U5
U6 MOC3011
P1-9 18Vrms
P1-8 C.T.
P1-10 18Vrms
BR67 U7
78115K U9
7915 U10
P2-5 +15Vdc
P2-6
P2-7 -15Vdc
P1-5
6.5Vrms
P1-6
BR62 U8
79105 U11
P2-4 +5Vdc
P2-11 LEVEL REF.
P2-10 METER COM
P2-3 W1/WPWR
P2-2 W1/BRIDGE
P2-1 GATE
MARCH INSTRUMENTS
SCALE: N/S
APPROVED BY:
DRAWN BY D.E.H.
DATE 2-5-91
REVISED 9/20/93
RF GENERATOR/CONTROL PCB
MATERIAL
DRAWING #
5-131020
REV
B

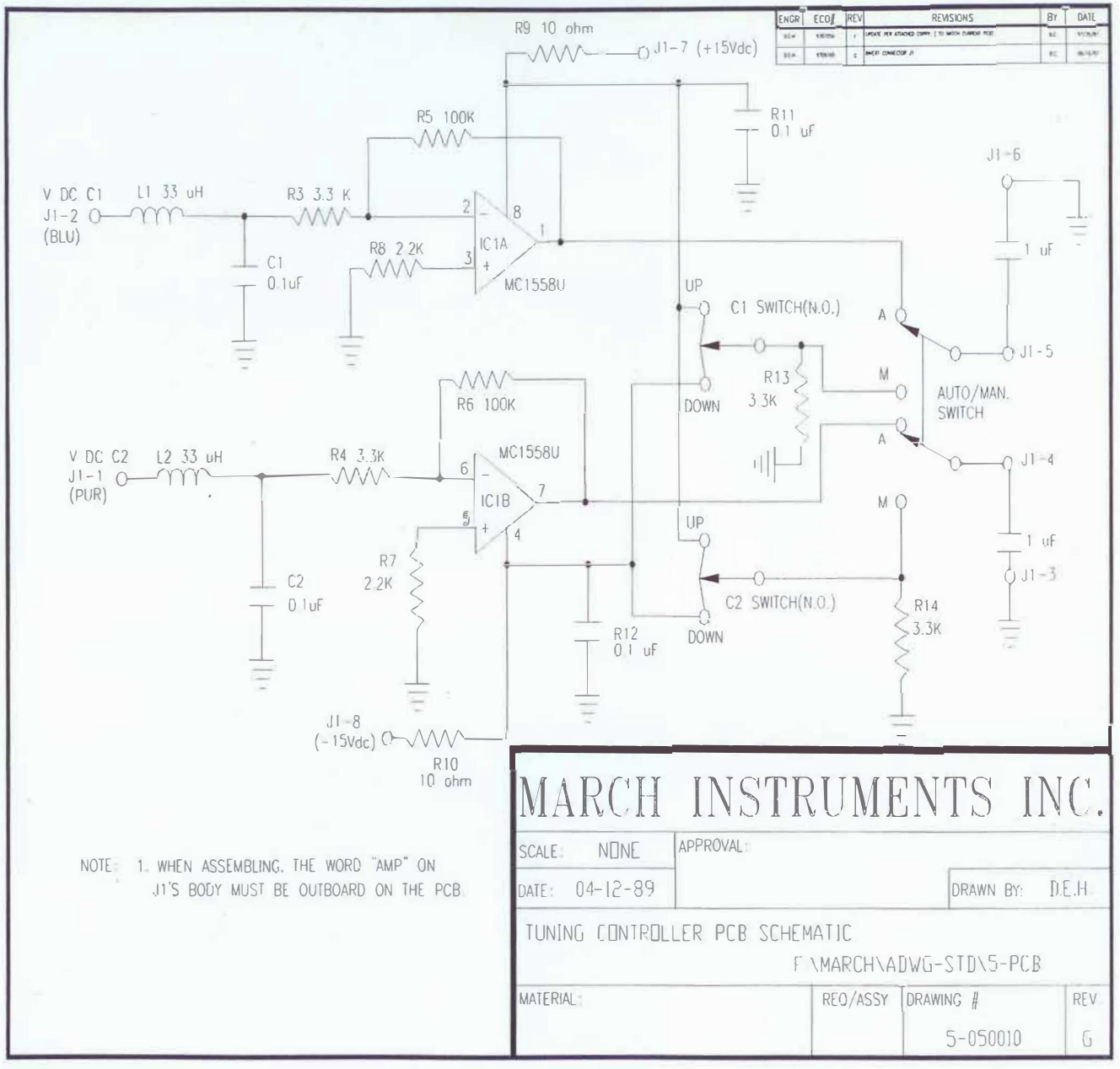


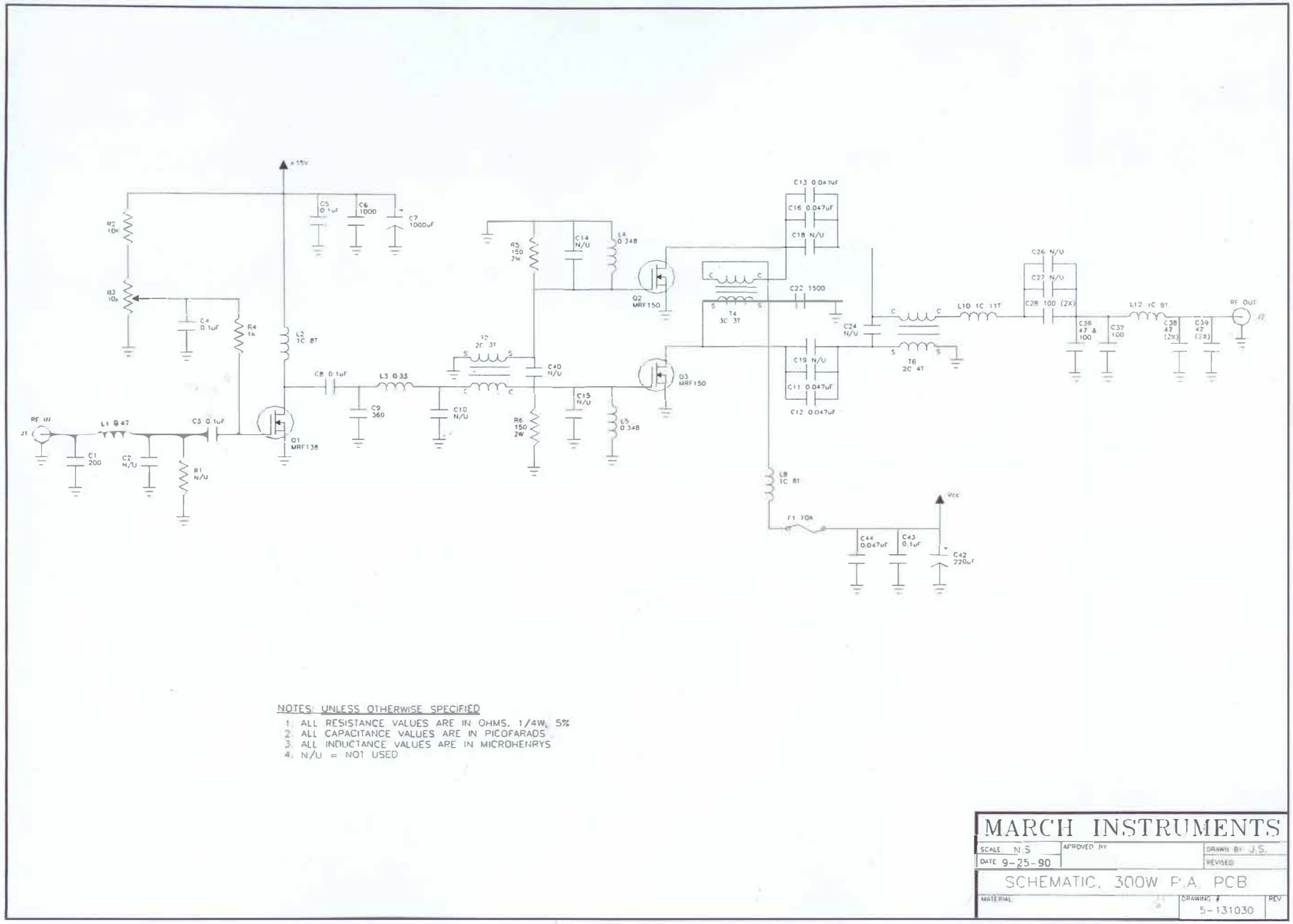
MARCH INSTRUMENTS

SCALE: N/S	APROVED BY:	DRAWN BY: D.E.H.
DATE: 4-12-89		REVISED:

PHASE/MAG. P.C.B. SCHEMATIC

MATERIAL:	DRAWING #: 5-050011	REV


ENGR
ECO#
REV.
REVISIONS
BY
DATE
R9 10 ohm
J1-7 (+15Vdc)
R5 100K
R11
0.1 uF
J1-6
V DC C1
J1-2
(BLU)
L1 33 uH
R3 3.3 K
2
8
1
IC1A
3
MC1558U
R8 2.2K
C1
0.1uF
1 uF
UP
C1 SWITCH(N.O.)
A
J1-5
R13
3.3K
M
AUTO/MAN.
SWITCH
DOWN
R6 100K
V DC C2
J1-1
(PUR)
L2 33 uH
R4 3.3K
MC1558U
6
7
IC1B
5
4
A
J1-4
M
UP
1 uF
J1-3
R7
2.2K
C2
0.1uF
C2 SWITCH(N.O.)
R14
3.3K
R12
0.1 uF
DOWN
J1-8
(-15Vdc)
R10
10 ohm
NOTE: 1. WHEN ASSEMBLING, THE WORD "AMP" ON
J1'S BODY MUST BE OUTBOARD ON THE PCB.
MARCH INSTRUMENTS INC.
SCALE: NONE
APPROVAL:
DATE: 04-12-89
DRAWN BY: D.E.H.
TUNING CONTROLLER PCB SCHEMATIC
F:\MARCH\ADWG-STD\5-PCB
MATERIAL:
REQ/ASSY
DRAWING #
5-050010
REV
G



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCE VALUES ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITANCE VALUES ARE IN PICOFARADS
3. ALL INDUCTANCE VALUES ARE IN MICROHENRYS
4. N/U = NOT USED

MARCH INSTRUMENTS			
SCALE N S	APPROVED BY	DRAWN BY J.S.	
DATE 9-25-90		REVISED	
SCHEMATIC, 300W P.A. PCB			
MATERIAL		DRAWING # 5-131030	REV

DuPont Chemicals

MSDS MATERIAL SAFETY DATA SHEET

5357PP | Revised 2-NOV-1993 | Printed 8-MAY-1995

"KRYTOX" 1500, 1600, 16000 & 16000N Series Fluorinated Vacuum Pump Fluids/Oil s

CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification

"KRYTOX" is a registered trademark of DuPont.

Corporate MSDS Number	DU002671
Grade	SEE ADDITIONAL INFORMATION AND REFERENCES

Company Identification

MANUFACTURER/DISTRIBUTOR

DuPont
1007 MARKET STREET
WILMINGTON, DE 19898

PHONE NUMBERS

Product Information	1-800-441-7515
Transport Emergency	CHEMTREC 1-800-424-9300
Medical Emergency	1-800-441-3637

COMPOSITION/INFORMATION ON INGREDIENTS

Components

Material	CAS Number	%
PERFLUOROALKYLETHER	60164-51-4	100

HAZARDS IDENTIFICATION

Potential Health Effects

ANIMAL DATA:

Perfluoroalkylether:

Inhalation 4 hour ALC:	19.54 mg/l in rats
Skin absorption ALD:	>17,000 mg/kg in rats
Oral ALD:	>25,000 mg/kg in rats

(Continued)

The product is a mild eye irritant. A single inhalation exposure caused nonspecific effects such as respiratory irritation. Toxic effects described in animals exposed to decomposition products of the product formed above 260 degC (500 degF) include lung irritation, irregular respiration, tremors and increased liver weight. Pulmonary edema and death occurred in rats exposed to the decomposition products of the product formed at around 290 degC (554 degF).

HUMAN HEALTH EFFECTS OF OVEREXPOSURE:

Skin contact may cause skin irritation with discomfort or rash. Prolonged skin contact may cause redness and inflammation of the hair follicles without skin sensitization.

Eye contact may cause eye irritation with discomfort, tearing or blurring of vision.

Inhalation of fluorine compounds released as decomposition products at around 290 degC (554 degF) may cause lung irritation and pulmonary edema which require medical treatment. Inhalation of burning material or smoke from cigarettes or tobacco contaminated with this product may cause throat irritation, cough and tightness in the chest.

Carcinogenicity Information

None of the components present in this material at concentrations equal to or greater than 0.1% are listed by IARC, NTP, OSHA or ACGIH as a carcinogen.

FIRST AID MEASURES

First Aid

INHALATION

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT

Flush skin with water after contact. Wash contaminated clothing before reuse.

EYE CONTACT

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

INGESTION

(Continued)

FIRST AID MEASURES (Continued)

If swallowed, do not induce vomiting. Immediately give 2 glasses of water. Never give anything by mouth to an unconscious person. Call a physician.

Notes to Physicians
Activated charcoal mixture may be administered. To prepare activated charcoal mixture, suspend 50 grams activated charcoal in 400 mL water and mix thoroughly. Administer 5 mL/kg, or 350 mL for an average adult.

FIRE FIGHTING MEASURES

Flammable Properties

Flash Point	Does not ignite
Method	PMCC

Fire and Explosion Hazards:

Non-combustible

Extinguishing Media
As appropriate for combustibles in area.

Fire Fighting Instructions
Wear self-contained breathing apparatus. Wear full protective equipment.

Decomposition at flame temperatures may form toxic fluorine compounds. Avoid breathing decomposition products.

ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel)
NOTE: Review FIRE FIGHTING MEASURES and HANDLING (PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up.

Spill Clean Up
Soak up with sawdust, sand, oil dry or other absorbent material. Shovel or sweep up.

Accidental Release Measures
Place in container for disposal. Remove source of heat and flame.

HANDLING AND STORAGE

Handling (Personnel)
Avoid contact with eyes. Avoid contact with skin. Wash thoroughly after handling. Do not store or consume food, drink or tobacco in areas where they may become contaminated with this

(Continued)

HANDLING AND STORAGE (Continued)

material.

Storage
Keep container tightly closed. Do not store or consume food, drink or tobacco in areas where they may become contaminated with this material.

Keep away from heat and flames to avoid decomposition products.

EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls
Use only with adequate ventilation. Keep container tightly closed.

Keep away from heat and flames.

 # Personal Protective Equipment
EYE/FACE PROTECTION

Wear safety glasses or coverall chemical splash goggles.

REKSPIRATOR

Wear NIOSH/MSHA approved respiratory protection as appropriate.

PROTECTIVE CLOTHING

Where there is potential for skin contact have available and wear as appropriate, impervious gloves, apron, pants, and jacket.

Exposure Guidelines
Exposure Limits
"KRYTOX" 1500, 1600, 16000 & 16000N Series Fluorinated Vacuum Pump Fluids/Oils

PEL	(OSHA)	None Established
TLV	(ACGIH)	None Established

PHYSICAL AND CHEMICAL PROPERTIES

Physical Data

Solubility in Water	Negligible WT%
pH	Neutral
Odor	Odorless
Form	Liquid, viscous oil
Color	Colorless
Specific Gravity	1.86-1.91 @ 24 deg C (75 deg F)

Pour Point : -45 to -5 deg C (-49 to -25 deg F)

(Continued)

MALLINCKRODT

Material Safety Data Sheet

Mallinckrodt, Inc. Science Products Division, P.O. Box M Paris, KY 40361

Emergency Telephone Number: 314-982-5000

Addendum to Material Safety Data Sheet

REGULATORY STATUS

This Addendum Must Not Be Detached from the MSDS

Identifies SARA 313 substance(s)

Any copying or redistribution of the MSDS must include a copy of this addendum

(Chem.Key: ISALC)

Hazard Categories for SARA Section 311/312 Reporting

Acute	Chronic	Fire	Pressure	Reactive
X	X	X		

Product or Components of Product:	SARA EHS Sect. 302 RQ (lbs.)	SARA EHS Sect. 302 TPQ (lbs.)	SARA Section 313 Chemicals Name List	SARA Section 313 Chemicals Chemical Category	CERCLA Sec.103 RQ (lbs.)	RCRA Sec. 261.33
ISOPROPYL ALCOHOL (67-63-0)	No	No	Yes	No	No	No

SARA Section 302 EHS RQ: Reportable Quantity of Extremely Hazardous Substance, listed at 40 CFR 355.
SARA Section 302 EHS TPQ: Threshold Planning Quantity of Extremely Hazardous Substance. An asterisk (*) following a Threshold Planning Quantity signifies that if the material is a solid and has a particle size equal to or larger than 100 micrometers, the Threshold Planning Quantity = 10,000 LBS.
SARA Section 313 Chemicals: Toxic Substances subject to annual release reporting requirements listed at 40 CFR 372.65.
CERCLA Sec. 103: Comprehensive Enviromental Response, Compensation and Liability Act (Superfund). Releases to air, land or water of these hazardous substances which exceed the Reportable Quantity (RQ) must be reported to the National Response Center, (800-424-8802); Listed at 40 CFR 302.4
RCRA: Resource Conservation and Reclamation Act. Commercial chemical product wastes designated as acute hazards and toxic under 40 CFR 261.33

SECTION 5 Health Hazard Information

A. EXPOSURE / HEALTH EFFECTS

Inhalation:
May cause irritation of the nose and throat. Exposure to high concentrations has a narcotic effect, producing symptoms of drowsiness, headache, staggering, unconsciousness and possibly death.

Ingestion:
May cause drowsiness, unconsciousness, and death. Gastrointestinal pain, cramps, nausea, vomiting, and diarrhea may also result. The single lethal dose for a human adult = about 250 mls (SAX Sixth Edition).

Skin Contact:
Has a defatting action of the skin that can cause irritation. May cause irritation with a stinging effect and burning sensation.

Eye Contact:
Vapors may irritate the eyes. Splashes may cause severe irritation, possible corneal burns and eye damage.

Chronic Exposure:
Prolonged contact with skin may cause mild irritation, drying, cracking, or contact dermatitis may develop.

Aggrevation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

B. FIRST AID

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:
Give water to drink. Induce vomiting if medical help not is immediately available. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Exposure:
Remove any contaminated clothing. Wash skin with soap or mild detergent and water for at least 15 minutes. Get medical attention if irritation develops or persists.

Eye Exposure:
Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY DATA (RTECS, 1986)

Oral rat LD50: 5840 mg/kg. Skin rabbit LD50: 13 gm/kg. Inhalation rat LC50: 16000 ppm/8H. Mutation references cited Aquatic Toxicity rating TLm96: 1000-10 ppm.

SECTION 6 Occupational Control Measures

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
400 ppm (TWA), 500 ppm (STEL)

-ACGIH Threshold Limit Value (TLV):
400 ppm (TWA), 500 ppm (STEL)

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.

Personal Respirators: (NIOSH Approved)
If the TLV is exceeded a full facepiece chemical cartridge respirator may be worn, in general, up to the maximum use concentration specified by the respirator supplier. Alternatively, a supplied air full facepiece respirator or airlined hood may be worn.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

SECTION 7 Storage and Special Information

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from oxidizing materials. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment.

.....

MALLINCKRODT

aterial Safety Data Sheet

linckrodt, Inc.* Science Products Division, P.O. Box M Paris, KY 40361

Emergency Telephone Number: 314-982-5000

SOPROPYL ALCOHOL

RODUCT IDENTIFICATION:

onyms: 2-propanol; sec-propyl alcohol; isopropanol

rmula CAS No.: 67-63-0

olecular Weight: 60.10

hemical Formula: $(CH_3)_2$ CHOH

azardous Ingredients: Isopropyl alcohol

RECAUTIONARY MEASURES

ARNING! FLAMMABLE LIQUID. HARMFUL IF WALLOWED OR INHALED. AFFECTS CENTRAL NERVOUS YSTEM. CAUSES IRRITATION.

eep away from heat, sparks and flame.
eep container closed.
se with adequate ventilation.
Avoid breathing vapor.
Wash thoroughly after handling.
Avoid contact with eyes, skin and clothing.

EMERGENCY/FIRST AID

If swallowed, give water to drink. Induce vomiting if medical help is not immediately available. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. In all cases call a physician.
SEE SECTION 5.

DOT Hazard Class: Flammable Liquid

SECTION 1 Physical Data

Appearance: Clear, colorless liquid.

Odor: Rubbing alcohol.

Solubility: Infinite in water.

Boiling Point: 82°C (180°F).

Melting Point: -89°C (-128°F).

Specific gravity: 0.79

Vapor Density (Air=1): 2.1

Vapor Pressure (mm Hg): 33 @ 20°C (68°F)

Evaporation Rate: (n-BUAC = 1) 2.83

SECTION 2 Fire and Explosion Information

Fire:
Flammable Liquid
Flashpoint: 12°C (53°F). (closed cup).
Autoignition temperature: 399°C (750°F).
Flammable limits in air, % by volume:
lel: 2.0; uel: 12.0.

Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Contact with strong oxidizers may cause fire or explosion.

Fire Extinguishing Media:
Water spray, dry chemical, alcohol foam, or carbon dioxide. Water spray may be used to keep fire exposed containers cool.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Water may be used to flush spills away from exposures and to dilute spills to non-flammable mixtures. Vapors can flow along surfaces to distant ignition source and flash back.

SECTION 3 Reactivity Data

Stability:
Stable under ordinary conditions of use and storage. Heat and sunlight can contribute to instability.

Hazardous Decomposition Products:
Toxic gases and vapors such as carbon monoxide may be released in a fire involving isopropyl alcohol.

Hazardous Polymerization:
Will not occur.

Incompatibilities:
Heat, flame, strong oxidizers, acetadehyde, chlorine, ethylene oxide, hydrogen-palladium combination, hydrogen peroxide-sulfuric acid combination, potassium tert-butoxide, hypochlorous acid, isocyanates, nitroform, phosgene, oleum and perchloric acid.

SECTION 4 Leak/Spill Disposal Information

Remove all sources of ignition. Ventilate area of leak or spill. Clean-up personnel require protective clothing and respiratory protection from vapors. Small spills may be absorbed on paper towels and evaporated in a fume hood. Allow enough time for fumes to clear hood, then ignite paper in a suitable location away from combustible materials. Contain and recover liquid for reclamation when possible. Larger spills and lot sizes can be collected as hazardous waste and atomized in a suitable RCRA approved combustion chamber, or absorbed with vermiculite, dry sand, earth or similar material for disposal as hazardous waste in a RCRA approved facility.

Ensure compliance with local, state and federal regulations.

AD

NFPA Ratings: Health: 1 Flammability: 3 Reactivity: 0

STABILITY AND REACTIVITY

Chemical Stability
Stable.

Incompatibility with Other Materials
None reasonably foreseeable.

Polymerization
Polymerization will not occur.

Other Hazards
Decomposition: Heating above 260-290 deg C (550-554 deg F) may form potentially toxic fluorine compounds.
Depolymerization may occur in the presence of some metal oxides at temperatures above 288 deg C (550 deg F).
Decomposition occurs at increasing rates as temperature is raised above 355 deg C (670 deg F).

DISPOSAL CONSIDERATIONS

Waste Disposal
Treatment, storage, transportation, and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations. Do not flush to surface water or sanitary sewer system.

TRANSPORTATION INFORMATION

Shipping Information
DOT
Proper Shipping Name Not Regulated.

Shipping Containers

Plastic: 8 Fl, oz. (1 lb.), pint (2 lbs.), quart (4 lbs.), one-half gallon (8 lbs.), one gallon (16 lbs.), five gallons (50 - 75 lbs.).

REGULATORY INFORMATION

U.S. Federal Regulations
TSCA Inventory Status Reported/Included.

TITLE III HAZARD CLASSIFICATIONS SECTIONS 311, 312

Acute : Yes
Chronic : No
Fire : No
Reactivity : No
Pressure : No

(Continued)

OTHER INFORMATION

NFPA, NPCA-HMIS

NPCA-HMIS Rating

Health	1
Flammability	0
Reactivity	0

Personal Protection rating to be supplied by user depending on use conditions.

Additional Information

GRADES

1506, 1514, 1525, 1618, 1625, 1645, 16140, 16256, 16350, 16140N & 16256N

The data in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.

Responsibility for MSDS	Robert V. Daum
Address	DuPont Chemicals Wilmington, DE 19898
Telephone	800-441-9442

# Indicates updated section.

End of MSDS