**BRANSON/IPC**
**a SmithKline company**

**BRANSON INTERNATIONAL PLASMA CORPORATION**

# INSTRUCTION MANUAL
# for
# BRANSON/IPC 3000 SC SERIES
# PLASMA SYSTEM

A00133 REV B
9-28-81

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# WARRANTY

## INTERNATIONAL PLASMA CORPORATION

IPC warrants that for a period of one year they or their representatives will repair or replace any part that is found to be defective in factory materials or workmanship (except tubes, which are warranteed separately by their manufacturers, and glassware).

Under this warranty, repairs or replacements by IPC representatives will be made free of charge for both parts and labor for the first 90 days after delivery, and with no charge for parts for the first year.

This guarantee does not cover abuse, neglect, tampering by unauthorized personnel, or damage inadvertently caused by the user. IPC's only obligation shall be to repair or replace such parts of the equipment proved to be defective in accordance with this warranty. All parts to be replaced under warranty are to be returned to IPC for inspection and subsequent dispensation. IPC shall not be liable for any injury, loss or damage, direct or consequential, arising out of the use of, or the inability to use, the equipment.

IPC reserves the right to modify the specifications and to incorporate desirable electrical or mechanical changes in the equipment prior to delivery.

No statement or recommendation not contained herein shall have any force or effect unless in an agreement signed by officers of International Plasma Corporation.

# INSTRUCTION MANUAL

# IPC 3000 SERIES PLASMA SYSTEM

## 1.0 INTRODUCTION

### 1.1 Description:

The IPC 3000 Series Plasma Systems generate a low pressure, low temperature gaseous plasma. In this machine plasma reactions, such as ashing, etching, and polymer surface modification can be performed quickly and reproducibly. The machine comprises a source of RF electrical power, means for coupling the RF power into the plasma treatment chambers, and a system to control the flow of reactant plasma gases.

The reactor treatment chambers vary from model to model in this series. Each chamber has a hinged access door through which samples are inserted or removed. The door is sealed with a bell jar gasket. The RF generator in this series provides RF power, dynamically regulated to maintain constant level into a normal load or to limit power output if the load is removed.

Two seperate units are provided which are interconnected by gas hoses and electrical cables. These are the RF GENERATOR and the REACTOR CENTER. The REACTOR CENTER contains the Reactor Chambers, the Gas Controls, RF Power Matching Controls, and Timer.

### 1.2 Specifications:

Specifications for the IPC 3000 Series of plasma machines depends on two sets of specifications for the two individual units which make up the system. Reactor center specifications are given on the following page. Specifications for the generator-control console are given in the generator section of this manual.

1.2 (Continued)

MODEL --------- PM ____________________ REACTOR CENTER

Enclosure Dimensions ---- Width ________ inches

Height ________ inches

Depth ________ inches

Reactor Chamber Dimensions ----- Diameter ______ inches

Length ________ inches

Weight ________ pounds

Weight ------------------ ____________ pounds

Power Rating -------- __________ watts continuous input

Impedance Control ------- Matches from 10 to __________ watts to present input impedance of 50 ohms at input connector.

Operating Pressure Range ---------------- 0.1 to 5 torr

Pressure Transducer ----------------- thermocouple type

Vacuum Seals ------ Silicone "O"rings and silicone bell jar gasket.

Flow Meters ------------------- Range - 0 to 900cc/min.

Timer ------------------------- Selects process period

Chart Recorder ---- (Optional) provided with DPS-1000 only; 1div./min. range - 0 to 1mA; input impedance - 100 ohms.

## 2.3 Equipment Supplied:

The following equipment is supplied to:

______________________________________________

Under P. O. Number: ______________________________

Model Number: IPC________________________, comprising:

PM________________R.F. Generator (Serial No.______________)

PM________________Reactor Center (Serial No.______________)

PM 906 Integral Programmer (Serial No.__________________)

DPS-2300 EOP Detector (Serial No.__________________)

PM 921C Temperature Controller (Serial No.______________)

Cables as follows:

______P/N 1163-001

______P/N 2349-005

______P/N 2350-005

______P/N 2351-001

______P/N 2492-001

______P/N 3895-001

______P/N 2973-002

______P/N 6548-001

______Plus P/N 04010

______Cap. P/N 5970-0026

Instruction Manual

Vacuum Pump (Serial No._______________)

Special Features:

# 2.0 INSTALLATION

## 2.1 Unpacking and Handling:

The IPC 3000 Series Plasma System is thoroughly tested and inspected, then carefully packed for shipment. The units should be unpacked with the care due any precision instrument. If the packages show that they have been dropped or handled roughly, return them to the carrier unopened.

Remove the packing cartons, being careful not to scar or damage the units. Make a complete visual inspection of the equipment, checking for damage or loose or broken components.

Careful inspection of glass components for damage should be made at this time.

## 2.2 General Placement:

No special difficulties should be encountered when installing the instrument. The Reactor Center should be placed in a fairly close proximity to the R.F. Generator.

A location must be chosen that will allow the placement of the vacuum pump within four feet of the Reactor Center.

Do not impede air circulation of the system's cooling fans.

## 2.3 Cable Connections:

Connect the cables between the generator and the Reactor Center consoles as indicated by the panel labeling and designation on the cable identification tags.

BE SURE TO REMOVE SHORTING WIRES ON METERS IN GENERATOR BEFORE OPERATION!

DO NOT, at this time, CONNECT ANY CABLE TO THE AC POWER LINE.

### 2.4 Gas Connections:

The unit requires industrial gases at an input pressure of 5 PSIG.* A common single stage gas regulator plus gas cylinder may be used. (A typical regulator would be a Matheson Gas Products #IL-540 or equal). Plastic or metal tubing may be run from the gas regulator to the fittings at the back of the Reactor Center.

There are two 1/4" Swage-lock fittings in the back of the Reactor Center. One is for the reactive gas and one is for the purge gas, and they are so marked.

(Insure that the gas connections are tight).

### 2.5 Vacuum Connections:

The mechanical vacuum pump is supplied with its own installation instructions. These should be referred to for installation, addition of pump oil and attachment of the power cord.

The exhaust manifold extension protrudes from an opening in the rear of the Reactor Center. The flexible hose provided is coupled directly from the exhaust manifold extension to the vacuum pump. Hose clamps are provided for each hose connection.

(Insure that the hose clamps are tight.)

## 3.0 OPERATION

### 3.1 General:

A nominal 115 volt, 20 amp service outlet is required for the IPC 3000 Series Plasma System. Under ordinary load conditions the service will be called on to deliver 15 amps maximum.

The IPC 3000 Series Plasma System uses a standard three pin "U" ground plug. If the wall outlet is not supplied with the proper receptacle, it will be necessary to provide the proper receptacle. It is recommended that the outlet be checked with a tester to insure that it is wired properly.

The IPC 3100 system uses a 208-240V 20a 3 wire circuit.

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*See process tips section for recommended parameters.

## 3.2 Controls and Indicators:

The operating controls and indicators of the IPC 3000 Series Plasma System are located on the front panels of the generator and the Reactor Center. The connectors are on the rear panel. In the text all operating controls and rear panel connectors are described in the following tables:

### 3.2.1 Generator Front Panel Controls and Indicators

1) AC POWER ON/OFF SWITCH..... Applies AC power to the generator.

2) AC POWER INDICATOR..... The lamp above AC POWER switch lights when the AC POWER is ON.

3) READY INDICATOR..... The lamp to the left of the RF POWER switch lights approximately three minutes after AC POWER is turned ON, indicating the generator is warmed up and ready to provide RF POWER.

### 3.2.2 Generator Rear Panel Connectors

1) AC POWER CORD..... A three-wire cord through which the line power is obtained.

2) VACUUM TRANSDUCER CONNECTOR ..... Allows the vacuum transducer which drives the vacuum meter to be attached to the generator. It supplies power to the transducer and couples the return signal to the meter.

3) AUXILLIARY POWER OUTPUT CONNECTOR..... Supplies AC power to auxilliary units and connects to an interlock switch which removes RF Power when the switch is activated. Also supplies the vacuum trigger signal from the generator to the Reactor.

### 3.2.2 (Continued)

4) RF POWER OUTPUT CONNECTOR..... Connects generator output power to the load via UHF type connector.

### 3.2.3 Reactor Center Front Panel Controls and Indicators

1) MODE CONTROL SWITCH..... Selects either automatic or manual operation.

2) START PUSHBUTTON..... Starts automatic sequence.

3) RESET PUSHBUTTON..... Actuates purge at end of automatic sequence.

4) VACUUM ON/OFF SWITCH ..... Actuates exhaust valve for chamber evacuation.

5) PURGE ON/OFF SWITCH ..... Controls entrance of purge gas.

6) FLOW NEEDLE SWITCH ..... Sets flow rate of reactant gas.

7) GAS ON/OFF SWITCH ..... Actuates gas flow.

8) FLOWMETER ..... Measures gas flow in cc/min.

9) MATCHING FINE*..... Fine control for impedance matching network.

10) MATCHING COARSE*..... Coarse control for impedance matching network.

11) TIMER ..... Setable timer to control run time in automatic mode.

12) RF POWER ON/OFF SWITCH ..... Allows RF drive to be applied to Generator power amplifier. In the ON position the RF power is determined by the setting of the level control.

*Not provided if system includes AutoMatch option.

### 3.2.3 (Continued)

13) RF POWER LEVEL CONTROL ..... Provides continuous control of RF power from zero to the maximum available.

14) REFL/FWD SWITCH ..... Selects whether the wattmeter displays Forward or Reflected power.

15) VACUUM METER..... Reads Reactor Chamber Pressure in Torr.

16) POWER METER ..... Reads the power passing through the output connector of the generator. When the REFL/FWD switch is in the FWD position the meter reads power transmitted to the load. When the REFL/FWD switch is in the REFL position the meter read power reflected by the load.

### 3.2.4 Reactor Center Rear Panel Connectors

1) VACUUM TRANSDUCER CONNECTOR ..... This is an octal plug which mates with the socket of the vacuum transducer cable to the generator.

2) RF CABLE CONNECTOR ..... UHF type connector through which RF power to the reactors is obtained.

3) AUXILIARY POWER CONNECTOR ..... Connects to generator and provides power for fans, solenoid valves, lights, RF interlock, and vacuum trigger.

4) EXHAUST MANIFOLD EXTENSION ..... Hose from the vacuum pump fits over this extension.

3.2.4 (Continued)

5) GAS INLET CONNECTORS (3) ..... Gas to the reactor chambers enters through these connectors.

## 3.3 Manual Operation of the IPC 3000 Series Plasma Machine:

### 3.3.1 General Comments*

The following sections deal with the operation and use of all the controls and functions of the IPC 3000 Series Plasma Machine. These procedures are a necessary preliminary to the fully automatic programmed operation described in the following section of this manual. At this point the modules should be completely connected by cables and the gases installed as described in the previous sections. The switches on the generator should be in the positions described below:

AC POWER ................. OFF

On the Reactor Center the switches should be in the following position:

| | |
|---|---|
| R.F. POWER | OFF |
| POWER LEVEL CONTROL | Fully Counterclockwise |
| R.F. METER- FORWARD/REFLECTED | FORWARD |
| FLOW ON/OFF | OFF |
| FLOW METERING VALVE | Fully Clockwise |
| VACUUM PURGE | OFF |
| VACUUM | OFF |
| MODE | MANUAL |
| TIMER | Set to Zero |
| FINE MATCHING | Arbitrary Position |
| COARSE MATCHING | Arbitrary Position |

Check the gasket on the Reactor Center. Remove any foreign material and see that gasket is s seated snugly against Reactor Chamber lips. Close Reactor doors.

Plug in the R.F. Generator and the vacuum pump. Turn ON the vacuum pump.

To operate the plasma system, turn ON the AC POWER switch on the generator. The amber light should now be lit and the fans should be operating.

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* See process tips for recommended parameters.

### 3.3.2 Chamber Evacuation

Throw the vacuum switch to the ON position. The pump noise will noticeably increase and the Reactor doors will be sealed against the gasket. Observe the vacuum gauge on the generator, it should fall below 0.2 torr within a few minutes.

### 3.3.3 Gas Flow Control

Turn on the Gas flow control and adjust to the desired flow rate. As flow is adjusted, observe the torrmeter until the pressure stabilizes at about 1 torr.

### 3.3.4 R.F. Power Level Control & Matching

If the READY lamp has lit, turn on the R.F. power switch on the generator. Turn the R.F. level Control clockwise and observe the R.F. Power Meter.

#### 3.3.4.1 Systems with AutoMatch Option

The AutoMatch will automatically cause the plasma to strike and then tune. The operator need only adjust the R.F. level to the desired value. Verify that a match exists by switching the R.F. switch to REFL and observe that the "reflected power" on the lower scale is less than 2% of the forward power rating.

#### 3.3.4.2 Systems with Manual Matching

Turn COARSE adjust counterclockwise until plasma ignites. Once the plasma is ignited and sustained turn the FINE and COARSE Impedance Matching Network controls until a maximum of forward power is obtained. The forward power is monitored with a FORWARD/REFLECTED switch on the generator. Then adjust for minimum of reflected power with both the COARSE and FINE controls simultaneously. The Matching Network is wide ranging, but must be set initially. Once set, only occasional adjustments will be needed to maintain a good match from run to run. A good matching condition is obtained when the reflected power is less than 5% of the forward power.

### 3.3.5 Review of the Initial Start Up and Manual Operation Procedures

1) Vacuum Pump ON.
2) Main AC power ON.
3) Vacuum ON to obtain low pressure.
4) R.F. switch ON and R.F. level set to desired value.
5) Gas flow ON and set to flow rate desired.
6) Match the impedance of the load.

### 3.3.6 Turning Off the Plasma and Purging the Chambers

To turn the plasma off at the end of a run and remove the samples from the chamber, perform the following steps in the listed sequence:

1) R.F. OFF (level control remains in the run Position).
2) Vacuum OFF
3) Purge ON.

### 3.3.7 Restarting the Plasma

1) Load new samples and close doors.
2) Purge OFF.
3) Vacuum ON (wait for pressure to decrease below about 0.2 torr).
4) R.F. ON.
5) Gas ON.

Note that these operations involve actuating the right switches. The gas flow and R.F. level have been set up in the previous run and the impedance matching remains the same from run to run.

## 3.4 Automatic Operation - Single Program:

### 3.4.1 Starting the Automatic Sequence

The following steps describe the operation of the IPC 3000 Series Plasma System in the automatic mode. The conditions of R.F. power level and gas flow should have been set up and established in the manual mode previously described in section 3.3.

1) MODE switch to AUTO.
2) R.F. ON.
3) Gas flow ON.
4) Purge ON.

3.4.1 (Continued)

5) If reset light comes on, push RESET button.
6) Set TIMER for desired run time.
7) Load samples and close door.
8) Push START button.

Step #8 above actuates a fully automatic sequence which consists of the following steps:

a. The chamber is pumped down to a preset vacuum level (about 0.2 torr).
b. The R.F. power will come on at this preset vacuum level.
c. The gas flow will start at this preset vacuum level.
d. The plasma will be sustained for the time set on the timer.
e. After the timer has run down to zero, the gas flow and the R.F. power go off.
f. The red light above the reset button comes on, along with a sonic alert to tell the operator that the cycle is complete.

### 3.4.2 Changing Samples in the Automatic Mode

The red light over the RESET button and the sonic alert signal the end of the automatic sequence. To change samples, push the RESET button. This actuates the purge and resets the timer. Once the chambers have returned to atmosphere, remove the samples, reload the chamber, and the machine is ready to run again.

## 4.0 MAINTENANCE

### 4.1 General:

This section covers procedures used to keep the IPC Plasma System operating at maximum efficiency. These procedures are primarily inspection and adjustment of all components on a periodic maintenance schedule. Maintenance of the R.F. Generator-Control Console is covered in the separate manual at the rear of this system manual.

## 4.2 Reactor Chambers:

The principal maintenance requirement in the module is to treat the Reactors and doors with care; do not slam or scratch or spill chemicals on the doors or in the reactors. When evacuated the reactors are under an atmospheric force of hundreds of pounds. Doors, reactors, and gaskets are easily cleaned with ordinary agents.

NOTICE

ALL QUARTZWARE SHOULD BE HANDLED WITH COTTON GLOVES

In case of breakage the reactors and doors can be readily replaced with new units.

## 4.3 Vacuum System:

The vacuum pump is the key to trouble-free operation of the vacuum system. Refer to the pump manual for information on oil changes, ballast adjustment, and general maintenance. "o" rings or gaskets damaged by extreme temperatures or corrosive gases should be replaced.

## 4.4 Flow Control:

The gas system is simple so that little trouble should be expected here. All joints should be checked for leaks with a soap solution if disconnected and remade. Swagelock fittings should be tightened one and one-quarter turns past finger tight. If the ball in the flowmeter gets dirty, the unit may be disassembled and cleaned. Watch for tiny parts. If valves fail to function, they may be disassembled and the gaskets cleaned or replaced.

## 4.5 R.F. Electrodes:

Electrodes should last indefinitely. If the reactors are run at extreme temperatures the Teflon support buttons may melt or flow, requiring replacement. They are snapped into perforations in a uniform pattern.

## 4.6 Impedance Matching Network:

As these parts are purely mechanical they should provide years of trouble-free service. If, through some accident, the inductor or capacitor contacts arc over to burn they will need to be replaced.*

*For systems with AutoMatch, see AutoMatch section for maintenance and calibration.

| REV. | DWG. NO. |
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# DIONEX GAS PLASMA SYSTEMS

# ENGINEERING PARTS LIST

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|---|---|---|---|---|
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| F | E.O. #10836 MS | 4-17-80 | | |
| E | TYPED M.M. | 8/24/79 | // | |
| D | E.O. #10513 K.G. | 3/28/79 | | |
| C | REVISED S.S. | 8/10/78 | | |
| B | REVISED S.S. | 8/10/78 | | |
| A | INITIAL ISSUE J.V. | 7/25/78 | | |
| **REV** | **DESCRIPTION** | **DATE** | **CHK** | **APPR** |

**REVISION LEVEL**

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|---|---|---|
| DRAWN S.SLOSEK | DATE 8/10/78 | TITLE 3000 SC SERIES<br>CONTROL PANEL ASSEMBLY |
| CHECKED | DATE [illegible] | |
| ENG. | DATE | D |
| | | DRAWING NO. 04542 |
| | | REV. F |
| | | DO NOT SCALE THIS DRAWING |

NEXT ASSY.

A05495 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| REF | MANUAL | A 00133 | 1 |
| 1 | PLUG BRACKET | B 02669 | 1 |
| M2 | TORRMETER, 0-760 TORR | A 02708 | 1 |
|  | MODUTEC |  |  |
| M1 | WATTMETER, 500 WATT | A 02712 | 1 |
|  | MODUTEC |  |  |
| 2 | METER MOUNTING BRACKET, CENTER | B 02900 | 1 |
| 3 | RELAY MOUNTING BRACKET | C 03785 | 1 |
| 4 | CONTROL PANEL | C 03912 | 1 |
| 5 | CONNECTOR MOUNTING BRACKET | C 03990 | 1 |
| 6 | DECAL | C 04011 | 1 |
| 7 | FLOWMETER MOUNTING BRACKET | B 04118 | 2 |
| REF | SCHEMATIC | C 04123 | 1 |
| 8 | METER MOUNTING BRACKET, SIDE | B 04356 | 2 |
| 9 | BEZEL BAR | B 04405 | 1 |
| REF | WIRING HARNESS | D 04543 | 1 |
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| TITLE | 3000 SC SERIES<br>CONTROL PANEL ASSEMBLY | | | | |
| SIZE<br>D | DWG. NO.<br>04542 | REV.<br>F | CHK.<br>/ | APPR. | |
| DRAWN<br>S. SLOSEK | DATE<br>8/10/78 | SHEET 3 OF 6 | | | |

A 04288 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| C6 | CAPACITOR, .01uF 500V | 1500-0001 | 1 |
| | SPRAGUE #5GAS-S10 | | |
| 10 | RELAY SOCKET, 11 PIN F | 2110-0046 | 1 |
| | AMPHENOL #77-M1P-11 | | |
| 11 | SOCKET, 8 PIN OCTAL | 2110-0170 | 3 |
| | CINCH JONES #8AM | | |
| 12 | CONNECTOR, FEMALE DISCONNECT | 2120-5077 | 4 |
| | HOLLINGSWORTH #SO-5077 | | |
| 13 | CONNECTOR, MALE DISCONNECT | 2120-5078 | 4 |
| | HOLLINGSWORTH #SO-5078 | | |
| J5 | CONNECTOR, 5 PIN FEMALE | 2130-0020 | 1 |
| | AMPEHNOL #126-218 | | |
| P1 | RECEPTACLE, 14 PIN MALE | 2152-2215 | 1 |
| | AMPHENOL #MS-3102A-22-19P | | |
| J2 | CONNECTOR, 4 PIN FEMALE | 2152-2417 | 1 |
| | AMPHENOL #MS-3106A-14S-2S | | |
| E1-E4 | TERMINAL, INSULATED | 2160-0207 | 4 |
| | USECO #1417-9 | | |
| M3 | TIMER, 1 HR. 60 HZ 120V | 2200-0004 | 1 |
| | EAGLE #HP 56A6 | | |
| 14 | KNOB, 3/4" DIA. | 2400-0001 | 1 |
| | ALCO #DPN-700-AB | | |
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A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 16 | M-F THD SPACER | 2860-8257 | 4 |
| | H.H. SMITH #8257 | | |
| 17 | FLOWMETER, 900cc/MIN. | 2900-0370 | 1 |
| | LABCREST #10A1460MB11D | | |
| DS1 | LAMP, AMBER 115V | 3900-0001 | 1 |
| | DIALCO #507-4537-1433-640 | | |
| DS2 | LAMP, RED 115V | 3900-0002 | 1 |
| | DIALCO #507-4537-1431-640 | | |
| 18 | LAMP HOLDER | 3900-0107 | 2 |
| | DIALCO #250-7445-14-504 | | |
| K2, K4 | RELAY, 120V | 4500-0009 | 2 |
| | P-B #KRP-11A | | |
| K1 | RELAY | 4500-0010 | 1 |
| | SIGMA #42R02500S-S1L | | |
| K3 | RELAY 3PDT 120V 5A | 4500-0165 | 1 |
| | P-B #KRP-14A | | |
| R1 | POTENTIOMETER 100K 2W | 4750-0001 | 1 |
| | OHMITE #CMU 1041 | | |
| PB1-2 | SWITCH, SPDT | 5100-0002 | 2 |
| | C & K #8121 | | |
| S8 | SWITCH, DPDT | 5100-0004 | 1 |
| | C & K #7201 P | | |
| S1 | SWITCH, 4PDT | 5100-0005 | 1 |
| | C & K #7401P | | |
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A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| S2-4, 7 | SWITCH, SPDT | 5100-0027 | 4 |
| | C & K #7101P | | |
| SV3, 5 | VALVE, SOLENOID N.C. 120V | 5930-0002 | 2 |
| | SKINNER #B02A1052 | | |
| 19 | HEX NIPPLE, 1/8 P | 5965-1802 | 2 |
| | IMPERIAL #122B | | |
| 20 | BULKHEAD RETAINER | 5970-0024 | 3 |
| | SWAGELOCK #S-402-61F | | |
| 22 | BULKHEAD FITTING 1/4T | 5970-0903 | 3 |
| | PARKER #4-4-DBZ-B | | |
| 21 | STREET TEE 1/8P | 5970-0229 | 1 |
| | CAJON #B-25T | | |
| 23 | MALE ELBOW, 1/4T X 1/8 P | 5970-1306 | 2 |
| | PARKER #4-2-CBZ-B | | |
| 24 | MALE BRANCH TEE, 1/4T X 1/8P | 5970-2003 | 1 |
| | PARKER #4-4-25BZ-B | | |
| 25 | RING TERMINAL 22 GA X #10 STUD | | 4 |
| | H.H. SMITH #4803 NON-INS | | |
| 26 | LOCKING TERMINAL LUG | | 1 |
| | H.H. SMITH #1416-6 | | |
| 27 | RING TERMINAL 22GA X #6 STUD | | 6 |
| | H.H. SMITH #4801 | | |
| 28 | CABLE | | A/R |
| | BELDEN #8763 | | |
| | | | |

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SHEET 6 OF 6

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# DIONEX GAS PLASMA SYSTEMS

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|---|---|---|---|---|---|
| S | E.O. #11122 | MS | 8/17/81 | | |
| R | E.O. # 10878 | AS | 6-3-81 | | |
| Q | E.O. #10888 | | 9-9-80 | | PGS |
| P | E.A.R. #20328 | | 9-5-80 | | PGS |
| O | E.O. #10655 | MS | 4-1-80 | PB | |
| N | E.O.#10703 | PB | 3/80 | PB | |
| M | E.O. #10686 | MS | 3/80 | PB | |
| L | E.O. #10841 | M.S. | 3/80 | PB | |
| K | E.O. #10811 | KJ | 2/80 | PB | |
| J | E.O. 10765 | MM | 1/80 | | |
| H | E. O. #10745 | | 12/79 | | |
| G | E. O. 10743 | | 12/12/79 | | |
| F | E.O. #10712 | | 10-79 | | |
| E | E.O. #10527 | | 4/25/79 | | |
| D | E.O. #10528, 10535, 10540 | | 4/19/79 | PB | |

REVISION LEVEL

**DIONEX** GAS PLASMA DIVISION

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HAYWARD, CALIF. 94544

| NEXT ASSY. | DRAWN | DATE | TITLE | | REV. |
|---|---|---|---|---|---|
| | K.G. | 4/19/79 | REACTOR CENTER ASSEMBLY<br>PM 11020 | | |
| | CHECKED | DATE | | | |
| | | [illegible] | | | |
| | ENG. | DATE | | DRAWING NO. | |
| | M. McArthur | [illegible] | A | 05266 | S |
| | | | DO NOT SCALE THIS DRAWING | | |

A0545 REV

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 30 | FLANGED AIR OUTLET | B 02596 | 1 |
| | | | |
| 31 | FAN SCREEN | B 02799 | 1 |
| 32 | TRANSDUCER MOUNTING BRACKET | B 03110 | 1 |
| 33 | HINGE GUSSET | C 05352 | 1 |
| 58 | WINDOW STOP | A 03162 | 4 |
| | | | |
| 14 | DOOR STOP (LEFT HAND) | B 03165 | 1 |
| 15 | HINGE | B 03167 | 1 |
| 16 | OUTER REACTOR DOOR | C 03169 | 1 |
| 17 | INSIDE DOOR PLATE (LEFT HAND) | D 03171 | 1 |
| 28 | MODESTY PLATE | C 03176 | 1 |
| 27 | FRONT PANEL | D 03497 | 1 |
| 11 | ULTRA VIOLET SHIELD | B 03579 | 1 |
| 10 | SPRING DOOR TENSION | B 03752 | 2 |
| 6 | HANGER BRACKET ELECTRODE FRAME | B 03934 | 4 |
| | | | |
| 2 | HORIZONTAL BAR | B 03940 | 2 |
| 4 | GUSSET | B 03943 | 2 |
| 9 | REAR PANEL | D 03947 | 1 |
| 1 | DECK AND SUPPORT ASSEMBLY | E 03948 | 1 |
| | | | |
| | DUMMY PLUG | B 04010 | 3 |
| 52 | AUTOMATCH "L" BRACKET | B 04418 | 1 |
| 61 | HOUSING ASSY (REF ONLY) | D 04156 | |

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94544

| | | | | |
|---|---|---|---|---|
| TITLE REACTOR CENTER ASSY<br>PM 11020 | | | | |
| SIZE A | DWG. NO. 05266 | REV S | CHK. FB | APPR. |
| DRAWN MMC | DATE 3/29/79 | SHEET 1 OF 4 | | |

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 12 | TEFLON WINDOW SLIDE | C 04224 | 1 |
| 45 | CHAMBER RETAINER | D 04229 | 1 |
| 50 | TEFLON PAD | C 04247 | 1 |
| 34 | CAPACITOR MOUNTING BRACKET | B 04425 | 1 |
| | CAPACITOR BRACKET | B 04426 | 1 |
| 39 | BELLOWS1" STAINLESS STEEL | B 04616 | 1 |
| | | | |
| 26 | ELECTRODE ASSY | D 05375 | 4 |
| | | | |
| | ELECTRODE SUPPORT ASSY | A 05388 | 2 |
| | | | |
| | GROUND STRAP, AUTOMATCH TO CHAMBER | B 05290 | 1 |
| | WELDMENT CLAMP SUPPORT | B 07747 | 1 |
| | | | |
| | | | |
| | CLAMP HOOK | B 06177 | 2 |
| | WINDOW, R. F. SHIELD | C 06227 | 1 |
| | R/C FILTER ASSEMBLY | A 06979 | 1 |
| | KIT DOOR HANDLE AND STRIKER PLATE | B 06526-01 | 1 |
| | | | |
| | | | |
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| | | | | |
|---|---|---|---|---|
| TITLE | REACTOR CENTER ASSY<br>PM 11020 | | | |
| SIZE<br>A | DWG. NO.<br>05266 | REV.<br>S | CHK.<br>FB | APPR. |
| DRAWN<br>MMC | DATE<br>3/29/79 | SHEET 2 OF 4 | | |

A 04233

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| | | | |
| C13, 14 | CAPACITOR, CERAMIC TUBULAR | 1500-0189 | 2 |
| 57 | CONNECTOR, FEMALE (HOLLINGSWORTH #50-5077) | 2120-5077 | 2 |
| 56 | CONNECTOR, MALE (HOLLINGSWORTH #50-5078) | 2120-5078 | 2 |
| | | | |
| B1 | FAN (HOWARD #3450) | 2600-0004 | 1 |
| | FURNITURE LEVELER | 2800-0005 | 4 |
| | INTERLOCK SWITCH #23AC1 | 5100-0017 | 1 |
| 48 | "O" RING SILICON 1" (PARKER #A-120) | 5900-0120 | 3 |
| | | | |
| 49 | "O" RING SILICON 3/4" (PARKER #2-116) | 5900-2116 | 3 |
| 13 | BELL JAR GASKET | 5905-2452 | 1 |
| 37 | GAUGE TUBE (HASTINGS #DV4DM) | 5930-0322 | 1 |
| SV5 | VALVE SOLENOID HIGH VACUUM | 5935-0027 | 1 |
| 43 | THOMAS CLAMPS FOR 28/15 CUP JOINT | 5950-0001 | 3 |
| 44 | THOMAS CLAMPS FOR 35/25" CUP JOINT | 5950-0002 | 1 |
| | RELAY LABELS | 6100-0006 | 1 |
| | 1/8 PIPE TO 1/4 TUBE ELBOW (BRASS) 4-2CBZ-B | 5970-1306 | 1 |
| | 1/8 PIPE HEX NIPPLE (BRASS) | 5965-1802 | 1 |
| | REAR PANEL LABELS | 6100-0008 | 1 |
| | 1/8 PIPE TO 1/8 TUBE CONNECTOR (BRASS) 2-2FBZ-B | 5970-0614 | 2 |
| | HOSE CLAMP | 2800-0237 | 1 |
| | HEX NUT SPACER | 2860-8427 | 20 |
| | GROUND STRAP SCREWS #6-32 BRASS | | 4 |
| | | | |

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|---|---|---|---|---|---|
| TITLE | REACTOR CENTER ASSY<br>PM 11020 | | | | |
| SIZE<br>A | DWG. NO.<br>05266 | | REV.<br>S | CHK.<br>HE | APPR. |
| DRAWN<br>MMC | DATE<br>3/29/79 | SHEET 3 OF 4 | | | |

A 04289 REV C

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| | 35/25" GROUND GLASS SOCKET | B 04439 | 1 |
| | BLIND BALL | B 04444 | 1 |
| 21 | 11 1/2" SQUARE QUARTZ WINDOW | C 04480 | 1 |
| | PM 702 AUTOMATCH ASSY | D 04488 | 1 |
| 20 | 10 X 20 QUARTZ CHAMBER | E 05361 | 1 |
| 22 | 28/15 X 1/4 TUBE TRANSDUCER BALL | C 05377 | 1 |
| | 38/15 X 1/4 TUBE GAS BALL | B 05378 | 1 |
| | ACORN NUT | B 05754 | 5 |
| | | | |
| | | | |
| | | | |
| | | | |
| | NOTE: TO COMPLETE SYSTEM SELECT APPROPRIATE | | |
| | PIPE AND TUBE KIT | | |

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| | | | | |
|---|---|---|---|---|
| TITLE | REACTOR CENTER ASSY<br>PM 11020 | | | |
| SIZE<br>A | DWG. NO.<br>05266 | REV.<br>S | CHK. | APPR. |
| DRAWN<br>MMC | DATE<br>3/29/79 | SHEET 4 OF 4 | | |

DWG. NO. D 06221
REV. D

# DIONEX GAS PLASMA SYSTEMS

# ENGINEERING PARTS LIST

| REV | DESCRIPTION | DATE | CHK | APPR |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| D | E . 0 #10927 M.S | 1-27-81 | | |
| C | E.O. #10836 MS | 4-17-80 | | |
| B | E.O. #10829 MS | 3/80 | | |
| A | RELEASE E.O. #10812 K.J. | 1/80 | | |

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**DIONEX** GAS PLASMA DIVISION
31159 SAN BENITO
HAYWARD, CALIF. 94544

NEXT ASSY.

DRAWN: K.J.
DATE: 1/25/80
CHECKED:
DATE: 1/29/80
ENG.:
DATE:

TITLE: 3000 SERIES W/DPS-1000 CONTROL MODULE ASSEMBLY

D
DRAWING NO.: 06221
REV.: D

DO NOT SCALE THIS DRAWING

A05495 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| 1 | DPS /1000 CONNECTOR BRACKET | C 03354 | 1 |
| M2 | TORRMETER, 0-760 TORR MODUTEC | A 02708 | 1 |
| M1 | WATTMETER, 500 WATT MODUTEC | A 02712 | 1 |
| 2 | METER MOUNTING BRACKET, CENTER | B 02900 | 1 |
| | | | |
| | | | |
| 3 | RELAY MOUNTING BRACKET | C 03785 | 1 |
| 4 | FRONT PANEL | C 03912 | 1 |
| 5 | CONNECTOR MOUNTING BRACKET | C 03990 | 1 |
| | | | |
| | | | |
| 7 | FLOWMETER MOUNTING BRACKET | B 04118 | 2 |
| | | | |
| 8 | METER MOUNTING BRACKET, SIDE | B 04356 | 2 |
| 9 | BEZEL BAR | B 04405 | 1 |
| | | | |
| | | | |
| | SCHEMATIC | C 05982 | REF |
| | | | |
| REF | WIRING HARNESS | D 07237 | 1 |
| 6 | DECAL | D 06220 | 1 |

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| | | | | | |
|---|---|---|---|---|---|
| TITLE | 3000 SERIES W/DPS-1000<br>CONTROL MODULE ASSEMBLY | | | | |
| SIZE<br>D | DWG. NO.<br>06221 | | REV.<br>D | CHK. | APPR. |
| DRAWN<br>K.J. | DATE<br>1-25-80 | SHEET 3 OF 5 | | | |

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| C1,C6, C5 | CAPACITOR, .01uF 500V<br>SPRAGUE #5GAS-S10 | 1500-0001 | 3 |
| | | | |
| | | | |
| 10 | RELAY SOCKET, 11 PIN F<br>AMPHENOL #77-MIP-11 | 2110-0046 | 1 |
| 11 | SOCKET, 8 PIN OCTAL<br>CINCH JONES #8AM | 2110-0170 | 4 |
| 12 | CONNECTOR, FEMALE DISCONNECT<br>HOLLINGSWORTH #SO-5077 | 2120-5077 | 4 |
| J5 | CONNECTOR, 7 PIN FEMALE<br>AMPHENOL # MS-3102A-16S-1S | 2152-1608 | 1 |
| P3 | CONNECTOR, 7 PIN MALE<br>AMPHENOL #MS 3102-16S-1P | 2152-1607 | 1 |
| | | | |
| P1 | RECEPTACLE, 14 PIN MALE<br>AMPHENOL #MS 3102A-22-19P | 2152-2215 | 1 |
| J2 | CONNECTOR, 4 PIN FEMALE<br>AMPHENOL #MS 3106A-14S-2S | 2152-2417 | 1 |
| E1 - E4 | TERMINAL, INSULATED<br>USECO #1417-9 | 2160-0207 | 4 |
| DS3 | SONALERT<br>MALLORY #SC 110 | 2200-0001 | 1 |
| M3 | TIMER, 1 HR. 60 HZ 120V<br>EAGLE #HP 56A6 | 2200-0004 | 1 |
| A1 | CHART RECORDER<br>RUSTRACK #2802200-2882 (J3 IS PART OF A1) | 2200-2882 | 1 |
| 14 | KNOB, 3/4" DIA.<br>ALCO #DPN-700-AB | 2400-0001 | 1 |
| TS-1 | TERMINAL STRIP SMITH # 863 | 2860-0863 | 1 |
| 16 | M-F THD SPACER<br>H.H. SMITH #8257 | 2860-8257 | 4 |
| 17 | FLOWMETER, 900 cc/min.<br>LABCREST #10A1460MB11D | 2900-0370 | 1 |
| | | | |
| | | | |
| DS1 | LAMP, AMBER 115V<br>DIALCO #507-4537-1433-640 | 3900-0001 | 1 |
| DS2 | LAMP, RED 115V<br>DIALCO #507-4537-1431-640 | 3900-0002 | 1 |
| 18 | LAMP HOLDER<br>DIALCO #250-7445-14-504 | 3900-0107 | 2 |
| | | | |

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TITLE: 3000 SERIES W/DPS-1000
CONTROL MODULE ASSEMBLY

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| D | 06221 | D | | |

| DRAWN | DATE | |
|---|---|---|
| K.J. | 1-25-80 | SHEET 4 OF 5 |

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| K2, K4 | RELAY, 120V<br>P&B #KRP-11A | 4500-0009 | 2 |
| K1 | RELAY<br>SIGMA #42RO2500S-SIL | 4500-0010 | 1 |
| K5 | RELAY<br>SIGMA #42RO-1000S-SIL | 4500-0163 | 1 |
| K3 | RELAY, 3PDT 120V 5A<br>P&B #KRP-14A | 4500-0165 | 1 |
| R1 | POTENTIOMETER 100K 2W<br>OHMITE #CMU 1041 | 4750-0001 | 1 |
| K6 | OPTO RELAY # 240-D10 | 4500-0169 | 1 |
| | | | |
| PB1 | SWITCH, SPDT<br>C & K #8121 | 5100-0002 | 1 |
| S8 - 10 | SWITCH, DPDT<br>C & K #7201 P | 5100-0004 | 3 |
| S1 | SWITCH, 4PDT<br>C & K #7401P | 5100-0005 | 1 |
| S2-4, S7 | SWITCH, SPDT<br>C & K #7101P | 5100-0027 | 4 |
| PB2 | SWITCH, DPDT<br>C & K #8221 | 5100-0035 | 1 |
| SV3,5 | VALVE, SOLENOID N.C. 120V<br>SKINNER #B02A1052 | 5930-0002 | 2 |
| 19 | HEX NIPPLE, 1/8" P<br>IMPERIAL #122B | 5965-1802 | 2 |
| 20 | BULKHEAD RETAINER<br>SWAGELOCK #S-402-61F | 5970-0024 | 3 |
| 23 | MALE ELBOW, ¼" TUBE X 1/8" PIPE<br>PARKER #4-2-CBZ-B | 5970-1306 | 2 |
| 21 | STREET TEE 1/8" PIPE<br>CAJON #B-25T | 5970-0229 | 1 |
| 24 | MALE BRANCH TEE, ¼" TUBE X 1/8" PIPE<br>PARKER #4-4-25BZ-B | 5970-2003 | 1 |
| 22 | BULKHEAD FITTING ¼" TUBE<br>PARKDER #4-4-DBZ-B | 5970-0903 | 3 |
| 25 | RING TERMINAL 22 GA X #10 STUD<br>H.H. SMITH #4803 NON- INS | | 4 |
| 26 | LOCKING TERMINAL LUG<br>H.H. SMITH #1416-6 | | 1 |
| 27 | RING TERMINAL 22GA X #6 STUD<br>H.H. SMITH #4801 | | 6 |
| 28 | CABLE<br>BELDEN #8762 | | A/R |
| | | | |
| | | | |

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| TITLE | | | | |
|---|---|---|---|---|
| 3000 SERIES W/DPS-1000<br>CONTROL MODULE ASSEMBLY | | | | |
| SIZE<br>D | DWG.NO.<br>06221 | REV.<br>D | CHK. | APPR. |
| DRAWN<br>K.J. | DATE<br>1-25-80 | SHEET 5 OF 5 | | |

A 04289 REV

**BRANSON/IPC**
**a SmithKline company**

## BRANSON INTERNATIONAL PLASMA CORPORATION

# INSTRUCTION MANUAL

# for

# R. F. GENERATOR PM 112

A 00176 Rev. B 5/22/80

31172 Huntwood Avenue
P.O. Box 4136, Hayward, CA 94544
(415) 489-3030 Telex: 337-759

# WARNING

The High Voltage Regulator Board, Assembly C03409D, for this Generator, S/N__________, has been conditioned to operate at______Hz. Operation at ______Hz may result in serious damage.

# INSTRUCTION MANUAL

for

PM 112

## Table of Contents

# ADDENDUM TO INSTALLATION INSTRUCTIONS FOR PM 112

The following assembly instructions are necessary for the proper installation of your power beam tube and thermal isolation parts. Correct assembly of these thermal "protection" parts is essential so as not to transfer exhaust heat from the power tube to the chassis which could damage power AMP components. The metal screw provides ground for any RF energy radiating off of tube.

1. Unpackage generator and cable box where you will find power tube and related parts. A parts list is provided should any parts be missing.

2. Set generator on its side so 4" hole in back of generator is at the top. Reach in and remove packing material from RF plate strap/clip.

3. Unpackage power tube and carefully insert thru hole to socket. Push straight back to stop and turn clock-wise to stop. Clip on RF strap to top of tube.

4. Twist clip counter-clockwise to take up slack. Insert teflon chimney so slot accommodates strap. Push in so edge of chimney is flush with chassis.

5. Place flange on table (Fig. 1A). Place fan screen on flange face. Place dress plate over screen. Line holes up. (Fig. 1B).

6. Drop screws in holes. Pick up assembly and tip up-side-down holding screws in place. Drop fiber washers over screws. Place assembly against port in generator and tighten screws. <u>DO</u> <u>NOT</u> TORQUE NYLON SCREWS.

## PARTS LIST

| | | |
|---|---|---|
| 1 | Power Tube | 5700-0187 |
| 1 | Flange | 3978 |
| 1 | Fan Screen | 4148 |
| 1 | Dress Plate | 4538 |
| 1 | Teflon Exhaust Tube | 4149 |
| 3 | Nylon 8-32 1" Screws | |
| 1 | Steel 8-32 3/4" Screw | |
| 4 | Fiber Washers | |

11/29/79

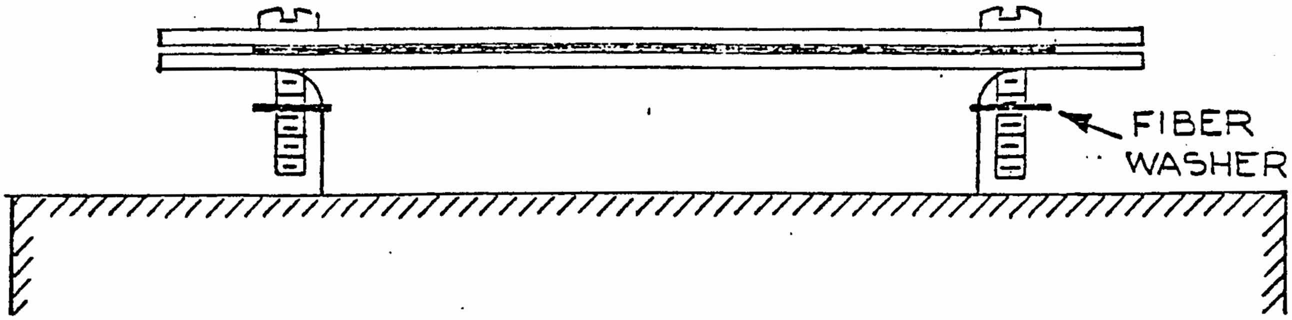

Figure 1A

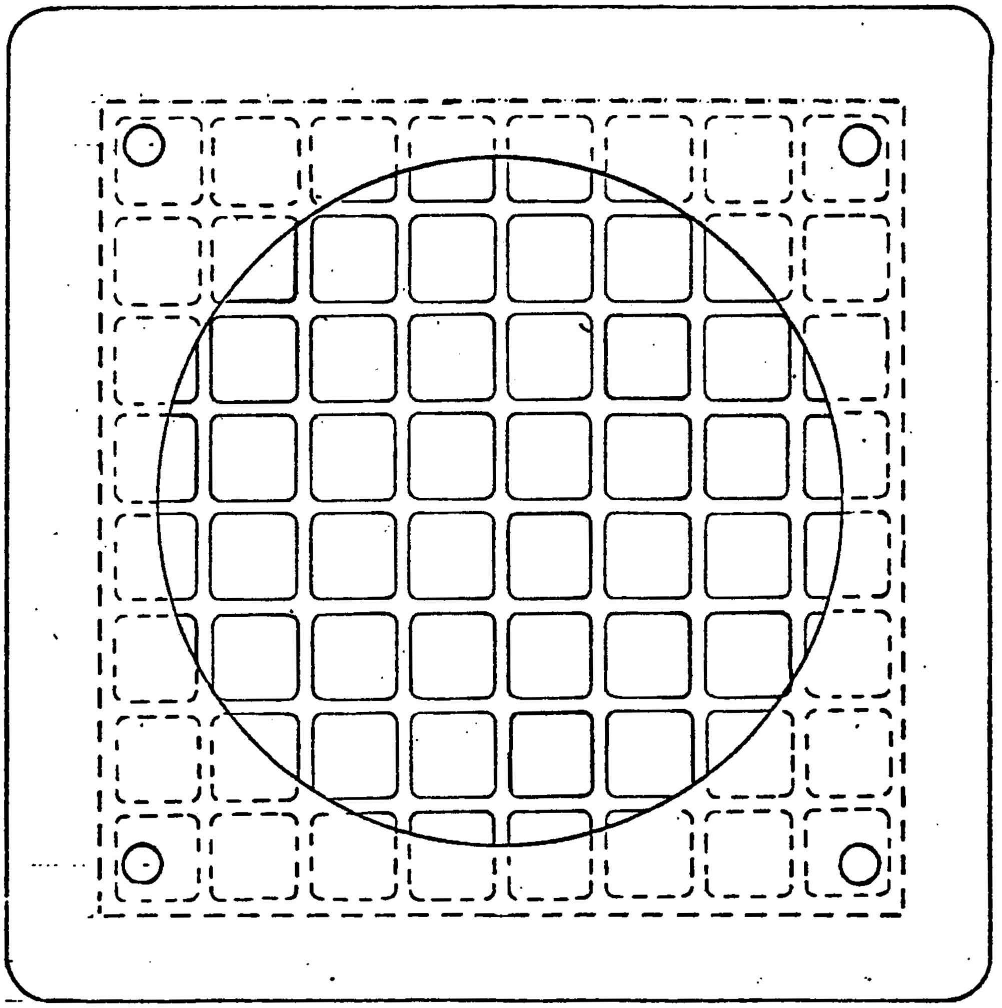

Figure 1B

# 1.0 INTRODUCTION

## 1.1 General Description:

The PM 112 RF Generator provides the necessary radio frequency power to generate a plasma in IPC Plasma Machines. It includes circuits which measure characteristics of the plasma in the Reaction Chamber, with provisions to drive meters remotely located in the system controller.

The metered quantities are the RF (radio frequency) power level transmitted to the chamber; the reflected power, indicating any impedance mismatch between the chamber impedance and 50 ohms; and the pressure of the gas in the chamber.

The output power level is continously controlled over the full 1500 watt range by a remote knob. The output level is regulated to withstand normal line voltage variations about 220 volts at either 50 or 60 hertz (internally selectable).

The output frequency is crystal controlled at 13.56 Megahertz. The output is designed to drive a 50 ohm load.

The PM 112 also includes provisions for initiating the process cycle in a 4000 Series controller. It detects that the reaction chamber has been evacuated to a preset level (approximately 0.1 torr) and transmits a signal to the controller which then begins the process cycle.

## 1.2 Specifications:

| | |
|---|---|
| Output Frequency | 13.56 Mhz ± 0.005%, crystal controlled. |
| Output Power | 0-1500*watts with continous control. |
| Output | Designed for 50 ohm load. |
| Output Connector | Type UHF. |
| Power Monitor | Output DC current is provided to drive an external meter which is calibrated to a full scale reading of 1500 watts* |

Some systems may be equipped with a PM 112 wherein the output power is limited to 750 watts or 1000 watts. In these systems the full scale reading of the meter is 1000 watts.

1.2 (Con't)

| | |
|---|---|
| Power Monitor (Con't) | Two separate outputs give the power transmitted to or reflected from the load. |
| Vacuum Monitor | A calibrated DC current is provided to drive a remote meter which is scaled from 0.1 to 20 torr with a shaded region to indicate atmospheric pressure. The drive signal to the meter is brought in from outside the PM 112, being generated by a vacuum transducer in the treatment console. |
| Power Control | A remote rotary control knob continuously varies power from zero to maximum. A remote toggle switch may switch the RF output on or off. A front panel AC line switch turns power to the PM 112 on or off. |
| Rear Panel Connections | A permanently attached three-wire power cord is provided at the rear panel. A rear connector provides AC Power, metering signals, interlock wires, and control wires to the system programmer. A second connector provides power to and receives the signal from the vacuum transducer. A third connector provides RF output. |
| Power Requirements | 220 volt nominal AC, 50-60 Hz, 35 Amp, maximum. Requires normal three-wire input with ground, neutral and 220 volt leads. |
| Dimensions | Width----24.25 inches<br>Height---13.00 inches<br>Depth----18.26 inches |
| Weight | 95 pounds. |

### 1.3 Equipment Supplied:

The following equipment is supplied with the PM 112 Control Console:

| | |
|---|---|
| 1 RF Power Output Cable | IPC #01163-001 |
| 1 Programmer Cable | IPC #02351-001 |
| 1 Vacuum Transducer Cable | IPC #02492-001 |

## 2.0 INSTALLATION:

### 2.1 Unpacking and Handling:

The IPC PM 112 RF Generators are thoroughly tested and inspected and then carefully packed before shipment. The unit should be unpacked with the care due any precision instrument. If the package shows that it has been dropped or handled roughly, return it to the carrier unopened.

Remove the packing carton, being careful not to scar or damage the unit. Make a complete visual inspection of the equipment, checking for damage or missing components. Report any damage immediately to your IPC representative.

### 2.2 Installation:

No special installation instructions are required for the PM 112 other than those required if special peripheral equipment is required. Mount it as close as possible to the RF power load and leave clear space at the back of the instrument to allow air flow. The PM 112 is attached to the RF load with the supplied RF power output cable. If the PM 112 is used in a standard IPC Plasma Generation System, Vacuum Transducer and Programmer cables may be used directly. Their connections will be explained in the manual for the system. Connections to other equipment must be taken up as special cases. Information must be obtained from an IPC representative or from reference to the schematic. NOTE: A plug and receptacle or positive disconnect box located within view of the generator should be provided for the main AC power cable.

## 3.0 OPERATION:

### 3.1 Controls and Indicators:

The operating controls and indicators for the PM 112 are located on the front panel of the reactor center except the AC power switch and indicator lights, which are on the generator front panel. The connectors are on the rear

### 3.1 (Con't)

panel. In the text, all operating controls are called out as they appear on the equipment. Front panel controls and rear panel connectors are described in the following table:

## Front Panel Controls and Indicators

| | |
|---|---|
| AC POWER ON/OFF Switch | Applies AC power to the PM 112. |
| AC POWER Indicator | The lamp above the AC POWER switch lights when the AC POWER is ON. |
| READY Indicator | The lamp lights when RF power is available. Approximately 3 minutes after the AC POWER has been turned on. |

## Rear Panel Connectors

| | |
|---|---|
| AC POWER Cord | A permanently attached three-wire cord through which the PM 112 obtains its line power. |
| VACUUM TRANSDUCER Connector | Allows the vacuum transducer which drives the vacuum meter to be attached to the PM 112. It supplies power to the transducer and couples the return signal to the meter. |
| PROGRAMMER Plug | This connects the PM 112 to the external controls which are necessary to operate the PM 112. Isolated AC voltage is sent to the remote unit. A control line to an external potentiometer determines the PM 112 output power level. Three sets of meter leads drive an external vacuum meter and forward and reflected power meter. A power interlock lead may be used to interrupt RF power from the PM 112. An output denoting a preset vacuum level is provided. |

3.1 (Con't)

RF POWER OUTPUT Connector.......Connects PM 112 output power to the load via a UHF type connector.

## 3.2 Operation:

Instructions in this section apply to operation of the PM 112 independently as a source of RF power. Operation in complete IPC Gas Plasma Systems is described in the manual which applies to that particular machine. Sufficient instructions are included here to operate the PM 112 as a power source to supply energy into a 50 ohm matched load.

Since power from the PM 112 is controlled via the Programmer cable, either appropriate auxiliary equipment must be provided which includes the RF control or a special control must be constructed. This may be simply a 100K, 2W potentiometer connected to pins L, J, and K of the PROGRAMMER jack. Fasten the wiper to pin J and the end of the pot contacted by the wiper in full clockwise rotation to pin K. The other end of the pot connects to pin L.

### Operating Procedure

1. Attach the RF power output cable to the power output connector on the rear panel of the PM 112 and connect a 50 ohm load to the other end of the cable.
2. When the PM 112 is used in a complete IPC Plasma System, the Programmer cable and Vacuum Transducer cables are installed. As it is here being used separately, install the special RF control discussed above. No RF power can be obtained without some connection to the Programmer jack. Additionally a simulated vacuum transducer connection must be made to the 4 pin transducer jack. This can be a 1 amp 600 volt diode connected between pins A and B, the cathode going to A.
3. Set the AC and RF POWER switches to OFF, the RF POWER LEVEL control full counterclockwise, and the FWD/REFL switch to FWD.
4. Plug the three-wire power cord into the appropriate power outlet socket.
5. Allow the PM 112 to warm up 3 minutes with the AC POWER switch ON before operating any other controls. The RF ready light should then come on. If the PM 112 is used in a complete IPC Gas Plasma machine, evacuate the Reaction Chamber to a pressure of 2 torr.

6. Turn the RF POWER switch to ON. This switch is on the reactor center control panel.

7. Raise the RF LEVEL control until the desired RF output is obtained. If the PM 112 is used in an IPC Gas Plasma System, the power may be read on the wattmeter provided in the system. If it is used separately, an external inline wattmeter must be provided between generator and load.

8. With the wattmeter reading about 200 watts, change the FWD/REFL switch to REFL. With a matched 50 ohm load, this reading should be very small. If it is large, more than 10-15 watts, then the load must be matched to bring the reflected power down. If the PM 112 is used in a standard IPC Gas Plasma System further instructions on matching will be contained in the manual for that system. If not, other means must be used to adjust the load to a matched condition. When the load is matched, the power may be raised to any value up to maximum.

9. Check the reflected power by switching the FWD/REFL switch to REFL, to be sure that the load remains matched. Reflected power should be less than 1.0% of the forward power. Power must be reduced if the match is not maintained.

# 4.0 THEORY OF OPERATION

## 4.1 Functional Description:

A functional block diagram of the PM 112 is shown in Fig. 1. The OSCILLATOR, POWER AMPLIFIER, COUPLER and REGULATOR constitute a feedback control system regulating the output power at a level determined by the RF level control. The OSCILLATOR generates a 13.56 mhz sine wave which is amplified by the POWER AMPLIFIER. The amplitude of the OSCILLATOR'S output is controlled by the REGULATOR. The COUPLER detects the power supplied by the POWER AMPLIFIER and outputs a DC voltage proportional to the power. This DC voltage is fed to the REGULATOR where it is compared with the setting of the RF power level control setting.

The POWER AMPLIFIER is designed to drive a resistive 50 ohm load, and the Reactor Center input circuitry is designed to present a 50 ohm load to the generator. This constitutes a "matched" modular system. In order to provide the appropriate 50 ohm impedance each Reactor Center includes a "matching network" which transforms the impedance of the plasma chamber to 50 ohms. This network must be adjusted to accomodate each set of operating parameters of the Reactor Chamber, e.g; power, pressure, gas. The adjustment of the matching network may be either manual or automatic, depending upon the option provided in the Reactor Center. However, during the time that the matching network is being adjusted, a mismatched condition exists which is a potential hazard to the output stage of the POWER AMPLIFIER. To prevent possible damage to the generator, the COUPLER detects the degree of "mismatch" and provides a DC signal proportional to the mismatch. This signal is referred to as "reflected power", and is fed to the REGULATOR. If the reflected power exceeds a preset limit, the REGULATOR automatically limits the output power to a level that is safe.

The VACUUM CIRCUIT provides the power required by the vacuum sensor in the Reactor Center, and provides the appropriate interface between the sensor and the vacuum display or meter. The VACUUM TRIGGER detects a preset vacuum level and transmits a signal to the Reactor Center. The 5 torr detector circuit disables RF when a pressure greater than 5 torr is detected in the Reaction Chamber. Operating the system at greater pressure could result in damage to the Reactor Center "matching network".

The power supply generates the appropriate DC voltages and AC filament voltage for the vacuum tubes of the oscillator and power amplifier. These are +350 VDC, -350 VDC, +3300 VDC, +700 VDC, and 6.1 VAC. It also supplies +12 VDC and -12 VDC for the control circuitry.

## 4.2 Circuit Description: Refer to Schematic D04111 Shts 1 & 2

### 4.2.1 Power Amplifier (Sheet 2):

The power amplifier utilizes a single vacuum tube tetrode V1, which is connected in a common cathode configuration. Capacitors C6 and C7 with inductors L3 and L4 constitute a two section filter to attenuate RF back to the high voltage power supply. Capacitors C14, C15, and C16 provide AC ground to the screen grid of the power tube. C20 through C26 are RF bypass capacitors for the filament. An RF voltage is fed to the control grid from the oscillator, and the resulting amplified plate signal is coupled to a pi matching network through C13. The RF signal amplitude and superimposed DC bias fed to the grid of the power amplifier bear proper relationship to operate the amplifier class C.

4.2.1 (Con't)

The pi matching network transforms the load impedance, normally 50 ohms, to a higher impedance appropriate for the plate circuit of the tetrode. It is composed of capacitors C8, C9, C10, C11, C19, C23, and C27, with inductor L6. The output of the pi filter is shunted by choke L2, which serves as a bleeder and filter to power supply ripple frequencies. The variable inductor L6 is the means for tuning the plate curcuit to the oscillator frequency, while variable capacitor C27 provides means for adjusting the efficiency of the power amplifier class C stage.

Resistor R15 is in series with the power amplifier screen grid and voltage across it serves as a measure of the screen current. Test points TP1 and TP2 are provided to facilitate this measurement. Fuse F1 limits the screen current to a safe value. The fuse is readily accessible on the front panel.

### 4.2.2 Coupler:

The RF Coupler Receives the signal from the power amplifier, and with minimal loss couples it to the output cable. It also generates DC signals representative of the power coupled to the output and of the impedance mismatch between the actual load and the desired 50 ohms. These two DC signals are fed to the regulator.

### 4.2.3 Oscillator:

The oscillator is a single stage tuned plate tuned grid vacuum tube oscillator. The frequency controlling element is a 13.56 mhz crystal, X501 in the grid circuit. R501 provides a DC path for the control grid current, as the grid bias is from self rectification, The plate tuned circuit is comprised of inductor/transformer L3 and capacitors C506, C509, C510, and C511. Variable capacitor C506 provides the means for adjusting the frequency of the plate circuit to crystal frequency. L3 also serves as an autotransformer which transforms the impedance of the power amplifier grid circuit to the higher impedance appropriate for the plate of the oscillator tube. R508 and C507 comprise an attenuator and phase shift network completing the feedback loop for the oscillator. C505 provides AC ground for the plate circuit. R502 with bypass capacitor C501 provide a means for monitoring the oscillator tube current at TP3 through an isolation resistor R503. The 700 volt plate supply is fed to

4.2.3 (Con't)

the plate through L501. L501 and C508 filter the RF to the supply. The amplitude of the oscillator output is determined by the positive DC voltage on the screen grid of the oscillator tube. This control voltage is supplied to the oscillator at terminal E503 by the regulator. The resistors R507, R504, R701, R9, R702, and R703 along with transistor Q703 are elements of a voltage divider which provide a resistive load and positive supply to the regulator output transistors. This network also serves to offset the regulator control voltage to bias the power amplifier tube control grid. (The emitter current, hence the collector voltage, of Q703 is determined by the regulator contol voltage). Transistor Q501 buffers the offset control voltage and supplies it to the power amplifier tube control grid through L3. An important feature of the voltage divider network is that saturation of Q703 prevents the power amplifier bias from going too far in the positive direction, thereby protecting the tube. Capacitor C505 is an RF bypass for the power amplifier bias voltage. Capacitors C502 and C503 are RF bypass capacitors for the oscillator screen.

### 4.2.4 RF Regulator:

The REGULATOR performs two functions. It monitors the power level through the coupler and controls its level according to the setting of the remote RF LEVEL control. It also monitors the "reflected power" from the COUPLER, and if it exceeds a preset level the REGULATOR automatically limits the drive to the POWER AMPLIFIER to a safe level.

Referring again to the schematic, the power level controller consists of operational amplifier A201, buffer transistor Q201, and associated circuitry. The DC signal from the COUPLER is fed through LC filter L201 and C201. This filtered voltage drives the wattmeter through R203. Rheostat R12 serves to calibrate the meter for "forward power". R205 provides a load for the coupler output in the absence of a meter.

The DC gain of the control loop is provided in two parts: The integrated amplifier A201 which has a gain in the order of $10^6$; and the amplifier comprised of transistor Q201 and resistors R211 and R213, with a gain of 22. The entire amplifier

4.2.4 (Con't)

is made an integrator with feedback capacitor C207 and input resistors R201, R220, R217, and R12. The reference voltage for the amplifier is signal ground through R207. Operationally the regulator output provides a positive voltage to the oscillator grid causing an RF signal through the coupler such that the positive polarity "forward power" signal exactly balances the negative voltage set up by the remote RF LEVEL control.

Capacitors C203, C211, and C209 insure dynamic stability for the feedback amplifier. The output of the integrated amplifier is prevented from going more negative than -5 volts by a clamping network comprised of CR204, CR201, and R209.

The amplifier comprised of integrated amplifier A201 and Q206, with their associated circuitry, perform the identical function as described above, except that it deals with the "reflected power" from the coupler. Its output is combined with the output of the forward power amplifier so that either can limit the RF power output.

If the magnitude of the "reflected power", a positive voltage, exceeds the magnitude of the negative voltage, set by R218, the amplifier shuts down the oscillator by decreasing the oscillator screen voltage.

### 4.2.5 Vacuum Circuit:

The vacuum transducer, which is located in the reactor center remote to the generator, is a thermocouple type. It requires a power source to power its heaters and a meter to display the voltage of its thermocouple. The power source is located in the generator.

The transducer power source is the vacuum circuit oscillator comprised of integrated circuit amplifier A401 and associated components, R401, R402, R403, C402, and C403. The oscillator generates a square wave at approximately one kilohertz. The amplitude of the square wave is adjusted with R13 and coupled to the transducer through transformer T401. The transducers thermocouple is then applied to the remote meter.

### 4.2.6 Vacuum Trigger:

Some plasma system controllers, e.g. 4000 Series, require the detection of a preset vacuum level. In the PM 112 this level is preset by R10. The signal is detected by the DC amplifier comprised of integrated circuit amplifier A401, transistor Q401, and their associated circuitry.

The voltage of the transducer thermocouple is applied to one input terminal of the amplifier and the voltage determined by R5 to the other. If the voltage of the thermocouple exceeds the potentiometer voltage, indicating that the chamber pressure is below the preset level, transistor Q401 is turned off. The voltage divider of the R10 and R407 with the +250 volt supply provide the appropriate drive for the relay located in the reactor controller.

### 4.2.7 5 Torr Detector Circuit:

If the PM 112 is used with a complete IPC Gas Plasma Machine, the 5 torr detector circuit inhibits RF when Reactor Chamber pressure is greater than 5 torr. Otherwise excessively high voltages occur in the Reactor Center "matching network" which could damage the network. The vacuum level signal is detected by the DC amplifier comprised of the integrated circuit amplifier A402, transistor Q402, and their associated circuitry, The voltage of the vacuum transducer thermocouple is applied to one input terminal of the amplifier, and the voltage determined by R414 to the other. If the voltage of the thermocouple is less than the potentiometer voltage, Q402 is turned ON. The screen grid of V101, the oscillator tube, is then shunted to ground and RF is inhibited.

# 5.0 MAINTENANCE

## 5.1 Packaging

The PM 112 is partitioned into three parts as follows:

1) A lower partition, which becomes accessible upon removal of the bottom cover.

2) A front partition, which becomes accessible upon removal of the hood and front portion of the top cover.

3) A rear partition, which becomes accessible upon removal of the hood and rear portion of the top cover.

All those adjustable components involved in alignment of the generator are included in the lower partition. Each adjustable component is accessible through an access hole in the front or rear panel, or by removing the bottom cover. The lower partition includes five circuit boards. The first contains the circuitry of the RF OSCILLATOR and is bolted directly to the chassis. All of the oscillator parts, except the vacuum tube, are mounted on the bottom side of the circuit board. The vacuum tube is accessible by removing the top rear cover.

The second circuit board is a plug-in board which includes the circuitry of the REGULATOR, the VACUUM CIRCUIT, and the VACUUM TRIGGER. Adjustments on this circuit board include the FORWARD POWER LIMIT and the REFLECTED POWER LIMIT, and the 5 torr trigger point.

The third board, the Grid Bias Control Assembly, is not a plug in board. It is mounted beside the oscillator board, and it includes the transistor (Q703) and several resistors of the control signal, voltage divider, circuit. Also it includes a differential amplifier comprising Q701 and Q702 and associated resistors. This amplifier receives its input from the "5 torr" trigger circuit of the RF regulator and vacuum board assembly. The output signal of the amplifier is applied to the rear panel connector J1 at pin F where it is routed to external equipment for actuating a remote DC relay. The remote relay disables gas flow when chamber pressure exceeds 5 torr. This "5 torr" trigger point is adjustable within limits.

5.1 (Con't)

The fourth printed circuit board is a plug-in board, which includes the circuits of the high voltage regulator and the vacuum tube filament supply regulator. There are three test points mounted on the board. As one observes the card edge with the test points (with the component side of the board up) the left most test point is TP-1, the center test point is TP-2, and the third test point is TP-3. The left most potentiometer adjustment, R343 adjusts the high voltage supplies. The right most potentiometer, R344, adjusts the filament supply voltage.

The fifth printed circuit board is a plug-in board, which includes the plus 12 volt and minus 12 volt supplies.

The front partition houses the several power resistors, the power supply filter capacitor C1, and the front panel parts.

The rear partition includes the circuitry for the RF POWER AMPLIFIER and the voltage supplies. The rectifier diodes with filter capacitors C103 and C104 are packaged on a circuit board which is mounted on top of the power supply transformer T1.

All connectors for mating with other system components are located on the rear panel.

## 5.2 Preventive Maintenance:

The most obvious requirement for preventive maintenance is cleansing the air filters mounted on the rear panel. They are aluminum mesh and can be cleaned with ordinary solvents. If they are not cleaned, restricted air flow could result in damage to the power amplifier tube. The cooling fan requires no lubrication.

## 5.3 Alignment:

As stated previously, all adjustable components are accessible through the front and rear panels, or by removing the bottom partition, it is most convenient to set the generator on the side nearest the ac power ON/OFF switch.

5.3 (Con't)

As discussed in Section 3.2, the PM 112 is controlled via the PROGRAMMER cable. Consequently, the controls necessary to perform the following adjustments must be provided in the manner indicated in Section 3.2. The PM 112 may either be installed in a system, such as an ICP 2000 Series system, which includes the necessary control circuits, or a special control must be provided. A test point bracket is included in the generator bottom partition to facilitate alignment. Refer to figure 2. Make certain the AC power switch is OFF and the AC POWER cord disconnected. Remove the bottom cover. Make the following initial adjustments:

1) Bias level (R9) - Mid position.
2) Oscillator tuning capacitor (C506) - Mid position.
3) Plate tuning Capacitor (C27) - Mid Position.
4) Plate coil (L6) - Fully out, then in three complete turns.
5) Forward limit (R217) - Full clockwise.
6) Reflected limit (R218) - Full clockwise.
7) High voltage adjustment (R334) - Full counter clockwise.

Turn the RF POWER LEVEL control to its minimum (fully counter clockwise) position.

Set the RF POWER ON/OFF switch to its OFF position.

Insert an in line wattmeter, e.g. a Thruline Model 43 wattmeter form Bird Electronic Corporation with a 1500 watt element, between the generator RF output connector and a 50 ohm dummy load. The dummy load should be rated for a continuous drive of 1500 watts or more.

An oscilloscope should be connected to the generator output. A coax tee can be inserted in the RF output cable to gain access to the output signal.

Plug in the AC Power cord.

Turn the AC Power switch on.

Wait approximately three minutes at which time the READY light will turn on.

Set the RF POWER ON/OFF switch to its ON position.

Set R344 on the high voltage regulator board for 6.1 volts true RMS at the 6.3 volt AC terminals on the oscillator board. NOTE: The correct voltage is 6.1 VOLTS true RMS, an ordinary VOM or DMM can not be used.

With a high voltage probe and DC voltmeter, measure the high voltage on the large filter capacitor just behind the air intake screen on the back of the generator. Adjust R343 for a reading of 3300 volts.

5.3 (Con't)

With a DC volt meter (10 volt range) observe the oscillator current signal between TP3 and TP8 and slowly turn the RF LEVEL control clockwise for a voltage of 4.0 to 5.0 volts. (Level control will be sensitive since the circuit is operating open loop without feedback from the RF coupler).

Adjust the oscillator plate tuning capacitor, C506, for a minimum voltage at TP3. Return the POWER LEVEL control to its minimum position. Turn OFF the RF ON/OFF switch.

Connect a DC voltmeter between TP4 and TP8. The voltage to be measured here represents the power amplifier plate current. Turn on the RF ON/OFF switch. Adjust the POWER LEVEL--control for about 500 watts at the output. Observe the voltage will be negative with respect to TP8.

Increase the setting of the POWER LEVEL control for an output power level of 1500 watts.

Observe the voltage on TP4. Adjust L6 for a minimum. Adjust C27 so that the screen current between TP1(+) and TP2(-) is approximately 0 volts at 1500 watts output. Set R9 for 3.6 volts at TP3.

As there is some interaction between the above adjustments, readjust C506, L6, C27, and R9 until the following test point voltages are observed:

| | |
|---|---|
| TP3(+) to TP8(-)..... | 3.6 volts |
| TP4(-) to TP8(+)..... | .75 to .80 volts |
| TP1(+) to TP2(-)..... | 0 volts |

5.4 Calibration: (Do not perform calibration unless 5.3 has been done).

5.4.1 Power Meter:

Calibration of the system power meter requires a reference meter, e.g. the Thruline Model 43, and 1500 watt element.

Insert the reference meter between the generator and the reactor center. Place the FWD/REFL switch in its FWD position, the RF LEVEL OFF and the AC POWER ON. Adjust the mechanical zero of the front panel power meter to read zero (0).

Turn the FWD LIMIT (located on the RF Regulator plug-in board) potentiometer to its extreme counter-clockwise position. With the POWER LEVEL control completely counterclockwise turn the POWER LEVEL

5.4.1 (Con't)

switch ON.

Slowly advance the POWER LEVEL control to extreme clockwise position. The output power should remain at zero. Adjust the FWD LIMIT potentiometer until the reference meter reads 1500 watts.

Turn the POWER LEVEL control counterclockwise until the reference meter reads 1500 watts. Adjust R12 FWD CAL, so that the front panel meter also reads 1500 watts.

Adjust the RF LEVEL control for zero (0) watts and turn the RF OFF. Disconnect the RF cable from the generator output connector. Turn the REFL LIMIT potentiometer to its extreme counter-clockwise position.

Turn the RF LEVEL ON, and turn the LEVEL control slowly to its maximum clockwise position. The RF output should remain at zero (0). Adjust the REFL LIMIT potentiometer until the meter reads 150 watts. Put the FWD/REFL switch to its REFL position. Adjust the REFL CAL potentiometer until the meter reads 150 watts on the "reflected power" scale.

5.4.2 Torrmeter:

The Torrmeter adjustment is one which must be made in conjunction with the vacuum transducer which is to be used with the Torrmeter. The transducer is normally located remotely in a unit external to the generator. In addition to the system transducer, another reference transducer/meter combination is needed on the same vacuum system. There also must be a means for adjusting the vacuum in the system.

5.4.2 (Con't)

If these conditions can be met, set the system pressure (utilizing air) to 0.2 torr according to the reference Torrmeter/transducer. Adjust the VAC CAL potentiometer so that the front panel meter also reads 0.2 torr. Set the system pressure to 2.0 torr according to the reference torrmeter/transducer. Adjust the mechanical adjustment on the front panel meter so that it also reads 2.0 torr. Repeat the process until no further adjustments are necessary.

### 5.4.3 Vacuum Trigger:

To set the VAC level, set the system pressure to 0.2 torr and observe the voltage at pin 7 of J3. J3 is the RF Regulator printed circuit board connector. The voltage will be either zero (0) volts or approximately +125 volts. Set the VAC TRIG adjustment so that this voltage just changes from its zero to its positive level. Allow the system pressure to rise above 0.5 torr (or until the voltage returns to its zero level). Reduce the pressure and verify that the voltage returns to its positive level at 0.2 torr. Readjust VAC TRIG as necessary.

### 5.4.4 5 Torr Detector:

To set the 5 torr level, set the system pressure to 5.0 torr and observe A402 pin 12 of the regulator PC board. The voltage will be either +12 VDC or -12VDC. Reduce the pressure and verify that the voltage switches to -12VDC.

DWG. NO. C 06514 REV. B

# DIONEX GAS PLASMA SYSTEMS

## ENGINEERING PARTS LIST

| REV | DESCRIPTION | DATE | CHK | APPR |
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| A | E.O. #10852 | 5-20-80 | | |

REVISION LEVEL

DIONEX GAS PLASMA DIVISION
31159 SAN BENITO
HAYWARD, CALIF. 94544

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| DRAWN D. YEH | DATE 5-20-80 | TITLE PM 112 RF GENERATOR<br>REGULATOR & VACUUM BOARD ASSY | |
| CHECKED | DATE 5/20/80 | | |
| ENG. | DATE 5-21-80 | C | DRAWING NO. 06514 | REV. B |

NEXT ASSY.

DO NOT SCALE THIS DRAWING

A05493 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 3 | HEATSINK | B 04485 | 4 |
| 2 | REGULATOR BOARD | C 06512 | 1 |
| | SCHEMATIC | D 04111 | REF |
| | | | |
| C 406 | CAPACITOR, CERAMIC DISC, .01uF 500V | 1500-0001 | 1 |
| | SPRAGUE #5GAS-S10 | | |
| C 214,405<br>C 409,410 | CAPACITOR, 22uF 16V | 1500-0011 | 5 |
| C 411 | | | |
| C 404,407 | CAPACITOR, CERAMIC DISK, .1uF 25V | 1500-0026 | 2 |
| | CENTRALAB #UK 20-104 | | |
| C 205,206<br>C 213,401 | CAPACITOR, CERAMIC DISC, .001uF 1000V | 1500-0032 | 5 |
| C 408 | SPRAGUE #5GA-D10 | | |
| C 201,202<br>C 211,212 | CAPACITOR, MICA 100pf | 1500-0117 | 4 |
| | ARCO/ELMENCO #DM 15 - ED 101J03 | | |
| C 402,403 | CAPACITOR, .05uF 500V | 1500-0210 | 2 |
| | SPRAGUE #5 HK-S50 | | |
| C 207,208 | CAPACITOR, 47pF 1000V | 1500-0217 | 2 |
| | SPRAGUE #5GA-Q47 | | |
| C 203,204<br>C 209,210 | CAPACITOR, CERAMIC DISK 10pF 1000V | 1500-0218 | 4 |
| | SPRAGUE #5GA-Q10 | | |
| C 231 | CAPACITOR, .1uF 50V | 1500-0047 | 1 |
| L 201,202<br>L 401,402 | CHOKE, 39uH | 1800-0012 | 6 |
| L 403,404 | MILLER #H9210-56 | | |
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**GAS PLASMA DIVISION**
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HAYWARD, CALIF.
94544

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| TITLE | PM 112 RF GENERATOR<br>REGULATOR & VACUUM BOARD ASSY | | | |
| SIZE<br>C | DWG.NO.<br>06514 | REV.<br>B | CHK. | APPR. |
| DRAWN<br>D. YEH | DATE<br>5-20-80 | SHEET 2 OF 4 | | |

A 04289 REV

# ENGINEERING PARTS LIST 0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | IC SOCKET 14 PIN | 2110-0001 | 3 |
| | AMPHENOL #821-20011-144 | | |
| 4 | BERGSTIK, GOLD | 2120-0401 | 1 |
| | BERG #65500-103 | | |
| W1, | JUMPER, GOLD | 2120-0402 | 1 |
| | BERG #65474-101 | | |
| R402 | RESISTOR, CARBON 22K, 1/4 W | 4702-0223 | 1 |
| R219 | RESISTOR, CARBON 100K , 1/4W | 4702-1003 | 1 |
| R 209,210 | RESISTOR, METAL FILM 5.1K ¼W | 4602-0053 | 2 |
| R 233,234 | RESISTOR, 442K ¼W | 4602-4423 | 2 |
| R 215,216 | RESISTOR, CARBON 100ohm ¼W | 4702-0101 | 2 |
| R 205,206<br>R410,413 | RESISTOR, CARBON 1K ¼W | 4702-0102 | 4 |
| R 211,212<br>R 238.401<br>R402,403 | RESISTOR, CARBON 10K ¼W | 4702-0103 | 6 |
| R 235,237 | RESISTOR, 1M ¼W | 4702-0105 | 2 |
| R 222 | RESISTOR, CARBON 10 Meg ¼W | 4702-0106 | 1 |
| R 204 | RESISTOR, CARBON 1.5K ¼W | 4702-0512 | 1 |
| R 220,<br>R 221 | RESISTOR, CARBON 47K ¼W | 4702-0473 | 2 |
| R 213,214 | RESISTOR, CARBON 220K ¼W | 4702-0224 | 2 |
| R 201,202<br>R 207,208 | RESISTOR, CARBON 27K ¼W | 4702-0273 | 4 |
| R 406,412 | RESISTOR, CARBON 3.3K ¼W | 4702-0332 | 2 |
| R 404,415 | RESISTOR, CARBON 390K ¼W | 4702-0395 | 2 |
| R 405,411<br>416,236,240 | RESISTOR, CARBON 4.7K ¼W | 4702-0472 | 5 |
| R 408,409 | RESISTOR, CARBON 680 ohm ¼W | 4702-0681 | 2 |
| R 203 | RESISTOR, CARBON 6.8K ¼W | 4702-0682 | 1 |

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A 04288 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| R 218 | POTENTIOMETER, 50K | 4750-0012 | 1 |
| | BOURNS #3069P-1-503 | | |
| R 232 | POTENTIOMETER, 10K | 4750-0013 | 1 |
| | BOURNS #3069-1-103 | | |
| R 414 | POTENTIOMETER, 1K | 4750-0021 | 1 |
| | BOURNS #3069P-1-102 | | |
| R 217 | POTENTIOMETER, 100K | 4750-0022 | 1 |
| | BOURNS #3069P-1-104 | | |
| | | | |
| | | | |
| A 201,401<br>A 402 | OPERATIONAL AMPLIFIER | 4800-0012 | 3 |
| | FAIRCHILD #MA 747 | | |
| Q 201,202<br>Q 401 | TRANSISTOR - 2N5657 - MOTOROLA | 4800-0024 | 3 |
| Q 402 | TRANSISTOR - 2N4921 - MOTOROLA | 4800-0047 | 1 |
| CR203,204,<br>417,230,<br>241. | DIODE | 4800-0045 | 5 |
| | MOTOROLA #IN 4151 | | |
| CR201,202 | DIODE, ZENER | 4800-0051 | 2 |
| | MOTOROLA #IN 5231B | | |
| | | | |
| | | | |
| T 401 | AUDIO TRANSFORMER | 5600-0014 | 1 |
| | ESSEX #TA-45 | | |
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REGULATOR AND VACUUM BOARD ASSY

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| DRAWN | DATE | |
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| D. YEH | 5-20-80 | SHEET 4 OF 4 |

A 04288 REV

| DWG. NO. | REV. |
|---|---|
| 04015 | T |

# DIONEX GAS PLASMA SYSTEMS

## ENGINEERING PARTS LIST

| REV | DESCRIPTION | | DATE | CHK | APPR |
|---|---|---|---|---|---|
| M | E.O.# 11153 | AS | 7-27-81 | | |
| S | E.O. 11010 | EA | 3-23-81 | | |
| R | E.O.10590 | DAH | 9-23-80 | | |
| Q | E.A.R.#20260 | | 9-8-80 | | PCD |
| P | E.A.R. #20415 | | 3-28-80 | | PCD |
| O | E.O. #10872 | MS | 4-25-80 | | |
| N | E.O. #10655, 10870 | MS | 4-1-80 | | |
| M | E.O. 10705 | PF | 3/80 | | |
| L | E.O. 10792 | KG | 1/80 | | |
| K | E.O. 10761 | | 1/80 | | |
| J | E.O. #10721 | K.G. | 11/79 | | |

REVISION LEVEL

DIONEX GAS PLASMA DIVISION
31159 SAN BENITO
HAYWARD, CALIF. 94544

| | | | |
|---|---|---|---|
| DRAWN K. GUINN | DATE 11/13/79 | TITLE PM 112 GENERATOR TOP ASSEMBLY | |
| CHECKED | DATE | | |
| ENG. | DATE | E | DRAWING NO. 04015 | REV. T |

NEXT ASSY. E04015

DO NOT SCALE THIS DRAWING

A05495 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | POWER TUBE SUPPORT BRK'T | C 02943 | 1 |
| 2 | TEFLON INSULATOR GEN. | B 02946 | 1 |
| 3 | RF SCREEN BRK'T | B 02959 | 1 |
| 4 | RF GENERATOR SKIDS | B 03057 | 3 |
| 5 | HV BD MT'G BRK'T | B 03076 | 4 |
| 6 | NEUTRALIZING CAP PART INSULATOR | B 03078 | 1 |
| 7 | OUTPUT COIL ADJ. SCREW | B 03085 | 1 |
| 8 | OUTPUT COIL TIE STRAP | B 03111 | 1 |
| 9 | RF TANK PARTITION & FAN BRK'T | D 03355 | 1 |
| 10 | FRONT PANEL BRK'T LEFT SIDE | C 03356 | 1 |
| 11 | BEZEL BAR | B 03358 | 2 |
| 12 | ADJ POT MT'G BRK'T | B 03359 | 1 |
| 13 | FLEXIBLE RF ANODE STRAP | B 03361 | 1 |
| 14 | RF OUTPUT PLATE | B 03363 | 1 |
| 15 | TOP COVER REAR SECTION | C 03366 | 1 |
| 16 | BOTTOM COVER | C 03368 | 1 |
| 17 | RIGHT SIDE COVER | C 03369 | 1 |
| 18 | RF WINDOW PARTITION | C 03370 | 1 |
| 19 | COIL SUPPORT BAR FIXED | B 03373 | 1 |
| 20 | CONNECTOR BRK'T REG BD | C 03375 | 1 |
| 21 | FRONT PANEL | D 03379 | 1 |
| 22 | MAIN CHASSIS | D 03381 | 1 |

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31159 SAN BENITO
HAYWARD, CALIF.
94544

TITLE PM112 GENERATOR
TOP ASS'Y

SIZE E
DRAWING NO. 04015
REV. T
APPR. AW
DRAWN
DATE 5/16/78
SHEET 4 OF 13

A 04289 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 23 | HV REGULATOR BRK'T | B 03476 | 1 |
| 24 | 12V SUPPLY BRK'T | C 03477 | 1 |
| 25 | CONNECTOR BRK'T 12V | B 03900 | 1 |
| | SUPPLY | | |
| | | | |
| | | | |
| 28 | EXHAUST AIR FLANGE | C 03978 | 1 |
| 29 | TOP COVER FRONT SECTION | C 03942 | 1 |
| 30 | VARIABLE CAP. STRAP | B 04151 | 1 |
| 31 | PLATE CAP. BRK'T | B 04276 | 1 |
| 32 | SIDE COVER LEFT | C 04277 | 1 |
| 33 | TEFLON EXHAUST TUBE | B 04149 | 1 |
| 34 | NEUTRALIZING CAP. PART | B 04302 | 1 |
| | ADJ STRAP | | |
| 35 | PM 112 GEN. FRONT PANEL | B 04304 | 1 |
| | BRK'T RIGHT SIDE | | |
| 36 | PM 112 GEN. FLEXIBLE | B 04308 | 2 |
| | RF STRAP | | |
| 37 | COIL SUPPORT BAR SPACER | B04535 | 1 |
| 38 | EXHAUST SCREEN | B 04148 | 1 |
| 39 | EXHAUST SCREEN RETAINER | B04538 | 1 |
| 40 | REAR PANEL | D 04270 | 1 |
| 41 | FRONT PANEL DECAL | D 03967 | 1 |
| 42 | INTAKE SCREEN | B 03056 | 1 |
| 43 | COIL SUPPORT BAR LOWER | B 03367 | 1 |

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31159 SAN BENITO
HAYWARD, CALIF.
94544

TITLE: PM 112 GEN TOP ASS'Y

| SIZE | DRAWING NO. | REV. | APPR. |
|---|---|---|---|
| E | 04015 | T | KAM |

| DRAWN | DATE | SHEET |
|---|---|---|
| [illegible] | 5/[illegible]-78 | SHEET 5 OF 13 |

A 04289 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| C1 | CAPACITOR 8μF 4KV | 1500-0178 | 1 |
| | PLASTIC CAP LK40-805 | | |
| C2 | CAPACITOR 4μF 440 V | 1500-0241 | 1 |
| | MALLORY OP-440 | | |
| C3 | CAPACITOR 300μF TO 480μF | 1500-0037 | 1 |
| | 450V MALLORY CGS-481-DF1 | | |
| | | | |
| C6,7,13, | CAPACITOR 1000 PF CRAMIC | 1500-0191 | 4 |
| 19 | TRAMSMITTING CENTRALAB | | |
| | 858S-1000 | | |
| C9,10 | CAPACITOR 50 pF 7.5KV | 1500-0192 | 2 |
| | CENTRALAB 850S-50Z | | |
| C8,23 | CAPACITOR 25 pF | 1500-0194 | 2 |
| | CENTRALAB 850S-25Z | | |
| C12 | CAPACITOR .47μF 600V | 1500-0228 | 1 |
| | SPRAGUE 6PS-P47 | | |
| C14-16 | CAPACITOR .001μF 1KV | 1500-0032 | 3 |
| | SPRAGUE 5GA-D10 | | |
| C11,19 | CAPACITOR 100pF 500V | 1500-0189 | 2 |
| | CENTRALAB 850S-100N | | |
| C20-22 | CAPACITOR .01μF 500V CERAMIC | 1500-0001 | 11 |
| C24-26<br>C30-34 | DISC - SPRAGUE 5GAS-S10 | | |
| C27 | CAPACITOR 99-718 DUAL AIR | 1550-0209 | 1 |
| | CARDWELL 1167-53 | | |
| | | | |

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94544

| | | | |
|---|---|---|---|
| TITLE | PM 112 GEN.<br>TOP ASSEMBLY | | |
| SIZE E | DRAWING NO. 04015 | REV. T | APPR. KJM |
| DRAWN JV | DATE 5-16-78 | SHEET 6 OF 13 | |

A 04289 REV A

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| L3, 4, 7 | RF CHOKE | 1800-0006 | 3 |
| | MILLER #4612 | | |
| L5 | INDUCTOR AIR DUX #1212A | 1800-0100 | 1 |
| L2 | RF CHOKE | 1800-0253 | 1 |
| | MILLER #4632 | | |
| TP1-8 | TEST POINT | 2000-0152 | 8 |
| | SELECTRO SKT-0804 | | |
| 44 | CARD GUIDE | 2100-0191 | 2 |
| | UNITRACK HS-2500-38-4 | | |
| 45 | CONNECTOR 22 PIN | 2100-0223 | 2 |
| | VECTOR R644 | | |
| 46 | CONNECTOR 18 PIN | 2100-0002 | 1 |
| | AMPHENOL 225-21821-101 | | |
| 47 | TUBE SOCKET 8 PIN | 2110-0170 | 1 |
| | CINCH JONES 8 AM | | |
| 48 | TUBE SOCKET | 2110-0200 | 1 |
| | EIMAC SK-800B | | |
| 49 | TUBE CHIMNEY | 2110-0201 | 1 |
| | EIMAC SK-806 | | |
| J1 | CONNECTOR | 2152-2216 | 1 |
| | AMPHENOL MS-3102A-22-19S | | |
| J2 | CONNECTOR | 2152-2417 | 1 |
| | AMPHENOL MS-3102A-14S-2S | | |
| 50 | TERMINAL STANDOFF | 2160-0207 | 4 |
| | USECO 1417-D | | |

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94544

TITLE: PM 112 GEN TOP ASSEMBLY

SIZE: E
DRAWING NO.: 04015
REV.: T
APPR.:
DRAWN: JJ
DATE: 5-16-72
SHEET 7 OF 13

A 04289 REV A.

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| TB1 | TERMINAL STRIP | 2170-0223 | 1 |
| | CINCH JONES 5-141 | | |
| 51 | MARKER STRIP | 2170-0224 | 1 |
| | CINCH JONES MS-5-141 | | |
| | | | |
| | | | |
| | | | |
| | | | |
| B1, 2 | FAN, ETRI | 2600-0010 | 2 |
| | | | |
| | | | |
| 53 | FURNITURE LEVELLER | 2800-0005 | 6 |
| | FRANKLIN 6242 SILENT GLIDE | | |
| 54 | CABLE CLAMP 1" ID | 2800-0240 | 1 |
| 55 | CAPACITOR MT'G RING | 1525-0002 | 1 |
| | 2"ID VAP MT'G RING | | |
| 56 | CAPACITOR BRK'T | 1525-0242 | 1 |
| | CORNELL DUBILIER 32107-1 | | |
| DS1 | LAMP AMBER 115V | 3900-0001 | 1 |
| | DIALCO 507-4537-1433-640 | | |
| DS2 | LAMP RED 115V | 3900-0002 | 1 |
| | DIALCO 507-1431-640 | | |
| 57 | LAMP HOLDER | 3900-0107 | 2 |
| | DIALCO 250-7545-14-504 | | |
| | | | |

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94544

TITLE: PM 112 GEN. TOP ASSEMBLY

SIZE: E
DRAWING NO.: 04015
REV.: T
APPR.: KAM
DRAWN: JV
DATE: 5-14-7[illegible]
SHEET 8 OF 13

A 04289 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| K1 | RELAY | 4500-0159 | 1 |
| | POTTER BRUMFIELD CHB-38-70003 | | |
| | | | |
| R1 | RESISTOR | 4702-0101 | 1 |
| | 100 Ω 1/4W 5% CAR. COMP. | | |
| R2,3 | RESISTOR 3000 Ω 100W | 4750-0231 | 2 |
| | OHMITE 2215 | | |
| R4 | RESISTOR 750 Ω 100W | 4750-0232 | 1 |
| | OHMITE 2210 | | |
| R5,15 | RESISTOR 500 Ω 12W | 4712-0501 | 2 |
| | OHMITE 1730 | | |
| R6 | RESISTOR | 4703-0272 | 1 |
| | 2.7K 1/2W 5% CAR. COMP | | |
| R7,8 | RESISTOR | 4705-0222 | 2 |
| | 2.2K 2W 5% CAR. COMP. | | |
| R9 | RESISTOR 100K | 4750-0001 | 1 |
| | OHMITE CMU-1041 | | |
| R10-12 | RESISTOR 750 Ω | 4750-0002 | 3 |
| | A&B JAIL040571UC | | |
| R13 | RESISTOR 2.5K 2W POT. | 4750-0968 | 1 |
| | OHMITE CLU-2521 | | |
| R14 | RESISTOR 50K 11W | 4711-0503 | 1 |
| | *OHMITE 4873* | | |
| 58 | RESISTOR MT'G BRACKET. | 4760-0001 | 4. |
| | OHMITE 5B | | |

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HAYWARD, CALIF.
94544

TITLE
PM 112 GEN.
TOP ASSM'Y

| SIZE | DRAWING NO. | REV. | APPR. |
|---|---|---|---|
| E | 04015 | T | [illegible] |

| DRAWN | DATE | SHEET | OF |
|---|---|---|---|
| JJ | 6-16-7[illegible] | 9 | 13 |

A 04289 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| Q1 | TRIAC ASSEMBLY | B06200 | 1 |
| | | | |
| S1 | CIRCUIT BREAKER | 5100-0151 | 1 |
| | ITE BQ2B040 | | |
| | | | |
| F1 | FUSE 3AG 250V 0.1A | 5150-0312 | 1 |
| | LITTLEFUSE 312.100 | | |
| 59 | FUSE CLIP | 5150-2210 | 1 |
| | LITTLEFUSE 129002 | | |
| 60 | FUSE HOLDER | 5150-2516 | 1 |
| F6 | IR FUSE 250V 35A | 5150-2535 | 1 |
| | | | |
| T4 | TRANSFORMER | 5600-0005 | 1 |
| | TRIAD N68X | 5150-2535 | 1 |
| T3 | TRANSFORMER | 5600-0016 | 1 |
| | STANCOR P6308 | | |
| T1 | HIGH VOLTAGE TRANSFORMER | C 03339C | 1 |
| T2 | POWER TRANSFORMER | C 03340C | 1 |
| L1 | INDUCTOR HIGH VOLTAGE | C 03256B | 1 |
| L6 | INDUCTOR TANK COIL | C 03371A | 1 |
| | | | |
| V2 | ELECTRON TUBE PWR BEAM | 5700-0187 | 1 |
| | EIMAC 4CX1500B Y763 | | |
| | | | |
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**INTERNATIONAL PLASMA CORPORATION**

31159 SAN BENITO
HAYWARD, CALIF.
94544

TITLE
PM 112 GEN
TOP ASS'Y

| SIZE | DRAWING NO. | REV. | APPR. |
|---|---|---|---|
| E | 04015 | T | KM |

| DRAWN | DATE | SHEET |
|---|---|---|
| JV | 5-16-7[illegible] | SHEET 10 OF 13 |

A 04289 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 61 | INSULATED NYLON COUPLER | 2120-5077 | 5 |
| | HOLLINGWORTH SO-5077 | | |
| | 18-22 GA (F) | | |
| 62 | INSULATED NYLON COUPLER | 2120-5078 | 7 |
| | HOLLINGWORTH SO-5078 | | |
| | 18-22 GA (M) | | |
| 63 | INSULATED NYLON COUPLER | 2120-5076 | 4 |
| | HOLLINGWORTH SO-5076 (M) | | |
| 64 | INSULATED NYLON COUPLER | 2120-5075 | 4 |
| | HOLLINGWORTH SO-5075 (F) | | |
| 65 | #6 LOCKING TERMINAL LUG | | |
| | H H SMITH 1416-6 | | |
| 66 | SOLDERLESS TERM. RING CONN | | |
| | VACO 11410 12-10 GA WIRE | | |
| 67 | RF I SHIELD | C04776 | 1 |
| 68 | TB COVER | C04718 | 1 |
| 70 | H.H. SMITH #8202 STANDOFF | 2860-8202 | 2 |
| | | | |
| | | | |
| 72 | FACE MTG BRACKET | C04889 | 1 |
| | ITE FB9555 | | |
| 73 | INSULATOR CONE | 3100-0185 | 1 |
| | 135-0500-001 | | |
| 74 | | | |
| | | | |

**INTERNATIONAL PLASMA CORPORATION**

31159 SAN BENITO
HAYWARD, CALIF.
94544

| | | | |
|---|---|---|---|
| TITLE | PM 112 GEN<br>TOP ASS'Y | | |
| SIZE E | DRAWING NO. 04,015 | REV. T | APPR. [illegible] |
| DRAWN JV | DATE 5-16-78 | SHEET 11 OF 13 | |

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| A1 | HV RECTIFIER / FILTER BD. ASS'Y | C03374B | 1 |
| A2 | 12.V POWER SUPPLY BD. ASS'Y | C03379C | 1 |
| A3 | HIGH VOLTAGE REGULATOR ASS'Y | C03409 | 1 |
| A4 | RF COUPLER | D03410C | 1 |
| A5 | RF OSCILLATOR | C03448G | 1 |
| A6 | RF REGULATOR + TORRMETER | C06514 | 1 |
|  | BD ASS'Y |  |  |
| 69 | HOUSING ASS'Y | D03769A | 1 |
|  |  |  |  |
|  |  |  |  |
| 75 | Insulator Fuse Holder | B06521 | 1 |
| 76 | Fuse Mounting Bracket | B06522 | 1 |
| C25 | CAPACITOR 1000 PF | 1500-0034 | 1 |
|  | CERIMAC TRANSMITTING |  |  |
|  | CENTRALAB # DD60-102 |  |  |
|  | LABELS, for PM 112 | 6100-0005 | 1 |
|  | LABELS, for PM 112 | 6100-0010 | 1 |

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CORPORATION

31159 SAN BENITO
HAYWARD, CALIF.
94544.

TITLE
PM 112 GEN
TOP ASS'Y

| SIZE | DRAWING NO. | REV. | APPR. |
|---|---|---|---|
| E | 04015 | T | KAW |

DRAWN JV | DATE 5-16-9[illegible] | SHEET 12 OF 13

A 04289 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| REF | ELECTRICAL SCHEMATIC | D 04111 | |
| | SHT 1 & 2 | | |
| | | | |
| REF | "A" HARNESS | D 04284 | |
| | HIGH VOLTAGE | | |
| REF | "B" HARNESS | D 04285 | |
| | LOW CURRENT | | |
| REF | TEST PROCEDURE · PM112 | A00113 | |

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31159 SAN BENITO
HAYWARD, CALIF.
94544.

TITLE PM 112 GEN.
TOP ASS'Y

SIZE E
DRAWING NO. 04015
REV. T
APPR. KAW
DRAWN JY
DATE 5-19-78
SHEET 13 OF 13

A 04289 REV A

DWG. NO. B 06200
REV. A

# DIONEX GAS PLASMA SYSTEMS

## ENGINEERING PARTS LIST

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| | | | | |
| A | INITIAL ISSUE E.O. #10792 | 1/80 | | |
| **REV** | **DESCRIPTION** | **DATE** | **CHK** | **APPR** |

**REVISION LEVEL**

**DIONEX GAS PLASMA DIVISION**

31159 SAN BENITO
HAYWARD, CALIF. 94544

| | | | | |
|---|---|---|---|---|
| DRAWN<br>K. GUINN | DATE<br>1/ 9/80 | TITLE<br>TRIAC ASSEMBLY<br>PM 112 GENERATOR | | |
| CHECKED | DATE<br>1-14-80 | | | |
| ENG. | DATE | B | DRAWING NO.<br>06200 | REV.<br>A |
| | | DO NOT SCALE THIS DRAWING | | |

NEXT ASSY. E 04015

A05495 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | MOUNTING BRACKET | B 06198 | 1 |
| 2 | HEAT SINK | B 06199 | 1 |
| | | | |
| | | | |
| 3 | STAND OFF | 2860-2607 | 2 |
| 4 | TRIAC | 4800-0101 | 1 |
| | | | |
| | | | |
| | | | |
| 5 | FLAT HEAD SCREW #8-32 x .375 LONG | | 4 |

**DIONEX**

GAS PLASMA DIVISION
31159 SAN BENITO
HAYWARD, CALIF.
94544

| | | | | |
|---|---|---|---|---|
| TITLE | TRIAC ASSEMBLY<br>PM 112 GENERATOR | | | |
| SIZE B | DWG. NO. 06200 | REV. A | CHK. | APPR. |
| DRAWN K. GUINN | DATE 1/9/80 | SHEET 2 OF 2 | | |

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
|  | P.C. BOARD | A04378 | 1 |
|  | "L" BRACKET | B04415 | 2 |
| Q701<br>Q702 | TRANSISTOR, NPN, 2N5657 | 4800-0024 | 2 |
| Q703 | TRANSISTOR, PNP, MJE350 | 4800-0215 | 1 |
|  |  |  |  |
| R701 | RESISTOR, CARBON, 1/4W, 5%, 82K | 4702-0823 | 1 |
| R702 | " " 1/4W, 5%, 470K | 4702-0474 | 1 |
| R703 | " " 2W, 5%, 240K | 4705-0244 | 1 |
| R704<br>R705 | " " 1/2W, 5%, 820Ω | 4703-0821 | 2 |
| R706 | " " 1/4W, 5%, 4.7K | 4702-0472 | 1 |
| R707 | " " 1/4W, 5%, 3.9K | 4702-0392 | 1 |
|  |  |  |  |
| E701<br>-710 | TERMINAL, H.H. SMITH #2008B | 2860-2008 | 10 |

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PLASMA
CORPORATION

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HAYWARD, CALIF.
94544

TITLE
PM112
GRID BIAS CONTROL BOARD

| SIZE | DRAWING NO. | REV. | APPR. |
|---|---|---|---|
| B | 04380 | A | PCD |

| DRAWN | DATE | |
|---|---|---|
| D. YEH | 6-15-78 | SHEET 2 OF 2 |

A 04289 REV A

DWG. NO. C 03448 REV. H

# DIONEX GAS PLASMA SYSTEMS

# ENGINEERING PARTS LIST

| REV | DESCRIPTION | DATE | CHK | AP |
|---|---|---|---|---|
| | | | | |
| | | | | |
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| | | | | |
| | | | | |
| H | E.O. #11010 EA | 3/81 | | |
| G | E.O. #10852 AR | 3/80 | | |

**REVISION LEVEL**

**DIONEX GAS PLASMA DIVISION**

31159 SAN BENITO
HAYWARD, CALIF. 94544

NEXT ASSY. E 04015

DRAWN JV
DATE 5/18/78
CHECKED
DATE 5/28/80
ENG.
DATE
TITLE A-5 OSCILLATOR BOARD ASSEMBLY
PM 112 GENERATOR
C
DRAWING NO. 03448
REV. H
DO NOT SCALE THIS DRAWING

A05495 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 3 | P. C. BOARD BLANK | C 03446 | 1 |
| T501 | OSCILLATOR TRANSFORMER | B 04162 | 1 |
| | SCHEMATIC | D 04111 | REF |
| 5 | HEAT SINK | B 05263 | 2 |
| | | | |
| | | | |
| C505 | CAPACITOR .01 μF 1K V | 1500-0003 | 1 |
| | SPRAGUE 5GA-S10 | | |
| C502,503 | CAPACITOR, .001 μF | 1500-0032 | 2 |
| | SPRAGUE 5GA-D10 | | |
| C504,508<br>C509 | CAPACITOR, 1000 pF 6 KV | 1500-0034 | 3 |
| | CENTRALAB DD 60-102 | | |
| C501 | CAPACITOR, 2200 μF | 1500-0212 | 1 |
| | SPRAGUE 5GA-D22 | | |
| C510,511 | CAPACITOR, 8.2 pF 1 KV | 1500-0222 | 2 |
| | SPRAGUE 5GA-V82 | | |
| C507 | CAPACITOR, 200 pF 500 V | 1500-0223 | 1 |
| | ARCO/ELMENCO CM05FD201 J03 | | |
| C506 | CAPACITOR, AIR VARIABLE | 1550-0002 | 1 |
| | JFD #VC54G | | |
| L501 | INDUCTOR - 100 μH | 1800-0253 | 1 |
| | MILLER 4632 | | |
| 1 | SOCKET CRYSTAL | 2110-0254 | 1 |
| | AUGAT 8000-D-G1 | | |
| | | | |

**DIONEX**
**GAS PLASMA DIVISION**
**31159 SAN BENITO**
**HAYWARD, CALIF.**
**94544**

TITLE A5- OSCILLATOR BOARD ASSEMBLY
PM 112 GENERATOR

SIZE C
DWG. NO. 03448
REV. H
CHK.
APPR.
DRAWN J.V.
DATE 5/18/78
SHEET 2 OF 3

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 4 | SOCKET, TUBE, 9 PIN; SAE #5-9388 | 2110-0306 | 1 |
| X501 | CRYSTAL, QUARTZ, 13.56 M HZ | 2300-0111 | 1 |
| | | | |
| E501-513<br>E515-517 | TERMINALS, STAKE-ON; H.H. SMITH #2008 | 2860-2008 | 16 |
| | | | |
| R503 | RESISTOR, 1K, 1/4W CARBON COMPOSITE | 4702-0102 | 1 |
| R501 | RESISTOR, 100K, 1/4W CARBON COMPOSITE | 4702-0104 | 1 |
| R511 | RESISTOR, 470K, 1/4W, 5% | 4702-0474 | 1 |
| R512 | RESISTOR, 82K, 1/4W, 5% | 4702-0823 | 1 |
| | | | |
| R502 | RESISTOR, 150, 2W CARBON COMPOSITE | 4705-0151 | 1 |
| R508,509 | RESISTOR, 2.2K, 2W CARBON FILM | 4705-0222 | 2 |
| R513 | RESISTOR, 240K, 2W, 5% | 4705-0244 | 1 |
| R504 | RESISTOR, 39K, 2W CARBON FILM | 4705-0393 | 1 |
| R507,510 | RESISTOR, 10K, 5W CARBON FILM | 4706-0103 | 2 |
| | | | |
| Q501 | TRANSISTOR; MOTOROLA #2N5657 | 4800-0024 | 1 |
| Q502 | TRANSISTOR PNP; MOTOROLA #MJE350 | 4800-0215 | 1 |
| | | | |
| V501 | OSCILLATOR TUBE; RCA 6JT6A | 5700-0112 | REF ONLY |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**BRANSON/IPC**
**a SmithKline company**

**31172 HUNTWOOD AVE**
**HAYWARD, CALIFORNIA**
**94544**

TITLE
A-5 OSCILLATOR BOARD ASSEMBLY
PM 112 GENERATOR

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| C | 03448 | H | | |

| DRAWN | DATE | |
|---|---|---|
| E. AcMoody | 3/24/81 | **SHEET** 3 **OF** 3 |

DWG. NO. C 03409 REV. N

# DIONEX GAS PLASMA SYSTEMS

# ENGINEERING PARTS LIST

| REV | DESCRIPTION | DATE | CHK | APPR |
|---|---|---|---|---|
| N | E.O. #10960 MS | 12-12-80 | | |
| M | E.O. 10913 | 10/28/80 | | PaD |
| L | E.A.R. #20416 | 9-8-80 | | PaD |
| G | REVISION E.O. #10722 | 3-17-80 | | PaD |
| F | REVISION | 12/79 | | |
| E | REVSION | | | |
| D | REVISION | | | |
| C | REVISION | | | |
| B | REVISION | | | |
| A | RELEASE J.V. | 5/78 | | |

REVISION LEVEL

**DIONEX** GAS PLASMA DIVISION

31159 SAN BENITO
HAYWARD, CALIF. 94544

| | | | |
|---|---|---|---|
| DRAWN<br>J.V. | DATE<br>5-18-78 | TITLE | A3 H.V. REGULATOR BOARD<br>PM 112 R.F. GENERATOR |
| CHECKED | DATE<br>5-23-80 | | |
| ENG. | DATE | C | DRAWING NO.<br>03409 |
| | | | REV.<br>N |

DO NOT SCALE THIS DRAWING

NEXT ASSY. E 04015

A05495 REV A

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| T301 | TRANSFORMER | B 03337 | 1 |
| 1 | P C BLANK BOARD | B 03407A | 1 |
| | | | |
| C304,C312 | CAPACITOR, .18 µF 250 V -SIEMENS B32-541-0 | 1500-0006 | 2 |
| C313 | (USED ON 50 Hz SYSTEMS ONLY) | 1500-0006 | 1 |
| C302,303 | CAPACITOR .1 µF 400 VDC | 1500-0025 | 2 |
| | SPRAGUE 4PS-P10 | | |
| C306-307 | CAPACITOR .001 µF 1 KVDC | 1500-0032 | 2 |
| | SPRAGUE 5GA-D10 | | |
| C309-311 | CAPACITOR, .1 µF, 50 V | 1500-0047 | 3 |
| | CENTRALAB UK10-474 | | |
| C301 | CAPACITOR 1.0 µF 100 VDC | 1500-0049 | 1 |
| | SPRAGUE 225P | | |
| C308 | CAPACITOR .47 µF 200 V | 1500-0211 | 1 |
| | SPRAGUE 2PS-P47 | | |
| C305 | CAPACITOR .047 µF 100 VDC | 1500-0261 | 1 |
| | | | |
| TP301-303 | TEST POINT | 2000-0004 | 3 |
| | | | |
| 2 | 14 PIN IC SOCKET | 2110-0001 | 3 |
| | AMPHENOL 821-20011-144 | | |
| | | | |
| W1 | JUMPER, GOLD | 2120-0401 | 1 |
| | BERG #65474-101 | | |
| | | | |

DIONEX
GAS PLASMA
DIVISION
31159 SAN BENITO
HAYWARD, CALIF.
94544

TITLE A-3 HV REGULATOR BOARD
PM 112 GENERATOR

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| C | 03409 | N | | |

| DRAWN | DATE | |
|---|---|---|
| JV | 5/18/78 | SHEET 2 OF 5 |

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 3 | BERGSTIK, GOLD | 2120-0402 | 1 |
|  | BERG #65500-103 |  |  |
|  |  |  |  |
| R325,326<br>351,352 | RESISTOR, METAL FILM 20 K 1% 1/4 W. | 4602-0203 | 4 |
| R317-319 | RESISTOR, METAL FILM, 100K 1/4 W. 1% | 4602-0104 | 3 |
| R310 | RESISTOR, METAL FILM, 75K 1/4 W ± 1% | 4602-0753 | 1 |
| R339 | RESISTOR, METAL FILM, 7.87K 1% 1/4 W | 4602-0782 | 1 |
| R324 | RESISTOR, METAL FILM 205K 1% 1/4 W | 4602-2055 | 1 |
| R330 | RESISTOR, METAL FILM, 2.26 MEG 1% 1/4 W | 4602-2266 | 1 |
| R312 | RESISTOR, METAL FILM, 39.2K 1/4 W 1% | 4602-3924 | 1 |
| R311 | RESISTOR, METAL FILM 57.6K, 1/4 W 1% | 4602-5764 | 1 |
| R348 | RESISTOR, CARBON COMP 200 Ω 1/4 W. | 4702-0201 | 1 |
| R346 | RESISTOR, CARBON COMP 100Ω 1/4 W | 4702-0101 | 1 |
| R304-307<br>R334 | RESISTOR, CARBON COMP 1K 1/4 W | 4702-0102 | 5 |
| R301-303 | RESISTOR, CARBON COMP 10K 1/4 W | 4702-0103 | 3 |
| R320-323 | RESISTOR, CARBON COMP 100K 1/4 W | 4702-0104 | 4 |
| R333 | RESISTOR, CARBON COMP 1 MEG 1/4 W | 4702-0105 | 1 |
| R327 | RESISTOR, CARBON COMP 10 MEG 1/4 W | 4702-0106 | 1 |
| R308,309 | RESISTOR, CARBON COMP 120K 1/4 W | 4702-0124 | 2 |
| R316,329 | RESISTOR, CARBON COMP 2K 1/4 W | 4702-0202 | 2 |
| R337 | RESISTOR, CARBON COMP 220K 1/4 W | 4702-0224 | 1 |
| R332 | RESISTOR, CARBON COMP 2.2 MEG 1/4 W | 4702-0225 | 1 |
| R345 | RESISTOR, CARBON COMP 27K 1/4 W | 4702-0273 | 1 |
| R340 | RESISTOR, CARBON COMP 36Ω 1/4 W | 4702-0360 | 1 |
| R315 | RESISTOR, CARBON COMP 470Ω 1/4 W | 4702-0471 | 1 |

**DIONEX**
GAS PLASMA
DIVISION
31159 SAN BENITO
HAYWARD, CALIF.
94544

TITLE
A-3 HV REGULATOR BOARD
PM 112 GENERATOR

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| C | 03409 | N |  |  |

| DRAWN | DATE | SHEET | OF |
|---|---|---|---|
| JV | 5/18/78 | 3 | 5 |

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| R328 | RESISTOR, CARBON COMP 4.7K 1/4 W | 4702-0472 | 1 |
| R314,335,<br>R336,33[illegible] | RESISTOR, CARBON COMP, 47K 1/4 W. | 4702-0473 | 4 |
| R313 | RESISTOR, CARBON COMP. 470K 1/4 W. | 4702-0474 | 1 |
| R349 | RESISTOR, CARBON COMP. 560Ω 1/4 W. 5% | 4702-0561 | 1 |
| R342 | RESISTOR, CARBON COMP 6.8K 1/4 W | 4702-0682 | 1 |
| R331 | RESISTOR, CARBON COMP. 750K 1/4 W. | 4702-0754 | 1 |
| R350 | RESISTOR, CARBON COMP. 8.2K 1/4 W., 5% | 4702-0822 | 1 |
| R341 | RESISTOR, CARBON COMP. 200Ω 1 W. | 4704-0201 | 1 |
| | | | 2 |
| R347 | RESISTOR, CARBON COMP. 1K 2W | 4705-0102 | 1 |
| R344 | POTENTIOMETER 50 K | 4750-0012 | 1 |
| | BOURNS 3069P-1-503 | | |
| R343 | POTENTIOMETER, 50 Ω | -0500 | 1 |
| | BOURNS 3069P-1-500 | | |
| Q303,304<br>Q306 | TRANSISTOR | 4800-0002 | 3 |
| | MOTOROLA MPS 6530 | | |
| A301-303 | OPERATIONAL AMPLIFIER | 4800-0012 | 3 |
| | FAIRCHILD MA747 | | |
| CR301,302<br>CR316,317 | DIODE | 4800-0013 | 4 |
| | MOTOROLA IN 4007 | | |
| CR304-315 | DIODE, MOTOROLA #IN4151 | 4800-0045 | 12 |
| Q305 | TRANSISTOR | 4800-0046 | 1 |
| | MOTOROLA 2N 4918 | | |
| Q301 | TRANSISTOR | 4800-0047 | 1 |
| | MOTOROLA 2N 4921 | | |

DIONEX
GAS PLASMA
DIVISION
31159 SAN BENITO
HAYWARD, CALIF.
94544

| TITLE | | | | | |
|---|---|---|---|---|---|
| A-3 HV REGULATOR BOARD<br>PM 112 GENERATOR | | | | | |
| SIZE<br>C | DWG.NO.<br>03409 | | REV.<br>N | CHK. | APPR. |
| DRAWN<br>J.V. | DATE<br>5/18/78 | SHEET 4 OF 5 | | | |

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| Q302 | TRIAC | 4800-0102 | 1 |
| | HUTSON 1T48 | | |
| | | | |
| | | | |
| REF | SCHEMATIC | D04111 | REF |

**DIONEX**

**GAS PLASMA DIVISION**
31159 SAN BENITO
HAYWARD, CALIF.
94544

TITLE A-3 HV REGULATOR BOARD
PM 112

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| C | 03409 | N | | |

| DRAWN | DATE | |
|---|---|---|
| J.V. | 5/18/78 | SHEET 5 OF 5 |

A 04269 REV

| DWG. NO. | REV. |
|---|---|
| D 03394 | C |

# DIONEX GAS PLASMA SYSTEMS

# ENGINEERING PARTS LIST

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| | | | | |
| C | E.O. #10855 AR | 3/80 | | |
| REV | DESCRIPTION | DATE | CHK | APPR |

REVISION LEVEL

DIONEX GAS PLASMA DIVISION
31159 SAN BENITO
HAYWARD, CALIF. 94544

| | | | | |
|---|---|---|---|---|
| DRAWN JV | DATE 5/18/78 | TITLE A 1 HV RECTIFIER BOARD<br>PM 112 | | |
| CHECKED | DATE | | | |
| ENG. | DATE | D | DRAWING NO. 03394 | REV. C |
| | | DO NOT SCALE THIS DRAWING | | |

NEXT ASSY.

A05495 REV A

0

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| C101-104 | CAPACITOR, ELECT 20 µF 450 V | 1500-0226 | 4 |
| C105 | CAPACITOR, ELECT. 100 µF 450 V | 1500-0227 | 1 |
| | | | |
| E101-111 | TERMINAL HH SMITH #2008 | 2860-2008 | 11 |
| | | | |
| R101-107 | RESISTOR, 330K Ω 2 W., CARBON COMP | 4705-0334 | 7 |
| R109-112 | RESISTOR, 47K, 2 W. CARBON COMP | 4705-0473 | 4 |
| | | | |
| R108 | RESISTOR, WIREWOUND 1 Ω 5 W. | 4706-0010 | 1 |
| | | | |
| CR101-140 | DIODE - MOTOROLA MR 510 | 4800-0008 | 40 |
| | | | |
| | | | |
| 1 | P.C. BOARD BLANK | C 03392 | 1 |
| | | | |
| REF | ELECTRICAL SCHEMATIC SHT 1 & 2 | D 04111 | 1 |
| | | | |
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**DIONEX**

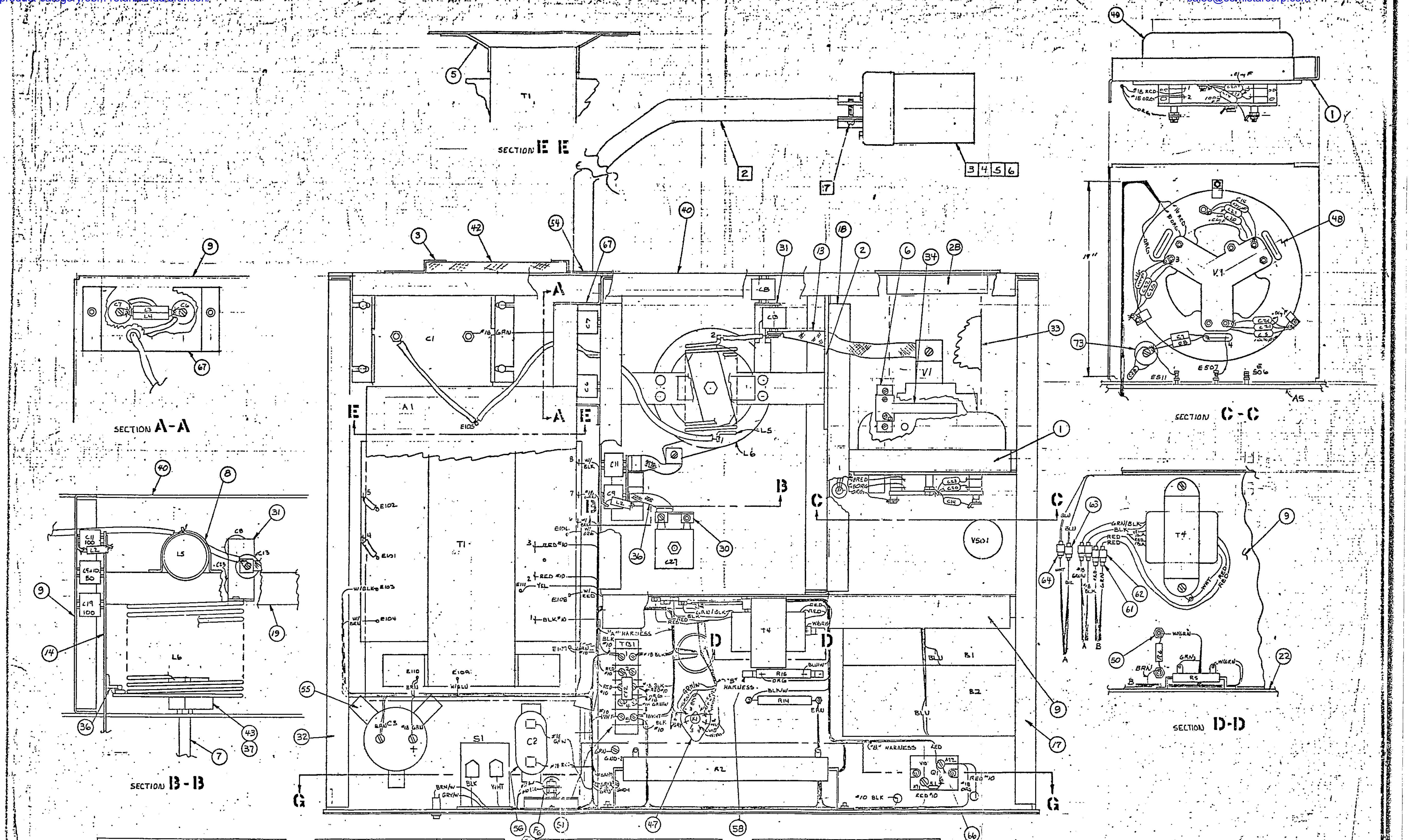
**GAS PLASMA DIVISION**
**31159 SAN BENITO**
**HAYWARD, CALIF.**
**94544**

TITLE
A 1 - HV RECTIFIER
PM 112 GENERATOR

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| D | 03394 | C | | |

| DRAWN | DATE | | |
|---|---|---|---|
| JV | 5/18/78 | SHEET 2 | OF 2 |

A 04289 REV



| "A" HARNESS | | | | |
|---|---|---|---|---|
| COLOR | START | BREAK OUT | END | NOTE |
| #10 BLK | S1-1 | | TB1-1 | |
| #10 WHT | S1-2 | | TB1-5 | |
| #10 BLK | TB1-5 | | F6 | |
| #10 RED | B1-M2 | | L1-R | |
| #10 BLK | T1-1 | | TB1-1 | |
| #10 RED | T1-2 | | TB1-2 | |
| #10 RED | T1-3 | TB1-3 | B1-M1 | |
| #18 GRN | C1-1 | | GND-1 | |
| [illegible] | E103 | | T1-8 | |
| #16 GRN | L1-7 | E107 | GND-1 | |
| W/ORG | E106 | | A3-17 | 1000V WIRES |
| WHT | E108 | | E501 | |
| W/BRN | E104 | T1-6 | R4-R | |
| #18 RED | R4-L | | C2-1 | |
| #18 GRN | C2-2 | | GND-1 | |
| W/BLU | E109 | R2-R | R3-L | |
| BRN | C3- | E110 R14-R | E705 | |
| #18 GRN | C3+ | | GND-1 | |
| BRN/W | DS1-B | | K1-2 | |
| GRY/W | DS1-A | | K1-7 | |
| #16 BLK | TB1-1 | E2-1 | B1-1 | |
| #16 WHT | TB1-5 | E1-2 | B2-2 | |
| #18 ORG | B1-M2 | | T3-4 | |
| #18 [illegible] | TB1-[illegible] | | T4-10 | |
| #18 BLK | TB1-3 | | T4-13 | |
| #18 BLK | TB1-1 | | T2-1 | |
| #18 WHT | TB1-5 | | T2-2 | |
| #18 GRN | T2-5 | | GND | |
| #18 WHT | T2-3 | | J1-A | |
| #18 GRN | T2-7 | | A7-4 | |

| | | | | |
|---|---|---|---|---|
| #18 GRN | A3-4 | | GND-1 | |
| #18 GRN | A3-2 | E510 | T3-6.3V | |
| #10 BLK | F6 | | L1-L | |
| #18 GRN | A6-18 | | GND- | |
| #18 GRN | A6-11 | | GND- | |
| #18 GRN | [illegible] | | GND- | |
| #18 GRN | L1-L | | GND- | |
| #18 GRN | L1-D | | GND- | |
| W/BLU | R2-R | | F1-A | |
| | C1+ | E105 | C6 | HIGH VOLTAGE LEADS |
| | C7 | | T5 | |
| | L5-2 | | C13 | |
| #18 RED | T3-10A | | V1-1 | |
| #18 ORG | T3-6.3V | | V1-2 | |
| ORG | TP2 | | V1-3 | |
| GRN/W | A5-1 | E508 | T3-10A | |
| YEL | R9-1 | | E706 | |

| JUMPERS | | | |
|---|---|---|---|
| E101 | | T1-4 | HIGH VOLTAGE LEADS |
| E102 | | T1-5 | |
| C1 | E105 | C6 | |
| C7 | | L5-1 | |
| L5-2 | | C13 | |
| T4-B/R | | T4-B/Y | |
| E507 | | V1-4 | BUSS WIRE W/ TEFLON SLEEVING |
| E511 | | C25 | |
| K1-6 | | K1-2 | |
| T4-W | | GND | |

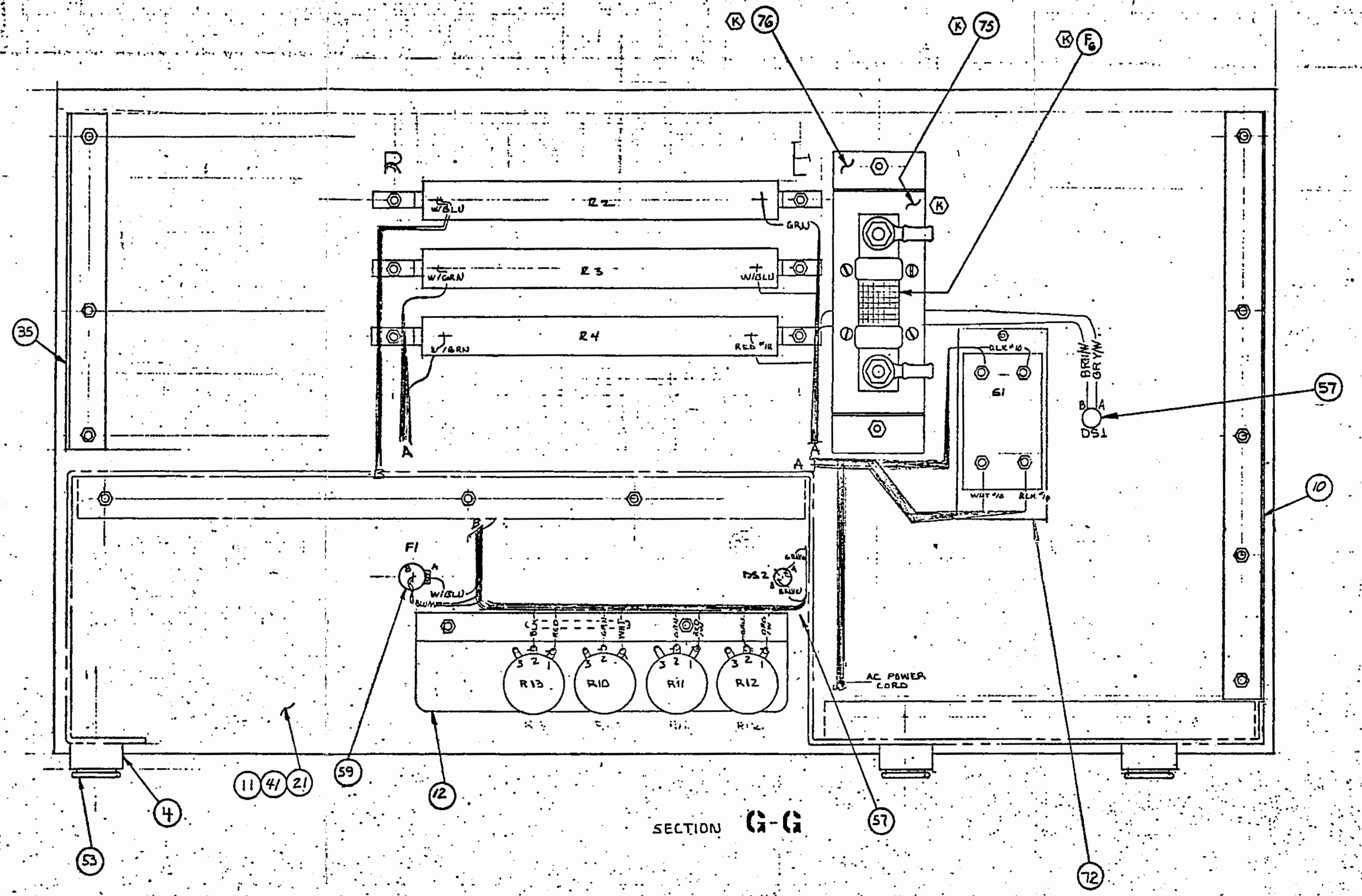
| "B" HARNESS | | | | |
|---|---|---|---|---|
| COLOR | START | BREAK OUT | END | NOTE |
| VIO | [illegible] | | K1-4 | |
| RED | [illegible] | | V1-1 | |
| BLU | T4 | | TP-5 | |
| GRN | T4-R | | GND | |
| [illegible] | [illegible]-R | R5-R | R6-T | |
| GRN | [illegible]-1 | | GND- | |
| GRY | [illegible]-7 | | GND | |
| BLK/W | [illegible]-L | | E505 | |
| BLU/W | [illegible]-K | E1-3 TB1 E502 | A2-1 | |
| ORG | [illegible]-L | | TP-2 | |
| VIO/W | [illegible]-G | A6-7 | [illegible] | |
| YEL | [illegible] | | TP-4 | |
| [illegible] | [illegible]-2 | | A3-21 | |
| [illegible] | [illegible]-4 | | A3-20 | |
| | | | | |
| [illegible] | [illegible]-8 | DS2-B | A3-22 | |
| BRN/W | [illegible]-7 | | DS2-A | |
| RED/W | [illegible]-2 | | T3-107 | |
| [illegible] | [illegible] | | T3-4 | |
| [illegible] | [illegible] | | A3-14 | |
| W/YEL | [illegible]-8 | | A3-13 | |
| | | | | |
| | | | | |
| GRN | [illegible]-2 | R11-2 | GND- | |
| [illegible] | [illegible]-1 | A6-14 | J1-F | |
| [illegible] | [illegible]-1 | A6-20 | J1-D | |
| WHT | [illegible]-1 | | A6-7 | BELDEN 8723 |
| GRN | [illegible]-2 | | A6-1 | |
| RED | [illegible]-1 | | A6-[illegible] | |
| BLK | [illegible]-7 | | A6-[illegible] | |

| | | | | |
|---|---|---|---|---|
| BRN | A3-13 | TP-6 A2-3 | A6-10 | |
| BLU | A3-8 | | A2-12 | |
| GRN | A3-14 | A3-6 | A3-4 | |
| BLK | A3-7 | | T3-COM | |
| ORG | A3-3 | A2-15 E710 | J1-N | |
| GRN | A7-2 | | GND- | |
| GRN | A2-17 | | GND- | |
| VIO/W | A6-[illegible] | | J1-J | |
| ORG/W | A6-11 | | A4-R | |
| VIO/W | A6-12 | | A4-F | |
| YEL | A6-15 | E503 | J1-C | |
| CLR | A6-[illegible] | | J1-H | BELDEN 8762 |
| BLK | A6-6 | | J1-G | |
| SHLD | | | GND | |
| RED | A6-5 | | J2-A | BELDEN 8772 |
| CLR | A6-4 | | J2-C | |
| BLK | A6-1 | | J2-B | |
| SHLD | | | GND | |
| BLU/W | A6-3 | | J1-F | |
| GRY | E501 | | TP-3 | |
| GRN | TP-8 | | GND | |
| VIO | C9-2 | R5-3 E504 | E703 | |
| | | | | |
| BLK | T2-4 | | T3-107 | |
| GRN | R2-L | | GND-1 | |
| | | | | |
| VIO | A3-18 | TP7 A2-16 A6-10 | E708 | J1-K |
| | | | | |
| GRN | T3-CT | | GND | |
| W/ORG | A6-17 | | E709 | |
| BRN/W | E702 | | E512 | |

7 TIGHTEN CORD GRIP SCREWS
6 REPLACE INTERIOR INTO METAL COVER AND ROTATE CLOCKWISE BEFORE TIGHTENING THREE HEX HEAD SCREW ON 2.
5 LOOSEN AND BACK OFF ALL TERMINAL SCREWS, INSERT ALL CONDUCTORS INTO ENTRANCE HOLES FULLY AND TIGHTEN ALL SCREWS TO APX 25" LBS
4 DO NOT SOLDER ENDS OF CONDUCTORS
3 STRIP CABEL JACKET 1.50"; STRIP INSULATION .75"
2 AC POWER CABLE 10 FT MIN. FROM REAR PANEL
1 DRESS ALL LEADS AS SHORT AS POSSIBLE

| | | | | | |
|---|---|---|---|---|---|
| T | EO#11153 | AS | 7/8 | | |
| S | E.O.#11010 | EA | 3/21 | | |
| R | E.O.10589 | | | 9-23-89 | |
| O | E.O.#10672 | MS | 15-[illegible] | | |
| K-N | CARRIED FORWARD | RVG | 15-[illegible] | | |
| J | EO 10721 | KG | 11-78 | | |
| H | REVISED | D.YEH | | | |
| G | EO 10489 | KG | | | |
| F | EO 10381 | KG | | | |
| E | EO. 10321, 10363 | KG | | | |
| D | EO. 10376 | KG | | | |
| C | ADDED ITEM# 68 & 70 NOTE #3 | JYS | | | |
| B | EO#10349 | JV | | | |

INTERNATIONAL PLASMA CORP
PM112
TOP ASS'Y & WIRING
04015



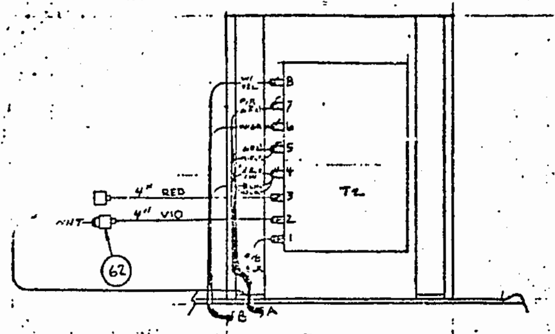
SECTION G-G

INTERNATIONAL PLASMA CORP

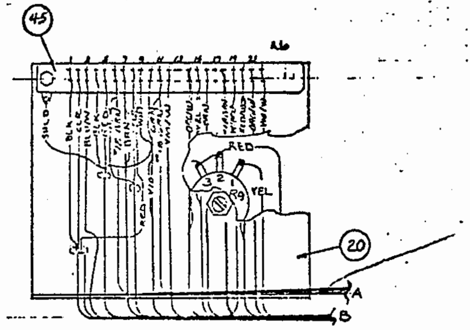
PM 112
TOP ASS'Y & WIRING

DWG. NO. 04015

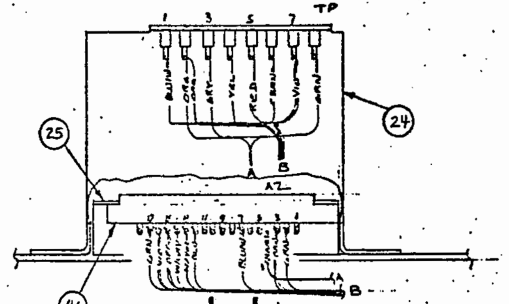
SHEET 2 OF 12



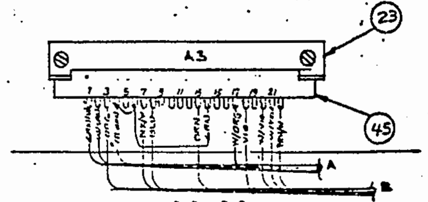
SECTION H-H



SECTION K-K



SECTION L-L



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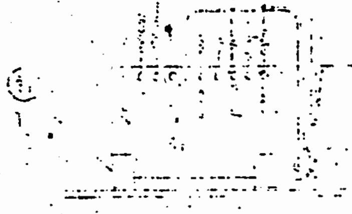

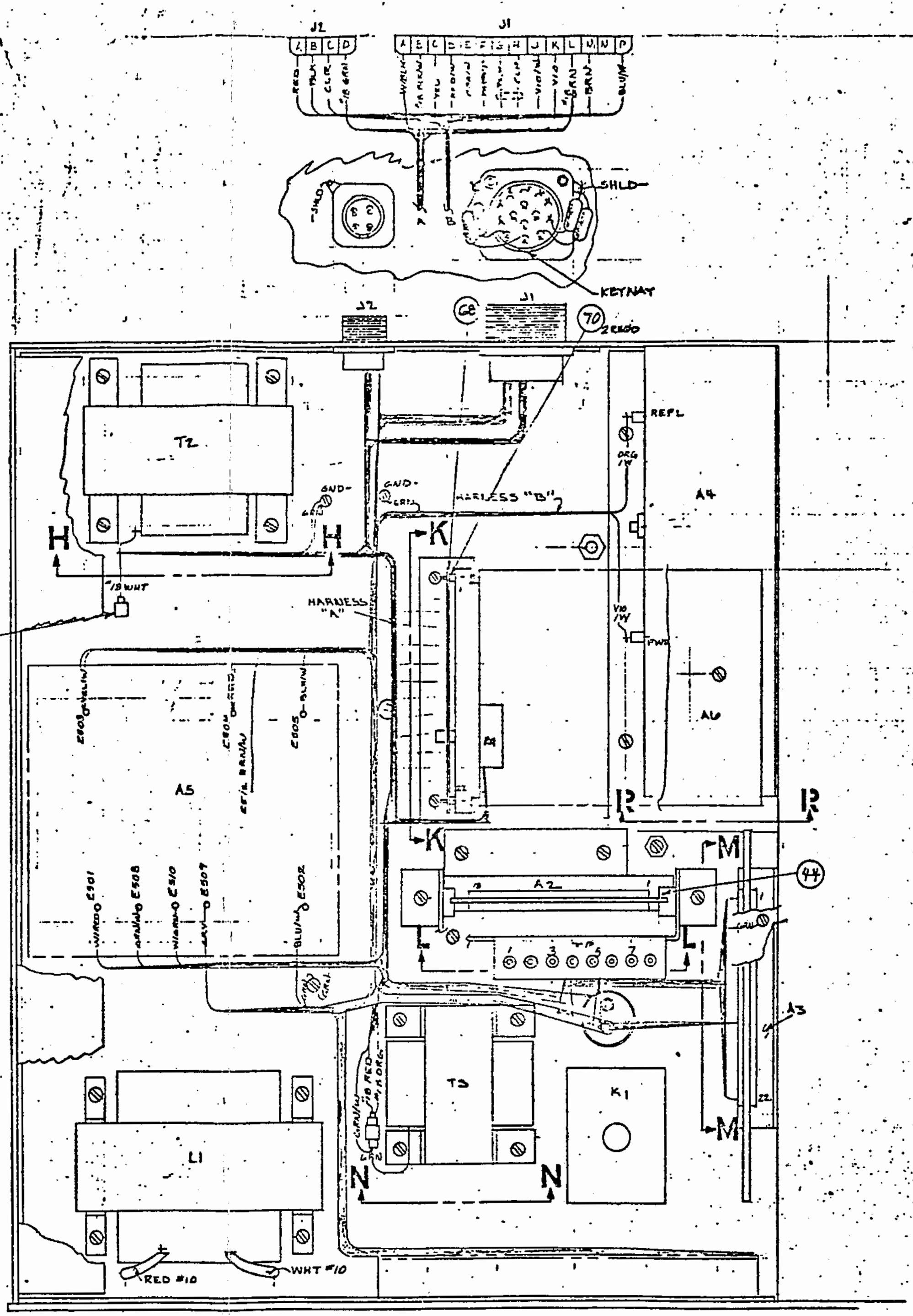

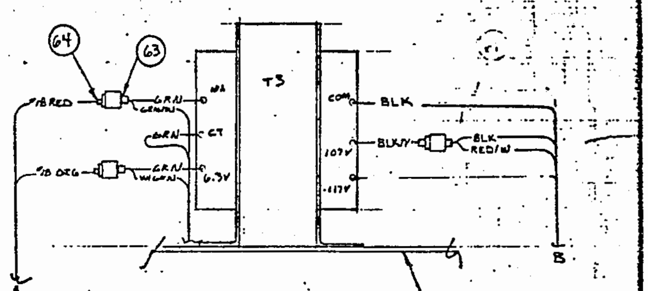

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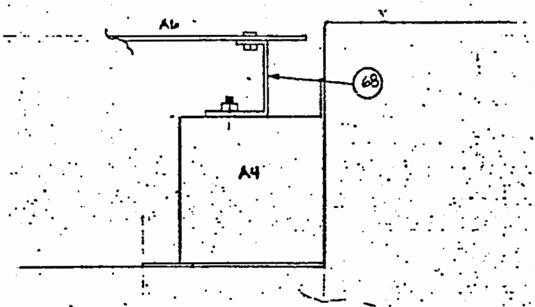
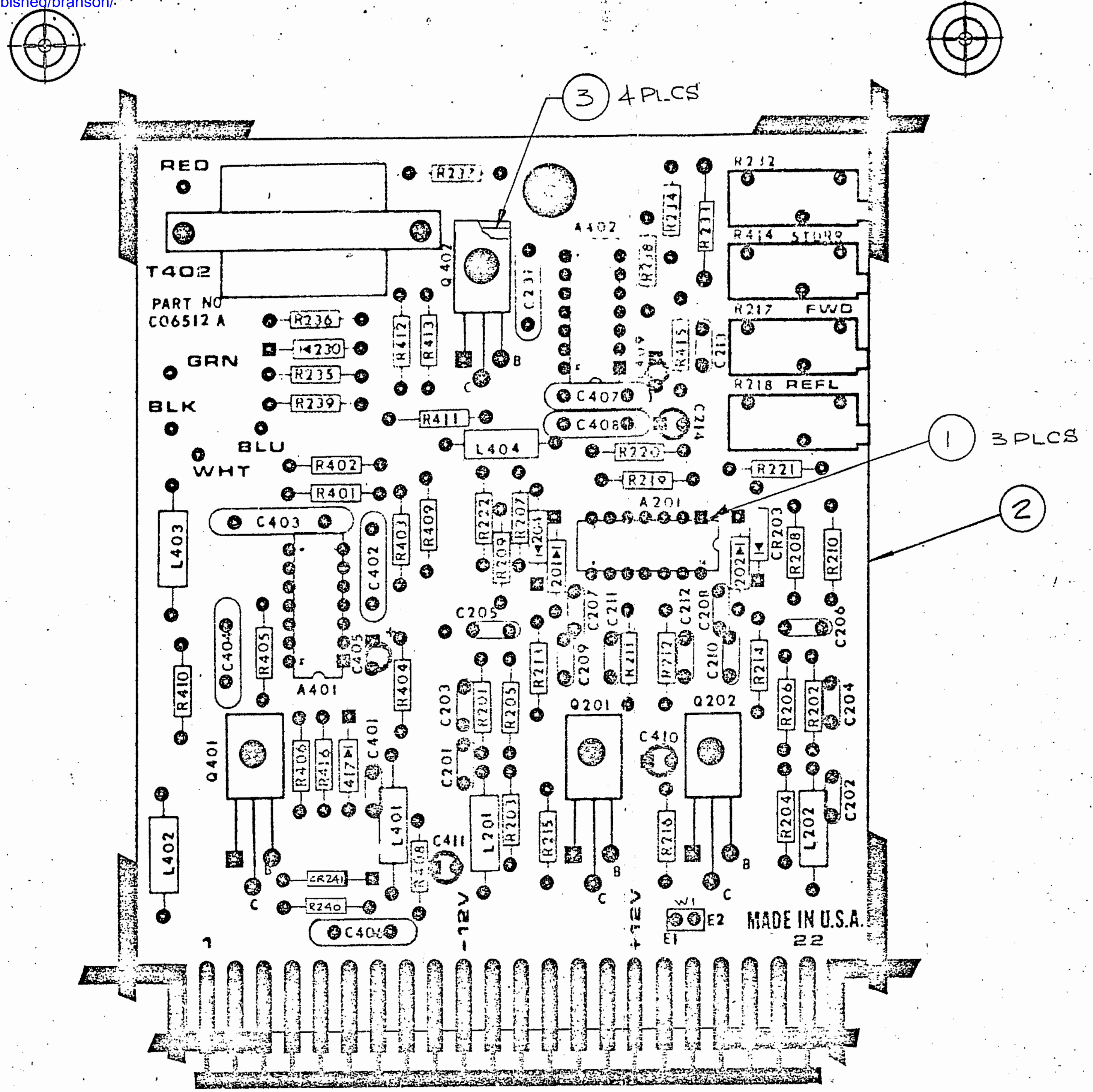


SECTION R-R

INTERNATIONAL PLASMA CORP

PM 112
TOP ASS'Y & WIRING
CHASSIS



| REV | DESCRIPTION | DATE | CHK | APPR |
|---|---|---|---|---|
| B | E.O. #11010 EA | 3-81 | | |
| – | E.O. # [illegible] | [illegible] | | |

REVISION LEVEL

DIONEX GAS PLASMA DIVISION
21159 SAN BENITO
HAYWARD, CALIF 94544

NEXT ASSY E04015

DRAWN
DATE
CHECKED
DATE

TITLE ASSEMBLY DRAWING
REGULATOR, VACUUM BOARD

C 06514 B

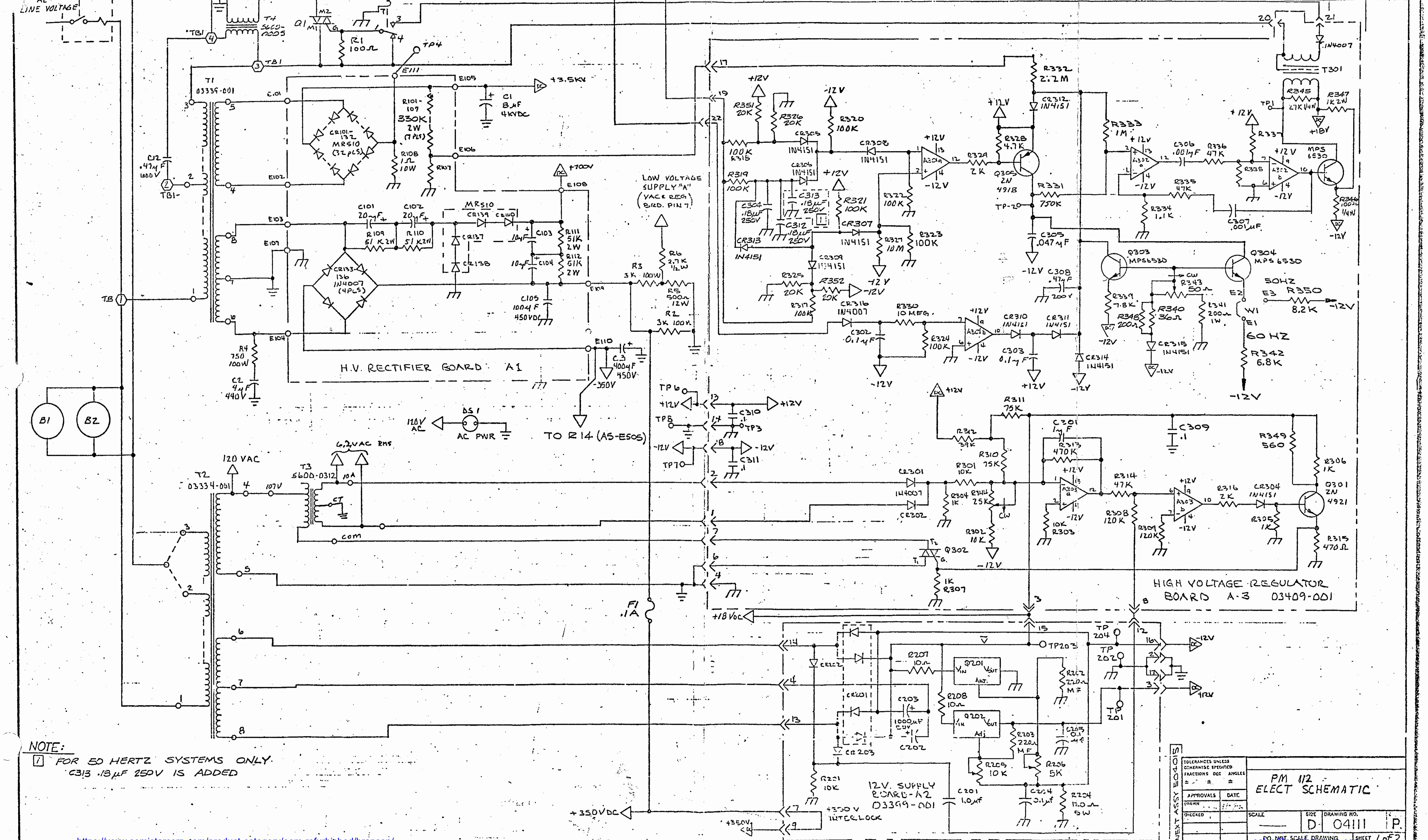
SHEET 1 OF 4

| LTR | DESCRIPTION | PREP | DATE | APPV |
|---|---|---|---|---|
| L | EO#10367 | | 12-4-79 | |
| M | EO# 10722 | A.R | 3-17-80 | |
| N | E.O # 10852 | A.R | 3-20-80 | |
| O | EAR 20416 | | 9-2-80 | |
| P | E.O. # 11010 | EA | 3-24-81 | |

| LTR | DESCRIPTION | PREP | DATE | APPD |
|---|---|---|---|---|
| F | ADDED C309,310,311 | | 10-24-78 | |
| G | EO 10383 | | 11-7-75 | |
| H | E.O. 10370, 10363 | | 11-8-78 | |
| J | E.O. #10367 | | | |
| K | REVISED | | 11-12-79 | |

REVISIONS

| LTR | DESCRIPTION | | DATE | APPROVED |
|---|---|---|---|---|
| A | RELEASE | JV | 3-3-78 | |
| B | EO# 10323 | JV | -11-78 | |
| C | EO#10349 | JV | 5-9-78 | |
| D | EO# 10377 SEE # 03409 | JV | 2-24-78 | |
| E | EO=10366 | | 11-13-78 | |



NOTE:
1 FOR 50 HERTZ SYSTEMS ONLY.
C313 .18μF 250V IS ADDED

NEXT ASSY E0405

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

| APPROVALS | DATE |
|---|---|
| DRAWN | |
| CHECKED | |

PM 112
ELECT SCHEMATIC

SCALE —
SIZE D
DRAWING NO. 04111
P.
DO NOT SCALE DRAWING
SHEET 1 of 2

**BRANSON/IPC**
**a SmithKline company**

**BRANSON INTERNATIONAL PLASMA CORPORATION**

# INSTRUCTION MANUAL

for

PM 702

AUTOMATCH W/DPS 1000

A00110 Rev D
August 9. 1977

31172 Huntwood Avenue
P.O. Box 4136, Hayward, CA 94544
(415) 489-3030 Telex: 337-759

# INSTRUCTION MANUAL
# for
# IPC PM 701-702-703
# AUTOMATCH

## 1.0 INTRODUCTION

### 1.1 Description

The R.F. Generator is designed and calibrated to drive a fixed 50 ohm resistive load. However, the reactor and plasma present a resistive/capacitive load. Its amplitude and phase depend upon the type and size of chamber and upon various operating parameters, e.g. power level, pressure, type of gas, and temperature. Therefore, a network which matches the impedance of the reactor to the desired 50 ohms is provided in each Reactor Center. The AutoMatch system continuously and automatically adjusts the matching network over the full operating range of the Reactor Center.

The matching network is a capacitor-inductor-capacitor pi network. Both amplitude and phase of the impedance at the input to the network must be correct, i.e. 50 ohms and zero degrees. This requires the adjustment of two components. Therefore both capacitors in the network are variable and are motor-driven. The series inductor is fixed.

As in any parallel tuned RLC network there are two values of capacitance for resonance (phase equals zero). In this application the only legitimate resonance is one where the magnitude of the input current is less than the magnitude of the current in the input capacitor, i.e. $/I_{in}/ < /I_{ci}$, (See Figure A). AutoMatch insures that this relationship holds by automatically increasing Ci and Co if $/I_{in}/ > /I_{ci}$.

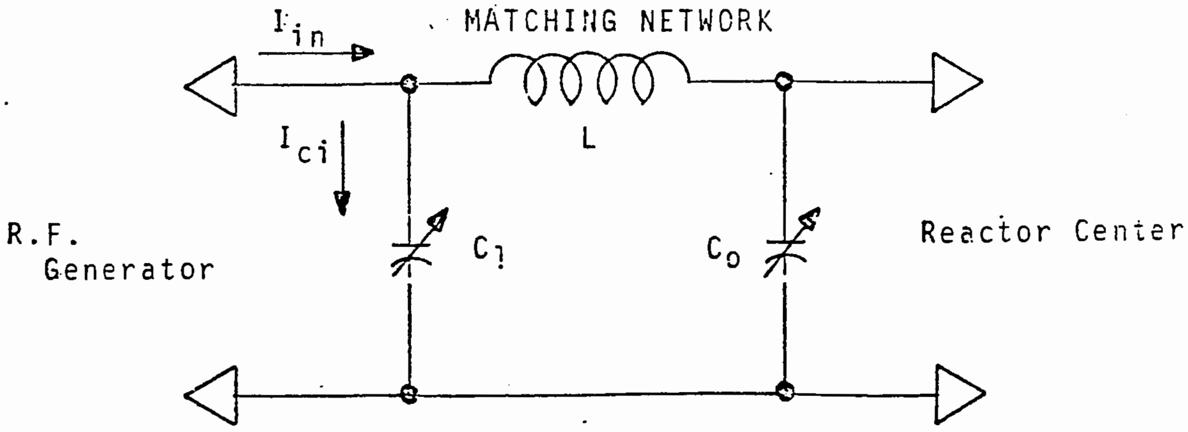


FIGURE A

## 2.0 OPERATION

The operation of AutoMatch is completely automatic over the functional range of the Reactor Center and requires no operator intervention.

## 3.0 FUNCTIONAL DESCRIPTION

### 3.1 Functional Inclusions

An R.F. Coupler which detects the inpedance at the input to the matching network, and provides signals indicative of errors in both amplitude and phase. The coupler also detects $/I_{in}/$ for subsequent comparison to $/I_{ci}/$.

3.2 An amplifier section which amplifies the error signals, i.e. amplitude error and phase error, and amplifies the signal comparing $/I_{ci}/$ and $/I_{in}/$.

3.3 A motor and gear drive section mechanically coupled to the rotors of the air variable capacitors of the matching network. The motors are driven by the appropriate amplifiers in the amplifier section, adjusting the capacitances for minimum error signals.

3.4 The pi matching network consisting of the variable capacitor at the input and output terminals and the series fixed inductor. It also includes circuitry to detect $/I_{ci}/$ for processing with $/I_{in}/$ in the amplifier section.

## 4.0 CIRCUIT DESCRIPTION

Refer to drawing C02661 for the schematic of AutoMatch.

### 4.1 R.F. Coupler

The R.F. Coupler, shown schematically within the dashed lines, is an arrangement of lumped components and distributed components mechanically arranged to generate D.C. voltages which, when properly combined, yield the appropriate error signals for both amplitude and phase. The phase error is proportional to the sum of voltages Vp1 and Vp2, which are the D.C. voltages developed on capacitors C205 and C204, respectively. The amplitude error is proportional to the sum voltages Va1 and Va2, which are the D.C. voltages developed on capacitors C207 and C206, respectively. Va1 is proportional to the total input current.

## 4.2 Phase Error Amplifier

The voltages Vp1 and Vp2 are summed algebraically by the phase error amplifier through input resistors R101 and R102. R108 is a potentiometer to adjust for any minor misalignment in the coupler. The phase error amplifier is a feedback amplifier comprised of A101 with output buffer power transistors Q101 and Q102. The amplifier drives the D.C. motor M202 which is mechanically geared to the rotor of the variable air capacitor C202*, the output capacitor of the matching pi network. The forward gain of the amplifier is determined by the voltage feedback via R116.

## 4.3 Limit Switches

Switch S201 and S202 are "limit" switches positioned to limit the range of rotation of the rotor of variable air capacitor C202. If the motor is driven by a positive voltage, the capacitor rotor will rotate to its extreme position when S202 is opened. Diode CR206 then prevents current through the motor until the amplifier output voltage is reversed. Limit switch S201 and CR205 similarly restrict the range of capacitor rotation for negative voltage drive.

## 4.4 Amplitude Error Amplifier

The amplitude error amplifier is identical to the phase error amplifier, driving D.C. motor M201 which is geared to the rotor of variable air capacitor C201*. Capacitor C201 with the fixed capacitors C211 and C212 comprise the input capacitance of the pi matching network. The current through the input capacitance (referred to previously as $I_{ci}$ and ci respectively) is detected by virtue of the voltage across the "gimmick" inductor and rectifier diode CR209. The resulting D.C. voltage Vi is added algebraically with Va in amplifier A101 through input resistor R121, R123, and potentiometer R122. If the input current, represented by Va, exceeds $I_{ci}$ the output of amplifier A101 becomes positive polarity. Diodes CR102 and CR101 then become forward biased driving the outputs of both error amplifiers positive. This results in C201 and C202 being driven to maximum capacitance.

## 4.5 Power Supply

Supply voltages B+ and B- of +15 and -15 volts respectively, are generated by two full wave rectifiers comprised of T1, capacitors C3, C4, and a diode bridge.

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* For PM702 and PM703 the reference designator for C201 is C215 and the reference designator for C202 is C216.

# 5.0 MAINTENANCE

WARNING: HIGH R.F. VOLTAGES EXIST THROUGHOUT THE UNIT. R.F. POWER SHOULD BE REMOVED DURING MAINTENANCE.

## 5.1 Electrical

All R.F. Coupler and Potentiometer alignments are made at the factory and require no further adjustment.

## 5.2 Mechanical

For ease of maintenance and to protect the motor driven gear heads, each drive train includes a slip clutch. The D.C. motors, gear heads, spur gears, slip clutch, and variable capacitors are precisely positioned at the factory. If it becomes necessary to replace any of these parts, exercise care in mating the spur gear on the capacitor shaft with the nylon slip clutch gear. The gear teeth should engage approximately 80-90% without binding for a full 360 rotation.

5.2.1 Excessive backlash, symptomized usually by a system oscillation (or hunting) may be caused by loose gears or set screws and/or improperly meshed gears.

5.2.2 The slip force on the slip clutch assemblies is set at the factory. If readjustment is necessary, the spring tension should be set to require a motor current of 25 ma at 12 volts with the nylon gear in a fixed position.

## 5.3 Capacitor Replacement

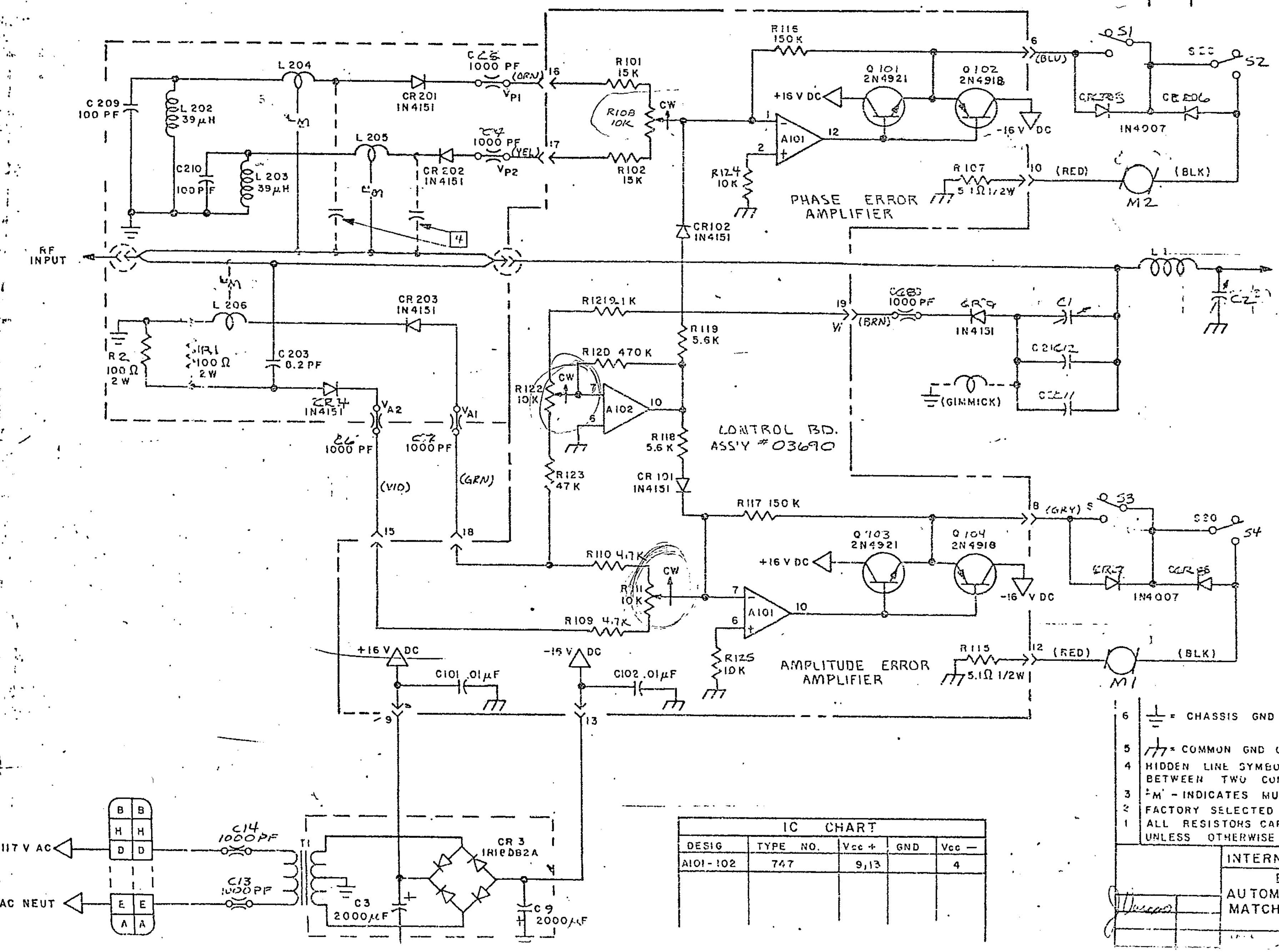
If replacement of a variable capacitor, C201 or C202, becomes necessary the following should be observed:

5.3.1 The spur gear should be firmly set on the capacitor shaft.

5.3.2 The limit switch actuating arm should be firmly set on the capacitor shaft with the following orientation:

> With the limit switch actuating arm set parallel to the AutoMatch baseplate, the capacitor rotor should be set for 50% capacitance. The limit switch actuating arm should be toward the outer edge of the baseplate, and the capacitor rotor should be toward the center of the baseplate.

| REV | | | | |
|---|---|---|---|---|
| A | [illegible] | | 7-12-75 | [illegible] |
| B | [illegible] | | 10-13-76 | [illegible] |



| IC CHART | | | | |
|---|---|---|---|---|
| DESIG | TYPE NO. | Vcc + | GND | Vcc − |
| A101 - 102 | 747 | 9,13 | | 4 |

6 ⏚ = CHASSIS GND

5 ⏚ = COMMON GND ON CIRCUIT BD.

4 HIDDEN LINE SYMBOLS INDICATE CAPACITANCE BETWEEN TWO CONDUCTORS

3 ˙M˙ - INDICATES MUTUAL COUPLING

2 FACTORY SELECTED FOR APPLICATION

1 ALL RESISTORS CARBON COMPOSITION 1/4 W UNLESS OTHERWISE SPECIFIED

INTERNATIOAL PLASMA CORP.

ELECTRICAL SCHEMATIC
AUTOMATIC IMPEDENCE
MATCHING NETWORK PM 702

## 5.4 Adjusting the Reflected Power

This adjustment should only be necessary in the event that the PM 701/702/703 is retrofitted in the field. Make the adjustment at one torr of oxygen and with an R.F. level of 300 watts per chamber.

### 5.4.1 Units Without DPS-1000

Refer to figure 6. There are three adjustable resistors in the auto tuner. These are accessible through a vertical slot in the rear panel of the Reactor Center, and the one of concern is R108, the center resistor. Observing the reflected power on the system power meter, adjust R108 for minimum reflected power. If the system "hunts" or oscillates, turn R108 clockwise until "hunting" ceases. The reflected power should be less than 6 watts.

### 5.4.2 Units with DPS-1000

Refer to figure 7. There are five adjustable resistors in the Auto tuner/DPS-1000. These are accessible through a vertical slot in the rear panel of the Reactor Center and the one of concern is R108, the second resistor from the top. Observing the reflected power on the system power meter, adjust R108 for minimum reflected power. If the system "hunts" or oscillates, turn R108 clockwise until "hunting" ceases. The reflected power should be less than 6 watts.

## 5.5 Tuning Procedure

5.5.1 Remove L201 and disconnect strap from coupler to C201.

5.5.2 Loosen motor clamp.

5.5.3 Disengage motor gears from C201 and C202 gears by pulling motor housings back into tuner body.

5.5.4 Gently tighten motor bracket to hold motors in place.

5.5.5 Open C201 to minimum capacitance position; keep it off both limit switches. There should be two 100pf ceramic tubular capacitors in the padder bracket of C201.

5.5.6 Open C202 to middle position.

5.5 (continued)

5.5.7 Refer to figure 2 for potentionmeter locations (R108, R111, & R122).

5.5.8 Remove A102.

5.5.9 Connect a 50 ohm dummy load directly to coupler output - nothing else should be connected to coupler output at this time.

5.5.10 Plug 701-702-703 into 117 volts AC supply.

5.5.11 Connect a 500 watt generator to coupler input.

NOTE: DURING THE FOLLOWING STEPS; COVER THE COUPLER SIDE ONLY WITH ALUMINUM SAFETY COVER TO PREVENT ACCIDENTAL CONTACT WITH HIGH VOLTAGES PRESENT IN THE R.F. COUPLER SECTION.

5.5.12 Turn generator on and up to 500 watts.

5.5.13 Adjust R108 until M202 turns clockwise (viewed from Gearhead end of the motor). Manually close switch S202, and observe that the motor does not stop rotating. Manually close switch S201 and observe that the motor stops.

5.5.14 Adjust R108 until M202 turns counter clockwise (viewed from gearhead end of the motor). Manually close S201 and observe that M202 does not stop. Manually close S202 and observe that the motor stops.

5.5.15 Adjust R108 until M202 stops. This will balance A101A for zero output.

5.5.16 Adjust R111 until M201 turns clockwise (viewed from the gearhead end of motor). Manually close S203, and observe that M201 does not stop rotating. Manually close S204 and observe that M201 stops.

5.5.17 Adjust R111 until M201 turns counter clockwise. Manually close S204 and observe that M201 does not stop rotating. Manually close S203 and observe that M201 stops.

5.5.18 Adjust R111 until M201 stops. This will balance A101B for zero output.

5.5.19 Disconnect AC power from PM 701/702/703. This will bleed supplies via M201 and M202.

5.5 (continued)

5.5.20 Turn off R.F. Power.

5.5.21 Disconnect 50 ohm dummy load.

5.5.22 Connect strap from 701 and 702 coupler output in C201. C201 should be the only thing connected at this point.

5.5.23 Install A-102 and reconnect to 117 volt AC supply.

5.5.24 Turn up R.F. to 50 watts.

5.5.25 Adjust R122 until neither M201 nor M202 rotate toward minumum capacitance.

5.5.26 Turn of R.F. Power.

5.5.27 Install L201.

5.5.28 Connect simulated load.
EXAMPLE: (refer to next page) Figure B.

5.5.31 (continued)

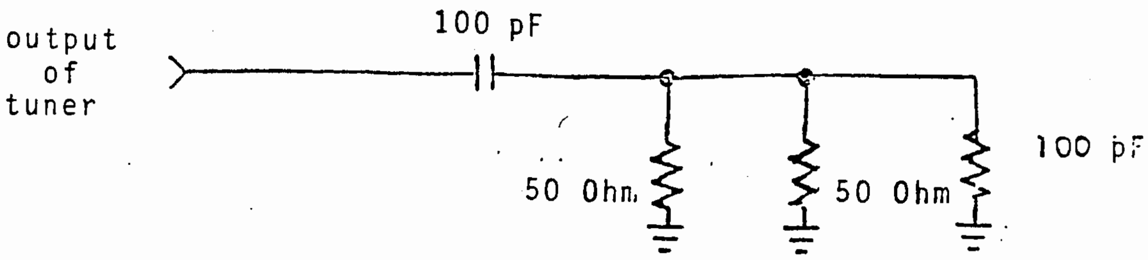


FIGURE B

5.5.31.1 Engage motors M201 and M202 to their proper positions.

5.5.32 Replace top cover.

5.5.33 Turn on R.F. Power to 500 watts if obtainable.

5.5.34 Rotate R108 clockwise for 6 watts or less reflected and 500 watts forward.

5.5.35 Turn off R.F. Power and disconnect generator.

5.5.36 Remove 117 volt AC supply from 701-702-703.

5.5.37 Disconnect simulated load.

5.5.38 Recheck mechanical connections.

## 5.6 Adjusting the Operating Range

The matching is achieved by virtue of two motor driven capacitors. Each of these capacitors has a limited range over which it will vary. They have been selected to accommodate the various operating parameters of a system, e.g. gas flow, pressure, R.F. Power, but differences in Reactor Chambers may require adjustment of the location or center of the range.

5.6.1 Upon installation of the unit in the system, note there is an upper variable capacitor with fixed capacitors in parallel with it, and mounted on a bracket on the variable capacitor. The location or center of the range for this variable capacitor is determined by the number of fixed capacitors on the bracket. If the range is such that the variable capacitor approaches or reaches its maximum value (fully meshed), it may be brought closer to the center or away from the maximum by adding fixed capacitance. Conversely, if the variable capacitor

5.6.1 (continued)

approaches or reaches its minimum value, it may be brought closer to the center or away from the minimum by removing fixed capacitance.

5.6.2 The upper variable capacitor is connected to the lower variable capacitor through a fixed inductor of approximately 6 turns of wound tubing. Although the inductor is fixed, its value can be adjusted by compressing the length so that the turns are closer together, or by stretching the length so that the turns become further apart. Compressing increases the inductance and stretching decreases the inductance. Adjusting the value of this inductor is the mechanism for centering the range of the lower variable capacitor. However, in order to adjust the inductor, first unfasten the top of the inductor. Refasten it after adjusting.

5.6.3 If the lower variable capacitor approaches or reaches its maximum value, it may be brought closer to its center or away from its maximum by increasing the inductance (compressing the inductor). If the lower variable capacitor approaches or reaches its minimum value, it may be brought closer to its center or away from its minimum by decreasing the inductance (stretchint the inductor). If the stretching or compressing of the inductor becomes too extreme, it may be necessary to use an inductor with a different number of turns. Increasing the number of turns increases the inductance. There are two inductors supplied with the unit in case substitution for the one installed is necessary.

5.6.4 The table below shows the operating parameters which the units are adjusted to cover at the factory. In case of retrofitting in the field, it may be necessary to readjust for the particular chamber(s) in the reactor. Simply set up each of the conditions, and for each verify that the variable capacitors are in their operating range, i.e. not at a minimum or maximum value. Correct or adjust the ranges by procedure described above.

5.6.4 (continued)

8" X 18" CHAMBER . . .

| | |
|---|---|
| ETCHING WITH TUNNEL | 0.3 TO 1.7 TORR<br>150 to 400 WATTS/CHAMBER |
| STRIPPING WITH OR WITHOUT TUNNEL | 1.0 TO 3.0 TORR<br>300 TO 500 WATTS/CHAMBER |

10" X 18" CHAMBER . . .

| | |
|---|---|
| ETCHING WITH TUNNEL | 0.3 TO 1.7 TORR<br>150 TO 450 WATTS/CHAMBER |
| STRIPPING WITH OR WITHOUT TUNNEL | 1.0 TO 3.0 TORR<br>400 TO 700 WATTS/CHAMBER |

## 6.0 INTRODUCTION (DPS-1000)

The optional DPS-1000, in conjunction with the system programmer, allows the operator to select one of two criteria to terminate the stripping cycle. The first is a fixed time determined by the setting of the cycle timer furnished standard with the system programmer. The second is directly related to the stripping process itself, for it is a signal based on direct detection of the stripping activity by the DPS-1000.

The DPS-1000 monitors the Reactor Chamber and measures the stripping activity. When the activity reaches a sufficiently low value, the DPS-1000 signals that fact to the system programmer. The system programmer automatically terminates the process cycle, sounding the audible alert and lighting the RESET light.

### 6.1 Functional Description

The DPS-1000 operates on those gaseous by-products that are generated during the stripping process. As long as photoresist remains in the chamber in presence of the oxygen plasma, these by-products will be generated. The by-products become plasma and emit light encompassing spectral energy not otherwise present. The DPS-1000 senses the presence of this spectral energy optically, utilizing the appropriate combination of photocell and optical filter.

## 6.1 (continued)

Fig. 1 shows a typical response of the photodetector throughout the stripping process. The initial high level transient is a result of residual air from the preceding evacuation step, as is the first of the following peaks. Following that is a true representation of the stripping activity, and it follows a curve similar to the familiar bell shape curve. From observation of the curve, the criteria for determining whether or not the stripping is complete could be either low signal level of trailing portion of the curve, or it could be the low value of the slope of the trailing portion of the curve. The DPS-1000 operates on the latter phenomena, the slope, thereby avoiding the anomolies caused by changes in off set or dc level of the curve.

However, there are several portions of the curve where the slope is low, and the DPS-1000 must ignore all but the pertinent one at the trailing end. This is accomplished by virtue of a built in time delay beginning at the start of the stripping sequence and lasting for approximately 2¼ minutes. During this time interval the detector ignores any indication of low slope and merely monitors the activity. At the end of this time interval the curve should be on its final upward slope, and the DPS-1000 stores and remembers the value of the curve at that time. As long as the activity is above that value the detector indicates stripping in progress. It is only after the curve returns to values lower than the one reached at the end of the time interval that the detector monitors the value of slope, and indicates stripping complete when the value becomes sufficiently low.

The DPS-1000 is shown functionally in Figure 2. When the system programmer initiates the stripping step by applying R.F. to the Reactor Chamber, it also starts the DPS-1000 by applying a "START TIMER" signal to it. For the first two minute fifteen second interval, the UP/DOWN COUNTER is under command of the COMPARATOR. During this interval the UP/DOWN COUNTER and DIGITAL-ANALOG CONVERTOR combination will track the amplified signal from the optical detector. The UP/DOWN COUNTER is incremented at a clock rate of four clock signals per second. Hence if the COMPARATOR indicates that the DAC output is less than the detector signal, the COUNTER will count up. If the COMPARATOR indicates that the DAC output is greater than the detector signal, the COUNTER will count down. Thus during those portions of the detector signal with positive slope, the COUNTER

6.1 (continued)

counts up; and during those portions of the detector signal with negative slope, the COUNTER counts down. The steepness of the slope will determine the rate at which the counter increments, or conversely the rate at which the counter is incremented is an indication of the steepness of the slope.

After the initial 2¼ minute interval, the counter is inhibited from counting up. At this time the detector signal should be beyond the initial transients and be somewhere on the positive going portion of the process curve. Subsequently, as long as the detector signal is greater than this value, the COMPARATOR will command UP counts, and this in turn "freezes" the system. When the detector signal returns to values below this level, the COMPARATOR commands down counts which the counter will follow. The criteria for process complete is that there must be three successive one minute intervals during which there are no more than eight down counts per interval. When this criteria has been met, the DPS-1000 indicates process complete and automatically terminates the program step.

Thus the functional block labeled "/4" (divided by 4), is a counter counting clock pulses, at the rate of two/minute. When it reaches the count of three it outputs a signal terminating the process. The "/4" counter is reset to zero if: a) there is an up count command from the COMPARATOR, b) if there are more than eight down counts during the one minute interval, and c) continuously during the initial 2¼ minute timer interval. The down counts are accumulated by the "/8" counter, which is reset to zero every one minute interval.

To recap, the sequence of events is listed below:

1. The relay in the system programmer indicates that the stripping step has started and R.F. is being applied to Reactor Chamber

2. A two minute fifteen second timer interval is started.

3. During this 2¼ minute interval the UP/DOWN COUNTER and DAC track the detector signal under command of the COMPARATOR. During this time interval the contents of the UP/DOWN COUNTER is a close digital representation of the analog signal of the detector, as the clocking rate for the UP/DOWN COUNTER is relatively high at four clocks per second. (To avoid consequences of system noise, the COMPARATOR has a built-in hysteresis of 3 DAC levels. Hence the COMPARATOR will indicate a change of direction if the DAC output deviates from the detector signal by three levels).

6.1 (continued)

4. At the end of the 2¼ minute interval the detector should be on its final positive slope.

5. The UP/DOWN COUNTER is inhibited from counting up, thereby freezing at its last value until the detector output returns to a value below this level.

6. Until the detector returns to a lower value the COMPARATOR indicates UP, thereby continuously resetting "/4". Since the "/4" never reaches the count of four it continuously indicates that the processing is in progress.

7. The detector output reaches its peak and proceeds to decrease until it reaches the value corresponding to the DAC.

8. At this time the COMPARATOR commands DOWN counts at a rate depending upon the steepness of the decline. Thus the COMPARATOR ceases to reset "/4".

9. The "/8" (Divided by 8), counts the DOWN counts. Since the rate of decline is steep, the count will reach a count of eight during the one minute intervals between resets of the "/8".

10. The "/8" resets the "/4" each time it reaches a count of eight. That is, eight down counts within the one minute interval will result in the "/4" being reset.

11. The "/4" continues to indicate that the process is in progress.

12. The slope of the detector output reaches a low level as the process nears completion.

13. The "/8" will not reach eight counts during its one minute counting interval and will cease to reset the "/4".

14. The "/4" will proceed to count at a rate of two counts per minute.

15. When the "/4" reaches a count of four it indicates to the programmer that the process is complete.

16. The programmer stops the processing, turning on the visual and audible signals.

## 6.2 Circuit Description

The DPS-1000 is comprised of C-MOS digital circuits and an analog amplifier/comparator circuit. The circuitry is packaged on a single printed circuit board. Refer to schematic drawing number D03200. Emitter follower regulators Q302 and Q303 are included on the P.C. Board to provide the necessary positive and negative ten volt supplies.

### 6.2.1 Comparator

Operational amplifier A301A amplifies the photo cell signal to a suitable amplitude for compatability with the comparator. Potentiometer R321 provides offset adjustment, and potentiometer R317 provides gain adjustment. C302 is included for dynamic stability. Comparison of the inverted and amplified photocell signal with the eight bit DAC output signal is accomplished with A301B, a high gain summing amplifier, refer to figure 3. Current into the summing node, pin 6 of A301B, depends upon the position of the analog switches internal to the DAC. ON/OFF control of these switches is determined by the digital inputs to the DAC from the UP/DOWN COUNTER. In the event that the DAC output current is less than the current into A301A pin 1, A301B output switches positive causing digital signal CU (count up) to become "true". If this occurs during the period in which the DAC is allowed to track the photocell signal, the CU signal gates 4/second clock signals to the COUNT UP input to the UP/DOWN counter through U307A. The counter continues counting up until the DAC output current is greater than or equal to the current into A301A pin 1.

Conversely, if the current into the summing node of A301B is greater than the current into A301A pin 1, A301B output switches negative CU becomes false, and CD (count down) becomes true. CD gates 4/second clock pulses to the COUNT DOWN input of the UP/DOWN counter, through U310C. The counter continues to count down until the DAC output current is less than or equal to the current into A301A pin 1.

### 6.2.2 Up/Down Logic

Refer to figure 5. Operation of the DPS-1000 is initiated by the enable switch.

The location of the enable switch is dependent upon the model of the system in which the DPS-1000 is installed. For IPC 2000 Series Systems, auxiliary contacts of the program 3 R.F. relay located in the PM310 module are used. In IPC 4000 Series Systems or 8000 Series Systems, an auxiliary relay located in the Reactor Center is used.

The enable switch opens to start the DPS-1000. At this time, U311 pin 4 becomes low enabling the UP/DOWN COUNTER and the timer (U301, U302, U303, U304, and U305 all use a positive signal for reset).

For the next 2¼ minutes, either count up COMPARATOR, will be gated to the UP/DOWN counter. The DAC should track the photocell signal for this period. Hysteresis is provided by R303 and R311 so that the response of the UP/DOWN COUNTER lags changes of state of the COMPARATOR.

During the 2¼ minute interval, the UP/DOWN counter is not allowed to count to a higher value that half of full scale. When the most significant bit (MSB) from the UP/DOWN counter becomes true, pin 12 of U310 becomes true through CR304. U307 pin 1 then becomes false and count up pulses are inhibited. CR304 and CR305 make up an "or" circuit. The count up pulses are inhibited by MSB from the UP/DOWN counter or by the COMPARATOR. Also, when the 2¼ minute timer input to U308 pin 2 becomes true, the latch comprised of U308A and U308B switches so that U308A pin 8 is false, U307 pin 13 is false, and count up pulses are inhibited. At the end of the initial 2¼ minute period, the UP/DOWN counter is allowed to count down only, so the DAC no longer tracks the photocell signal.

### 6.2.3 System Timing

Refer to figure 4. U301 is a fourteen stage ripple carry BINARY COUNTER/DIVIDER. It divides the 60/second clock signal to provide appropriate timing pulses. Pin 3 is the Q14 output which switches positive approximately 2¼ minutes after reset is removed from pin 11. Pin 15 is the Q11 output which switches positive approximately twice per minute. Pins 14, 15 and 1 are the Q10, Q11, and Q12 outputs respectively. Consequently, U307 pin 8 switches false at a rate of approximately once per minute. U302 is a four bit

6.2.3 (continued)

BINARY COUNTER type 74C93. U302 pin 10 is the Qc output of this divide by four counter. The end of the process is determined when U302 pin 10 becomes positive. This output is used to switch Q301. Q301 in turn provides the signal which will cause the enable switch to close and disable the DPS-1000 at the end of the process. When pin 3, 4, or 5 of U307 becomes low, pin 6 becomes high and resets U302 so that END OF PROCESS signal can not become high. Pin 5 of U307 resets U302 whenever count up ENABLE from the COMPARATOR becomes true. Pin 3 of U307 resets U302 continually during the initial 2¼ minute interval. Pin 4 of U307 resets U302 whenever the output of U303, the divide by 8 counter becomes high. U303 is also a 74C93 BINARY COUNTER. It is reset every 1 minute interval by the output of U307A at pin 8 and it is held reset during the initial 2¼ minute interval when U308 pin 4 becomes low.

After the initial 2¼ minute interval, U303 Qd output will continually reset U302 and prevent END OF PROCESS until the rate of the count down pulses into U302 pin 8 becomes less that 8 per minute for the period required for U302 to count to four.

## 6.3 Alignment Procedure

The DPS-1000 has two adjustments only: (1) Amplifier offset and (2) Amplifier gain. These variable resistor adjustments are accessible through a vertical slot in the rear panel of the Reactor Center. There are five resistors and the ones of concern are the bottom two. The second resistor from the bottom is R317, the gain adjustment. The bottom resistor is R321, the offset adjustment.

### 6.3.1 Equipment Required

If a chart recorder has not been provided with the system, a high impedance meter or an oscilloscope will be necessary to monitor the DPS-1000 amplifier output. In systems which do not include chart recorder, the amplifier output has been brought out to the rear of the Reactor Chamber to a five pin connector or a terminal strip labeled "Chart Recorder".

### 6.3.2 Offset Adjustment

Following is a step by step procedure for adjusting the amplifier offset:

1. Evacuate the chamber(s) to a vacuum of 2 torr.
2. Do not turn on R.F.
3. Monitoring the amplifier output with chart recorder, adjust the bottom resistor so that amplifier output voltage is at zero volts.

### 6.3.3 Gain Adjustment

Following is a step by step procedure for adjusting the amplifier gain:

1. Adjust the second resistor from the bottom fully counter clockwise.
2. Using oxygen gas, at a pressure of 2 torr, turn on the R.F. and adjust the power to 300 watts.
3. Adjust second resistor from bottom until chart recorder reads 0.25.

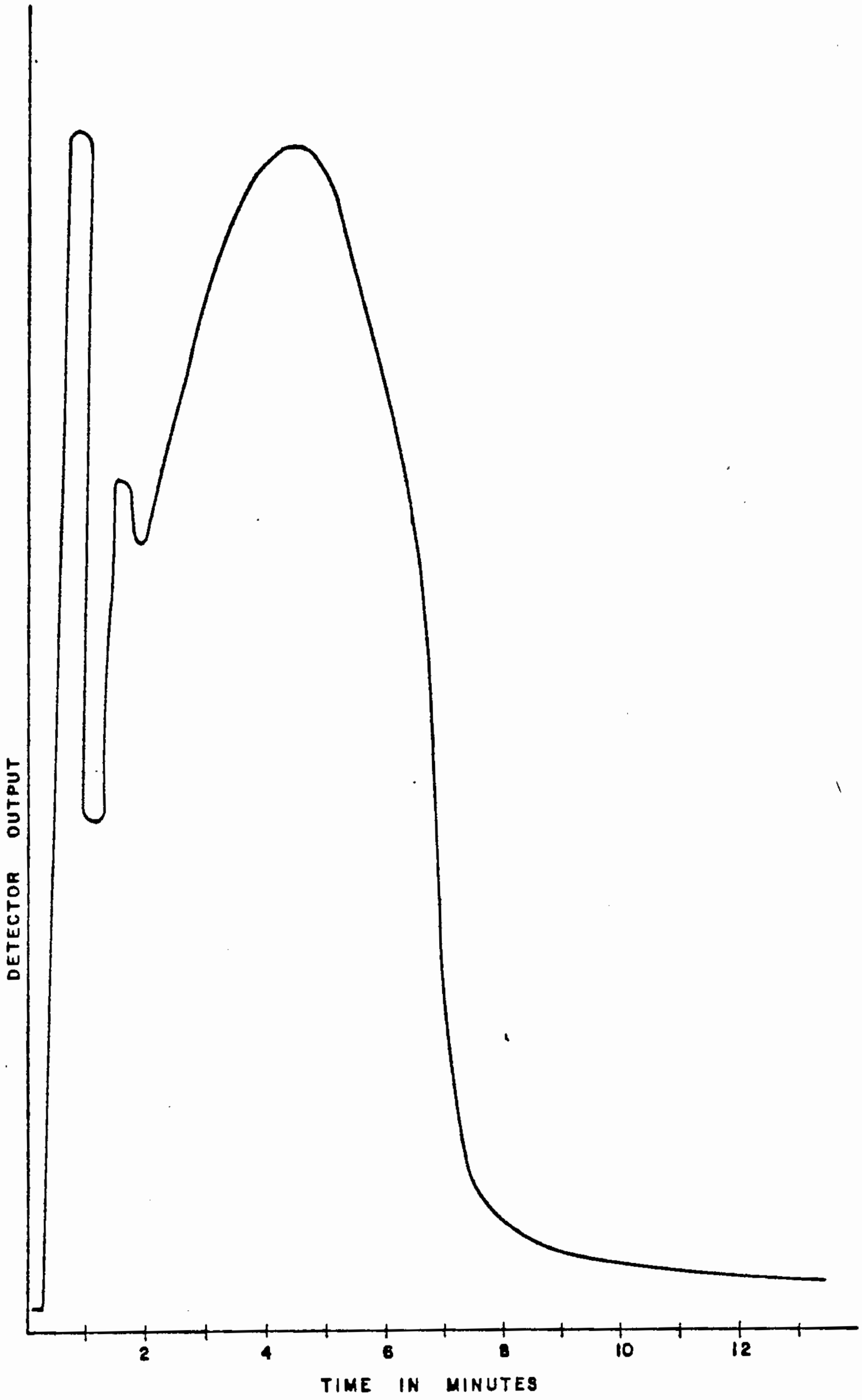


FIG. I

B 03294 REV.

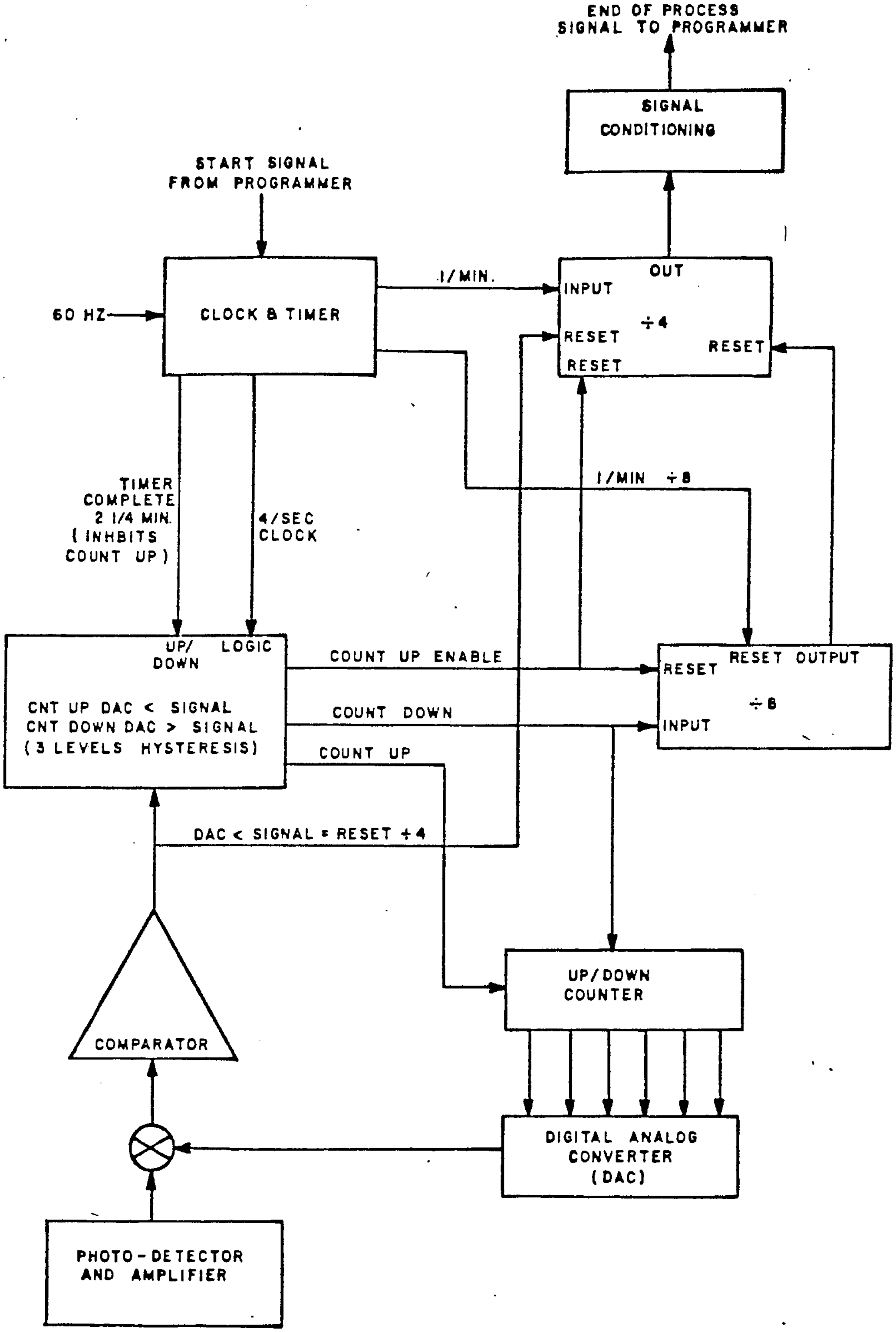


FIG. 2

DPC-1000 PROCESS DETECTOR
FUNCTIONAL BLOCK DIAGRAM

B-03293 REV.A 6-1.-77

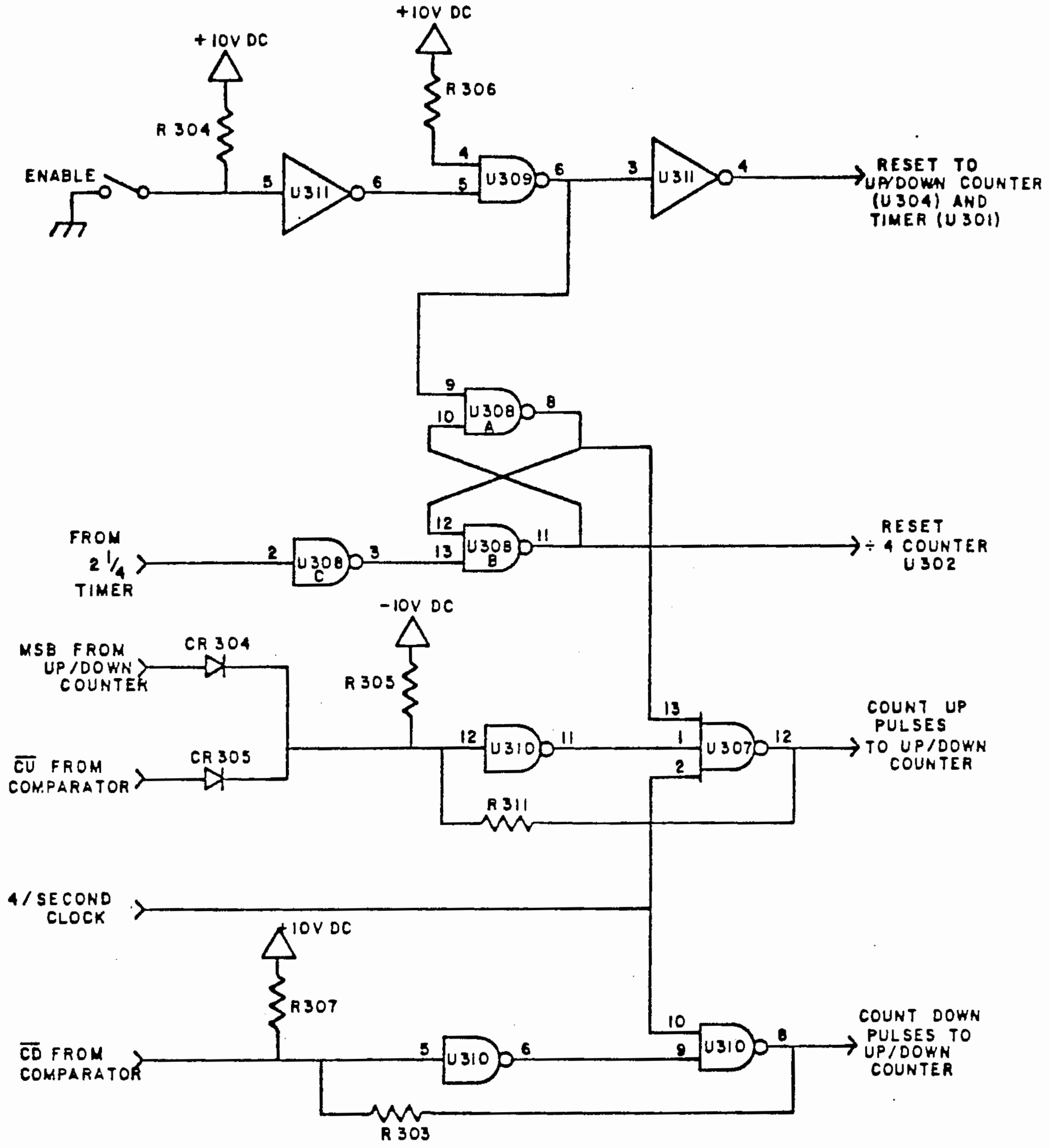
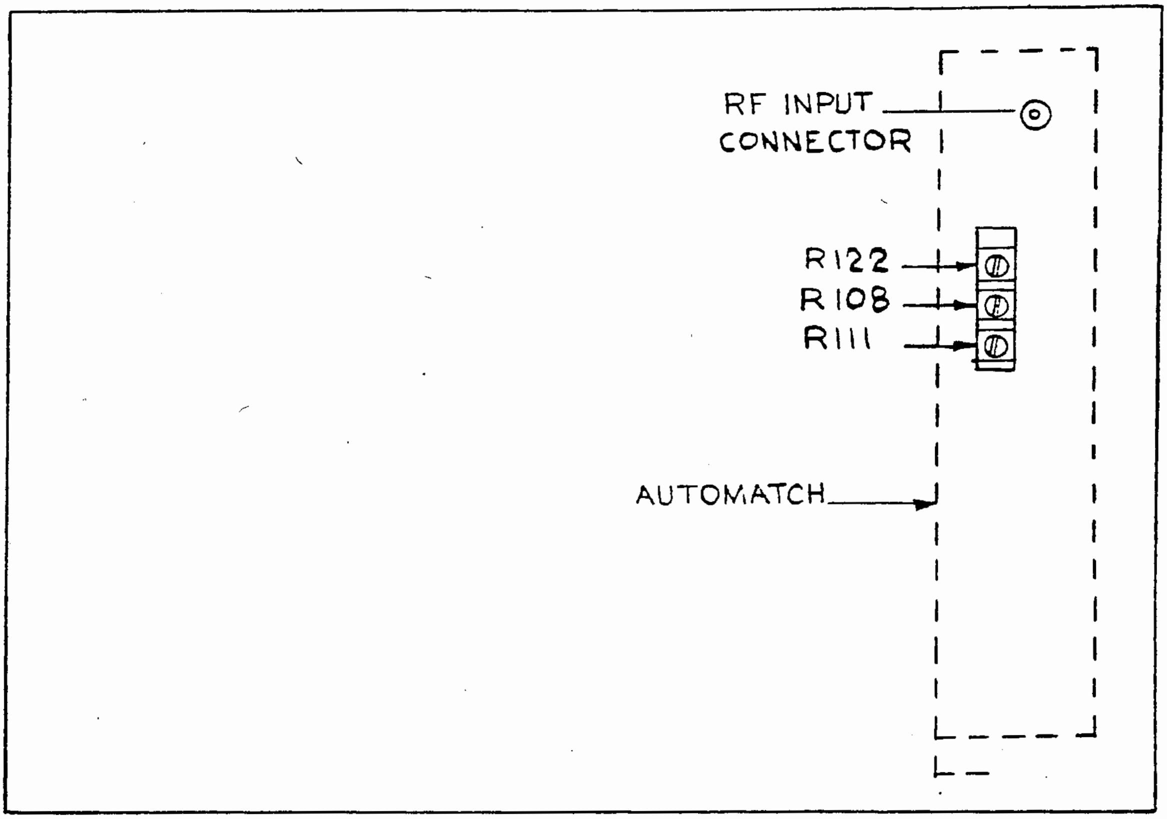
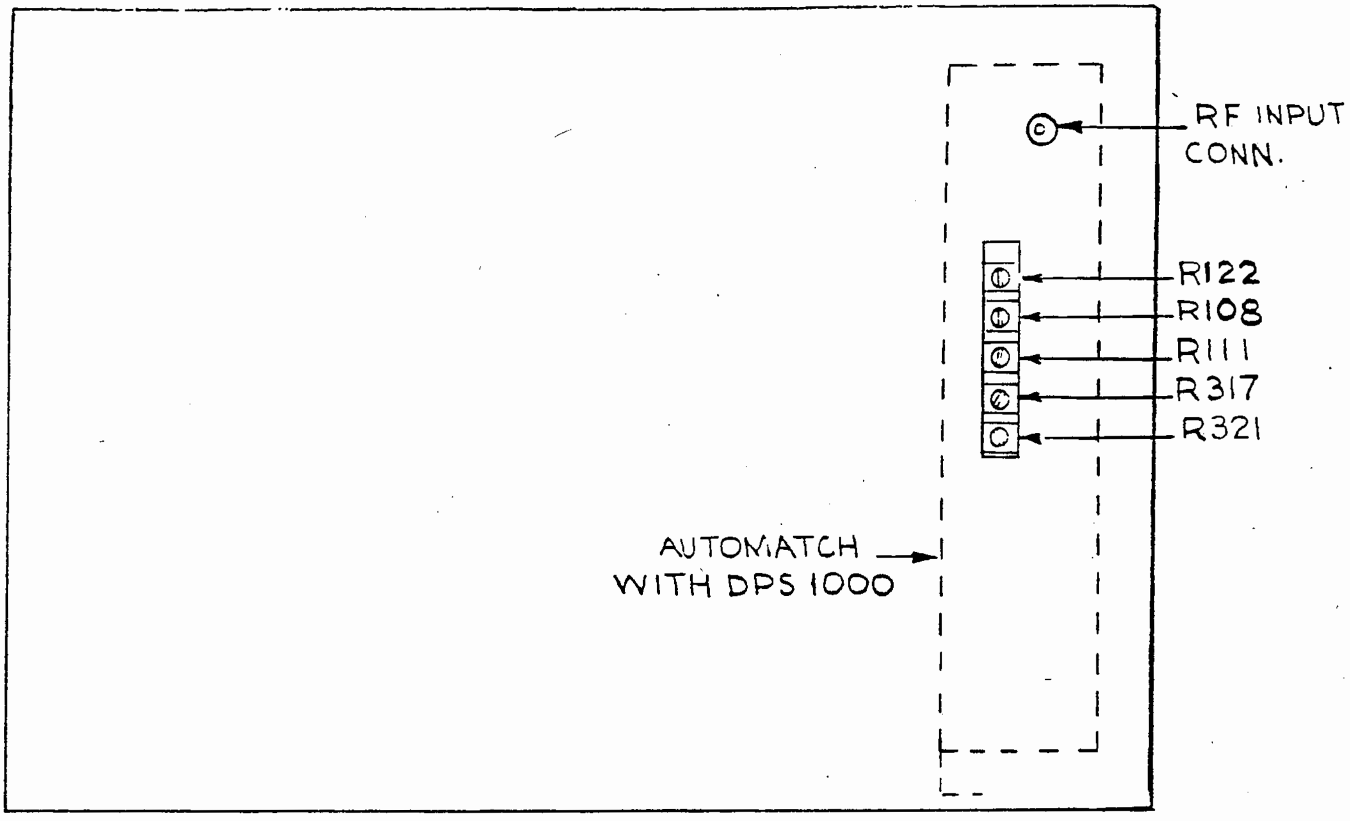

+10V DC
+10V DC
R 304
R 306
ENABLE
5
U311
6
4
5
U309
6
3
U311
4
RESET TO
UP/DOWN COUNTER
(U304) AND
TIMER (U301)
9
10
U308
A
8
12
13
U308
B
11
FROM
2 1/4
TIMER
2
U308
C
3
RESET
÷ 4 COUNTER
U302
-10V DC
MSB FROM
UP/DOWN
COUNTER
CR 304
R 305
CU FROM
COMPARATOR
CR 305
12
U310
11
13
1
U307
12
2
COUNT UP
PULSES
TO UP/DOWN
COUNTER
R 311
4/SECOND
CLOCK
+10V DC
R307
CD FROM
COMPARATOR
5
U310
6
10
9
U310
8
COUNT DOWN
PULSES TO
UP/DOWN
COUNTER
R 303

FIG. 5



REACTOR CENTER
REAR VIEW

FIGURE 6
LOCATION OF ADJUSTMENT
POTENTIOMETERS

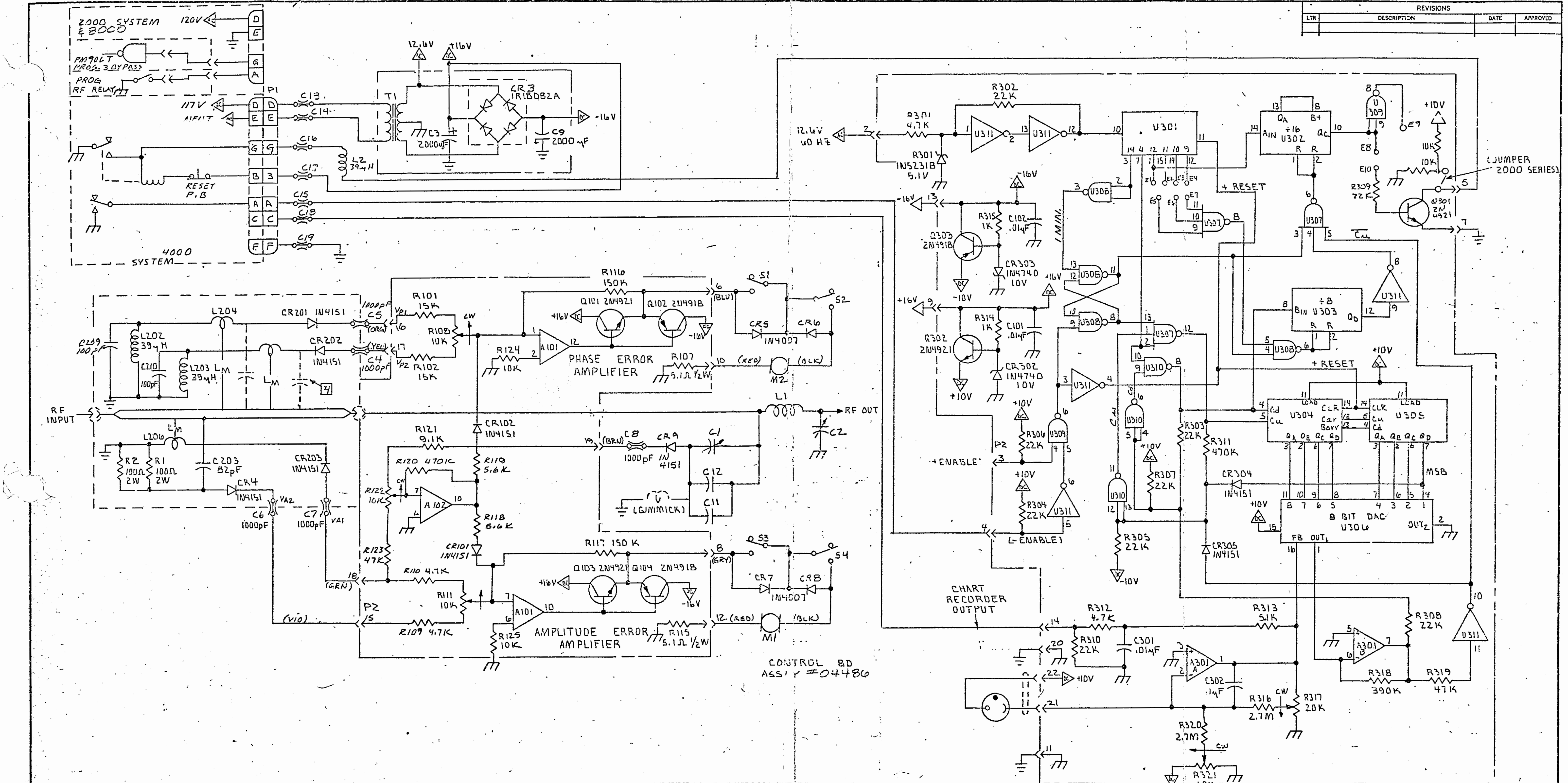


REACTOR CENTER
REAR VIEW

FIGURE 7

LOCATION OF ADJUSTMENT POTENTIOMETERS

| REVISIONS | | | |
|---|---|---|---|
| LTR | DESCRIPTION | DATE | APPROVED |



| IC CHART | | | | |
|---|---|---|---|---|
| DESIG | TYPE NO | Vcc+ | GND | Vcc− |
| A101-102 | 747 | 9 | | 4 |
| U301 | CD 4020 | 16 | 8 | |
| U302-303 | 74C93 | 4 | 11 | |
| U304 305 | 74C193 | 16 | 8 | |
| U306 | AD7530 | 14 | 3 | |
| U308 309, 310 | 74C00 | 14 | 7 | |
| U311 | 74C04 | 14 | 7 | |
| A301 | LM358 | 8 | 4 | |
| U307 | 74C10 | 14 | 7 | |

PM 702

6 C13 THRU C19. 1000 PF FEED THRU CAPACITOR
5 WIRE COLOR IN PARENTHESIS
4 HIDDEN LINES SYMBOLS INDICATE CAPACITANCE BETWEEN TWO CONDUCTORS
3 LM INDICATES MUTUAL COUPLING
2 FACTORY SELECTED FOR APPLICATION
1 ALL RESISTORS CARBON COMPOSITION 1/4 W UNLESS OTHERWISE NOTED

| | | | | |
|---|---|---|---|---|
| B | E.O. 10348 | KG/[illegible] | 01/31/78 | [illegible] |
| A | ECN 10348, 10352, 9355 | JV / 8-75 | 7-12-76 | [illegible] |
| REV | DESCRIPTION | [illegible] | DATE | APPR |

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

| APPROVALS | DATE |
|---|---|
| DRAWN JV | 7-12-76 |
| CHECKED [illegible] | [illegible] |

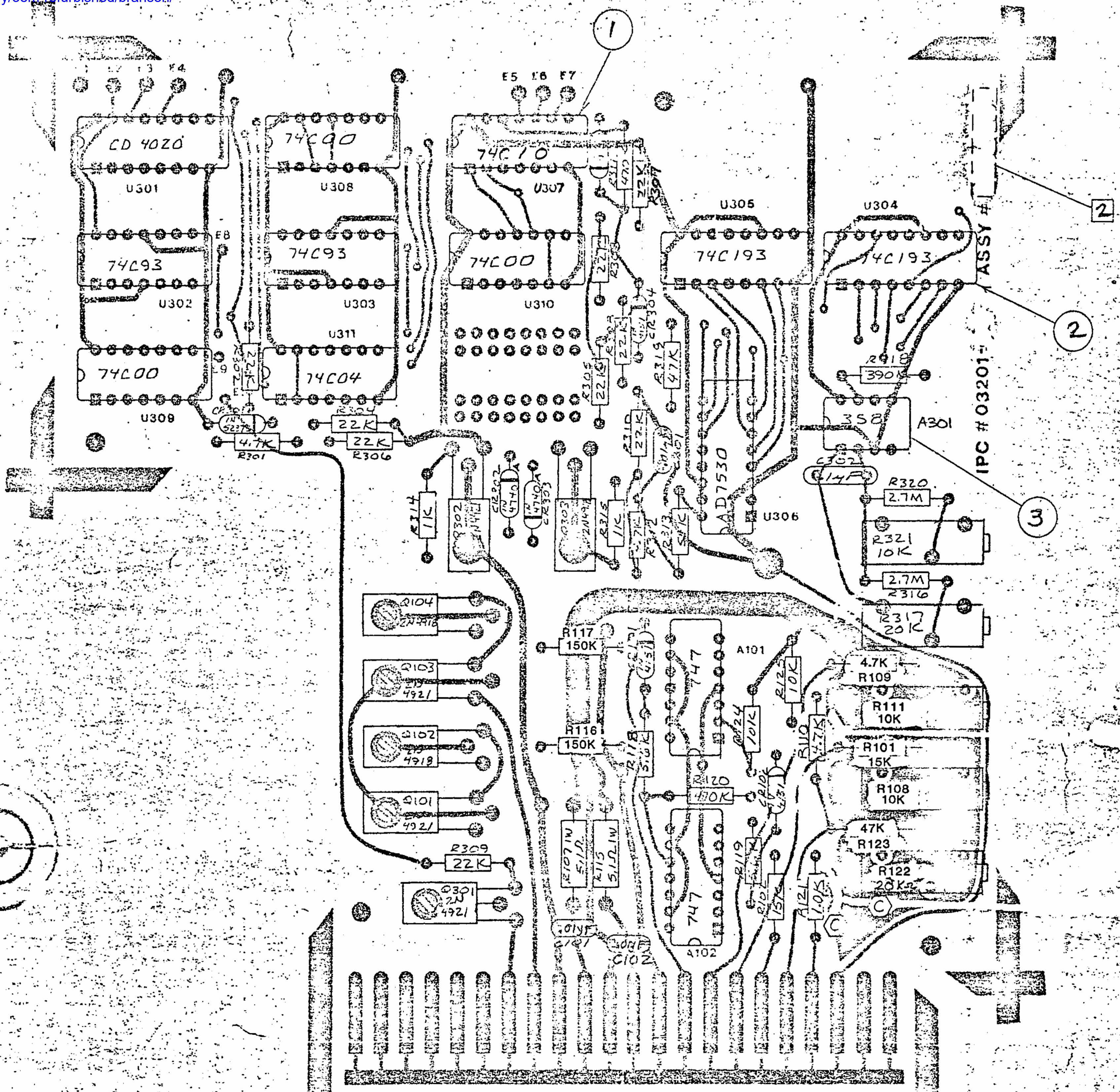
INTERNATIONAL PLASMA CORP

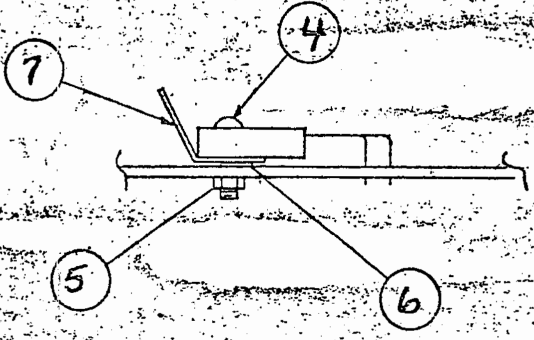
AUTOMATIC IMPEDENCE MATCHING NETWORK W/ IPS- 1000

SCALE — SIZE D DRAWING NO. 04495 REV B

SHEET 1 OF 1

| REV | DESCRIPTION |  |  | APPR |
|---|---|---|---|---|
| A | EO #10343 |  | 3-1-79 |  |
| B | EO #10343 | KG | 11-27-79 | PCD |
| C | EO 10543 KG |  | 5-79 |  |





TRANSISTOR MOUNTING DETAIL

2 STAMP ASS'Y NO. 04486
1 ALL RESISTOR 1/4 W CARBON 5% UNLESS OTHERWISE SPECIFIED

INTERNATIONAL PLASMA CORP.

AUTOMATCH WITH DPS-1000
BD. ASS'Y PM-702

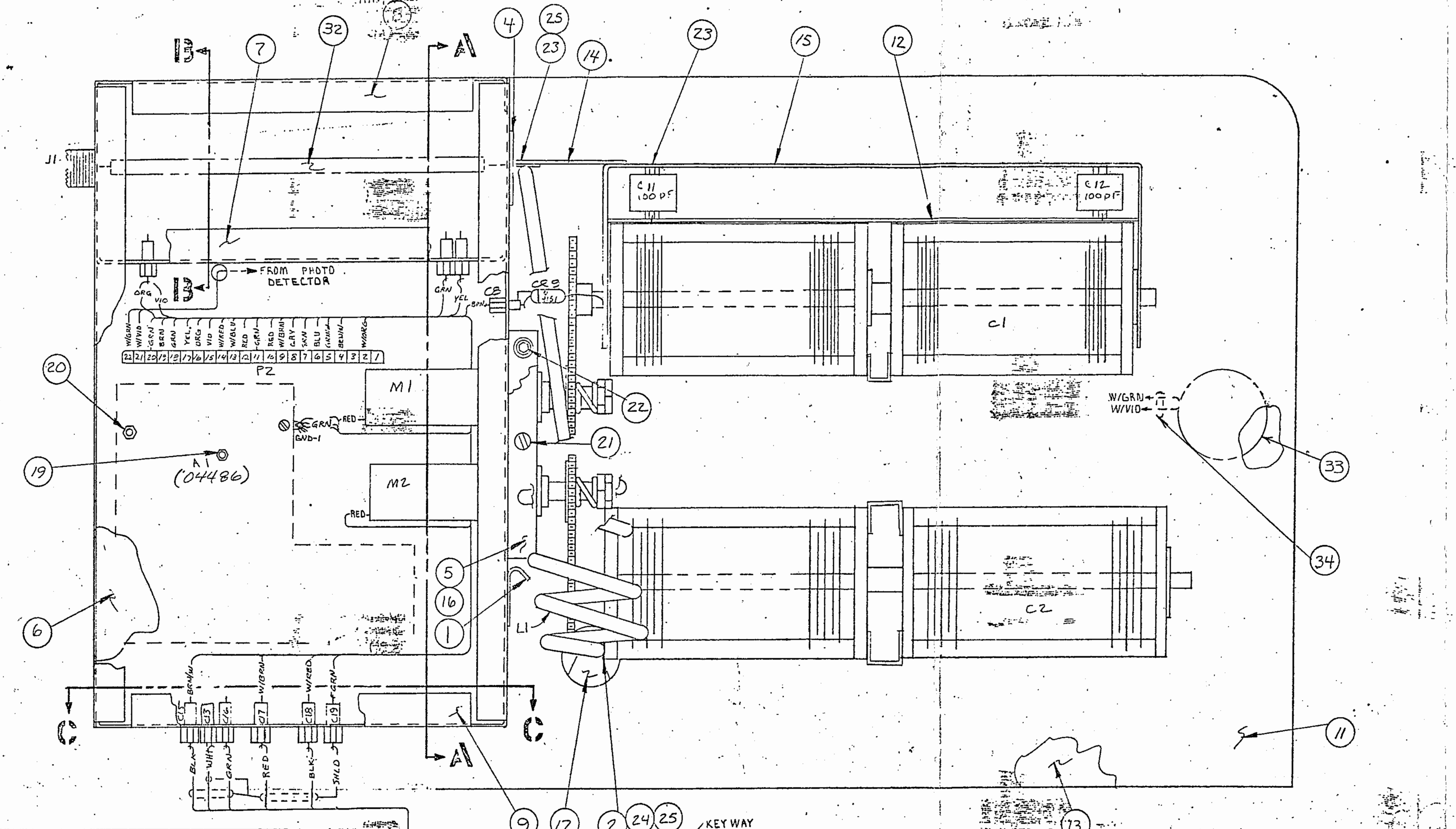
6-1-78
E-78

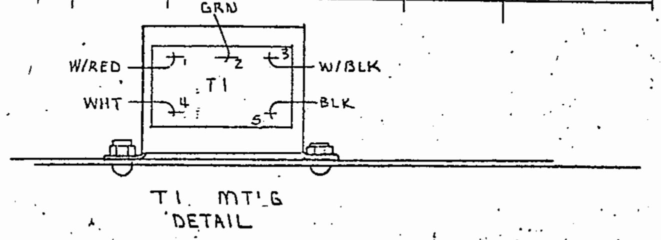
| SCALE | SIZE | DRAWING NO. | REV |
|---|---|---|---|
| 2X | C | 04486 | C |

1 of 6

REVISIONS

| LTR | DESCRIPTION | | DATE | APPROVED |
|---|---|---|---|---|
| A | EO # 16348 | | 7-17-78 | [illegible] |

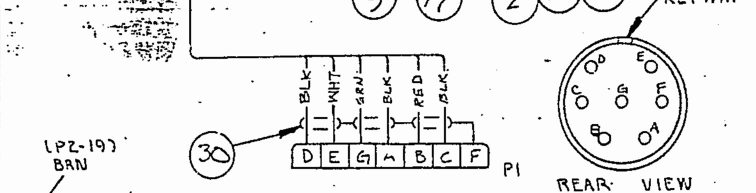


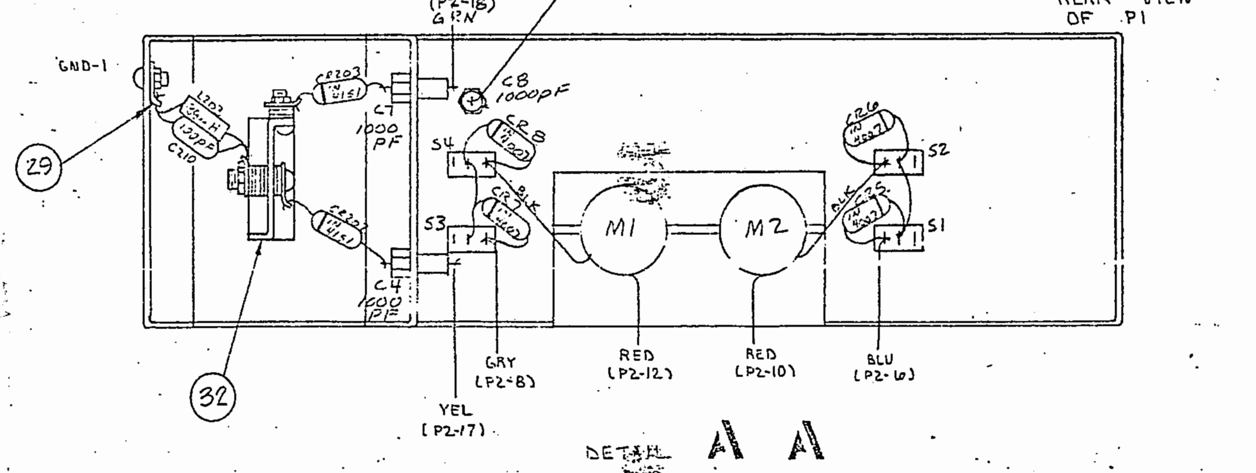


T1 MT'G DETAIL

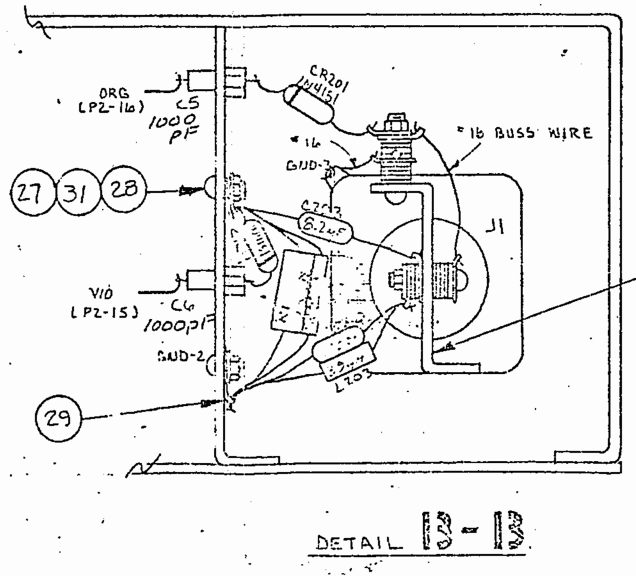
| WIRE CHART | | | | |
|---|---|---|---|---|
| COLOR | START | BREAK OUT | END | NOTE |
| | | | | |
| | | | | |
| RED | M 1 | | P2-12 | |
| RED | M 2 | | P2-10 | |
| BLK | M 1 | | S 4 | |
| BLK | M2 | | S 2 | |
| BLU | S 1 | | P2-6 | |
| GRY | S 3 | | P2- 8 | |
| GRN | C 7 | | P2- 18 | |
| YEL | C 4 | | P2- 17 | |
| BRN | C 8 | | P2- 19 | |
| WHT. | C 14 | | T1-4 | |
| B-K | C13 | | T1- 5 | |
| VIO | C 6 | | P2-15 | |
| ORG | C 5 | | P2-16 | |
| W/ BRN | C17 | E2 | P2-9 | |
| W/ BLU | E1 | | P2-13 | — |
| GRN | GND-3 | | T1-2 | |
| GRN | P2-20 | | GND-2 | |
| W/BLK | E5 | | T1-3 | |
| W/ORG | P2- 2 | | E 4 | |
| | | | | |
| | | | | |
| GRN | P2-7 | | GND-1 | |
| | | | | |
| GRN. | P2-11 | | GND-1 | |
| W/GRN | P2-22 | | FROM PHOTO DETECTOR | |
| W/VIO | P2-21 | | | |
| GRN | E7 | E6. . , GND - 2 | C 19. | |
| BRN/W | P2-4 | | C 15 | |
| GRN/W | P2-5 | | E 3 | |
| W/RED | C18 | | P2-14 | |

| WIRE CHART | | | | |
|---|---|---|---|---|
| COLOR | START | BREAK OUT | FROM | NOTE |
| WHT | P1-E | | C 14 | PAIR |
| BLK | P1-D | | C 13 | |
| RED | P1-B | | C 17 | PAIR |
| BLK | P1-C | | C 18 | |
| GRN | P1-G | | C 16 | PAIR |
| BLK | P1-A | | C 15 | |
| SHLD | P1-F | | C 19 | |

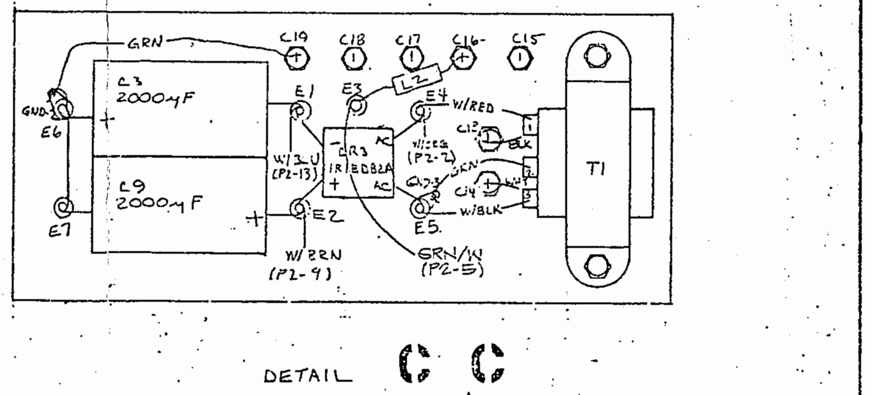




DETAIL A A



DETAIL B - B



DETAIL C C

1 ALL WIRES 22AWG UNLESS OTHERWISE SPECIFIED

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

| APPROVALS | DATE |
|---|---|
| DRAWN JV | 7-15-78 |
| CHECKED D.N.[illegible] | 11-6-78 |

INTERNATIONAL PLASMA CORP.
AUTOMATCH ASS'Y W/DPS 1000
PM 702

SCALE ~ SIZE D DRAWING NO. 04491 REV A
DO NOT SCALE DRAWING SHEET 1 of 5

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | RF CONDUCTOR | B 02821 | 1 |
| | | | |
| C203 | CAPACITOR 8.2 F | 1500-0222 | 1 |
| | SPRAGUE SGA-V82 | | |
| C210, | CAPACITOR 100pF | 1500-0117 | 2 |
| 209 | CM 05-ED-K1J03 | | |
| | | | |
| | | | |
| | | | |
| CR201- | DIODE | 4800-0045 | 3 |
| 203 | MOTORALO IN4151 | | |
| | | | |
| L202, | COIL 39 mH | 1800-0012 | 2 |
| _03 | J W MILLER 9210-56 | | |
| | | | |
| 1 | LOCKING TERMINAL LUG | | 8 |
| | H H SMITH 1416-8 | | |
| 2 | RING TERMINAL - NON INSULATED | | 6 |
| | 12-10 AWG HH SMITH 4934 | | |
| 3 | SCREW | | 4 |
| | 8-32 UNF-2A×3/4 BHMS NYLON | | |
| 4 | NYLON SPACER - RND | | 6 |
| | .25 OD× .125 LG - H H SMITH 4008 | | |
| 5 | NYLON SPACER-RND .25 OD×.187LG | | 3 |
| | H H SMITH 4005 | | |

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| | | | | |
|---|---|---|---|---|
| TITLE RF CONDUCTOR SUB ASS'Y | | | | |
| SIZE C | DWG. NO. 02827 | REV. E | CHK. EHS 8-78 | APPR. [illegible] |
| DRAWN JV | DATE 7-5-78 | SHEET 2 OF 3 | | |

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 10 | WASHER | | |
| | #8 FLATWASHER STL. | | |
| 7 | NUT | | |
| | 8-32 UNF-2B HEX KEPS NUT | | |
| | | | |
| 8 | WIRE | | A/R |
| | 12 GA BUSS WIRE | | |
| 9 | WIRE | | A/R |
| | 16 GA BUSS WIRE | | |

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PLASMA
CORPORATION

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HAYWARD, CALIF.
94544

TITLE RF CONDUCTOR SUB ASS'Y

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| C | 02827 | E | RHS 8-78 | |

| DRAWN | DATE | SHEET 3 OF 3 |
|---|---|---|
| JV | 7-5-78 | |

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| C1 | AIR VARIABLE CAP | 1550-0201 | 1 |
| | EF JOHNSON 154-513-101 | | |
| 1 | STL EXSPANSION PIN .062 DIA x .50 DP | 2860-9001 | 1 |
| | McMASTER-CARR 98296A109 | | |
| 2 | STL EXPANSION PIN .093 DIA x .750 DP | 2860-9003 | 1 |
| | McMASTER-CARR 98296A181 | | |
| 3 | GEAR MODIFICATION | B04564 | 1 |
| 4 | INTERCONNECTION BRK'T | B 03533 | 2 |

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TITLE: PM 702 & 703
C1 - INPUT CAPACITOR
ASS'Y

SIZE: C
DWG. NO.: 03470
REV.: C
CHK.: RHS
DRAWN: JV
DATE: 7-7-78
SHEET 2 OF 2

# ENGINEERING PARTS LIST

O

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | MOTOR | 3500-0005 | 1 |
| | MICRO MD 33D14D9-03-2-1734:1 | | |
| 2 | CLUTCH | 3500-0015 | 1 |
| | STERLING SLIPCLUTCH #MM-2 | | |
| 3 | STL EXPANSION PIN .062 DIA x .50 LG | 2860-9001 | 1 |
| | Mc MASTER-CARR #98296A109 | | |
| 4 | GEAR ALUM | 3500-0023 | 1 |
| | STERLING S21A-54 | | |

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TITLE: M1 INPUT MOTOR DRIVE ASS'Y

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| B | 03471 | B | RAS 8-78 | PW |

DRAWN: JV
DATE: 6-28-78
SHEET 2 OF 2

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| C2 | AIR VARIABLE CAP | 1550-0202 | 1 |
|  | EF JOHNSON 154-510 |  |  |
| 1 | STL EXPANSION PIN .062 DIA×.50 DP | 2860-9001 | 1 |
|  | M<sup></sup>C MASTER-CARR 98296A109 |  |  |
| 2 | STL EXPANSION PIN .093 DIA×.75 DP | 2860-9003 | 1 |
|  | MCMASTER-CARR 98296 A181 |  |  |
| ~~3~~ | ~~INTERCONNECT BRK'T~~ | ~~B-03533~~ | ~~2~~ |
| 4 | GEAR MODIFICATION | B 04564 | 1 |
|  | REVISED CO [illegible] |  |  |

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| | | | | |
|---|---|---|---|---|
| TITLE P/N 702.<br>C2- OUTPUT CAPACITOR ASS'Y | | | | |
| SIZE C | DWG. NO. 04440 | REV. B | CHK. RHS E-78 | APPR. |
| DRAWN JY | DATE 7-7-78 | SHEET 2 OF 2 | | |

# ENGINEERING PARTS LIST 0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | MOTOR | 3500-0004 | 1 |
| | MICRO MO 330/409-03-2-975:1 | | |
| 2 | CLUTCH | 3500-0015 | 1 |
| | STERLING SLIPCLUTCH * MM-2 | | |
| 3 | STL EXPANSION PIN .062 DIA×.50DP | 2860-9001 | 1 |
| | MC MASTER-CARR 98296A-109 | | |
| 4 | GEAR ALUM | 3500-0023 | 1 |
| | STEARLING 521A-54 | | |
| | REVISED E63471-002 | | |

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| | | | | |
|---|---|---|---|---|
| TITLE M Z OUTPUT MOTOR DRIVE ASS'Y | | | | |
| SIZE B | DWG. NO. 04416 | REV. A | CHK. RS 6-78 | APPR. PGS |
| DRAWN JV | DATE 6-78-78 | SHEET 2 OF 2 | | |

# ENGINEERING PARTS LIST 0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | LIMIT SWITCH STOP BRK'T | 03064 | 2 |
| 2 | RF CONDUCTOR STRAP, LOWER | B 02825 | 1 |
| 3 | | | |
| 4 | RF CONDUCTOR SUPPORT PLATE | B 02820 | 1 |
| 5 | MOTOR CRADLE | B 02819 | 1 |
| 6 | HOUSING COVER | C 02818 | 1 |
| 7 | HOUSING, RF PARTITION | C 02817 | 1 |
| 8 | HOUSING, REAR ANGLE | C 02816 | 1 |
| 9 | HOUSING, FRONT ANGLE | C 02815 | 1 |
| 10 | | | |
| 11 | BASE PLATE | D 04482 | 1 |
| 12 | INPUT CAPACITOR BRK'T | B 03212 | 1 |
| 3 | BASE PLATE MTG BRK'T | B 02814 | 1 |
| 14 | RF CONDUCTOR COUPLER | B 04427 | 1 |
| 15 | INPUT CAPACITOR BRK'T | B 04396 | 1 |
| 16 | MOTOR CAP | B 04452 | 1 |
| 17 | 2" CERAMIC STANDOFF | 3100-0142 | 1 |
| | H.H. SMITH #135-503 | | |
| 18 | | | |
| | | | |
| 19 | HEX THD STANDOFF, 6-32 × .25 LG. | | 1 |
| | H.H. SMITH #8421 | | |
| 20 | HEX THD STANDOFF, 8-32 × .25 LG. | | 2 |
| | H.H. SMITH #2325 | | |
| 21 | SCREW, 10-32 UNF-2A × 1.50 LG. BHMS STL. | | 1 |

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94544

TITLE AUTOMATCH ASS'Y - W/DPS-1000
PM 702

| SIZE | DWG. NO. | REV. | CHK. | APPR. |
|---|---|---|---|---|
| D | 04491 | A | D. Yeh | YuS |

| DRAWN | DATE | SHEET |
|---|---|---|
| S. Slosek | 8-17-78 | SHEET 2 OF 5 |

# ENGINEERING PARTS LIST

0

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 22 | SCREW, 8-32 UNC-2A × 1.25 SHCS STL | | 2 |
| 23 | SCREW, 6-32 UNC-2A × .187 BHMS BRASS | | 11 |
| 24 | SCREW, 10-32 UNF-2A × .375 BHMS BRASS | | 1 |
| 25 | NUT, 6-32 UNC-2B BRASS HEX | | 4 |
| 26 | | | |
| 27 | LOCKING TERMINAL LUG | | 1 |
| | H.H. SMITH #1416-8 | | |
| 28 | SCREW, 8-32 UNC-2A × .187 BHMS NYLON | | 1 |
| 29 | LOCKING TERMINAL LUG | | 5 |
| | H.H. SMITH #1416-6 | | |
| 30 | CABLE | | A/R |
| | BELDEN #8777 | | |
| 31 | WASHER, #8 NYLON, FLAT | | 2 |
| 32 | RF COUPLER ASS'Y | C 02827 | 1 |
| 33 | PHOTO DETECTOR ASS'Y | B 03324 | 1 |
| 34 | BRAID SHIELD, 7/32 | | A/R |
| | BELDEN #8863 | | |
| | | | |
| | | | |
| E1-7 | INSULATED TERMINAL | 2160-0207 | 7 |
| | USECO #1417-9 | | |
| C4-8,<br>13,14 | CAPACITOR, FEED THRU 1000 pF | 1500-0205 | 7 |
| | ERIE #327-005-X5U0-102M | | |
| C3,9 | CAPACITOR, 2000 µF 24 V | 1500-0203 | 2 |
| | SPRAGUE #TVA-1213 | | |

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TITLE AUTOMATCH ASS'Y- W/DPS 1000
PM 702

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REV. A
CHK. D.YEH
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DRAWN S.Slosek
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SHEET 3 OF 5

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| .12 | TRANSMITTING CAP 100pF 5KV | 1500-0189 | 2 |
| | CENTRALAB #8505-100N | | |
| CR5-8 | DIODE | 4800-0013 | 4 |
| | MOTOROLA #1N4007 | | |
| CR4,9 | DIODE | 4800-0045 | 2 |
| | MOTOROLA #1N4151 | | |
| CR3 | DIODE BRIDGE | 4800-0044 | 1 |
| | INTERNATIONAL RECTIFIER #18DB2A | | |
| R1-2 | RESISTOR, C.C. 100Ω, 2W, 5% | 4705-0101 | 2 |
| S1-4 | SWITCH- SPDT, MOMENTARY-ON | 5100-0154 | 4 |
| | C&K #7109 L2D2BE | | |
| T1 | TRANSFORMER | 5600-0006 | 1 |
| | SIGNAL #241-4-20 | | |
| | | | |
| L1 | INDUCTOR, 6½ TURNS | B 02824 | A/R |
| ↑ | ↑ 7½ ↑ | B 04455 | ↑ |
| \| | \| 8½ \| | B 04456 | \| |
| \| | \| 9½ \| | B 04457 | \| |
| \| | \| 10½ \| | B 04458 | \| |
| \| | \| 11½ \| | B 04459 | \| |
| \| | \| 2½ \| | B 04460 | \| |
| \| | \| 3½ \| | B 04461 | \| |
| ↓ | ↓ 4½ ↓ | B 04462 | ↓ |
| L1 | INDUCTOR, 5½ TURNS | B 04463 | A/R |
| | | | |

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PM 702

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| D | 04491 | A | D.Y2H | YLC |

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SHEET 4 OF 5

# ENGINEERING PARTS LIST

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| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| J1 | RF CONNECTOR | 2180-0190 | 1 |
| | AMPHENOL #83-798 | | |
| P1 | CONNECTOR, 7 PIN, MALE | 2152-1607 | 1 |
| | AMPHENOL #MS-3102-10S-1P | | |
| P2 | EDGE CONNECTOR, 22 PIN | 2100-0223 | 1 |
| | VECTOR #R644 | | |
| A1 | CIRCUIT BOARD ASS'Y | C04486 | 1 |
| M1 | INPUT MOTOR ASS'Y | B03471 | 1 |
| M2 | OUTPUT MOTOR ASS'Y | B04416 | 1 |
| C1 | INPUT CAPACITOR ASS'Y | C03470 | 1 |
| C2 | OUTPUT CAPACITOR ASS'Y | C04440 | 1 |
| | MANUAL | | REF |
| | SCHEMATIC | D04495 | REF |

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REV. C
DWG. NO. 04486

# DIONEX GAS PLASMA SYSTEMS

# ENGINEERING PARTS LIST

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| **REV** | **DESCRIPTION** | **DATE** | **CHK** | **APPR** |

**REVISION LEVEL**

**DIONEX GAS PLASMA DIVISION**
31159 SAN BENITO
HAYWARD, CALIF. 94544

NEXT ASSY.

DRAWN: K.G.
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DATE: 5/9/79
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TITLE: PM 702 AUTOMATCH W/DPS-1000 BOARD ASSEMBLY
C
DRAWING NO.: 04486
REV.: C
DO NOT SCALE THIS DRAWING

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| | PRINT CIRCUIT BOARD | 03201 | 1 |
| 7 | HEAT SINK | B 04485 | 7 |
| | | | |
| C101 | CAPACITOR .01 F 500V | 1500-0001 | 3 |
| 102, 301 | SPRAGUE 5GA-510 | | |
| C302 | CAPACITOR .1uF 20V | 1500-0026 | 1 |
| | SPRAGUE UK20-104 | | |
| 1 | DIP SOCKET 14 PIN | 2110-0001 | 9 |
| | AMPH 821-20011-144 | | |
| 2 | DIP SOCKET 16 PIN | 2110-0002 | 4 |
| | AMPH 821-20011-164 | | |
| 3 | DIP SOCKET 8 PIN | 2110-0015 | 1 |
| | AUGAT 508-AG10D | | |
| R314, 315 | RESISTOR CARBON | 4702-0102 | 3 |
| R121 | 1K 1/4W | | |
| R124, | RESISTOR CARBON | 4702-0103 | 4 |
| 125 | 10K 1/4W | | |
| R101, | RESISTOR CARBON | 4702-0153 | 2 |
| 102 | 15K 1/4W | | |
| R116 | RESISTOR CARBON | 4702-0154 | 2 |
| 117 | 150K 1/4W | | |
| R302- | RESISTOR CARBON | 4702-0223 | 9 |
| 310 | 22K 1/4W | | |
| R316, 320 | RESISTOR CARBON | 4702-0275 | 2 |
| | 2.7 MEG 1/4W | | |

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A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| R318 | RESISTOR CARBON | 4702-0394 | 1 |
| | 390K 1/4W | | |
| R109 | RESISTOR CARBON | 4702-0472 | 3 |
| 301, 110 | 4.7K 1/4W | | |
| R312 | RESISTOR CARBON | 4702-0473 | 3 |
| 319, 123 | 47K 1/4W | | |
| R313 | RESISTOR CARBON | 4702-0512 | 1 |
| | 5.1K 1/4W | | |
| R107 | RESISTOR CARBON | 4703-0050 | 2 |
| 115 | 5.1Ω 1/2W | | |
| R118, | RESISTOR CARBON | 4702-0562 | 2 |
| 119 | 5.6K 1/4W | | |
| R122 | POTENTIOMETER 20K | 4750-0010 | 1 |
| | BOURNES 3069P-1-203 | | |
| R317 | POTENTIOMETER 20K | 4750-0010 | 1 |
| | BOURNES 3069P-1-203 | | |
| R108 | POTENTIOMETER 10K | 4750-0013 | 3 |
| 111, R321 | BOURNES 3069P-1-103 | | |
| A101 | OPERATIONAL AMPLIFIER | 4800-0012 | 2 |
| 102 | FAIRCHILD 747 | | |
| CR302 | DIODE | 4800-0038 | 2 |
| 303 | ZENER IN4740A 10V | | |
| CR101,102 | DIODE | 4800-0045 | 4 |
| 304, CR305 | MOTOROLA IN4151 | | |
| | | | |

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| K.G. | 5/8/79 | SHEET 3 OF 5 |

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| Q102,104 | TRANSISTOR PNP | 4800-0046 | 3 |
| 303 | MOTOROLA 2N4918 | | |
| Q101,103 | TRANSISTOR NPN | 4800-0047 | 4 |
| 301,302 | MOTOROLA 2N4921 | | |
| A301 | OPERATIONAL AMPLIFIER | 4800-0130 | 1 |
| | NATIONAL LM 358 | | |
| U301 | COUNTER/DIVIDER | 4800-0131 | 1 |
| | BINARY 14 STAGE | | |
| | NATIONAL CD 4020C | | |
| U302, 303 | COUNTER 4 BIT BINARY | 4800-0132 | 2 |
| | NATIONAL MM 74C93 | | |
| U304, 305 | COUNTER 4 BIT BINARY | 4800-0133 | 2 |
| | UP/ DOWN | | |
| | NATIONAL 74C 193 | | |
| U306 | DAC 8 BIT | 4800-0134 | 1 |
| | ANALOG DEVICE AD 7530 | | |
| U307 | NAND GATE TRIPLE 3 INPUT | 4800-0135 | 1 |
| | NATIONAL MM 74C10 | | |
| U308 | NAND GATE QUAD 2 INPUT | 4800-0136 | 3 |
| -310 | NATIONAL MM 74C00 | | |
| U311 | HEX INVERTER | 4800-0137 | 1 |
| | NATIONAL MM 74C04 | | |
| CR301 | DIODE | 4800-0138 | 1 |
| | ZENER IN5237B 8.2V | | |

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W/ DPS-1000 BOARD ASSEMBLY

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SHEET 4 OF 5

A 04289 REV

# ENGINEERING PARTS LIST

| REF. NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| R120, 311 | RESISTOR CARBON | 4702-0474 | 2 |
| | 470K 1/4W | | |
| 4 | SCREW | | 7 |
| | 4-40 UNF-2A X .375 BHMS, STL. | | |
| 5 | NUT | | 7 |
| | 4-40 KEPNUT, STL. | | |
| 6 | WASHER | | 7 |
| | #4 FLAT FIBER WASHER | | |

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**BRANSON/IPC**
**a SmithKline company**
**Branson International Plasma Corporation**
31172 Huntwood Avenue, P.O. Box 4136, Hayward, CA 94544
(415) 489-3030 Telex: 337-759

**GAS PLASMA SYSTEMS**

# Fundamentals of Plasma-Etching

Plasmas are used extensively for etching metals, semiconductors and dielectrics during the processing of microelectronic wafers. Economical commercial processes have been developed for etching materials such as silicon, silicon dioxide, silicon nitride, aluminum, tantalum, tantalum compounds, chromium, tungsten, gold and glass.

This bulletin is an introduction to the plasma-etching of wafers. It gives basic information about the nature of plasmas, the features of typical plasma-etching systems, the advantages of plasma-etching over wet-chemical methods, and the control of plasma processes.

This bulletin doesn't discuss any process in detail, or give operating parameters for any process. Detailed discussions of individual plasma-etching processes appear in the Dionex Operating Bulletins, which are available to our customers without charge.

## Plasma Principles

Plasma sometimes is called "the fourth state of matter." A plasma resembles a gas in many ways, but with an important difference: The particles (atoms or molecules) of a gas are uncharged and electrically neutral. In a plasma, some fraction of the particles have been ionized and carry electric charges. Positive and negative ions are present in the plasma in roughly equal numbers.

The plasma also may contain a substantial population of free radicals. A free radical is an electrically neutral, highly reactive atom or group of atoms.

The presence of ions and free radicals in a plasma makes the plasma very reactive—so reactive, in fact, that it is unstable. Unless energy is supplied continuously to maintain the plasma, it will degenerate quickly into an ordinary gas. This is why lightning—a natural plasma—is so short-lived.

This extreme reactivity is the key to the commercial application of plasmas in various industries. Plasmas are used in chemical milling, in the nitriding of steel, in the synthesis of organic polymers, in the modification of polymers surfaces, and in the deposition and hardening of organic coatings and films.

But the most important applications of plasma processing (measured by the value of the materials processed) occur in microelectronics manufacturing. Plasmas are used not only for etching but also for cleaning, de-scumming, stripping and passivating delicate wafers and masks.

## Plasma-Etching Systems

Plasma-etchers are simple and reliable. Each system has three basic units: a **reactor,** which holds wafers during etching; a **radio-frequency (RF) generator,** which supplies energy for creating plasmas inside the reactor; and **control equipment,** housed in one or two modules.

After the reactor has been loaded with wafers, it is evacuated by a mechanical pump. Then a **reagent gas** enters the reactor and is ionized to form an etching plasma. Fresh reagent gas flows into the reactor continuously during etching, while gaseous reaction products are withdrawn from the reactor by a vacuum pump.

The reagent gases used most often are oxygen, silicon tetrafluoride ($SiF_4$) and various Freons. Freons are halogenated carbon compounds, such as $CF_4$ and $C_2F_6$.

In many etching processes, the reagent gas is a mixture. The most common commercial mixtures are oxygen/$CF_4$ and oxygen/$SiF_4$.

During a typical process, the plasma system's control module governs five variables: the composition of the reagent gas; the flow-rate of the reagent gas; the RF power; the pressure in the reactor; and the processing time. These parameters define the etching process. Their values—and the precision with which they are controlled—determine how effective the process will be.

Plasma-etching doesn't require the use of unusual photoresists or coatings. The same photoresists and coatings that are used in wet-chemical etching are used in plasma-etching.

## Reactor Design

There are two kinds of plasma reactors: cylindrical and planar. They differ substantially in their design and in their etching performance.

## Cylindrical Reactors

In a cylindrical reactor, wafers stand erect during etching, in racks made of quartz or aluminum. The wafers aren't exposed directly to the etching plasma. Etching is done by free radicals that migrate out of the plasma to reach the wafers.

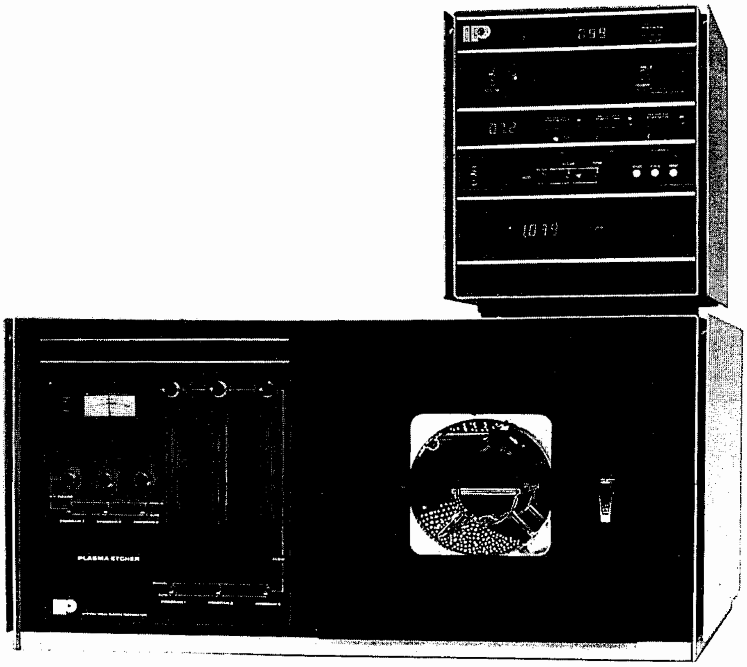

**Figure 1**

**A Dionex plasma-etcher with a cylindrical reactor. A rack of wafers is visible through the reactor door. The unit atop the controller includes the system's RF generator.**

Figure 1 shows a cylindrical reactor loaded with wafers. Notice that the rack of wafers stands inside a cylindrical, perforated-metal shield—the Etch-Tunnel cylinder.*

Figure 2 is a highly simplified diagram of the reactor, showing how it works. The reagent gas is introduced through the bottom of the reactor and flows toward the gas exhaust. As soon as the gas enters the reactor, RF energy from the upper and lower electrodes converts the gas into a plasma. In the diagram, the plasma is shown as a stippled area. The Etch-Tunnel cylinder restricts the plasma to the region between the cylinder and the reactor wall. If there were no cylinder in this system, the plasma would fill the entire reactor.

The plasma region contains various reactive entities—ions, free electrons, strong electric fields, intense ultraviolet radiation and free radicals. Only the free radicals are needed for etching. It is generally believed that the ions, electric fields and UV radiation aren't useful in etching, and that they can cause harmful overheating of the wafers. Overheating can degrade photoresist, damage wafers and make the etching difficult to control.

These ions, electric fields and radiation occur within the plasma only; they *can't* leave the plasma region. By creating a plasma-free space around the wafers, the Etch-Tunnel cylinder protects the wafers from these entities.

Free radicals, however *can* leave the plasma region. They pass through the perforations in the Etch-Tunnel cylinder, strike the wafers and promote etching reactions. The products from these reactions pass through the perforations and into the plasma region, to be withdrawn through the gas exhaust.

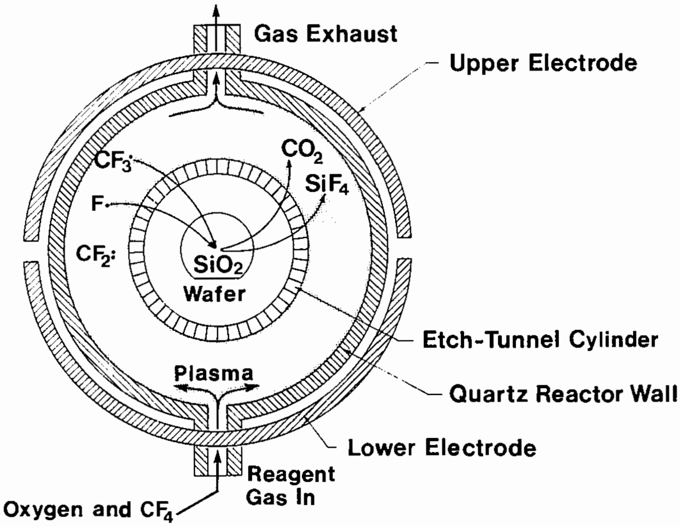

**Figure 2**

**A cross-section of a cylindrical reactor during etching. This diagram is explained in the text on this page.**

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***This shield was developed by Dionex.** ***Etch-Tunnel*** **is a registered trademark of Dionex.**

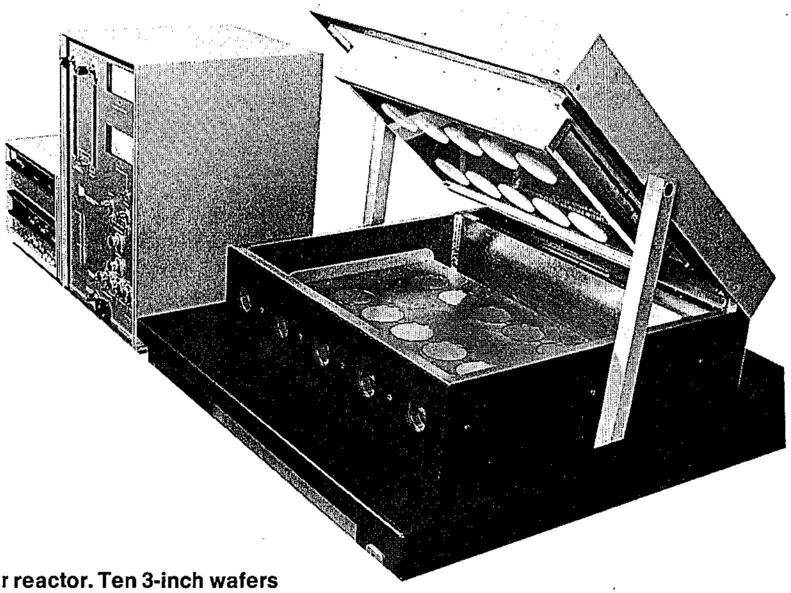

**Figure 3**

**A Dionex plasma-etcher with a planar reactor. Ten 3-inch wafers are lying on the reactor's lower electrode.**

All of these events are illustrated in Figure 4, which shows the etching of a layer of silicon dioxide ($SiO_2$) in an oxygen/$CF_4$ plasma. The free radicals $CF_3\cdot$ and $F\cdot$ are the chief etching agents. The radical $CF_2$: also occurs in oxygen/$CF_4$ plasmas, but it isn't important in the etching of $SiO_2$.

## Planar Reactors

In a planar reactor, wafers lie side-by-side on a flat, rectangular plate. This plate is the lower of two electrodes that create plasmas in the reactor. The upper electrode is a plate that hangs from the top of the reactor, about 1 inch above the wafers.

Figure 3 shows a planar reactor with its top raised, to display the load of wafers on the lower electrode.

Figure 4 is a section through the closed reactor during etching. The reagent gas enters the reactor from a manifold under the center line of the lower electrode. Reaction products leave through exhaust manifolds near the front and rear edges of the reactor. Both electrodes are water-cooled, to keep the wafers at a specified, constant temperature during etching.

A vital feature of the planar reactor is the upper electrode. The **focusing plate** on the face of this electrode produces a concentrated etching plasma that is directed at specific sites on the lower electrode. Wafers lie at these sites during etching.

Notice that the wafers are within the plasma region and exposed directly to the plasma. This merits explanation, because the preceding discussion of cylindrical reactors emphasized that a plasma generates ions, electric fields and radiation that can overheat wafers. In a planar reactor, overheating can't occur: The entire underside of every wafer touches the water-cooled lower electrode, and the whole wafer is kept at the temperature of the electrode.

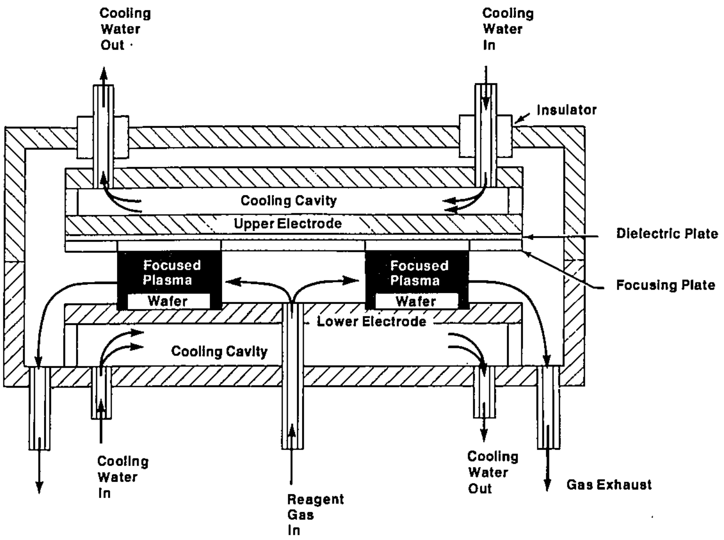

**Figure 4**

**A longitudinal section through a planar reactor during etching. For explanation, see the text on this page.**

## Effect of Reactor Design on Etching

There is an important difference between etching done in a cylindrical reactor and etching done in a planar reactor.

In a cylindrical reactor, etching is **isotropic:** It proceeds vertically and laterally at similar rates, so that an etched line grows narrower as it grows deeper. The narrowing of the line is called **undercutting.** It can cause the etched line to become significantly narrower than the corresponding line in the photoresist pattern. Isotropic etching and undercutting are illustrated in Figure 5.

In a planar reactor, etching is **anisotropic:** Vertical etching proceeds rapidly, but lateral etching is very slow. As a result, undercutting is negligible or imperceptible. Anisotropic etching is shown in Figure 6.

For etching broad, widely spaced lines, isotropic etching in a cylindrical reactor can be quite satisfactory. But for etching narrow lines—lines whose width is about equal to the thickness of the layer being etched—anisotropic etching in a planar reactor is required.

For this reason, Dionex usually recommends planar reactors for etching dense patterns and for etching lines whose width is less than 5 microns.

Generally, an etcher that has a planar reactor costs 20% to 40% more than a cylindrical-reactor system having the same capacity and process capabilities.

## Advantages of Plasma-Etching

In all of its applications to microelectronics manufacturing, plasma-etching offers important advantages over wet-chemical etching.

First: Reagent gases, such as oxygen and the Freons, are harmless to handle and are available in cylinders that can be shipped, stored and used without danger. This isn't true of the corrosive chemicals that are used in wet etching.

Second: Plasma-etching can provide finer resolution, with less undercutting, than wet etching can. No wet process offers the high accuracy and negligible undercutting that typify plasma-etching in a planar reactor. Even plasma-etching in a cylindrical reactor causes less undercutting and provides more precision than comparable wet processes do. Figure 7 and Figure 8 illustrate this.

Third: Plasma systems can clean, etch and strip wafers sequentially, in the same reactor. A typical sequence involves three steps: The wafers are de-scummed by brief exposure to an oxygen plasma; then they are etched in an oxygen/$SiF_4$ plasma; then they are stripped in another oxygen plasma. These three steps are performed automatically, without manual control. The wafers aren't handled between the steps, so they aren't exposed to contamination or damage.

Fourth: Plasma-etching creates almost no pollution problems. It releases little, if any, smoke or fumes into the factory environment. It is virtually silent. And it doesn't generate the large volumes of waste chemicals that typify wet processes.

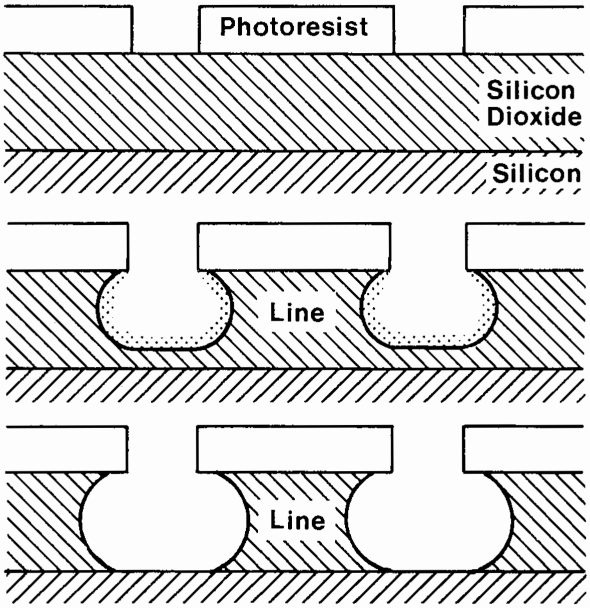

**Figure 5**

**Isotropic etching of a line through a layer of silicon dioxide. The stippling in the middle drawing shows where etching is occurring. As the channels adjacent to the line grow deeper, undercutting makes the line grow narrower. As a consequence, the finished line of oxide is considerably narrower than the corresponding line in the photoresist pattern.**

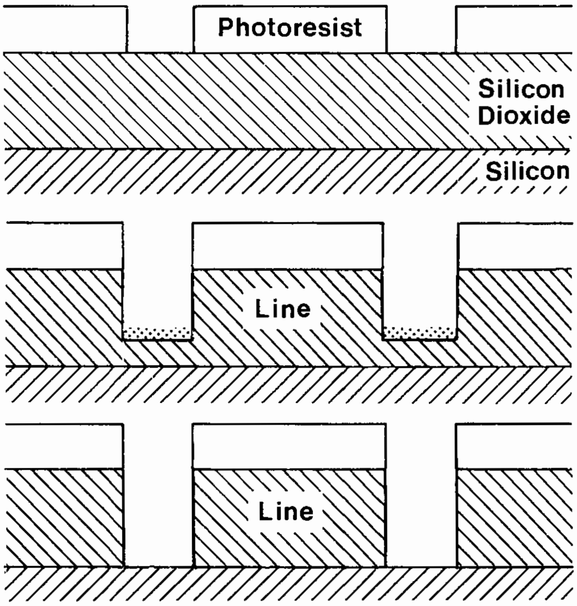

**Figure 6**

**Anisotropic etching of a line through a layer of silicon dioxide. The stippling indicates that etching is taking place only at the bottoms of the adjacent channels. The sides of the channels aren't being etched, so the line isn't growing narrower. The width of the etched line of silicon dioxide is the same as the width of the line in the photoresist pattern.**

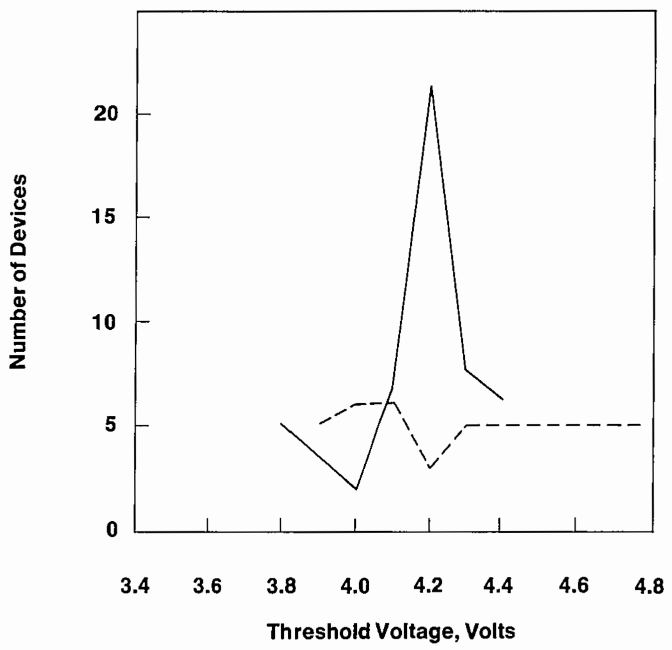

**Figure 7**

**Distribution of threshold voltage in MOS transistors whose silicon nitride was etched with plasma (solid line) or with wet chemicals (broken line). The narrow distribution of voltage in the plasma-etched devices illustrates the greater reproducibility and precision of plasma-etching.** *Redrawn from a figure by H. Abe in Proc. 6th Conference on Solid-State Devices, J. Japan Soc. Applied Physics 44: 287-295.*

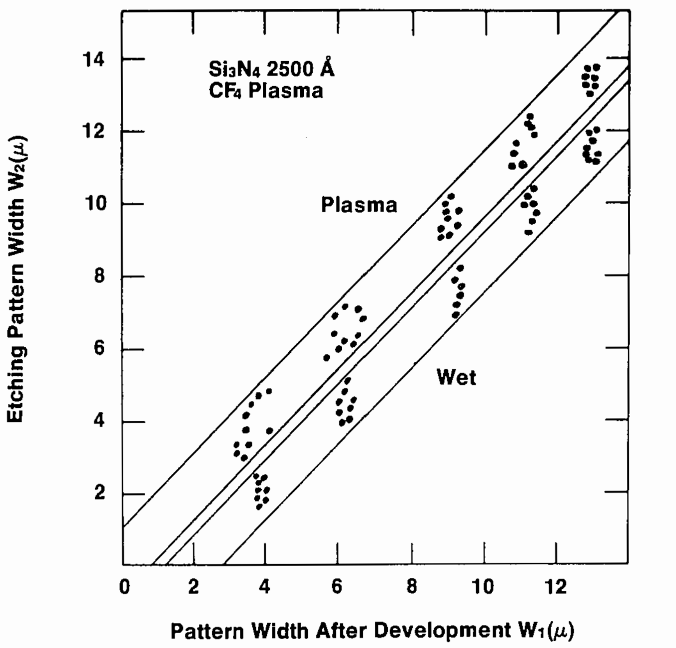

**Figure 8**

**Accuracy of plasma-etching and wet-chemical etching in creating isolated lines of silicon nitride. Wet etching (triangles) caused undercutting: Etched lines are consistently narrower than the lines on the photoresist, by about 2 microns. Plasma-etching data (circles) show little difference between width of an etched line and the width of the photoresist line.** *Redrawn from the source cited for Figure 7.*

Fifth: The cost of reagent for a plasma-etching process is markedly lower than the cost of reagent for a wet process. In a wet process, the reagent solution is used not only for etching wafers but also for sweeping away the products of the etching reactions. For this reason, the typical wet process requires excess reagent in huge amounts; a kilogram of reagent may be used in a process that removes micrograms of material from a batch of wafers. In plasma-etching, the reagent excess is modest. An example will demonstrate this:

Suppose that a silicon dioxide layer must be etched to a depth of 5,000 angstroms in an oxygen/$CF_4$ plasma. If the reactor is loaded with 25 three-inch wafers, about $1 \times 10^{21}$ $CF_4$ silicon atoms must be converted to $SiF_4$ and removed from the wafers during etching.

One molecule of $CF_4$ will supply the fluorine atoms needed for converting one atom of silicon to $SiF_4$. Hence, $1 \times 10^{21}$ $CF_4$ molecules must be changed into radicals that actually participate in etching reactions.

A typical flow-rate of $CF_4$ during the etching of silicon dioxide is 100 milliliters per minute (measured at standard temperature and pressure). At this flowrate, about $2 \times 10^{21}$ $CF_4$ molecules enter the reactor each minute, and we can assume that 10% of these molecules are converted to useful free radicals.

If all of these radicals enter into etching reactions, $1 \times 10^{22}$ $CF_4$ molecules will be consumed during the removal of $1 \times 10^{21}$ silicon atoms, and the etching will take about 5 minutes.

## Etching Rates

The etching rate obtained in a plasma process usually is expressed in angstroms per minute. It tells the depth of the new etching accomplished in 1 minute, under specified process conditions.

The process factors that have the strongest effects on etching rates are: the chemical nature of the material being etched; the number of wafers (wafer load) in the reactor; the temperature of the wafers; and the rate of free-radical-generation.

## Effect of Materials

Because etching rates are influenced by several interacting factors, it is impossible to state the *absolute* etching rate (in angstroms per minute) that will prevail during the etching of a specific material. The table on the next page shows some *relative* rates, which indicate how rapidly various materials can be etched under identical or comparable process conditions.

## Effects of Wafer Load

In a cylindrical reactor, typical loads range from 25 to 100 wafers. As the load increases, the etching rate decreases. Here is the reason for this:

The average residence time of a gas molecule or a free radical in a cylindrical reactor is relatively long. A typical radical stays in the reactor for many seconds *after* it has participated in an etching reaction, and thus has become unreactive. Some percentage of the radicals that reach a given wafer are these unreactive radicals that already have etched some other wafer. Clearly, this percentage increases as the number of other wafers increases. The etching rate decreases accordingly.

In a planar reactor, typical loads range from 10 to 25 wafers. The size of the load has almost no effect on etching rate. The average residence time of a radical in a planar reactor is very short. A typical radical is withdrawn from the reactor immediately after it has reacted with a wafer; it doesn't visit other wafers. For this reason, nearly all of the radicals that reach a given wafer are reactive radicals. The etching of the given wafer isn't affected by the presence of other wafers, so the etching rate isn't affected by the size of the wafer load.

### Importance of Temperature

Since etching is a chemical process, it isn't surprising that temperature affects the etching rate. In typical commercial processes, the etching rate increases by 1% to 2% when the temperature rises by 1 Centigrade degree.

### Importance of Free-Radical-Generation

Free radicals are the actual reagents in plasma-etching, and the etching rate depends on the plasma's ability to generate them. The creation of large numbers of free radicals is especially important during etching in a cylindrical reactor: The plasma must be rich in radicals, so that a substantial number can leave the plasma region and migrate to the wafers. The rate of free-radical-generation depends on two process parameters: the RF power and the composition of the reageant gas.

| Material | Relative Etching Rate in Etch Tunnel |
|---|---|
| *In oxygen/$SiF_4$ plasmas* | |
| polycrystalline silicon | 250 |
| silicon dioxide | 30 |
| silicon (111) | 300 |
| silicon nitride, plasma | 1100 |
| silicon nitride, LPCVD | 200–400 |
| *In oxygen/$CF_4$ plasmas* | |
| silicon nitride, LPCVD | 200–400 |
| silicon nitride, plasma | 1100 |
| silicon dioxide | 200 |
| silicon (111) | 1000–1500 |
| polycrystalline silicon | 1000–1500 |

**Relative etching rates of some microelectronic materials when they are etched in a cylindrical reactor. This table is based on data collected at Dionex's laboratories. A Dionex Etch-Tunnel cylinder was used in all of the experimental work.**

### RF Power

The radicals in an etching plasma are created when electrons collide with molecules of the reagent gas. The electrons are supplied in the current delivered by the RF generator. As RF power increases, this current becomes stronger and more electrons are available for productive collisions.

### Reagent Gas

Under identical conditions, different gases and gas mixtures create free radicals at different rates. Here is one example:

Pure $CF_4$ can be ionized to create a useful etching plasma, but the plasma is relatively poor in fluorinated free radicals. A mixture of $CF_4$ and oxygen produces a much richer plasma that generates free radicals about 10 times more rapidly than a pure $CF_4$ plasma does. In the oxygen/$CF_4$ plasma, free-radical generation proceeds in two steps: Electrons collide with oxygen molecules to produce free radicals of oxygen (such as $O\cdot$), then the oxygen radicals react with $CF_4$ to generate fluorinated radicals for etching.

### Process Control

Commercial etching requires close control of etching rates. The preceding text pointed out that etching rates depend chiefly on the material being etched, the wafer load, the wafer temperature and the generation of free radicals.

For a given process, the material being etched is a constant, and the wafer load can be governed easily and directly. The control of free-radical generation and the control of temperature require further discussion.

### Controlling Free-Radical-Generation

After the reagent gas has been specified, the rate of free-radical-generation depends almost entirely on the RF power. The power must be kept at an optimal value during etching, and it must be very stable.

To refine the control of RF power, Dionex has developed two proprietary control units. Both can be incorporated into any IPC plasma-etching system.

The first of these units provides electronic stabilization of RF power itself. The chief external cause of variation in RF power is variation in line voltage. Fluctuations as large as 10% are common. At the RF-power levels used in plasma-etching (150 to 1000 watts), a 1-watt fluctuation in power can cause a 1% change in the etching rate.

The second unit for controlling RF power is Dionex's AutoMatch 2 impedance-matching apparatus, which automatically and continuously equalizes the impedance of the etching plasma and the impedance of the RF generator. This matching is crucial: Any change in the relation between the two impedances alters the etching rate, just as a power fluctuation does.

### Controlling Temperature

The importance of temperature-control can be comprehended most easily by considering the three kinds of variations that are found in etched wafers:

**Across-wafer variation** describes differences in the nature and the extent of etching at different points on the same wafer.

**Wafer-to-wafer variation** embraces differences between two wafers that were etched during the same run of an etching process.

**Run-to-run variation** denotes differences between two wafers that were etched during different runs of the same process.

In any process, these variations must be minimized. And all of them are affected by temperature.

### Temperature and Across-Wafer Variation

Across-wafer variation is caused chiefly by local temperature differences on the wafer during etching.

In a planar reactor, these differences are insignificant. The temperature of each wafer is constant and uniform, because the entire underside of the wafer touches the water-cooled lower electrode.

In a cylindrical reactor, across-wafer temperature differences will be large if no Etch-Tunnel cylinder is used. Ions and radiation within the plasma will concentrate their energy on the periphery of each wafer and overheat it. Peripheral regions of the wafer may be severely over-etched while the center of the wafer remains under-etched.

These effects are prevented entirely by using the Etch-Tunnel cylinder to shield the wafers from the plasma.

### Temperature and Wafer-to-Wafer Variation

Variation among wafers etched during the same process run is caused almost wholly by wafer-to-wafer temperature differences.

In a planar reactor, such differences can't arise: All of the wafers have the same temperature as the lower electrode.

But in a cylindrical reactor, some wafers may be heated more than others, for two reasons: There may be "hot spots" at certain places within the etching plasma; and wafers near the ends of the reactor may become unusually hot, because the ends of the reactor concentrate heat.

Dionex's cylindrical reactors have been designed to minimize wafer-to-wafer temperature differences. Each reactor creates an extraordinarily uniform plasma without hot spots, and each has multiple ports for the injection of reagent gas and the withdrawal of reaction products. These multiple ports encourage a uniform flow of gases through the reactor. Moreover, the Etch-Tunnel cylinder suppresses wafer-to-wafer temperature differences by equalizing the flow of heat and free radicals throughout its interior.

### Temperature and Run-to-Run Variation

Temperature differences are an important cause—but not the only cause—of variation among wafers etched during different runs of the same process. To minimize run-to-run variation, the process engineer must make sure that all wafers in all runs have the same **initial temperature** when etching begins, and that they remain at the same temperature during etching.

In a planar reactor, this can be ensured easily: The temperature of the lower electrode is under automatic control, and can be kept at any specified temperature before and during etching.

In a cylindrical reactor, run-to-run temperature control requires some special tactics:

Consider first the simplest cylindrical-reactor systems. In these systems, the etching plasma is established as soon as the reactor has been sealed and evacuated, regardless of the initial temperature of the wafers. This temperature can vary considerably from run to run, since it depends on the recent histories of the reactor and of the wafers.

To equalize the initial temperature during all runs of a process, Dionex has developed temperature controllers for cylindrical reactors. In systems that have these controllers, the reactor and the wafers are heated to a specified temperature before the etching plasma is established. The heating is done by an inert plasma—a plasma that generates heat but doesn't react with any substance on the wafers. The gases used most often for creating inert plasmas are nitrogen and argon.

A typical Dionex cylindrical reactor system with a temperature controller can restrict run-to-run variation to 5% or less. In systems without temperature controllers, variation usually is between 10% and 30%.

### Chemically Selective Processes

The ideal etching is chemically selective: It etches one material only, and it can't attack other materials that might be exposed to the etching plasma. Such a process forgives process-control errors. Even if the process is allowed to run for an excessively long time, it can't damage wafers.

Not all plasma-etching processes are chemically selective, but several such processes have been developed. Some are **absolutely selective** and some are **preferential.** An absolutely selective process etches one substance and leaves all others completely unaffected. A preferential process etches one substance very strongly but has only mild effects on others.

Selective processes exist for etching aluminum, silicon dioxide, silicon nitride, polycrystalline silicon, chromium, tungsten and several other materials. Here are brief descriptions of five of these processes:

### DryAl Etching of Aluminum

This preferential process was developed by Dionex, and *DryAl* is a registered trademark of Dionex. The DryAl process is used for etching thin aluminum layers to form conducting patterns within circuits and between circuits. Etching must be done in a planar reactor. The reagent gas is a mixture of helium and carbon tetrachloride ($CCl_4$).

DryAl etching is done in two stages: a high-power step to etch through the aluminum oxide on the surface; and a low-power step to finish the etch. The power reduction maintains a high rate of aluminum etch but drastically reduces the etch rates of silicon dioxide and silicon.

The etching rate of single-crystal silicon under DryAl conditions is about 1½% of the etching rate of aluminum.

### Planar Etching of Polysilicon

The high-power etch conditions used in the first stage of aluminum etching can also be used very advantageously for selectively etching polysilicon. The selectivity of polysilicon over silicon dioxide is better than 10 to 1. And the anisotropic nature of the etch produces straight walls with no undercutting.

### Etching Silicon Dioxide in a Freon Plasma

One of the most common configurations in microelectronic devices is a layer of silicon dioxide atop a layer of silicon. Etching a window through the oxide is a delicate task, because most oxide-etching processes can etch silicon too. These

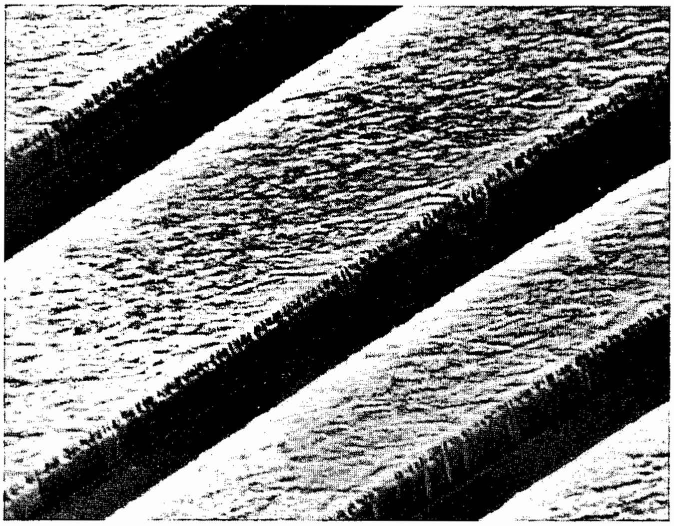

**Figure 9**

**An aluminum pattern, 1 micron thick, etched by the DryAl process. The smooth material under the aluminum is silicon dioxide. The magnification here is about 5000X.**

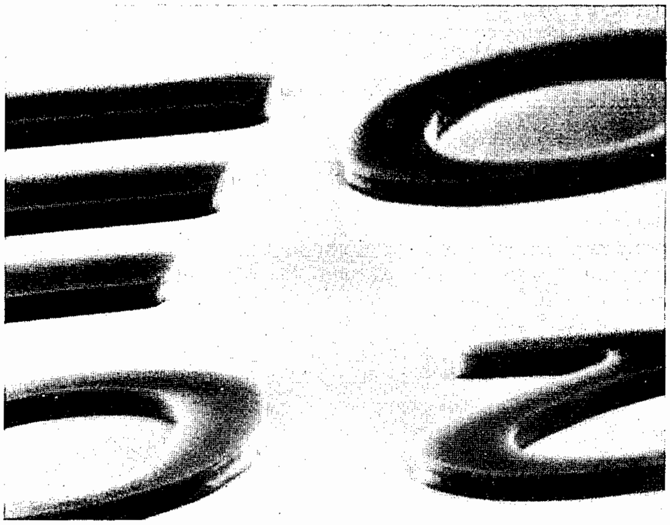

**Figure 10**

**These numerals are parts of an oxide pattern produced by DryOx etching. The oxide, 1 micron thick, lies on a substrate of silicon. The magnification here is 5000X.**

processes require very close control. Etching must be stopped as soon as the oxide has been removed, before the plasma can attack the underlying silicon.

Now Dionex has developed a preferential process that eliminates danger to the silicon. Etching is done in a planar reactor. The reagent gas is $C_2F_6$. At the prescribed temperature and pressure, the etching rate of oxide is about 15 times greater than the etching rate of silicon.

### DryOx Etching of Silicon Dioxide

This process too was developed and patented by Dionex. *DryOx* is a registered trademark of Dionex. The DryOx process has the same purpose as the preceding process does: etching through silicon dioxide on top of silicon. But DryOx etching is done in a special system that has a cylindrical reactor; and DryOx etching is absolutely selective: Under DryOx conditions, the etching rate of silicon is exactly zero. After the oxide layer has been removed, etching stops completely.

### Etching Silicon Nitride in an Oxygen/$SiF_4$Plasma

This process, performed in a cylindrical reactor, is used for etching nitride that lies atop silicon. Because an oxygen/$SiF_4$ plasma minimizes the etching of exposed silicon, it is markedly safer to use than is an oxygen/$CF_4$ plasma.

In an oxygen/$CF_4$ plasma, the etching rate of single-crystal silicon is about 7 times greater than the etching rate of nitride, and the etching rate of polycrystalline silicon is about 10 times greater. For this reason, oxygen/$CF_4$ plasmas often are impractical for etching nitride. Even with close control, occasional batches of wafers are ruined when the plasma is allowed to reach the silicon.

In an oxygen/$SiF_4$ plasma, the etching rates of single-crystal and polycrystalline silicon are about the same as the etching rate of nitride. Although this plasma isn't truly preferential for nitride, its relatively mild effect on silicon represents a selectivity unavailable in any other nitride-etching process.

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# Plasma-Etching Silicon Nitride

Silicon nitride ($Si_3N_4$) is used widely in the manufacture of microelectronics devices, to form dielectric layers or passivation films. A passivation film is a layer that protects underlying materials from contamination.

There are three important commercial methods for depositing silicon nitride films: pyrolytic deposition, plasma deposition, and low pressure chemical vapor deposition (LPCVD). All three types can be successfully plasma etched, although the etching characteristics vary according to film type.

### Advantages

In the etching of silicon nitride, the only important alternative to plasma-etching is wet etching with hot phosphoric acid. This process involves a hazardous, corrosive reagent; etching reactions that are hard to control; and large volumes of chemical wastes. And since hot phosphoric acid degrades most commercial photoresists, the etching pattern must be controlled by an oxide mask. Such masks are made by a multiple-step etching process that exposes wafers to extra handling and breakage.

Plasma-etching offers none of these drawbacks. It employs inexpensive gases as reagents; it can be controlled easily and precisely; it produces no noxious wastes; and it is more accurate and more uniform than wet-chemical etching.

## Barrel Reactor

### Operation

Silicon nitride can be etched by either a Freon 14 ($CF_4$) and oxygen plasma or a silicon tetrafluoride ($SiF_4$) and oxygen plasma. The process is generally performed in a Dionex etch tunnel.

Here are typical values for process variables in the etching of silicon nitride films with different etch mixtures.

Freon 14 with 4% or 50% oxygen

| | |
|---|---|
| **Temperature** | Preheat to about 80–120°C |
| **Pressure** | 0.3–0.5 Torr for 4% oxygen mixture<br>0.8–1.2 Torr for 50% oxygen mixture |
| **Power** | 50–200 Watts for 8″x18″ chamber<br>75–250 Watts for 10″x18″ chamber |
| **Pumping** | About 500 liters/minute for 8″x18″ chamber<br>About 675 liters/minute for 10″x18″ chamber |
| **Etch Rate** | Pyrolytic and LPCVD nitride—200–400 Å/minute<br>Plasma nitride—500–1000 Å/minute |
| **Spacing** | Wafers must be at least ⅜-inch apart<br>(wide spacing favors uniform etching) |

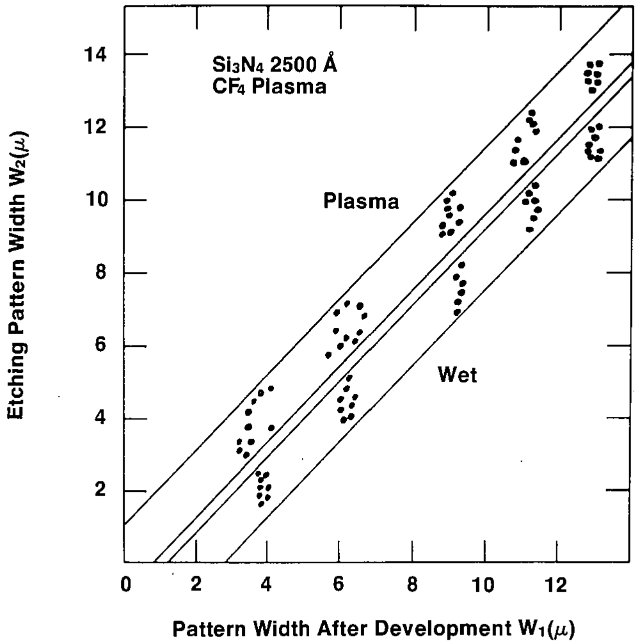

**Figure 1**

**Comparison of plasma and wet-chemical methods in etching isolated tongues of silicon nitride. Data for plasma-etching are clustered along the diagonal; there were virtually no differences between the widths of lines on the photoresist and the $Si_3N_4$ tongues generated from those lines. Data for wet etching show significant undercutting of the photoresist: etched tongues were narrower than the lines on the photoresist.** *From H. Abe, 1974. Proc.6th Conf. Solid State Devices, J. Japan. Soc. Appl. Phys. 44:287–295.*

Silicon tetrafluoride ($SiF_4$) with 4% oxygen

| | |
|---|---|
| **Temperature** | 80–120°C |
| **Pressure** | 0.7–1.2 Torr |
| **Power** | 150–250 Watts for 8″x18″ chamber<br>250–350 Watts for 10″x18″ chamber |
| **Pumping** | About 500 liters/minute for 8″x18″ chamber<br>About 650 liters/minute for 10″x18″ chamber |
| **Etch Rate** | Pyrolytic and LPCVD nitride—150–300Å/minute<br>Plasma nitride—800–1000 Å/minute |
| **Spacing** | Wafers must be at least ⅜-inch apart<br>(wide spacing favors uniform etching) |

**This publication is part of a series of Dionex Operating Bulletins that describe applications of plasma in the manufacture of semiconductor devices. Each bulletin covers a single plasma-etching or plasma-stripping process. General information about plasma systems in microelectronics manufacturing can be found in** *Bulletin 70001 Fundamentals of Plasma-Etching.*

Bulletin No. 71/79

## Process Control

The control of the etching process depends partly on the other materials that will be exposed to the etching plasma. For example, GaAsP is impervious to Freon-oxygen plasmas, and the etching of a nitride film that lies on a GaAsP layer isn't a critical process. Even after the nitride has been etched away, the GaAsP cannot be damaged by the plasma.

Silicon, on the other hand, is attacked vigorously by Freon/oxygen plasmas. Therefore, the etching of silicon nitride film atop a layer of silicon demands precise control. If the process isn't terminated promptly, the plasma can damage the underlying silicon severely.

Such a critical process requires a gas mixture that will maximize the etching of silicon nitride and minimize the etching of other materials. The table below shows the relative etching rates of some materials in the two gas mixtures that commonly are used in etching silicon nitride.

| **Material** | **Relative Etching Rates** | | |
|---|---|---|---|
| | **with 4% $O_2$** | **with 50% $O_2$** | **in $SiF_4/O_2$** |
| Silicon nitride, LPCVD | 1.0 | 1.0 | 1.0 |
| GaAsP | 0.0 | 0.0 | ** |
| Aluminum | 0.0 | 0.0 | 0.0 |
| Silicon dioxide (thermal) | 0.4 | 0.3 | 0.2 |
| Silicon (111) | 6.9 | 0.6 | 1.0 |
| Silicon (poly) | 9.9 | 0.6 | 1.0 |
| Negative resist | 0.2 | 2–50 | 0.2 |
| Positive resist | 0.4 | 2–50 | 0.4 |
| Undoped CVD oxide | 1.2 | 1.2 | ** |
| Doped CVD oxide | 3.0 | 3.0 | ** |

*Using the Dionex Etch-Tunnel cylinder in all cases.
**Not available.

For the etching of silicon nitride atop silicon, a two-step process can be used. In the first step, a 4%-oxygen mixture is used for removing about 90% of the nitride film. Then the etching is completed with a 50%-oxygen mixture, which etches silicon nitride more slowly than 4%-oxygen, but will not ruin the underlying silicon. This two-step process limits the etching of silicon to about 2% of the depth of the original nitride layer.

The disadvantage of using a 50% oxygen and $CF_4$ mixture is that the erosion rate of photoresist goes up with the oxygen content. When selectivity is important, it is recommended that a $SiF_4/O_2$ gas mixture be used as the etch gas. The etch ratio given in the above table can be further improved by using a helium-diluted $SiF_4/O_2$ mixture.

In general, critical nitride-etching processes require the close control provided by Dionex 2000T and 8000T etcher/strippers. These are temperature-controlled plasma systems: they use a preheating step to make certain that all wafers, in all runs, have the same temperature and thermal history when etching begins. Information about these systems appears in *Product Bulletin 7408 and Product Bulletin 7409.* The Dionex 9000, the most advanced barrel plasma system available, is capable of storing sixteen complete and separate programs, each with up to sixteen individual steps. *Refer to Product Bulletin 9000/79.*

## Special Considerations

- **Fast-Etching Films**

All nitride films that are especially thin or unusually silicon-rich will be etched very rapidly by Freon/oxygen plasmas. Excessively fast etching is neither accurate nor uniform in its effects. For this reason, the etching process must be adjusted so that it takes at least three minutes to complete. The easiest way to slow the etching of silicon nitride is to use a low pressure, low power condition or a diluent such as helium or nitrogen. A recommended diluted gas mixture for etching silicon-rich films contains 75% nitrogen (or helium), 24% Freon 14 and 1% oxygen.

- **Using $SiF_4$**

Silicon tetrafluoride is a toxic gas that reacts rapidly with moisture to form HF, a corrosive and toxic gaseous compound. $SiF_4$ by itself is not corrosive unless combined with water. Special care must be taken to keep the chamber leak-tight to prevent possible hydrolysis of $SiF_4$ and its escape into the atmosphere. Special safety features are built in Dionex barrel systems that are to be used with $SiF_4$.

- **Protecting Backs of Wafers**

During any process for etching silicon wafers, the plasma must be restrained from attacking the backs of the wafers. There are two reasons for this. First, rapid etching of the wafer backs will heat the wafers, making process-control difficult. Secondly, the backs of the wafers will absorb large numbers of reagent particles, slowing or even stopping the etching of the nitride on the front surfaces of the wafers.

Four methods are available for protecting wafer backs: oxidizing them, coating them with photoresist, shielding them with aluminum plates, or arranging the wafers so that they stand back-to-back during etching.

## Planar Reactor

### Operation

Silicon nitride can be etched in a planar etcher using $C_2F_6$ (Freon 116) and other gases. If the nitride is on an oxide layer which is to be selectively etched down to the silicon, the nitride and oxide can be etched in a single step using the same parameters. If the nitride is on silicon, the selectivity is better than that obtained in a barrel reactor. Planar etching is anistropic, producing straight walls and no undercutting.

**Etch Rates — Planar Reactor**

| | **Å/min.** |
|---|---|
| LPCVD $Si_3N_4$ | 200–300 |
| Pyrolytic $Si_3N_4$ | 200–350 |
| Plasma $Si_3N_4$ | 150–200 |
| Thermal $SiO_2$ | 200–350 |
| Silicon (100) and (111) | 30–40 |

### Process Control

The Dionex 5200 and 5400 planar etchers provide precise control over all parameters: (temperature, mass flow, pressure, and power) necessary to obtain uniform and reproducible results.

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# Plasma-Etching Polycrystalline Silicon in a Barrel Reactor

Polycrystalline silicon is a common material in microelectronic devices. It appears most often in semiconductive layers that are 3,000 to 5,000-Å thick. It also is used to construct conductive layers in transistors and other circuit elements. Such layers are about 1,000-Å thick.

The most important commercial method for depositing films of polycrystalline silicon is the thermal decomposition of silane ($SiH_4$).

## The Plasma-Etching Process

### Advantages

In the etching of polycrystalline silicon, the only important alternative to plasma-etching is wet etching with a mixture of two powerful mineral acids—hydrofluoric and nitric. The process is inherently dangerous and hard to control, and it generates large volumes of waste chemicals whose disposal can be costly.

Plasma-etching presents none of these problems. It employs inexpensive gases as reagents; it can be controlled easily and precisely; and it is more accurate and more uniform than wet-acid etching.

### Operation

The reagent mixtures that are commonly used in the plasma-etching of microelectronic materials are Freon 14 ($CF_4$) and oxygen or silicon tetrafluoride ($SiF_4$) and oxygen. Plasmas formed from these mixtures are rich in fluorinated active species that are capable of reacting with the surface of workpieces to perform the required etching.

$CF_4/O_2$

Polycrystalline silicone can be etched very rapidly by Freon/oxygen plasmas. And etch rates as high as 3000Å are easily obtained. Such fast etching, however, is not desirable because it is difficult to control and can cause severe undercutting and non-uniform etch patterns. Control of the process is achieved by slowing down the etch rate by adding an inert diluent such as helium or nitrogen to the etch gas, or by reducing the pressure and power.

The Dionex etch tunnel is generally used in the etching of polycrystalline silicon with $CF_4/O_2$. The tunnel protects the wafers from possible radiation damage and enhances uniform etching.

For practical purposes, the etching of polycrystalline silicone with $CF_4/O_2$ is an isotropic process (one that proceeds in all directions through the silicon layer). This properly limits the pattern geometry which can be processed by this means. (See Figure 1.)

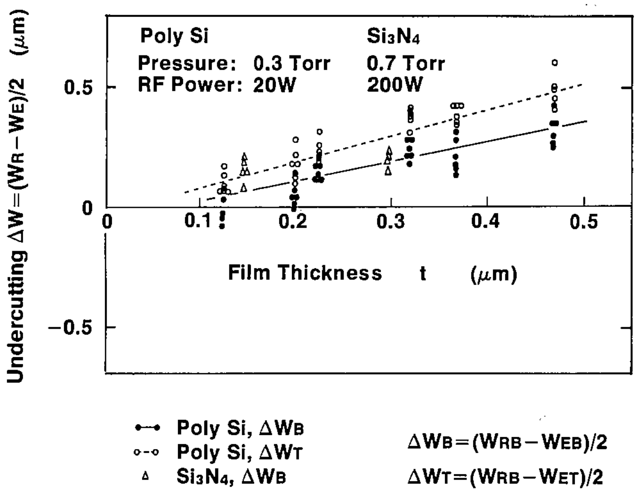

**Figure 1**

**Isotropic etching of polycrystalline silicon. The extent of undercutting always is comparable to the thickness of the etched film, indicating that etching proceeds at virtually the same rate in all directions through the silicon. This relationship doesn't hold during the etching of silicon nitride.** *From H. Komiya et al., Proc. 7th Conf. Solid State Devices: pages 19–24. Japan Soc. Appl. Phys.*

$SiF_4/O_2$

This gas mixture offers the possibility of etching polycrystalline silicon in the barrel reactor anisotropically, thus allowing wafers with small geometric patterns to be etched in the more economical barrel reactors.

Etching of polycrystalline silicon with $SiF_4/O_2$ can be either with or without the etch tunnel. An etch rate of 300–1000Å/minute can be obtained, depending on specific conditions. When etching is done without the etch tunnel, anisotropic etching with minimal undercutting is obtained. Geometries can be held to <0.1 micron when etching 0.5 micron films. Figures 2 and 3 show the comparison between 100% over-etched identical polysilicon samples using $CF_4/O_2$ and $SiF_4/O_2$ mixtures.

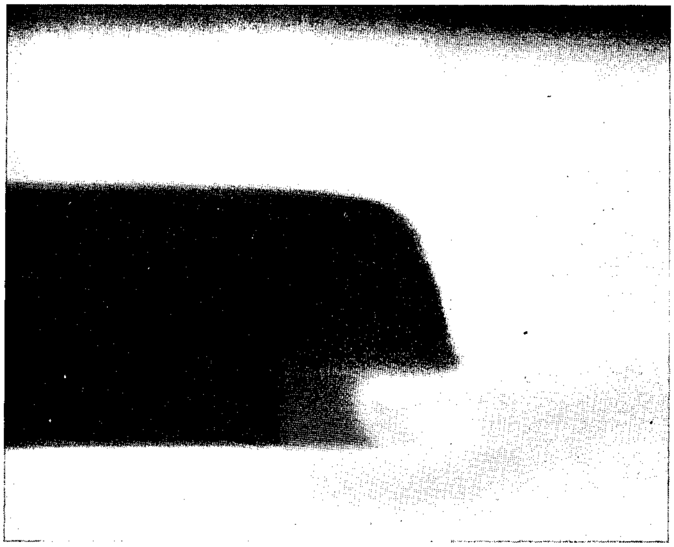

**Figure 2** **20,000X**

**$CF_4$ etched polysilicon with undercutting.**

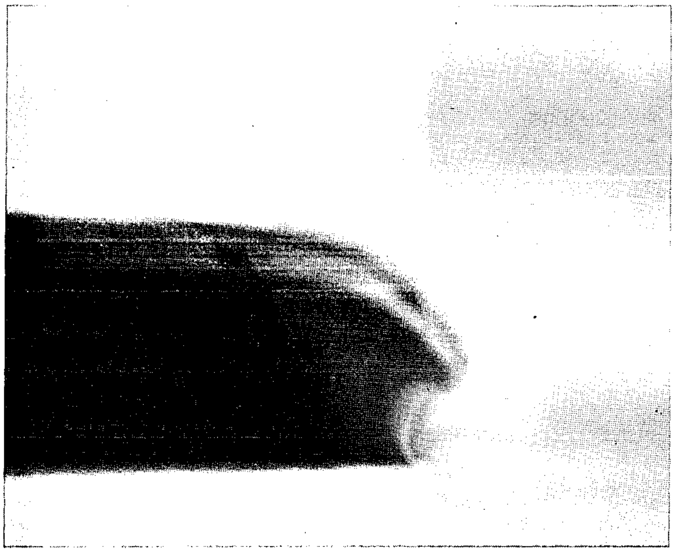

**Figure 3** **20,000X**

**$SiF_4$ etched polysilicon with significantly less undercutting.**

### Process Variables

Here are representative values for process varibles in the etching of polycrystalline silicon films, using the Etch-Tunnel cylinder.

$CF_4/O_2$

| | |
|---|---|
| **Temperature** | Preheat to 80–100°C |
| **Gas** | Freon 14 (96%), oxygen (4%) |
| **Pressure** | 0.25–0.5 Torr |
| **Power** | 75–100 Watts for 10″x18″ chamber |
| **Pumping** | About 23 CFM/reactor |
| **Etch Rate** | About 1500–2000Å/minute |
| **Spacing** | At least ¾ inch apart for 3-inch wafers, loading back-to-back |

Diluted $CF_4/O_2$ Mixtures

| | |
|---|---|
| **Temperature** | Preheat to 80–100°C |
| **Gases** | Freon 14 (24%), oxygen (1%), helium (75%)<br>Freon 14 (24%), oxygen (1%), nitrogen (75%) |
| **Pressure** | 0.7–1.5 Torr |
| **Power** | 150–250 Watts for 10″x18″ chamber |
| **Pumping** | About 23 CFM/chamber |
| **Etch Rate** | About 600–1200Å/minute |
| **Spacing** | At least ¾ inch apart for 3-inch wafers, loading back-to-back |

$SiF_4/O_2$ Mixtures

| | |
|---|---|
| **Temperature** | Preheat to 80–120°C if using tunnel, no preheat without tunnel |
| **Gas** | $SiF_4$ (96%), oxygen (4%) |
| **Pressure** | 0.8–1.2 Torr if using tunnel,<br>0.0–0.8 Torr without tunnel |
| **Power** | 250–300 Watts |
| **Pumping** | 23–35 CFM/chamber |
| **Etch Rate** | About 300–500Å/minute using tunnel,<br>About 500–1000Å/minute without tunnel |
| **Spacing** | At least ¾ inch apart for 3-inch wafers, loading back-to-back |

### Process Control

Because polycrystalline silicon is so sensitive to etching plasmas, it can be processed most successfully under the close control provided by the Dionex 2000T, 8000T and the 9000 etcher/strippers. These are temperature-controlled plasma systems: they use a preheating step to make certain that all wafers, in all runs, have the same temperature and thermal history when etching begins. Information about these systems appear in *Product Bulletins 2000T/79, 8000T/79 and 9000/79.*

## Special Considerations

### Protecting Backs of Wafers

During any process for etching silicon wafers, the plasma must be restrained from attacking the backs of the wafers. There are two reasons for this. First, rapid etching of the wafer backs will heat the wafers, making process-control difficult. Secondly, the backs of the wafers will absorb large numbers of reagent particles. This will retard, in an uncontrollable way, the etching of the front surfaces of the wafers.

Four methods are available for protecting wafer backs: oxidizing, coating with photoresist, shielding with aluminum plates, or arranging the wafers so that they stand back-to-back during etching.

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# Stripping Wafers with Plasma

Plasma-stripping is a safe, fast and clean technique for removing positive or negative photoresist from wafers, chromium photoplates and other microelectronic workpieces that have been etched. Typical photoresist layers are about 1 micron thick, but plasma-stripping can remove layers as thick as 25 microns without difficulty.

Under production conditions, photoresist layers about 1 micron thick can be stripped in 15 to 40 minutes. Even very thick dry-film resists can be stripped in 30 to 40 minutes, using an oxygen/Freon plasma.

Several different stripping processes are used commercially. The most important are:

*Stripping with oxygen:* In this process, stripping is performed by a highly reactive oxidizing plasma. The plasma is created by ionizing industrial-grade oxygen. Oxygen plasmas are used for stripping photoresist from substrates that are relatively insensitive to oxidation. These substrates include silicon, silicon compounds, titanium, tungsten, tin and indium oxide.

*Stripping with oxygen and Freon:* Some photoresist layers are unusually thick or difficult to oxidize. Such layers can be stripped with oxygen, but the process is slow. They can be stripped more rapidly in a plasma formed from a mixture of oxygen and a fluorinated gas, such as Freon 14 ($CF_4$). Oxygen/Freon plasmas must be used carefully, because fluorine-bearing free radicals in the plasma can damage certain substrates, such as silicon nitride.

*Stripping with wet air:* In this process, the stripping plasma is formed by ionizing wet air—air that has been bubbled through water, so that it is saturated with moisture when it reaches the plasma reactor. A wet-air plasma is a much milder oxidizing agent than is an oxygen plasma or an oxygen/Freon plasma. Wet-air plasmas are used to strip substrates that would be damaged by the stronger plasmas. These substrates include chromium, gold and nichrome. Wet-air stripping is used widely in the production of chromium photoplates.

The remainder of this bulletin presents details about these three stripping processes.

## Stripping with Oxygen

### Operating Parameters

Here are typical values for process variables when wafers are stripped in an oxygen plasma.

*RF power*
500 watts for 8″x18″ reactor
700 watts or more for 10″x18″ reactor

*Vacuum pumping*
500 liters/minute (17 cu. ft./minute) for 8″x18″ reactor
675 liters/minute (23 cu. ft./minute) for 10″x18″ reactor

*Reactor pressure*
1 to 2 Torr in 8-inch reactor
1 to 2 Torr in 10-inch reactor

*Oxygen flow-rate*
Depends on reactor pressure:
300 milliliters/minute for 1 Torr
800 milliliters/minute for 2 Torr

*Reactor temperature*
100°C is the minimum for a commercial process. Generally, temperature needn't be closely controlled. It will rise as stripping progresses, and might reach 200° to 250°C by the end of the run.

*Time*
Under the conditions given here, a 1-micron layer of positive photoresist can be stripped from 100 2-inch wafers in about 20 minutes.

For 100 3-inch wafers under the same conditions, the time is about 35 minutes.

### Process Refinements

The speed and effectiveness of a stripping process can be improved substantially by two tactics:

- Preheating the wafers
- Dividing the stripping process into multiple steps, using different combinations of RF power and oxygen flow-rate.

### Advantage of Preheating Wafers

Stripping is accelerated significantly if the wafers are heated before stripping begins. Boats full of wafers can be heated in an oven before they are placed into the reactor. Or reactors can be equipped with infrared lamps that will heat the wafers to 200°–300°C as soon as the stripping plasma is established in the reactor, and will maintain this wafer temperature throughout the process. Such lamps, which can reduce stripping time by as much as 50%, are available as optional equipment on all Dionex etcher/strippers.

### Advantage of Multiple-Step Stripping

In principle, an increase in the flow-rate of oxygen to the plasma reactor should accelerate the stripping process. This certainly happens when a few wafers, widely spaced in the reactor, are stripped under experimental conditions. But in production situations, when the reactor holds 100 to 200 closely spaced wafers, a high flow-rate may retard effective stripping.

**Bulletin No. 73/79**

Here is the explanation for this. As the oxygen flow-rate increases, the pressure inside the reactor increases proportionally. The higher pressure inhibits the movement of reactive plasma particles in the spaces between wafers. The edges of the wafers will be stripped more rapidly, but the centers of the wafers will be stripped slowly and poorly.

Dionex has developed a technique for exploiting the advantages of a high oxygen flow-rate while avoiding its drawbacks. The stripping cycle is divided into two or three steps. In the first step, a high flow-rate and strong RF power are used for rapidly stripping the edges of the wafers. Then the flow-rate and the RF power are reduced, so that the centers of the wafers can be stripped quickly and thoroughly. Such a process can be significantly faster than one that uses a constant flow-rate and constant RF power.

*Example:* 100 3-inch wafers, spaced $^3/_{16}$ inch apart, were stripped in an 8-inch reactor. Each wafer carried a 1.5-micron layer of positive photoresist. With the optimal combination of oxygen pressure and RF power (2.0 Torr, 450 watts), stripping time was 34 minutes.

An identical batch of wafers was stripped by a two-step process: 15 minutes at 2.0 Torr and 450 watts; then 7 minutes at 0.5 Torr and 150 watts. This 22-minute process (15 minutes + 7 minutes) was just as effective as the 34-minute process that used a constant flow-rate and constant RF power.

The advantages of multiple-step stripping increase as the diameter of the wafers increases. In the conservative example given above, the time required to strip 3-inch wafers was reduced by about 35%. When 4-inch or 5-inch wafers must be stripped, a multiple-step process can reduce stripping time by 50% or more.

## Process Control

All Dionex etcher/strippers have automatic control units that govern the oxygen flow-rate, RF power, reactor pressure and processing time. Series 4000 etcher/strippers can execute single-step processes only. Series 8000 machines are designed for two-step processes, and Series 2000 for three-step processes. The Dionex 9000 is the newest and most advanced of the barrel plasma systems. It can store sixteen separate programs, each with up to sixteen individual steps.

## Advanced Automation: DPS-1000

All Dionex etcher/strippers can be equipped with the DPS-1000 stripping-controller. This is a proprietary Dionex device that monitors the progress of stripping reactions, and automatically stops the process when all of the wafers have been stripped completely. Here is how it works:

During stripping, photoresist is oxidized to gaseous reaction products, including hydrogen compounds. These products are converted to plasma, and the hydrogen in this plasma emits light at about 6560 angstroms. DPS-1000 measures the concentration of reaction products in the reactor by measuring the intensity of this light. When the intensity reaches a stable minimum, stripping is complete. DPS-1000 then turns off the plasma and sounds an alarm.

DPS-1000 brings unprecedented accuracy and economy to stripping operations. It automatically and precisely accommodates run-to-run variation in the number of wafers being stripped, and in the amount of photoresist on each wafer; and it reduces process time to an absolute minimum.

During each run, DPS-1000 prints a curve that shows how the intensity of light from the pertinent reaction products changes with time. Figure 1 shows a representative curve. When stripping begins, the optical signal quickly rises to a maximum. As photoresist is removed from the wafers, the intensity falls. After about 10.5 minutes of stripping (in the process depicted here), it has stabilized at a minimum, positive value that represents background light from the stripping plasma. DPS-1000 then turns the stripping plasma off, and light intensity falls to zero.

DPS-1000 is so precise that it can monitor the stripping of a single wafer, or of batches as large as 300 wafers.

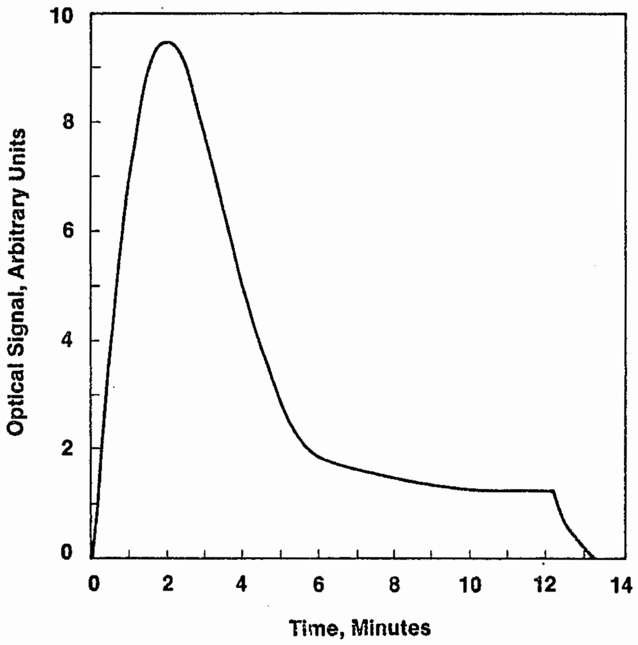

**Figure 1**

**Concentration of oxidation products in a reactor during a stripping process. This figure is a redrawing of a record produced by a DPS-1000 stripping-controller. The ordinate shows the intensity of light (at about 6560 angstroms) from hydrogen atoms in the oxidation products.**

## Stripping in the Etch-Tunnel

The Etch-Tunnel cylinder is a proprietary Dionex product that is used widely in plasma-etching processes. It is a perforated metal cylinder that protects workpieces from ions and radiation created by the etching plasma. It thus prevents local overheating of the workpieces, and enhances across-wafer and wafer-to-wafer uniformity. The cylinder is described fully in *Product Bulletin 7501*.

The Etch-Tunnel cylinder retards stripping. Wafers usually are removed from the cylinder before they are stripped. But in some cases, it is desirable to leave the wafers inside the cylinder during stripping. There are two reasons for doing this:

*Vulnerable workpieces:* During the stripping of very sensitive workpieces, the cylinder shields the workpieces from ions and radiation associated with the stripping plasma. In other words: the cylinder performs the same function during stripping that is performed during etching.

*Convenience:* If workpieces have been housed in an Etch-Tunnel cylinder during etching, it will be convenient to leave them in the cylinder during stripping—even if the workpieces could tolerate exposure to ions and radiation. This eliminates the need to open the reactor or handle the workpieces before stripping them.

### Stripping Vulnerable Workpieces

Here are typical values for process variables when vulnerable workpieces are stripped inside an Etch-Tunnel cylinder. Under these conditions, no plasma will exist inside the cylinder, and no ions or radiation will reach the workpieces.

*RF power*
200 to 300 watts for 8-inch reactor

*Vacuum pumping*
500 liters/minute (17 cu. ft./minute) from each reactor

*Reactor pressure*
1.5 Torr, minimum

*Oxygen flow-rate*
650 milliliters/minute

*Time*
Stripping a 1-micron layer of photoresist from 50 3-inch wafers, in an 8-inch reactor, takes about 30 minutes. (Without the Etch-Tunnel cylinder, the same stripping could be performed in 12 to 15 minutes.)

### Stripping Tolerant Workpieces

Here are typical operating parameters for stripping, in an Etch-Tunnel cylinder, workpieces that can tolerate exposure to ions and radiation generated by the stripping plasma. Under these conditions, some plasma will exist inside the cylinder.

*RF power*
400 to 500 watts for 8-inch reactor

*Vacuum pumping*
500 liters/minute (17 cu. ft./minute) for 8″x18″ reactor
675 liters/minute (23 cu. ft./minute) for 10″x18″ reactor

*Reactor pressure*
0.5 to 0.7 Torr

*Oxygen flow-rate*
100 milliliters/minute

*Time*
Under these conditions, stripping a 1-micron layer of photoresist from 50 3-inch wafers takes about 20 minutes.

## Stripping with Oxygen and Freon

### Applications

A plasma made from a mixture of oxygen and Freon 14 ($CF_4$) can oxidize photoresist more quickly than a pure-oxygen plasma can. The time required for stripping typical photoresists with oxygen/Freon is less than 50% of the time needed for stripping the same photoresists with oxygen alone.

Oxygen/Freon stripping is used most often for:

- Stripping very thick photoresist layers—e.g., dry-film photoresists as thick as 25 microns.
- Removing photoresist that has been toughened by long exposure to etching plasmas that contain halogens—e.g., fluorine-bearing plasmas, and the chlorinated plasma that is used in the Dionex DryAl process for etching aluminum. These plasmas can toughen photoresist by cross-linking and halogenating its surface.

Oxygen/Freon stripping plasmas must be used carefully, because they attack exposed substrates, such as silicon and its compounds. This hazard can be minimized by choosing an appropriate ratio of Freon to oxygen. Figure 2 shows how the etching rates of silicon, $SiO_2$ and $Si_3N_4$ depend on the percentage of Freon in the reagent gas mixture. When the percentage is 30% or less, etching rates are so low that they are negligible for most practical purposes. A mixture containing 30% Freon is used widely in commercial stripping processes.

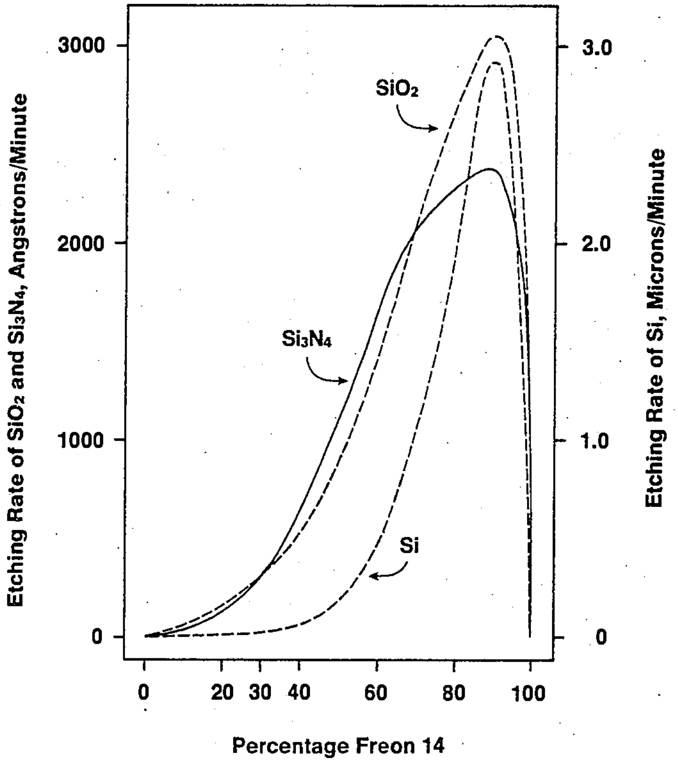

**Figure 2**
**Etching rates of silicon and silicon compounds in plasmas formed from different mixtures of oxygen and Freon 14 ($CF_4$). Reactor pressure is 1.0 Torr, and RF power is 300 watts. The materials tested aren't etched vigorously if the Freon percentage is 30% or less.** *These curves are based on experiments by S. Iwamatsu and K. Hirobe of Hitachi, Ltd.*

### Process Refinements and Control

All of the process-refinement and process-control information given under *Stripping with Oxygen* applies to stripping with oxygen and Freon.

### Stripping in the Etch-Tunnel Cylinder

The role of the Etch-Tunnel cylinder in stripping was described above, under *Stripping with Oxygen*. When workpieces are stripped inside a cylinder, the advantages of using an oxygen/Freon mixture are especially dramatic. In typical cases, the time required for stripping photoresist with an oxygen/Freon plasma is about 25% of the time needed for stripping the same photoresist with oxygen alone.

## Stripping with Wet Air

### Operating Parameters

The suggestions given here apply to the processing of chromium photoplates. These are the substrates most often stripped in wet-air plasmas. For suggestions about the stripping of gold, nichrome or less common substrates, please contact the Dionex headquarters in Hayward, California.

Here are typical values for process variables when photoplates are stripped in a wet-air plasma.

*RF power*
500 to 600 watts for 10-inch reactor
650 to 750 watts for 12-inch reactor

*Vacuum pumping*
500 liters/minute (17 cu. ft./minute) for 8"x18" reactor
675 liters/minute (23 cu. ft./minute) for 10"x18" reactor
880 liters/minute (30 cu. ft./minute) for 12"x18" reactor

*Reactor pressure*
1 to 2 Torr in 10-inch reactor
1 to 2 Torr in 12-inch reactor

*Wet-air flow-rate*
1000 milliliters/minute

*Reactor temperature*
Chromium photoplates—and most of the other substrates that require wet-air plasmas—cannot tolerate strong heating. The substrate temperature should be held between 80° and 100°C during the entire process. Overheating can cause two problems: chemical degradation of the substrate, and loss of substrate material by oxidation and vaporization.

*Time*
In a reactor 20 inches long and 12 inches in diameter, loaded with 10 square 4-inch chromium photoplates, the time required to remove a 1-micron layer of positive photoresist is about 15 minutes. Stripping time is minimized when the photoplates stand parallel to the long axis of the reactor.

### Process Control

All Dionex etcher/strippers can execute wet-air stripping processes in which RF power, reactor pressure, wet-air flow-rate and stripping time are controlled automatically. Series 4000 etcher/strippers can perform one-step processes only. Series 8000 machines are designed for two-step processes, and Series 2000 for three-step processes. The advanced, fully programmable, Dionex 9000 is capable of storing up to sixteen complete programs, each with up to sixteen individual steps.

The Dionex DPS-1000 stripping-controller, described earlier in this bulletin, *cannot* be used during wet-air stripping.

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# De-Scumming Wafers with Plasma

De-scumming removes photoresist residue (scum) from exposed parts of a workpiece, before the workpiece is etched. Typical residues are less than 0.1 micron (1000 angstroms) thick. A plasma usually can remove such residues in less than 1 minute.

De-scumming is most effective and least expensive when it is a part of the etching process. Wafers are loaded into the plasma reactor and de-scummed in an oxygen plasma. Then the oxygen is turned off automatically, and the etching plasma is established. This automatic, sequential processing eliminates handling and contamination of the wafers between the de-scumming and etching steps.

## Operating Parameters

Here are typical parameters for de-scumming 50 3-inch wafers in an 8-inch plasma reactor, during a sequential process that includes de-scumming and etching. The wafers are inside a Dionex Etch-Tunnel cylinder.* The cylinder isn't needed during de-scumming: de-scumming times are so short that the wafers can't become overheated. But it usually is convenient to have the wafers in a cylinder during de-scumming, so that they can be etched as soon as de-scumming is completed. This tactic obviously must be used when wafers are de-scummed and etched by an automated sequential process.

*Reagent gas*
industrial-grade oxygen

*Temperature*
100°C

*RF power*
150 watts

*Oxygen flow-rate*
100 milliliters/minute

*Reactor pressure*
0.6 Torr

*Vacuum pumping*
500 liters/minute (17 cu. ft./minute) from each reactor

*Time*
about 1 minute

## Process Control

De-scumming must be controlled very closely. If the process lasts too long, the oxygen plasma can alter photoresist patterns—especially in regions near the edges of the wafers. This can seriously reduce across-wafer uniformity.

Generally, it is advantageous to preheat wafers before de-scumming them. This can be done best by an inert-gas plasma; nitrogen is the gas used most often. The wafers are loaded into the reactor and the nitrogen plasma is turned on. When the wafers reach the desired de-scumming temperature, the nitrogen plasma is extinguished automatically and an oxygen plasma is established; this plasma de-scums the wafers for a selected period of time.

By ensuring that all of the wafers—in all runs—are at the same temperature when de-scumming begins, this preheating makes de-scumming a highly reproducible, controllable process.

Preheating always is necessary during the de-scumming of wafers and photoplates that carry dense, sub-micron patterns formed by electron-beam methods.

When preheating is used, de-scumming becomes a two-step process. Such a process can be performed automatically and reliably in the Dionex 8000T etcher/strippers. These machines were designed specifically for two-step processes that include preheating with an inert-gas plasma.

Two-step de-scumming can be combined with etching in an automatic three-step process, using Dionex 2000T etcher/strippers.

The Dionex 9000, the most advanced barrel plasma system available, is capable of storing sixteen complete and separate programs, each with up to sixteen individual steps. De-scumming can easily become an automatic step in any or all of these programs.

All Dionex etcher/strippers have control units that govern all process parameters during each step in a sequential process.

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***The Etch-Tunnel cylinder is a proprietary Dionex product for improving plasma-etching processes. It is a perforated metal cylinder that protects wafers from ions and radiation created within the etching plasma. This enhances greatly the across-wafer and wafer-to-wafer uniformity of the etched wafers. The cylinder is described fully in** ***Product Bulletin 7501*****.**

**Bulletin No. 77/79**

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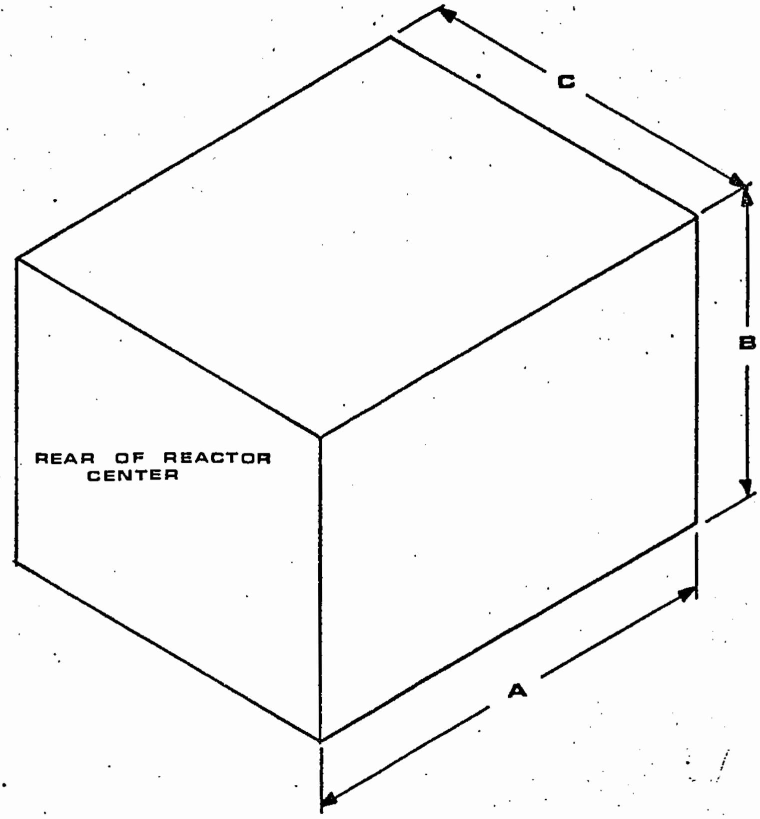

| REACTOR DIMENSIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| PM | A | B | C | WEIGHT (LBS)<br>NET | GROSS | WEIGHT (KGS)<br>NET | GROSS |
| 248 | 23 1/2 (597) | 14 1/2 (368) | 31 3/4 (806) | 80 | 95 | 36 | 43 |
| 448 | 23 1/2 (597) | 14 1/2 (368) | 39 (991) | 125 | 140 | 57 | 64 |
| 1-8×13 | 33 (838) | 20 1/2 (521) | 36 1/2 (927) | 200 | 235 | 91 | 107 |
| 2-8×13 | 33 (838) | 20 1/2 (521) | 53 (1,346) | 250 | 270 | 113 | 122 |
| 1-8×20 | 33 (838) | 20 1/2 (521) | 36 1/2 (927) | 200 | 235 | 91 | 107 |
| 2-8×20 | 33 (838) | 20 1/2 (521) | 53 (1,346) | 250 | 270 | 113 | 122 |
| 1-10×20 | 33 (838) | 20 1/2 (521) | 36 1/2 (927) | 200 | 235 | 91 | 107 |
| 2-10×20 | 33 (838) | 20 1/2 (521) | 53 (1,346) | 300 | 340 | 136 | 154 |
| 1-10×30 | 47 (1,194) | 20 1/2 (521) | 36 1/2 (927) | 265 | 300 | 120 | 136 |
| 2-10×30 | 47 (1,194) | 20 1/2 (521) | 53 (1,346) | 400 | 450 | 181 | 204 |
| 1-12×20 | 39 (991) | 25 (635) | 43 1/2 (1,105) | 375 | 415 | 170 | 188 |
| 1-14×20 | 39 (991) | 25 (635) | 43 1/2 (1,105) | 375 | 415 | 170 | 188 |
| 1-16×30 | 42 7/8 (1,089) | 22 1/2 (572) | 42 3/4 (1,086) | 385 | 450 | 175 | 204 |
| | | | | | | | |
| 9000<br>1-10×20 | 33 (838) | 21 3/4 (552) | 45 (1,143) | 275 | | 125 | |
| 1-12×30 S | 47 (1,194) | 23 (584) | 35 (889) | 150 | | 68 | |

1. DIMENSIONS A THRU C ARE IN INCHES; DIMENSIONS IN PARENTHESES ARE IN MILLIMETERS AND ARE FOR REFERENCE ONLY.

2. ALL GAS CONNECTIONS ARE MADE TO REAR OF MODULE.

3. ALL GAS INLETS HAVE A MAXIMUM PRESSURE RATING OF 40 PSIG AND OPERATING PRESSURE RATING OF 5 TO 10 PSIG.

4. GAS CONNECTIONS ARE MADE BY THE 1/4" TUBE NUT PROVIDED.

5. EXHAUST FAN OUTLET 4" O.D.

6. MINIMUM REAR CLEARANCE 8".

7. AC POWER DERIVED FROM RF GENERATOR.

8. A 1/4" AIR LINE WITH 60 - 100 PSI OF DRY AIR OR NITROGEN IS REQUIRED TO OPERATE CHAMBER EXHAUST.

9. VACUUM HOSE LENGTH 6 FT.

10. ALL WEIGHTS ARE APPROXIMATE.

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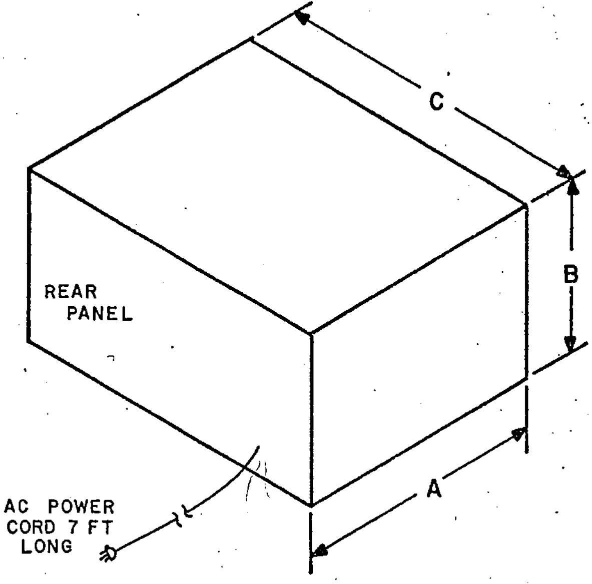

| RF GENERATOR SPECIFICATIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DIMENSIONS | | | | POWER REQUIRED | | | | RATED OUTPUT PWR |
| PM | A | B | C | AC VOLTS | PHASE | FL AMP | PLUG CAP | WATTS |
| 119/118 | 16 1/4 | 11 7/8 | 21 1/4 | 117 V | 1 Ø | 15 | NEMA 5-15 P | 0-500 |
| 101 C/102 C | 20 | 14 | 37 | 208/240 V | 1 Ø | 16 | NEMA L6-20 P | 0-1000 /0-1500 |
| 104C/105 D | 19 | 7 1/4 | 13 1/2 | 117 V | 1 Ø | 12 | NEMA 5-15 P | 0-150/0-300 |
| PM 112 | 20 | 14 | 25 | 208/240 | 1 Ø | 31 | HUBBEL 7763 | 0-1500 |
| | | | | | | | | |

1 DIMENSIONS IN INCHES
2 CABLE INTERCONNECTION ARE MADE TO REAR OF MODULE
3 A CLEARANCE OF 10" MUST BE LEFT BEHIND THE GENERATOR FOR AIR FLOW TO AND FROM THE INTERNAL COOLING FAN