E L E C T R O N I C   M A I L

Title: Technical Tip on Valleylab ESU's
From: Eleazar J. Belen
To: Technical Personnel Sent: 08/13/92

PROBLEM: Low output wattage reading on a Valleylab SSE2L ESU as per RF302 Electrosurgery Analyzer.

If you get a call from a district with the same problem as above, ask them to check the line voltage first (The safety analyzer should give them a fairly accurate reading). Every one (1) VOLT drop difference from 120V is equivalent to a 10-watt drop on your ESU output. For instance, if the line voltage is 115V instead of 120V, your ESU output will be 50 watts lower.

One interesting situation is when the line voltage in your bench is 120V while the district's is lower and you tell them there's nothing wrong with the unit. That's a situation you'd rather not be in (but of course you know how to handle it now).

Zar

Force 2

Electrosurgical
Generator

800-255-8522 - Steve George

Service Manual

Has isolated input

Valleylab

FORCE 2

SERVICE MANUAL

110 V

The following service instructions are for use only by qualified personnel to repair and service the equipment described in this manual.

Caution: Federal (USA) law restricts this device to sale by or on the order of a physician.

Effective Date: October, 1989

Valleylab Part Number: 945 100 111 B

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INTRODUCTION

This Service Manual covers the installation and basic service instructions for the Force 2 Electrosurgical Generator. Also included are sections covering the Technical Specifications, Circuit Descriptions and the Testing of the generator. Instructions for use and cautions and warnings concerning electrosurgery are beyond the scope of this manual. The reader is directed to the Force Instruction Manual supplied with the generator.

Valleylab, its dealers and representatives reserve the right to make changes in equipment built and/or sold by them at any time without incurring any obligation to make the same or similar changes on equipment previously built and/or sold by them.

SECTION 1

INSTALLATION

INSTALLING THE FORCE 2

The compact size of the Force 2 system allows a variety of installations. The generator may be placed on the mounting cart available from Valleylab, or on any convenient and sturdy table or cart. At high power settings considerable power is dissipated within the generator and it is important that the vents on the bottom and sides remain unobstructed for proper cooling. For this reason the Force 2 should not be installed in a closely fitting cabinet or cart which might restrict the free circulation of air. Under continuous use for extended periods of time, it is normal for the top and rear panel to feel warm to the touch.

POWER FOR THE FORCE 2

95 – 140 VAC, 50/60 Hz

The Force 2 is designed to operate over a wide range of input voltages within specified output regulation. In case of brownouts or power surges the output of the Force 2 will remain constant.

PROPER GROUNDING

An important consideration in assuring patient safety while using electrical equipment is proper grounding. The ground wire in the power cord is connected to the generator chassis and insures that no dangerous currents will flow from the cabinet of the generator in the event of an internal electrical failure. Undesirable 50/60 Hz leakage currents are also affected by the polarization of the input 50/60 Hz power to the generator. It is the responsibility of the user to assure proper grounding and polarity in the power outlets furnishing power to the Force 2.

POWER PLUG

The Force 2 is shipped with an approved Hospital Grade three–prong connector. This connector meets all requirements for safe grounding. Its purpose should not be defeated by using extension cords or 3–prong to 2–prong adapters. The connector should be periodically inspected by qualified service personnel. Cords should always be grasped by the plug. DO NOT PULL ON THE CORD ITSELF.

ROUTINE MAINTENANCE AND INSPECTIONS

We recommend that the Force 2 be inspected by qualified service personnel twice a year. This Service Manual describes the recommended inspection, testing and calibration procedures. For major repairs the Force 2 can be returned to Valleylab. If desired, Valleylab will supply any parts or information needed to repair the Force 2.

CLEANING INSTRUCTIONS

Use a mild detergent and damp cloth to clean the generator cover, keyboard and cord. The generator is not sterilizable. Do not allow fluids to enter the chassis.

SECTION 2

DESCRIPTION OF CONTROLS, INDICATORS, AND RECEPTACLES

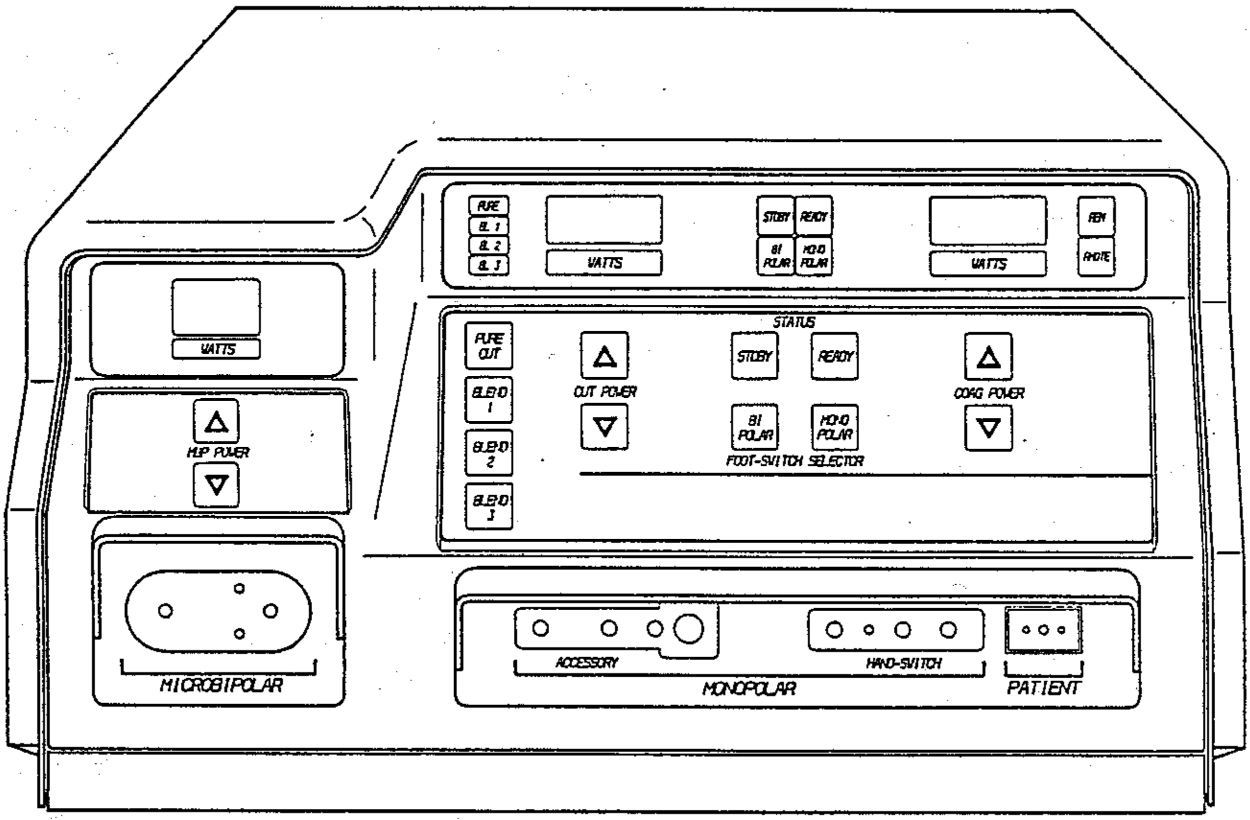


Figure 1

Front Panel

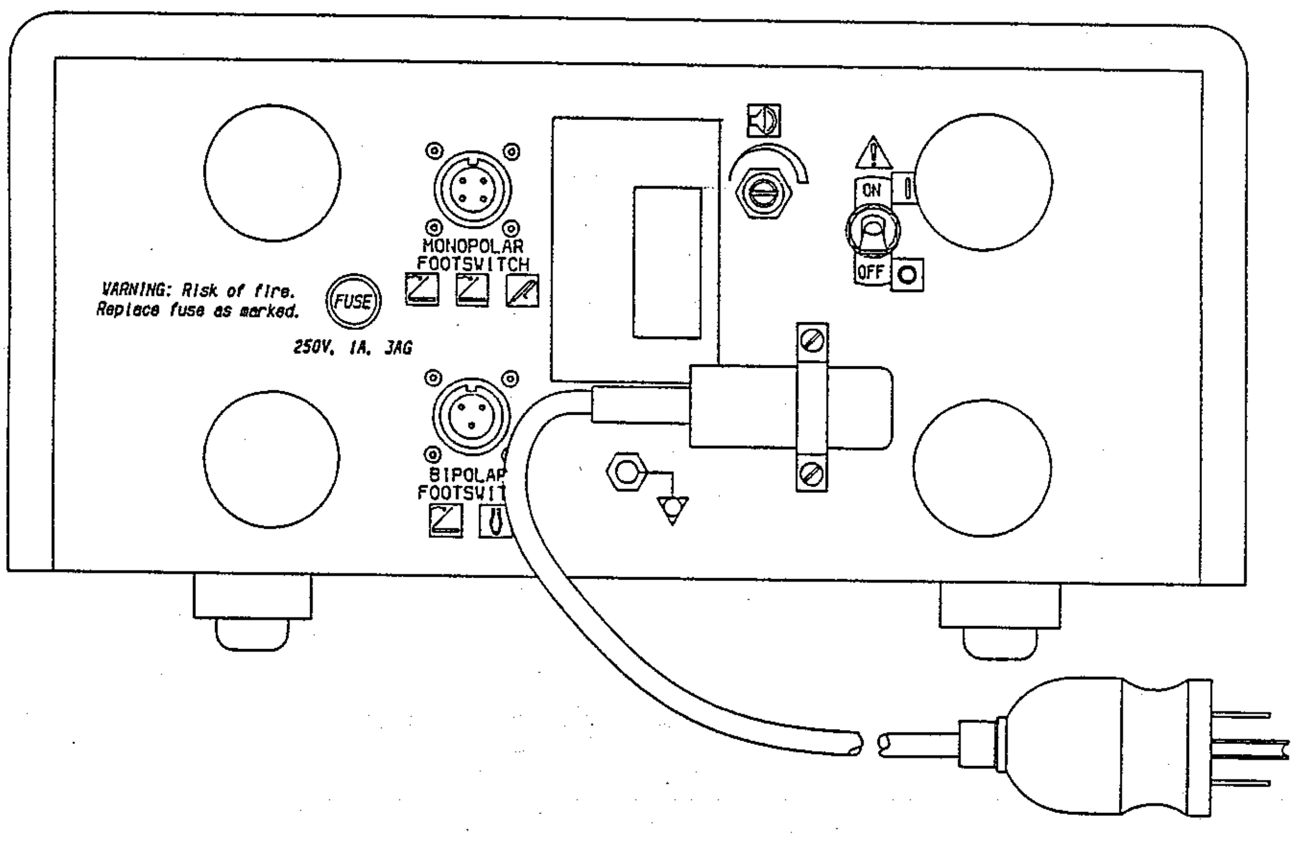


Figure 2

Rear Panel

CONTROLS

Standby – Depressing this button places the electrosurgical generator in a hold mode. The generator cannot be activated and all audio alarms are silenced. Power settings are retained in memory and the display shows "dashes".

Ready – Depressing this button places the generator into service with power outputs, displays and alarms fully functional.

Monopolar – Selects monopolar footswitch control for activating ACCESSORY output

Bipolar – Selects bipolar output when using the monopolar footswitch.

Up – Increases power in the selected mode. A single depression of the key increases the power setting by one watt. Continuous depression gradually increases the power to maximum.

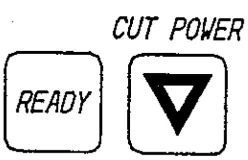
Down – Decreases power in the selected mode. A single depression lowers the power setting by one watt. Continuous depression gradually decreases the power to minimum.

Cut – Selects pure cut with lowest level of hemostasis.

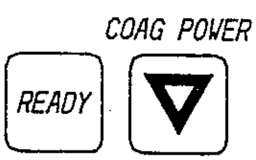
Blend 1 – Selects cut with minimum hemostasis.

Blend 2 – Selects cut with average hemostasis.

Blend 3 – Selects cut with maximum hemostasis.



Power Control Pencil Mode – The Power Control Pencil feature does not have a dedicated button to access (illuminate) this mode. A two-step procedure is required.

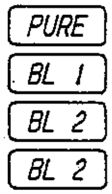


Low Voltage Coag – Low Voltage Coag does not have a dedicated button to access (illuminate) this mode. A two-step procedure is required. For a detailed explanation of the Low Voltage Coag mode, refer to the Instruction manual.

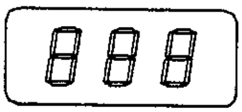
INDICATORS

Standby Indicator – Indicates generator is on, but cannot activate outputs.

Ready Indicator – Indicates generator is ready for use.

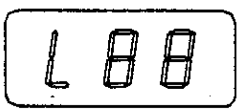


Cut Mode Indicators – One of four CUT mode indicators is illuminated to show the selected Cut mode.



Power Setting Display – The digital power setting display is visible on the generator in the Ready mode. The number displayed indicates the nominal power, in watts, which will be delivered to the patient when the mode is activated. In Standby mode "dashes" are displayed.

Output Power Indicators – The indicator labeled "Watts" illuminates when that output power (Cut, Coag, Bipolar) has been activated by the surgeon. One of the two distinct mode indicator tones will sound in conjunction with the visual output power indicator.



Low Voltage Coag Mode Indicator – An "L" in the hundreds digit of the Coag Power Setting Display indicates that the Low Voltage Coag mode has been selected.

Bipolar Indicator – This indicator is illuminated when the generator's Monopolar footswitch control is selected to activate the Bipolar output.

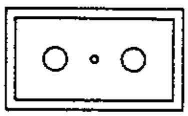
Monopolar Indicator – This indicator is illuminated when the generator's monopolar footswitch is selected for Monopolar Accessory activation.

Remote Indicator – This lamp will illuminate and the audio alarm will sound once when the remote power change feature is activated. When this indicator is illuminated, power changes can be made using the Power Control handswitching pencil.

ALERTS

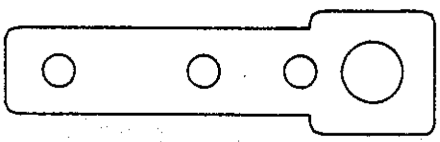
REM™ Fault Indicator – This indicator illuminates when the patient contact quality monitoring system senses that contact between the patient return electrode and the patient is not adequate. The audio tone will sound twice when the condition is first detected. The generator will not produce output power when this alarm condition exists. The alarm condition is cleared when the REM™ system senses that the patient/pad contact resistance is within the acceptance range.

RECEPTACLES



PATIENT

Patient Return Electrode Receptacle – This 2–pin receptacle accepts the patient return electrode connector used in monopolar procedures. The receptacle will accept both REM™ (dual–section) and conventional patient return electrode connectors.

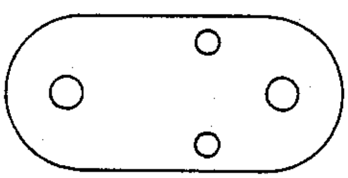


ACCESSORY

Monopolar Active Receptacle (Accessory) – This receptacle has two output jacks. It will accept 3–pin handswitching active accessories or standard 1–pin accessories which can be activated by the monopolar footswitch. Cut and Coag modes may be activated at this receptacle. The handswitching pencil can be footswitch activated when connected to this output jack. Caution: DO NOT connect more than one device to the ACCESSORY output receptacle. Both output jacks (3–pin and 1–pin) will activate simultaneously.

HAND-SWITCH

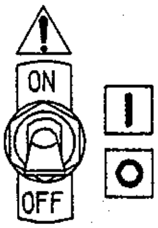
Monopolar Active Receptacle (Handswitch) – This receptacle will accept the 3–pin handswitching active accessories. Power output from this receptacle is activated only by using the handswitch mechanism. No power is available through use of the footswitch. Cut and Coag modes may be activated at this receptacle. Note: The Power Control pencil is only functional through this jack.



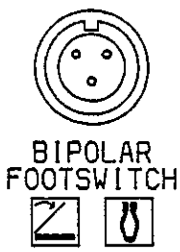
MICROBIPOLAR

Bipolar Active Receptacle – This receptacle will accept 3–pin handswitching bipolar accessories. These accessories can also be footswitch activated. This receptacle will also accept 2–pin bipolar footswitching accessories.

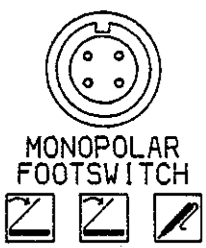
REAR PANEL FUNCTIONS



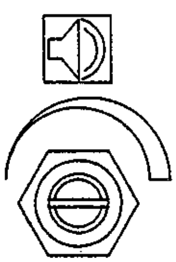
ON/OFF Switch – This switch includes a circuit breaker. Press the toggle upward to turn power on and down to shut power off.



Bipolar Footswitch Receptacle – This 3–pin receptacle accepts a single–treadle Bipolar footswitch connector.



Monopolar Footswitch Receptacle – This 4–pin receptacle accepts a two–treadle Monopolar footswitch connector.



Audio Volume Control – The volume of the Cut, Coag, and Bipolar mode indicator tones produced when the generator is activated may be adjusted with this control. The volume of the audio alarm for alert conditions is not adjustable.

SECTION 3

TECHNICAL SPECIFICATIONS

OUTPUT WAVEFORM

Cut	500 kHz sinusoid
Blend 1	500 kHz bursts of sinusoid at 50% duty cycle recurring at 31 kHz
Blend 2	500 kHz bursts of sinusoid at 37.5% duty cycle recurring at 31 kHz
Blend 3	500 kHz bursts of sinusoid at 25% duty cycle recurring at 31 kHz
Coag	500 kHz damped sinusoidal bursts with a repetition frequency of 31 kHz
Low Volt Coag	500 kHz bursts of sinusoid at 25% duty cycle recurring at 31 kHz
Bipolar	500 kHz sinusoid, unmodulated

OUTPUT CHARACTERISTICS

Mode	Maximum (open circuit) P–P Voltage	Rated Load (Ohms)	Nominal Power (at Rated Load) (Watts)	Crest Factor at Rated Load (typical*)
Cut	3000	300	300	2.1 @ 100W
Blend 1	3500	300	250	3.4 @ 100W
Blend 2	3700	300	200	3.9 @ 100W
Blend 3	4000	300	150	4.7 @ 100W
Coag	7000	300	120	8.5 @ 50W
Low Volt Coag	4000	300	99	4.7 @ 100W
Bipolar	800	100	70	2.0 @ 40W

Power readouts agree with actual power into rated load to within ± 15% or 5 watts, whichever is greater.

LOW FREQUENCY LEAKAGE (50/60 Hz)

Source current, patient leads, all outputs tied together.

Normal polarity, intact chassis ground – < 10 microamperes

Normal polarity, ground open – < 100 microamperes

Reverse polarity, ground open – < 100 microamperes

Sink current, 140V applied, all inputs – < 150 microamperes

Chassis source current, ground open: < 110 microamperes

HIGH FREQUENCY RISK PARAMETERS

Bipolar RF leakage current: < 150 milliamperes.

Monopolar RF leakage current: < 150 milliamperes.

REM CONTACT QUALITY MONITOR

Measurement Frequency: 140 kHz + 10 kHz

Measurement Current: 1.5 mA + 0.5 mA

Acceptable Resistance Ranges:

Single–area pad – nominally < 20 ohms

Dual–area REM™ – nominal range 5 – 135 ohms

If impedance measured is outside the acceptance range, a REM™ fault condition will occur. In the REM™ mode, if resistance increases by more than 40% above the reference value, or above 135 ohms, an alarm will be generated.

AUDIO VOLUME

The mode indicator tones are adjustable to a maximum level of 65 dba at 1 meter. The alarm tones are not adjustable.

INPUT POWER SOURCE

Full regulation range of 95 – 140 VAC. The frequency of the line may vary from 45 to 65 Hz.

Current:	Idle – 0.4 A, max	Power:	Idle – 50 W, max
	Cut – 6 A, max		Cut – 700 W, max
	Coag – 3 A, max		Coag – 300 W, max
	Bipolar – 1.5 A, max		Bipolar – 180 W, max

LINE REGULATION

Between 90 and 140 volts input, output power into nominal load will vary no more than 5% or 5 watts, whichever is greater.

WEIGHT

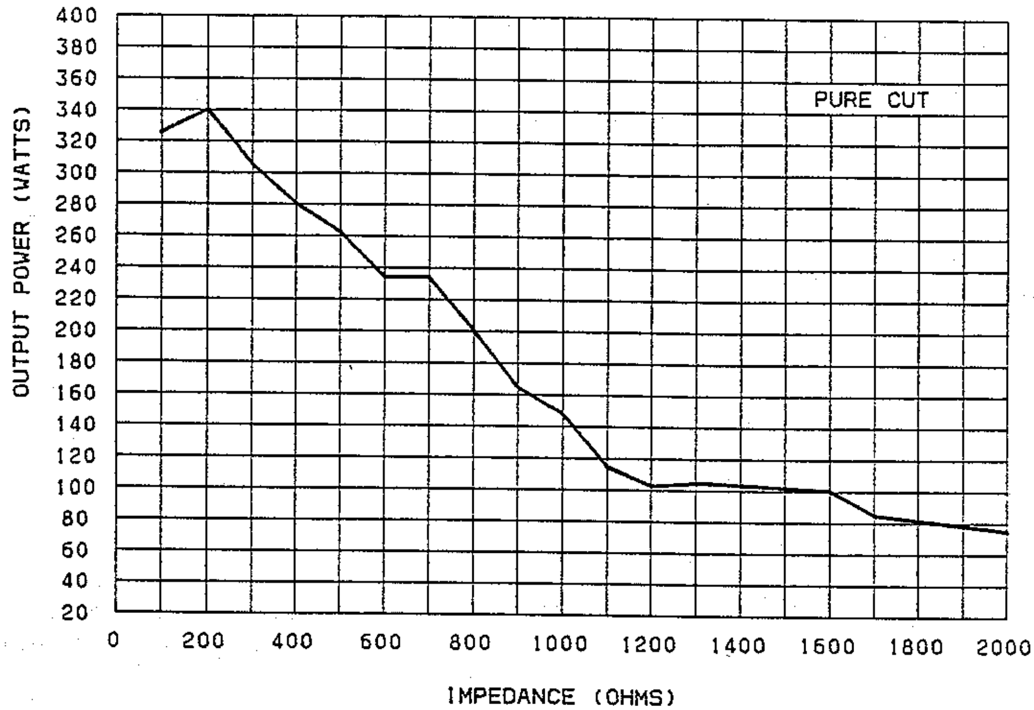
23 lbs., 10.4 kg

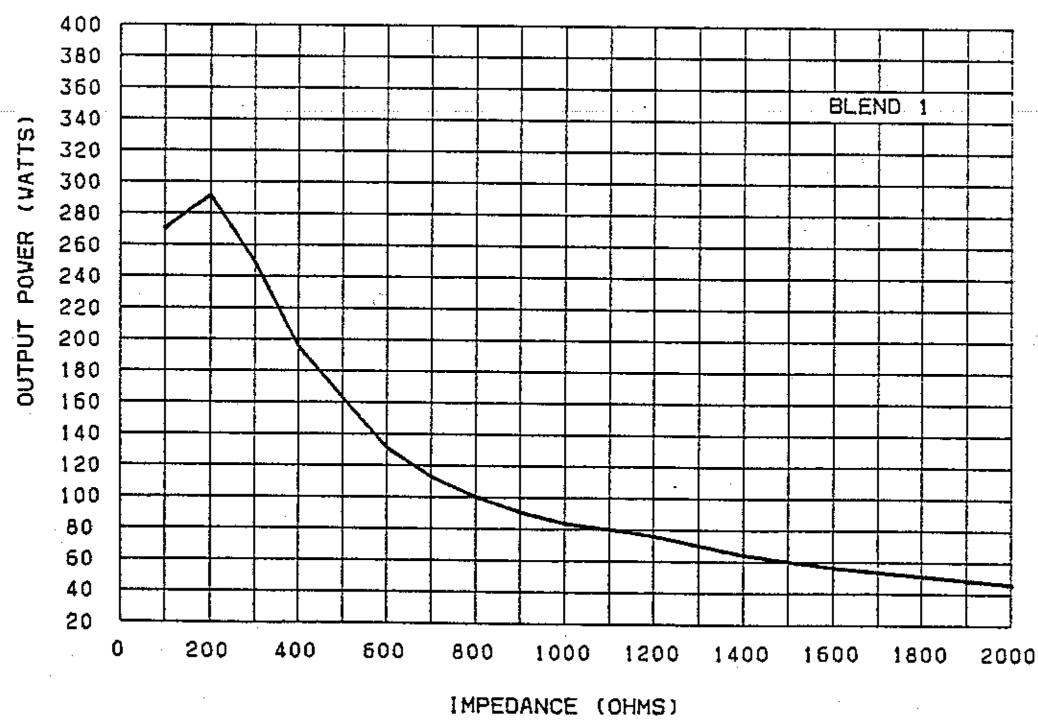
SIZE

8 x 13 x 21 inches, 20 x 33 x 53 cm

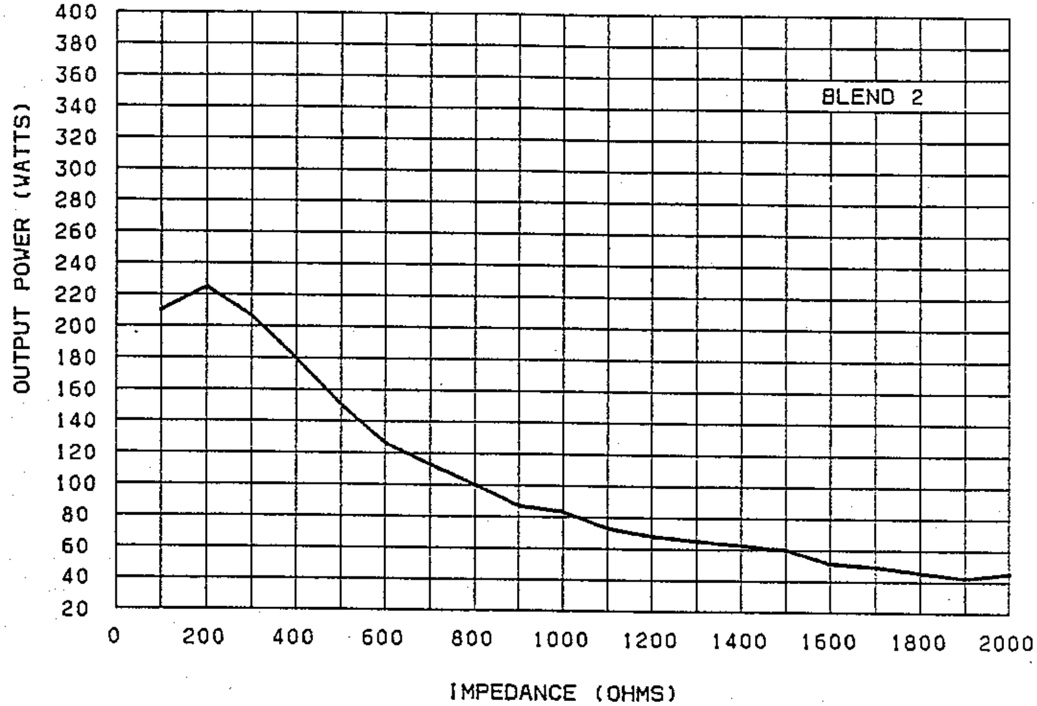
Specifications subject to change without notice.

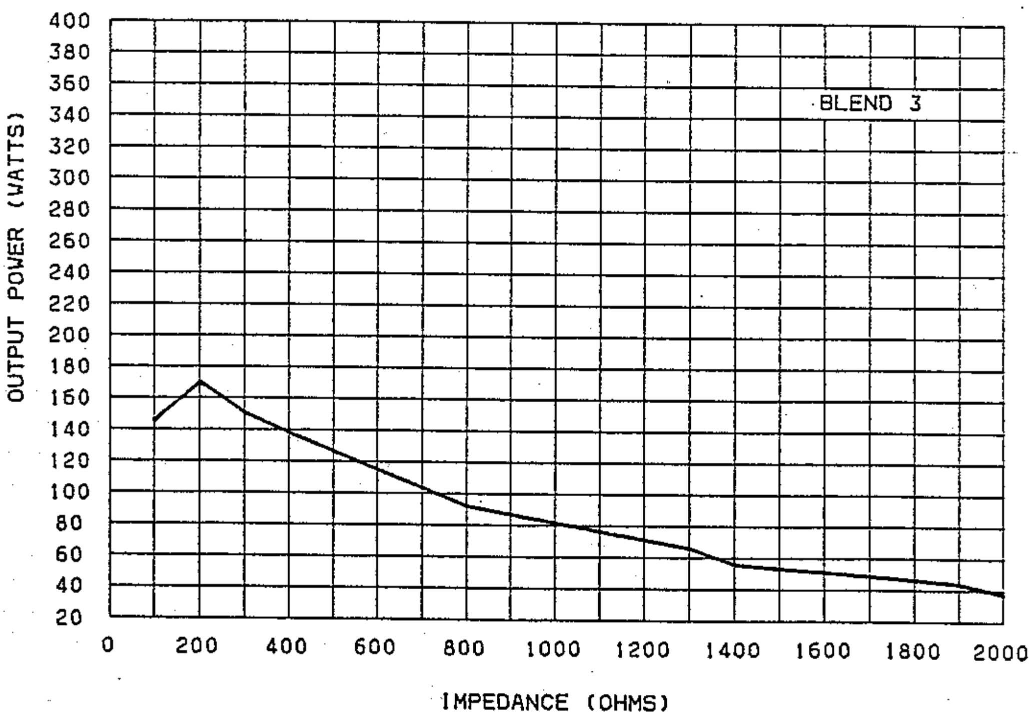
*In this section "typical" refers to a specification that is within 20% of a stated value.



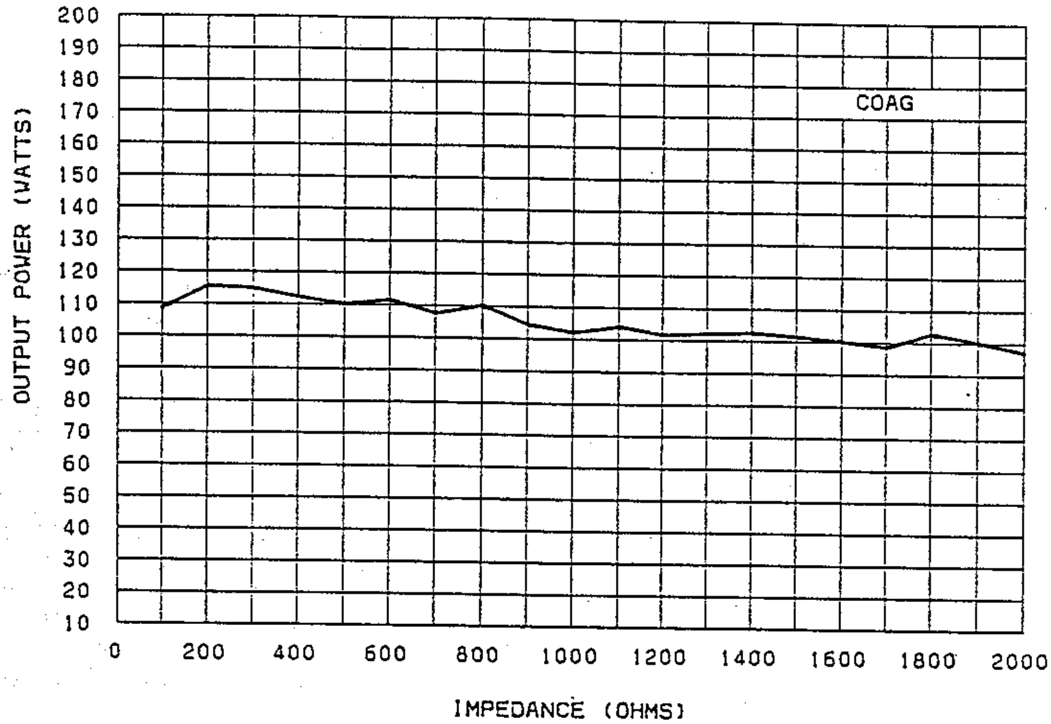


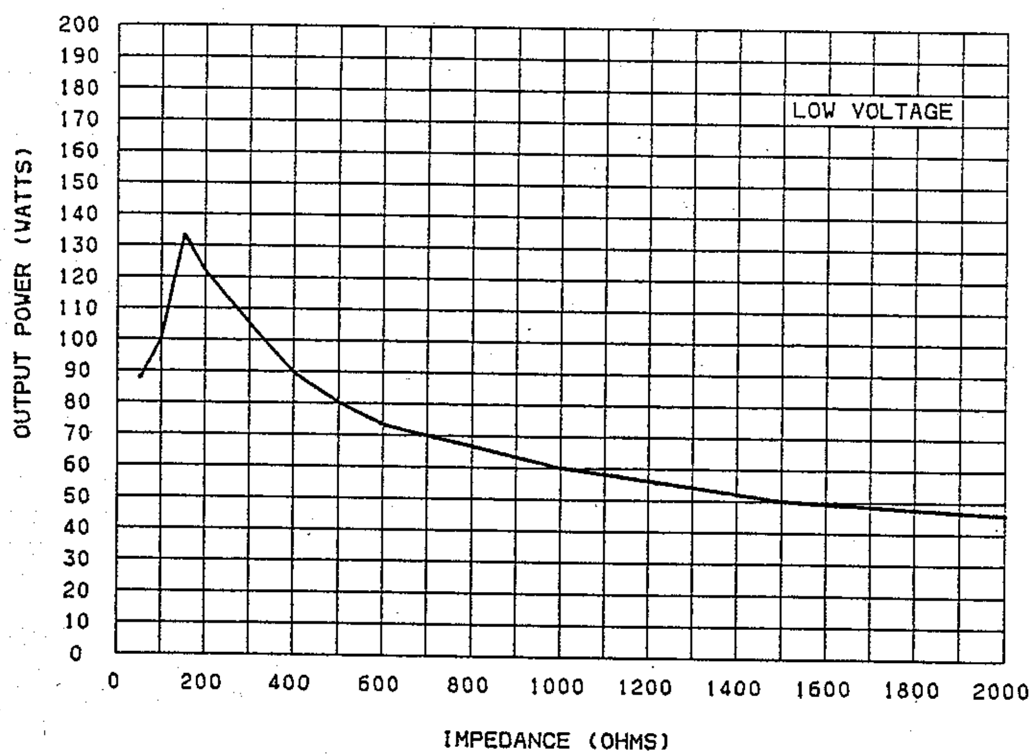
Typical Output Power vs Load – Monopolar Cut Modes


BLEND 2
OUTPUT POWER (WATTS)
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
200
400
600
800
1000
1200
1400
1600
1800
2000
IMPEDANCE (OHMS)

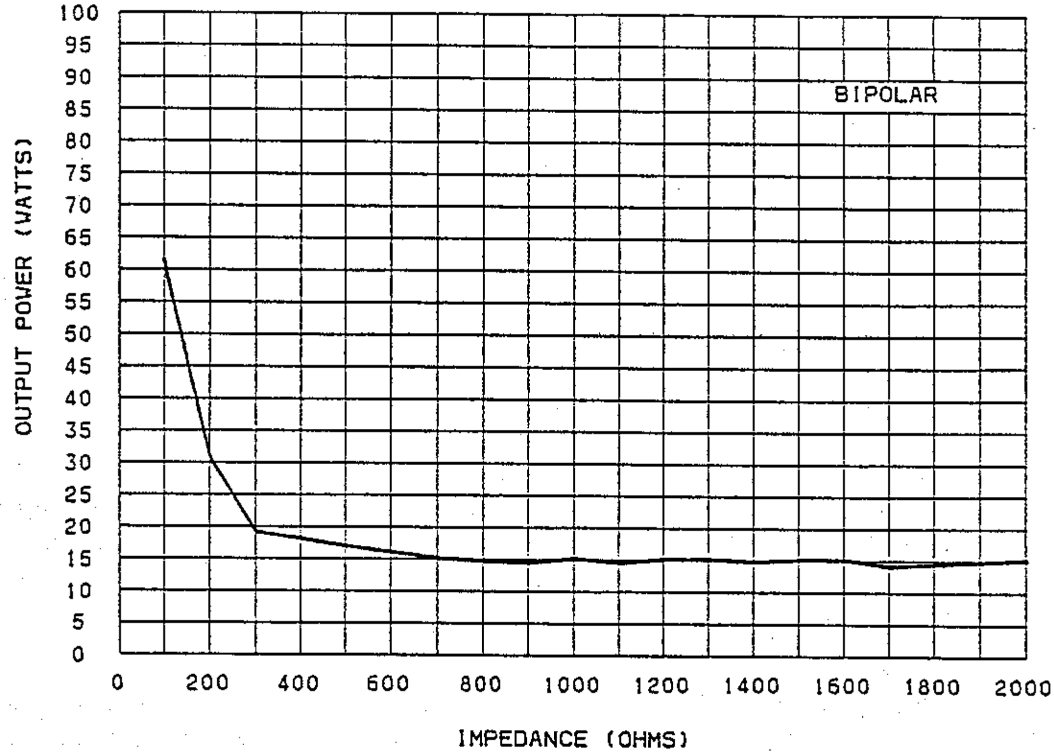

BLEND 3
OUTPUT POWER (WATTS)
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
200
400
600
800
1000
1200
1400
1600
1800
2000
IMPEDANCE (OHMS)

(Continued)





Typical Output Power vs Load – Monopolar Coag Modes



Typical Output Power vs Load – Bipolar

SECTION 4

CIRCUIT DESCRIPTIONS

BIPOLAR DISPLAY BOARD

The Bipolar Display Board is used as the numeric display for the mode's power set point and to display the bipolar RF lamp. The signals for these indicators are derived from the multiplexed display driver on the Monopolar Display/Control board for the former, and the latter is generated by signals from the RF circuitry.

An audio alarm is also present on this board. The frequency select for the alarm is done by circuitry on the Microprocessor Board. Volume is controlled by a potentiometer mounted on the rear panel. In the case of an alarm condition the volume pot is bypassed and a full volume alarm is sounded. This circuitry is located on the Monopolar Display/Control Board.

POWER SUPPLY

The generator power supply is located on the main PCA. It is an off–line DC–DC switching convertor operating at 80 kHz. Input power is supplied by a voltage doubler, two hold–up capacitors and four power FETs in a bridge configuration. The FETs drive the power transformer T3 primary at 320V peak and varying duty cycles. The power transformer rectified secondary voltage is filtered by a 0.75 mH inductor and two 15 uf capacitors which convert a constant amplitude variable duty cycle input to a variable DC output. Duty cycle control is performed by a 3526 IC regulator with emitter followers to drive the transformers T1 and T2 which switches the power FETs. The IC contains a sawtooth oscillator, pulse steering logic and a comparator. The error voltage on pin 1 varies from 0.5 to 3.5 volts to change the output duty cycle. The power transformer has snubber networks to limit voltage spikes.

Power supply control uses an Op Amp within the 3526 to amplify the difference between a feedback fraction of the DC output and a reference voltage ECON. The reference is generated by the CPU and scaled as the square root of the front panel power setting. There is a DC current limit implemented with a comparator and pulse stretcher. The pulse stretcher shuts down the supply's control IC for about 1/3 of a second and then soft starts the supply. An R–C network on the 3526 pin 7 provides a power–on reset.

Low voltage supplies at +12 and + 5 volts are regulated with 3 pin ICs. The raw DC is generated by a transformer, rectifier, capacitor circuit. There are no low voltage adjustments.

WARNING: THE POWER FETS AND OTHER COMPONENTS ON THE SUPPLY HEATSINK ARE AT LINE POTENTIAL. USE EXTREME CAUTION WHEN PROBING THIS CIRCUITRY.

RF OUTPUT

This circuitry resides on the main circuit board assembly and amplifies the CPU signals Ton, Toff to the level required by the front panel power setpoint. Current limiting and peak voltage limiting circuits prevent damage under extreme load conditions. Power control is done by varying the supply voltage. Both DC supply and RF current limit levels are calibrated for each mode – Cut, Coag, Blend 2 and Bipolar. The output tuning and transformer turns ratio is different for Cut and Coag waveforms and the selection is done by a relay. Eight power FETS act as RF switching elements. A current sampling resistor at the sources provides input to a current limit circuit. Gate drive is direct at a 12V level. The drains have diodes in series to allow the output transformer primary voltage to swing negative in Coag. The Cut waveform drive is at a 50% duty cycle with a 1us on time. The Coag drive waveform is generated by turning on the FETs for two microseconds every 32 microseconds.

RF control uses a set–reset flip–flop toggling at 500 kHz in Cut. The flip–flop is set by Ton and turns on the output FETs. The flip–flop is cleared by Toff or by a current limit pulse from the LM306 comparator. The current limit reference ICON is supplied by the CPU and varies as the square root of power with an offset at low powers. When peak voltage limiting occurs the reference voltage to the LM306 current limit comparator is reduced to reduce the output pulse width. At high load impedances a one shot is triggered by transformer primary voltages below –100 volts. This one–shot turns on a FET to load the output and reduce high frequency risk currents.

The FET output is rather low impedance and its voltage compliance is limited by the choice of DC supply voltage as the power control parameter. Above 300 ohms load, the output resembles a constant voltage source. Below 300 ohms load, the current limit circuitry enforces a constant current characteristic. A peak detector and comparator provide RF lamp control. The bipolar control adds an Op Amp to the power supply feedback path. This amplifies the difference between the RF output peak voltage and the power supply set point voltage. The difference is summed with the fedback supply voltage by injecting current into the feedback divider to reduce the supply under high impedance load conditions. Current injection is enabled only in the Bipolar mode.

All eight output FETS must be the same type. Check current matching in Coag by clipping a current transformer around the 0.2 ohm strip resistors.

MONOPOLAR DISPLAY/CONTROL BOARD

The Monopolar Display/Control PCB, hereafter referred to as the CPU card, has two major functions in the Force 2. The first is as the main control element of the generator. The second is to act as an interface between the user inputs and the generator.

In performing the first function the CPU card generates the proper RF drive per the mode selected, calculates and generates the power supply control voltage, calculates and generates the RF output stage current limit, and performs adaptive REMtm monitoring when the generator is not keyed.

In acting as the interface between user and generator the CPU board receives all operator keyboard inputs and performs the proper functional response (e.g. increment power register and display, change Cut mode, etc.). It further accepts all keying signals after they have been decoded by the Interface PCB and performs the proper algorithm to initiate the desired RF output.

The main control element on the CPU board is an 8749, a single chip microprocessor with 2k of on–board EPROM. It is this chip with its host of dedicated peripherals that performs the functional responses required of the CPU board. The actual software program within the 8749 carries the brunt of the performance requirements of the CPU card. As this is a hardware description of the card the software program will only be outlined.

The major display requirements of the CPU card are performed using an Intersil Display Multiplexer, the ICM 7218C, which is U3. The device is a universal eight digit LED driver system. Internally it contains all the circuitry necessary to interface a microprocessor to an LED display. Included on the chip is an 8 x 8 static memory array with storage for the displayed information, 7 segment decoders, all the multiplex scan circuitry, and the high power digit and segment drivers.

Consequently, the microprocessor is able to write the display information to this chip in BCD format and the display multiplexer does the rest. This stand alone feature is used for almost all of the required display systems. The RF watt lamps and the REMtm and RMOTE lamps are individually driven by microprocessor port lines.

However, the ICM7218C is not capable of driving the mode indicator lamps with sufficient power to make them fully visible through the translucent display windows. To overcome this deficiency, segment H, the decimal point drive output of the ICM7218C, is individually gated with each of the eight digit drives to externally multiplex the mode lamp indicator information. The resultant mode lamp drives are current boosted by U14, an ULN2803A, to drive the indicator LED's. The external multiplexing is done by U15 and U29.

Two digit drive lines and seven segment drive lines are bussed from the CPU card to the bipolar display PWB to control the bipolar display seven segment digits.

The REMtm and RMOTE lamps are not controlled by the ICM7218C. Individual microprocessor port lines are assigned to these two displays, P12 and P16 respectively, to drive these LED displays. The pull–up resistors, R14 and R17, are required to insure that the outputs of the open collector driver pull high when its inputs are low.

An additional circuit in parallel with the REMtm LED is transistor Q1, which is turned on when the REMtm light is on. This transistor shorts out the volume control potentiometer and allows the audio alarm tone to be sounded at full volume.

The audio tone frequency and its enable are both controlled by port lines of the 8749, P11 and P10 respectively. These two control lines activate an on/off analog gate which either allows audio drive to the speaker or not and a second analog gate which changes (increases) the capacitance of a one gate oscillator.

The single gate oscillator, a part of U7, is the typical R–C type circuitry recommended in the literature. However, several additions have been added to it to clarify the actual audio output. A large R–C filter, R21 and C8, has been put on the power input to U7 to completely remove all AC noise that would otherwise be transmitted as amplitude and frequency modulation superimposed on the oscillator output to the speaker creating a "warbling" effect. R31 and CR3 are added to change the duty cycle of the oscillator to fine tune the final audio output.

The output of the oscillator is current boosted by a pair of drivers in U1. The resistor R1 in series with the speaker limits the maximum audio output. The RF lamps are the only other display elements not controlled by the display driver. Each of these lamps is driven by an assigned port line of the CPU. The port line is current boosted by an open collector driver in U1. The lamps are further controlled by Q3. This transistor must be on for the RF lamps to be lit.

There are two ways that Q3 can be turned on. The first is by the CPU directly with an assigned port line, P13. This is only done at turn on when the generator performs a display test turning all of the display digits and lamps on. The second way the transistor is activated is by the RF sense line from the PSRF PCB. This line is activated whenever RF power is being generated by the unit.

The 8749 converses directly with the ICM7218C, that is, the display driver is on the CPU's data bus. For the CPU to be able to communicate with its peripherals, chip selects must be generated external to the CPU to activate that peripheral which is being either written to or read from. The falling edge of the ALE, address latch enable, line on the CPU indicates that a valid address is present on the data bus. A 74LS374, octal D–type latch, U6, is used to decode the address information into chip select signals to activate given peripherals.

The latch signal is only enabled if external memory is being addressed. This is decoded whenever either the read or write outputs of the CPU are activated by going low, the two signals are negative true. U22 performs the nor function. R2 is used to shift the read enable for the address decoder to ensure that the decoded chip select remains valid during the CPU read of the data bus. A low on an address line, the outputs of U6, is used as a chip select. Consequently, to insure that only one peripheral is addressed at a time all external memory locations have addresses with all bits high except one.

There are eight external memory locations. Three of them are read only and five are write only. One of the write only has already been discussed, the ICM7218C. The other seven locations will now be discussed with the reads covered first.

The three read locations are used to input the twenty–two user inputs. Fourteen of these are the keyboard inputs and the remaining eight are decoded keying inputs. The signals are divided logically, keying inputs, mode selection and power UP/DOWN control, and are each separately addressable. Integrated circuits, U16, U23, and U24 are used to buffer these read signals onto the CPU data bus. The devices are 74LS240's which are octal inverting data bus drivers with tri-state output capability. Using the chip selects generated by U6 to control the output enable of these devices makes a convenient way of placing them on the CPU data bus.

Two eight bit DACs are on the data bus. They are configured as write only devices. One of these circuits, U26, is used to generate the power supply control voltage, ECON, and the other, U25 is used to generate the RF current limit analog voltage ICON.

The outputs of the two DACs are inverted, amplified with a gain of one, inverted again, and amplified again with a gain of two; giving the final output range of the two analog signals of 0 to 5 volts. The amplifiers are all contained in a Quad Op. Amp chip, U27. Various capacitors (e.g. C29, C41) are used to limit RF interference.

The fourth write only location is dedicated to U5, an eight bit parallel, in–serial out shift register, 74LS165, whose output is used to gate the principal RF clock frequency to generate the final RF drive waveshape. How this is done will be explained later.

The final write location is a 74LS374, U17, an octal D–type latch, which is used in the keying circuitry. The actual explanation will be taken up later.

To generate the 6MHz clock requirements of the 8749 a crystal is used. The output is inverted and drives the clock inputs for the CPU.

The write pulse generated by the CPU is not able to meet all of the timing requirements of the various peripheral circuits. Consequently, U13 is used to phase shift and shorten the pulse width with respect to ALE. The output of TO is internally programmed to be 2 MHz. The resultant output is then ORed with various peripheral chip select lines to generate the required write pulses for these circuits.

The RF on and off drive generation: U28 is used to divide the crystal frequency from 6MHz to 500 kHz. One half of U9 is configured as a toggle flip–flop to further divide the clock to 250kHz. The two analog gates of U10 are used to select the on/off drive frequency of the RF drive pulse trains. The selection is controlled by microprocessor port line P15.

The clock is then steered to a three input AND gate, U11, dedicated to RF Ton, the on drive. RF Toff, the off drive, is the inversion of RF Ton. The clock is ANDed with the serial output of the shift register U5. R35–C29 are used to account for timing skews on the clock generation circuitry. R36–C6 are required to stop RF interference from entering the shift register.

The output signal of the AND gates are the drive pulses. Since the 8 bit shift register is cyclically loading itself while data is being shifted out the drive frequency of modulation is 250/8 = 31.25 KHz. To avoid RF interference problems with the CPU when the generator is keyed the microprocessor shuts itself off by setting the flip–flop in U9. This is clocked at power up to allow the CPU to run.

Two things can reset this flip–flop, a REM fault occurs or the keying input configuration changes. The Q output of this flip–flop is the third input to the enable AND gates for RF drive. Consequently, RF drive trains, and therefore RF, are only generated when the CPU is shut off.

The 8749 is shutdown by pulling the input single step line to ground. When this occurs ALE is no longer generated and port two's lower nibble is configured to show the upper nibble of the CPU address. To keep the CPU board I/O constant when the CPU is shutdown, U4, a 74LS374 is used to latch port two information. When ALE is halted the chip has latched the last port two I/O configuration.

With this knowledge it can be discerned that the auxiliary CPU board keying circuitry has to be able to detect several unique conditions, no keying input and/or a change in keying inputs, and REM™ fault.

REM™ fault is detected on the interface board and is merely an input line to the CPU board. Q4 is required to ignore the REM™ fault line when the unit is in bipolar mode. U20 is used to detect when there are no keying inputs. U17 in combination with U18 and U19 detects a keying input change.

The way the latter is done is that the CPU writes to the 74LS374, U17, the present keying configuration. The two bit magnitude comparators constantly compare this keying configuration to the decoded outputs from the interface PWB. If the two are not the same U19 pin 6 will go low, with R23–C13 providing time delay and moderate RF filtering to this line. This signal is then gated with the no keying signal from U20 and the REM™ fault line from the Interface PWB to generate the reset signal for the CPU single step flip–flop.

INTERFACE BOARD

This circuit assembly is mounted vertically at the front panel shield. It contains the patient circuit generator functions: keying, output jack selection and return electrode monitoring. This assembly has isolated, high voltage, patient connected circuitry, and component replacement must be done with exact equivalent parts.

The keying circuits comprise an isolated power source, comparators to detect switch closure and optical couplers. The power source is two flyback converters and toroid transformers. The handswitch circuits use three comparators to sense active to Cut, active to Coag, Cut to Coag, and active to Cut to Coag connections. These codes for Cut, Coag, increase power and reduce power respectively. The remaining keying circuits simply have resistors in series with the opto couplers to limit current. There are four isolated circuits, each with its own transformer winding for power.

This generator has three possible RF output jacks. Selection of the jack is done by single pole, normally open, high voltage relays. The CPU turns on the relays via BIPOLAR drivers on the Interface PCB. A CPU controlled delay between relay closure and initiation of RF drive reduces contact wear. Note the 0.0047 microfarad capacitors in series with the RF output and return. These are the primary patient protection against electrocution and must be high voltage parts.

The REM™ circuitry measures the pad–to–pad resistance of dual–pad patient return electrodes or the wiring resistance of single–pad patient return electrodes. A microswitch in the connector is opened for REM™ patient return electrodes and selects one of two alarm signal paths in the alarm logic string.

Resistance is measured as the load on the REM™ transformer secondary. The secondary is resonated by two 0.22 microfarad capacitors and the reflected primary load is sensed by a synchronous detector. Four clocked CMOS switches perform synchronous detection. The oscillator is tuned to the transformer by a pot. The detector output is amplified and input to four comparators. Two comparators provide hard–wired alarm limits at 5 and 135 ohm alarm limit for REM™ patient return electrodes. The third comparator provides a hard–wired alarm limit at 20 ~~ohms for single–pad electrodes~~. The fourth comparator generates a pulse width modulated waveform by comparing the REM™ resistance to a triangle wave generated by an oscillator. This pulse width is decoded by the CPU to implement the adaptive REM™ feature for dual pad resistances between 5 and 135 ohms.

SECTION 5

TESTING PROCEDURE

OPERATIONAL TESTING – GENERATOR OUTPUT

The purpose of an operational test is to quickly determine whether the generator is functioning and generating the necessary electrosurgical waveforms. In the Acceptance Test Procedure, measurements are described which accurately determine the condition of the generator.

NOTE: The Force 2 is not rated for continuous duty operation. (Maximum on time at a power setting of 100 is two minutes).

ACCEPTANCE TEST PROCEDURE

Equipment needed

Tektronix type 465 Oscilloscope.
Tektronix type P6013A High Voltage Probe.
Tektronix type P6007 X100 Probe.
Tektronix type P6010 X10 Probe.
Simpson Model 1339 RMS RF Ammeter, 0–250mA.
Wattmeter , 0–500 Watts 300 ohm load and 100 ohm load
with reactive phase angle of less than 20o at 500 kHz

In testing RF equipment, proper test procedures must be adhered to in order to duplicate factory test data. Test leads must be kept to the minimum length usable; lead inductance and stray capacitance can affect readings adversely. The selection of suitable "ground" points must be made with care to avoid ground–loop errors.

Keep in mind that the meter accuracy of many RF instruments is 5–10% of full scale. Using uncompensated scope probes may cause large errors in the measurement of high–voltage RF waveforms. When fractional microampere leakage currents are measured, accidental capacitive or inductance coupling may cause order–of–magnitude errors in the observed values.

CALIBRATION PROCEDURE

Note: A Valleylab E3002 Analyzer should not be used to perform the calibration.

The best performance will be obtained if each adjustment is made to the exact setting even if the Performance Check is within the allowable tolerance. The procedure uses equipment listed under "Equipment Needed". If substitute equipment is used, it must meet, or exceed the specifications of the recommended equipment. Also, all calibrations listed in the procedure are made at the factory before the generator is accepted by QA. If only RF output power needs to be re–calibrated, proceed directly to step six of the procedure.

NOTE: RF power should be measured with the cover ON.

Special care must be taken in Step 4. The 10X or 100X probe to be used should be closely calibrated with the oscilloscope to be used.

PROCEDURE

1. Remove the cover from the Force 2 to expose the internal controls and test points.

2. a. +12 Volt Supply: Connect the digital multimeter between pins 5 or 6 and pins 1 or 2 on the 40–pin interconnect cable. The meter should read +12 $\pm$ .3 volts.

   b. +5 Volt Supply: Connect the digital multimeter between pins 3 or 4 and pins 1 or 2 on the 40–pin interconnect cable. The meter should read +5 $\pm$ .25 volts.

   c. –5 Volt Supply: Connect the digital multimeter between pin 7 and pins 1 or 2 on the 40–pin interconnect cable. The meter should read –4.75 $\pm$ .2 volts.

3. Adjust the High Voltage Clamp:

   a. Set the Coag display to 30 watts.

   b. Attach a 300 ohm load from the HAND–SWITCH receptacle to the PATIENT receptacle.

   c. Key generator in Coag. Output power should be 30 $\pm$ 5 watts.

   d. Remove the 300 ohm load.

   e. Adjust the Coag display to 1.

   f. Attach an oscilloscope with a 10X or 100X probe between the anode of CR3 and ground. Key the generator in Coag. Slowly increase the Coag power display and observe the peak positive voltage. Adjust R29 on the PSRF Board so that the maximum peak voltage is 400 volts. Do not let the peak voltage exceed 425 volts while making this adjustment.

4. Potentiometers R91 and R95 on the Power Supply/RF Board are critical to the output power adjustments for Coag. Follow steps a through d using a 300 ohm wattmeter connected to the HAND–SWITCH receptacle and PATIENT receptacle.

   a. Set ECON R95 to mid–setting. Turn ICON R91 fully clockwise.

   b. Set Coag display at 120 watts and adjust R95 for 120 watts output in Coag.

   c. Change wattmeter load to 100 ohms. Turn R91 to mid–setting before proceeding.

   d. With Coag display at 120 watts, adjust R91 for 100 $\pm$ 20 watts output in Coag.

5. Potentiometer R89 and R93 on the Power Supply/RF Board are the output power adjustments in Pure Cut. Follow steps a through d using a 300 ohm wattmeter as connected in step 4.

   a. Set R93 to mid–setting. Turn R89 fully clockwise.

   b. Set Cut display at 300 watts and adjust R93 for 300 watts output on Pure Cut.

   c. Change wattmeter load to 100 ohms. Turn R89 counterclockwise to midsetting before proceeding.

   d. With Cut display at 300 watts adjust R89 for 260 $\pm$ 40 watts output in Pure Cut.

6. Potentiometer R90 and R94 on the Power Supply/RF Board are for the output power adjustments for the Blend modes. Follow steps a through e using a 300 ohm wattmeter.

   a. Set R94 to mid–setting. Turn R90 fully clockwise.

   b. Set Cut power display to 200 watts and adjust R94 to 200 watts output in Blend 2.

   c. Change wattmeter load to 100 ohms. Turn R90 counterclockwise to midsetting before proceeding.

   d. Adjust R90 for 150 ± 50 watts output in Blend 2.

   e. Without adjusting R94 and R90 confirm that Blend 1 and Blend 3 are within instrument specifications with a 300 ohm load setting on wattmeter. If not, fine adjust R94 and R90 to bring them on.

7. Potentiometers R88 and R92 on the Power Supply/RF Board are for the output power adjustments for Bipolar. Follow steps a through c using a 100 ohm wattmeter connected across the MICROBIPOLAR output jacks.

   a. Set R92 to mid–setting. Turn R88 fully clockwise.

   b. Set Bipolar display at 70 watts and adjust R92 for 70 watts output in Bipolar with wattmeter load set at 100 ohms.

   c. Turn R88 counterclockwise until it effects Bipolar output in step b. Then turn R88 clockwise one turn.

REM™ TEST PROCEDURE

Connect a variable resistance across the PATIENT terminals using a REM™–type connector. Set the resistance to 135 ohms and adjust R73 for the highest possible voltage on TP3. Turn R74 counterclockwise until EREM is below 4 volts. Turn R74 clockwise until REMFT (TP1) goes high (5V). Monitor REM PW (TP4) and adjust R75 until one period of square wave is 10 milliseconds ± .1 µS. Decrease the resistance to 50 ohms. Increase the resistance gradually and record the value at which the REM™ alarm turns on (70 ± 10 ohms). Decrease the resistance and note that the REM™ alarm again turns off. Decrease the resistance and record the value at which the REM™ alarm again turns on (5 ± 2 ohms).

Repeat above test set–up utilizing a non–REM™ type connector. Set the variable resistance to 5 ohms. Note that the REM™ alarm is off. Gradually increase resistance and record value at which REM™ alarm turns on (less than 24 ohms). The REM™ alarm should remain off below this value and turn on again if above this value.

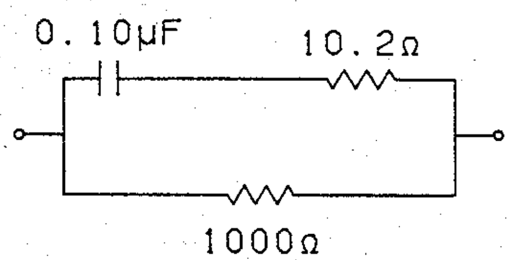
LINE FREQUENCY (50/60 HZ) CURRENT LEAKAGE TEST PROCEDURE

This test measures potentially dangerous 50/60 Hz leakage currents.

The Force 2 is left ON BUT NOT KEYED.

The current is measured indirectly by observing the voltage developed across a 1k ohm resistor to ground from each front panel jack. A 0.10 microfarad capacitor is connected across the 1k ohm resistor to remove any trace of high frequency noise generated by the oscillator inside the generator. This capacitor has little effect on the 50/60 Hz leakage current. Leakage current is calculated from I = E/R, where R = 1k ohms and E is the voltage measured across the resistor. The maximum acceptable voltage across the 1k ohm resistor for 10.0 microamps leakage is 0.010 volts (10 millivolts).

INPUT CIRCUIT:



NOTE: Because of the extreme difference in magnitude of the 50/60 Hz leakage current in the RF signals when the generator is activated, it is very difficult to make a 50/60 Hz leakage measurement. When the generator is activated there can be as much as 7000 volts peak–to–peak of RF compared to 20 millivolts of 50/60 Hz. This ratio (110 db) of voltages would require the use of sophisticated measuring techniques. In practice, the 50/60 Hz leakage currents do not change significantly when the generator is keyed.

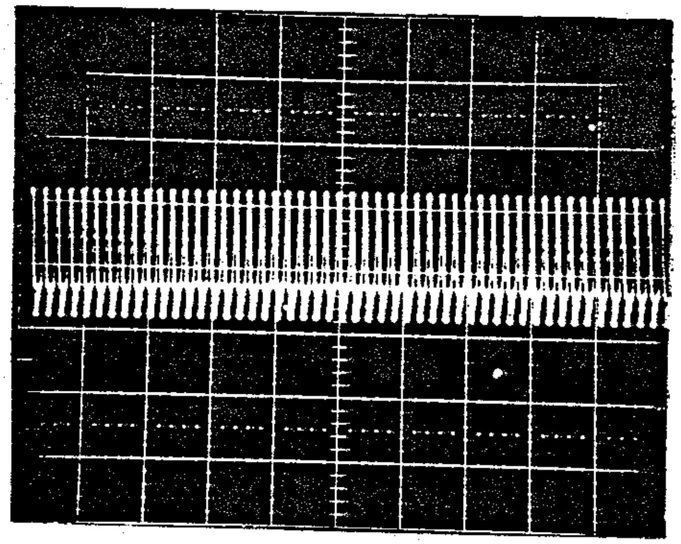
Third wire leakage current is measured by opening the green grounding wire at the plug and connecting the 1k ohm resistor from chassis to ground. The maximum voltage across the 1k ohm resistor for 100 microamps leakage would be 100 millivolts. Commercially available leakage testers may be used for this test.

The typical value of 50 microamperes is valid for factory installed 15 foot 16/3 AWG line cords. Longer line cords or extension cords will increase the third wire leakage and are not recommended. With the Force 2 turned off, the third wire leakage should be less than 10 microamps.

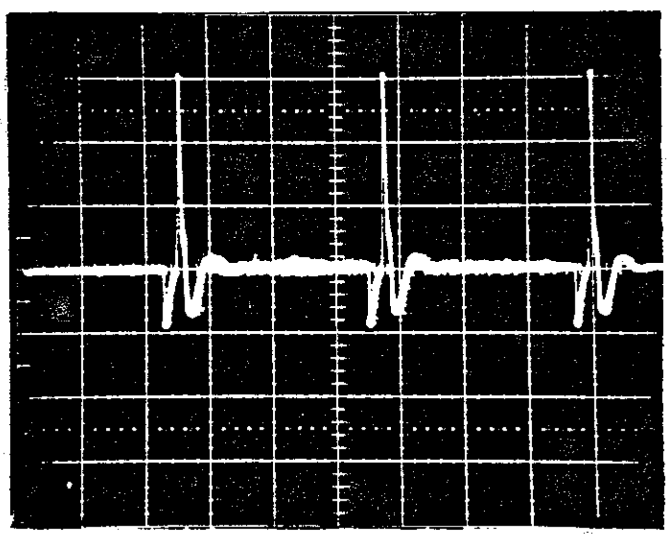
The line frequency sink leakage is the current that will pass into the patient leads when a 110 volt, 50/60 Hz potential is applied between a PATIENT lead and the chassis. The voltage source should be a 110 volt isolation transformer with a 120k ohm current limiting resistor in series with a secondary.

The current is calculated from the voltage measured across a 1k ohm resistor in series with the AC volt source and the PATIENT or active jacks. This current should be less than 100 microamperes.

ALL WAVEFORMS SEEN ACROSS A 300 OHM LOAD
HORIZONTAL SENSITIVITY – 10µs/cm
VERTICAL SENSITIVITY – 500V/cm



CUT @ 300W

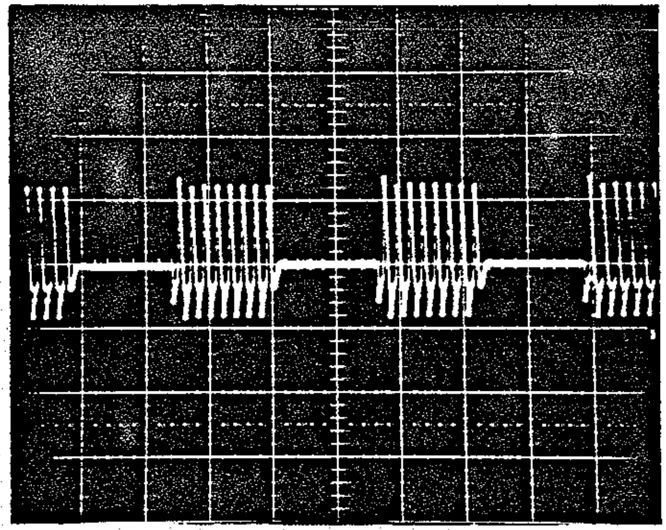


COAG @ 120W

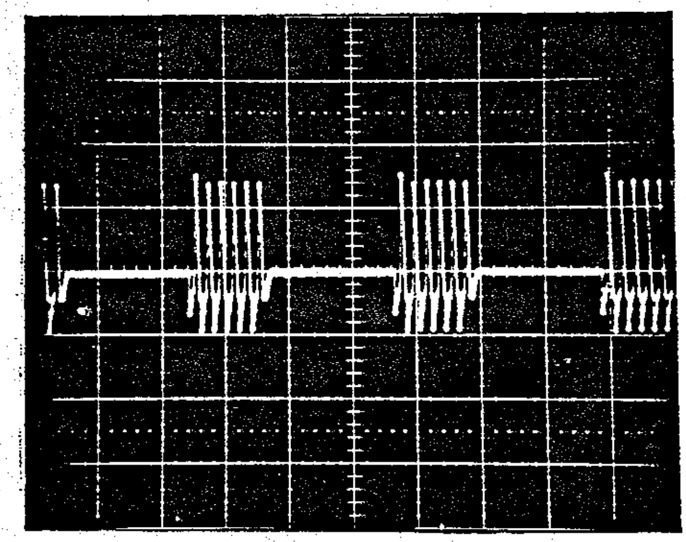
Figure 6

Monopolar Output Waveforms

BLEND 1 @ 250W



BLEND 2 @ 200W



BLEND 3 @ 150W

LOW VOLTAGE COAG
@ 99W

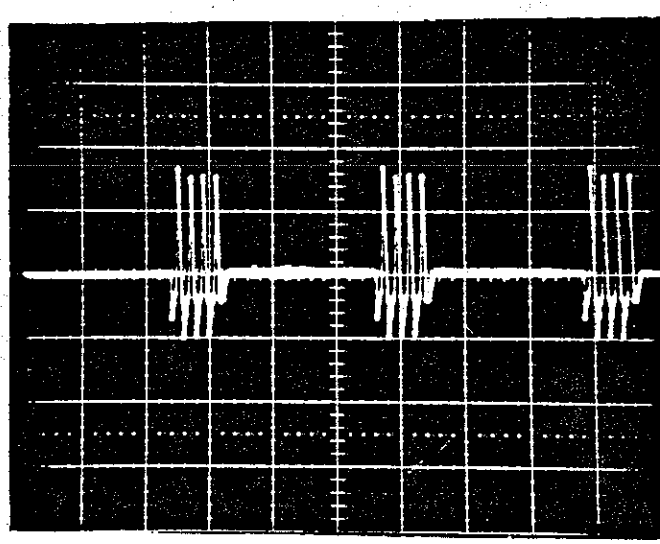
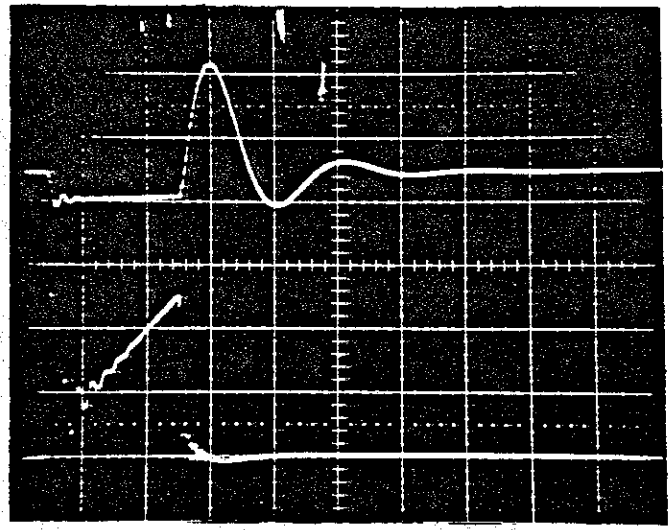
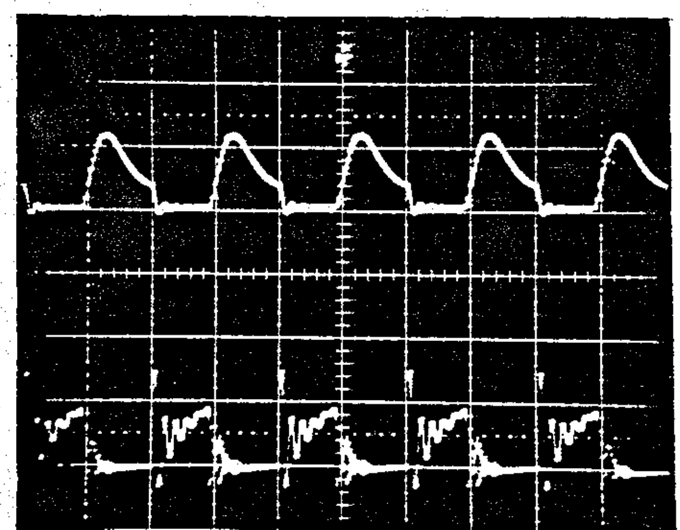


Figure 6 (Continued)

TOP VERTICAL = 100V/DIV
BOTTOM VERTICAL = 1A/DIV
HORIZONTAL = 1μS/DIV



COAG @ 30W



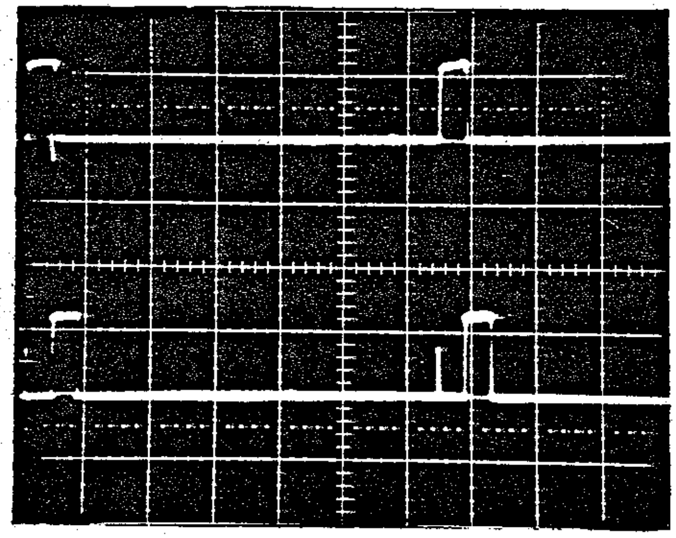
CUT @ 75W

Figure 7

RF Output FET Voltage and Current

VERTICAL = 100V/DIV
HORIZONTAL = 1A/DIV

COAG
TOP TRACE – Ton
BOTTOM TRACE – Toff



BLEND 3
TOP TRACE – Ton
BOTTOM TRACE – Toff

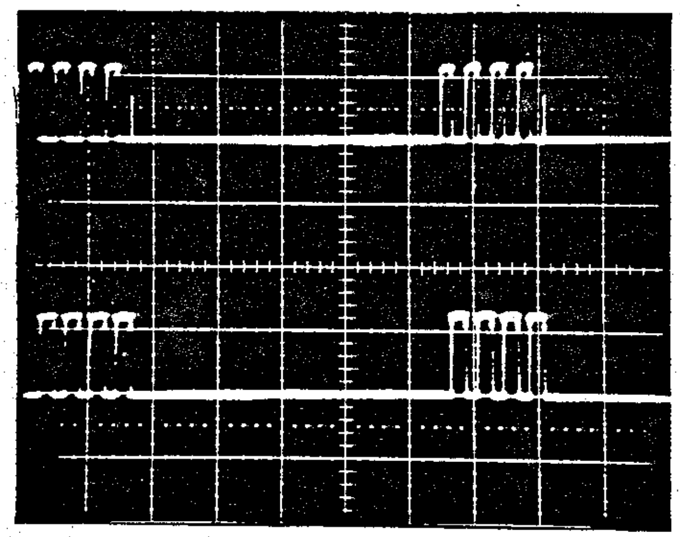
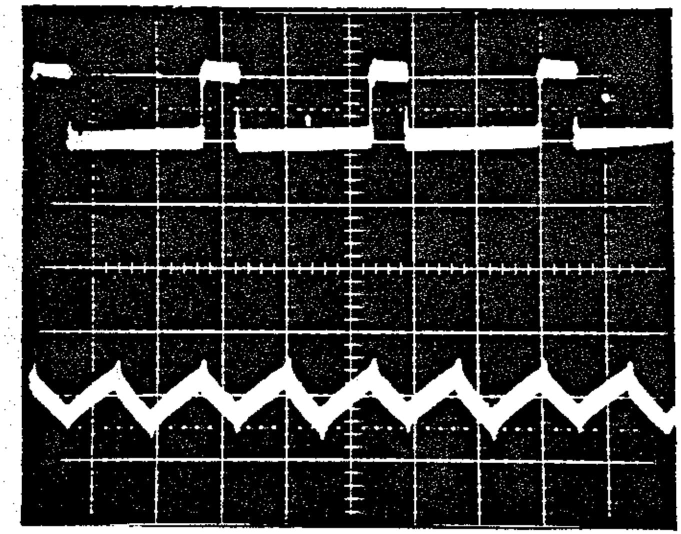


Figure 8

RF Output FET Gate Drive Waveforms at Q18 and Q19 Drains

TOP VERTICAL = 10V/DIV
BOTTOM VERTICAL = 5A/DIV
HORIZONTAL = 10µS/DIV

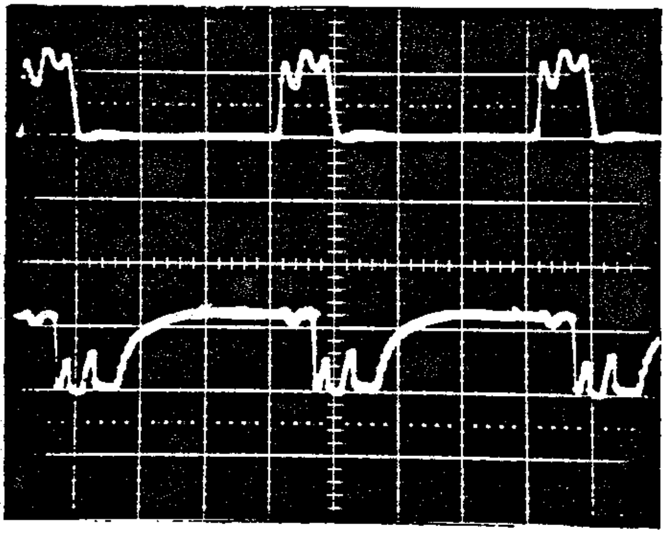
U7, PIN 16



CURRENT IN L2

TOP VERTICAL = 10V/DIV
BOTTOM VERTICAL = 10V/DIV
HORIZONTAL = 0.5µS/DIV

Q1–8 GATES



U3, PIN 7, RF CURRENT
LIMIT CONTROL

Note: Drive Pulse width shortened from 1µS to 0.5µS

Figure 9

Power Supply and RF Current Limit Waveforms

INTERCONNECT LISTING

J200, P800

1 HANDSWITCH ACTIVE
2 HANDSWITCH COAG
3 HANDSWITCH CUT

J201, P801

1 ACCESSORY ACTIVE
2 ACCESSORY COAG
3 ACCESSORY CUT

J202, P802

1 BIPOLAR OUT 1
2 BIPOLAR SWITCH
3 BIPOLAR OUT 2

J202, P1103

1 REM SWITCH 1
2 REM SWITCH 2
3 N.C.
4 N.C.
5 REM RETURN 1
6 REM RETURN 2

P204, J304

1 MONOPOLAR RF
2 N.C.
3 RF RET

J205, J305

1 BIPOLAR RF 1
2 BIPOLAR RF 2

J206, P1106

1 MONOPOLAR FTSW CUT "D"
2 MONOPOLAR FTSW COAG "A"
3 MONOPOLAR FTSW COMMON "C"
4 BIPOLAR FTSW COMMON "C"
5 BIPOLAR FTSW DESICCATE "A"
6 FOOTSWITCH GROUND "B"

P309, J309

1 +5V FILTER CAP
2 +12V FILTER CAP
3 LO V RETURN
4 +12V
5 +5V

J208, P1108 – J316, P1116 – J1117,P1117

1 DIGITAL GROUND
2 DIGITAL GROUND
3 +5 VOLTS
4 +5 VOLTS
5 +12 VOLTS
6 +12 VOLTS
7 –5 VOLTS
8 ANALOG GROUND
9 ECON VOLTAGE
10 ICON VOLTAGE
11 REM FAULT
12 RF SENSE
13 N.C.
14 N.C.
15 VOLUME
16 VOLUME
17 N.C.
18 N.C.
19 BIPOLAR ENABLE
20 CUT ENABLE
21 COAG ENABLE
22 BLEND ENABLE
23 BIPOLAR RELAY
24 HANDSWITCH RELAY
25 ACCESSORY RELAY
26 CUT RELAY
27 REM PULSE WIDTH
28 N.C.
29 HANDSWITCH CUT
30 HANDSWITCH COAG
31 HANDSWITCH U/D
32 ACCESSORY SWITCH CUT
33 ACCESSORY SWITCH COAG
34 FOOTSWITCH CUT
35 FOOTSWITCH COAG
36 BIPOLAR FOOTSWITCH
37 N.C.
38 N.C.
39 Ton
40 Toff

P310, J310
1 HVDC SOURCE
2 HVDC SOURCE
3 HVDC SNUBBER
4 HVDC RETURN
5 HVDC POS.

P311, J311

1 LINE HIGH
2 LINE LOW
3 LINE TRANSFORMER
4 N.C.
5 LINE SNUBBER
6 N.C.

J312, P1112
1 AC NEUTRAL
2 N.C.

J313, P1113
1 AC HOT
2 N.C
3 N.C.

J314, P1114
1 5V UNREG IN
2 5V UNREG RET
3 12V UNREG IN
4 12V UNREG RET

J315,P1115
1 +12V.
2 VOLUME CONTROL
3 SHIELD GROUND

J320
1 Q5 DRAIN
2 HV CLAMP RESISTOR

J421, P521
1 SHIELD
2 DIGITAL GROUND
3 BIPOLAR UP SWITCH
4 BIPOLAR DOWN SWITCH

J118, P1118 – J419, P1119
1 DIGIT 1
2 DIGIT 2
3 SEGMENT A
4 SEGMENT B
5 SEGMENT C
6 SEGMENT D
7 SEGMENT E
8 SEGMENT F
9 SEGMENT G
10 BIPOLAR UP
11 BIPOLAR DOWN
12 LAMP DRIVE
13 BIPOLAR POWER
14 SPEAKER 1
15 SPEAKER 1
16 SPEAKER 2
17 SPEAKER 2.
18 SHIELD.
19 DIGITAL GROUND
20 DIGITAL GROUND

J120, P620
1 SHIELD
2 DIGITAL GROUND
3 PURE CUT SWITCH
4 BLEND 1 SWITCH
5 BLEND 2 SWITCH
6 BLEND 3 SWITCH
7 CUT UP SWITCH
8 CUT DOWN SWITCH
9 STANDBY SWITCH
10 BIPOLAR FOOTSWITCH SWITCH
11 READY SWITCH
12 MONOPOLAR FOOTSWITCH SWITCH
13 COAG UP SWITCH
14 COAG DOWN SWITCH

SECTION 6

ASSEMBLIES AND SCHEMATICS

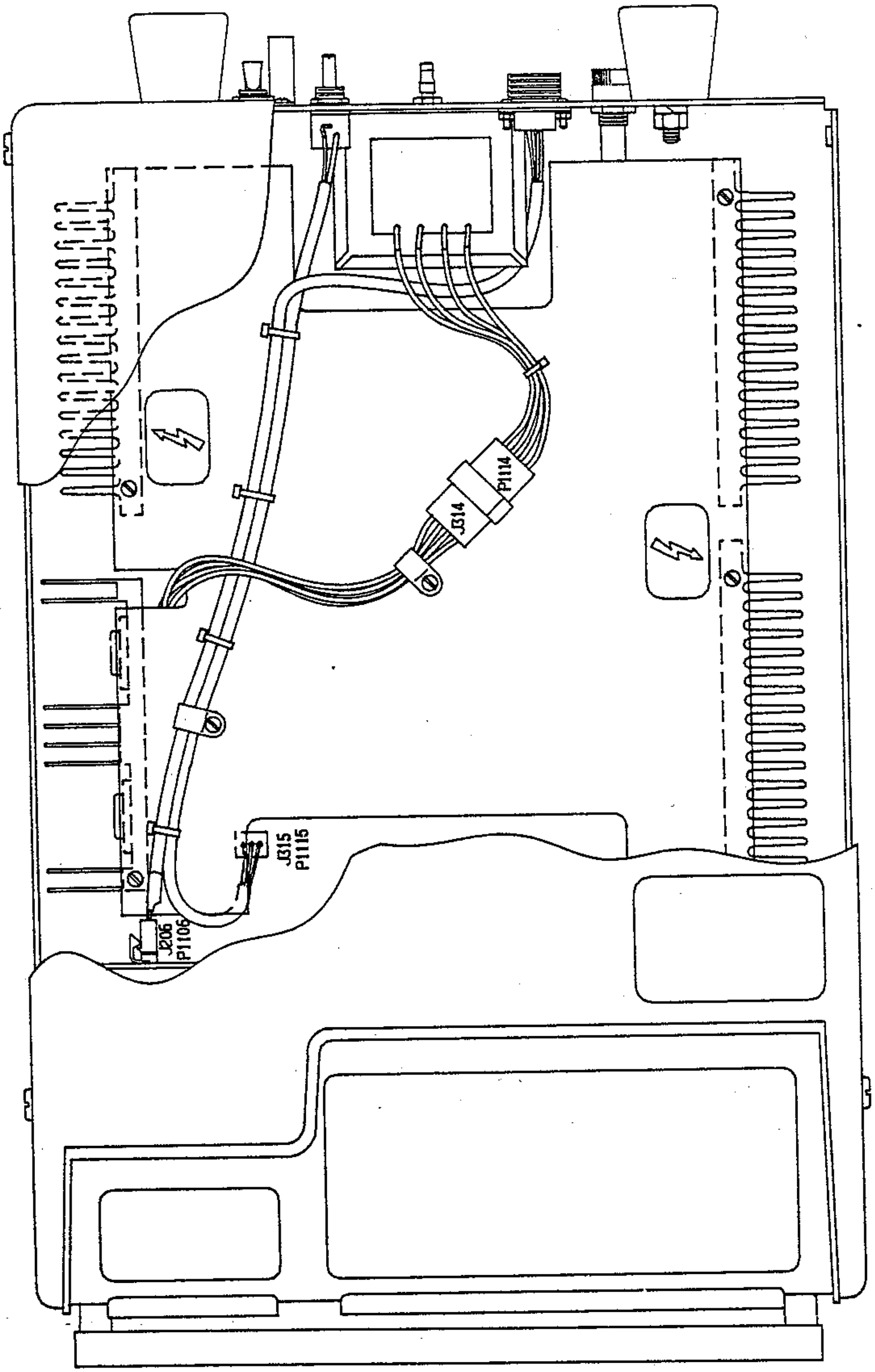
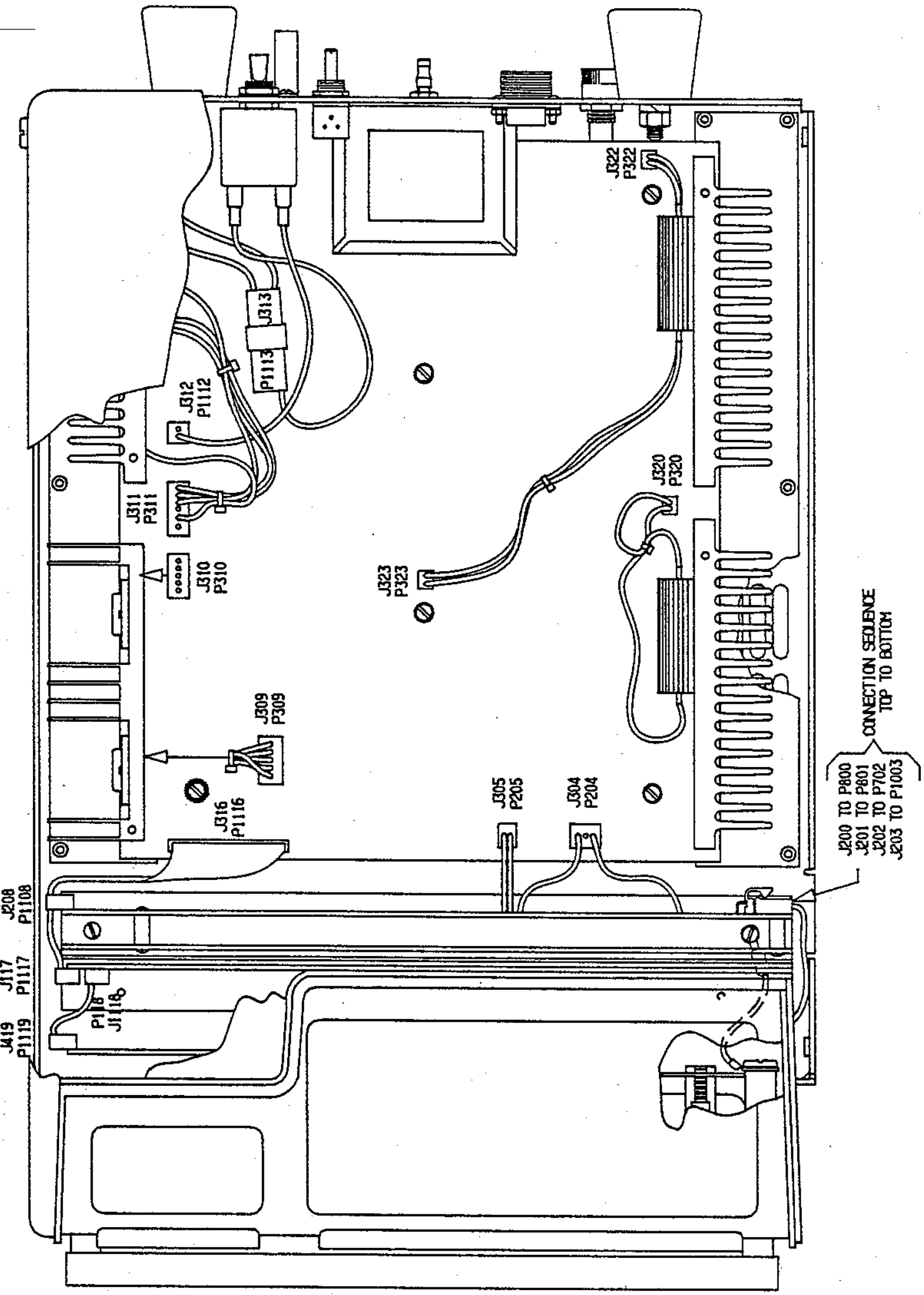


Figure 10

Component/Connector Locations


J322
P322
J313
P1113
J312
P1112
J311
P311
J310
P310
J323
P323
J320
P320
J309
P309
J316
P1116
J305
P205
J304
P204
J208
P1108
J117
P1117
P1118
J1118
J419
P1119
CONNECTION SEQUENCE
TOP TO BOTTOM
J200 TO P800
J201 TO P801
J202 TO P702
J203 TO P1003

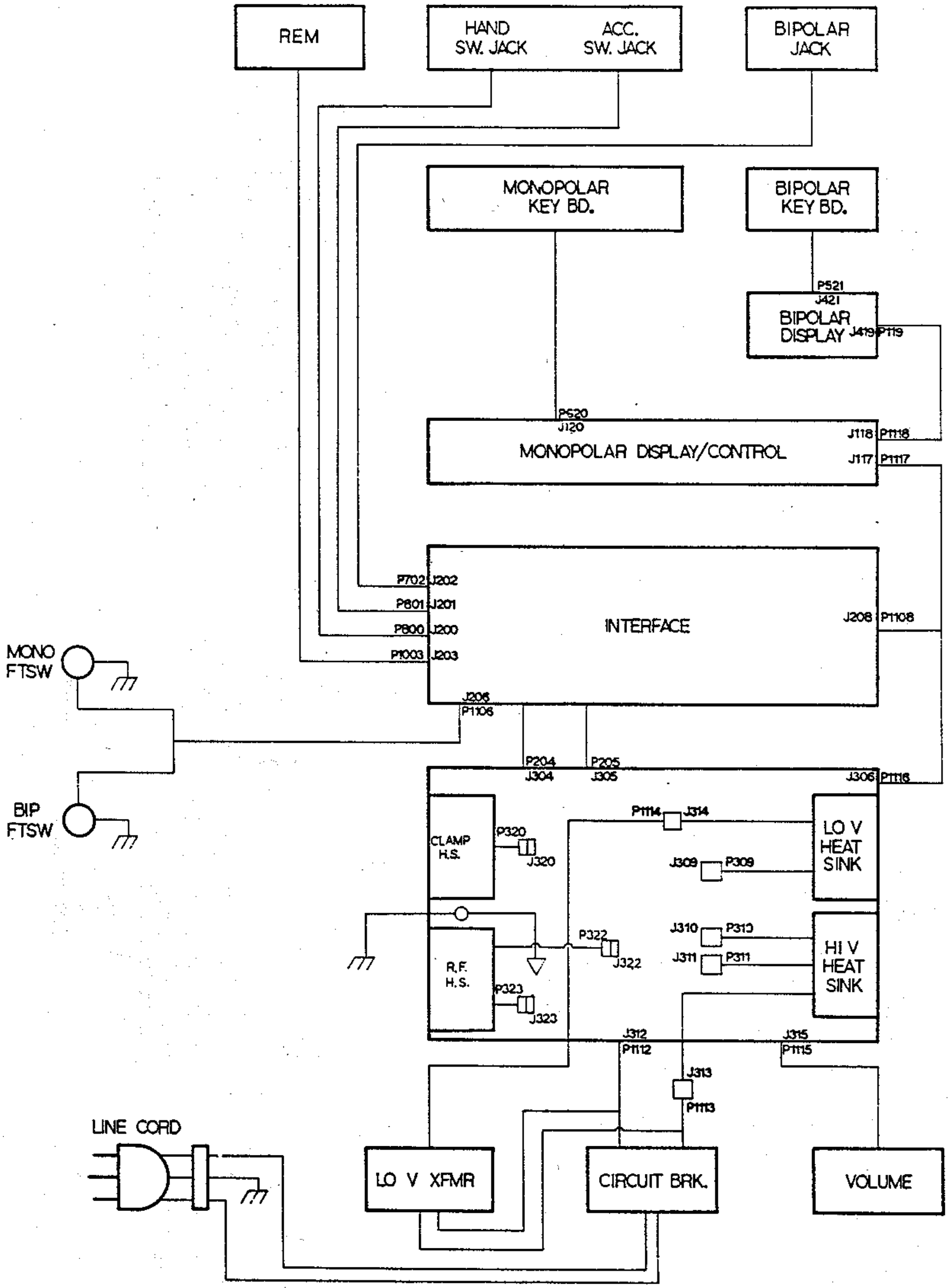


Figure 11

System Interconnect Diagram

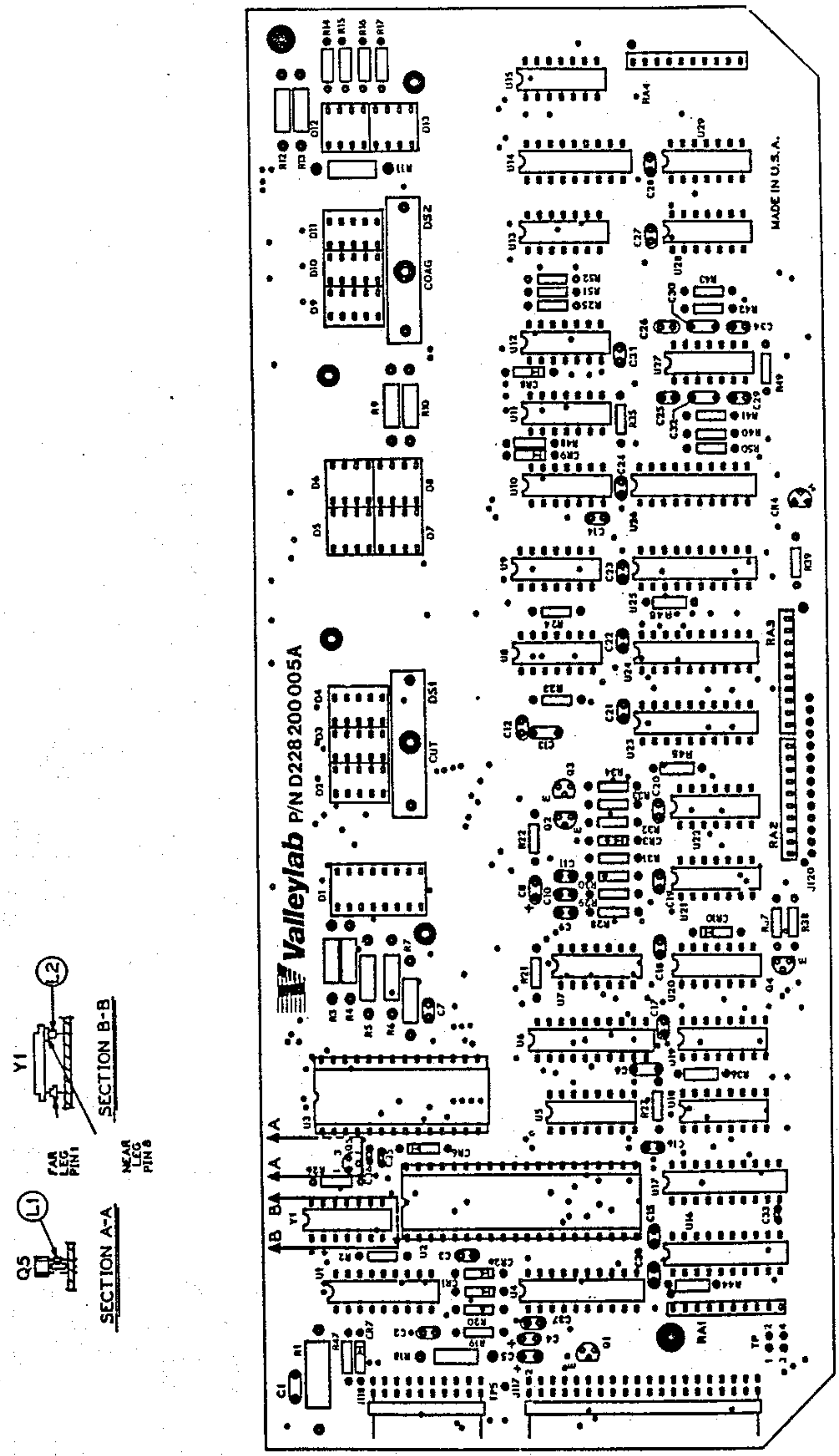
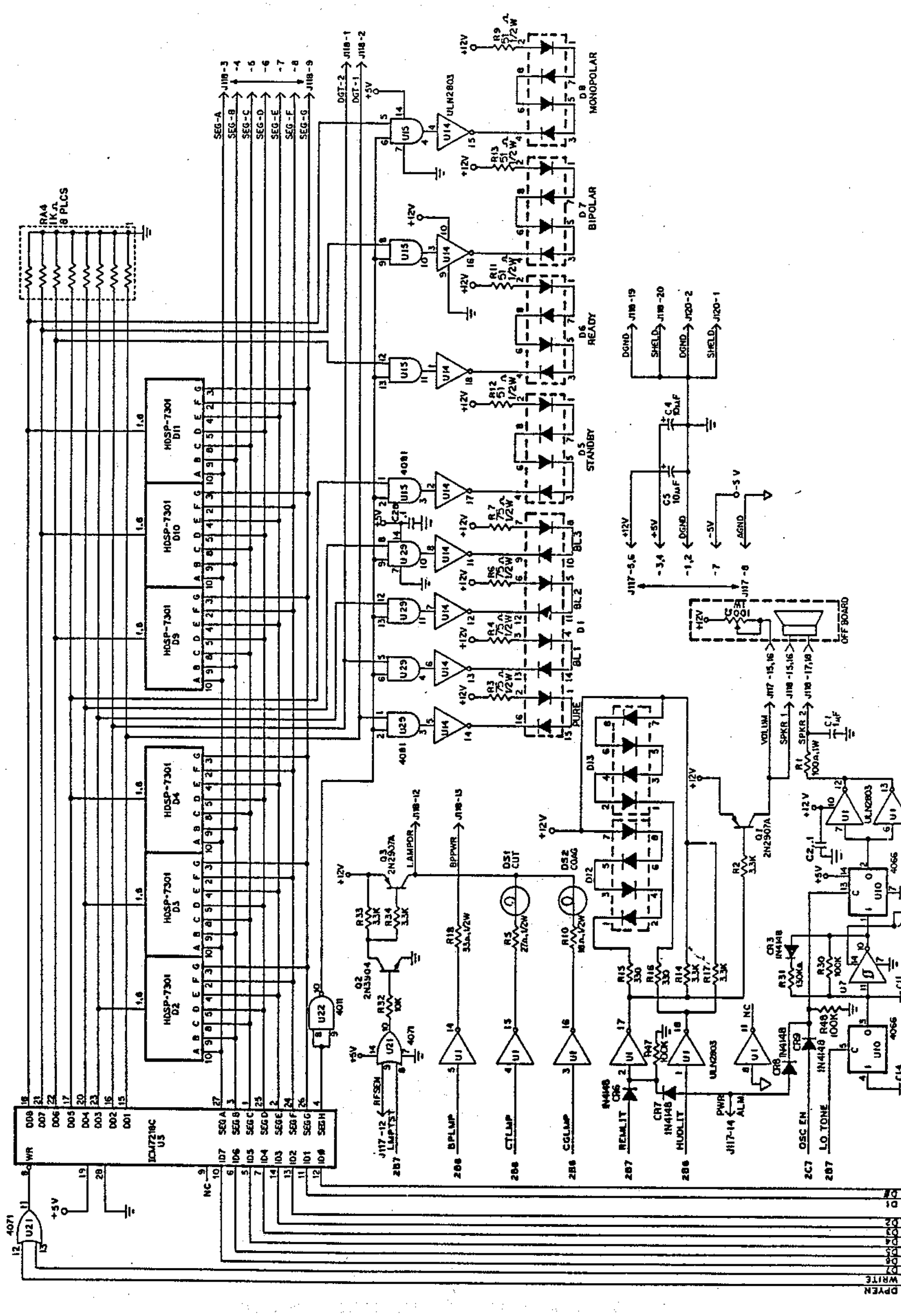
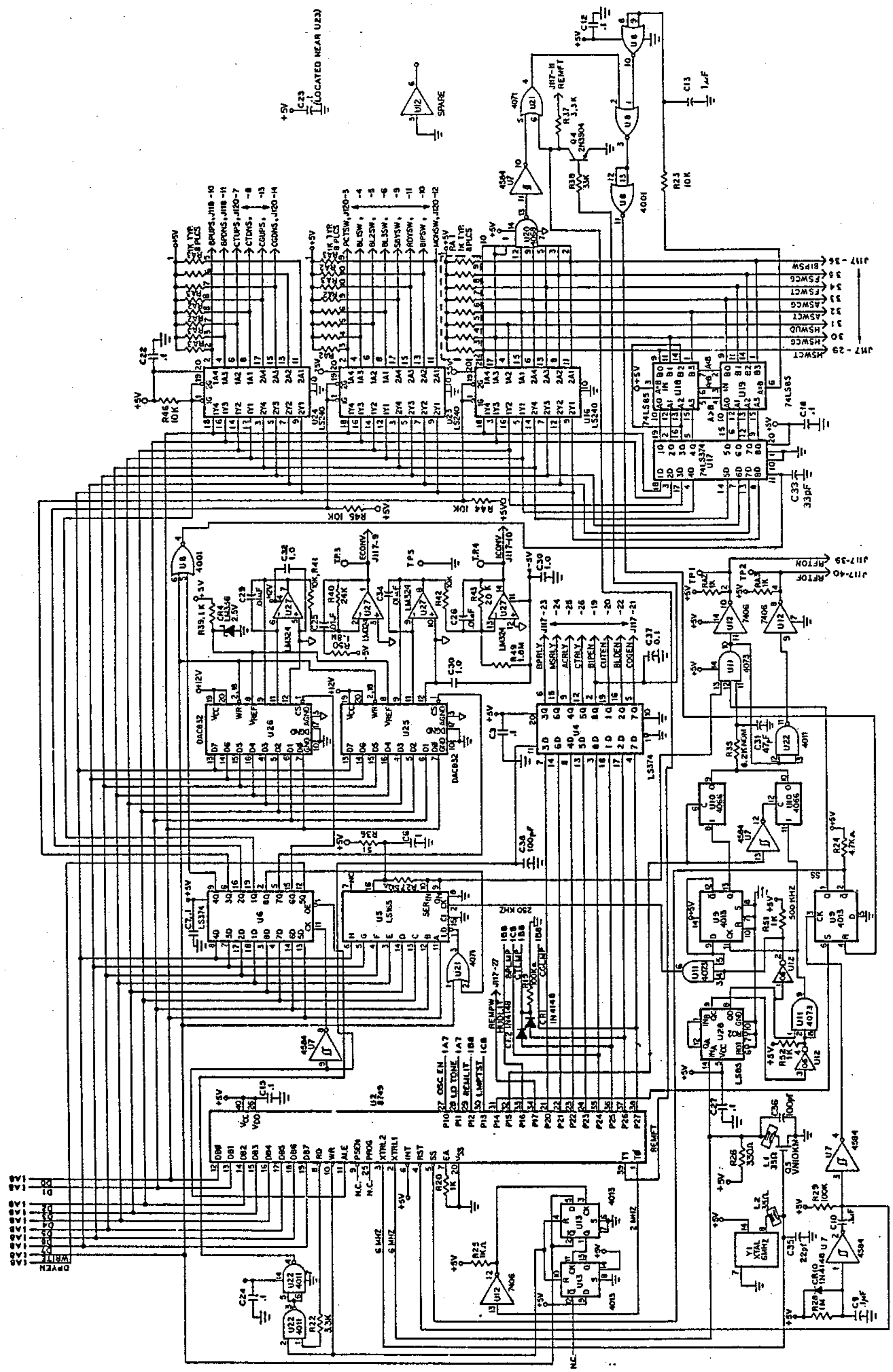


Figure 12

Monopolar Display–Control Board/Schematic



ICM7218C
U3
HDSP-7301
D2
D3
D4
D9
D10
D11
RA4
1K Ω
8 PLCS
SEG-A
SEG-B
SEG-C
SEG-D
SEG-E
SEG-F
SEG-G
DGT-2
DGT-1
+5V
+12V
-5V
U15
U14
U29
U25
U22
U21
U1
U7
U10
4081
4071
4011
4066
ULN2803
D8
MONOPOLAR
D7
BIPOLAR
D6
READY
D5
STANDBY
D1
PURE
BL 1
BL 2
BL 3
D12
D13
DS1
CUT
DS2
COAG
Q1
2N2907A
Q2
2N3904
Q3
2N2907A
LAMPDR
BPPWR
BPLMP
CTLMP
CGLMP
REMLIT
HUDLIT
PWR ALM
OSC EN
LO TONE
LMPTST
RFSEN
VOLUM
SPKR 1
SPKR 2
OFF BOARD
DGND
SHELD
AGND
WRITE
DPYEN



(LOCATED NEAR U23)
SPARE
DAC0832
LS374
74LS374
74LS85
LS240
8749
4001
4071
4013
4011
4073
4066
4584
7406
2N3904
OSC EN
LO TONE
REMLIT
LMPTST
XTAL 6MHZ
250 KHZ
500 KHZ

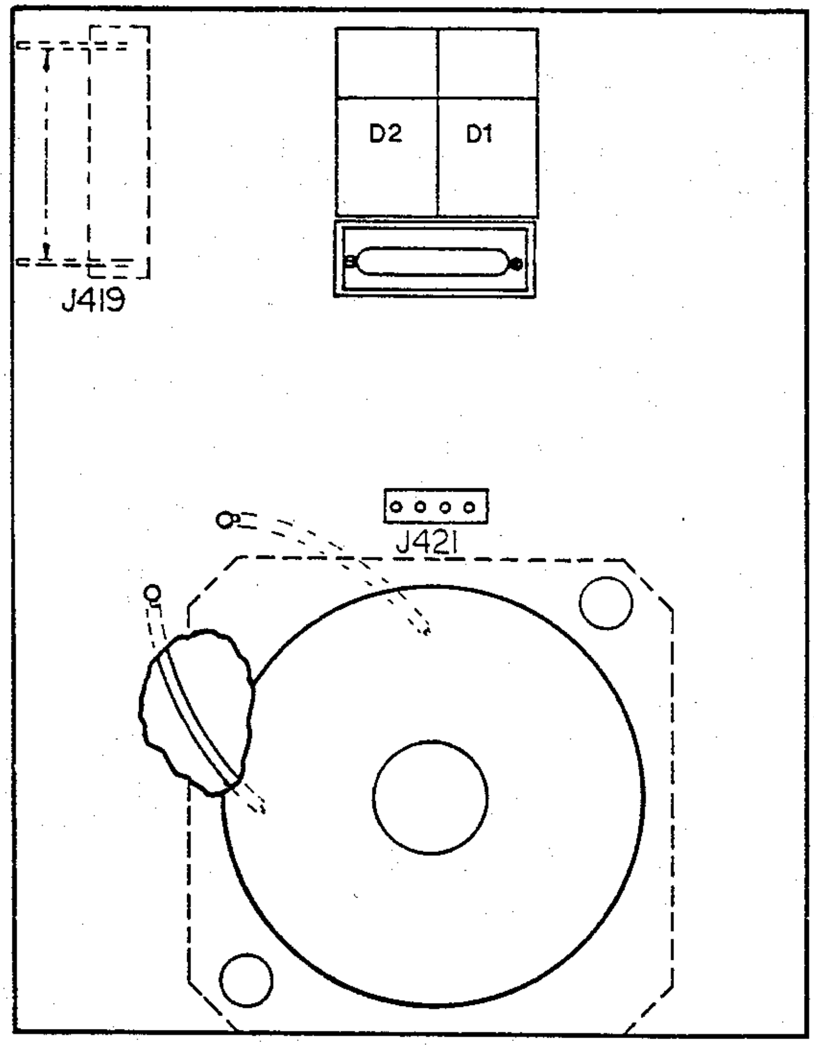
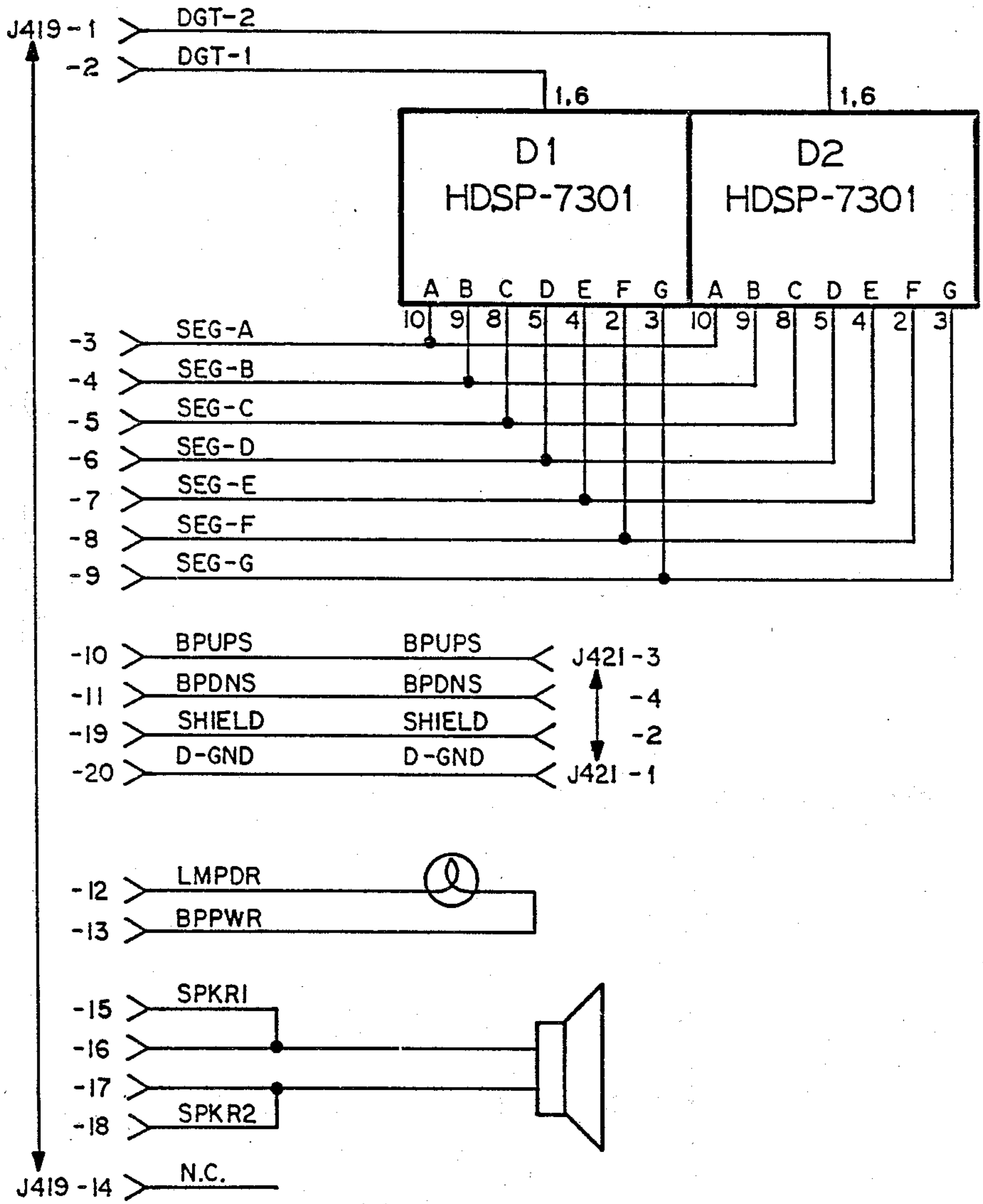


Figure 13

Bipolar Display Board/Schematic


J419 - 1
DGT-2
-2
DGT-1
1,6
1,6
D1
HDSP-7301
D2
HDSP-7301
A B C D E F G
A B C D E F G
10 9 8 5 4 2 3
10 9 8 5 4 2 3
-3 SEG-A
-4 SEG-B
-5 SEG-C
-6 SEG-D
-7 SEG-E
-8 SEG-F
-9 SEG-G
-10 BPUPS
BPUPS J421-3
-11 BPDNS
BPDNS -4
-19 SHIELD
SHIELD -2
-20 D-GND
D-GND J421 -1
-12 LMPDR
-13 BPPWR
-15 SPKR1
-16
-17
-18 SPKR2
J419 -14 N.C.

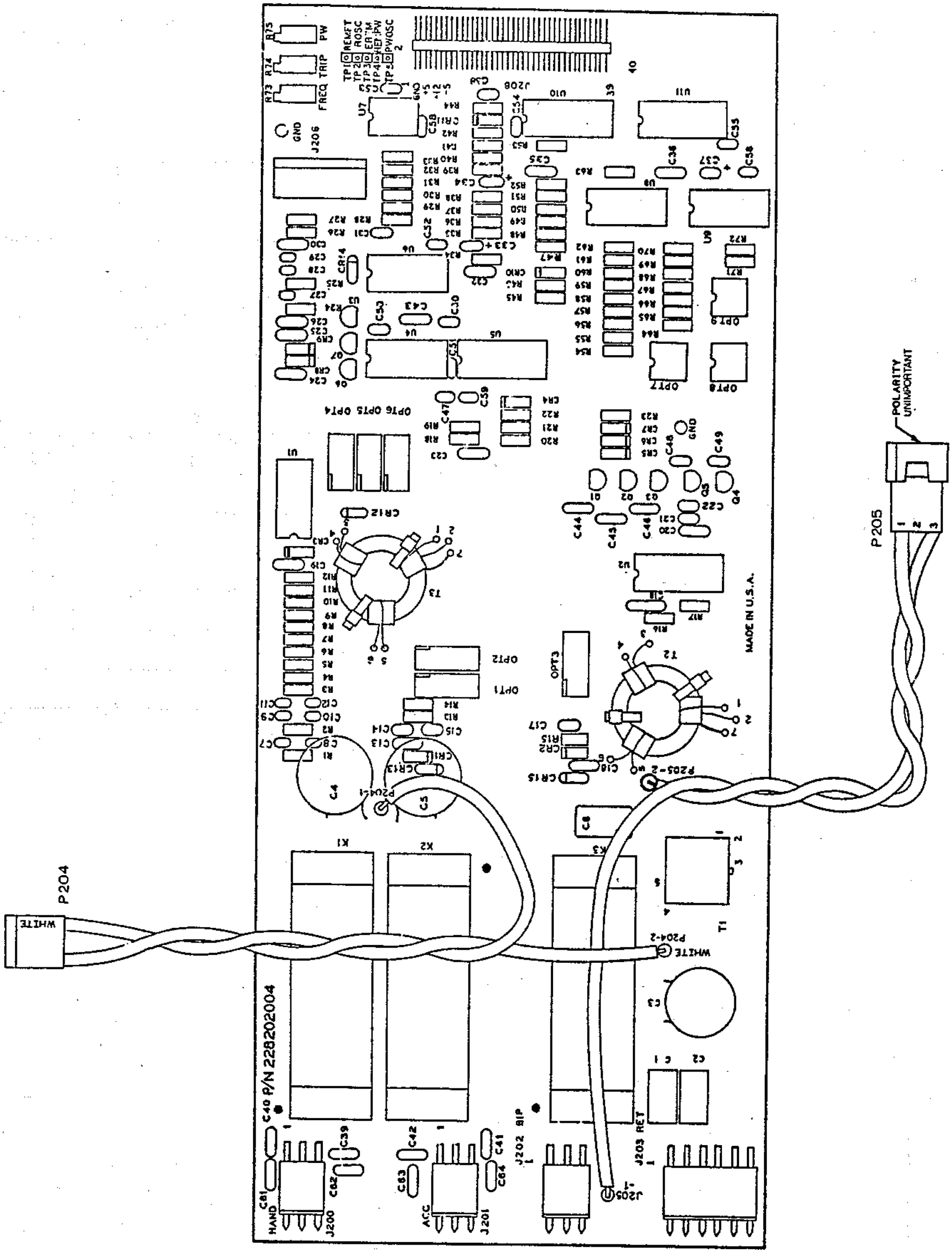
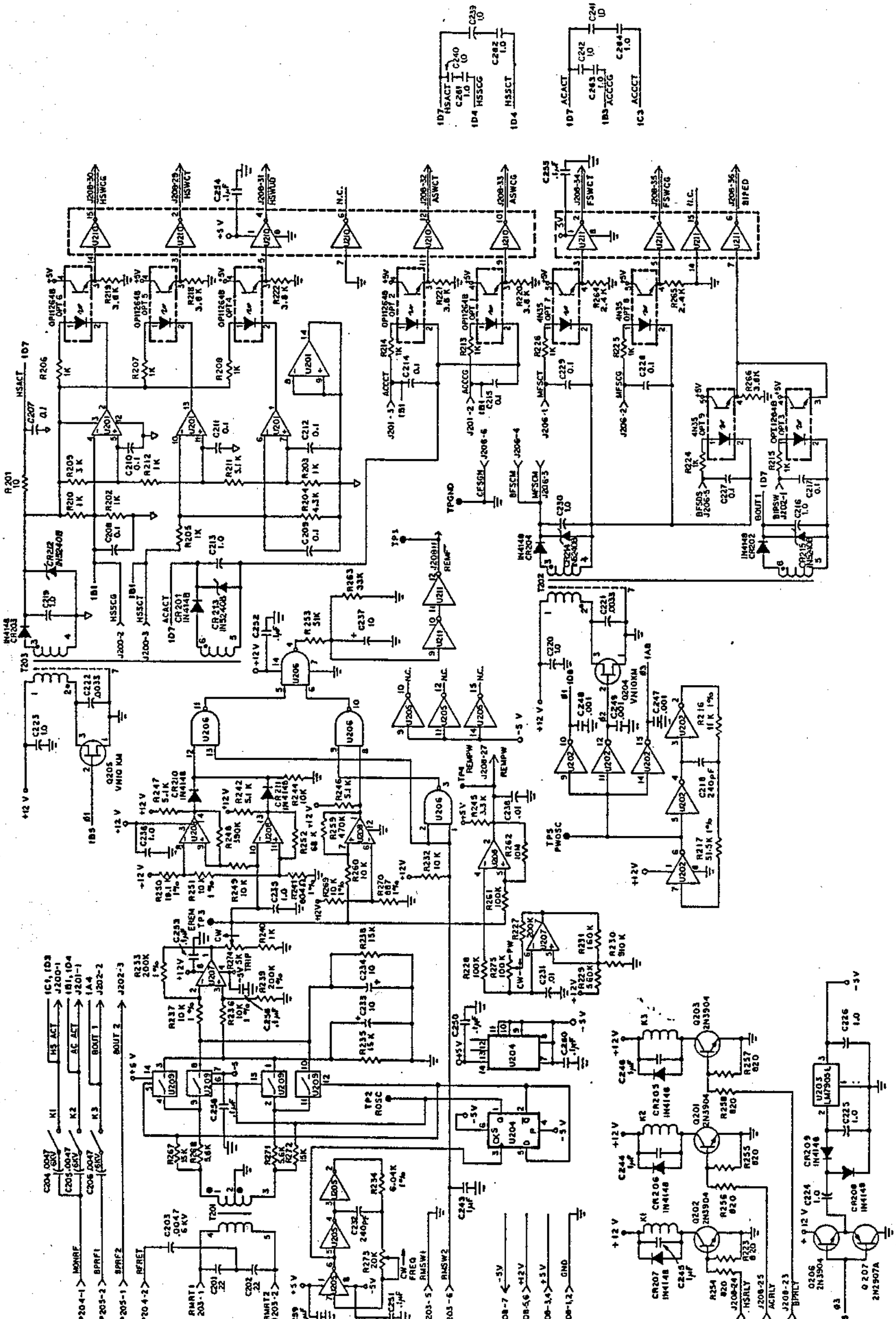


Figure 14

Interface Board/Schematic



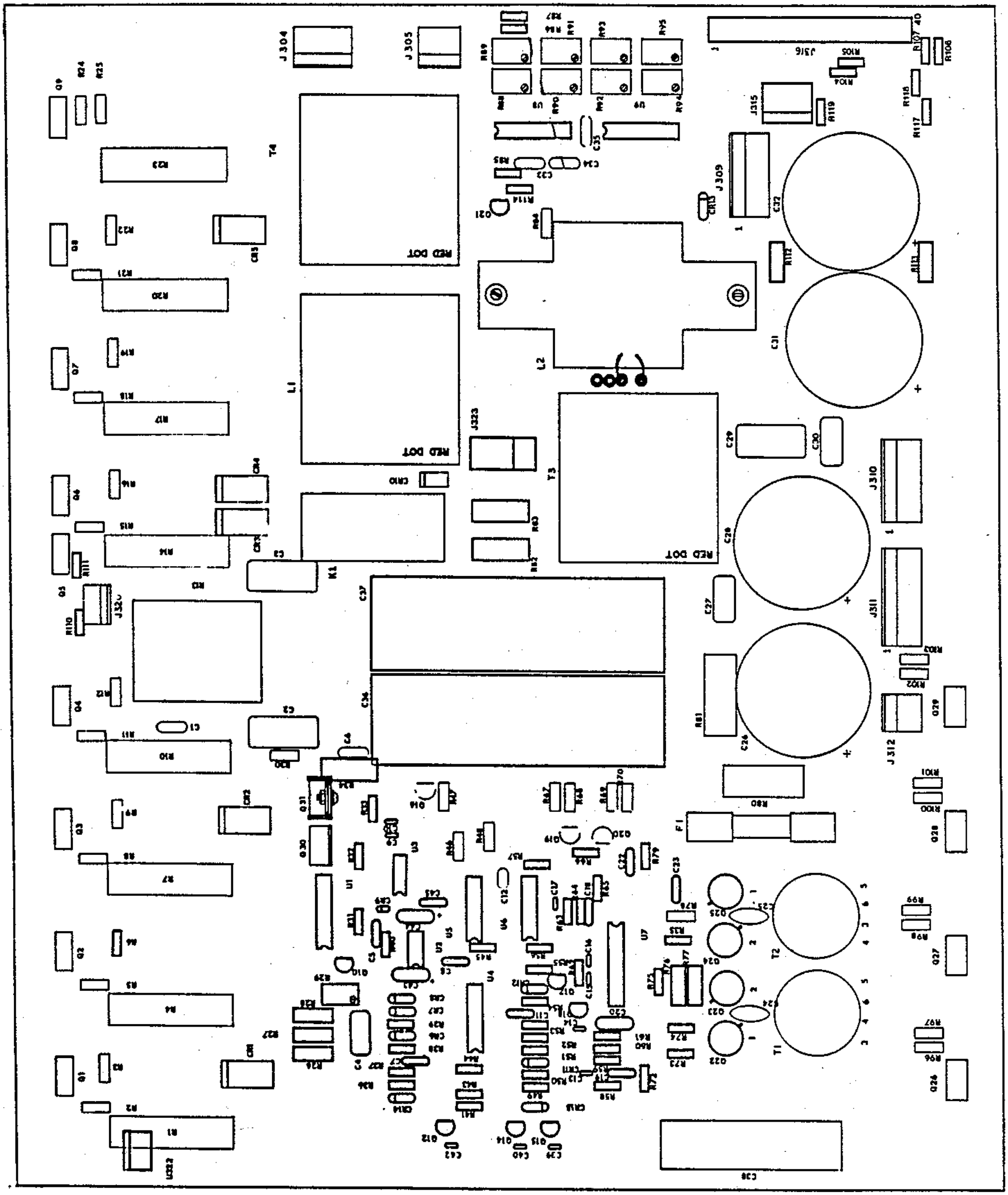
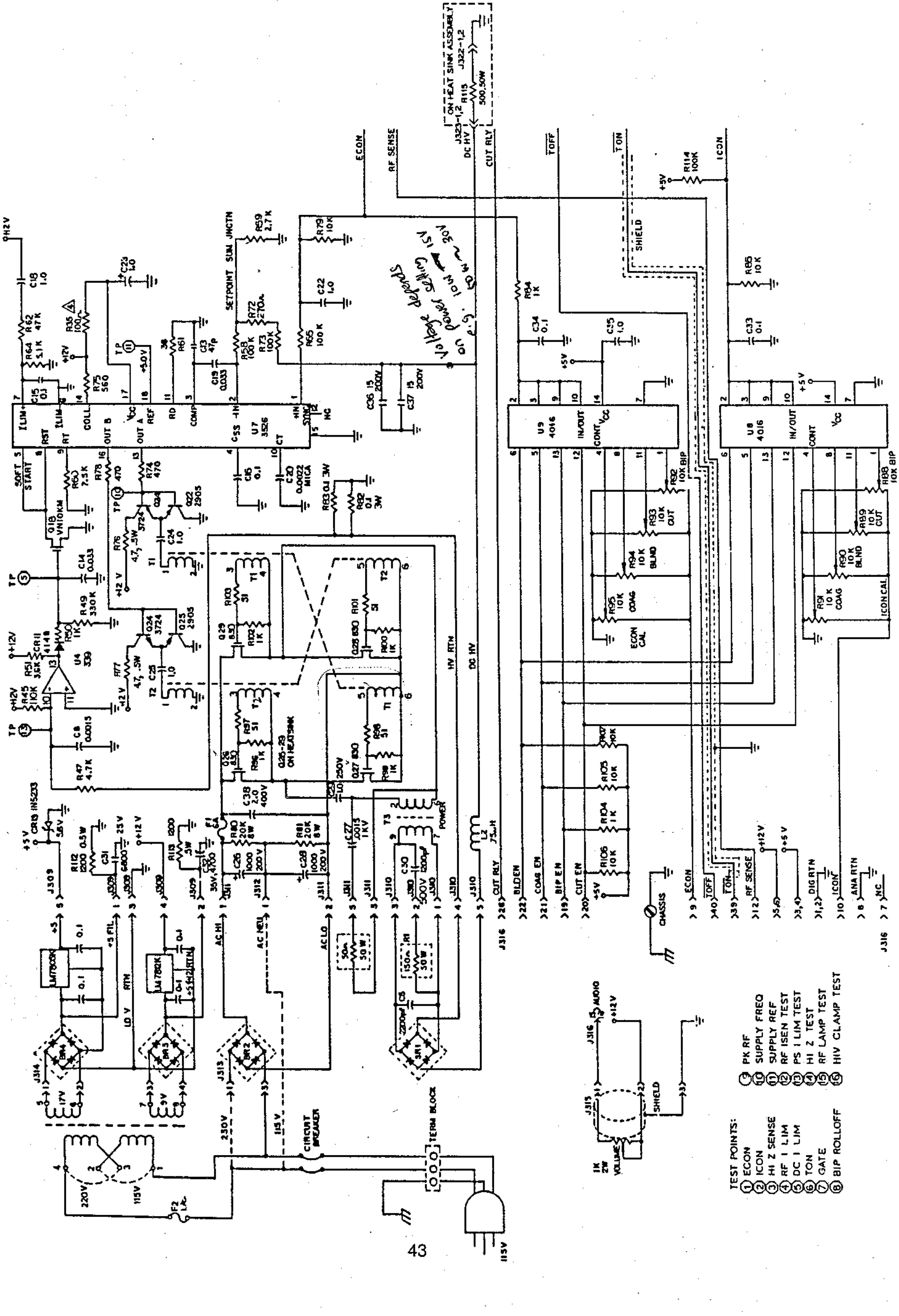
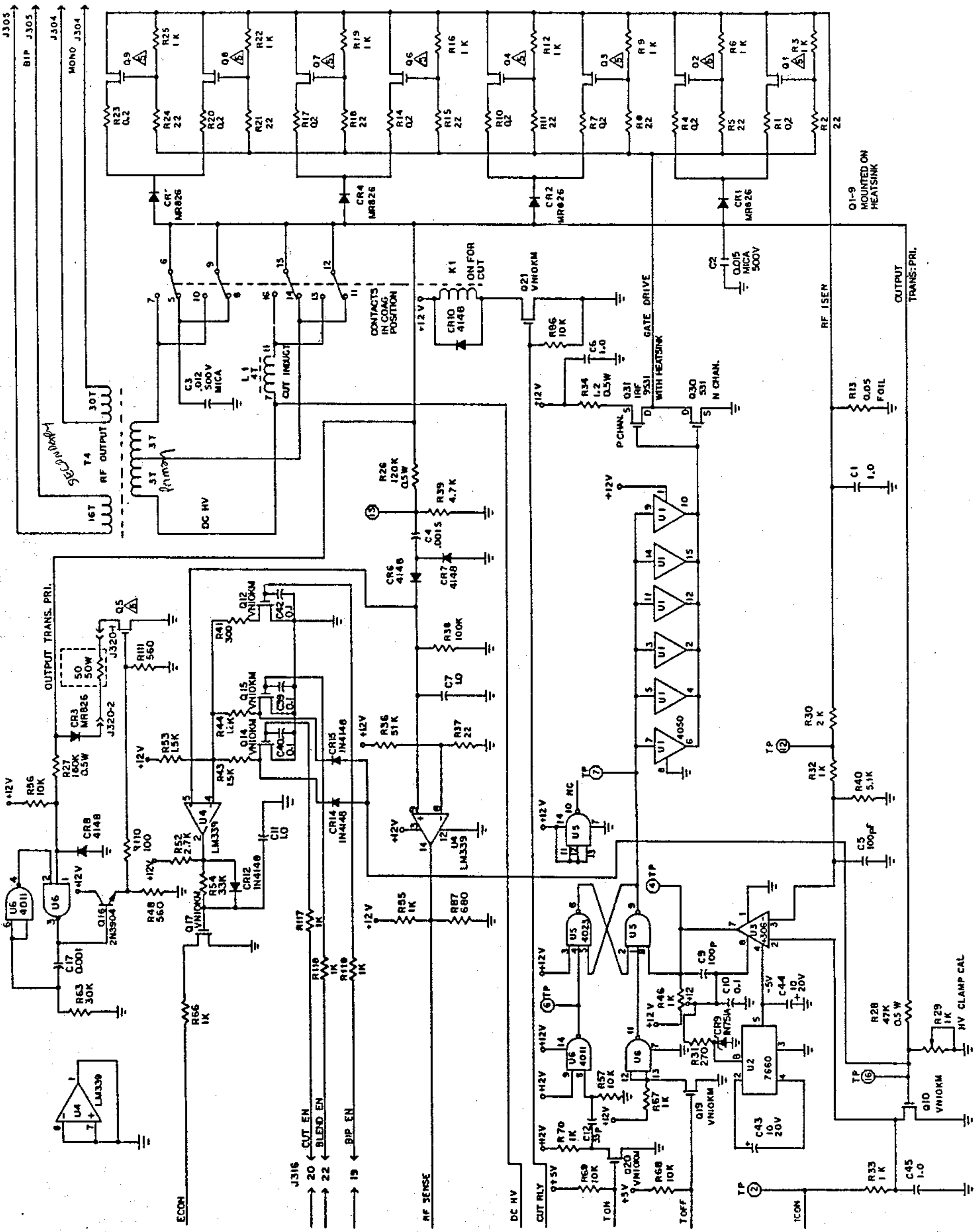


Figure 15

Power Supply–RF Output Board/Schematic


TEST POINTS:
1 ECON
2 ICON
3 HI Z SENSE
4 RF I LIM
5 DC I LIM
6 TON
7 GATE
8 BIP ROLLOFF
9 PK RF
10 SUPPLY FREQ
11 SUPPLY REF
12 RF ISEN TEST
13 PS I LIM TEST
14 HI Z TEST
15 RF LAMP TEST
16 HIV CLAMP TEST
ON HEAT SINK ASSEMBLY
SETPOINT SUM JNCTN
SHIELD
CIRCUIT BREAKER
TERM BLOCK
CHASSIS
Voltage depends on power setting 15V e.g. 100 w ~ 30V



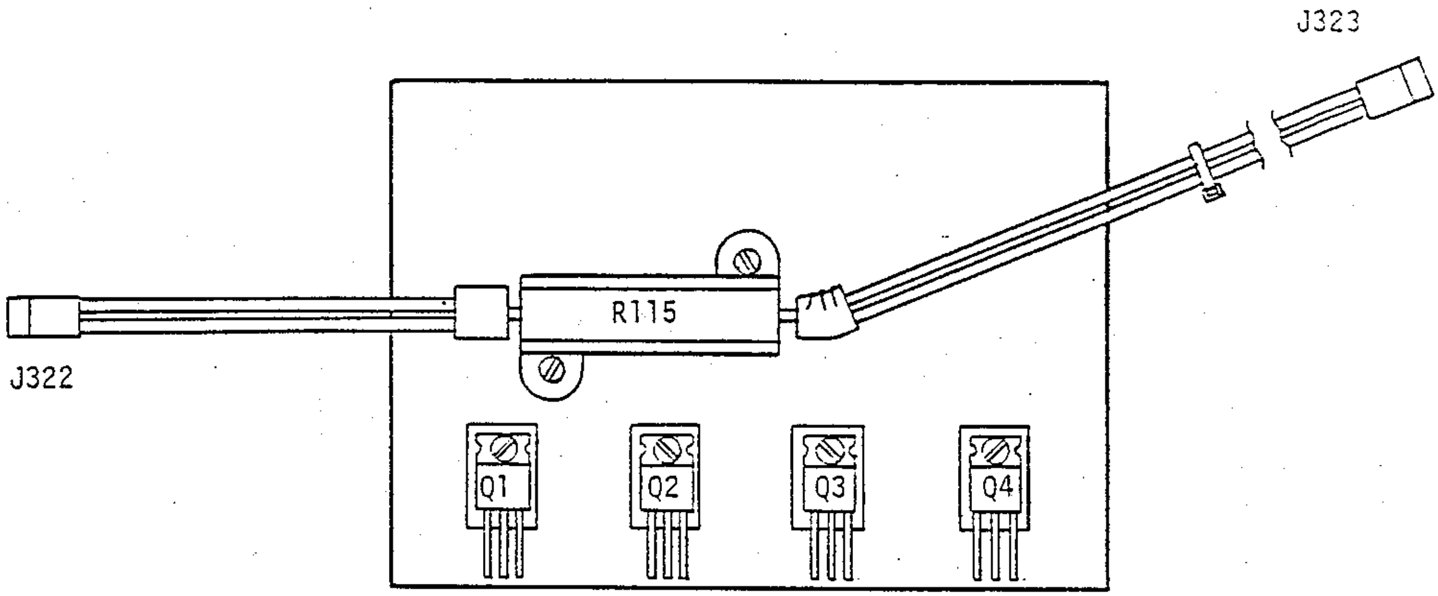


Figure 16

Heatsink Assy, RF Out

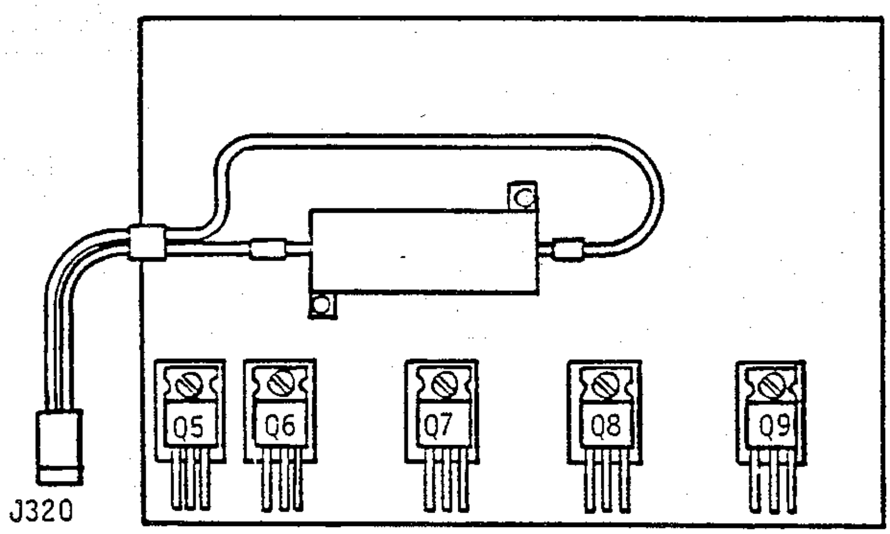


Figure 17

Heatsink Assy, Clamp

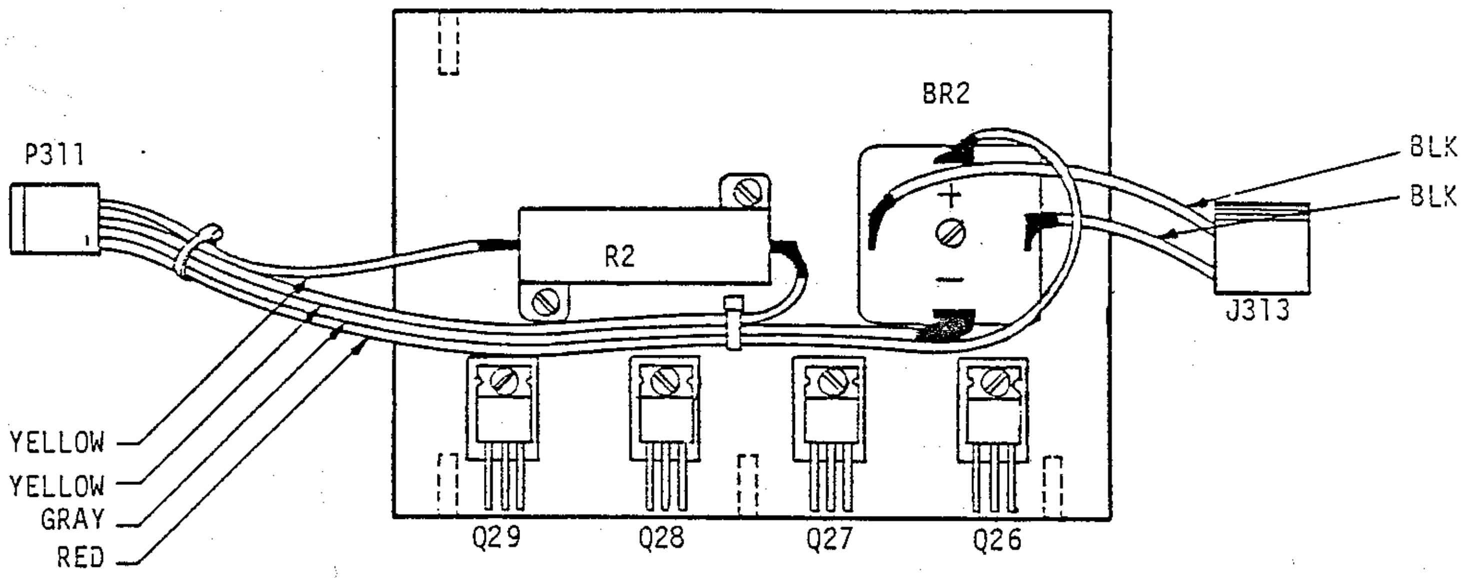


Figure 18

Heatsink Assy, Power Supply

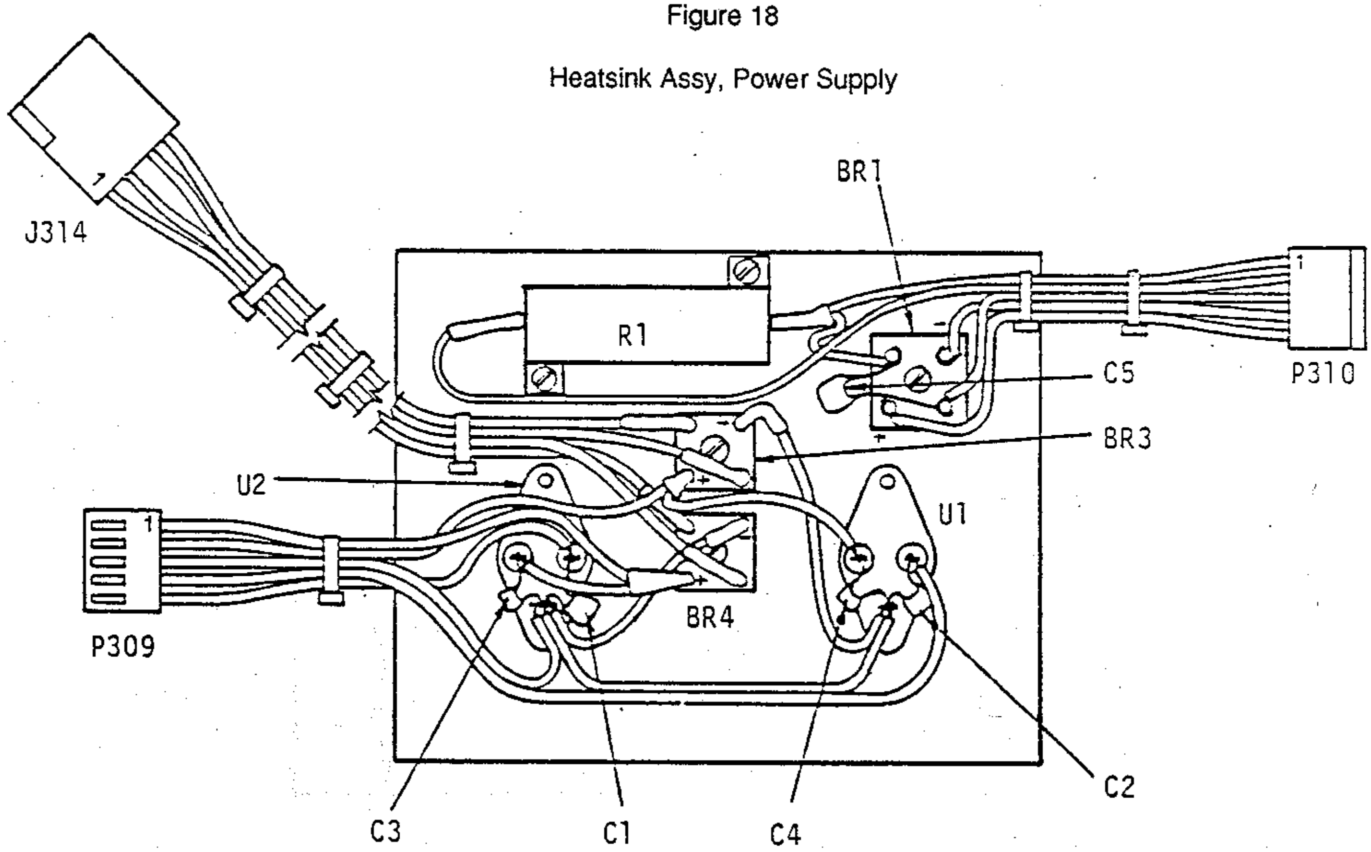


Figure 19

Heatsink Assy, LVPS

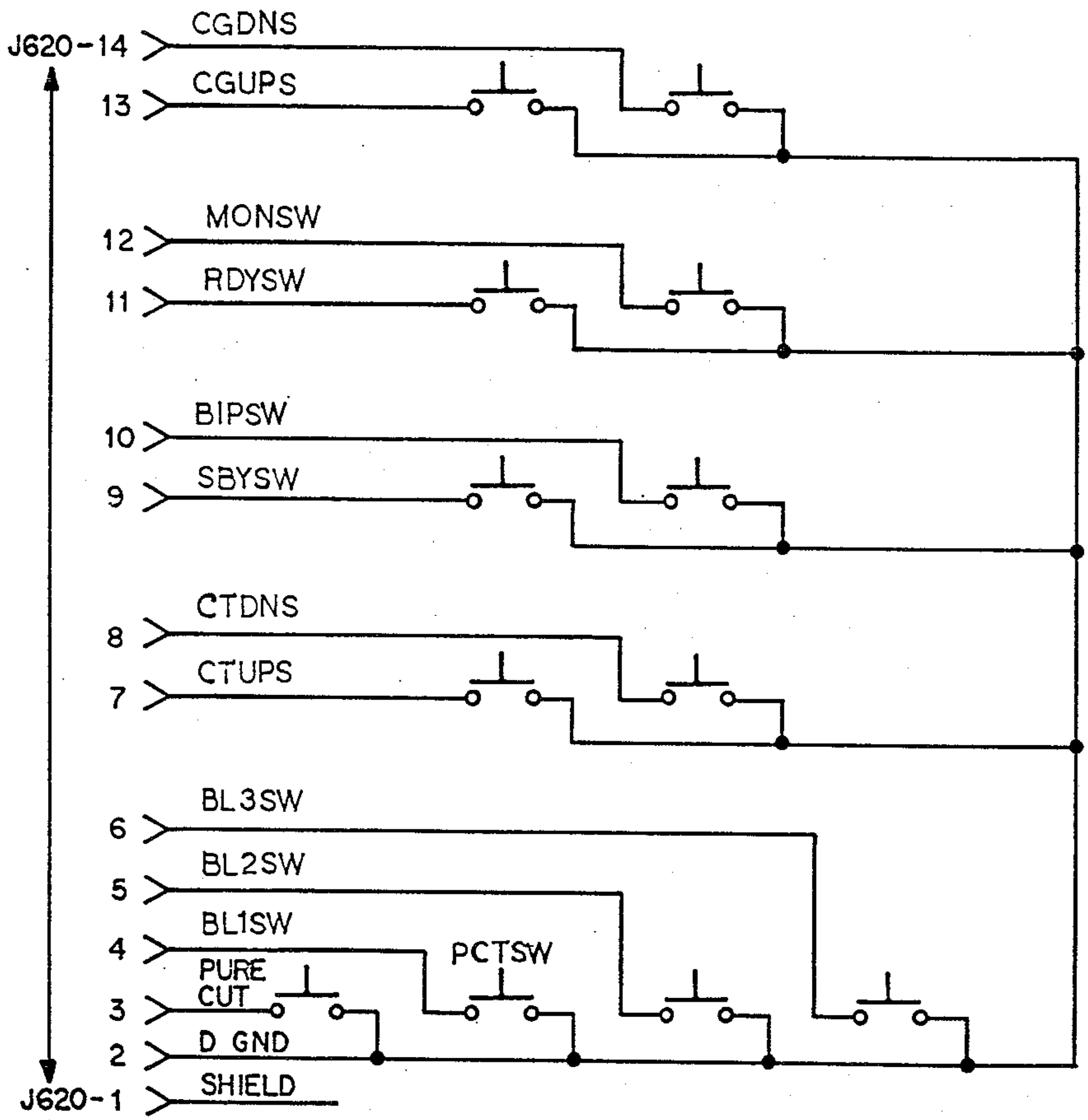


Figure 20

Monopolar Keyboard Schematic

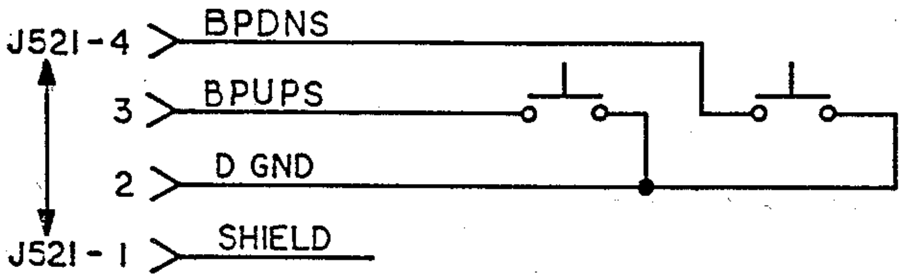


Figure 21

Bipolar Keyboard Schematic

SECTION 7

PARTS LIST

PCB ASSEMBLY, MONOPOLAR DISPLAY — 201 200 017 A

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R1	100 ohm ± 5%, 1W	234 022 039
R2, 14, 17, 22, 33, 34, 37	3.3k ohm ± 5%, 1/4W	234 024 075
R3, 4, 6, 7	75 ohm ± 5%, 1/2W	234 014 086
R5	27 ohm ± 5%, 1/2W	234 014 077
R9, 11, 12, 13	51 ohm ± 5%, 1/2W	234 014 083
R10	18 ohm ± 5%, 1/2W	234 014 073
R15,16, 26	330 ohm ± 5%, 1/4W	234 024 051
R18	33 ohm ± 5%, 1/2W	234 014 078
R19, 29, 30, 47, 48	100k ohm ± 5%, 1/4W	234 024 111
R20, 25, 39, 51, 52	1k ohm ± 5%, 1/4W	234 024 063
R21	100 ohm ± 5%, 1/4W	234 024 039
R23, 32, 41, 42, 44+46	10k ohm ± 5%, 1/4W	234 024 087
R24	4.7k ohm ± 5%/ 1/4W	234 024 079
R27	510 ohm ± 5%, 1/4W	234 024 056
R28	1 Meg ohm ± 5%, 1/4W	234 024 135
R31	130k ohm ± 5%, 1/4W	234 024 114
R35, 36	51 ohm ± 5%, 1/4W	234 024 032
R38	33k ohm ± 5%, 1/4W	234 024 099
R40	24k ohm ± 5%, 1/4W	234 024 096
R43	20k ohm ± 5%, 1/4W	234 024 094
R49, 50	1.8 Meg ohm ± 5%, 1/2W	234 024 141
RA1+4	RESISTOR ARRAY, 1k ohm	234 100 134
CAPACITORS		
C1, 6, 13, 30, 32	1.0 µf ± 20%, 50V	204 118 014
C2, 3, 7, 9, 10, 12, 15+24, 27, 28, 37	0.1 µf ± 20%, 50V	204 118 007
C4, 5, 8	10 µf ± 20%, 25V	204 102 028
C11	.033 µf ± 20%, 50V	204 118 004
C14, 25, 26, 29, 34	.01 mf ± 20%, 50V	204 118 001
C31	47 pf ± 15%, 100V	204 200 009
C33	33 pf ± 15%, 100V	204 200 007
C35	22 pf ± 15%, 100V	204 200 005
C36, 38	100 pf ± 15%, 100V	204 200 013

INTEGRATED CIRCUITS

U1, 14	2803A	210 800 002
U2	8749, Programmed	210 730 066
U3	ICM7218C	210 700 001
U4, 6, 17	74LS374	210 520 374
U5	74LS165	210 520 165
U7	MC14584B	210 212 106
U8	4001B	210 210 001
U9, 13	4013B	210 027 001
U10	4066	210 200 022
U11	4073B	210 210 073
U12	SN7406	210 500 005
U15, 29	4081	210 210 081
U16, 23, 24	74LS240	210 520 240
U18, 19	74LS85	210 520 085
U20	4068B	210 210 068
U21	4071B	210 210 071
U22	4011B	210 210 011
U25, 26	DAC0832	210 075 001
U27	LM324N	210 022 000
U28	74LS92	210 520 092
CR4	M336	210 300 016

TRANSISTORS

Q1, 3	2N2907A	239 100 012
Q2, 4	2N3904	239 015 000
Q5	VN10KM	239 200 012

DIODES

CR1, 2, 3, 6–10	1N4148	239 014 000

LED'S

D1	HLMP2720	239 750 022
D2, 3, 4, 9, 10, 11	HDSP7031	239 750 029
D5, 7, 8	HLMP2755	239 750 033
D6, 13	HLMP2855	239 750 039
D12	HLMP2655	239 750 042

MISCELLANEOUS

Y1	CRYSTAL, 6 MHz	250 010 005
L1, 2	EMI FERRITE BEAD	251 100 090
	LAMP, PTL 20D/12	215 200 070

PCB ASSEMBLY, BIPOLAR DISPLAY — 201 201 003 C

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
D1, 2	HDSP7301	239 750 029
	SPEAKER, 8 ohm	241 003 001
	LAMP, PTL 6/12	215 200 071

PCB ASSEMBLY, INTERFACE — 201 202 006 A

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R201	10 ohm ± 5%, 1/4W	234 024 015
R202, 203, 205–208, 210, 212–215, 224–226, 240	1k ohm ± 5%, 1/4W	234 024 063
R204	4.3k ohm ± 5%, 1/4W	234 024 078
R209	3k ohm ± 5%, 1/4W	234 024 074
R211, 242, 246, 247	5.1k ohm ± 5%, 1/4W	234 024 080
R216	11k ohm ± 1%, 1/8W	234 201 389
R217	51.1k ± 1%, 1/8W	234 201 453
R218–222, 266	3.6k ohm ± 5%, 1/4W	234 024 076
R223, 254–258	820 ohm ± 5%, 1/4W	234 024 061
R227	200k ohm ± 5%, 1/4W	234 024 118
R228, 261	100k ohm ± 5%, 1/4W	234 024 111
R229	560k ohm ± 5%, 1/4W	234 024 129
R230	910k ohm ± 5%, 1/4W	234 024 134
R231	160k ohm ± 5%, 1/4W	234 024 116
R232, 244, 249, 260	10k ohm ± 5%, 1/4W	234 024 087
R233, 239	200k ohm ± 1%, 1/8W	234 024 510
R234	6.04k ohm ± 1%, 1/8W	234 201 364
R235, 238, 267, 272	15k ohm ± 5%, 1/4W	234 024 091
R236, 237, 251, 269	10k ohm ± 1%, 1/8W	234 201 385
R241	604 ohm ± 1%, 1/8W	234 201 268
R245	3.3k ohm ± 5%, 1/4W	234 024 075
R248	390k ohm ± 5%, 1/4W	234 024 125
R250	19.1k ohm ± 1%, 1/8W	234 201 412
R252	68k ohm ± 5%, 1/4W	234 024 107
R253	51k ohm ± 5%/ 1/4W	234 024 104
R259	470k ohm ± 5%, 1/4W	234 024 127
R262	10 Meg ohm ± 5%, 1/4W	234 024 158
R263	33k ohm ± 5%, 1/4W	234 024 099
R264, 265	2.4k ohm ± 5%, 1/4W	234 024 072
R268, 271	5.6k ohm ± 5%, 1/4W	234 024 081
R270	887 ohm ± 1%, 1/8W	234 201 284
R273	TRIMPOT, 20k ohm	236 010 008
R274	TRIMPOT, 5k ohm, #3299X	236 010 006
R275	TRIMPOT, 100k ohm, #3299X	236 010 011

CAPACITORS

C201, 202	.22 µf ± 10%, 250V	204 400 120
C203–206	.0047 µf ± 20%, 6kV	204 025 050
C207–212, 214, 215, 217, 227–229, 250–256, 258–260	0.1 µf ± 20%, 50V	204 118 007
C213, 216, 219, 220, 223–226, 230, 235, 236, 239–246, 261–264	1.0 µf ± 20%, 50V	204 118 014
C218, 232	240 pf ± 5%, 500V	204 105 011
C221, 222	3300 pf	204 200 031
C231, 238	.010 µf ± 15%, 100V	204 200 037
C233, 234, 237	10 µf ± 20%, 25V	204 102 028
C247–249	.001 µf ± 20%, 50V	204 121 060

INTEGRATED CIRCUITS

U201, 208	LM339AN	210 300 015
U202, 205, 210, 211	4049B	210 210 049
U203	I79L05AC	210 300 071
U204	4013B	210 027 001
U206	4011B	210 210 011
U207	LM358AN	210 300 013
U209	4066	210 200 022

TRANSISTORS

Q201–203, 206	2N3904	239 015 000
Q204–205	VN10KM	239 200 012
Q207	2N2907A	239 100 012

DIODES

CR201–211	1N4148	239 014 000
CR212–215	1N5240B	239 600 001

TRANSFORMERS

T201	TRANSFORMER ASSY	202 900 017
T202, 203	TOROID ASSY	202 224 000

MISCELLANEOUS

K1–3	REED RELAY, 8 kV	230 006 019
OPT201–206	OPTO–ISOLATOR 1264B	239 750 019
OPT207–209	OPTO–ISOLATOR 4N35	239 750 002

PCB ASSEMBLY, POWER SUPPLY — 201 203 005 A

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R1, 4, 7, 10, 14, 17, 20, 23	RESISTOR ASSY, .2 ohm	203 077 001
R2, 5, 8, 11, 15, 18, 21, 24, 37	22 ohm ± 5%, 1/4W	234 024 023
R3, 6, 9, 12, 16, 19, 22, 25, 32, 33, 44, 46, 50, 55, 66, 67, 70, 84, 96, 99, 100, 102, 104, 117–119	1k ohm ± 5%, 1/4W	234 024 063
R13	FOIL INCONEL, .04 ohm	222 640 001
R26	120k ohm ± 5%, 1/2W	234 014 124
R27	160k ohm ± 5%, 1/2W	234 014 127
R28	47k ohm ± 5%, 1/2W	234 014 115
R29	TRIMPOT, 1k ohm	236 200 076
R30	2k ohm ± 5%, 1/4W	234 024 070
R31, 72	270 ohm ± 5%, 1/4W	234 024 049
R34	1.2k ohm ± 5%, 1/2W	234 014 048
R35, 110	100 ohm ± 5%, 1/4W	234 024 039
R36	51k ohm ± 5%, 1/4W	234 024 104
R37, 39	4.7k ohm ± 5%, 1/4W	234 024 079
R38, 58, 65, 73, 114	100k ohm ± 5%, 1/4W	234 024 111
R40, 64	5.1k ohm ± 5, 1/4W	234 024 080
R41	300 ohm ± 5%, 1/4W	234 024 050
R43, 53	1.5k ohm ± 5%, 1/4W	234 024 067
R45	110k ohm ± 5%, 1/4W	234 024 112
R48, 75, 111	560 ohm ± 5%, 1/4W	234 024 057
R49	330k ohm ± 5%, 1/4W	234 024 123
R51	3.6k ohm ± 5%, 1/4W	234 024 076
R52, 59	2.7k ohm ± 5%, 1/4W	234 024 073
R53	1.5k ohm ± 5%, 1/4W	234 024 067
R54	33k ohm ± 5%, 1/4W	234 024 099
R56, 57, 68, 69, 79, 85, 86, 105–107	10k ohm ± 5%, 1/4W	234 024 087
R59	2.7k ohm ± 5%, 1/4W	234 024 073
R60	7.5k ohm ± 5%, 1/4W	234 024 084
R61	36 ohm ± 5%, 1/4W	234 024 028
R62	47k ohm ± 5%, 1/4W	234 024 103
R63	30k ohm ± 5%, 1/4W	234 024 098
R71	150k ohm ± 5%, 1/4W	234 024 115
R74, 78	470 ohm ± 5%, 1/4W	234 024 055
R76, 77	4.7 ohm ± 5%, 1/2W	234 014 060
R80, 81	20k ohm ± 5%, 8W	234 000 017
R82, 83	.1 ohm ± 3%, 3W	234 028 001
R87	680 ohm ± 5%, 1/4W	234 024 059
R88–95	TRIMPOT, 10k ohm	236 200 079
R97, 98, 101, 103	51 ohm ± 5%, 1/4W	234 024 032
R112, 113	1.2k ohm ± 5%, 1/2W	234 014 041

CAPACITORS

C1, 6, 7, 11, 18, 22–25, 35, 45, 47–49	1.0 µf ± 20%, 50V	204 118 014
C2	.015 µf ± 10%, 500V	204 085 012
C3	.012 µf ± 10%, 500V	204 085 010
C4, 8	1500 pf ± 10%, 1000V	204 079 059
C5, 9	100 pf ± 15%, 100V	204 200 013
C10, 15, 16, 33, 34, 39, 40, 42	0.1 µf ± 20%, 50V	204 118 007
C12	33 pf ± 10%, 600V	204 200 007
C13	47 pf ± 15%, 100V	204 200 009
C14, C19	.033 µf ± 20%, 50V	204 118 004
C17	1000 pf ± 15%, 100V	204 200 025
C20	2200 pf ± 5%, 500V	204 105 034
C26, 28	1000 µf ± 20%, 200V	204 500 103
C27	1500 pf ± 5%, 500V	204 105 030
C29	1µf ± 10%, 250V	204 400 138
C30	1200 pf ± 5%, 200V	204 105 028
C31	6800 µf, +30 –10%, 25V	204 500 106
C32	4700 µf, +30 –10%, 35V	204 500 105
C36, 37	15 µf ± 10%, 220V	204 400 130
C38	2 µf, 400V	204 400 001
C43, 44	10 µf ± 10%, 20V	204 055 002

INTEGRATED CIRCUITS

U1	4050B	210 210 050
U2	ICL7660CPA	210 300 072
U3	LM306	210 016 002
U4	LM339AN	210 300 015
U5	4023B	210 210 023
U6	4011B	210 210 011
U7	SG3526	210 300 062
U8, 9	4066	210 200 022

TRANSISTORS

Q10, 12, 14, 15, 17, 18–21	VN10KM	239 200 012
Q16	2N3904	239 015 000
Q22, 25	2N2905A	239 019 000
Q23, 24	MM3724	239 052 000
Q30	IRF531	239 200 014
Q31	IRF9533	239 200 015

DIODES

CR1–5	MR826	239 066 005
CR6–8, 10–12, 14, 15	1N4148	239 014 000
CR9	1N751A	239 600 011
CR13	1N5233B	239 600 000

MISCELLANEOUS

T1, 2	TRANSFORMER, PULSE	251 200 024
T3	TRANSFORMER, PWR SWITCHING	251 200 029
T4	TRANSFORMER, OUTPUT	251 200 030
L1	INDUCTOR, CUT	251 100 077
L2	INDUCTOR, .75mH, #T–0403	251 039 000
F1	FUSE, 6 AMPS	215 005 039
K1	RELAY, 4 POLE	230 007 002

HEATSINK ASSY, RF OUT **202 701 282 C**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
R115 ✓	RES. 500 ohm ± 5%, 50W	234 003 008
Q1–4	TRANSISTOR BUZ80A	239 200 020

HEATSINK ASSY, CLAMP **202 701 283 C**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
R1	RES. 50 ohm ± 5%, 50W	234 003 007
Q5–9	TRANSISTOR BUZ80A	239 200 020

HEATSINK ASSY, P.S. **202 701 069 H**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
R2	RES. 50 ohm ± 5%, 5W	234 003 007
Q26–29	POWER FET SGS	239 200 018
BR2	BRIDGE RECT. MDA3504	239 700 003

HEATSINK ASSY, LVPS **202 701 331 A**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
R1	RES. 50 ohm ± 3%, 50W	234 003 005
C1– 4	CAP. 1.0 µf ± 20%, 50V	204 118 014
C5	.0022 µf ± 20%, 6kV	204 025 044
U1	VOLT. REG. LM340K–5.0	210 300 073
U2	VOLT. REG. LM340K–12	210 300 074
BR1	BRIDGE RECT. VK648X	239 700 034
BR3, 4	BRIDGE RECT. VS247	239 006 000

SECTION 8

WARRANTY

Valleylab, Inc. ("Manufacturer") warrants each product manufactured by it to be free from defects in material and workmanship under normal use and service. Manufacturer's obligation under this warranty is limited to the repair or replacement, at its option, of any product, or part thereof, which has been returned to it or its Distributor within the applicable time period shown below after delivery of the product to the original purchaser, and which examination discloses, to Manufacturer's satisfaction, that the product is defective. This warranty does not apply to any product, or part thereof, which has been repaired or altered outside of Manufacturer's factory in a way so as, in Manufacturer's judgment, to affect its stability or reliability, or which has been subjected to misuse, negligence or accident.

The warranty periods for Manufacturer's products are as follows:

ELECTROSURGICAL GENERATORS	One Year
Mounting Fixtures (all models)	One Year
Footswitches (all models)	One Year
Return Electrodes	Shelf life only, as stated on packaging.
Sterile Disposables	Sterility only, as stated on packaging.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS, AND OF ALL OTHER OBLIGATIONS OR LIABILITIES ON THE PART OF THE MANUFACTURER. Manufacturer neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale or use of any of Manufacturer's products. There are no warranties which extend beyond the terms hereof.

This warranty and the rights and obligations hereunder, shall be construed under and governed by the laws of the State of Colorado, U.S.A.

Valleylab, Inc., its dealers and representatives, reserve the right to make changes in equipment built and/or sold by them at anytime without incurring any obligation to make the same or similar changes on equipment previously built and/or sold by them.