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FORCE 4

SERVICE MANUAL

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SECTION 1

INTRODUCTION

This Service Manual covers the installation and basic service instructions for the Valleylab Model FORCE 4 Electrosurgical Generator. Also included are sections covering the Technical Specifications, Circuit Descriptions and the Testing and Troubleshooting of the Generator. Detailed instructions in the use of electrosurgery is beyond the scope of this manual and the reader is directed to the Operator's Instruction Manual provided by Valleylab.

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SECTION 2

INSTALLATION

INSTALLING THE FORCE 4

The compact size of the FORCE 4 system allows a variety of installations. The unit 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 unit and it is important that the vents on the rear and sides remain unobstructed for proper cooling. For this reason the FORCE 4 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 4

180 - 280 VAC, 50 - 60 Hz

The FORCE 4 is designed to operate over an unusually wide range of input voltages with essentially perfect output regulation. This means that in case of brownouts or power surges the output of the FORCE 4 will always remain constant. The FORCE 4 is normally supplied for operation on 220 volts AC (nominal).

PROPER GROUNDING

An important consideration in assuring patient safety while using electrical equipment is proper grounding. The ground wire in the power cable is connected to the generator chassis and insures that no dangerous currents will flow from the cabinet of the unit in the event of an internal electrical failure.

Undesirable 60 Hz leakage currents are also affected by the polarization of the input 60 Hz power to the unit. It is the responsibility of the user to assure proper grounding and polarity in the power outlets furnishing power to the FORCE 4.

POWER PLUGS FOR THE FORCE 4

Unless an explosion-proof connector is specified, the 110 volt FORCE 4 is equipped with an approved hospital duty 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 disassembled and inspected by qualified maintenance personnel.

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220 volt AC versions of the FORCE 4 are shipped with a standard U.S.A. 220 volt tandem blade connector of equivalent quality and construction to the Hospital Grade 110 volt connector. At present there are no Hospital Grade 220 volt connectors and we do not have access to all the various 220 volt connectors used in other countries. The Valleylab representative in your country will equip your FORCE 4 with the proper connector for your operating room.

ROUTINE MAINTENANCE AND INSPECTIONS

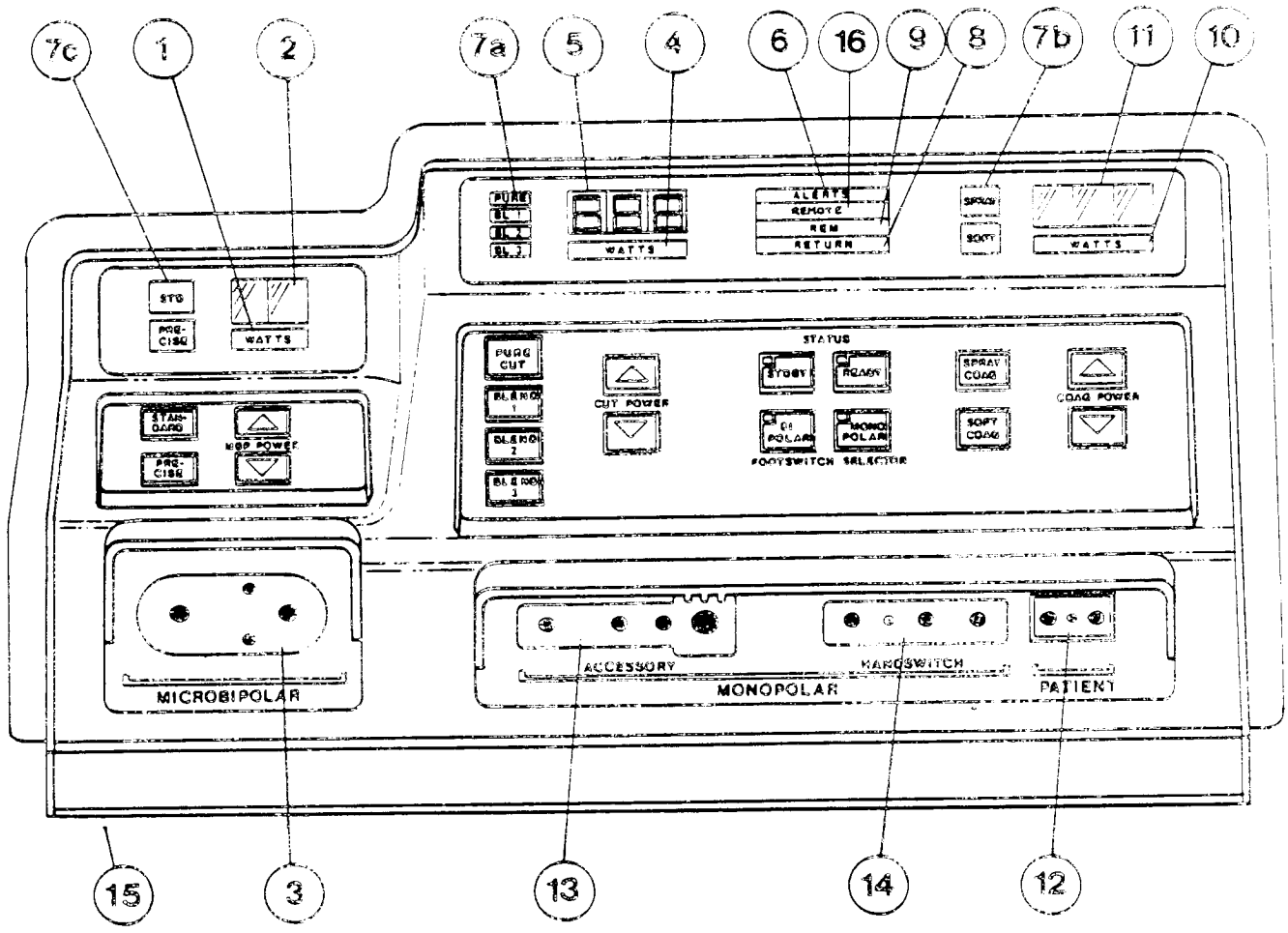
The solid-state design of the FORCE 4 assures virtually maintenance-free use. Maintenance is limited to periodic inspections. Repair should be limited to repairing cords and replacing accessories. Should breakage or wear occur to the cord it should be replaced. Proper handling will minimize repair and replacement problems. Cords should always be grasped by the plugs. DO NOT PULL ON THE CORD ITSELF.

We recommend that the FORCE 4 be inspected by the hospital engineer twice a year. This Service Manual describes the recommended inspection and check-out procedures. For major repairs the FORCE 4 can be returned to Valleylab or your Valleylab representative. If desired, Valleylab will supply any parts or information needed to repair the FORCE 4.

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SECTION 3

DESCRIPTION OF CONTROLS AND INDICATORS



1, 2	Microbipolar Power
4, 5	Monopolar Power - Cut
6-9	Alarm and Mode Indicators
10, 11	Monopolar Power - Coag
12	REM connector
13, 14	Monopolar Output Jacks
3	Bipolar Output Jacks
15	Audio Volume
16	Remote Power Change Indicator

FIGURE 1

THE FORCE 4 INDICATORS AND OUTPUTS ON THE FRONT PANEL

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A. FRONT PANEL INDICATORS AND OUTPUTS (SEE FIG. 1)

1. BIPOLAR OUTPUT ACTIVE INDICATOR

The word 'WATTS' will be illuminated when useful output power is available at the Microbipolar Output Jack (3). Absence of illumination when the generator is keyed in the bipolar mode may indicate generator malfunction.

2. BIPOLAR POWER READOUT

This digital LED display is visible when the generator is in the ready mode (2, Fig. 2). The number displayed predicts the level of bipolar power, in watts, which will be delivered to a 100 ohm load when the generator is keyed in the bipolar mode.

3. BIPOLAR ACTIVE RECEPTACLE

This receptacle will accept the three prong active bipolar accessories and will be keyed by the handswitch. It will also accept two prong active accessories and the bipolar generator is then keyed by the foot switch when the bipolar foot switch button, (18, Fig. 2), is pressed.

4. MONOPOLAR CUT OUTPUT ACTIVE INDICATOR

The backlit word 'WATTS' will be visible when the generator is keyed in the cut mode and useful output power is available at either of the monopolar output jacks (13) and (14). Absence of illumination when the generator is keyed indicates a malfunction.

5. MONOPOLAR CUT POWER READOUT

This digital LED display is visible when the generator is in the ready mode (2, Fig. 2). The number displayed predicts the level of monopolar cut power, in watts, which will be delivered to a 300 ohm load when the generator is keyed in the monopolar cut mode.

6. ALERT INDICATOR

This LED lamp is on whenever the generator is disabled by an alarm condition. The audio alarm will sound twice when this lamp goes on.

7. MODE INDICATOR LAMPS

A. One of four CUT mode indicators is illuminated to show the CUT power waveform. The mode may be changed by pressing one of the four mode selector push buttons (9,10,11,12; Fig. 2)

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Pure: 750 kHz sinusoid
Blend 1: 50% duty cycle, 750 kHz sinusoid
Blend 2: 25% duty cycle, 750 kHz sinusoid
Blend 3: 25% duty cycle, 750 kHz sinusoid plus inductive discharge pulses.

B. One of two COAG mode indicators is illuminated to show the COAG power waveform. Select by pushing one of the mode selector push buttons (15,16; Fig. 3)

SPRAY COAG: 31 kHz inductive discharge
SOFT COAG: 22 kHz inductive discharge

C. One of two bipolar power mode indicators is illuminated to show the bipolar output power versus load impedance characteristics. Selection is by the push buttons (5,6; Fig. 2).

STANDARD: Output power at 50 and 200 ohm loads is 1/2 of the power at a 100 ohm load.
PRECISE: Output power at a 200 ohm load is 1/4 of the 100 ohm output power.

8. *RETURN FAULT INDICATOR*

This LED illuminates if the FORCE 4 is keyed without a proper patient electrode connection, producing a situation where a significant proportion of the RF current returns to the generator by some path other than the patient connector (12). The FORCE 4 is disabled so long as the indicator is on. The audio alarm will sound twice when the alert is first detected. The alarm can be cleared by releasing the hand or footswitch and then rekeying the unit.

9. *REM FAULT INDICATOR (Return Electrode Monitor)*

This LED illuminates when the patient electrode contact monitor senses an alarm condition. For a single-section patient electrode the alarm condition is a resistance greater than 16 ohms between the pins of the patient electrode connector (12). For a dual-section patient electrode the alarm condition is a resistance outside the range of 5 - 135 ohms or a 30% increase in resistance. The audio alarm will sound twice when the alarm is first detected. The alarm is cleared when the resistance is lowered and is within the acceptance range.

10. *MONOPOLAR COAG OUTPUT ACTIVE INDICATOR*

The backlit word 'WATTS" will be visible when the generator is keyed in the coagulation mode and useful output power is available at either of the monopolar output jacks (13) and (14). Absence of illumination when the generator is keyed may indicate a malfunction.

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11. *MONOPOLAR COAGULATION POWER READOUT*

This digital LED display is visible when the generator is in the ready mode (2, Fig. 2). The number displayed predicts the level of monopolar coagulation power, in watts, which will be delivered to a 300 ohm load when the generator is keyed in the monopolar coagulation mode.

12. *PATIENT RETURN ELECTRODE RECEPTACLE*

This 2 pin receptacle accepts the patient return electrode connector used in monopolar procedures. A pin on the patient electrode connector actuates a switch within the receptacle to indicate the use of the dual-section patient electrode used for contact area (REM) monitoring.

13. *MONOPOLAR ACTIVE RECEPTACLE - HAND OR FOOTSWITCH*

This receptacle will accept three-prong handswitching active accessories (Valleylab LectroSwitch) or standard one-prong active accessories. This output can be activated by the footswitch when the monopolar footswitch button (17, Fig. 2) is pressed or by the handswitching accessory. Cut mode or coagulation mode power may be keyed at this receptacle.

14. *MONOPOLAR ACTIVE RECEPTACLE - HANDSWITCH*

This receptacle will accept the three-prong handswitching active accessories. This output is activated only by the handswitch and will have no power available if the generator is keyed by the footswitch. Cut mode or coagulation mode power may be keyed at this receptacle.

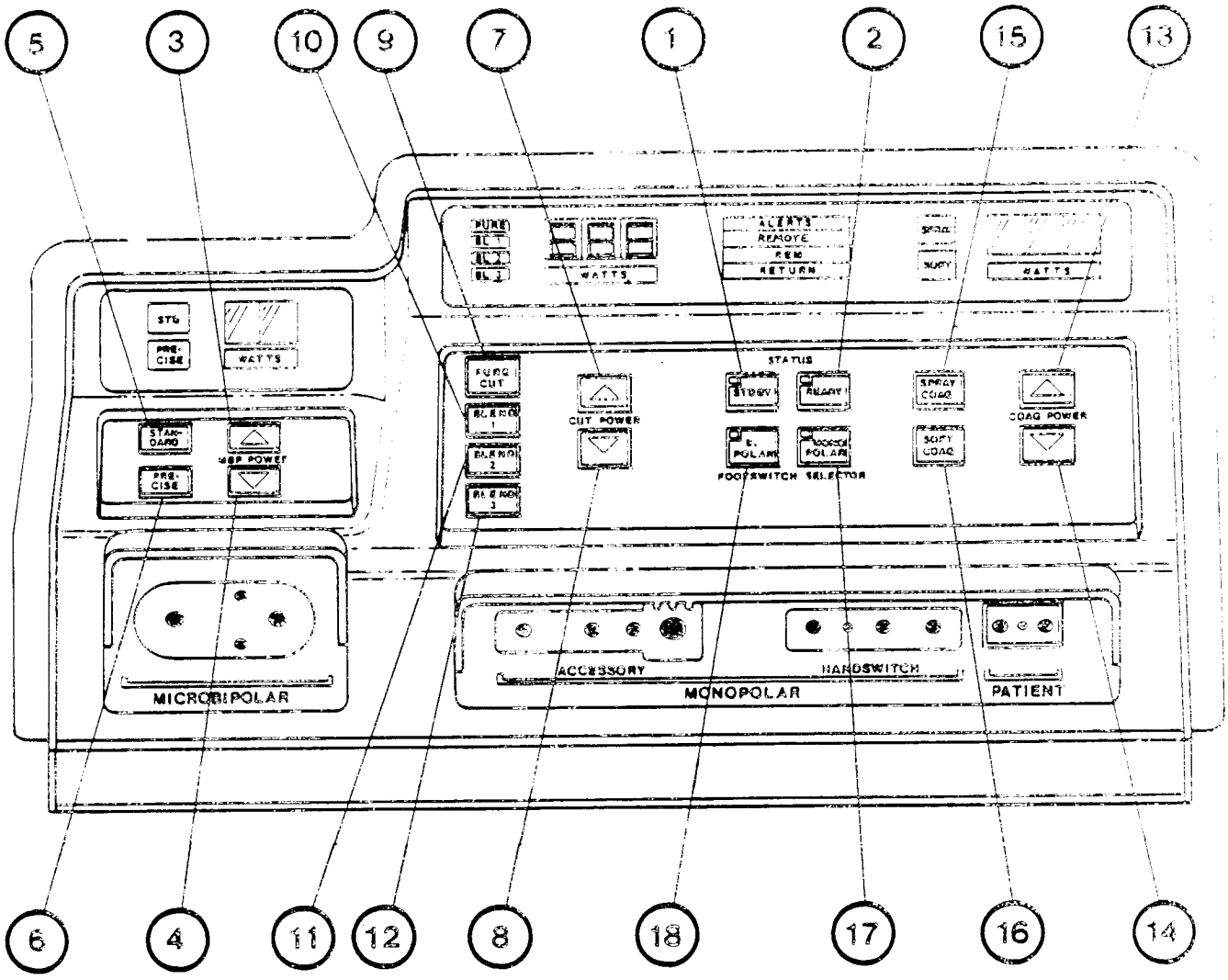
15. *AUDIO VOLUME CONTROL*

The volume of the cut and coag audio tones produced when the generator is keyed may be adjusted with this 4-position slide switch. Pull the switch forward to increase the volume, push it back to decrease the volume. The volume of the 'bong' produced by alarm conditions is not adjustable.

16. *REMOTE INDICATOR*

This lamp will be illuminated and the audio will 'bong' once when the remote power change feature is activated at the handswitching accessory. When the lamp is on, remote power changes can occur. The lamp is turned off by switching to standby (1, Fig. 3).

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3-6 Bipolar Controls
7-12 Monopolar CUT controls
1, 2 Standby, Ready Mode Selectors
17, 18 Footswitch Keying Selectors
13, 16 Monopolar COAG controls

FIGURE 2

THE SSE4 CONTROL KEYBOARD ON THE FRONT PANEL

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B. **FRONT PANEL KEYBOARD CONTROLS** (SEE FIGURE 2)

1. STANDBY MODE SELECTOR

In this mode the generator cannot be keyed and the audio alerts are suppressed. Prior power level settings are retained but the displays will be blank. The generator is in standby when power is first applied.

2. READY MODE SELECTOR

Pressing this button places the generator in service with outputs and alarms fully active.

3. BIPOLAR POWER INCREASE BUTTON

This button increases the bipolar power readout. A single push will raise the power by one watt. Holding the button down continuously will cause the display to increase continuously to 70 watts maximum.

4. BIPOLAR POWER DECREASE BUTTON

Pressing this button decreases the bipolar power display by one watt per push, or continuously if the button is held down.

5. STANDARD MODE SELECTOR

Pressing this button will select the Standard Bipolar mode.

6. PRECISE MODE SELECTOR

Pressing this button will select the Precise Bipolar mode.

7. MONOPOLAR CUT POWER INCREASE BUTTON

This button increases the monopolar cut power readout. A single push will increase the power by one watt, and holding the button down will increase the display to the mode maximum.

8. MONOPOLAR CUT POWER DECREASE BUTTON

Pressing this button decreases the monopolar cut mode power display by one watt per push, or continuously if the button is held down.

9. CUT MODE SELECTOR - PURE CUT

Pressing this button will select a continuous sinewave cut waveform output.

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10. *CUT MODE SELECTOR - BLEND 1*

Pressing this button will select a 50% duty cycle sinewave cut waveform output.

11. *CUT MODE SELECTOR - BLEND 2*

Pressing this button selects a cut mode waveform of 25% duty cycle sinewave for moderate hemostasis.

12. *CUT MODE SELECTOR - BLEND 3*

Pressing this button selects a cut mode output waveform of 25% sinewave plus inductive discharge. This is the cut waveform producing maximum hemostasis.

13. *MONOPOLAR COAGULATION POWER INCREASE BUTTON*

This button increases the monopolar coagulation power display. A single push will raise the power by one watt, and holding the button down will cause a continuous increase.

14. *MONOPOLAR COAGULATION POWER DECREASE BUTTON*

This button decreases the coagulation power display by one watt per push, or continuously when it is held down.

15. *COAG MODE SELECTOR - SPRAY COAG*

Pressing this button will select an inductive discharge with a 31 KHz repetition rate coagulation waveform.

16. *COAG MODE SELECTOR - SOFT COAG*

Pressing this button will select a coagulation waveform with inductive discharge at a lower repetition rate (22 KHz).

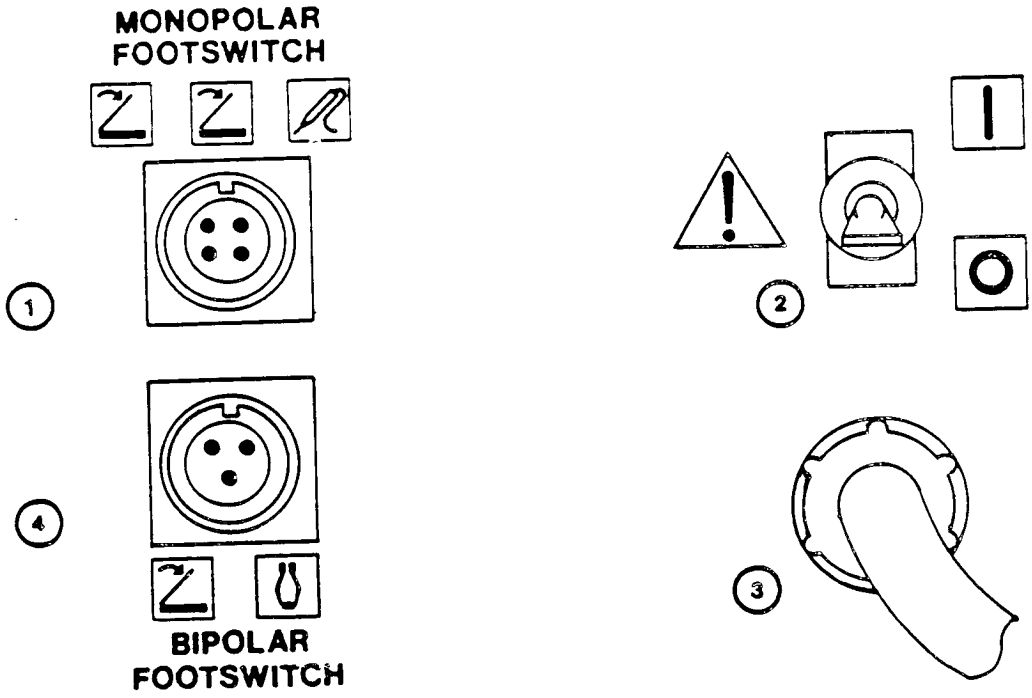
17. *FOOTSWITCH SELECTOR - MONOPOLAR*

Pressing this button places the monopolar output under footswitch keying control.

18. *FOOTSWITCH SELECTOR - BIPOLAR*

Pressing this button places the bipolar output under footswitch control.

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Wiring Diagrams

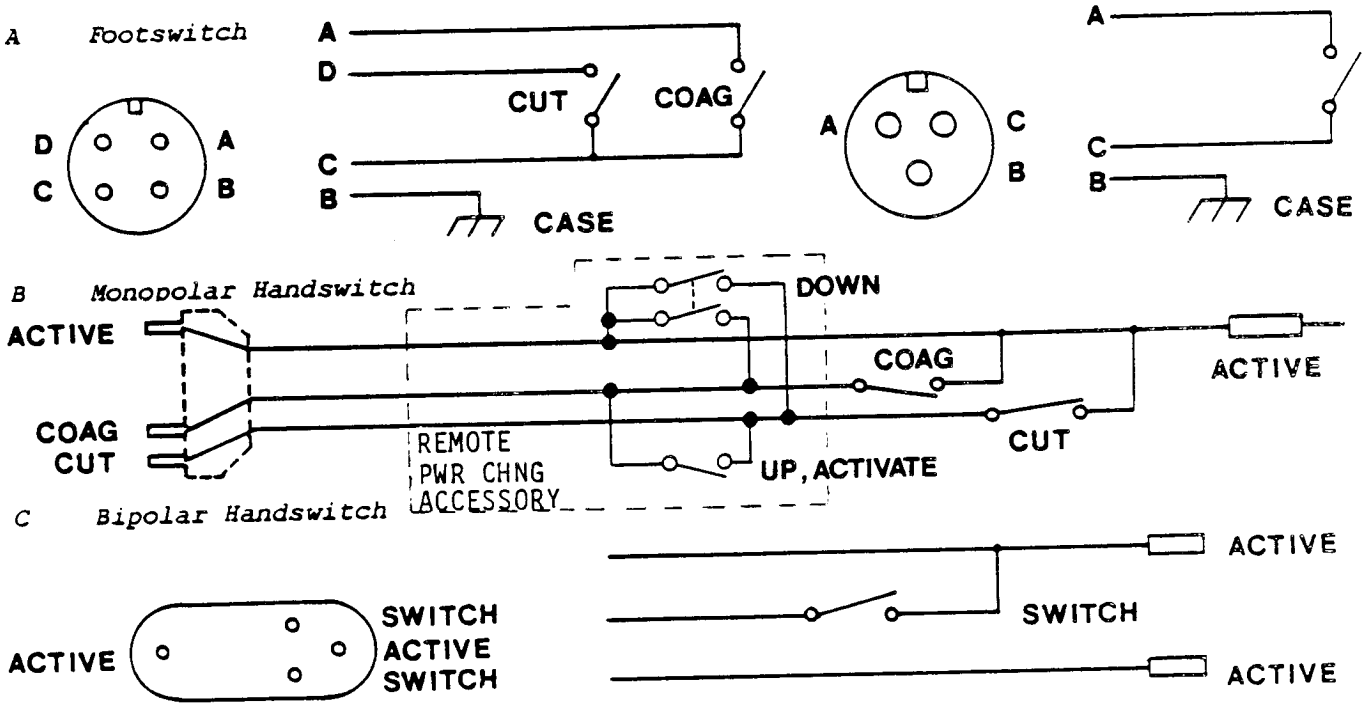


FIGURE 3

THE FORCE 4 REAR PANEL CONTROLS AND CONNECTORS

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REAR PANEL CONTROLS AND CONNECTORS (SEE FIG. 3)

1. *FOOTSWITCH RECEPTACLE-MONOPOLAR/BIPOLAR*

   This 4-pin MS-type receptacle accepts the two-treadle footswitch connector. The wiring diagram is shown in Fig. 3.A.

2. *POWER SWITCH*

   This power switch includes a circuit breaker. Press the toggle upward to apply power and down to shut power off.

3. *POWER CORD*

   The line cord is terminated in a grounded 3-pin plug and should be connected to a properly phased, grounded receptacle.

4. *FOOTSWITCH RECEPTACLE-BIPOLAR*

   This three-pin MS-type receptacle accepts the single-treadle footswitch connector.

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SECTION 4

MONOPOLAR AND BIPOLAR ELECTROSURGICAL CONFIGURATIONS & ACCESSORIES

The FORCE 4 features three separate outputs which may be activated. Two of these outputs are used primarily in monopolar configurations. The MONOPOLAR HANDSWITCH output is designed for use with either switching forceps or a switching pencil. The MONOPOLAR ACCESSORY output is designed for use with switching accessories or it can be activated by the footswitch. The third output is a reduced power BIPOLAR output which may be used with switching or nonswitching bipolar accessories and may be activated by either the switching accessory or by the footswitch.

MONOPOLAR CONFIGURATION

Monopolar Accessories

The FORCE 4 has a radio frequency (RF) grounded output. In monopolar operation, the radio frequency current passes from the active accessory, through the patient, and returns to the generator via a patient plate which contacts the patient's skin.

The Valleylab hand-switching accessories plug into the three banana pin jacks on either the "Handswitch" or "Accessory" receptacles. All three pins are "active" since there are only low, switching voltages between the pins. Models E4001 and E4002 coagulation forceps also plug into either monopolar receptacle. The standard active "accessory" jack will accept the plugs of most standard accessories directly or through an appropriate adapter. The footswitch then controls the current flow to the accessory. Both the Model E6008 and E6009 footswitches are designed for operating room use and are connected to the FORCE 4 by means of a four-pin footswitch receptacle on the back panel of the generator. The E6008 footswitch pedals activate the generator in CUT/BLEND or COAG as needed. The E6009 activates the Force 4 in Bipolar only. The FORCE 4 has an override circuit to insure that only COAG is activated in the event that both pedals are pushed simultaneously. The FORCE 4 has an "intrinsically safe" footswitch circuit. This means that the switching currents are too low to cause a spark even in the most dangerous mixture of flammable gas and oxygen. To qualify as intrinsically safe, the spark energy which occurs at the switch contacts must be less than 1 millijoule. The energy present in the FORCE 4 switching circuits is about 1/5000 of the amount considered a conservative limit for safe, open- contact operation.

The Patient Return Electrode

In a monopolar configuration, a return electrode is used to limit the current densities to a safe level.

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An accepted standard for gelled plate or foil electrodes is 1.5 watts per square centimeter of return electrode area or roughly 9 or 10 square inches per hundred watts of generator output. (NFPA Bulletin No. 76CM, Part II.)

A delicate procedure which uses low power settings requires only a few square inches. Gelled foam pad electrodes, and conductive adhesive electrodes such as Valleylab Model E7503, 5, 6, 7 have come into common usage and with proper adherance to manufacturer's instructions, they can be an effective and safe method of providing the return connection. The FORCE 4 is an RF grounded system with a return fault circuit which continuously monitors the flow of electrosurgical current in the patient circuit and the power distribution ground. The circuit prevents FORCE 4 operation if the proportion of current returning through ground is excessive and thus provides a high degree of safety from patient burns under common fault conditions.

BIPOLAR CONFIGURATION

Bipolar Accessories

The most common bipolar instruments are forceps, the jaws of which are connected to the BIPOLAR output jacks. In bipolar operation the current flow is limited to the tissue which is grasped by the jaws. The FORCE 4 BIPOLAR output operates at lower power levels than the MONOPOLAR output and has impedance characteristics optimized for desiccation. This means faster coagulation at a given power setting and an automatic reduction of output power when the coagulation is complete.

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SECTION 5

FORCE 4 TECHNICAL SPECIFICATIONS

OUTPUT WAVEFORM

CUT 750 kHz sinusoid

BLEND 1 750 kHz bursts of sinusoid at 50% duty cycle recurring at 31 kHz.

BLEND 2 750 kHz bursts of sinusoid at 25% duty cycle recurring at 31 kHz.

BLEND 3 750 kHz bursts of sinusoid at 25% duty cycle plus inductive discharge damped sinusoidal bursts, all bursts recurring at 31 kHz. Power is adjusted so that the sinusoid bursts account for 75% of the power into a 300 ohm load and the damped sinusoid bursts account for the remainder.

SPRAY COAG 750 kHz damped sinusoidal bursts with a repetition frequency of 31 kHz.

SOFT COAG 750 kHz damped sinusoidal bursts with a repetition frequency of 22 KHz.

MICROBIPOLAR 750 kHz sinusoid, unmodulated

OUTPUT CHARACTERISTICS

Mode	Maximum (open circuit) P-P Voltage	Rated Load (Ohms)	Maximum Power (at Rated Load) (Watts)	Crest Factor At Rated Load +10%
CUT	2500	300	300 ± 20	1.9 @ 100W
BLEND 1	2800	300	250 ± 20	2.6 @ 100W
BLEND 2	3000	300	200 ± 20	3.7 @ 100W
BLEND 3	3400	300	200 ± 20	4.4 @ 100W
SPRAY COAG	9000	300	120 ± 10	9.0 @ 50W
SOFT COAG	9000	300	60 ± 5	13.0 @ 30W
MICROBIPOLAR	400	100	70 ± 8	1.6 @ 40W

Microbipolar has selectable output characteristics: power approximately proportional to I/R or I/R^2 (Standard or Precise).

POWER READOUTS

Three L.E.D. displays (for coag, cut and microbipolar) indicate output power. Power readouts agree with actual power into rated load to within ± 10% or 5 watts, whichever is greater.

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LOW FREQUENCY LEAKAGE (50/60 Hertz)

Source current, patient leads, all outputs tied together.
Normal polarity, intact chassis ground, less than 2.0uA
Normal polarity, ground open, less than 30uA
Reverse polarity, ground open, less than 30uA
Sink current, 140 volts applied, all inputs, less than 150uA

HIGH FREQUENCY RISK PARAMETERS

Bipolar RF leakage current, 40 pf output to ground: 150 mA rms.

Trip capacitance (mid power setting)
Normal sensitivity: 130 ± 15 pf

A trip defeats output for a period of one second ± 10%. Under typical conditions, a trip occurs in 0.15 seconds.

Patient to chassis voltage, after 40 pf accessory capacitance, less than 60 V rms.

Return Electrode Monitor (REM)

Measurement Frequency 140 kHz ± 5
Measurement Current 1.5 mA ± 0.5
Acceptable resistance ranges:
- *Effective RF pad resistance 6-30 ohms.*
- *Dual area mode 5-135 ohms*
- *Single area mode less than 20 ohms*

Mode selected automatically by return electrode connector. Outside acceptance range generator will be shut down and fault warning given. If resistance increases by more than 30% the generator will be shut down and an alarm given.

COOLING

Natural convection cooled. No fan.

CONTROL PANEL

The control panel is a flat sealed unit with no openings thus preventing fluids from entering the system.

INDICATORS

The RF indicators for COAG, CUT, and MBP will be illuminated only when RF power is available at unit output connections. In addition to the digital L.E.D.s, two indicator lamps are used with COAG to indicate either the normal or fulgurate modes. Four indicator lamps are used with CUT to indicate either Pure Cut or three available Blend modes, B1, B2, or B3. Two indicator lamps are used with MBP to indicate either Standard or Precise power characteristics. REM has a "fault" indicator light that gives an intermittant 800 Hz tone for fault warning. There is also a return fault indicator light. Monopolar and bipolar lamps indicate footswitch function.

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AUDIO VOLUME

Mode indicator tones: 65 dba at 1 meter, maximum
Adjustable external volume control.
REM fault tone is 65 dba at 1 meter min. Not externally adjustable.

FOOTSWITCH LOGIC

Front panel touch buttons select monopolar standard output or bipolar output. Footswitch function starts in the monopolar mode. Depression of both footswitch pedals selects COAG mode.

OUTPUT POWER ADJUSTMENT

When an "up" button located on the instrument control panel is actuated, the power of that function is increased. When a "down" button is actuated, the power of that function is decreased. The operator can view the L.E.D. display for power level while adjusting it to the desired level. Power levels will range from 1 watt to a set maximum.

INPUT POWER SOURCE

Nominal voltage 220 volts rms
Regulation range 190-280 volts rms
Operation range 180-280 volts rms
Frequency 45-64 Hertz

CURRENT:	Idle:	.2 amperes maximum
	Cut:	6 amperes maximum
	Coag:	3 amperes maximum
	Bipolar	2 amperes maximum
POWER:	Idle:	50 watts maximum
	Cut:	900 watts maximum
	Coag:	375 watts maximum

LINE REGULATION

Between 190 and 280 volts input, output power into a nominal load will vary no more than 2% or 2 watts.

WEIGHT: 38 lb, 17 kg.

SIZE: 6 X 13 X 22 inches, 15 X 33 X 56 cm.

Specifications subject to change without notice.

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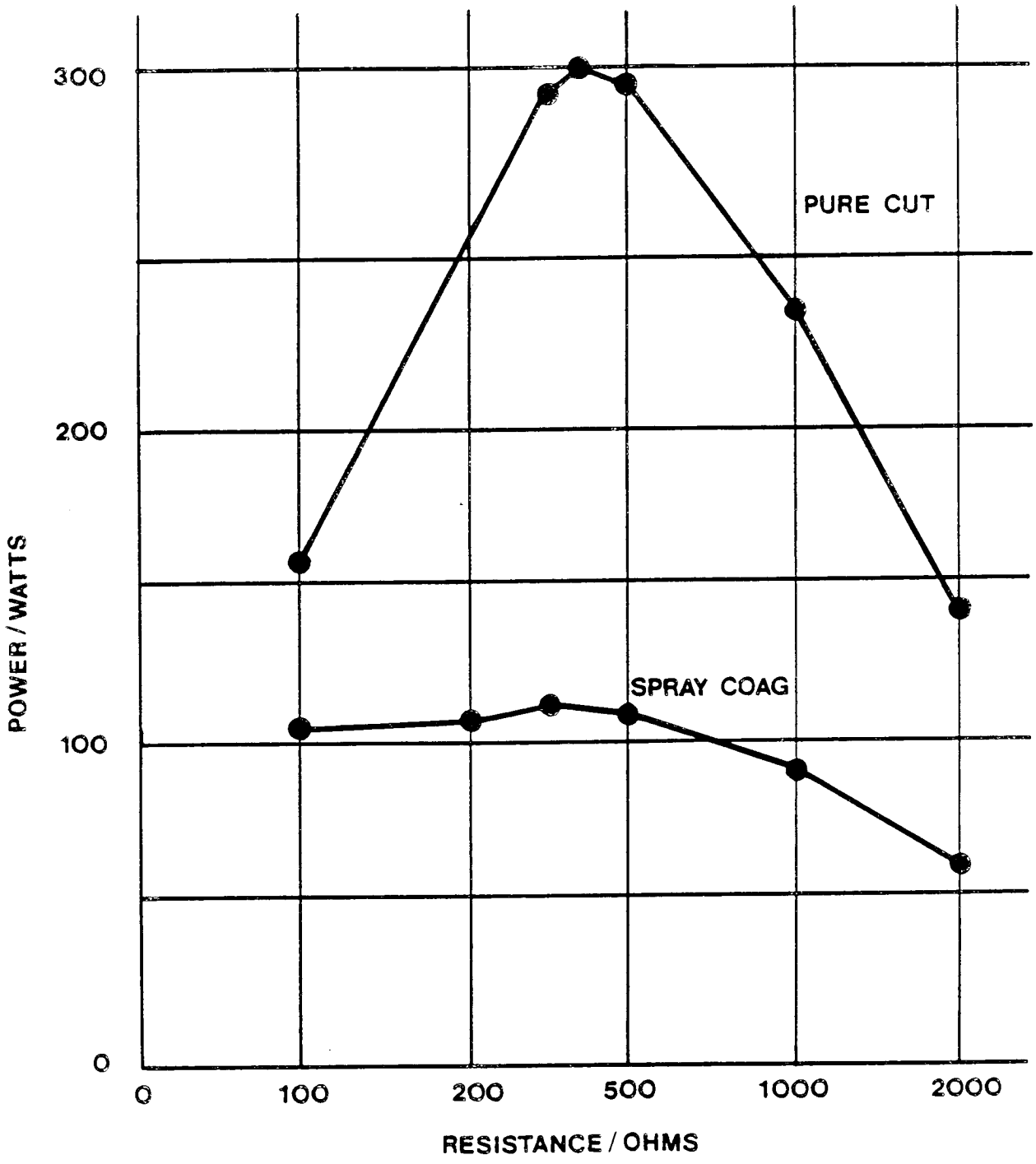


FIGURE 4

OUTPUT POWER VS LOAD - MONOPOLAR OUTPUT

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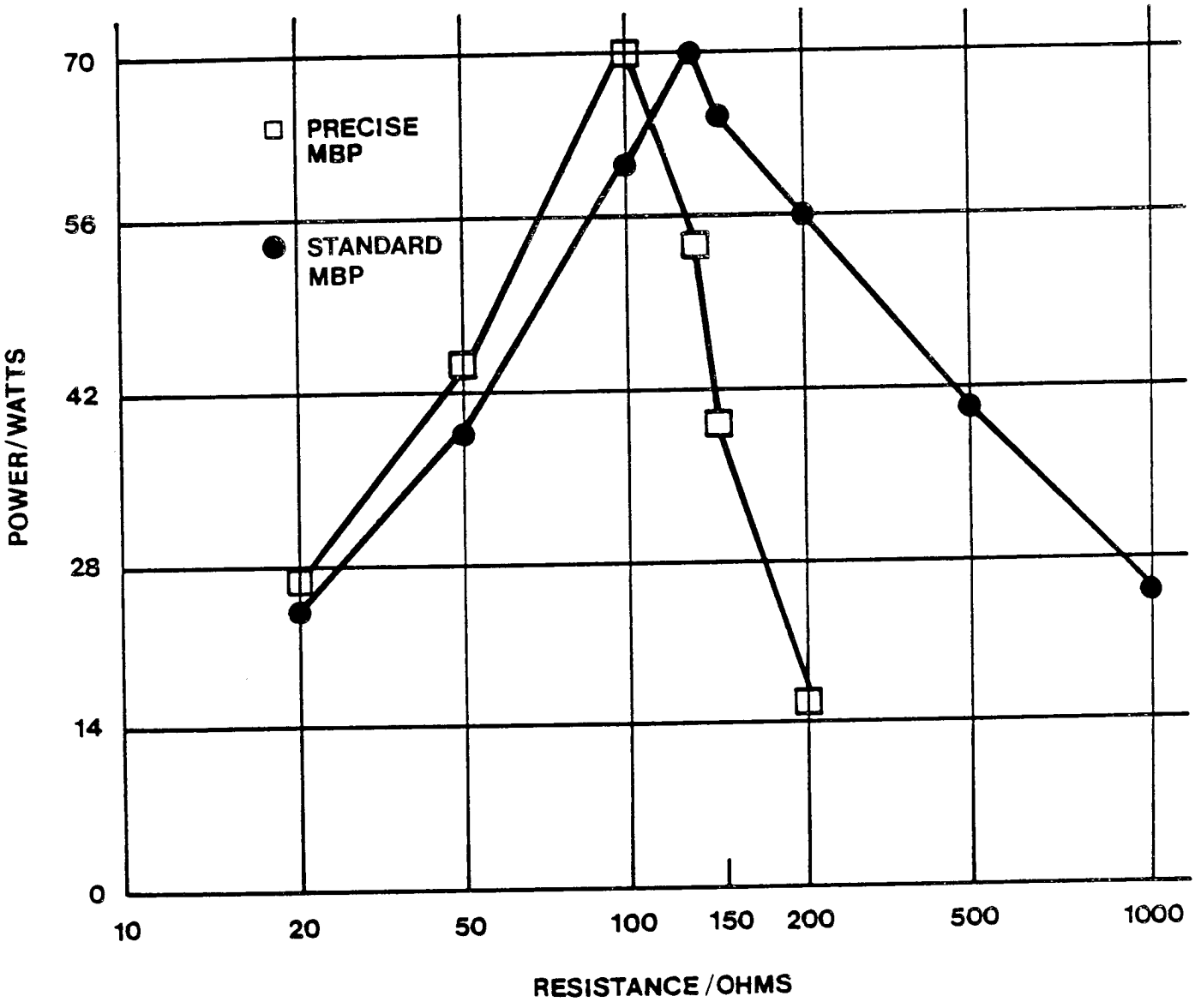
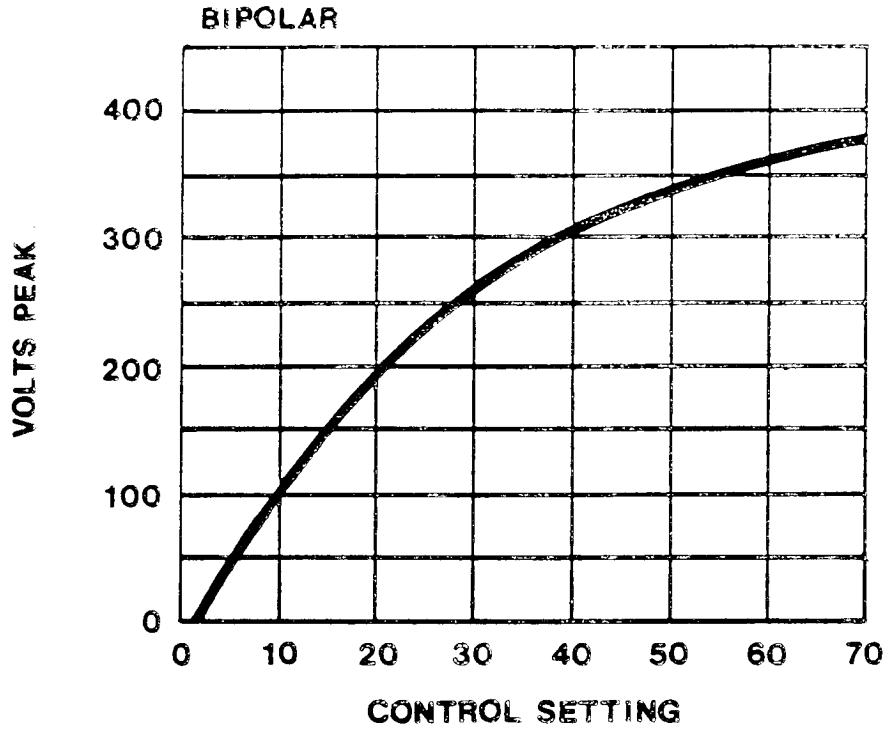


FIGURE 5

OUTPUT POWER VS LOAD - BIPOLAR OUTPUT

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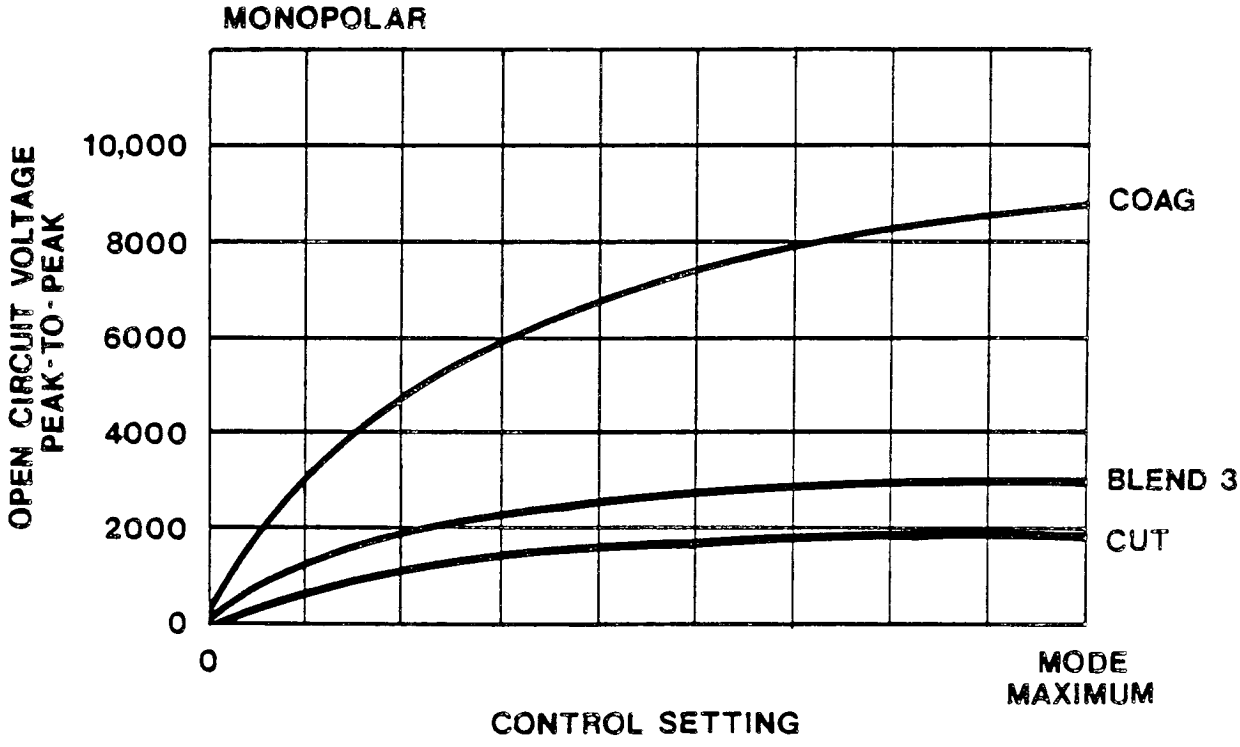


FIGURE 6

OUTPUT VOLTAGE VS CONTROL SETTING

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SECTION 6

CIRCUIT DESCRIPTIONS

POWER SUPPLY MODULE

The FORCE 4 power supply module generates the isolated power supplies required by the FORCE 4 generator. It is capable of operation at 50-60Hz from 190VAC to 280VAC input voltage. It will be used in FORCE 4 generators destined for Europe, Australia, South America and other parts of the International market. The four power supplies consist of: +15V, +5V, -5V and the high voltage 60-220V D.C. There are also four separate returns: analog, digital, high voltage and chassis. All four are connected at the large controller PCB P2002 pins 2-5. Transformer T1 isolates the three fixed power supplies and T2 isolates the high voltage supply. Power FETS 2006-2009 are line connected and attached to the large heatsink at the rear of the module. This heatsink has electrically isolated beds thermally connected through epoxy to the grounded heat exchange fins. USE EXTREME CAUTION WHEN PROBING LINE CONNECTED PARTS!

The small snubber PCB components protect the high voltage bridge, CR4, from very high voltage transients. The soft start unit protects the mains from the large surge current, otherwise necessary to charge the filter capacitor C5 on power up.

Two 50 watt power resistors are also mounted in the power supply module. R2 loads the R.F. output transformer primary and R3 discharges the high voltage clamp capacitors mounted on the output module PCBS.

-5V Supply

The -5V supply originates on the Supply Module. Input power is passed through T1, and rectified by CR2. The rectified AC is filtered by C4, C3 and regulated by U1.

+5V Supply

This is a switching supply with 15V input and 5V output. U2004 is a comparator which provides overvoltage protection by firing SCR2002 to clamp the output. L2001 is the 140 microhenry switching buck inductor, operating at a nearly constant current equal to the load current. When Q2004 is on, the inductor current increases and when Q2004 is off CR2010 holds the input side of the inductor at -0.7V and the inductor current decreases. The duty cycle of Q2004 is controlled by U2006. The conduction pulse width is constant while the duty cycle varies. The 5v output is divided down by R2064, R2065 and compared to an internal reference of 1.25V to enable the output and turn on Q2004. A second comparator shuts down the oscillator when pin 14 drops 0.33 volts below pin 13. The maximum output duty cycle is 50% and regulation is accomplished by gating the oscillator to lower duty cycles.

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+15V Supply

This regulator uses a buck inductor with pass device Q2003 and catch diode CR2003. The output voltage is divided down by R2039, R2049, and R2059 and compared to a zener diode CR2006 voltage divided by R2048, R2057. When the output is less than the reference, comparator U2005 turns on the pass device via Q2001, Q2002. With the pass device on, current increases in L1, the 0.75 mH inductor, until the output exceeds the reference. At this time, the pass device is shut off and the inductor current passes through CR2003. Note that U2005 is wired as a schmidt trigger with hysteresis. This regulator controls the output voltage and ripple, and runs at varying frequency and duty cycles as the load is varied.

Ancillary circuits provide over voltage protection, current limiting and detection of loss of the -5V supply. CR2005 is the over voltage sensor and SCR2001 is the output crowbar. U2002 is the comparator which shuts off the supply when current through the sense resistors R2036, R2046 exceeds the limit adjusted by R2058. CR2009 and Q2005 shut off the +15V supply when the -5V supply goes below -3.3 volts.

High Voltage Supply

This supply is an off-line pulse width modulated type. The switching transistors are power FETs connected in the full bridge configuration. DC input is provided by C5 and CR3 in the module and fed to the transistor bridge input. Transistors Q2006, - Q2009 conduct alternately to provide primary drive for the isolation transformer T2. The secondary output of T2 is rectified by CR4 and smoothed by inductor L2 and capacitors C1103, C1104 and C1105 which are located on the Stripline PCB. The return for these capacitors is routed individually back to the power supply PCB and is labeled H.V. return. Inductor L2 acts as a current source under low duty cycle conditions and the bridge rectifier CR4 performs the catch diode function. Drive for Q2006 - Q2009 is supplied from transformer T2001 on the power supply controller PCB.

Drive pulses are generated by the controller U2003. The sawtooth oscillator output at pin 5 (70KHz) is compared to to the pulse width modulator comparator input at pin 3 of U2003. The dead time comparator and steering control are both internal to U2003. Two drive waveforms are generated, both being duty modulated identically, but 180° out of phase.

The pulse width modulator comparator input (pin 3 of U2003) is the amplified and integrated difference between Vs, the program voltage generated in the clock-control PCB, and the actual high voltage output taken from the high voltage bus. An on board error amp accomplishes this. Several protection circuits are provided for the HV supply. An on board error amp (U2003) monitors the RDY line and shuts off the H.V. in case the FORCE 4 is placed in STANDBY.

U2002 (pin 5, 6, 7) monitors the +15V supply and disables the HV supply if the +15V drops to +13V.

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U2001 monitors the HV current and disables the output voltage if the current exceeds 7 amps. The output voltage will automatically return every 2.5 seconds to interrogate the load impedance.

Supply shut off during a short-circuit overload takes approximately .3 seconds. R2010 calibrates the current limit.

ISO Footswitch P.C.B.:

The ISO-footswitch PCB is included to meet I.E.C. requirements for a foot-switch whose switching circuitry is NOT referenced to ground. Q503, along with Q501 form an oscillator to supply an isolated D.C. voltage across C504. OPTO-isolators OPT501-503 couple the signals generated from the bipolar and monopolar footswitches to the CPU PCB or the bipolar controller PCB. A sample signal, sample, occasionally disconnects the input to OPT501-503 and the CPU monitors these opto-isolators for correct ouput during the sample interval. If defective OPTO isolators are found, the RF output of the FORCE 4 is disabled.

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INTERFACE PRINTED CIRCUIT ASSEMBLY

The function of the interface printed circuit assembly is to perform the measurement and control functions which link the monopolar output circuitry of the FORCE 4 Electrosurgical unit with the microcomputer control. The sections of circuitry which are contained in this assembly are the output networks, return fault monitor, lamp enable circuit, keying isolating circuit, and the return electrode monitor (REM).

This assembly contains components which are connected to the output terminals of the electrosurgical unit and they are at high voltage with respect to ground during operation of the FORCE 4. Use extreme caution when making measurements on or handling this assembly during operation.

The purpose of the output networks are to connect the output transformers located on the stripline assembly with the output jacks located on the front panel. These networks provide the necessary series capacitors for the monopolar outputs (for example C102), and provide the interconnection modes for other assembly modules. Physical spacings of approximately 1 centimeter are provided between components of this module and other modules. It is important that these spacings be maintained for continued safe operation of the FORCE 4 generator.

Components C110 and R112 serve to provide a grounding link to the return electrode. These components have high impedance to line frequency voltages, however, they have low impedance to radio frequency current so that typically patient to ground voltages are under 30 volts rms. C116 provides a small amount of radio frequency current at the output mode and out of phase with typical currents in that mode so that patient to ground voltage is minimized. Transformers T101, T103, and T104 provide the interface between the output networks and the return fault monitor. T101 isolates against high voltages present on the FORCE 4 monopolar actives and it is important that insulation in this transformer be maintained. T101 is balanced in response with respect to T103 for proper return fault operation.

The return fault monitor provides a current summing function between the active and return currents flowing in the monopolar output. A voltage corresponding with this current sum is compared with a reference which is dependent upon the radio frequency voltage in the activated monopolar output circuit. If the sum exceeds a pre-determined level an alert is asserted and further electrosurgical operation is inhibitied. This function assures that harmful alternate return current will not be present during the use of the FORCE 4 generator. Active and return currents are summed in opposite sign in the CR106 network. Higher active current than return causes disabling. Further, C117, C118, and C140 operating through the CR106 network provide an output voltage dependent reference which when summed with the other currents causes a bias opposite from the direction of trip. The above circuit function causes tripping to be approximately related to a given level of impedance between the active electrode and ground for a specified load condition between active and return.

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Adjustment of this level of impedance between active and ground is provided through C140. The net voltage developed within the CR106 network is measured as it appears across R125 by comparator U110. Whenever the voltage exceeds a fixed reference dependant upon the five volt supply the comparator places an output at J101-19.

The indicator lamps on the FORCE 4 front panel which indicate activation in either the cutting or the coagulation modes are enabled by the presence of radio frequency power available from the output amplifier. The provisions for this on the interface board are as follows: current is coupled from the output amplifier via C124 to CR105 and CR104, rectified, limited by CR108, filtered by C125 and detected in U109. A signal indicating the presence of RF power is coupled to the controller through J101-16.

Activation switching components located on the active accessory handles are capacitively coupled to the electrosurgical active output. To prevent excessive radio frequency leakage currents these switching components must be allowed to float independent of grounded circuitry. Q103-106 driving T102 provide isolated 6 volt supplies. R143-147 and R149-152 provide well-defined input voltages to comparators in U101 and 102 which are dependent upon the keying switch states. The output of the comparators is fed through optoisolators to output from the Interface PCB.

The Interface PCB contains the circuitry necessary to support the FORCE 4's function of verifying acceptable return electrode impedance conditions. L101, a matched capacitor and U103 form an oscillator which produces 140 kilohertz square waves at the output pins 6 and 8 of U105. These signals appear as symmetrically injected currents into the tuned network comprised by T105, C113 and C114. Voltages present across the tuned network are detected by U107 also using the outputs from U105. The voltages present across C111 and C112 are dependent upon the resistive loading across the return electrode outputs J105 - 3 and J105 - 4. The components in the oscillator and load tuned networks have matched temperature drift characteristics by virtue of similar inductor and capacitor temperature coefficients. The outputs of U105 pins 6 and 8 have fast edges and are exactly opposing in phase. These two conditions assure that the monitoring circuitry will have repeatable response to return electrode resistance and also that the detected outputs will be independent of coupled electrosurgical currents. The detected outputs are amplified by differential amplifier U108 and a range adjustment is provided by R118. The analog signal representing the measured value of return electrode impedance is present on J101 pin 19, calibrated to 5 volts at 150 ohms.

The following characteristics of the Interface PCB affect the safety of the FORCE 4: 1) insulation; 2) creepage distances; 3) component values; 4) component types; 5) component location. Any service operation affecting these characteristics should be performed with care so that none of the critical characteristics are altered.

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BIPOLAR OUTPUT

The bipolar output stage is a high efficiency, low impedance RF generator which functions independently of the monopolar system in the FORCE 4. It will deliver a maximum power of 70 watts into a nominal load impedance of 70 to 100 ohms. Two modes are provided which differ only in the power output at high load impedance.

In STANDARD mode, the power output decreases from 70 watts at 100 ohms to about 35 watts at 200 ohms, while the power output in PRECISE mode would decrease to about 20 watts. Figure 4 is a plot of output power vs load for the bipolar output.

Figure 5 is a block diagram of the bipolar stage. The major blocks are 1) The RF output stage, 2) The switching power supply which modulates the DC voltage supplied to the RF stage from 0 to 100 volts to control output power, 3) The control microprocessor which takes operator commands (keying, mode and power level) as inputs, measures voltage and current at the output, and adjusts the power supply for correct power output.

Figure 22 is a schematic diagram of the bipolar output board. The functional blocks of the output board are 1) The switching power supply, 2) The RF driver circuitry, 3) The switching output stage, 4) Voltage and current sensors, 5) Handswitching circuit.

The switching power supply consists of the controller, U201, the switching transistors Q201, Q203 and Q204, and the filter L201 and C201. When the generator is keyed in the bipolar mode, +100 volts is present at HV. The switching supply regulates this to a voltage from 0 to 100 volts, determined by the feedback voltage AFB. By comparing AFB with the scaled DC voltage at DCSEN, the controller adjusts the width of the drive pulses applied to the emitter of Q204. If the DC voltage is too low, (AFB DCSEN) the pulse width is increased.

Current drawn through Q204 is applied to the base of Q203, whose collector current becomes the drive for Q201. The switched current through Q201 is filtered by L201 and C201, and fed back through the divider R215 - R216 to the controller. CR202 is a freewheeling diode which supplies the current for L201 after Q201 is turned off.

The RF driver circuitry develops the 750KHz to drive the output FET. U206 is a binary divider which receives the 6MHz from the bipolar control board and divides by eight to give a precise 750KHz square wave. Two gates of U207 gate the 750KHz to Q210 when key (NOT) is low, Q210 amplifies the drive to 12 volts and Q207-Q208 supply the high transient currents to drive the power FET.

The power FET Q203 is operated in switched mode at 750KHz with a 50% duty cycle. L202 is the RF choke, and supplies DC to the FET. C205, C206, and T202 form the output filter stage, which is designed to minimize power dissipation in the FET by maintaining low voltage at turn on and turn off. T202 has a third winding which is used to sense the RF voltage. C207 and C208 are blocking capacitors which, along with T202, provide redundant DC isolation at the output.

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The sense winding on T202 develops a voltage proportional to the voltage at the output. This voltage is rectified and filtered by CR208 and C227. The maximum voltage appearing on C227 is about 35 volts. R246 and trimpot R247 scale this down so that 128V of RF will appear as 5VDC at the output of amplifier U204. The RF sense voltage is also applied to comparator U203 which pulls the lamp enable line (LE(NOT)) low if RF voltage is present.

Current sense transformer T201 has a turn ratio of 20:1 so that current flowing in the load appears across trimpot R228, decreased by a factor of 20. The voltage across R228 is filtered by the combination of R227 and C228 and buffered by U204 to become the current sense output, ISEN. This is adjusted to 1 volt = 250MA of load current.

The function of the handswitching circuit is to place a low voltage at HSDS (NOT) only when a low is present at SAMPLE(NOT) and the handswitching contact RF out (3) is electrically connected to the active output RF out (2).

The isolated handswitching circuitry consists of a free running oscillator, isolation transformer T203, optoisolators OPI-201, 202, comparator U205, and resistor network HY201.

The free running oscillator Q209 runs at abut 150 KHz. Energy is coupled through T203, rectified and filtered to become the isolated DC voltage +5A.

Referring to the schematic, note that the voltage at PIN 2 of U210 is +1.2V when J202, Pin 3 is open, and +2.4V if J202, Pin 3 is connected to J202, Pin 2. Also the voltage at non-inverting input PIN 3 is 3.0 volts if PIN 7 (the output of the second comparator) is high and 1.8 volts if it is low. PIN 7 is held low only when SAMPLE(NOT) is low, which causes the first comparator to switch states and follow the closure of the handswitch. Thus, OPI-201 has current through the diode and asserts HSDS(NOT) only if the handswitch is closed and SAMPLE(NOT) is low.

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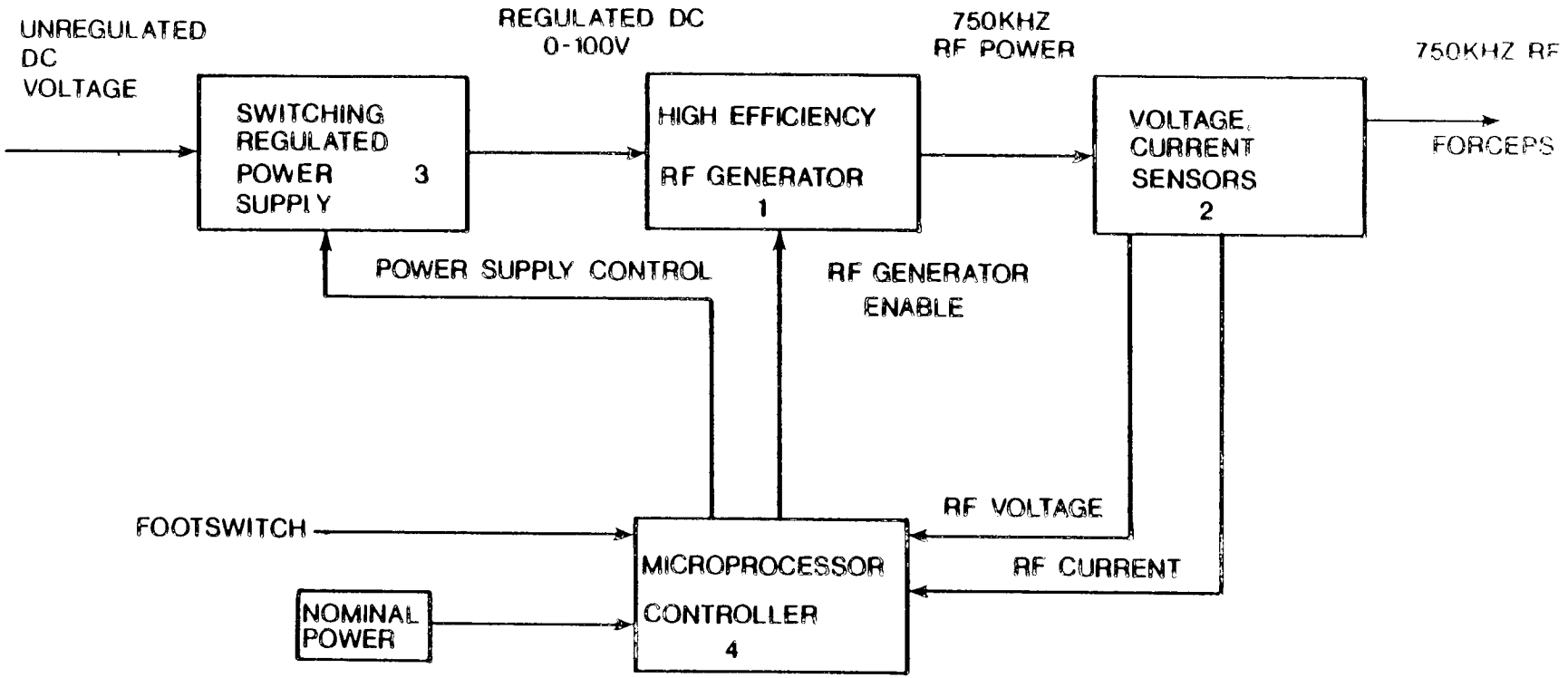


FIGURE 7

BLOCK DIAGRAM - BIPOLAR STAGE

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BIPOLAR CONTROL BOARD

The Bipolar Control Board receives signals from the CPU Board (DSE, DS1E, DS2E and ECON) and sends appropriate signals (KEY(NOT), reset(NOT) and AFB) to the bipolar output board.

The Control Board contains the microprocessor U307, program memory U302, analog to digital conversion (ADC) U313, digital to analog conversion (DAC) U301 and miscellaneous logic.

The Control Board performs the following functions when a keying command is received (DS1E or DS2E):

1) Analog to digital conversion of the control voltage ECON sets the nominal power level (0 to 70 watts). ECON is set at 16.4 watts/volt or 4.25 volts for 70 watts.

The digital reset line which holds the power supply controller off is disabled and the KEY(NOT) line is enabled.

2) The output voltage AFB is initially set so that the DC voltage on the output board will be 10 volts.

3) After a delay of about 20 mS for the circuit conditions to stabilize the ADC reads the RF output voltage (VSEN) and current (ISEN)

4) From the voltage and current measurements the microprocessor computes the delivered power and the load impedance and adjusts the feedback voltage AFB up or down to achieve the required power.

Figure 4 shows the required power vs impedance for the two modes STANDARD and PRECISE. The two modes are identical at impedances below 100 ohms. Above 100 ohms, the STANDARD mode holds the output voltage constant while the PRECISE mode reduces the output voltage as the impedance rises, giving a power dropoff proportional to the square of the resistance.

5) The processor checks for DS1E or DS2E. If the generator is still keyed, it then goes back to step 3. Otherwise, AFB is set to zero and the KEY(NOT) line is unasserted.

U305 and the associated gates form a 'watchdog' timer which must be periodically reset by the processor. The processor pulses the base of transistor Q301 at 20 MSEC intervals, keeping the voltage across C309 low. If the processor fails, it will stop issuing these pulses and the 555 will time out within 1 second. The 555 output is pulled low, which forces key(NOT) high and reset(NOT) low. The timer will reinitialize when the generator is turned off and C307 discharges. CR301 is a precision 2.5 volt reference which is used as the reference voltage for the DAC and is amplified by U312 to become the 5 volt reference for the ADC.

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TABLE 1 INPUT & OUTPUT LINES - BIPOLAR CONTROL

NAME	ANALOG/ DIGITAL	VOLTS	DESCRIPTION
DSE	D	+12	Master Desiccate Enable - From CPU Board
DS1E	D	+12	Desiccate Mode 1 Enable
DS2E	D	+12	Desiccate Mode 2 Enable
*	*	*	Note: DSE DS1E DS2E Causes entry to Test Routine
ECON	A	+5	Analog Power Set Voltage: 1 Volt = 16.4 Watts
DCSEN	A	+5	Scaled DC Supply Voltage: 1 Volt: 20 Volts
ISEN	A	+5	Scaled RF Load Current: 1 Volt = 2.56 ma RMS
VSEN	A	+5	Scaled RF Load Voltage: 1 Volt = 25.6 Volts RMS VSEN = ISEN @ 100 ohm Load
AFB	A	+5	Analog Drive to Switching Supply: 1 Volt = 20 Volts
$\overline{KEY}$	A	+5	Low on key enables RF drive to the Output Stage
RESET	A	+5	Low on RESET holds the Power Supply off.
FSDS			Footswitch Desiccate Enable
$\overline{HSDS}$			Handswitch Desiccate Enable

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CENTRAL PROCESSOR UNIT (CPU) BOARD

The functions of the CPU Board fall into two categories, the first being to provide the interface through which the FORCE 4 is controlled and through which the status of various systems within the generator are displayed. For purposes of discussion, the front panel keyboard and display assemblies will be treated as an extension of the CPU Board.

The second function of the CPU Board is to provide control of other subsystems of the generator in response to operator input as well as various internal conditions. In addition to interfacing with displays and sensing and interpreting key closures, the CPU Board must calculate and generate the analog control voltage ECON (energy control) which scales the output power when keyed and generate the associated logic input to other circuits. Analog voltage EREM (REM output) must be sensed and processed on the CPU card and audio tones associated with keying and various alert conditions must be produced. A "watchdog" timer under program control provides continuous assurance of proper program operation.

The 8039 CPU addresses 4K bytes of program memory via the multiplexed address/data bus and the lower four bits of port 2. U406 latches the lower 8 bits of address at the negative transition of the ALE (address latch enable) line allowing the instruction fetched from U407 to be transferred to the bus at the positive transition of the PSEN(NOT) line.

U403 is a bidirectional 16 bit I/O expander through which the CPU controls the status of 11 front panel lamps, enables steering and cut relays K1101 and K1102, strobes the isobloc circuit and resets the "watchdog" timer. U403 addressing and data transfer is via the lower 4 bits of port 2 which functions as a multiplexed 4 bit address/data bus when this device is accessed.

Keyboard/display interface U410 and 3 to 8 line decoder U402 drive the eight 7 segment displays and eight status LEDs on the front panel assembly, sense the closure of various switches and read handswitch related logic from the interface card.

The display consists of eight seven segment displays and eight mode lamps configured as an 8 by 8 matrix. The eight displays are scanned sequentially every 10.3mS while the corresponding segment drive lines are asserted accordingly. This data is stored in a 64 bit display RAM internal to the 8279 which is only updated as needed, thus freeing the processor from continually accessing the display.

Front panel switches are arranged as elements in an 8 by 8 matrix in which the scan lines are common to the LED array. Return lines RL0 through RL7 of the 8279 are internally biased high. The scan lines are sequentially asserted low, thus a key closure will be sensed as a logic zero on one return line. Logic input is read similarly, with tri-state buffers enabled by the scan lines allowing the input to be sensed. Input data is updated every 10.3mS and is stored in a 64 bit sensor RAM which may be accessed as needed under software control.

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ECON is produced by U416, a ten bit digital to analog converter and U415, a current to voltage converter. U416 is addressed as external memory by chip selecting via address line A2 and strobing the WR(NOT) (write) line by executing a MOVX instruction. Data is transferred in two bytes by writing the low order eight bits to address FA, then writing the high order two bits to address FB, which selects the BYTE2(NOT) input mode for U416.

Keying the generator initiates the following program sequence. The power level for the mode actuated is retrieved from RAM and the required value for ECON is calculated and written to U416. Mode and function enables are written through ports 1 and 2 of U414 and buffers U411 and U413. When the keying input is released, the mode and function enables cease and ECON is set to zero volts. the presence of a REM fault or return fault condition will cancel the keying input and produce an alert indication.

U417 is an eight-bit analog to digital converter which processes analog input EREM every 20 mS. The conversion is initiated when the chip select line CS(NOT) and WR(NOT) are enabled by a MOVX write instruction at address EF and requires 640 microseconds. When the conversion is complete, the processor will be interrupted via the INTR(NOT) line and conversion data read by executing a MOVX read instruction at address EF.

Sections 1 and 2 of U421 are a two tone oscillator which runs continuously and provides a signal to a variable gain audio amplifier comprised of section 3 of U421 and U428. The audio level at PIN 8 of U421 is the level at PIN 1 of U421 multiplied by the ratio data in (U418) / 255. The audio level is set by strobing the CS(NOT) line of U418 by executing a MOVX write instruction to address F7. U420 is a medium power OP-AMP in a bridge amplifier configuration which drives the loudspeaker located in the control panel LS1701. The audio level will be constant when the generator is keyed, and will be a function of VOL1 and VOL2 volume control switches in the control panel, which are read through the keyboard interface U410. When an alert condition is present, a chime-like tone will be created by first writing the maximum audio level to U418 and then diminishing the level to zero in 55 successive steps occuring every 20 mS.

U404 is a "watchdog" timer which defeats all mode and function enables in the event of a CPU failure. It is a oneshot timer which if not reset every 500 mS or less by the CPU, will time out causing output PIN 3 to go low defeating all enables. The timer is reset by the master reset generated by two sections of U405 during the "Power On" sequence.

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TABLE 2 SIGNALS ON CPU BOARD

SIGNAL	FUNCTION
EREM	Program voltage for REM
FSCT	(Not) Footswitch CUT Enable
FSCG	(Not) Footswitch COAG Enable
HS1CT	(Not) Handswitch 1 CUT Enable
HS2CT	(Not) Handswitch 2 CUT Enable
HS2CG	(Not) Handswitch 2 COAG Enable
HS2UP	Handswitch 2 Increase Power
HSDS	Handswitch Desiccate (Bipolar)
VOL2	Most Significant Bit of Volume Input
VOL1	Least Significant Bit of Volume Input
RTF	Return Fault (Hi for fault)
REM MODE	CoHesive vs. Single Pad Switch
DS2E	Desiccate Mode 2 Enable (Precise)
DS1E	Desiccate Mode 1 Enable (Standard)
CG2E	COAG 2 Enable (Soft)
CG1E	COAG 1 Enable (Spray)
B3E	Blend 3 Enable
B1E	Blend 1 Enable
ECON	Power Control Voltage
CPE	Pure CUT Enable
DSE	Desiccate Enable
CGE	COAG Enable
CTE	CUT Enable
CTL	CUT Lamp
CGL	COAG Lamp
DSL	Desiccate (Bipolar) Lamp
CTRYE	Cut Relay Enable
HSRYE	Handswitch Relay Enable
ACRYE	Accessory Relay Enable
SAMPLE	Signal to check OPI 101-107 on Interface PCB
750 kHz	Clock
INT FLT	Internal Fault Lamp
CHG	Remote Power Change Lamp
RET FLT	Return Fault Lamp
REM FLT	REM Fault Lamp
BP	Footswitch Select Bipolar
MP	Footswitch Select Monopolar
RDY	Ready
SBY	Standby
Audio 1	Audio Output to Speaker
Audio 2	Audio Output to Speaker

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CLOCK/CONTROL BOARD

The Clock/Control PCB generates the on (OND) and off ($\overline{OFD}$) control signals to initiate and terminate each RF pulse. It also controls the high voltage power supply voltage by generating Vs, the power supply programming voltage. Input to the card are a 750 kHz clock and mode enable signals from the CPU and four signals from the sense board; CSCT, CSCG, $\overline{S}$, $\overline{OS}$, which indicate current limits or saturation of the output transistors.

The board generates six clock signals by dividing down the 750 kHz CPU clock in U615, a dual 4 bit counter. The master clock signal (MC) occurs at 750 kHz and is gated by the cut clock enable (CCE) to provide 25% and 50% duty cycle bursts for the blend outputs. MC is not gated in pure cut. Neither clock is used in the coag modes. The gate clock, (G), controls the off drive and terminates the on drive at U601/2 independently of any other on drive signals. In the cut modes, G is derived from MC. In the coag modes G is derived from the hemostasis window (HW). HW and the clock (CL) are signals with a 32 kHz repetition rate (16 kHz in coag 2). CL is not mode dependent and is used as a flip-flop reset in circuits controlling output pulse width. HW sets the maximum on time in the coag modes. The last clock is voltage reset, (VR). It occurs at a 4 kHz and is mode independent. VR is used as a flip-flop reset in circuitry controlling the power supply set point.

To discuss the pulse width control circuitry, we will examine COAG in detail. The coag control sequence is initiated by CL which sets flip-flops U601/4, U607/6, and by HW which goes high at the same time. HW high turns off clamp transistor Q602 and allows current source Q601 to charge capacitor C606; HW also terminates the off drive by forcing G high. When the voltage on C606 exceeds that on C601 the high speed comparator U602 output (CGVCM) goes high. At U605 the three inputs HW, CGVCM, and the flip-flop Q output are high and the on drive signal OND goes high initiating changing of the output transformer primary. The primary current increases until HW goes low (maximum pulse width possible) or until the sense PCB generates the COAG current sense pulse (CSCG). When CSCG occurs U619/4 clears the flip-flop and terminates the output OND via U601. For a maximum pulse width CSCG never occurs and OND is terminated by HW via U605/6. Pulse width regulation is done by changing the voltage on C601 which is the average value of the flip-flop output. For instance, if CSCG doesn't occur then C601's voltage decreases until it is below the clamp voltage on C602 and the coag pulse starts as soon as HW goes high. If CSCG occurs soon after HW goes high then the voltage on C601 increases well above the C602 clamp voltage and there will be a delay between HW going high, and U602's CGVCM signal going high, and the OND will be delayed by the same amount.

Two additional circuits are involved with the coag pulse. The first is single step SS. It is generated when HW goes high and persists for about 5 microseconds after HW goes low. Its function is to stop the microprocessor until the coag pulse is over and prevent false computations. The second circuit is a one millisecond one-shot which is triggered by the sense PCB saturation ($\overline{S}$) or oversaturation ($\overline{OS}$) pulses.

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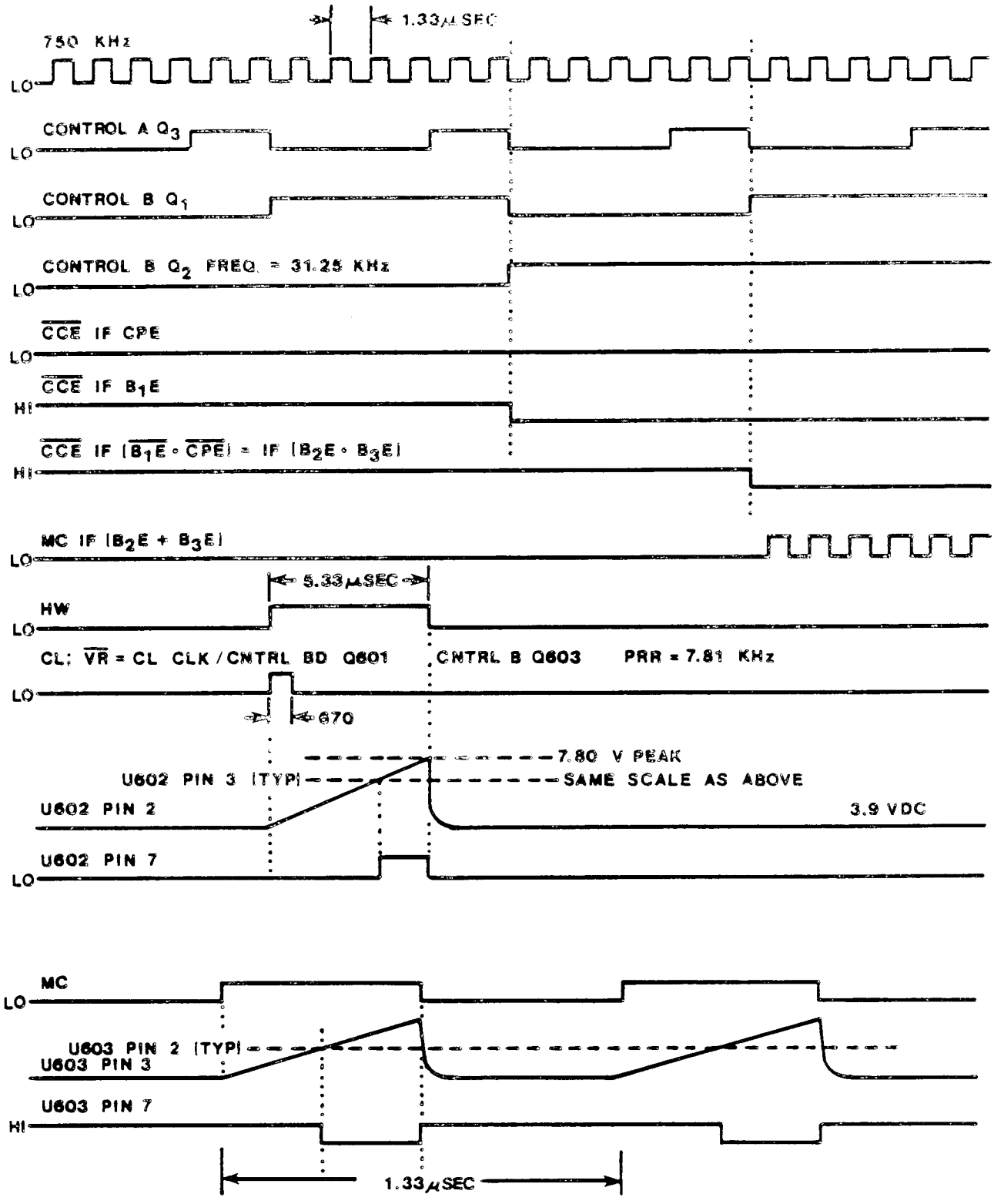
The one-shot output ($\overline{M}$) asserts the OFD and terminates any output pulses. $\overline{M}$ also drives the coag and cut pulse width control circuits in the direction of shorter pulses and boosts the power supply set point voltage.

The CUT pulse width is controlled in a manner similar to the COAG pulse width. The MC clock unclamps C604 and U603 compares a slowly varying voltage on C610 to the rapid ramp on C604. C610 is driven by transmission gate U611/3 which is enabled by the CCE clock.

The CUT flip-flop is comprised of U610/4 and U607/9. It is set by the CL clock and cleared by the current sense cut (CSCT) pulse from the sense board. The flip-flop output passes through a gate array U612 which selects either CSCT or the saturation signal ($\overline{S}$) as the input to transmission gate U611. An LED, CR601, indicates current mode operation (CMO) with CSCT in control. Voltage mode operation (VMO) with S in control always occurs when the power supply set point exceeds 8V and the generator is driving a high impedance. The test for VMO/CMO is also done at the VR clock rate when the flip-flop U606/10, U606/11 is set and forces VMO operation until CSCT occurs, clearing the flip-flop.

The power supply set point controller uses flip-flop U606/4, U605/10. It is set by the VR clock and cleared by $\overline{S}$ or $\overline{OS}$. The flip-flop output is integrated by U621/14 to generate Vs. In the dessicate or COAG mode Vs is set to either 4.0 or 2.4V by the R645, R646, R647 network.

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NOTE: Propogation discrepancies not shown.

FIGURE 8

TIMING WAVEFORMS - CLOCK/CONTROL BOARD

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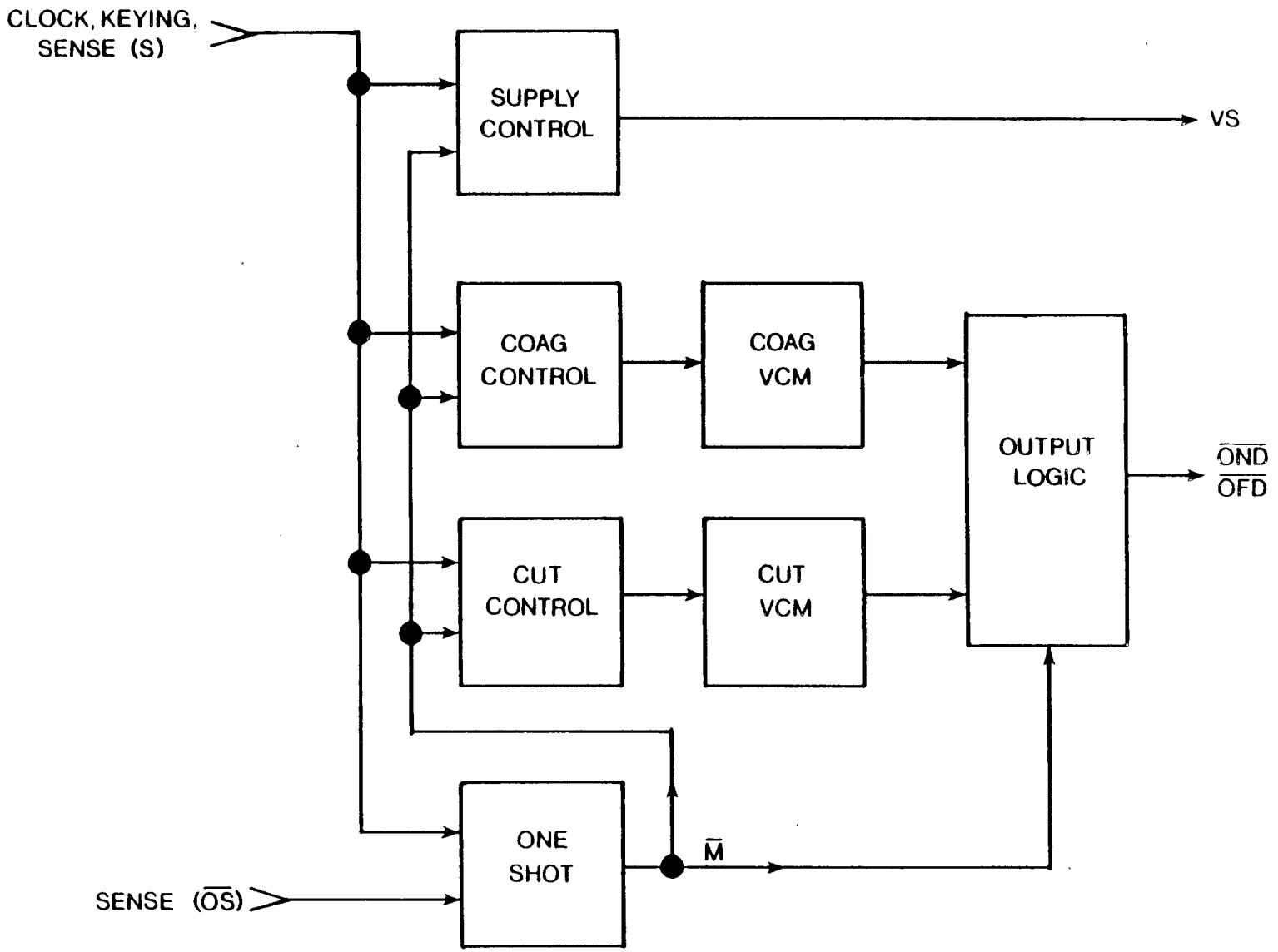


FIGURE 9

CONTROL MODULE BLOCK DIAGRAM

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SENSE BOARD

The Sense Board generates logic signals used on the Clock/Control Board for regulation of output pulse width and the high voltage set point. Two signals sense saturation of the output transistors and two are output as current sense signals, one for CUT and one for COAG.

The FORCE 4 output transistors are designed to operate class C as current sources. To insure class C operation under varying load conditions the high voltage supply is boosted for high load resistances. The $\overline{S}$ and $\overline{OS}$ signals indicate that saturation is occurring. The S signal is calibrated at about 30 volts by R803 and the $\overline{OS}$ signal is fixed and occurs when the output collectors go below about 10 volts. Both signals are generated by comparators (U806, U807) with one input from the output collectors through a 23:1 resistive divider and the second input from a reference voltage.

The current drawn from the HV supply is sensed by the foil resistor board and two comparators. When the comparators trip, indicating the current limit has been reached, the $\overline{CSCT}$ and $\overline{CSCG}$ signals are generated. These signals are processed by the Clock/Control Board and terminate the present output pulse in COAG as well as reducing the length of the next output pulse. The comparators are operated at the HV level and optical couplers (U802, 804) translate the signals to logic levels. The comparator power supply comprises a 40 mA current source, Q801, with high voltage compliance and a 10V voltage regulator VR803. A bias voltage is supplied by Q802. The comparators are discrete units with differential inputs and output current amplifiers Q803, 804. The inputs are connected to CSH, CSL (current sense high and low) through resistors R829, 844, 857, 867. The inputs are biased off by currents through R844, 867. The CSH, CSL voltage difference must exceed the bias to trip the comparator.

The comparator off bias and current limit is controlled by the ECON voltage generated by the CPU Board. This voltage is proportional to the square root of the output power setting. The bias currents are generated by current sources Q809, 805 with high voltage compliance. The current is controlled by U805. The U805 op amp offset is adjusted by R801, 802 and this provides a low power calibration. The input to U805 is CTPG, CGPG (cut program, coag program) which are calibrated by R806, 805. U805, Q805, Q809 constitute a voltage to current converter.

The CGPG voltage is generated by the ECON voltage passing through transmission gates U808 and pots. The gates are used to alter CGPG in Blend 3. The coag current limit in Blend 3 depends on the cut power setting rather than the coag power setting and R804 controls the coag pulse current level in Blend 3. The pots R805, 806 are the pure cut and coag power calibration pots and are adjusted at high power levels. Thus R802, R806 are the offset and gain calibrations for cut power output, and R801, R805 are the corresponding calibrations for coag power.

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Regulators VR801 and VR802 provide clean +12V and -2.5V power to the board circuits. R821 and L801 isolate the HV comparator power. Q810, 811 and Q806, 807 are level shifters on the optical coupler outputs. The display blanking, Q808, is not used at present.

DRIVER BOARD

The driver board in the FORCE 4 has three functions:

1) Drive the output relays to select the handswitch or footswitch output and put the cut inductor in the output collector circuit.

2) Sense the high voltage clamp level and discharge the output collector peak detector capacitors through R3 (750 ohms) in the power supply module.

3) Amplify the OND and OFD turn on and turn off signals to generate T/ON and T/OFF.

The HVCL (high voltage clamp) level is divided by 100 and compared to a nominal 4.75V reference level (adjust with R1001) by U1001. When the reference is exceeded, a 20 microsecond one-shot (U1002) is triggered and turns on Q1001 to connect the load resistor (R3 in the power supply) to the high voltage return on pins 3, C. The reference is regulated by CR1003.

The output drive signals T/ON and T/OFF are generated from OND and OFD by two cascades of three transistors. The on drive is amplified by Q1001, Q1007 and Q1006. CR1001 and CR1002 around Q1007 eliminate saturation. The off drive is generated by Q1008, Q1003 and Q1002. The on drive is about +10V, controlled by the R1022, R1019 divider. The off drive is to -5V. There is some overlap on the falling edge of T/ON because Q1002 is used to shut off Q1006 but it shouldn't exceed 0.1 microsecond.

VR1001 provides regulated +12V power to the board circuitry.

STRIPLINE BOARD

The Stripline Board contains driver transistors for the output modules, a current sensing resistor, the high voltage power supply filter capacitors and three relays. One relay, K1101, selects the accessory output. The second relay K1102, selects the handswitch output. The third relay K1103 connects the cut inductor in the cut mode and selects a tap on the output transformer in COAG modes.

There are three turn-on transistors, Q1104 1105, 1106, connected as emitter followers to the T/ON signal. 1.5 ohm emitter resistors ensure equal load current sharing. Three turn-off transistors Q1101, 1102, 1103, are connected as emitter followers to the T/OFF signal. R1105 holds the output transistor bases low when both T/ON and T/OFF are not present.

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The current sensor is a low inductance 0.05 ohm foil resistor mounted at J1102. The load current is sensed to control the output power. The CSH, CSL, (current sense high and low) signals are sent to the sense board where they are input to a comparator. The comparator threshold changes with the output power setting on the control panel.

The HV supply is a 20 kHz switcher whose output is a transformer secondary. This winding is full wave rectified and then filtered by L2 in the power supply module and C1103, 1104, 1105 at the stripline. R1101 and C1116 reduce high frequency noise above the switching frequency.

The output load is either T1, the upper transformer, which drives the handswitch jack and connects to E1; or T2, the middle transformer, which drives the footswitch jack and connects to E2. In addition, in the cut modes, the cut inductor and C1101, 1102 are placed across the transformer primaries to alter the output tuning. All three output coils have one end connected to E4, 5, 6, and the current sense resistor, which in turn connects to the high voltage supply. The output transformers have a 3:7:32 turns ratio and their primary inductance is 2.5 and 12 microhenries. The cut inductor is 2 microhenries.

The FORCE 4 is a controlled current machine. In the cut modes, calibration is performed at a 300 ohm load. The generator acts as a constant current source and the output power is roughly proportional to $R \times [300/(R+300)]^2$ where R is the load resistance and 300 ohms is the generator output resistance viewed from the front panel jacks. Most of this output resistance is due to transformer losses. In the coag modes, the output transformer primary inductance is charged to a calibrated current level when the output transistors are on and this stored energy is discharged into the load and generator output resistance when the transistors go off. The output power versus load impedance curve is flatter in coag than in cut.

OUTPUT MODULES

The FORCE 4 Output Modules are identical to those used in the SSE3B. Five modules are connected in parallel and matching ensures that all of them carry equal currents. The most important parameter is the transistor fall time. A wire loop is provided for current sensing. A 0.1 ohm emitter resistor reduces variation due to V_{BE} differences.

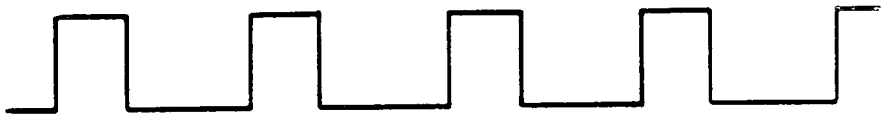
The output load is inductive and C4 is used to tune the 2.5 microhenry inductance. This load will tend to reverse bias the collector junction when the transistor is switched off. Diode CR3 disconnects the transistor from the load to prevent reverse bias damage. CR3 cannot turn off instantly and CR4 absorbs any transmitted energy through CR3. Capacitor C3 is used to equalize the turn off times of the five CR3 diodes. Diode CR1 is used to drive the turn off transistors Q1101, 1102, 1103 on the stripline board and remove the output transistor's base drive when saturation occurs. Diode CR2 and C1 act as peak detector for the output transistor collector voltage. Each output transistor is mounted on a heatsink. They are to be replaced as matched sets.

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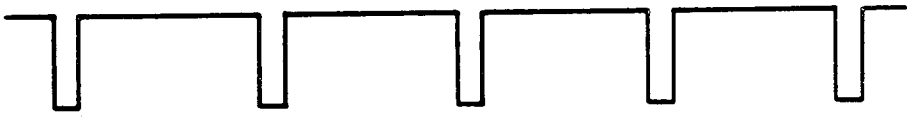
(A) U2008, PIN 6 - OSCILLATING
U2008, PIN 7 - D.C.



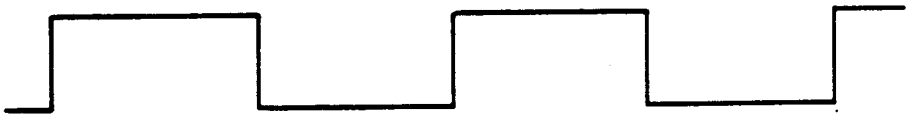
(B) U2008, PIN 1



(C) U2009, PIN 3



(D) U2003, PIN 11



(E) U2003, PIN 9
$E = \overline{B \cdot C \cdot D}$



(F) U2003, PIN 10
$E = \overline{B \cdot C \cdot D}$



FIGURE 10

OUTPUT POWER SUPPLY TIMING DIAGRAM

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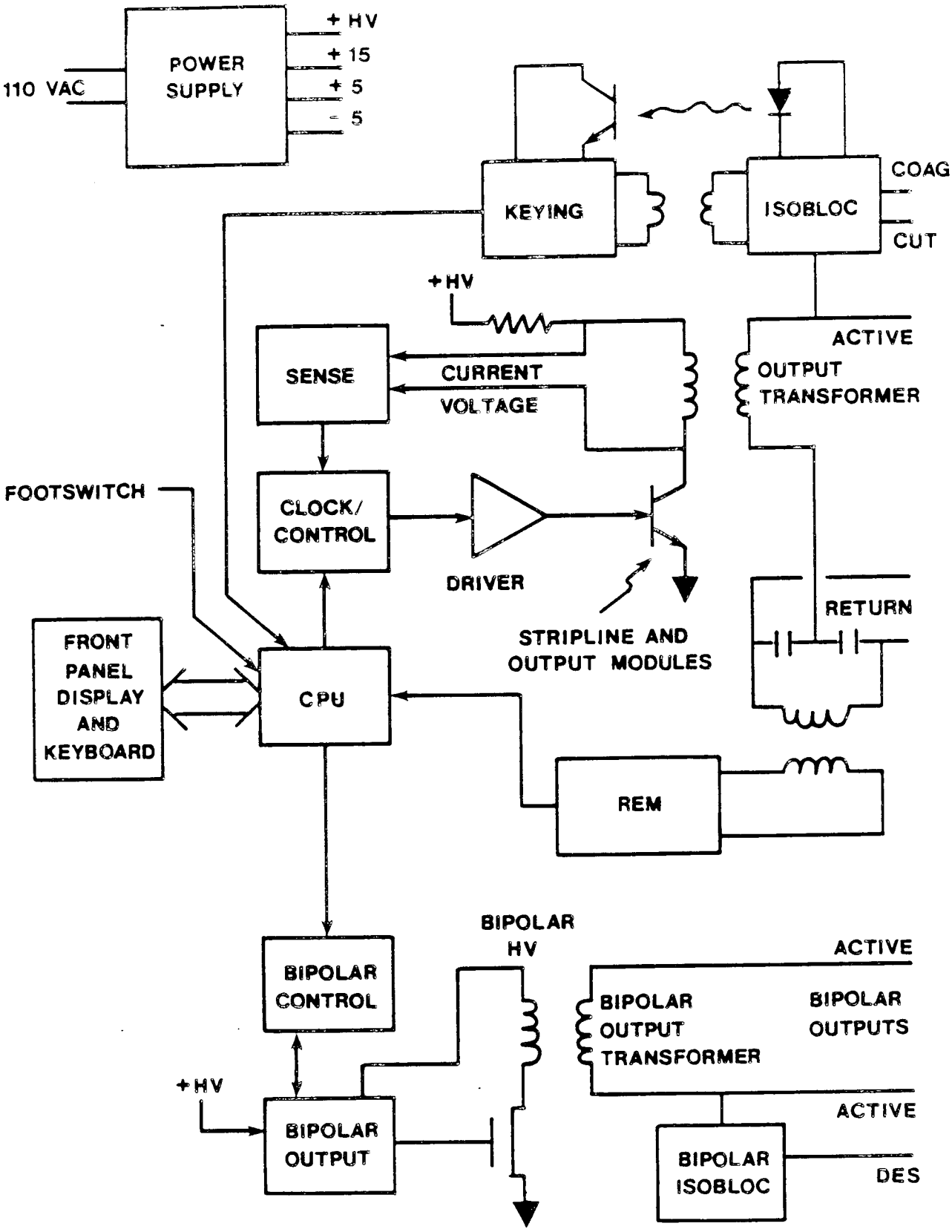


FIGURE 11

FORCE 4 BLOCK SCHEMATIC

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SECTION 7

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.

A significant amount of information can be obtained about the generator's output by a simple arc-test. This test can be used to determine whether the CUT and COAG outputs are present.

To test the output of the generator, a working switching pencil is required, along with a patient plate clamp and patient plate. In order to avoid burning surgical electrodes, a "dummy" electrode, with a 1/8 inch diameter shaft, can be used.

Switch the pencil in the SPRAY COAG mode, starting at a setting of (10), and attempt to start an arc to the patient plate. At low settings a very small arc should occur, growing larger as the front panel control setting is increased. At full output is should be possible to sustain an arc with the electrode about 1/4" from the patient plate. If this test is repeated in the CUT or BLEND modes, the arc will be stronger and larger. At full output (300) a very strong arc should be obtained.

NOTE: Electrosurgical generators are 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.
Fluke type 8920A Voltmeter.
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 20° at 750 kHz, 2.5mHz (Valleylab E3002).
82 pf, 20%, 6KV Ceramic Capacitor.
150 pf, 20%, 6KV Ceramic Capacitor.
General Radio 1192 Frequency Counter.

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NOTE: In testing RF equipment, proper test procedures must be adhered to in order to have a reasonable chance of duplicating 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

GENERAL

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 units are accepted by QA. If just 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 4 to expose the internal controls and test points.

2. Adjust the ± 15 volt supply:

   A. Connect the digital multimeter between the ± 15 volt test point 5 and ground J2002 pin 2 on the Power Supply Printed Circuit Board.

   B. Adjust R2059 for a meter reading of exactly + 15.0 volts.

3. Adjust the high voltage supply minimum output:

   A. Connect the digital multimeter between the High Voltage test point 6 and ground J2002 pin 2 on the Power Supply controller Board.

   B. Adjust R2061 on the Power Supply Controller Board for a meter reading of 60 volts.

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4. *Adjust the High Voltage Clamp:*

   A. *Set the COAG display to 30 watts.*

   B. *Attach a 300 ohm load from the ACTIVE output to the PATIENT output.*

   C. *Key generator in SPRAY COAG. Output power should be 30 ± 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 on an output module and chassis ground. Key the unit in SPRAY COAG. Slowly increase the COAG power display and observe the peak positive voltage. Adjust R100 on the Driver Board so that the maximum peak voltage is 475 volts. Do not let the peak voltage exceed 475 volts while making this adjustment.*

5. *Potentiometers R801 and R802 on the Sense PCB are critical to the output power adjustments of the FORCE 4. Follow steps A through E using a 300 ohm wattmeter.*

   A. *Set R801, R802 to mid-setting.*

   B. *Set CUT display at 300 watts and adjust R806 on the Level PC Board for 300 watts output in PURE CUT.*

   C. *Set CUT display at 1 watt and adjust R802 on the Sense PC Board for 1 watt in PURE CUT. Repeat steps B and C if R802 was rotated more than one turn.*

   D. *Set COAG display at 120 watts and adjust R805 on the Level PC Board for 120 watts output in COAG.*

   E. *Set COAG display at 1 watt and adjust R801 on the Sense PC Board for 1 watt in COAG. Repeat steps D and E if R801 was rotated more than one turn.*

6. *Midrange CUT Power Calibration*

   A. *Follow steps B through G using a 300 ohm wattmeter.*

   B. *Set the CUT power display to 75 watts and key the generator.*

   C. *If the output power is less than 70W or more than 80 watts, adjust R806 (Level PCB), R802 (Sense PCB) until power output is between 70-80W.*

   D. *Repeat step 5, B and C until the power output is at 300 ± 20 watts, display is 300 ± 20 watts; and the output at 1 watt, display is 0-4 watts.*

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E. Set the CUT display to 300 watts and key the generator. Note the output power.

F. Set the CUT display to 1 watt and key the generator. Note the output power.

G. If the output power in steps E or F is in error by more than ± 2 watts at 1 watt or ± 30 watts at 300 watts, repeat sections 5 and 6.

7. Midrange COAG Power Calibration

A. See 6.A.

B. Set the COAG power display to 25 watts and key the generator in SPRAY COAG.

C. If the output power is less than 20 watts or more than 30 watts, adjust R805 (Level PCB), and R801 (Sense PCB) until power output is between 20-30 watts.

D. Repeat step 5, D and E until the power output at 120 watt display is 120 ± 10W, and the output at 1W display is 0-4 watts.

E. Set the COAG display to 120 watts and key the generator in SPRAY COAG. Note the output power.

F. Set the COAG display to 1 watt and key the generator in SPRAY COAG. Note the output power.

G. If the output power in steps E and F is in error by more than ± 2 watts at a display setting of 1 watt or ± 10 watts at a display setting of 120 watts, repeat Sections 5 and 7.

H. If SW1 was moved during Step C, then CUT midrange calibration (Step G) must be repeated.

8. Blend Mode Power Calibration

A. Set the CUT power display to 200 watts and select Blend 3. Key the generator into a 300 ohm load and adjust R804 on the sense board until the output power equals 200 watts.

B. Select Blend 2 and check for 200 watts power output.

C. Select Blend 1 and check for 200 watts power output.

D. Set the CUT display to 75 watts, select Blend 3. Key the generator and verify power output of 75 ± 5 watts.

E. Repeat step D for Blend 1, Blend 2.

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9. *Bipolar Output Power Calibration*

   A. *Connect the wattmeter with a 100 ohm load across the two outside terminals of the bipolar output jack. Set the power level to 40 watts and key the generator.*

   B. *Adjust R244 on the bipolar output board until CR303 on the bipolar control board flickers. This sets the current sense.*

   C. *Adjust R245 on the bipolar output board until CR304 on the bipolar control board flickers. This sets the voltage sense.*

   D. *Check that the output power is 40 ± 4 watts.*

RETURN FAULT TEST PROCEDURE

Equipment needed:

1. *0-250 mA RF meter.*
2. *300 ohm non-inductive resistance (350 watt rated).*
3. *1200 and 550 ohm non-inductive resistance (30 watt rated).*
4. *40 pf, 110 pf, 150 pf capacitor (3KV rated) or E.F. Johnson, Part No. 154-8 variable capacitor.*

PROCEDURE:

1. *Insert 300 ohm load from ACTIVE to PATIENT. Insert 1200 ohm load from ACTIVE to GROUND. Set CUT display to 150W and COAG display to 55W, key unit from footswitch. Return fault should not trip in any mode.*

2. *Insert 550 ohm resistor from ACTIVE to GROUND. Insert 300 ohm load from ACTIVE to PATIENT. Key unit from footswitch with CUT and SPRAY COAG displays as in step 1. Return Fault should trip indicating excessive current returning through the chassis and not through the patient terminal.*

3. *Repeat step 2 for B1, B2, B3 and SOFT COAG.*

4. *Repeat steps 1, 2, 3 for Handswitch output.*

5. *Attach a 40 picofarad capacitor from ACTIVE to GROUND. Attach another 40 picofarad capacitor from ACTIVE through 0-250 RF milliamp meter to GROUND. Key unit in CUT. Increase CUT Level Control from 1 to 300 watts. Current should be less than 250 mA. Repeat for B1, B2, B3 and SPRAY COAG.*

6. *Attach a 40 picofarad capacitor from ACTIVE to GROUND. Attach another 110 picofarad capacitor from ACTIVE through 0-250 RF milliamp meter to GROUND. Key unit in CUT. Increase CUT Level Control from 0 to 300 watts. Return fault should trip before current reaches 250 milliamps. Repeat for B1, B2, B3 and SPRAY COAG.*

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7. Attach a 40 picofarad capacitor from ACTIVE to GROUND. Leave patient terminal open. Key the unit in PURE CUT with CUT Level Control at 150 watts. Return fault should not trip. Now, change the capacitor to 150 picofarads. Key unit as above. Return fault should trip. Repeat for B1, B2, B3 and SPRAY COAG.

RETURN ELECTRODE MONITOR (REM) TEST PROCEDURE

Connect a variable resistance across the PATIENT terminals using a REM-type connector. Set the resistance to 150 ohms and adjust R118 for a reading of 5.00V at J101/19 or J401/22. Decrease the resistance gradually and record the value at which the REM alert turns off (130 ± 20 ohms). Decrease the resistance again to 50 ohms and wait for six seconds. Increase the resistance gradually and record the value at which the REM alert turns on (70 ± 10 ohms). Decrease the resistance and note that the REM alert again turns off. Continue to decrease the resistance and record the value at which the REM alert again turns on (5 ± 2 ohms).

Repeat above test set-up utilizing a non-REM-type connector. Set variable resistance to 150 ohms. Note that the REM alert is on. Gradually decrease resistance and record value at which REM alert turns off (20 ± 5 ohms). REM alert should remain off below this value and turn on again if above.

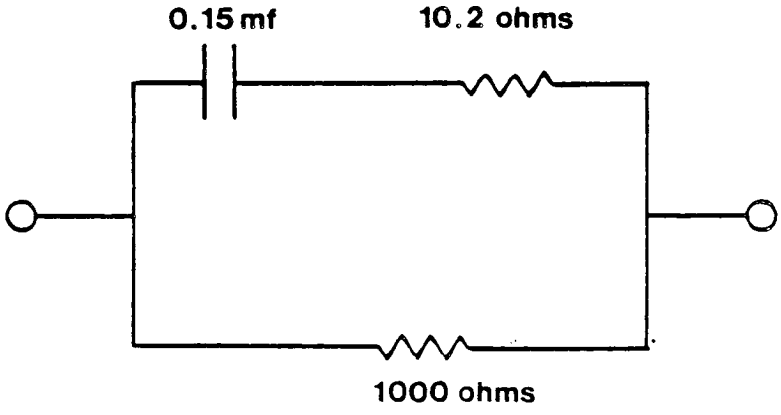
LINE FREQUENCY (50/60HZ) CURRENT LEAKAGE TEST PROCEDURE

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

The FORCE 4 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 0.15 microfarad capacitor is connected across the 1K ohm resistor to remove any trace of high frequency noise generated by the oscillator inside the unit. 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 2.0 microamps leakage is 0.002 volts (2 millivolts).

INPUT CIRCUIT:



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NOTE: Because of the extreme difference in magnitude of the 50/60 Hz leakage current in the RF signals when the generator is keyed, it is very difficult to make a 50/60 Hz leakage measurement when the unit is keyed. When the unit is keyed, there can be as much as 9000 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 unit 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 100 microamps is valid for factory installed 10 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 4 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 220 volt, 50/60 Hz potential is applied between a PATIENT lead and the chassis. The voltage source should be a 220 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 220 volt source and the PATIENT or ACTIVE jacks. This current should be less than 300 microamps.

BIPOLAR OUTPUT RF LEAKAGE TEST PROCEDURE

In this test the RF leakage current to earth ground from the bipolar output is measured. The readings are made with an RF ammeter from either bipolar output to ground. Caution: Accidental connection of the meter from one bipolar output to the other will result in instant destruction of the meter.

Connect a 250 milliamp RF ammeter from one of the bipolar output jacks to ground. Connect a 40 picofarad capacitor from the other output to ground. This may be approximated by draping a 10 foot accessory cord across the test bench. Set the Bipolar level to 20 watts and key the generator. The RF leakage to ground should not exceed 150 milliamps.

CHASSIS GROUND INTEGRITY TEST PROCEDURE

Check for the existence of a low impedance connection between the generator chassis and the third wire ground plug. To avoid any problems with contact resistance when measuring this impedance (0.1 ohm), it is recommended that a four wire resistance measuring technique be used. The recommended maximum impedance of 0.1 ohm is for the standard 10 foot, 16/3 AWG line cord. Use of longer cords is not recommended.

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SECTION 8

TROUBLESHOOTING PROCEDURES

I. Introduction

The FORCE 4 is a modular unit and anyone attempting to repair the generator should consider stocking the modules listed in Section 10. Replacement of a suspected defective module can save hours of time and greatly simplify troubleshooting. Replacement of a suspected defective module will help isolate the malfunction. Defective boards can be returned to Valleylab for repair or partial credit.

In this procedure the technician is instructed to unplug printed circuit boards or connectors. Power should be OFF when either making or breaking these connections.

II. Symptoms

Each symptom listed refers to a particular procedure and in some cases to a particular assembly. Check this list to determine which are applicable to your unit.

Symptom 1 - No monopolar RF output. Display works normally. No alert or fault lights on front panel. Audio tones in CUT, COAG are normal.

Symptom 2 - No RF output in monopolar CUT modes only or COAG modes only. No alert or fault lights on front panel. Audio tones in CUT, COAG are normal. Also, follow this procedure if both CUT and COAG are defective and you have first followed procedure 1.0.

Symptom 3 - One or more RF indicator lamps out (CUT, COAG, MBP). (FORCE 4 must be activated at a display setting greater than 3 watts in CUT, COAG, or Bipolar modes to activate RF indicator lamps.)

Symptom 4 - Incorrect audio for CUT/COAG warning tones, or for alarm warning tones.

Symptom 5 - All displays, audio tones correct. RF power correct at low display settings. However, when settings are increased, power output in monopolar or bipolar modes is 30% or more below normal. Output modules J1103 thru J1107 may fail at higher display settings. High voltage power supply may go into over-current shut-off.

Symptom 6 - Unit appears non-functional. Display is dead, or flickers briefly on power-up or power-down. Unit will not activate in any mode.

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Symptom 7 - REM circuit defective. REM alarm enables even though proper terminating impedance is present, or REM does not alarm when impedance is incorrect.

Symptom 8 - Return Fault defective.

Symptom 9 - Front Panel displays show incomprehensible pattern or are frozen (cannot be changed by power buttons). All power supplies check OK. (See Symptom 6)

Symptom 10 - Inability to key one or all handswitches.

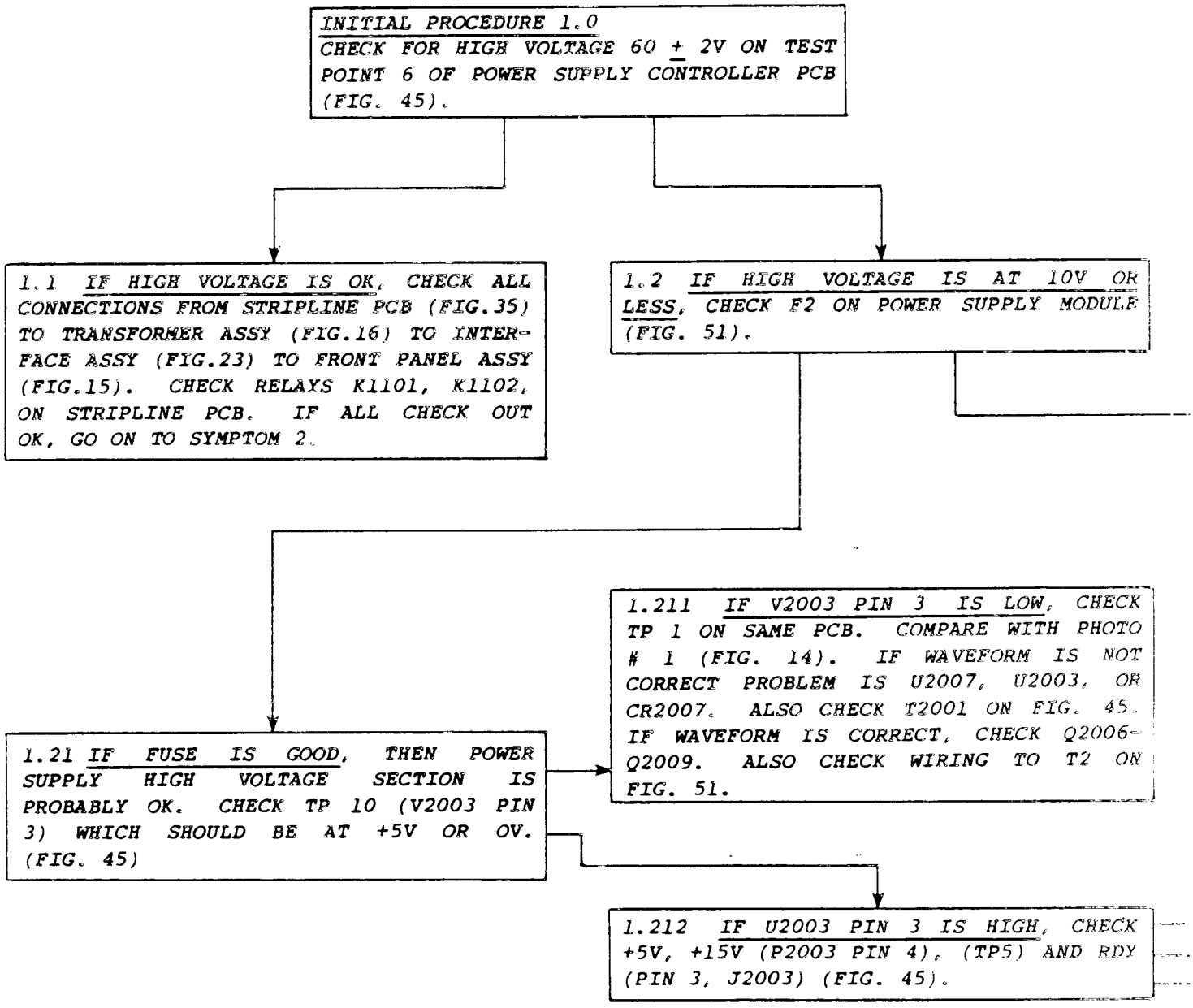
Symptom 11 - No bipolar output. Monopolar output OK. Audio tone in bipolar activates normally.

NOTE: For JXXX number identification, refer to System Interconnect Schematic, Figure 17.

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SYMPTOM 1

NO MONOPOLAR RF OUTPUT. DISPLAY WORKS NORMALLY. NO ALERT OR FAULT LIGHTS ON FRONT PANEL. AUDIO TONES IN CUT, COAG ARE NORMAL.



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1.22 IF F2 IS OPEN, CHECK TP 1 ON POWER SUPPLY CONTROLLER PCB (FIG.45). COMPARE WITH PHOTO # 1 (FIG. 14). DO NOT REPLACE FUSE.

1.221 IF WAVEFORM IS INCORRECT, OR ASYMMETRICAL, REPLACE U2007 ON FIG. 45. ALSO CHECK Q2006-2009 ON FIG. 45. IF WAVEFORM IS STILL INCORRECT, CHECK U2003, U2002, U2001, CR2007 ON FIG. 45. WHEN WAVEFORM RETURNS FOLLOW STEP 1.222.

1.222 IF WAVEFORM IS CORRECT AT TP 5, CHECK Q2006-2009 (FIG. 45). REPLACE DEFECTIVE Q's; REPLACE F2. TURN ON UNIT. IF F2 FAILS AGAIN SUSPECT CR4 ON POWER SUPPLY MODULE (FIG. 51). IF F2 STAYS GOOD BUT HIGH VOLTAGE IDLE (+60V) DOES NOT RETURN, FOLLOW STEP 1.2121.

1.2121 IF $\overline{RDY}$ IS LOW AND TP 5 IS +15V + .5V, THEN POWER SUPPLY IS CURRENT LIMITED BECAUSE OF EXCESSIVE LOAD ON THE HIGH VOLTAGE. REMOVE THE FIRST OUTPUT MODULE, J1103 ON THE STRIPLINE PCB. REACTIVATE SSE4 AND CHECK FOR HIGH VOLTAGE (+60V) IDLE. CONTINUE TO REMOVE, ONE BY ONE, EVERY OUTPUT MODULE J1103-J1107 UNTIL HIGH VOLTAGE RETURNS.

1.21211 IF HIGH VOLTAGE RETURNS, REPAIR DEFECTIVE OUTPUT MODULES. CHECK Q1, CR2, CR3. WHEN MODULES ARE REPAIRED AND REINSTALLED, CHECK POWER OUTPUT AT A SETTING OF 10W IN COAG. CHECK EACH MODULE WITH A CURRENT PROBE (TEKTRONIX P6021, OR EQUIV.) COMPARE WITH PHOTO # 2 (FIG. 14). THEN FOLLOW TESTING PROCEDURE SECTION 7. BE SURE TO CHECK HIGH VOLTAGE CLAMP SECTION 7.4.

1.21212 IF HIGH VOLTAGE DOES NOT RETURN, SEARCH FOR SHORT IN STRIPLINE PCB OR PARENT PCB (FIGS. 35 AND 18).

1.2122 IF $\overline{RDY}$ IS HIGH, CHECK FIG. 19, J401 PIN 10, J402 PIN 34, FOR RDY FROM MONOPOLAR DISPLAY BOARD.

1.2123 IF TP 5 IS NOT AT +15V + .5V, GO TO SYMPTOM 6.

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SYMPTOM 2

NO RF OUTPUT IN MONOPOLAR CUT MODES ONLY OR COAG MODES ONLY. NO ALERT OR FAULT LIGHTS ON FRONT PANEL. AUDIO TONES IN CUT, COAG ARE NORMAL. ALSO, FOLLOW THIS PROCEDURE IF BOTH CUT AND COAG ARE DEFECTIVE AND YOU HAVE FIRST FOLLOWED PROCEDURE 1.0

INITIAL PROCEDURE 2.0
PUT CLOCK/CONTROL BOARD J601 ON EXTENDER CARD AND OBSERVE WAVEFORM ON TP601, SIGNAL "G". COMPARE WITH PHOTOS # 3 THRU # 7 ON FIGURE 14. ACTIVATE SSE4 IN EACH MODE AND OBSERVE "G".

2.1 IF "G" IS NOT CORRECT IN ANY MODE, EXAMINE 750KHz WAVEFORM AT PIN W ON CLOCK CONTROL PCB (FIG. 29, PHOTO #8). IF 750KHz WAVEFORM IS INCORRECT, CHECK Y401, U405, U412 ON CPU BOARD (FIG. 19). IF WAVEFORM IS CORRECT, CHECK U615, U614, U608, U609, U610, U616 ON FIG. 29. REFER TO TIMING WAVEFORMS (FIG. 8).

2.2 IF "G" IS CORRECT, OBSERVE $\overline{OND}$ AND $\overline{OFD}$ AT PINS 8, J OF FIG. 29. THESE WAVEFORMS SHOULD BE SIMILAR TO THE "G" WAVEFORMS. HOWEVER, THE PULSE WIDTH OF THE WAVEFORMS $\overline{OND}$ AND $\overline{OFD}$ SHOULD VARY WITH THE DISPLAY SETTING OF THE MODE BEING ACTIVATED. BUT IF, FOR EXAMPLE, PURE CUT HAD NO OUTPUT WHEN ACTIVATED WITH FOOTSWITCH AT MAXIMUM, THEN OND SHOULD HAVE FULL PULSE WIDTH IN CUT (SAME AS "G").

2.21 IF $\overline{OND}$, $\overline{OFD}$ ARE OK BUT THERE IS STILL NO RF OUTPUT, CHECK T/ON, T/OFF ON THE DRIVER PCB (PINS 9, 10 FIG. 33) (PHOTO # 8)

2.22 IF $\overline{OND}$ OR $\overline{OFD}$ IS NOT CORRECT, CHECK PIN K, $\overline{CSCT}$ FOR CUT MODES, AND PIN L, $\overline{CSCG}$ FOR COAG MODES ON CONTROL PCB (FIG. 29).

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2.211 IF T/ON, T/OFF ARE OK, BUT THERE IS NO RF OUTPUT, THEN CHECK Q1104-Q1106 ON STRIPLINE PCB (FIG.35). IF THEY ARE OK, GO TO STEP 1.2.

2.212 IF T/ON, T/OFF ARE NOT CORRECT, CHECK Q1006 ON DRIVER PCB (FIG. 33). IF Q1106 IS OK, CHECK Q1007, Q1011, Q1002, Q1008, CR1001, CR1002.

2.221 IF THERE IS NO CUT RF OUTPUT, $\overline{CSCT}$ SHOULD BE AT +12V. IF IT IS NOT, THEN PROBLEM IS IN SENSE PCB OR SIGNAL "ECON", TP 404 ON THE CPU BOARD (FIG. 27). "ECON" SHOULD BE APPROX. 2.1 $\pm$ .3 VDC FOR 150W IN PURE CUT ON DISPLAY. CUT MUST BE ACTIVATED TO TEST.

2.2211 IF "ECON" IS AT 0V OR DOES NOT VARY WITH DISPLAY SETTING, CHECK U415, U416 ON CPU BOARD (FIG. 19). ALSO CHECK J1201 FOR INTEGRITY.

2.2212 IF "ECON" IS CORRECT, CHECK SENSE PCB Q801, U801, U808, U805, Q809, U802, Q810, AND Q811.

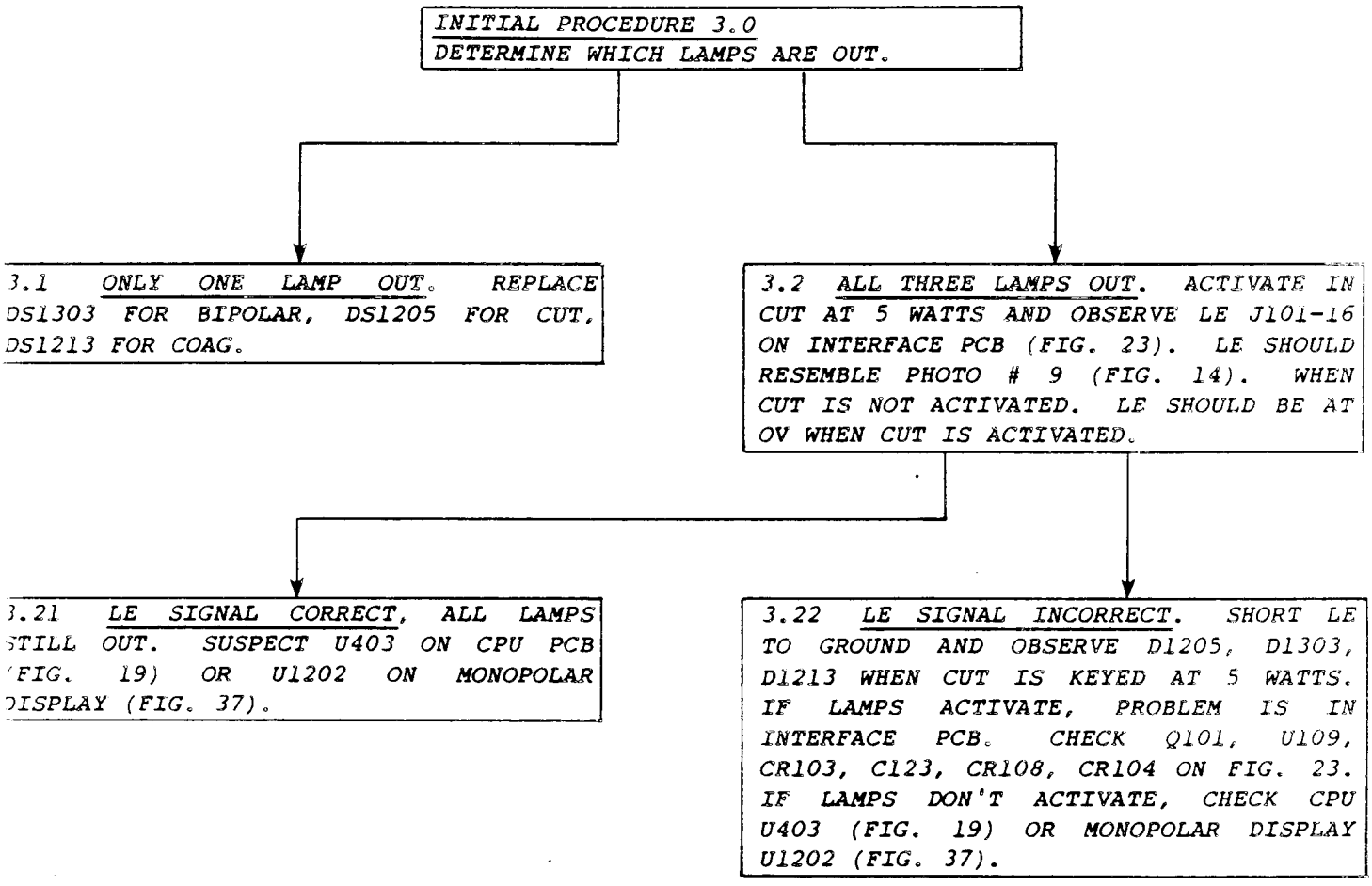
2.222 IF THERE IS NO COAG RF OUTPUT, $\overline{CSCG}$ SHOULD BE AT +12V. IF IT IS NOT THEN FOLLOW THE SAME PROCEDURE AS 2.221. "ECON" SHOULD BE 3.5 $\pm$ .3 VDC AT 58W IN SPRAY COAG.

2.223 IF THERE IS NO CUT RF OUTPUT, $\overline{CSCT}$ SHOULD BE AT +12 VDC WHEN CUT IS ACTIVATED. IF THERE IS NO COAG RF OUTPUT, $\overline{CSCG}$ SHOULD BE AT +12 VDC WHEN COAG IS ACTIVATED. IF THESE STATEMENTS DESCRIBE THE SYMPTOM, THE THE CLOCK/CONTROL PCB IS DEFECTIVE. CHECK U602 AND ASSOCIATED CIRCUITRY FOR COAG, AND U603 FOR CUT. REFER TO TIMING WAVEFORMS (FIG. 8).

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SYMPTOM 3

ONE OR MORE RF INDICATOR LAMPS OUT (CUT, COAG, MBP) (FORCE 4 MUST BE ACTIVATED AT A DISPLAY SETTING GREATER THAN 3 WATTS IN CUT, COAG, OR BIPOLAR MODES TO ACTIVATE RF INDICATOR LAMPS.)



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SYMPTOM 4

INCORRECT AUDIO FOR CUT/COAG WARNING TONES, OR FOR ALARM WARNING TONES.

INITIAL PROCEDURE 4.0
ISOLATE MALFUNCTION TO MODE, (CUT COAG, ALARM, OR ALL THREE) AND TO DESCRIPTION (VOLUME TOO HIGH, NO ADJUSTMENT, NO VOLUME AT ALL.)

4.1 IF COAG AUDIO TONE SOUNDS IDENTICAL TO CUT AUDIO TONE, CHECK Q401 ON CPU PCB (FIG. 19).

4.2 IF AUDIO ABSENT OR DISTORTED, CHECK PIN 6 OF U421 ON FIG. 19. WAVEFORM SHOULD BE 2 VOLTS P-P AT 400 Hz FOR CUT, 1KHz FOR COAG. ALSO CHECK TP 405 FOR 6 VOLT P-P WITH SCOPE PROBE COMMON ON TP 406.

4.21 IF SIGNAL ON U421, PIN 6 IS CORRECT, BUT SIGNAL AT TP 405 IS INCORRECT, CHECK U421, U420, U419, U418. (FIG. 19)

4.22 IF SIGNAL ON U421 IS INCORRECT, CHECK OSCILLATOR COMPONENTS R417, C416, C417, AND ASSOCIATED PARTS.

4.3 IF AUDIO FOR ALARM TONE VARIES WITH VOLUME SWITCH, OR IF AUDIO FOR CUT, COAG DOES NOT VARY WITH VOLUME SWITCH, CHECK VOL 1, VOL 2 SIGNALS ON CPU PCB (FIG. 19) PINS F AND 6. THE VOLUME LOGIC IS:

VOL 2	VOL 1	VOLUME
0	0	VERY HI
1	0	HI
0	1	LO
1	1	VERY LO

IF SIGNALS ARE OK, PROBLEM IS IN CPU PCB. IF NOT, VERIFY CORRECT SIGNALS VOL 1, VOL 2 ON SPEAKER PCB (FIG. 41) AND THRU PARENT PCB CONNECTIONS (FIG.18).

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SYMPTOM 5

ALL DISPLAYS, AUDIO TONES CORRECT. RF POWER CORRECT AT LOW DISPLAY SETTING. HOWEVER, WHEN SETTINGS ARE INCREASED, POWER OUTPUT IN MONOPOLAR OR BIPOLAR MODES IS 30% OR MORE BELOW NORMAL. OUTPUT MODULES J1103 THRU J1107 MAY FAIL AT HIGHER DISPLAY SETTINGS. HIGH VOLTAGE POWER SUPPLY MAY GO INTO OVER-CURRENT SHUT-OFF.

INITIAL PROCEDURE 5.0

USING AC CURRENT PROBE (TEKTRONIX P6021 OR EQUIV.) MEASURE COLLECTOR CURRENT IN EACH MODULE J1103-J1107 IN COAG AT A SETTING OF 25 WATTS. SEE FIGURE 14, PHOTO # 2 . PEAK CURRENT WILL BE MUCH LESS THAN PHOTO # 2 , BUT WAVEFORM SHOULD LOOK GENERALLY EQUIVALENT. ALSO MONITOR VOLTAGE WITH AN X100 PROBE ON E8 OF THE STRIPLINE PCB (FIG. 35). (PHOTO #10, FIG. 14) ACTIVATE SSE4 WITH FOOTSWITCH TO GIVE OUTPUT AT E8. ACTIVATE PURE CUT AT 100 WATTS. USE A 300 OHM LOAD AT OUTPUT. COMPARE WITH FIG. 14, PHOTO # 11. WHEN CUT IS ACTIVATED, NOTICE LED CR602 ON CLOCK/ CONTROL BOARD (FIG.29) IT SHOULD COME ON FOR .3 SECONDS WHEN UNIT IS ACTIVATED IN ANY CUT MODE. IT SHOULD NOT COME ON IN COAG.

5.1 IF CR602 ON THE CLOCK/CONTROL PCB DOES NOT COME ON BRIEFLY WHEN CUT IS KEYED, THE $\overline{M}$ CIRCUIT IS DEFECTIVE. CHECK $\overline{S}$, $\overline{OS}$, PINS P, 9 ON FIG. 31.

5.2 IF CR602 COMES ON AND STAYS ON DURING THE WHOLE PERIOD THAT A CUT MODE IS ACTIVATED, THE WAVEFORM AT E2 ON THE STRIPLINE PCB (FIG. 14), PHOTO #11) MAY BE INCORRECT. IT SHOULD SHOW A MINIMUM VOLTAGE OF +15V. THIS IS NORMALLY ADJUSTED WITH R803 ON FIG. 31. IF THIS MINIMUM VOLTAGE IS LESS THAN 6 V FOR THE ACTIVATION PERIOD, THIS INDICATES THAT THE HIGH VOLTAGE POWER SUPPLY IS NOT RESPONDING TO THE OVER-SATURATION CONDITION. MEASURE TP 3 (VS) ON FIG. 45. IT SHOULD BE AT +3VDC WHEN THE GENERATOR IS IDLING. WHEN THE GENERATOR IS ACTIVATED IN ANY CUT MODE, THIS VOLTAGE SHOULD GO UP PAST +4V WHEN THE POWER SETTING IS AT 100 WATTS IN PURE CUT.

5.3 IF ALL WAVEFORMS LOOK OK IN PROCEDURE 5.0, ACTIVATE COAG AT 58 WATTS WITH THE OUTPUT OPEN CIRCUITED. PLACE PROBE ON STRIPLINE PCB E8. MEASURE THE PEAK VOLTAGE. IT SHOULD NOT EXCEED 475V PEAK. IF OK, GO TO 116 WATTS IN COAG AND NOTE CLAMP VOLTAGE.

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5.11 IF $\overline{S}$ OR $\overline{OS}$ IS NOT LOW FOR THE FIRST .3 SECONDS OF ACTIVATION IN CUT, CHECK U806, U807, AND ASSOCIATED CIRCUITRY ON THE SENSE PCB, FIG. 31.

5.12 IF $\overline{S}$, $\overline{OS}$ ARE LOW FOR THE FIRST .3 SECONDS OF ACTIVATION IN CUT, CHECK M, A 1 MS ONE-SHOT SIGNAL AT U618, PIN 4. IF M IS NOT ENABLED, CHECK U618, U619, U614, U613, U611, CR602

5.21 IF TP 3 (VS) DOES RAMP UP PROPERLY, THEN PROBLEM IS IN POWER SUPPLY, CHECK U2007, R2061, U2008, AND ASSOCIATED PARTS. THE HIGH VOLTAGE SHOULD INCREASE FROM 60V UP TO THE DC VOLTAGE NECESSARY TO KEEP THE COLLECTORS VOLTAGE (E2 ON STRIPLINE) AT +15V MINIMUM.

5.22 IF TP 3 (VS) DOES NOT RAMP UP TO +4V OR HIGHER WHEN THE SSE4 IS ACTIVATED AT 150 WATTS IN CUT, THEN CHECK VR PIN 6 OF U616 (FIG. 29). SEE TIMING DIAGRAM (FIG. 8). CHECK U605, U616, U621, AND ASSOCIATED PARTS.

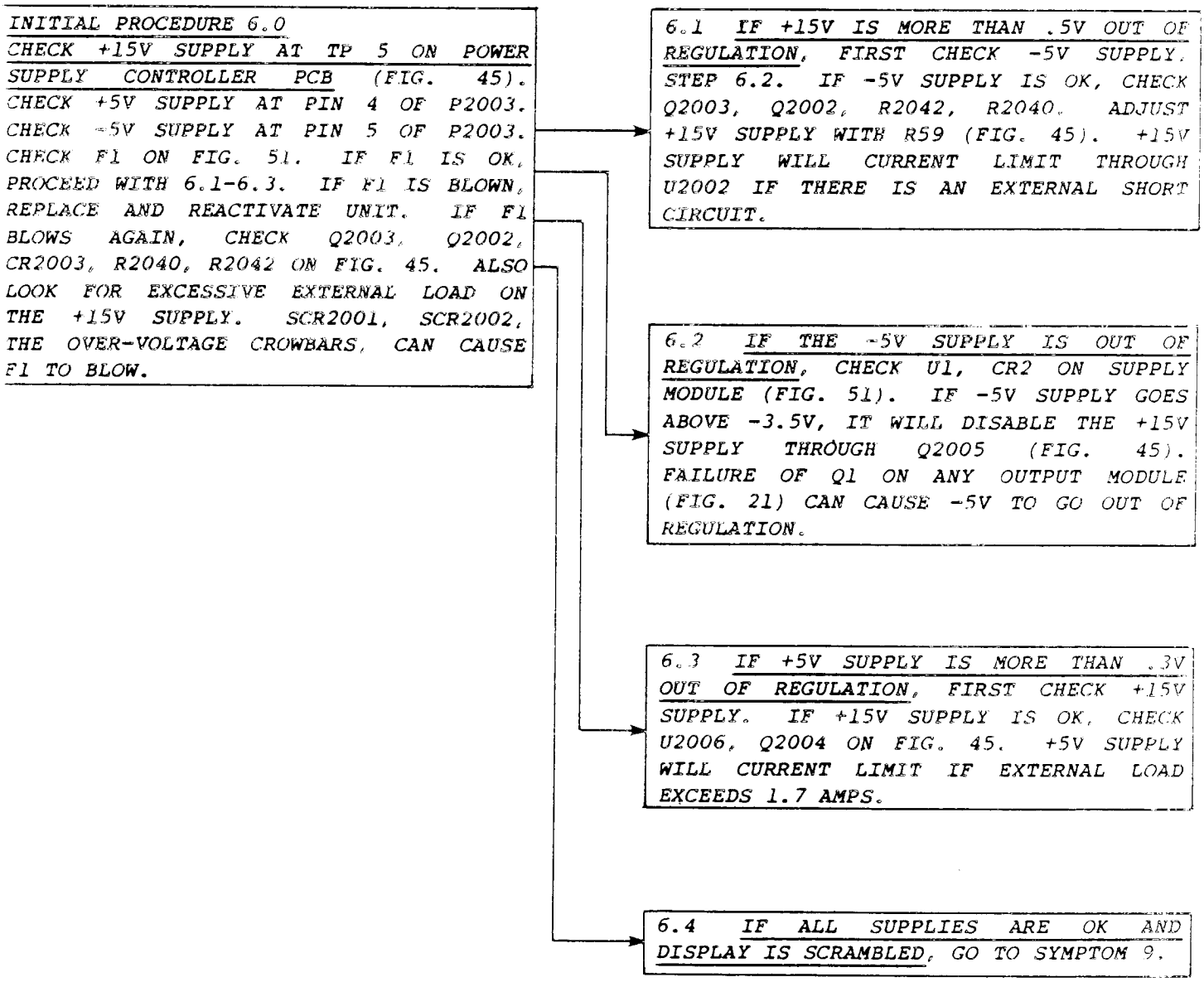
5.31 IF CLAMP DOES SEEM TO BE WORKING BUT VOLTAGE EXCEEDS 485V, ADJUST R1001 ON FIG. 33 FOR 475V.

5.32 IF NO CLAMP IS NOTICED AND VOLTAGE EXCEEDS 500V, THE CLAMP CIRCUITRY IS DEFECTIVE. CHECK U1001, U1002, Q1001, AND ASSOCIATED PARTS ON DRIVER PCB (FIG. 33). ALSO CHECK CONNECTIONS TO R3, 750 OHM, ON THE POWER SUPPLY MODULE (FIG. 51). CONNECTIONS TO THIS RESISTOR TRAVEL THROUGH THE PARENT PCB (FIG. 18).

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SYMPTOM 6

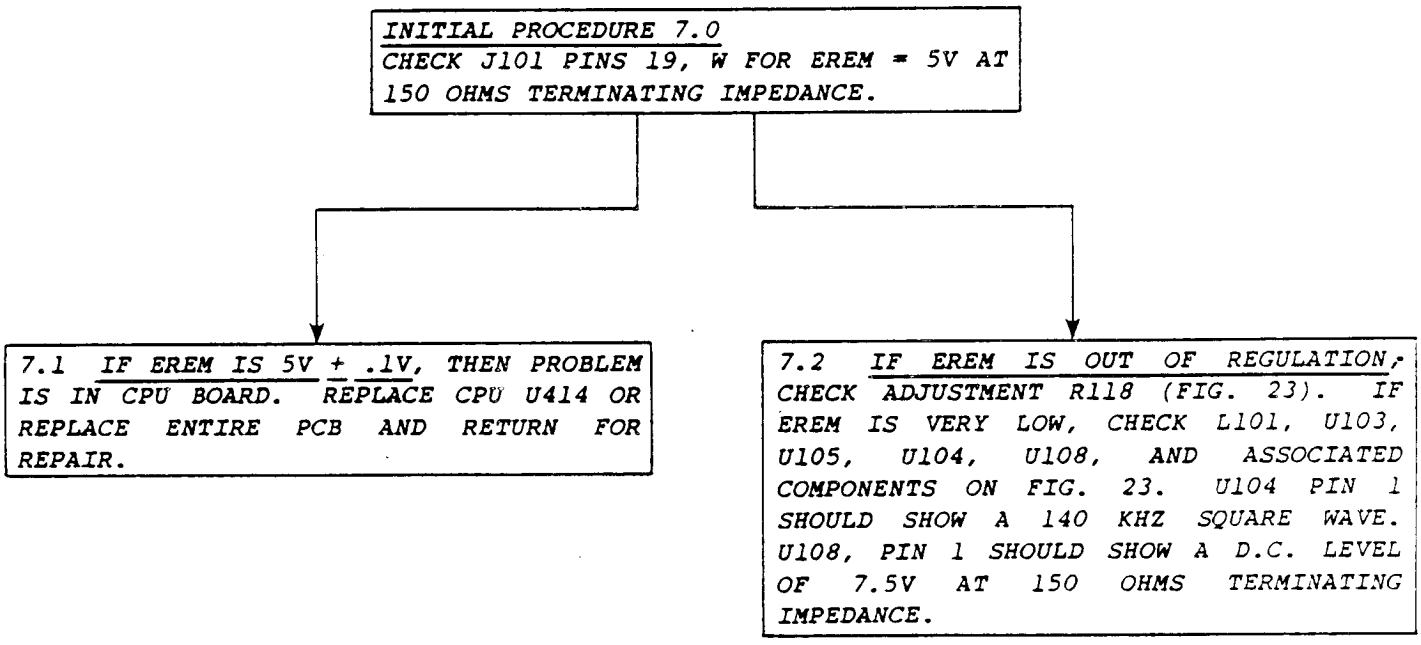
UNIT APPEARS NON-FUNCTIONAL. DISPLAY IS DEAD OR FLICKERS BRIEFLY ON POWER-UP OR POWER-DOWN. UNIT WILL NOT ACTIVATE IN ANY MODE.



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SYMPTOM 7

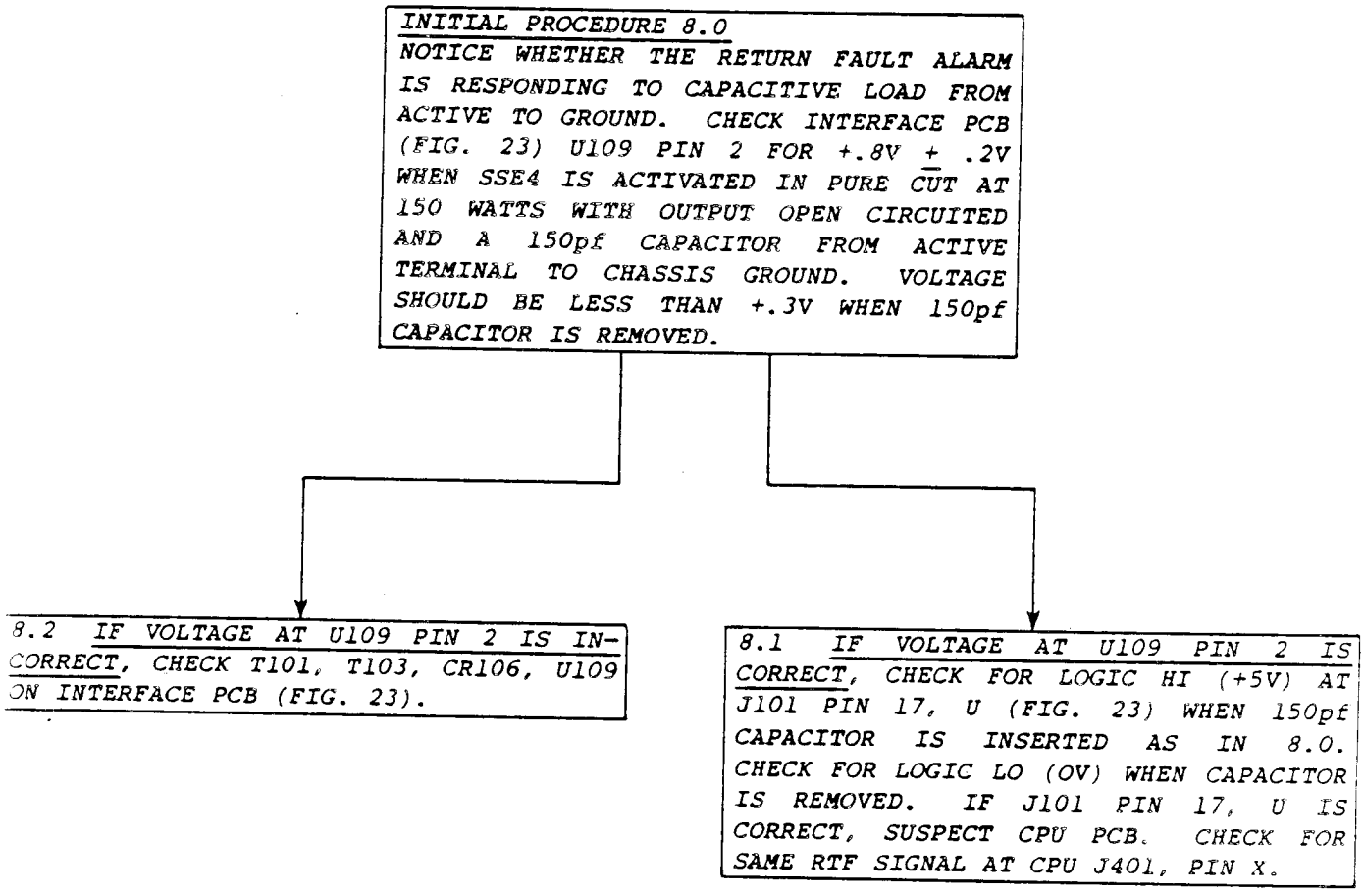
REM CIRCUIT DEFECTIVE. REM ALARM ENABLES EVEN THOUGH PROPER TERMINATING IMPEDANCE IS PRESENT, OR, REM DOES NOT ALARM WHEN IMPEDANCE IS INCORRECT.



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SYMPTOM 8

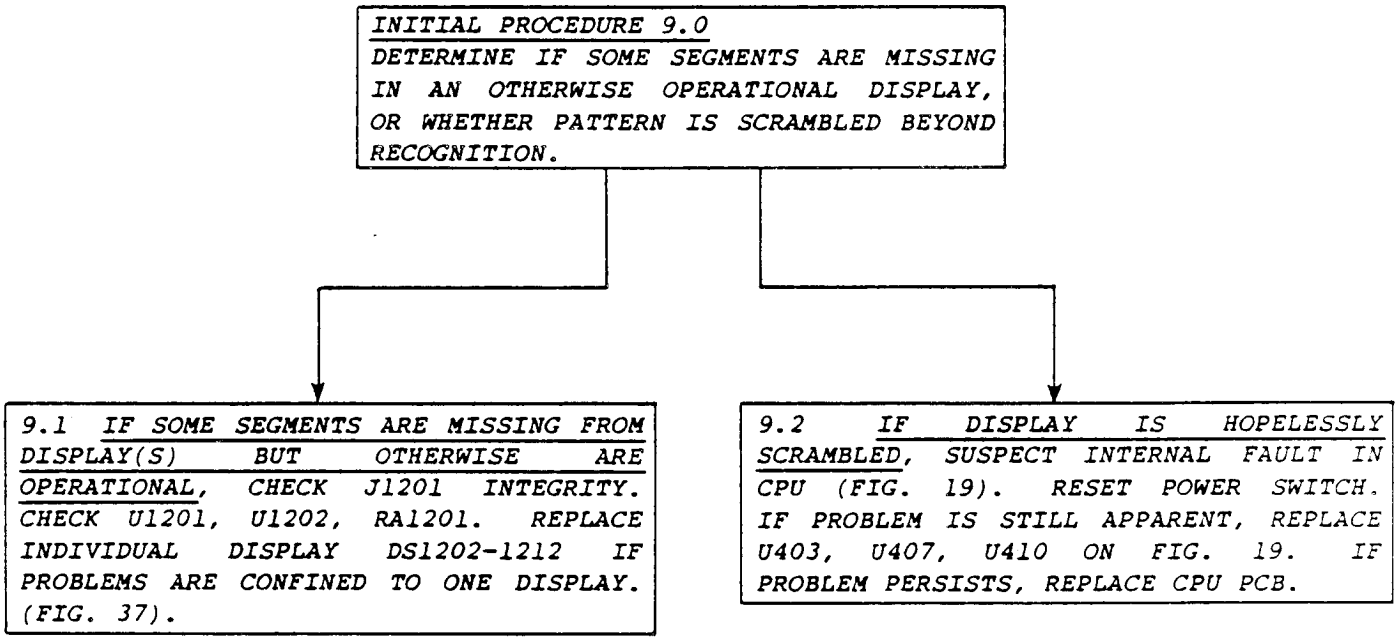
RETURN FAULT DEFECTIVE.



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SYMPTOM 9

FRONT PANEL DISPLAYS SHOW INCOMPREHENSIBLE PATTERN. ALL POWER SUPPLIES CHECK OK. (SEE SYMPTOM 6)



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SYMPTOM 10

INABILITY TO KEY ONE OR ALL HANDSWITCHES.

INITIAL PROCEDURE 10.0
DETERMINE IF PROBLEM IS MONOPOLAR MODES ONLY, BIPOLAR MODES ONLY, OR BOTH.

10.1 IF PROBLEM IS IN BIPOLAR MODE ONLY CHECK C232 (FIG. 25) FOR 5-8 VDC. HSDS PIN 5 OF MBP OUTPUT BOARD SHOULD BE LOW WHEN HANDSWITCH IS ACTIVATED. IF C232 VOLTAGE IS TOO LOW, CHECK Q213, T203. IF HSDS IS INCORRECT, CHECK U209.

10.2 IF PROBLEM IS IN MONOPOLAR MODE ONLY, MEASURE THE FOLLOWING VOLTAGES ON U101, U102 ON INTERFACE PCB (FIG. 23). ALL MEASUREMENTS MUST BE MADE WITH REFERENCE TO ▽1 AT C101 FOR U101, TO ▽2 AT C132 FOR U102, SAMPLE AT +5V FOR ALL MEASUREMENTS EXCEPT AS NOTED.

LM339	PIN #	MODE	DC VOLTS
U101	2	HANDSWITCH COAG ONLY	0
	2	ALL OTHERS	6-8
	13	HANDSWITCH CUT ONLY	0
	13	ALL OTHERS	6-8
	9	SAMPLE LOW	0
	9	SAMPLE HIGH	3-5
U102	2	HANDSWITCH CUT ONLY	0
	2	ALL OTHERS	6-8
	1	HANDSWITCH COAG ONLY	0
	1	ALL OTHERS	6-8
	9	SAMPLE	0
	9	SAMPLE HIGH	3-5

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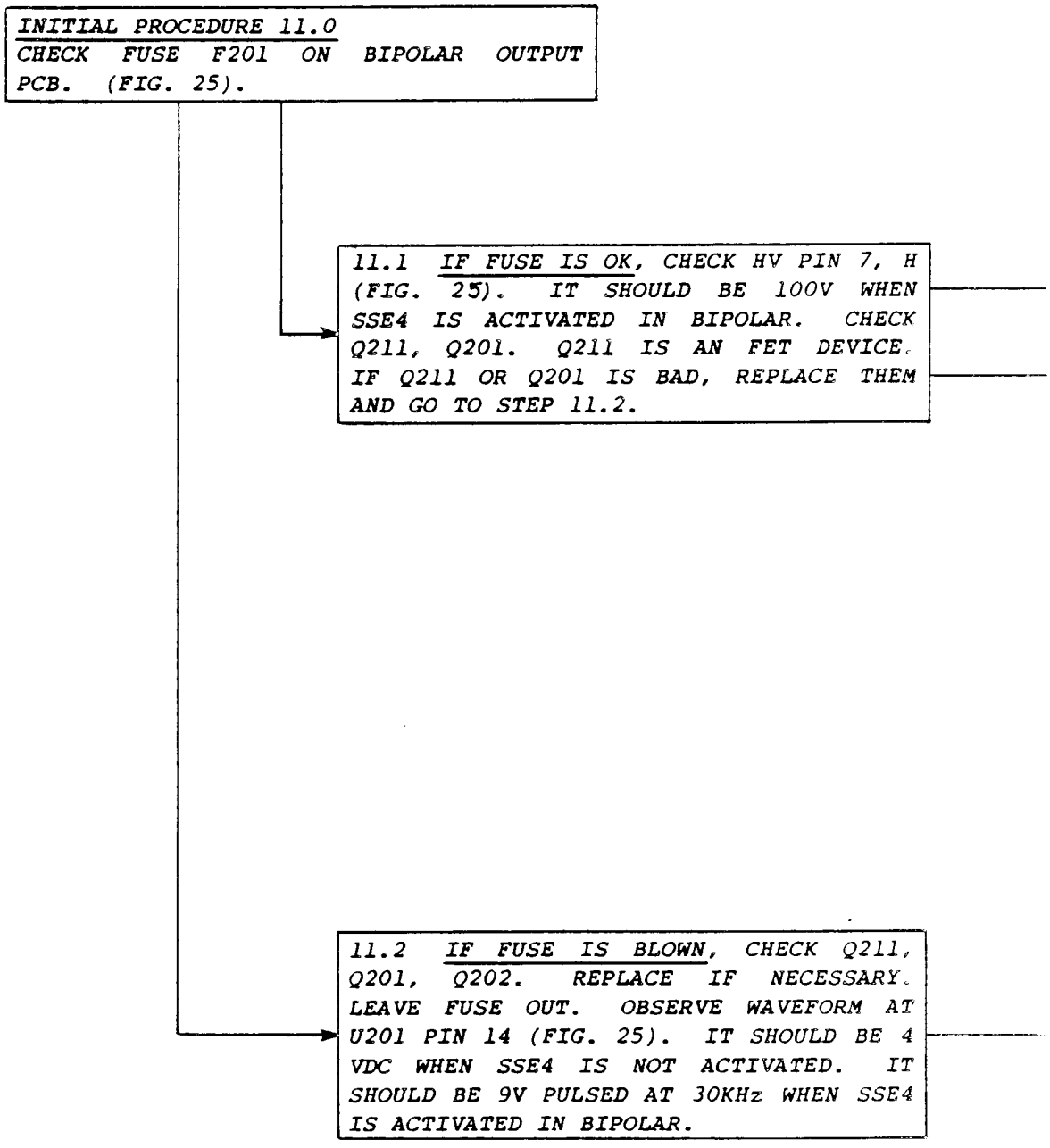
10.21 IF ALL VOLTAGES ON U101, U102 ARE OK, CHECK OPI101-107 (FIG. 23). ALSO CHECK CTE, CGE PINS R, 13 ON J104 (FIG. 23). IF OPI101-107 ARE OK, PROBLEM IS IN CPU PCB.

10.22 IF VOLTAGES ON U101, U102 ARE INCORRECT, CHECK C101, C132 FOR 6 VDC MINIMUM. ALSO CHECK HY101, HY102 OR REPLACE THEM. CHECK WIRE HARNESS FROM P102-105 TO FRONT PANEL.

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SYMPTOM 11

NO BIPOLAR OUTPUT. MONOPOLAR OUTPUT OK. AUDIO TONE IN BIPOLAR ACTIVATES NORMALLY.



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11.11 IF HV IS NOT AT 100V, CHECK DSE PIN 14 ON CLOCK/CONTROL PCB (FIG. 29). IT SHOULD BE HI WHEN BIPOLAR IS ACTIVATED. ALSO CHECK U621.

11.12 IF HV IS OK, Q211, Q201 ARE OK, CHECK RESET PIN P AND KEY PIN T (FIG. 25). BOTH SIGNALS SHOULD BE HI WHEN BIPOLAR IS NOT ACTIVATED, LOW WHEN BIPOLAR IS ACTIVATED. REMOVE FUSE F201 AND OBSERVE AFB PIN 16. AFB SHOULD START LOW AND GO HIGH WITHIN 100mS AFTER BIPOLAR IS ACTIVATED. ALSO CHECK PIN W FOR 6 mHz CLOCK.

11.121 IF RESET. KEY, CLOCK OR AFB ARE INCORRECT, PROBLEM IS PROBABLY IN BIPOLAR CONTROLLER PCB. REPLACE BIPOLAR CONTROLLER PCB.

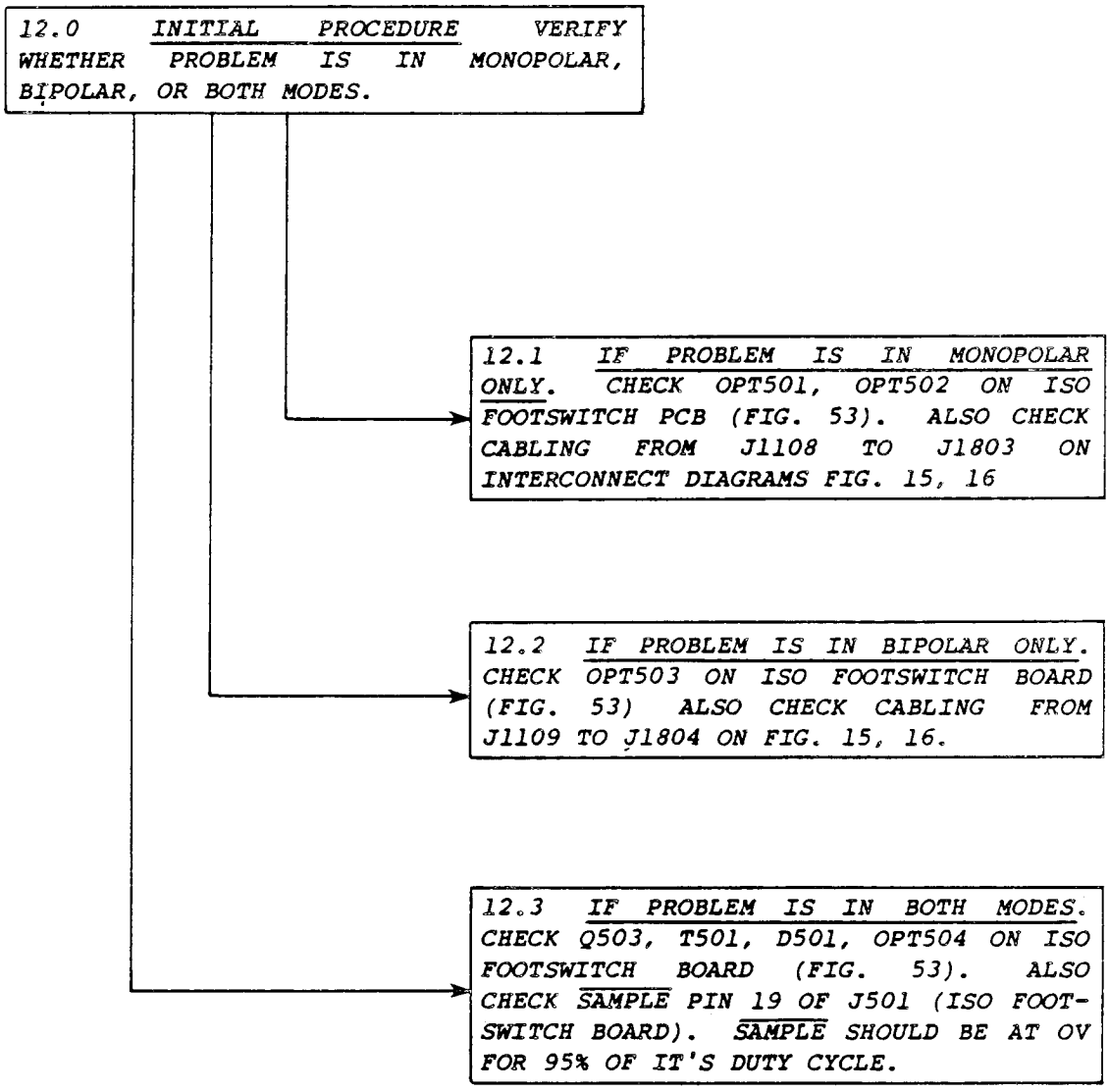
11.122 IF ALL SIGNALS FROM CONTROLLER PCB ARE OK, CHECK U204 PIN 11 FOR 750 kHz WAVEFORM, CHECK U203 PIN 3 FOR 750 kHz ONLY WHEN ACTIVATED IN BIPOLAR MODE. CHECK Q211 GATE FOR 8 VOLTS SQUARE WAVE WHEN ACTIVATED IN BIPOLAR.

11.21 IF WAVEFORM AT U201 PIN 14 IS OK, REPLACE F201. REACTIVATE SSE4 IN BIPOLAR. IF F201 FAILS AGAIN, RECHECK Q211, Q201, Q202. ALSO CHECK Q207 THRU Q210 IF Q211 WAS BAD. IF FUSE CONTINUES TO BLOW, OR PARTS CONTINUE TO FAIL, GO TO 11.1.

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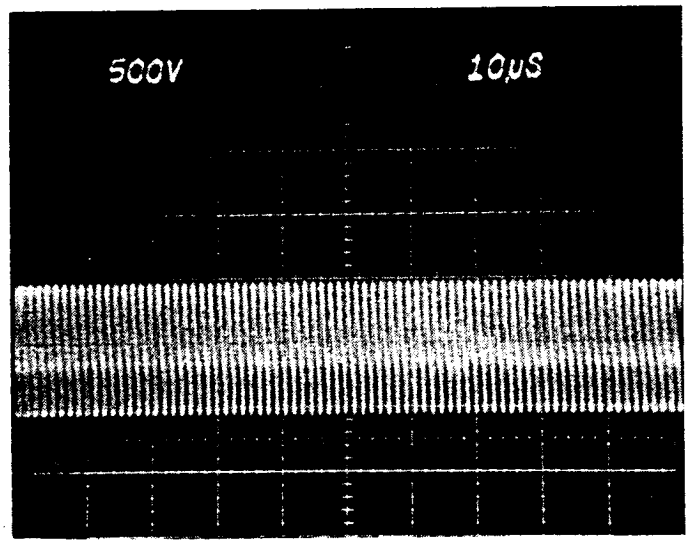
SYMPTOM 12

CUT MODES, COAG MODES OR BIPOLAR MODES WON'T KEY WITH FOOTSWITCH.

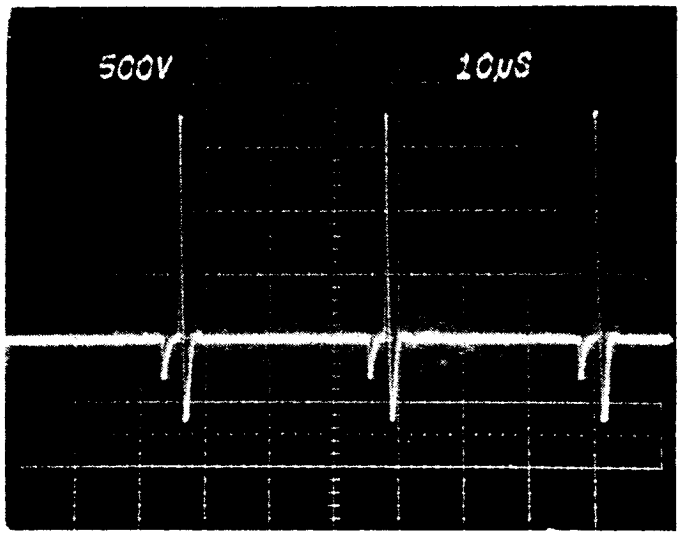


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ALL WAVEFORMS SEEN ACROSS A 300 OHM LOAD
HORIZONTAL SENSITIVITY - 10us/cm
VERTICAL SENSITIVITY - 500V/cm



CUT @ 300 W

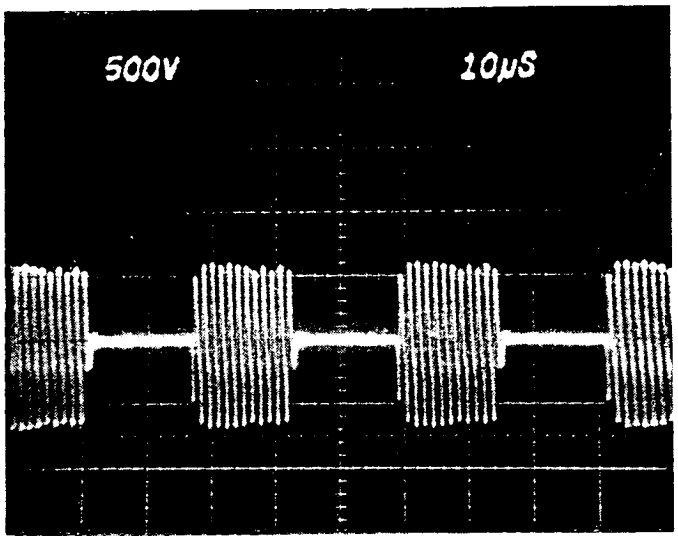


SPRAY COAG @ 116 W

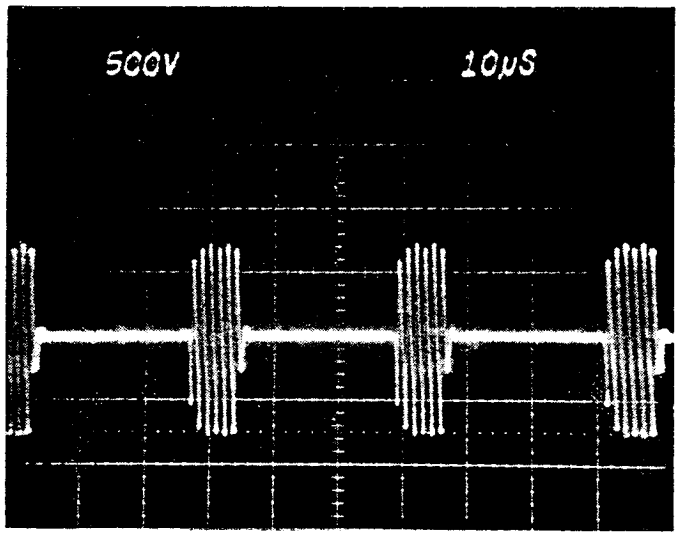
FIGURE 12

MONOPOLAR OUTPUT WAVEFORMS

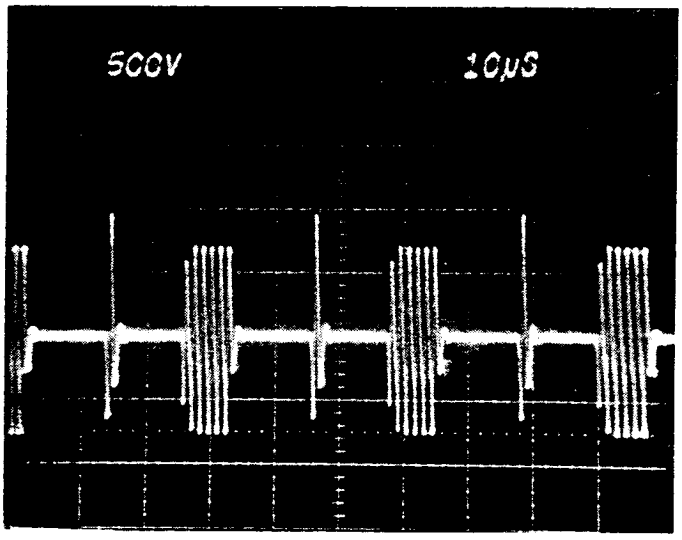
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BLEND 1 @ 250 W



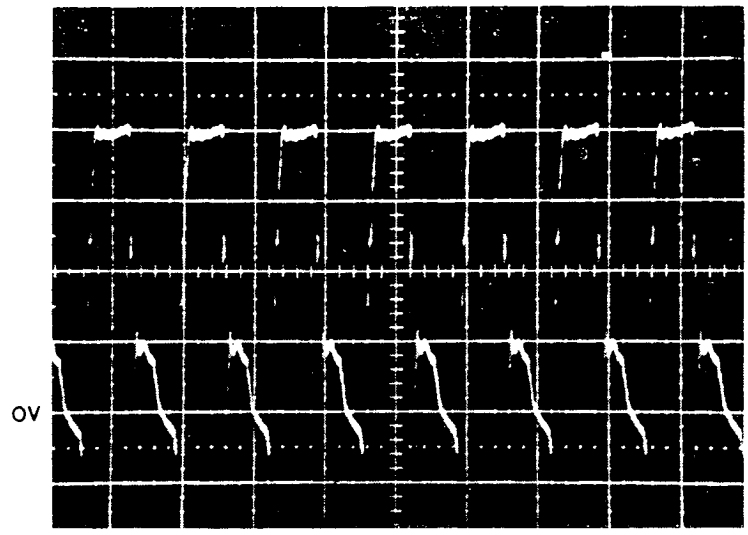
BLEND 2 @ 200 W



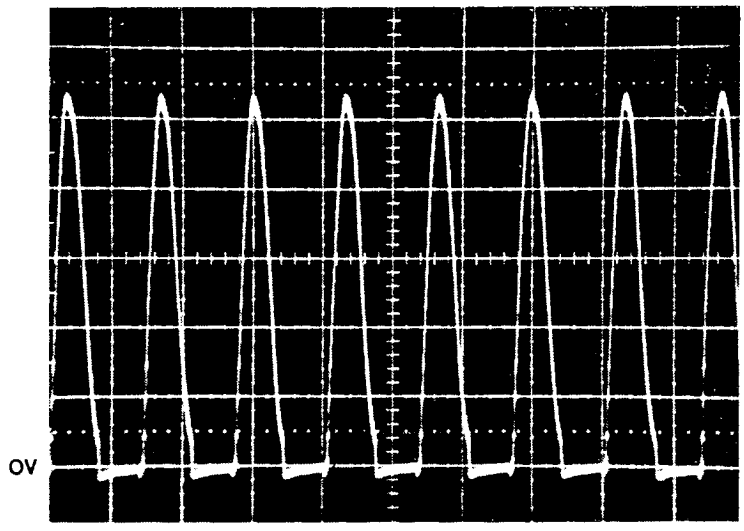
BLEND 3 @ 200 W

FIGURE 12 CONTINUED

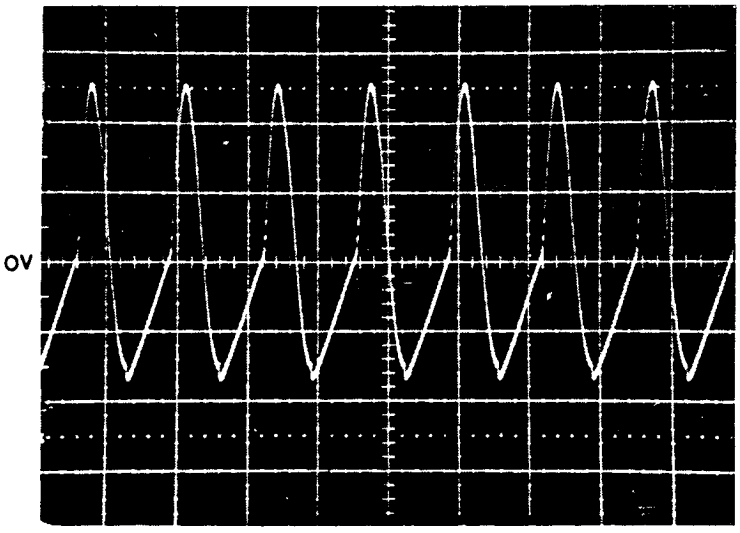
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KEY MBP
Q211 GATE
2V/div
1uS/div
SETTING - 40W
300 OHM LOAD



KEY STD MBP
Q211 DRAIN
50V/div
1uS/div
SETTING -40W
100 OHM LOAD

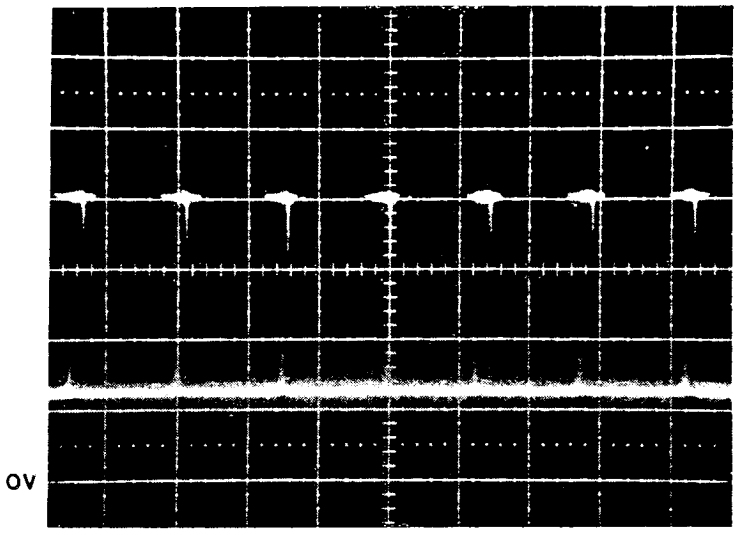


KEY STD MBP
RF OUTPUT
50V/div
1uS/div
SETTING - 40W
100 OHM LOAD

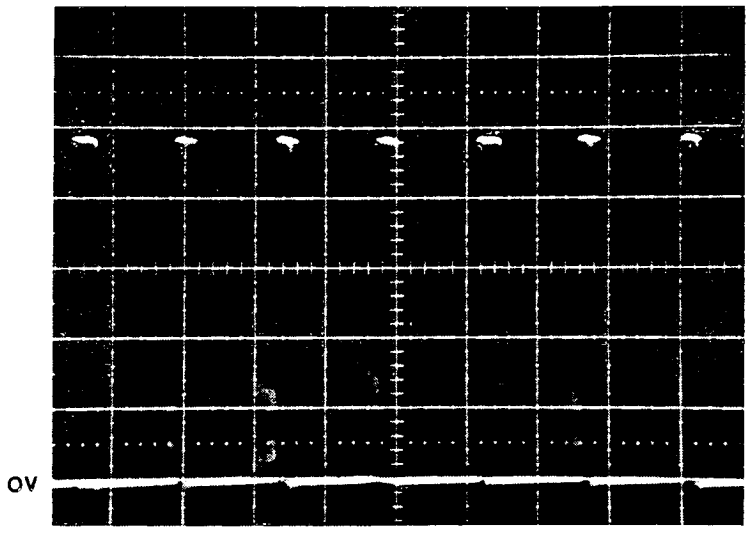
FIGURE 13

BIPOLAR OUTPUT WAVEFORMS

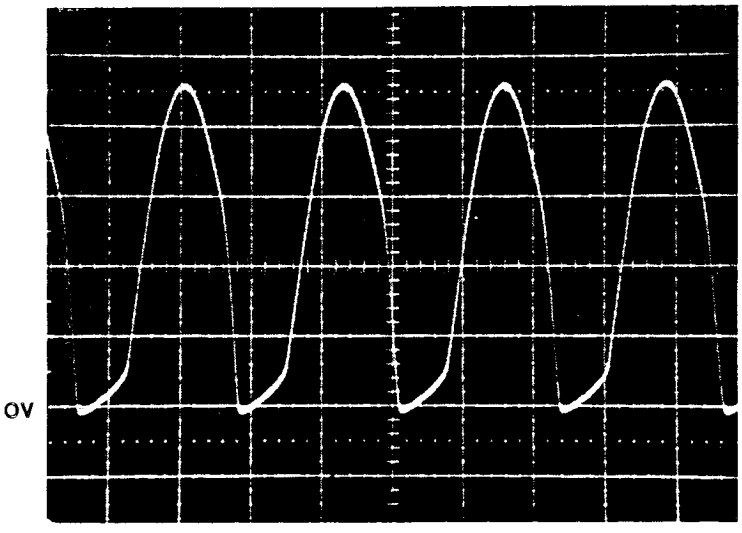
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KEY STD MBP
Q203 COLLECTOR
20V/div
20uS/div
SETTING - 1W
100 OHM LOAD



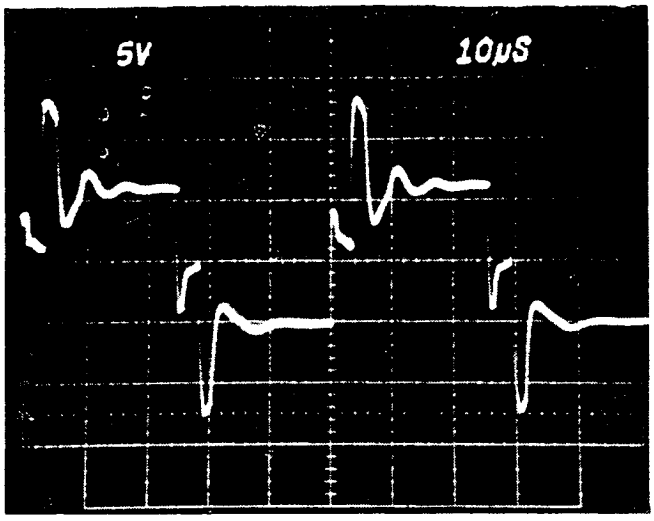
KEY STD MBP
Q201 EMITTER
20V/div
20uS/div
SETTING - 1W
100 OHM LOAD



UNKEYED
Q213 COLLECTOR
5V/div
5uS/div

FIGURE 13 CONTINUED

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1

SIGNAL HV SWITCHING
POWER SUPPLY CONTROLLER BOARD
TEST POINT 5 (SEE FIGURE 46)

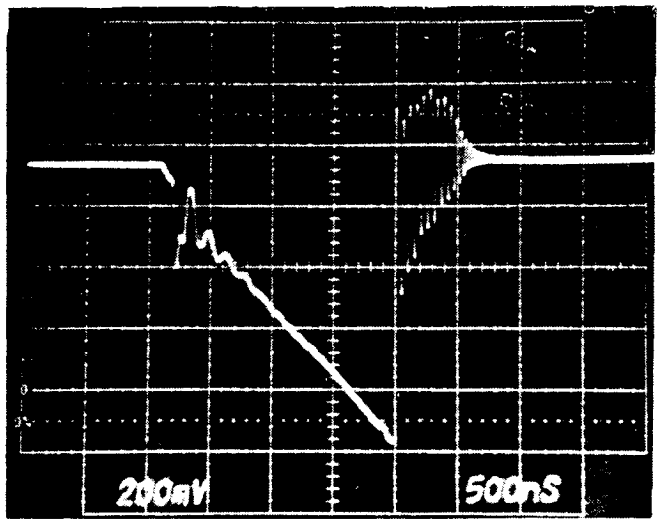
F2 (8 AMP) REMOVED

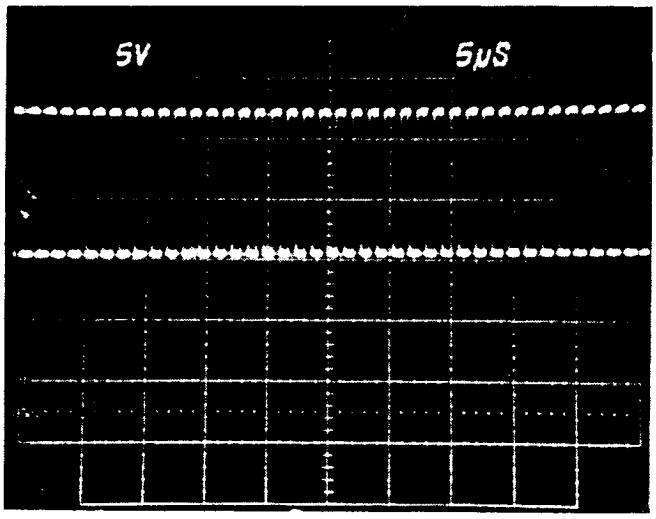
2

SIGNAL COLLECTOR CURRENT
OUTPUT BOARD
RED WIRE LOOP (SEE FIGURE 21)

KEY COAG

CONTROL SETTING 58 WATTS
300 OHM LOAD





3

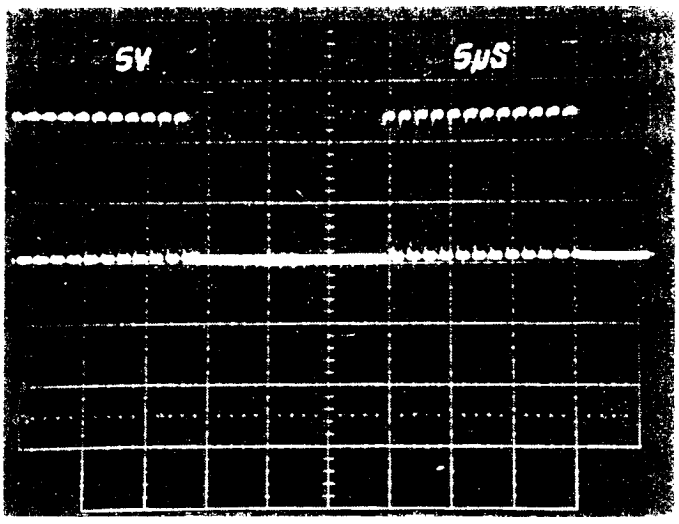
SIGNAL G
CLOCK/CONTROL BOARD
TEST POINT 601 (SEE FIGURE 30)

KEY PURE CUT

FIGURE 14

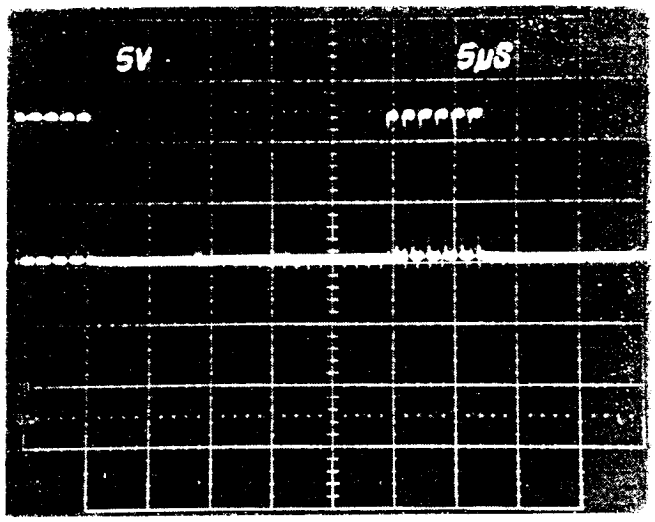
TROUBLESHOOTING WAVEFORMS

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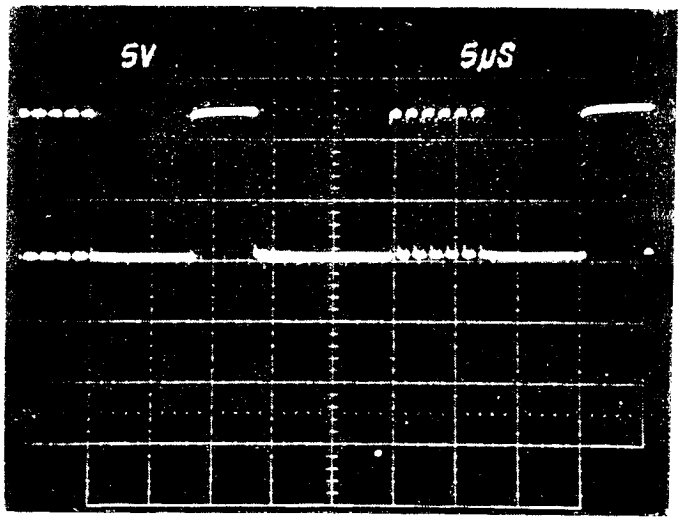


0V

4 KEY BLEND 1

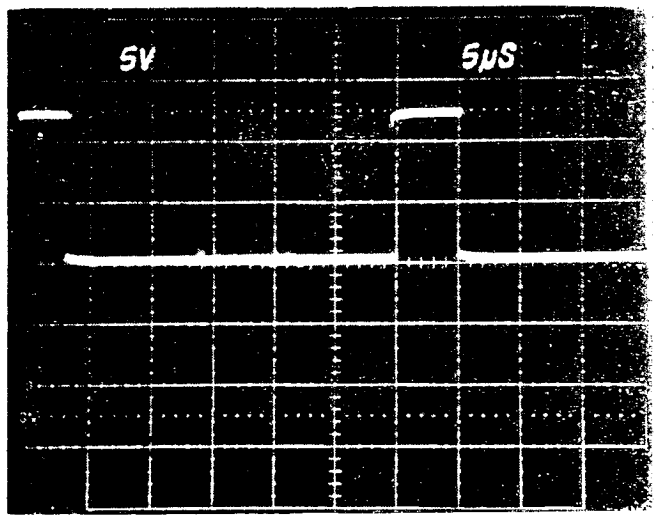


5 KEY BLEND 2



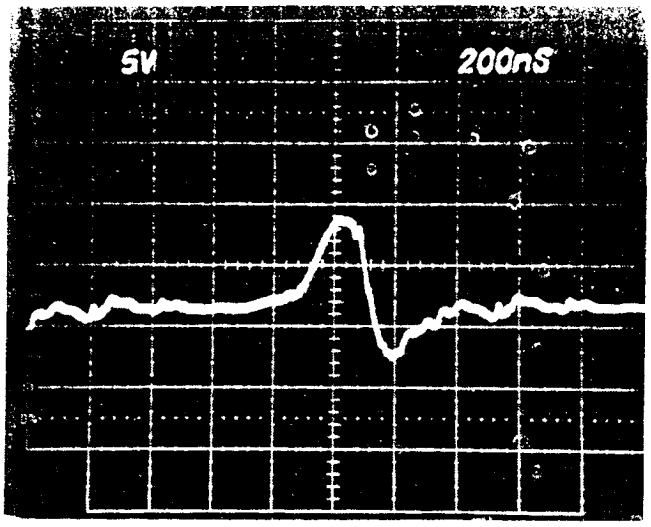
0V

6 KEY BLEND 3

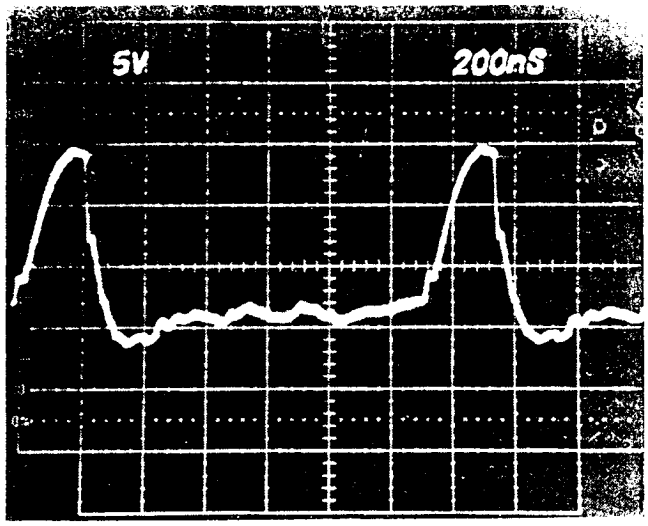


7 KEY SPRAY COAG

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OV



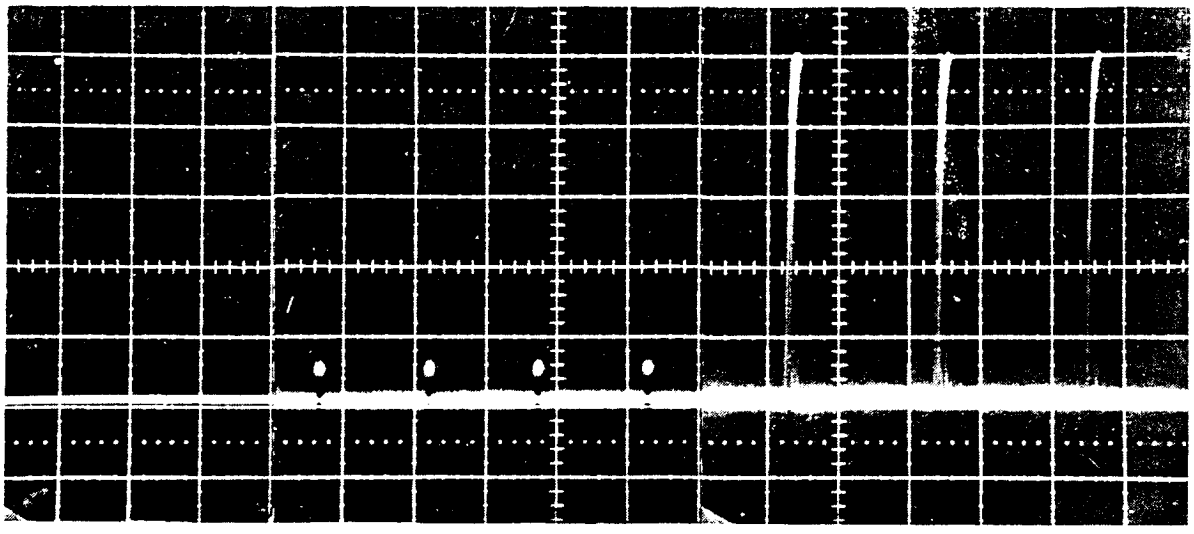
8A KEY PURE CUT

SIGNAL T/ON
DRIVER BOARD PIN 10
(SEE FIGURE 34)

8B KEY PURE CUT

SIGNAL T/OFF
DRIVER BOARD PIN 9
(SEE FIGURE 34)

CONTROL SETTING 150 WATTS
300 OHM LOAD



OV

SSE4 NOT ACTIVATED
IN CUT, COAG, OR
BIPOLAR

SSE4 ACTIVATED
WITH RF OUTPUT
(ANY MODE)

SSE4 ACTIVATED
WITH NO RF OUTPUT
(ANY MODE)

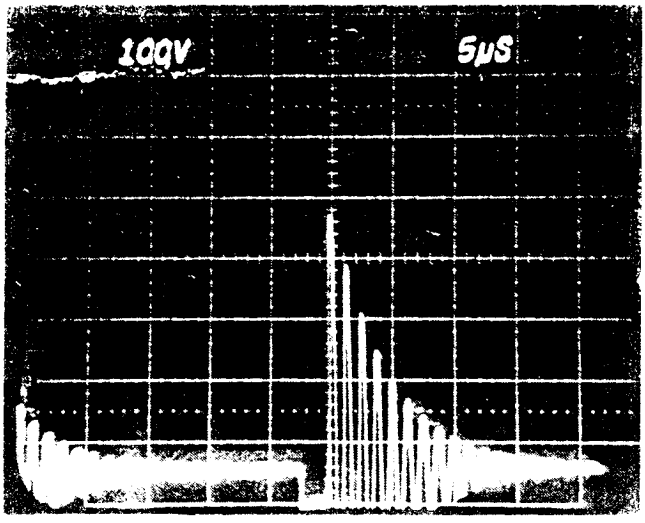
9 LAMP ENABLE

1V/div, .5mS/div

CPU BOARD U403, PIN 5

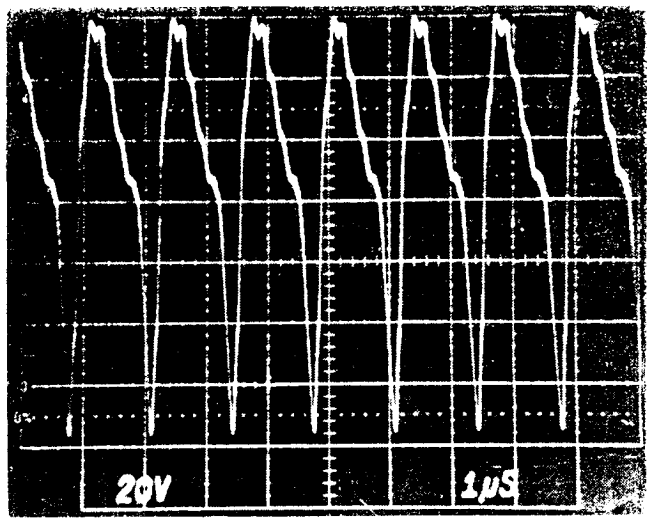
(SEE FIG. 19)

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10 KEY LOAD

SIGNAL COLLECTOR
BASELINE BOARD
KEY OR FOOTSWITCH
(SEE FIGURE 35)
CONTROL SETTING



11 KEY PUR

SIGNAL COLLECTOR
BASELINE BOARD
KEY OR FOOTSWITCH
(SEE FIGURE 35)
CONTROL SETTING

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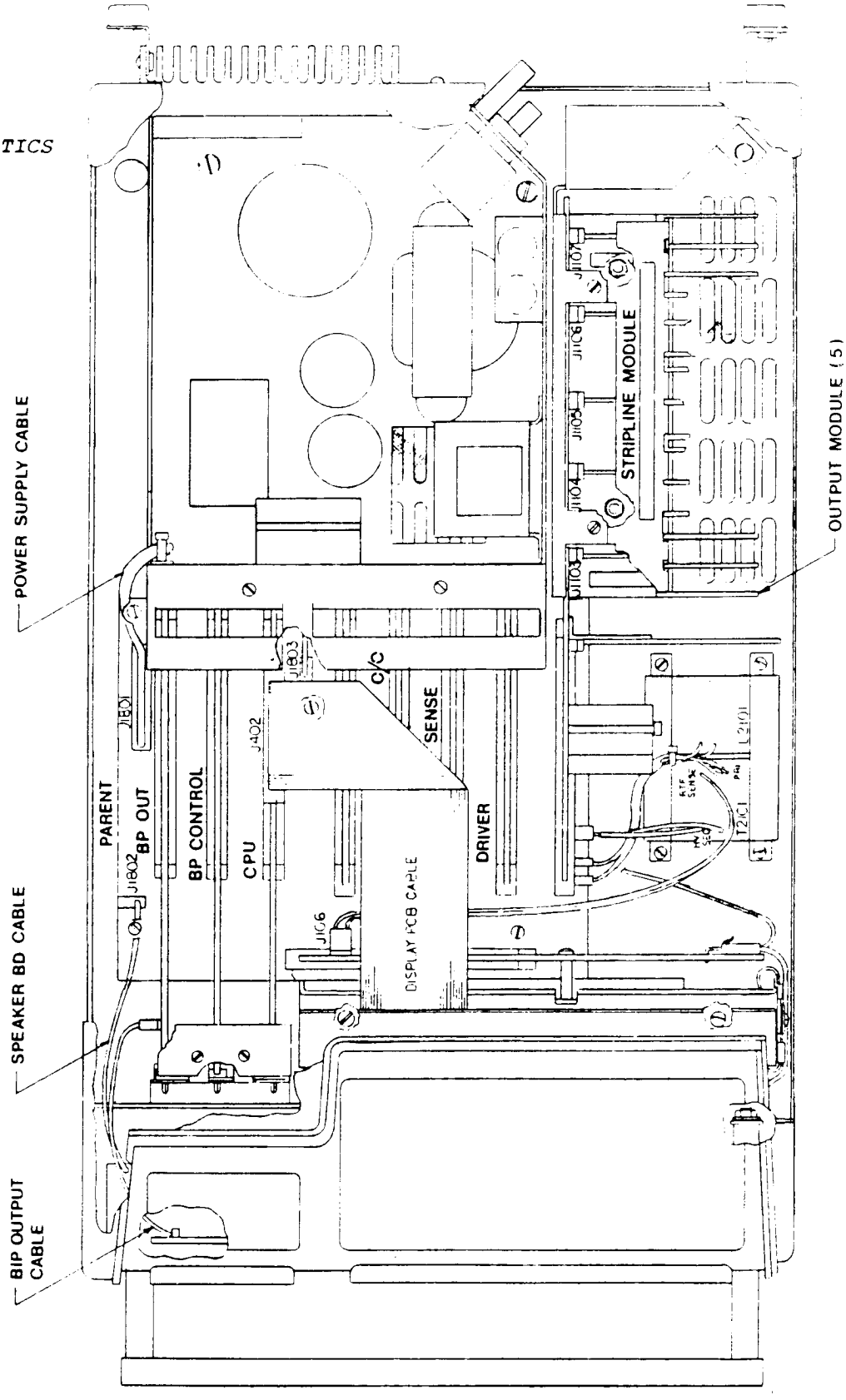


FIGURE 15

FORCE 4 COMPONENT/CONNECTOR LOCATIONS - TOP VIEW

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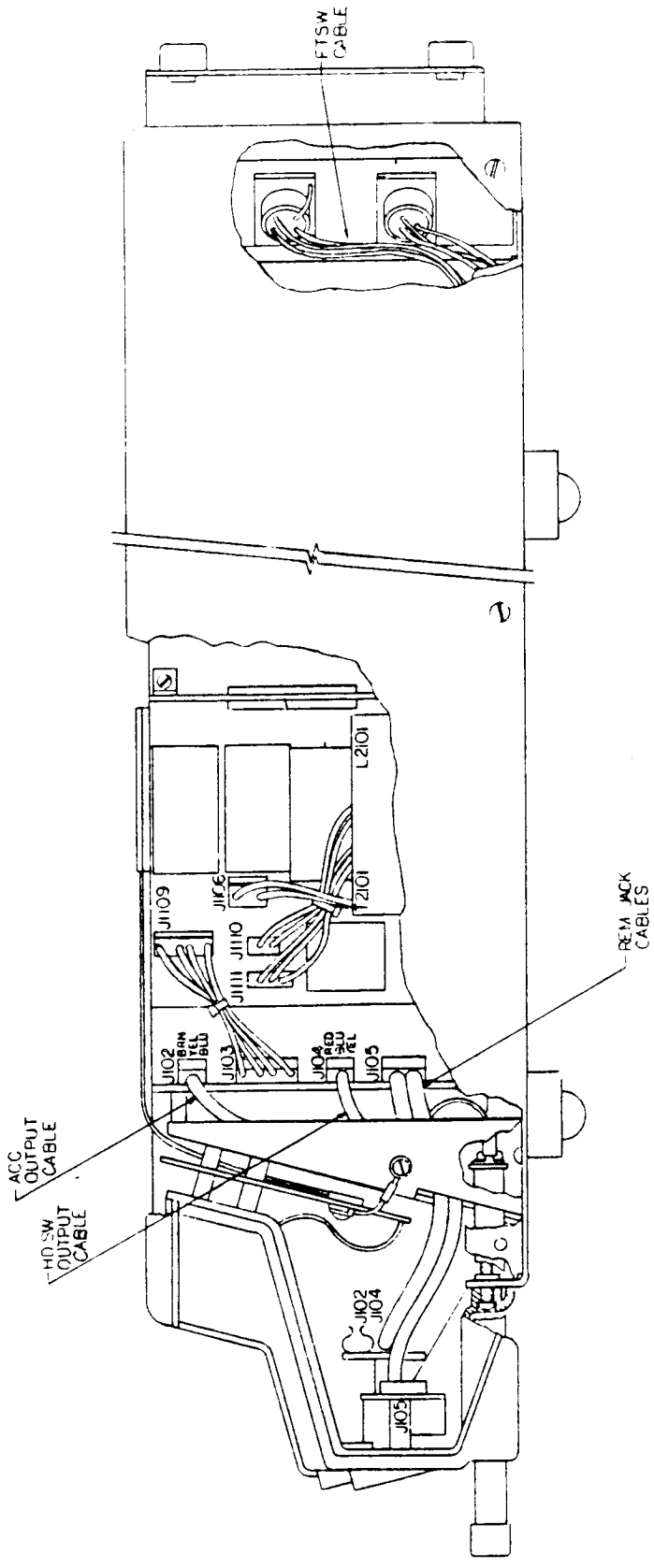


FIGURE 16

FORCE 4 COMPONENT/CONNECTOR LOCATIONS - SIDE VIEW

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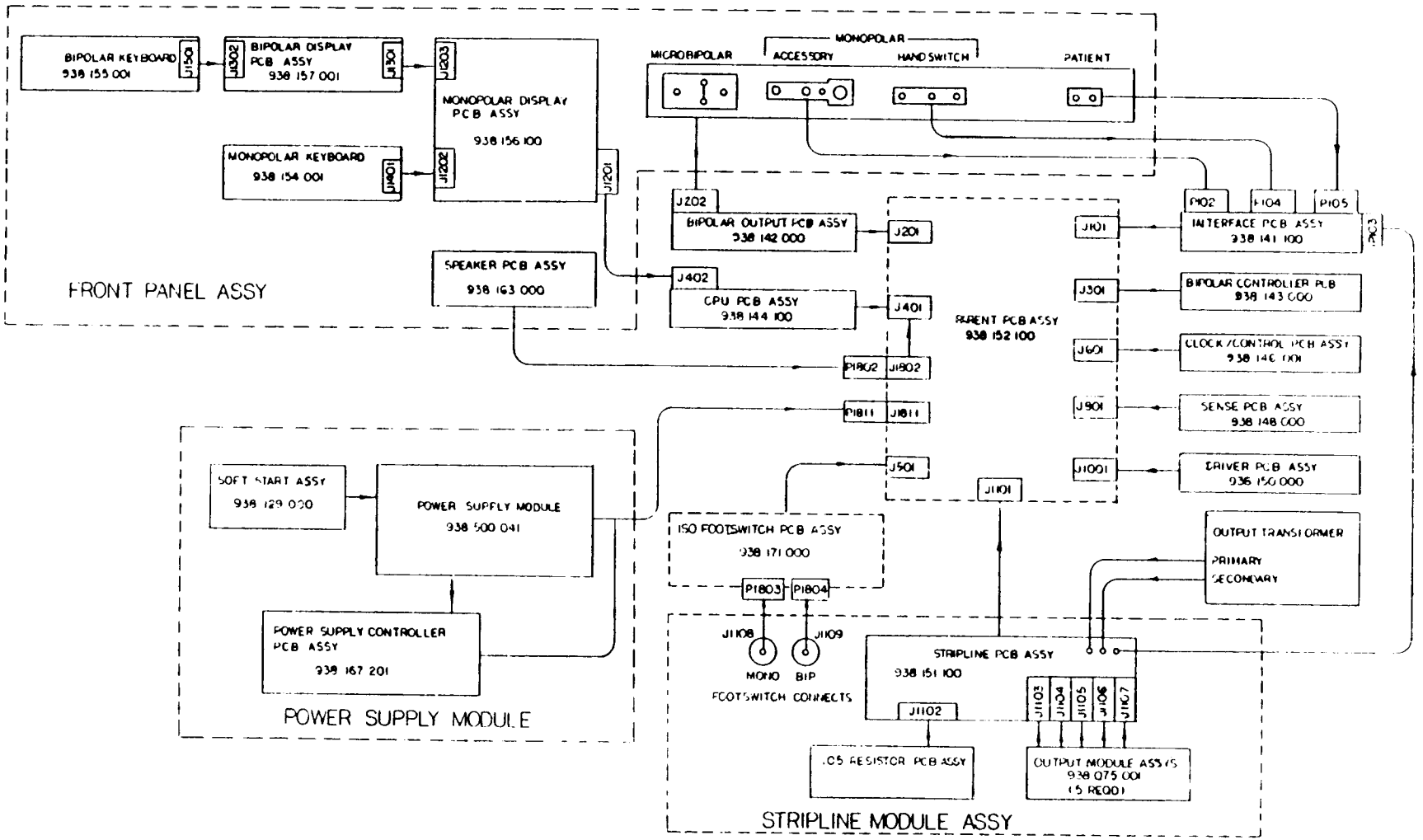


FIGURE 17

SYSTEM INTERCONNECT SCHEMATIC

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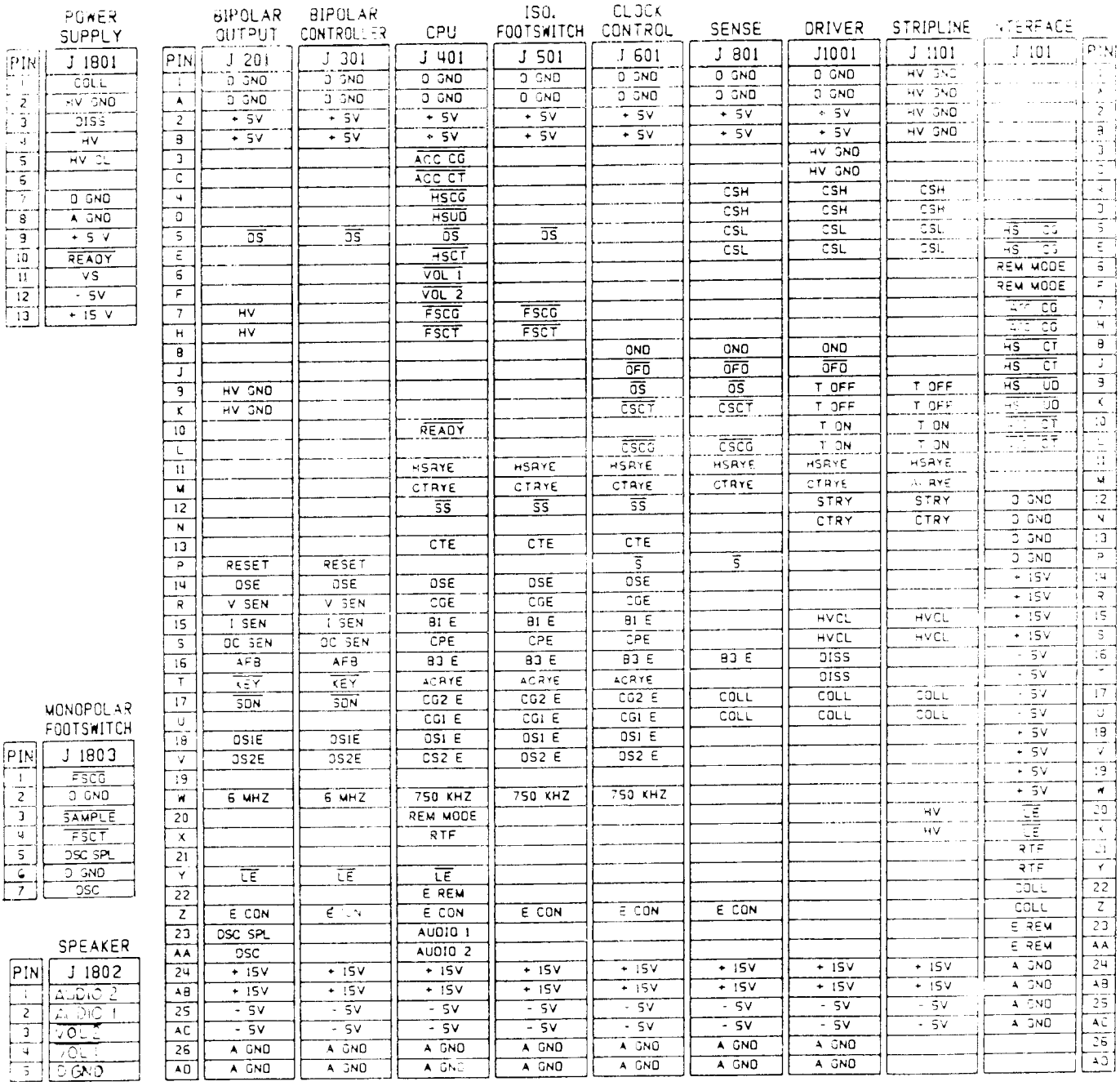


FIGURE 18

PCB INTERCONNECT LIST

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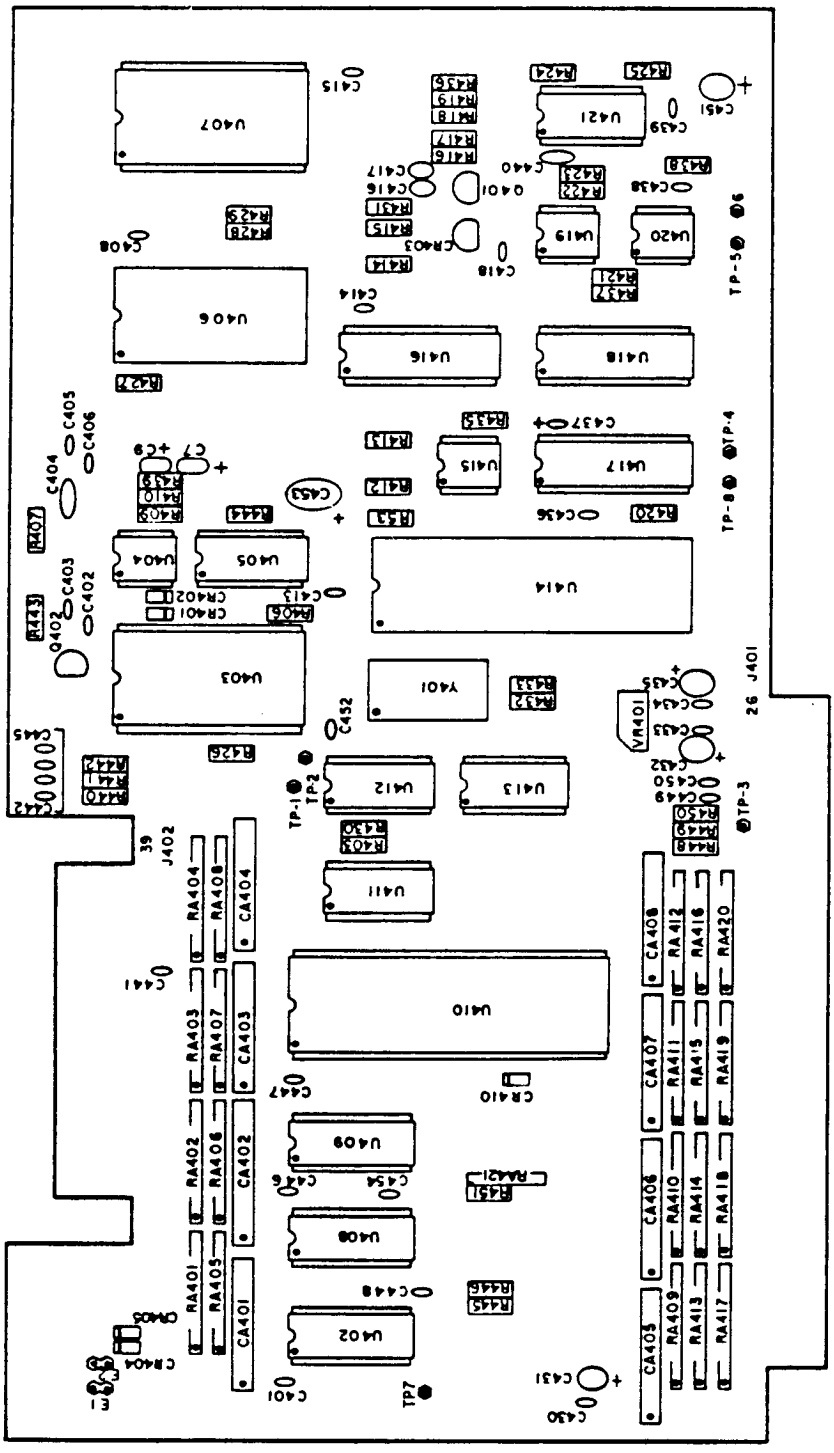
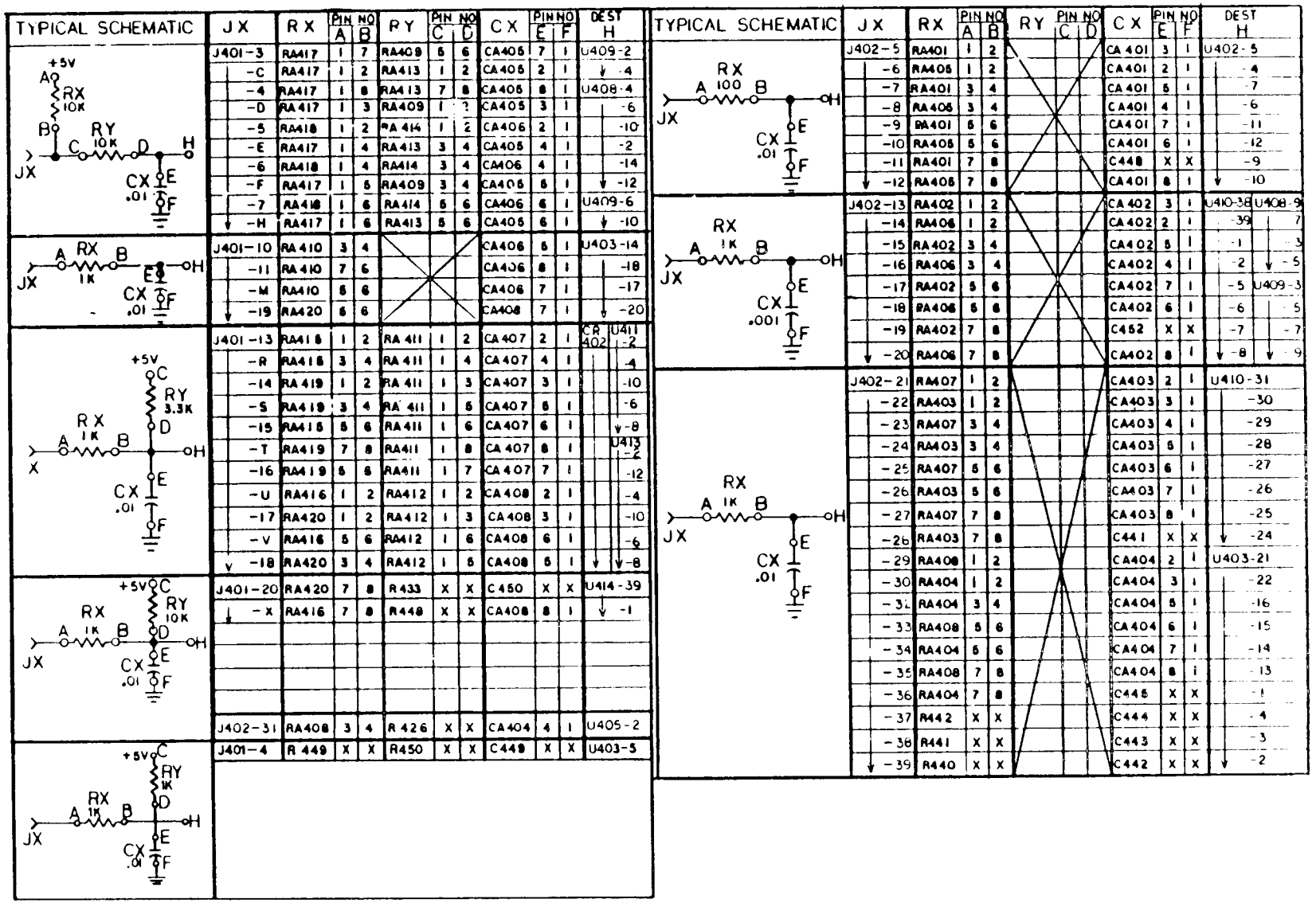


FIGURE 19

CPU BOARD

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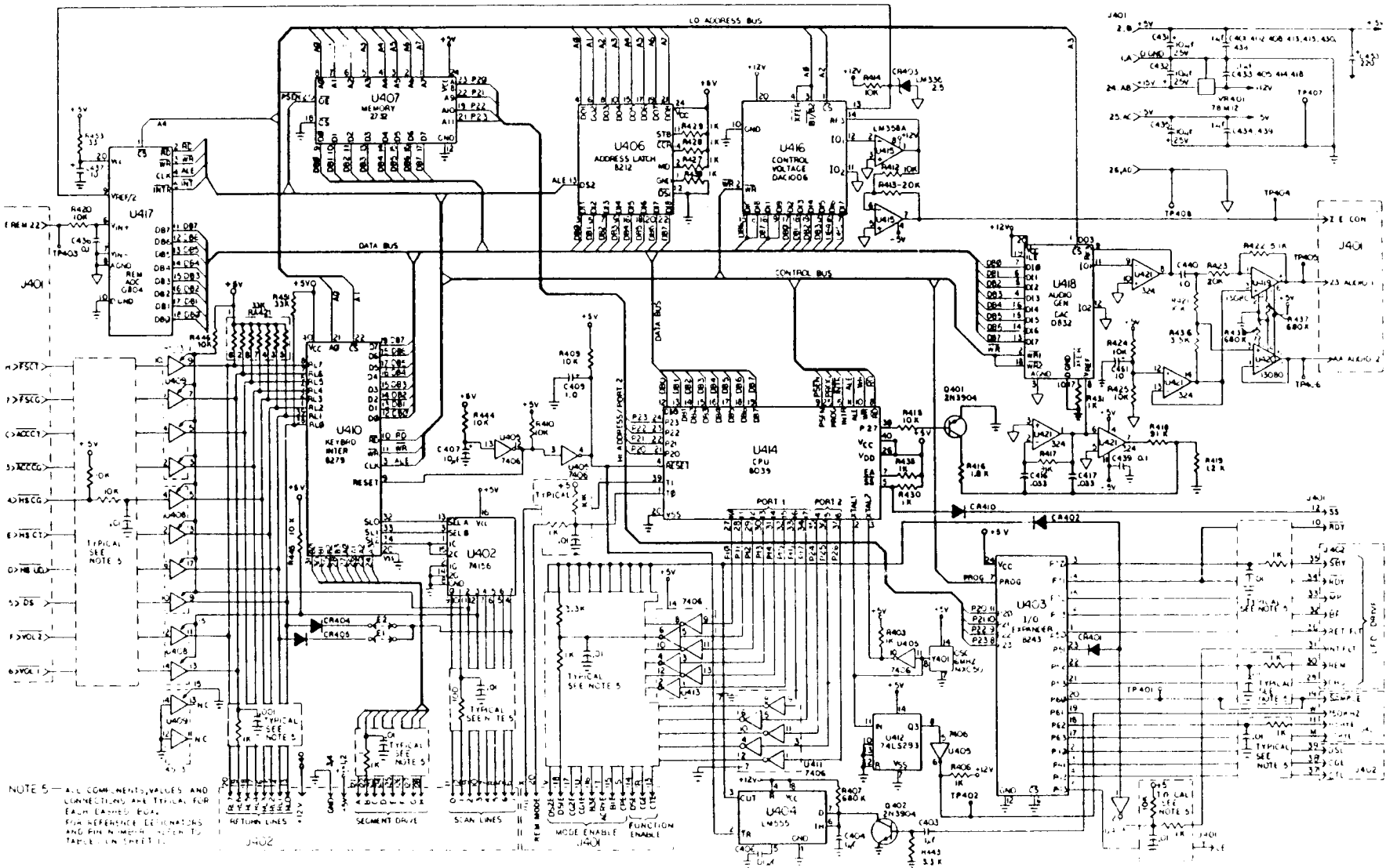
TYPICAL SCHEMATIC	JX	RX	PIN NO A	PIN NO B	RY	PIN NO C	PIN NO D	CX	PIN NO E	PIN NO F	DEST H
+5V, RX 10K, RY 10K, CX .01	J401-3	RA417	1	7	RA409	5	6	CA405	7	1	U409-2
	-C	RA417	1	2	RA413	1	2	CA405	2	1	-4
	-4	RA417	1	8	RA413	7	8	CA405	8	1	U408-4
	-D	RA417	1	3	RA409	1	7	CA405	3	1	-6
	-5	RA418	1	2	RA414	1	2	CA406	2	1	-10
	-E	RA417	1	4	RA413	3	4	CA405	4	1	-2
	-6	RA418	1	4	RA414	3	4	CA406	4	1	-14
	-F	RA417	1	5	RA409	3	4	CA405	5	1	-12
	-7	RA418	1	6	RA414	5	6	CA406	6	1	U409-6
	-H	RA417	1	6	RA413	5	6	CA405	6	1	-10
RX 1K, CX .01	J401-10	RA410	3	4				CA406	5	1	U403-14
	-11	RA410	7	6				CA406	8	1	-18
	-M	RA410	5	6				CA406	7	1	-17
	-19	RA420	5	6				CA408	7	1	-20
+5V, RY 3.3K, RX 1K, CX .01	J401-13	RA418	1	2	RA411	1	2	CA407	2	1	CR402 U411-2
	-R	RA418	3	4	RA411	1	4	CA407	4	1	-4
	-14	RA419	1	2	RA411	1	3	CA407	3	1	-10
	-S	RA419	3	4	RA411	1	5	CA407	5	1	-6
	-15	RA418	5	6	RA411	1	6	CA407	6	1	-8
	-T	RA419	7	8	RA411	1	8	CA407	8	1	U413-2
	-16	RA419	5	6	RA411	1	7	CA407	7	1	-12
	-U	RA416	1	2	RA412	1	2	CA408	2	1	-4
	-17	RA420	1	2	RA412	1	3	CA408	3	1	-10
	-V	RA416	5	6	RA412	1	6	CA408	6	1	-6
	-18	RA420	3	4	RA412	1	5	CA408	5	1	-8
+5V, RY 10K, RX 1K, CX .01	J401-20	RA420	7	8	R433	X	X	C450	X	X	U414-39
	-X	RA416	7	8	R448	X	X	CA408	8	1	-1
	J402-31	RA408	3	4	R426	X	X	CA404	4	1	U405-2
+5V, RY 1K, RX 1K, CX .01	J401-4	R449	X	X	R450	X	X	C449	X	X	U403-5

TYPICAL SCHEMATIC	JX	RX	PIN NO A	PIN NO B	RY	PIN NO C	PIN NO D	CX	PIN NO E	PIN NO F	DEST H
RX 100, CX .01	J402-5	RA401	1	2				CA401	3	1	U402-5
	-6	RA408	1	2				CA401	2	1	-4
	-7	RA401	3	4				CA401	5	1	-7
	-8	RA408	3	4				CA401	4	1	-6
	-9	RA401	5	6				CA401	7	1	-11
	-10	RA408	5	6				CA401	6	1	-12
	-11	RA401	7	8				C448	X	X	-9
	-12	RA408	7	8				CA401	8	1	-10
RX 1K, CX .001	J402-13	RA402	1	2				CA402	3	1	U410-38 U408-9
	-14	RA406	1	2				CA402	2	1	-39 7
	-15	RA402	3	4				CA402	5	1	-1 3
	-16	RA406	3	4				CA402	4	1	-2 -5
	-17	RA402	5	6				CA402	7	1	-5 U409-3
	-18	RA406	5	6				CA402	6	1	-6 5
	-19	RA402	7	8				C452	X	X	-7 -7
	-20	RA406	7	8				CA402	8	1	-8 -9
RX 1K, CX .01	J402-21	RA407	1	2				CA403	2	1	U410-31
	-22	RA403	1	2				CA403	3	1	-30
	-23	RA407	3	4				CA403	4	1	-29
	-24	RA403	3	4				CA403	5	1	-28
	-25	RA407	5	6				CA403	6	1	-27
	-26	RA403	5	6				CA403	7	1	-26
	-27	RA407	7	8				CA403	8	1	-25
	-28	RA403	7	8				C441	X	X	-24
	-29	RA408	1	2				CA404	2	1	U403-21
	-30	RA404	1	2				CA404	3	1	-22
	-31	RA404	3	4				CA404	5	1	-16
	-33	RA408	5	6				CA404	6	1	-15
	-34	RA404	5	6				CA404	7	1	-14
	-35	RA408	7	8				CA404	8	1	-13
	-36	RA404	7	8				C445	X	X	-1
	-37	R442	X	X				C444	X	X	-4
	-38	R441	X	X				C443	X	X	-3
	-39	R440	X	X				C442	X	X	-2

FIGURE 20

CPU SCHEMATIC

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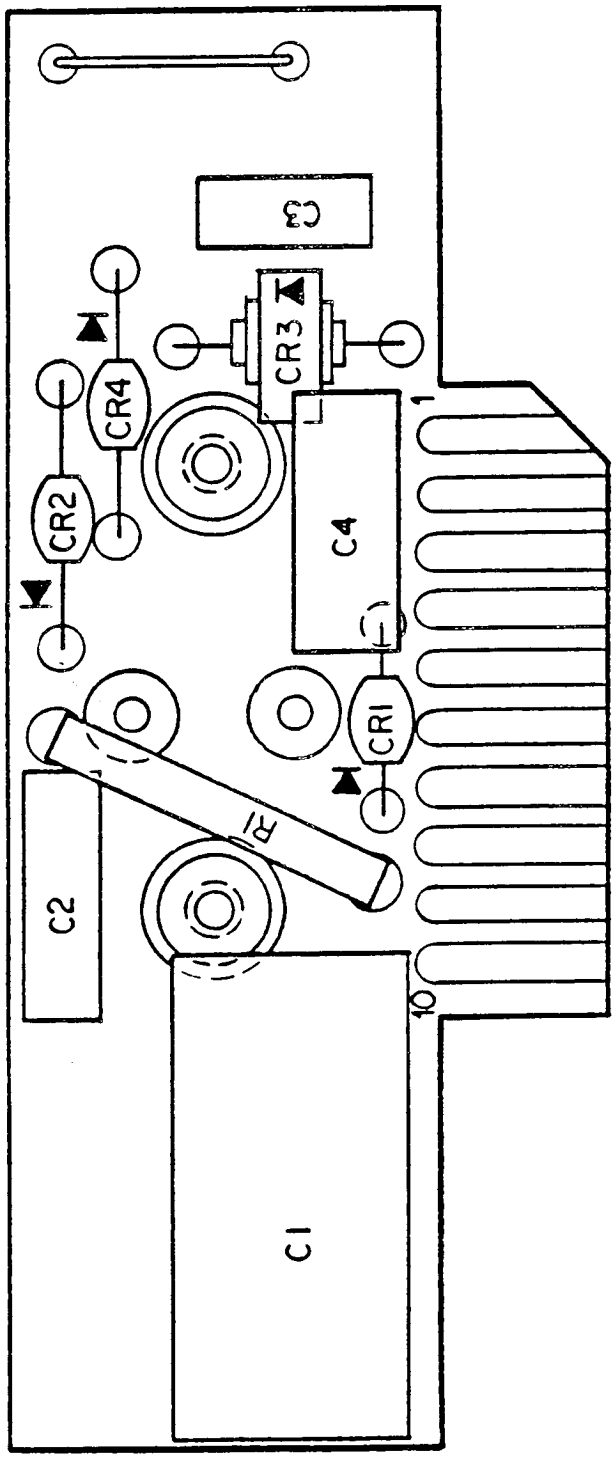


FIGURE 21

OUTPUT BOARD

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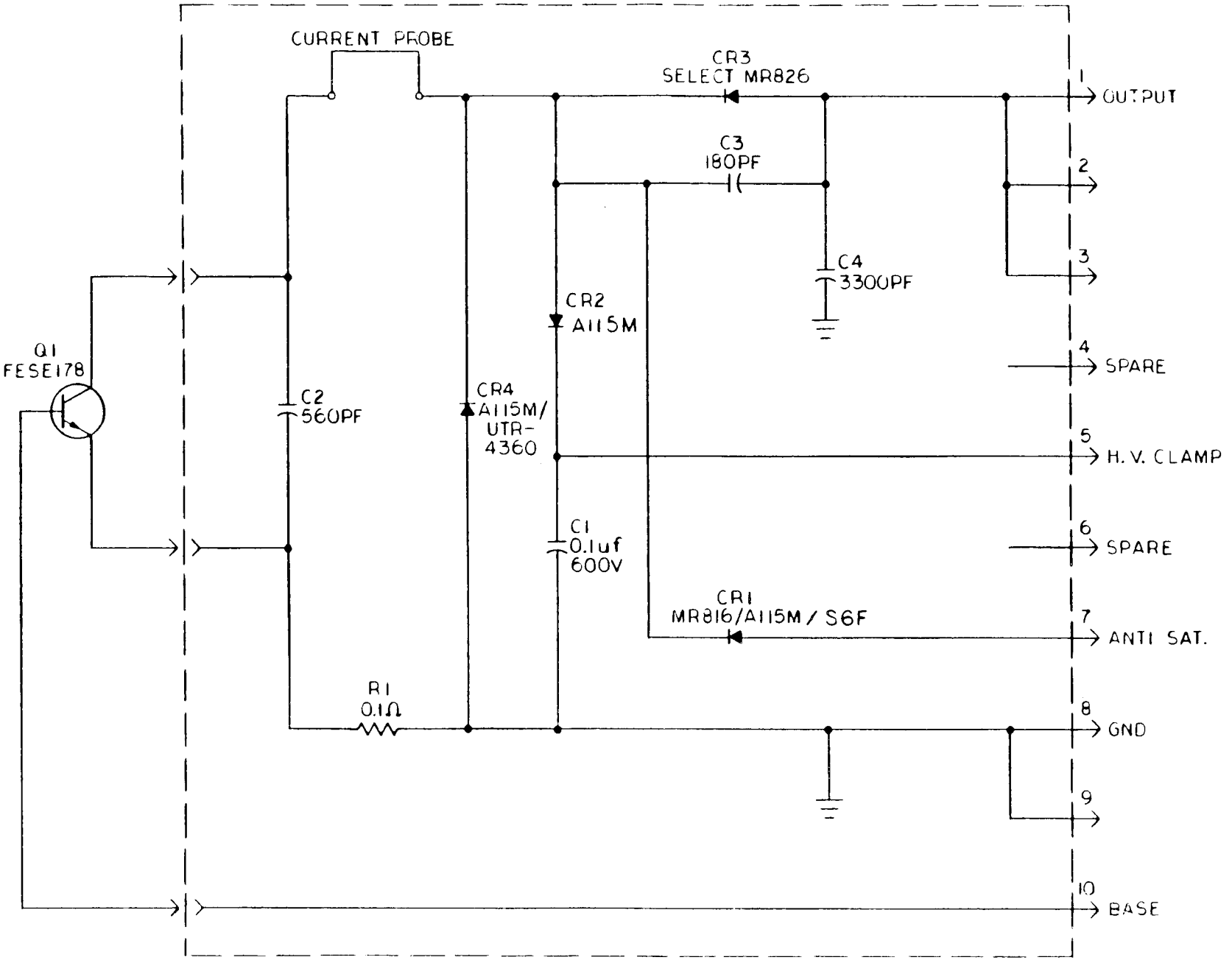


FIGURE 22

OUTPUT BOARD SCHEMATIC

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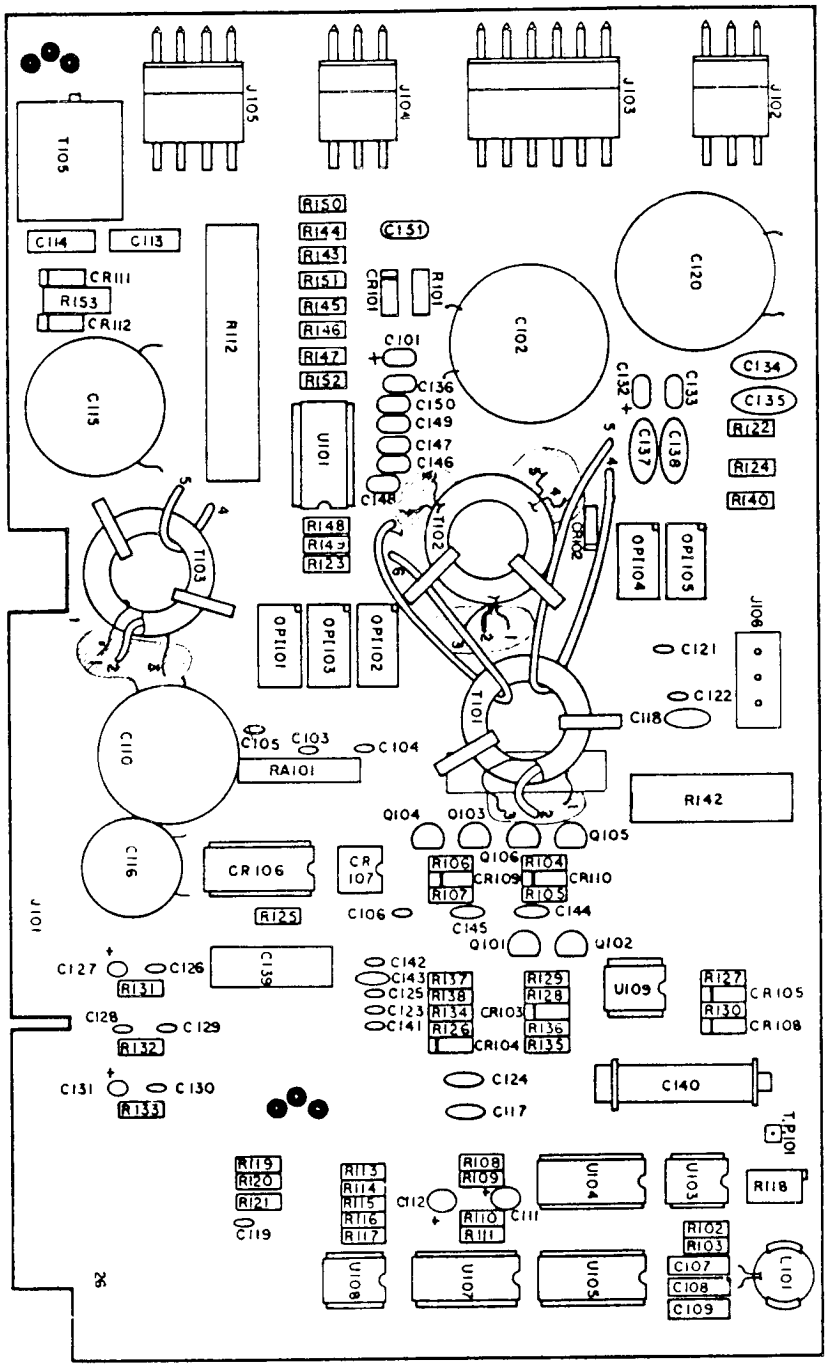


FIGURE 23

INTERFACE BOARD

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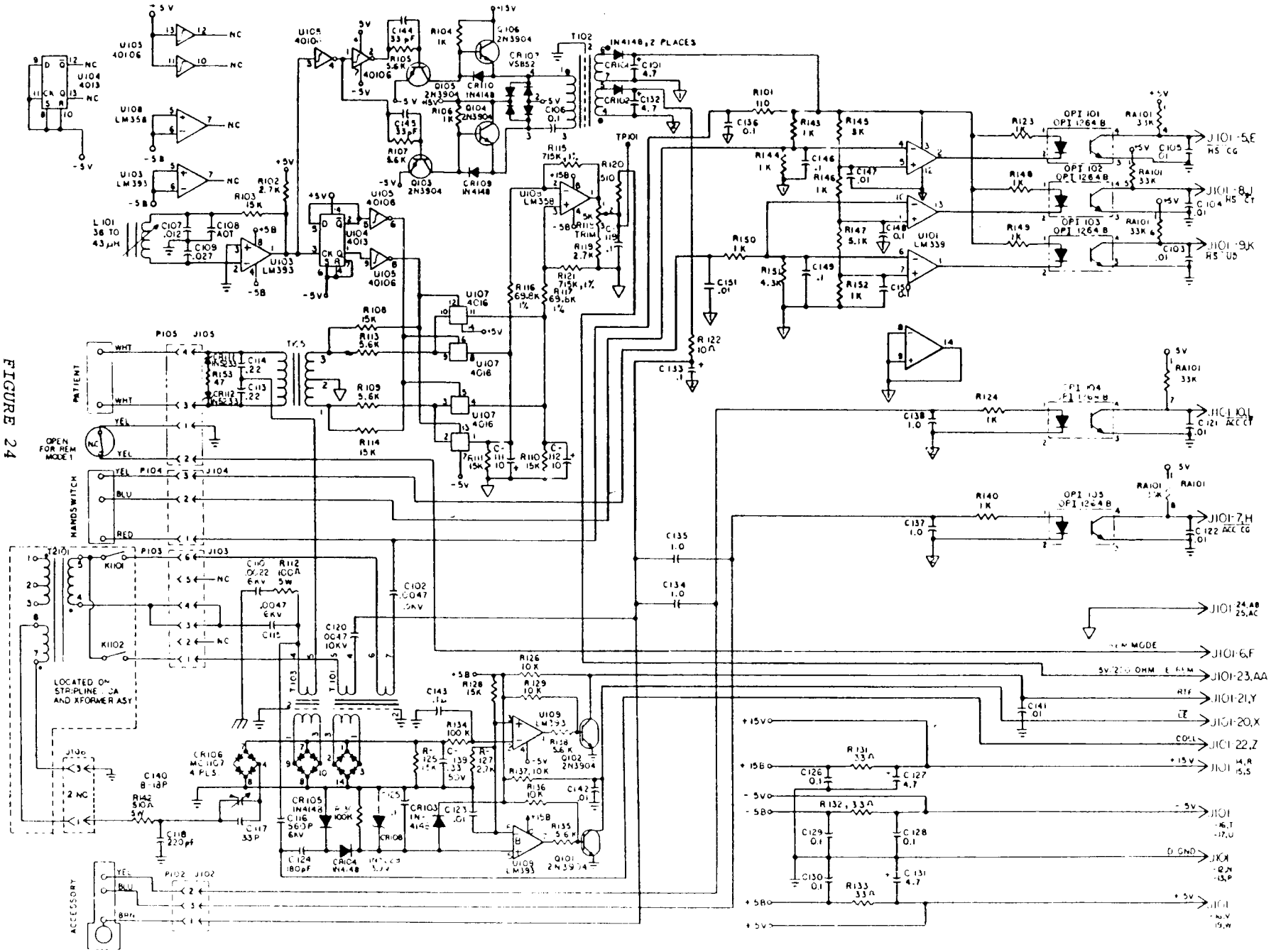


FIGURE 24 INTERFACE BOARD SCHEMATIC

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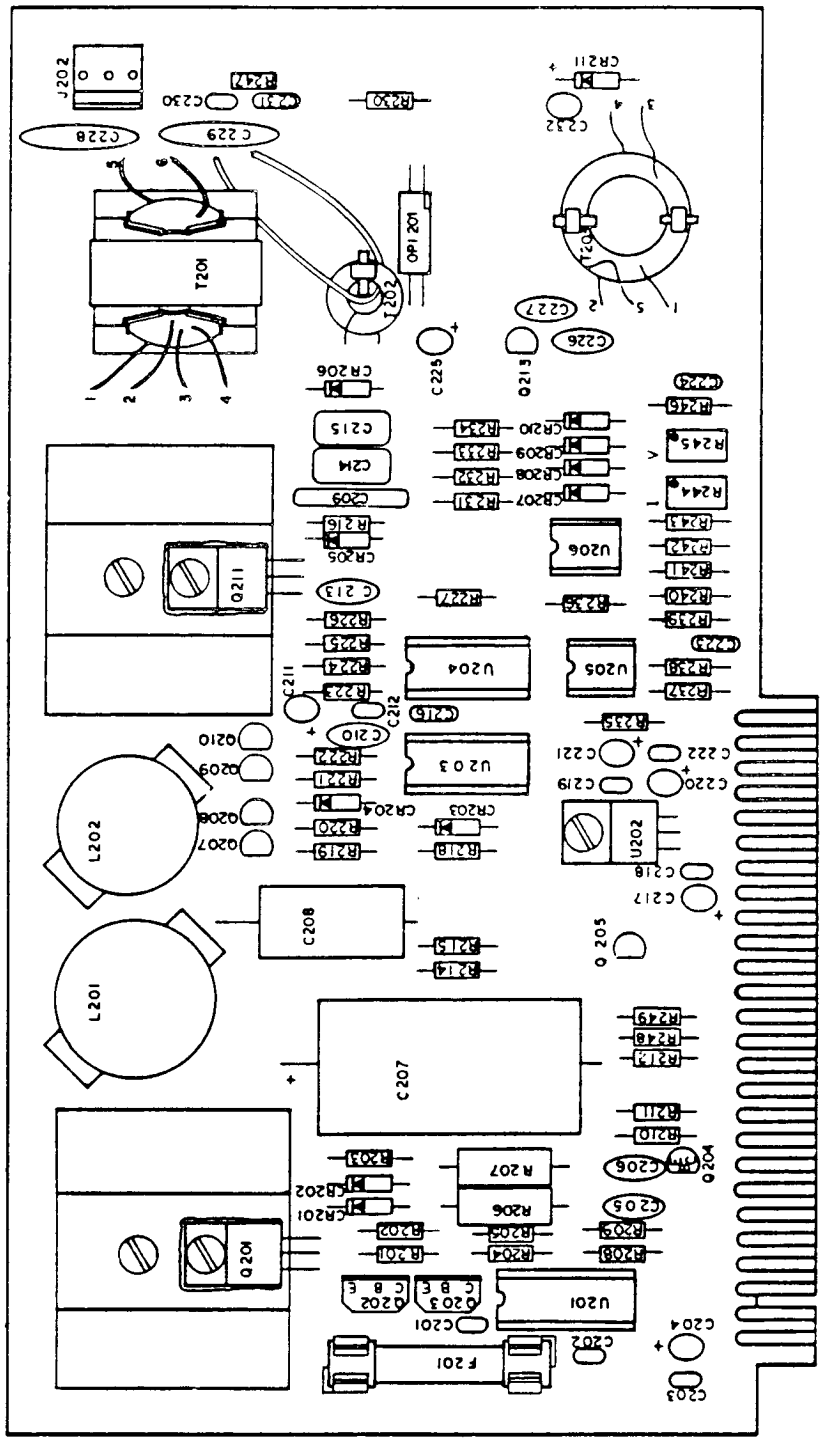


FIGURE 25

BIPOLAR OUTPUT BOARD

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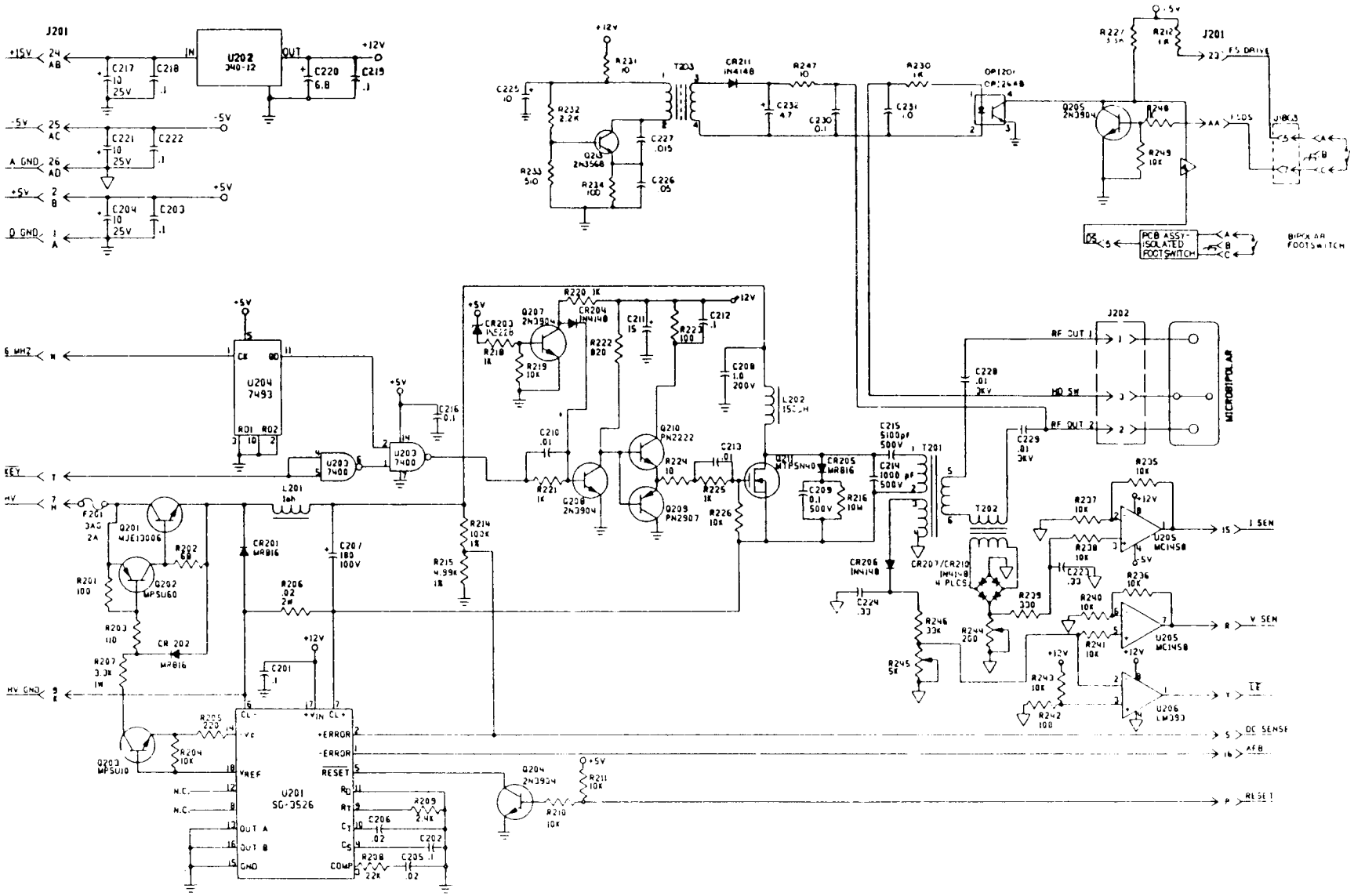


FIGURE 26

BIPOLAR OUTPUT BOARD SCHEMATIC

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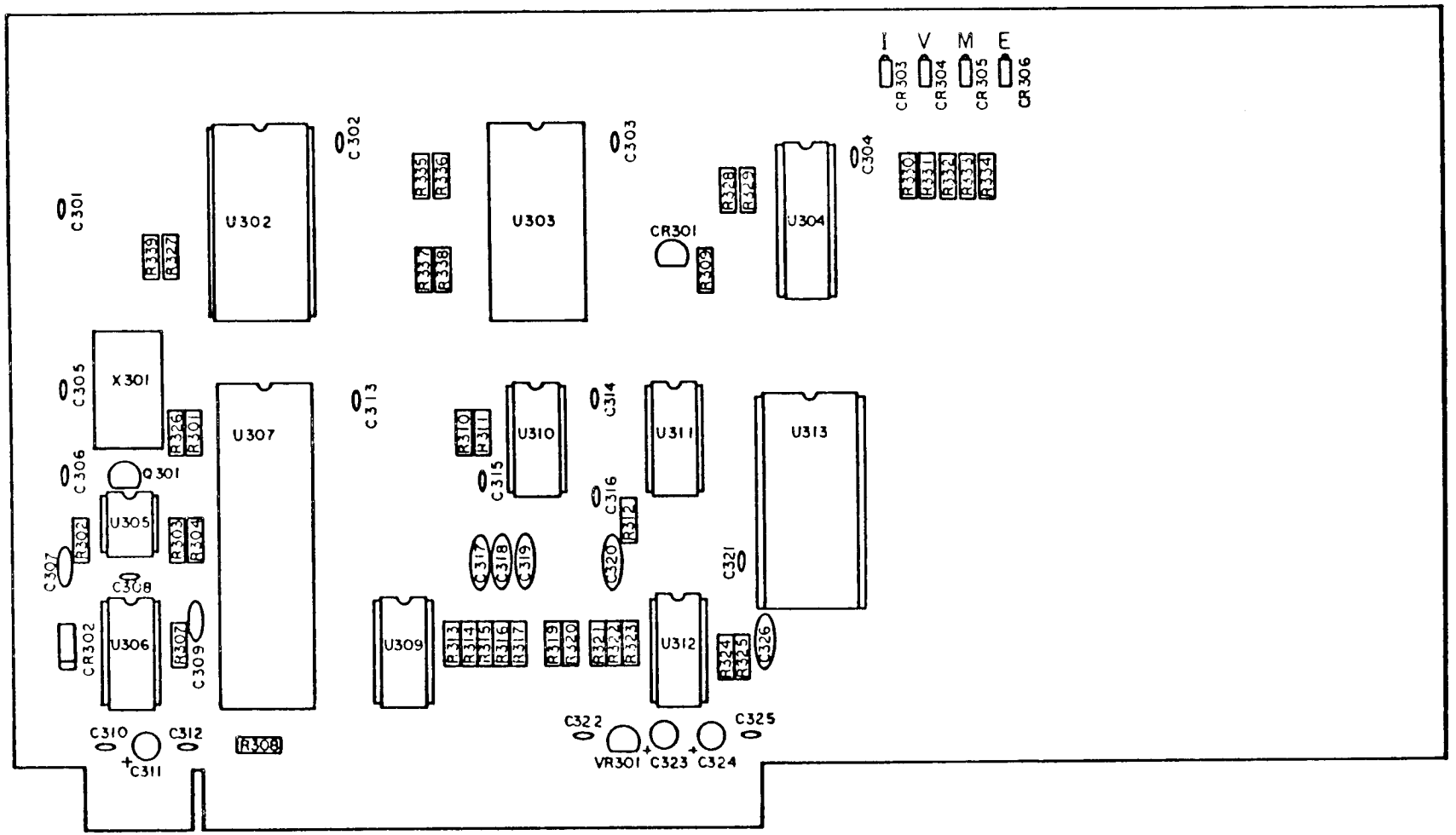


FIGURE 27

BIPOLAR CONTROLLER BOARD

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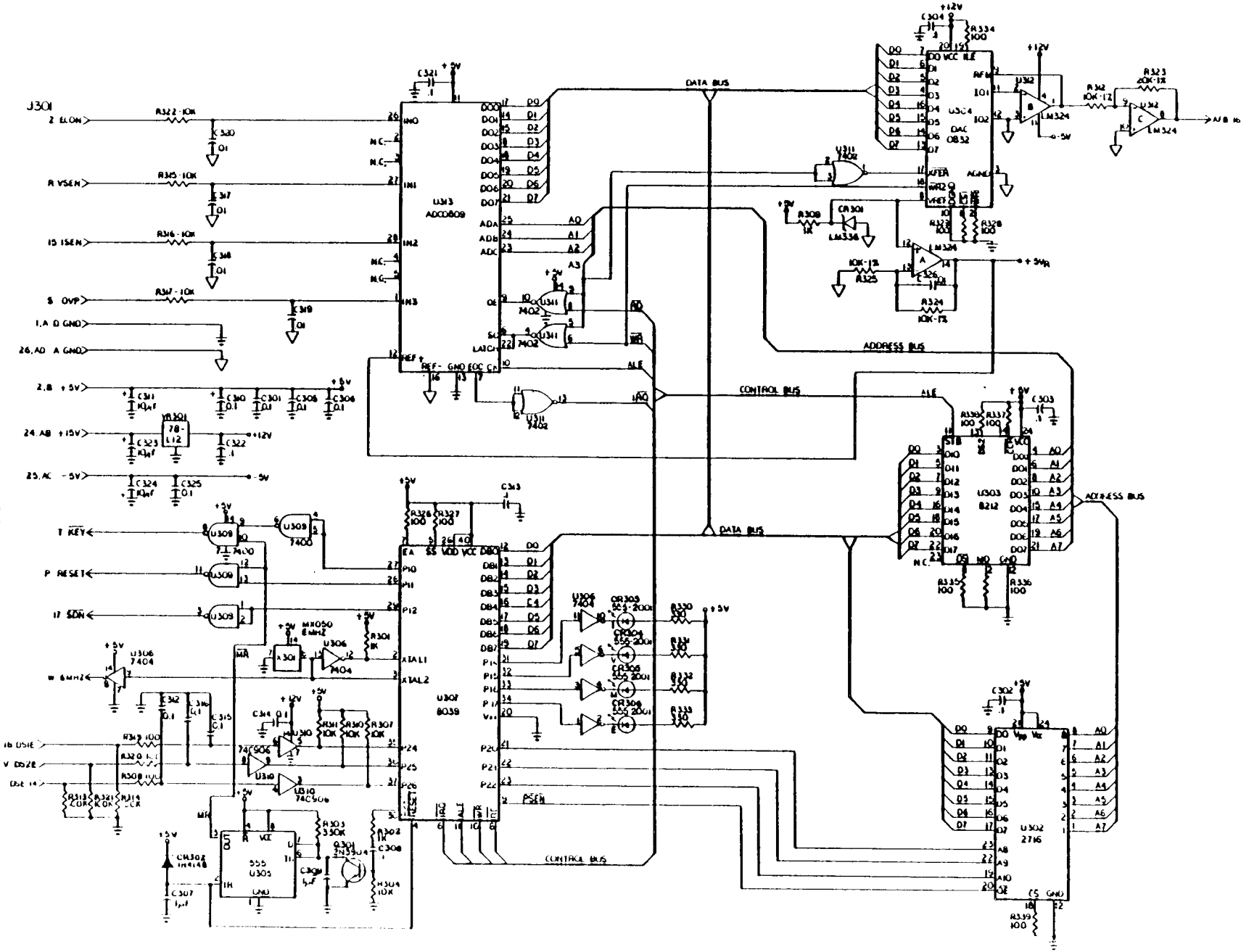


FIGURE 2.8 BIPOLAR CONTROLLER BOARD SCHEMATIC

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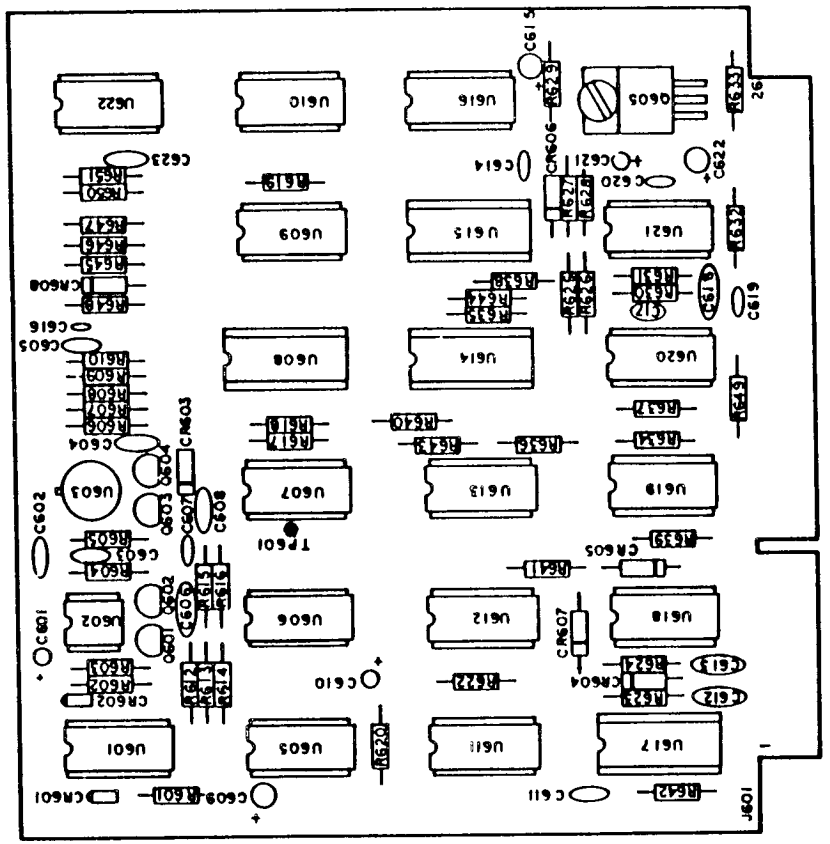


FIGURE 29

CLOCK/CONTROL BOARD

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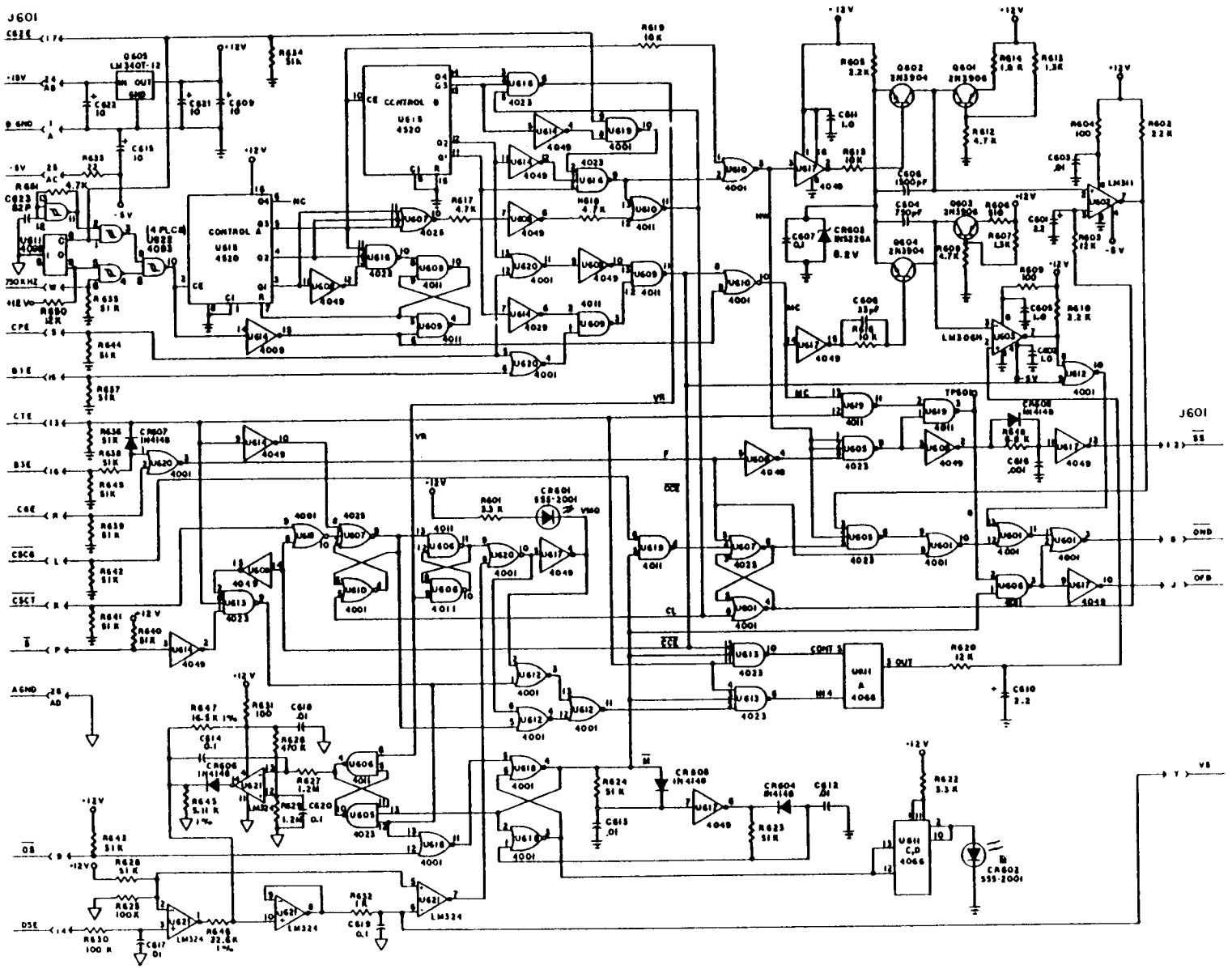


FIGURE 30

CLOCK/CONTROL BOARD SCHEMATIC

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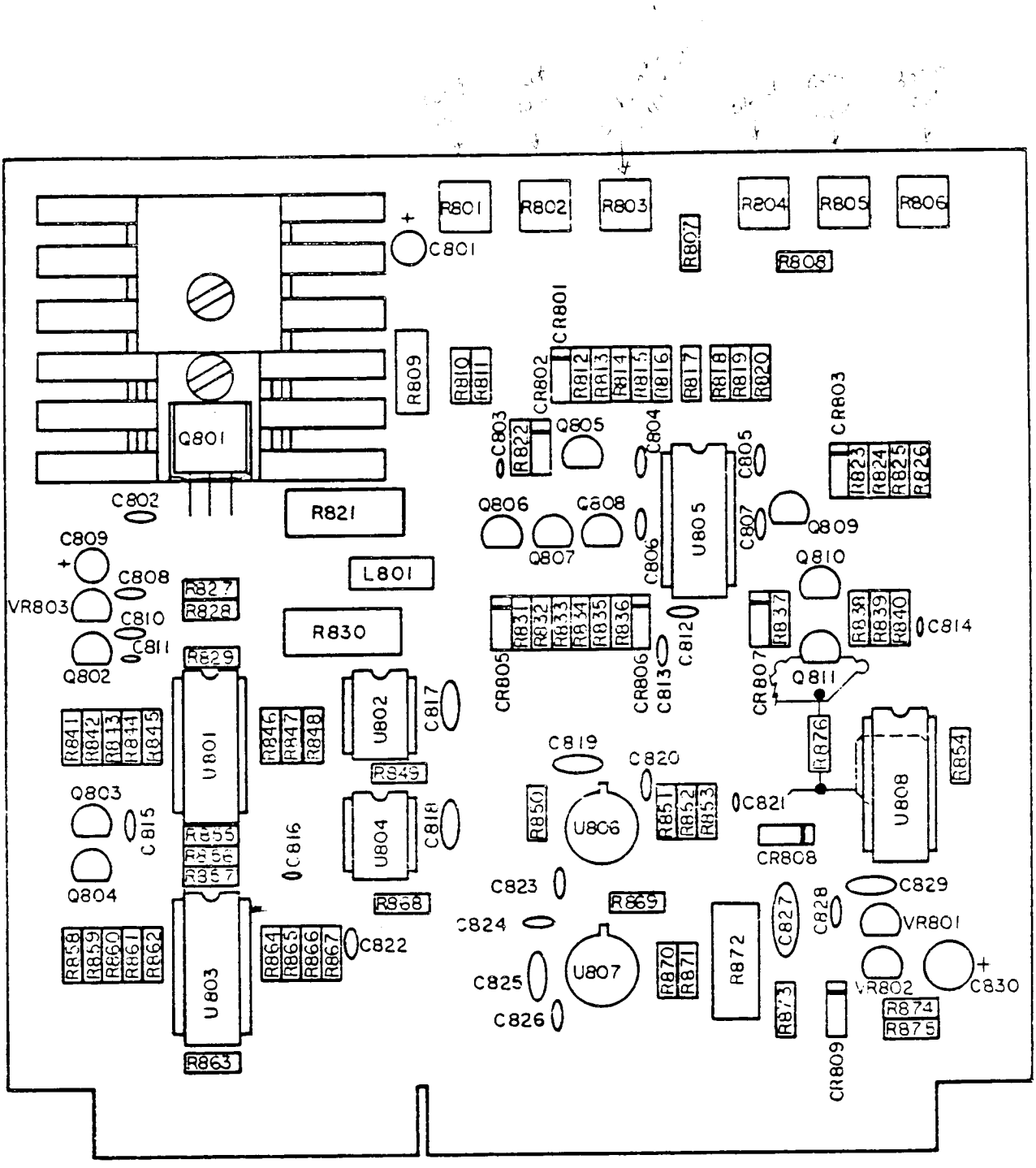


FIGURE 31

SENSE BOARD

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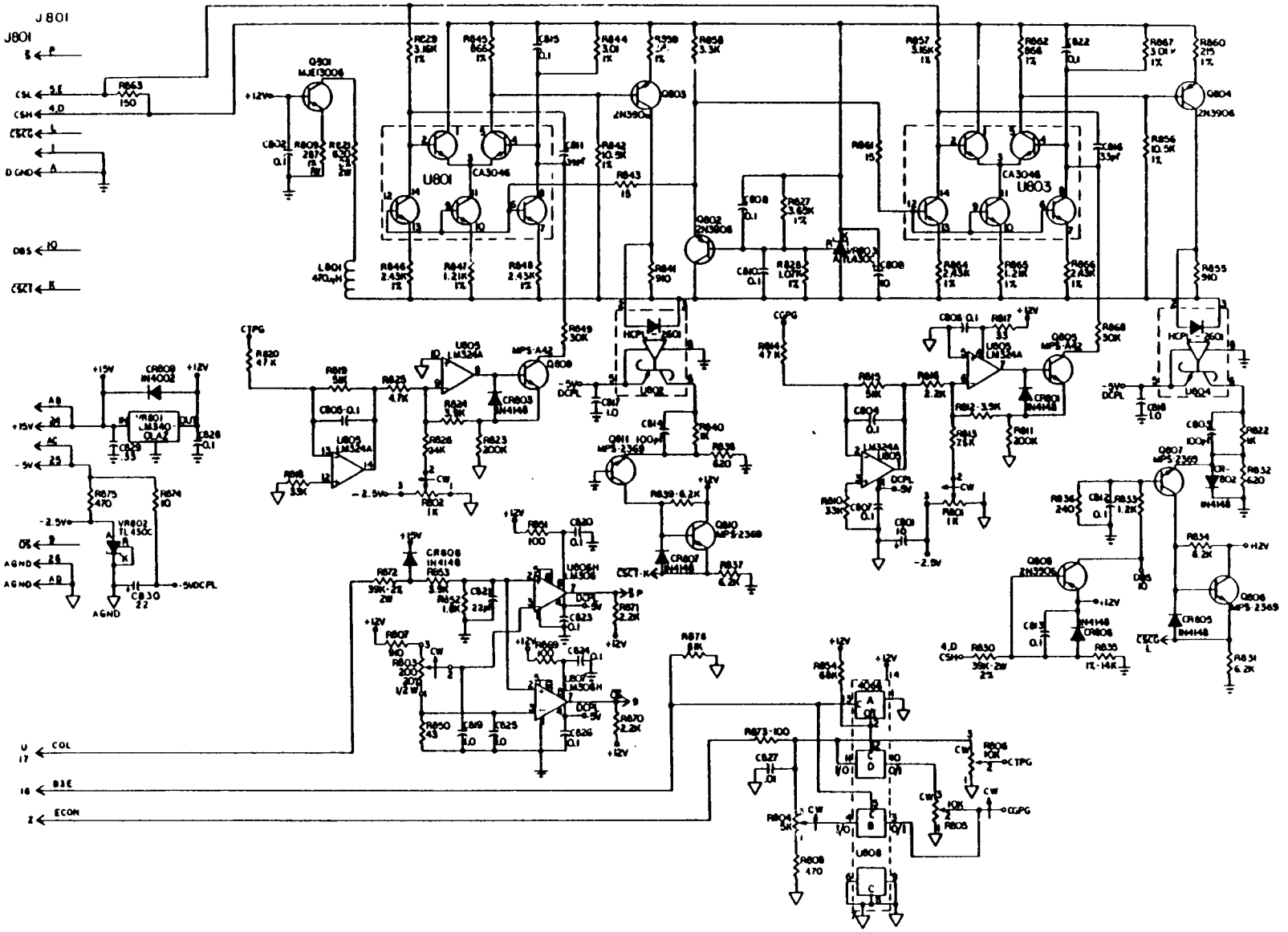


FIGURE 32

SENSE BOARD SCHEMATIC

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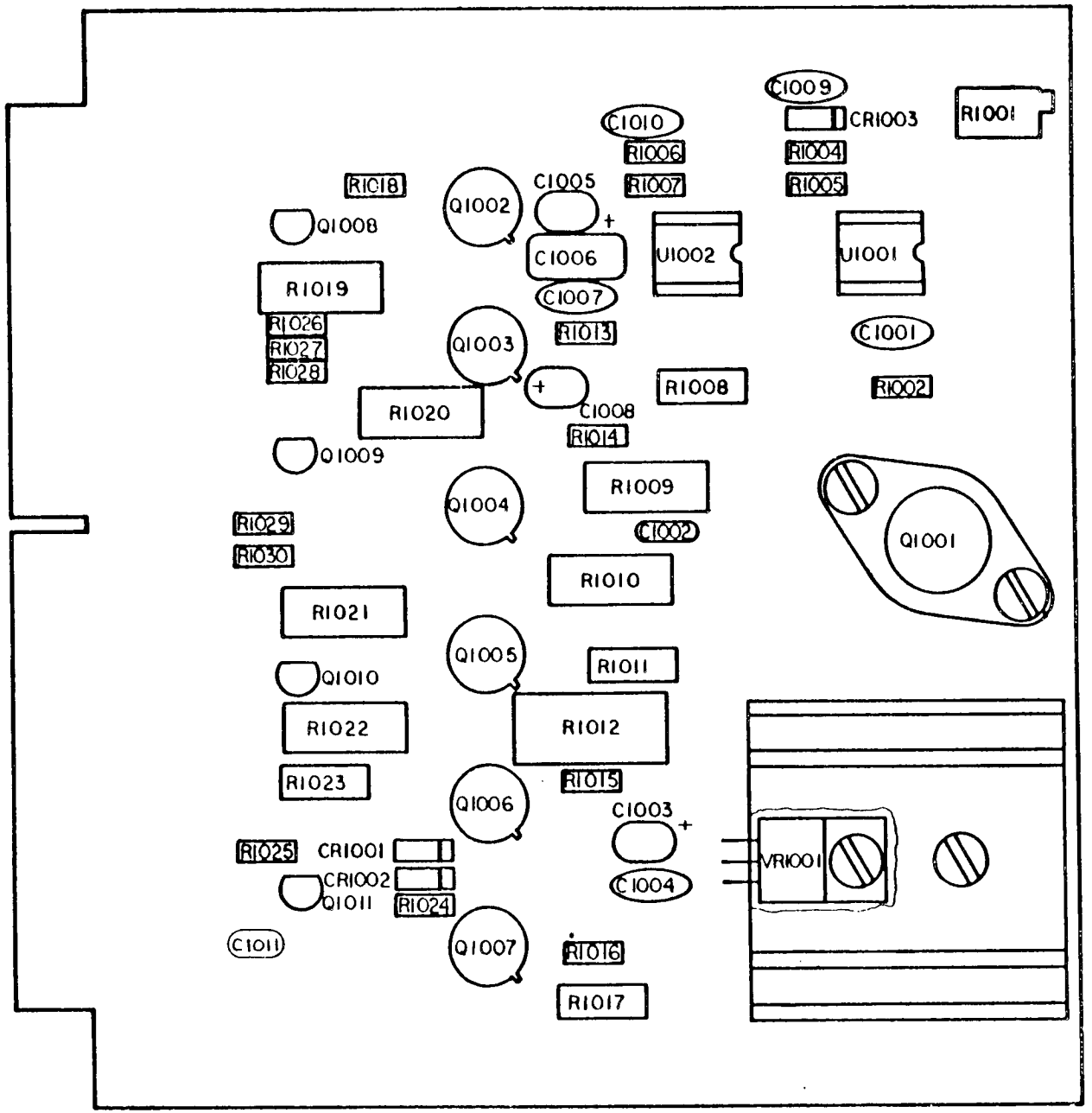


FIGURE 33

DRIVER BOARD

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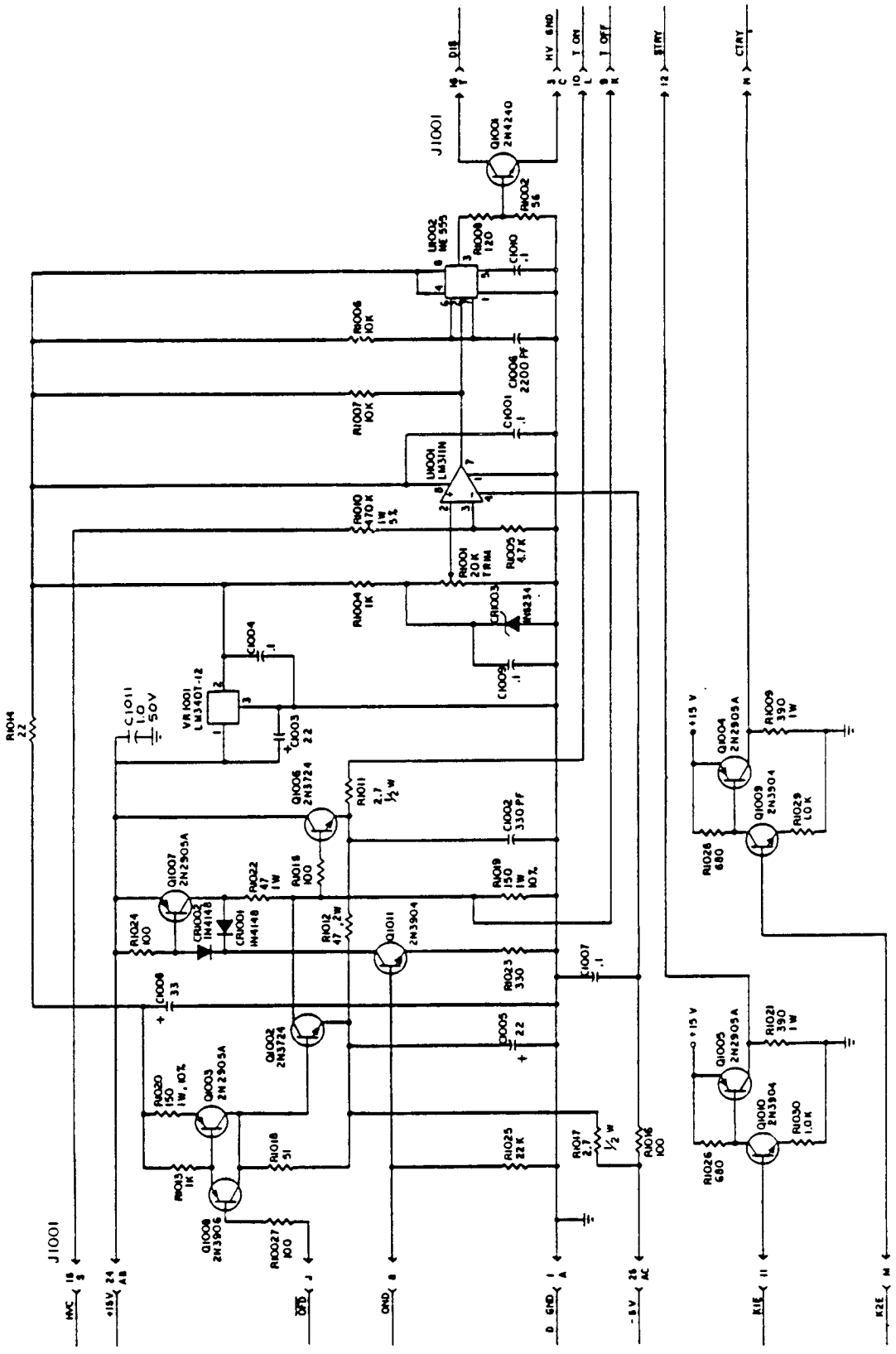


FIGURE 34

DRIVER BOARD SCHEMATIC

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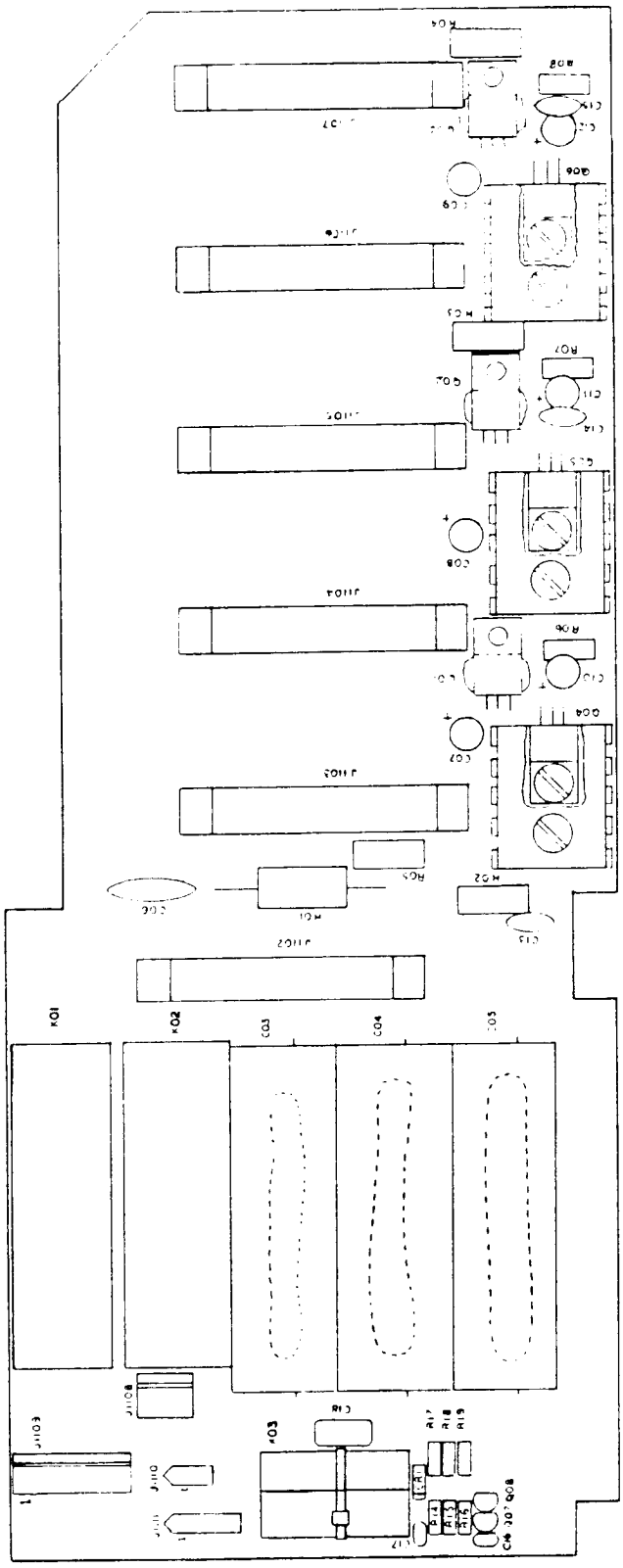


FIGURE 35

STRIPLINE BOARD

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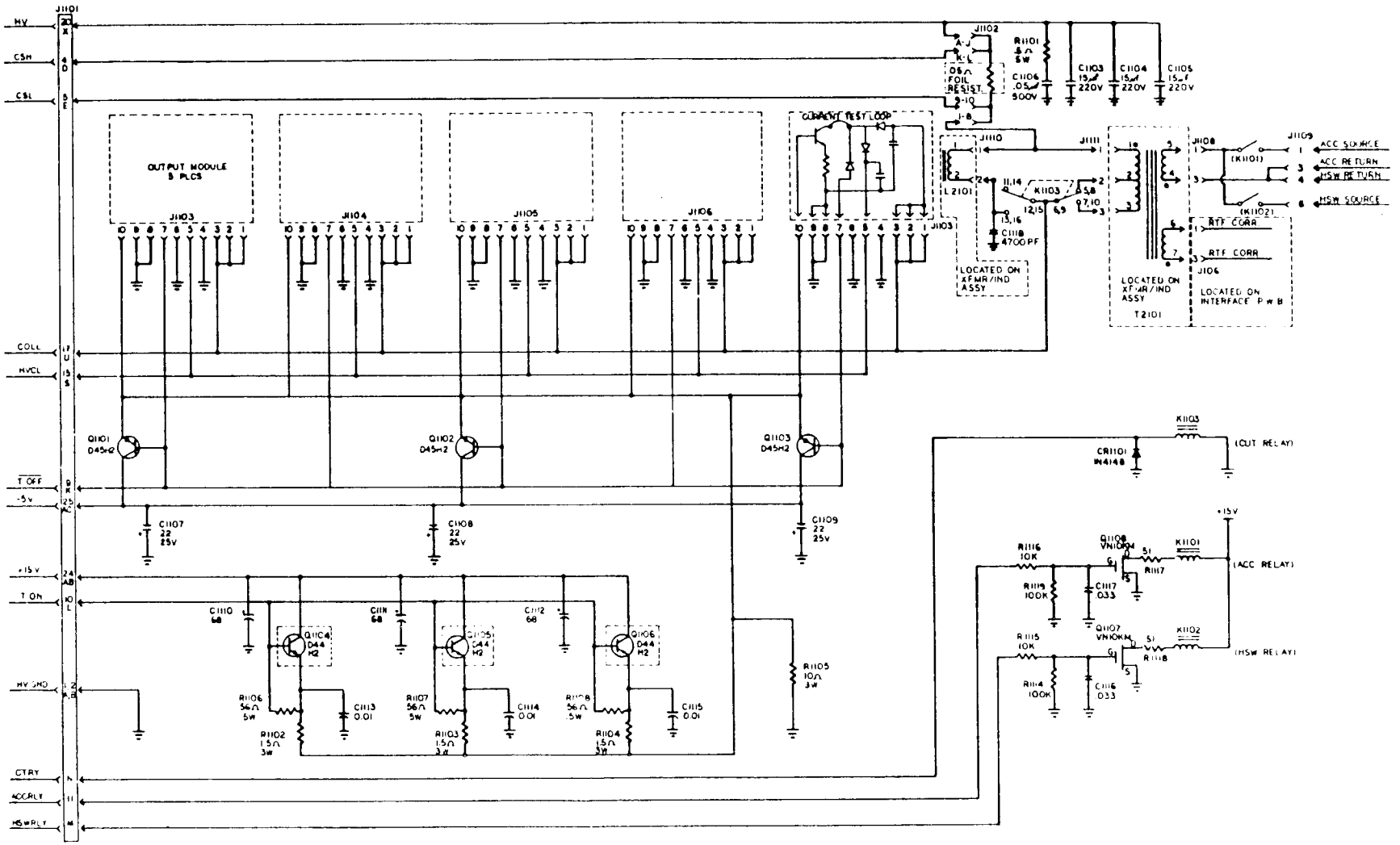


FIGURE 36

STRIPLINE BOARD SCHEMATIC

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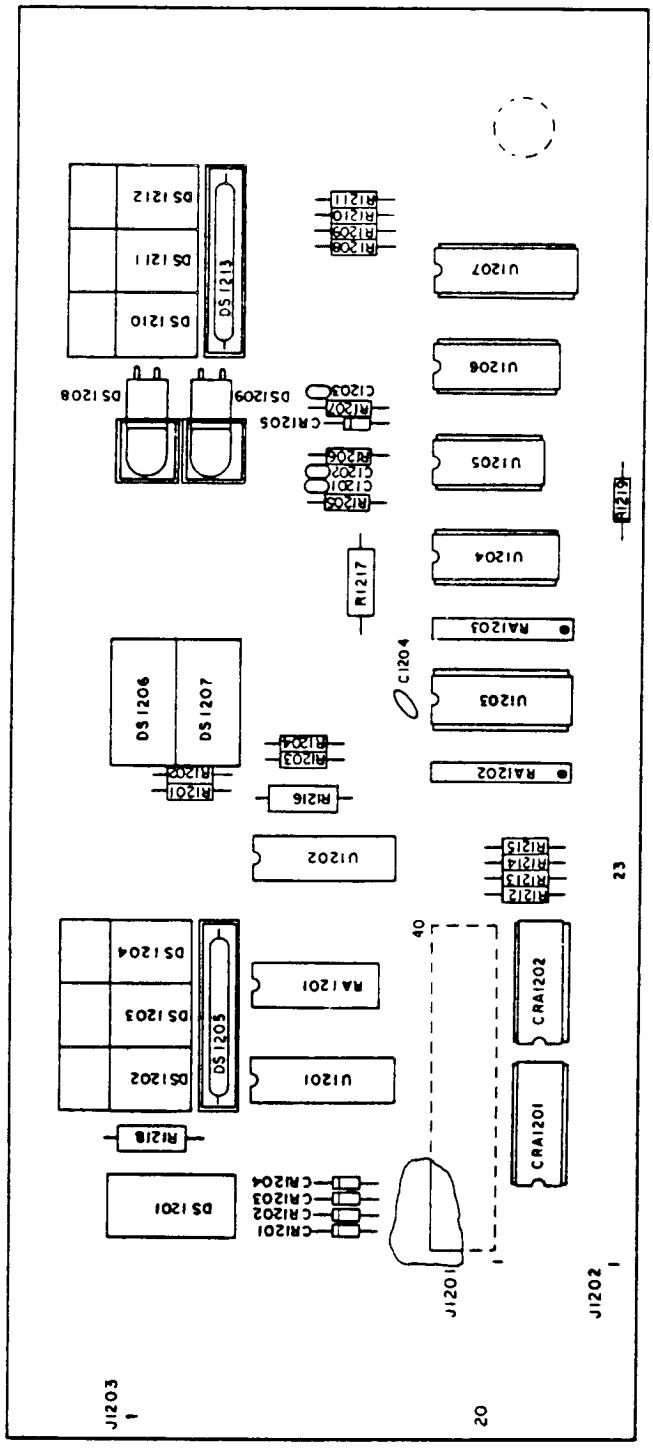


FIGURE 37

MONOPOLAR DISPLAY BOARD

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Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

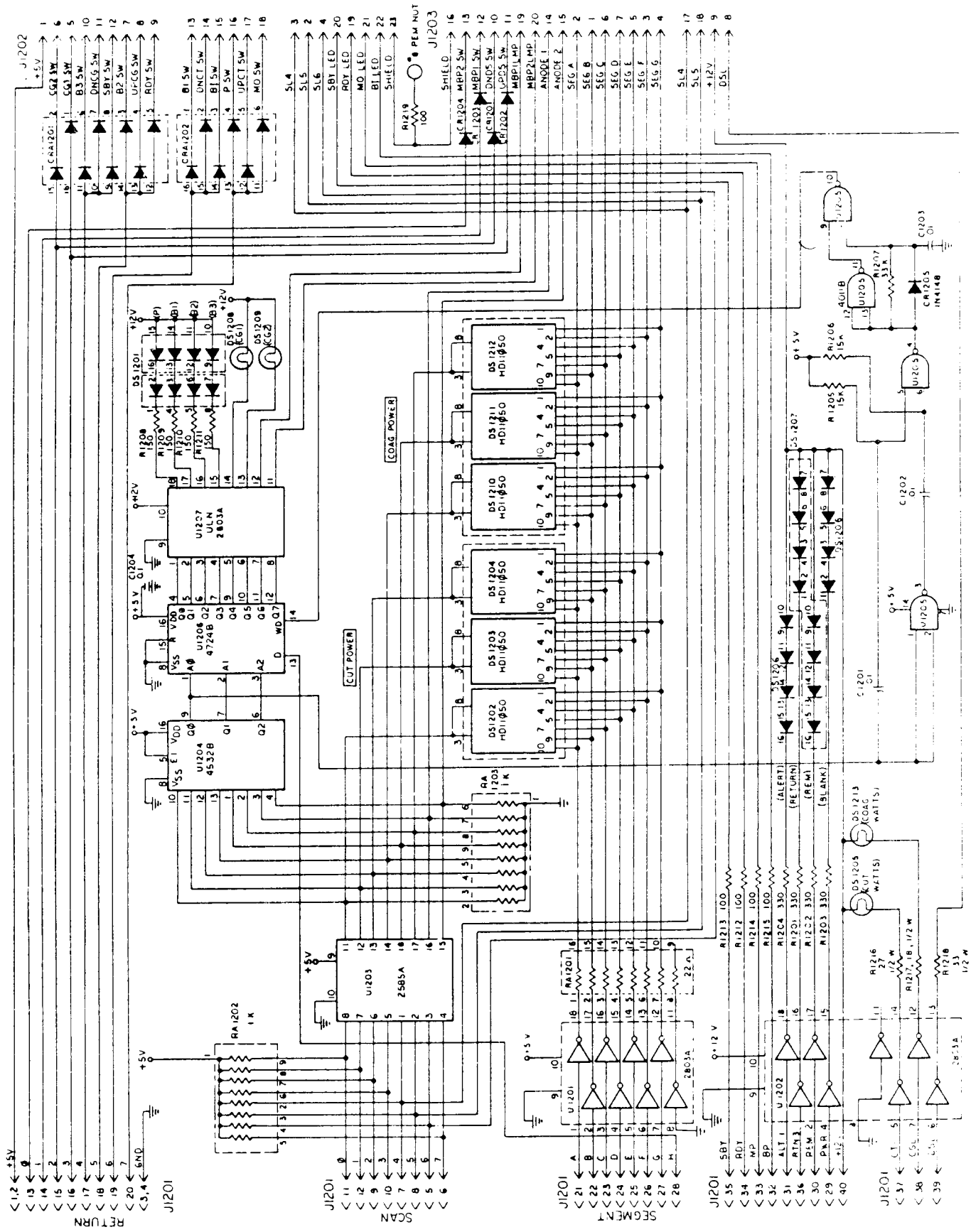


FIGURE 38

MONOPOLAR DISPLAY BOARD SCHEMATIC

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

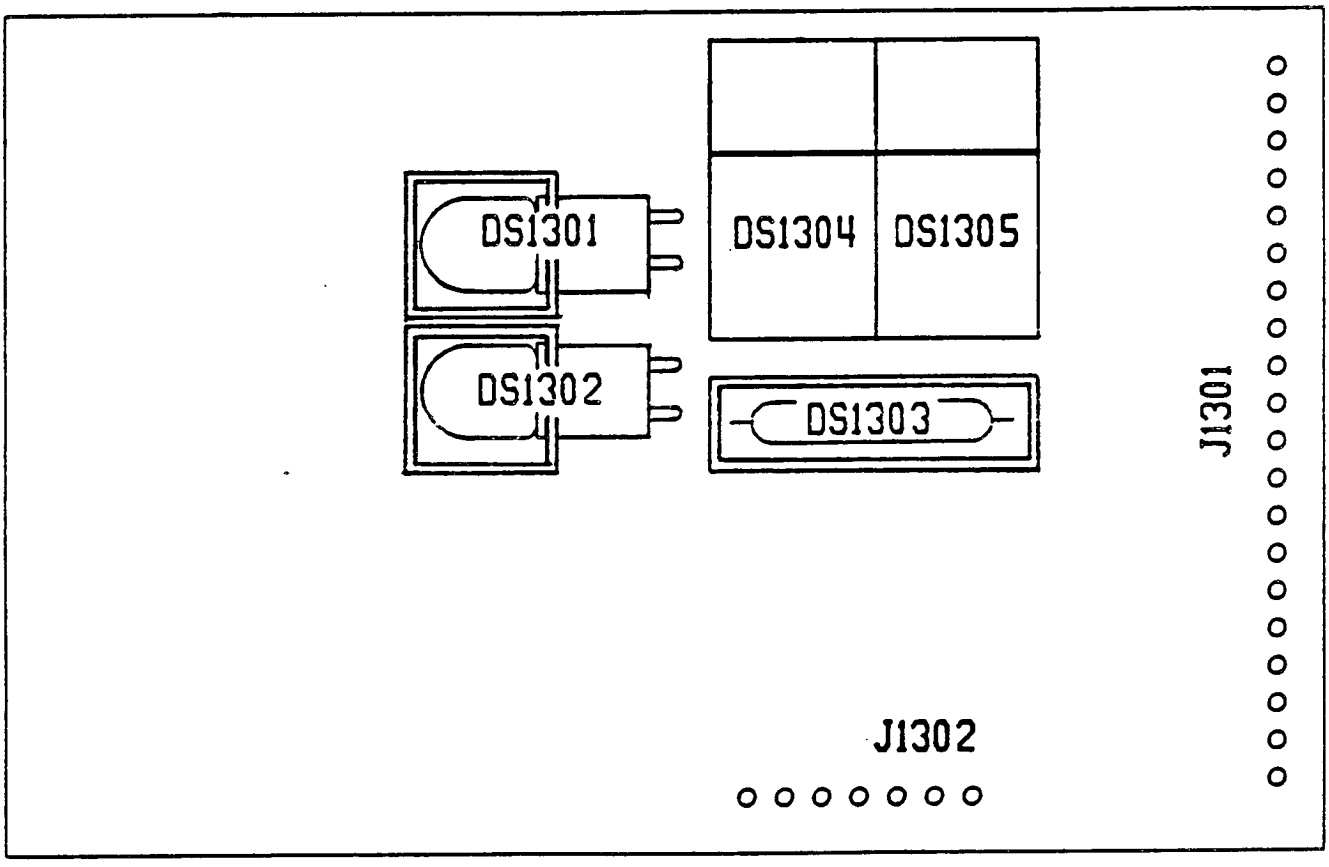


FIGURE 39

BIPOLAR DISPLAY BOARD

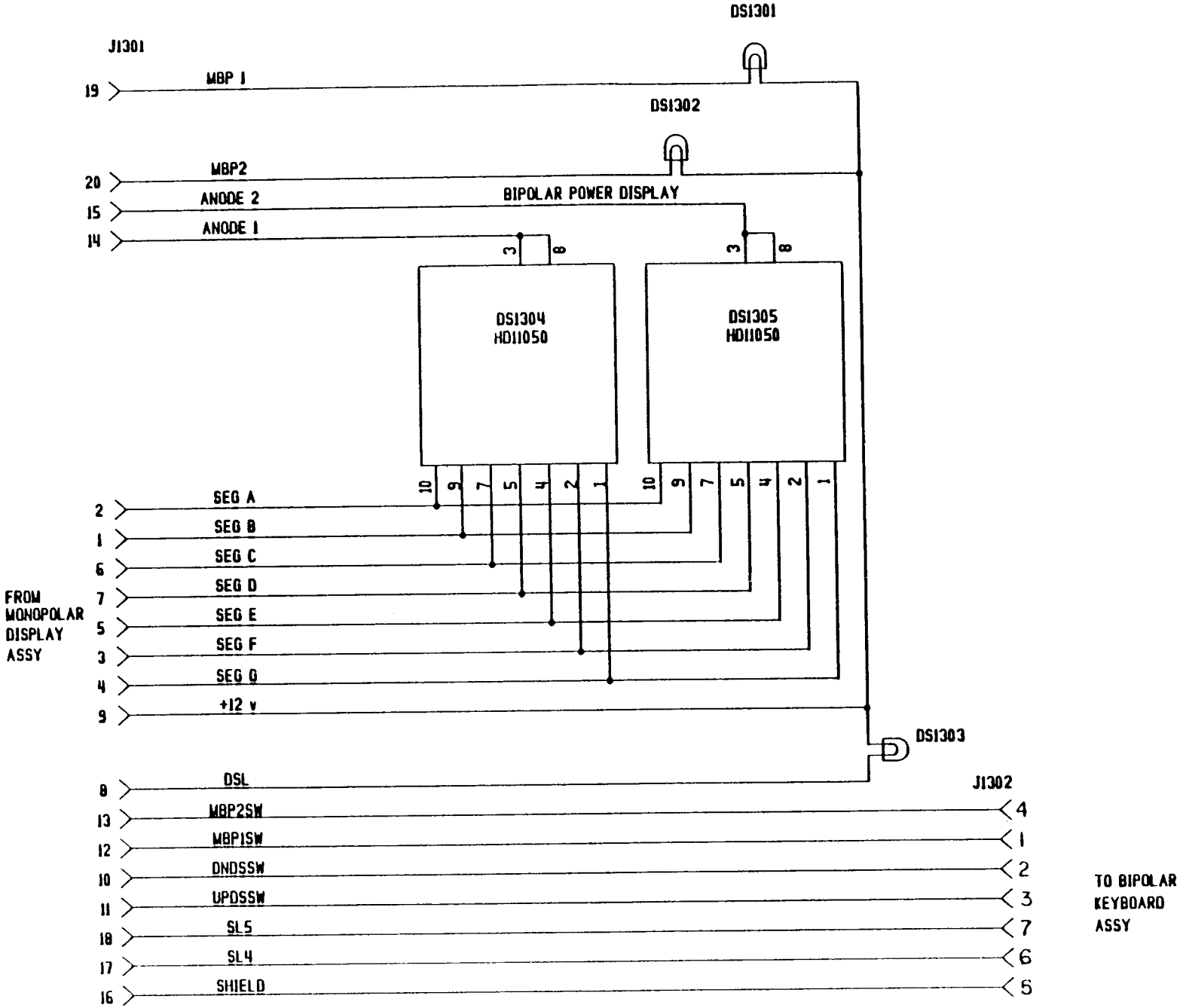
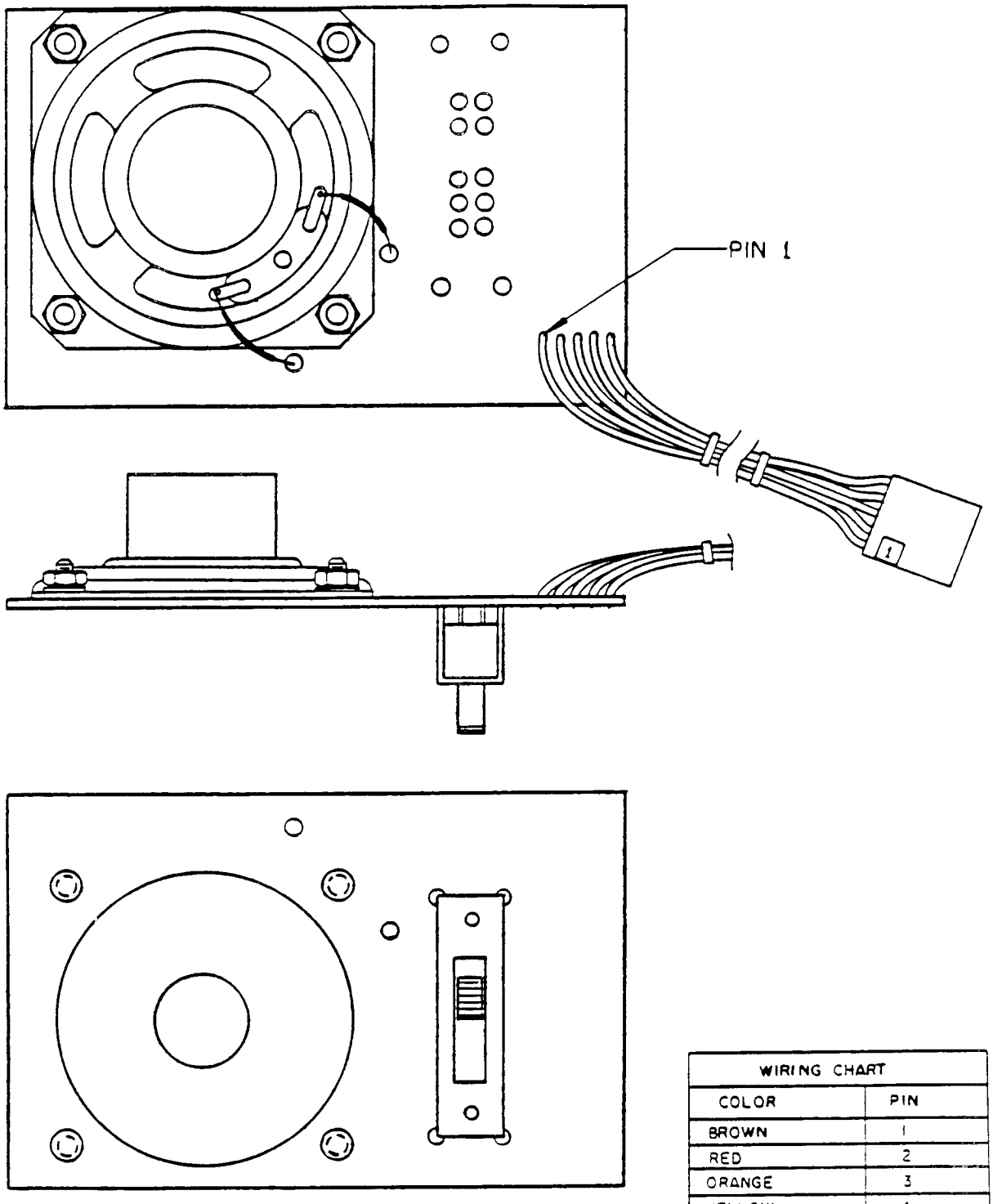


FIGURE 40

BIPOLAR DISPLAY BOARD SCHEMATIC

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WIRING CHART	
COLOR	PIN
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5

FIGURE 41

SPEAKER BOARD

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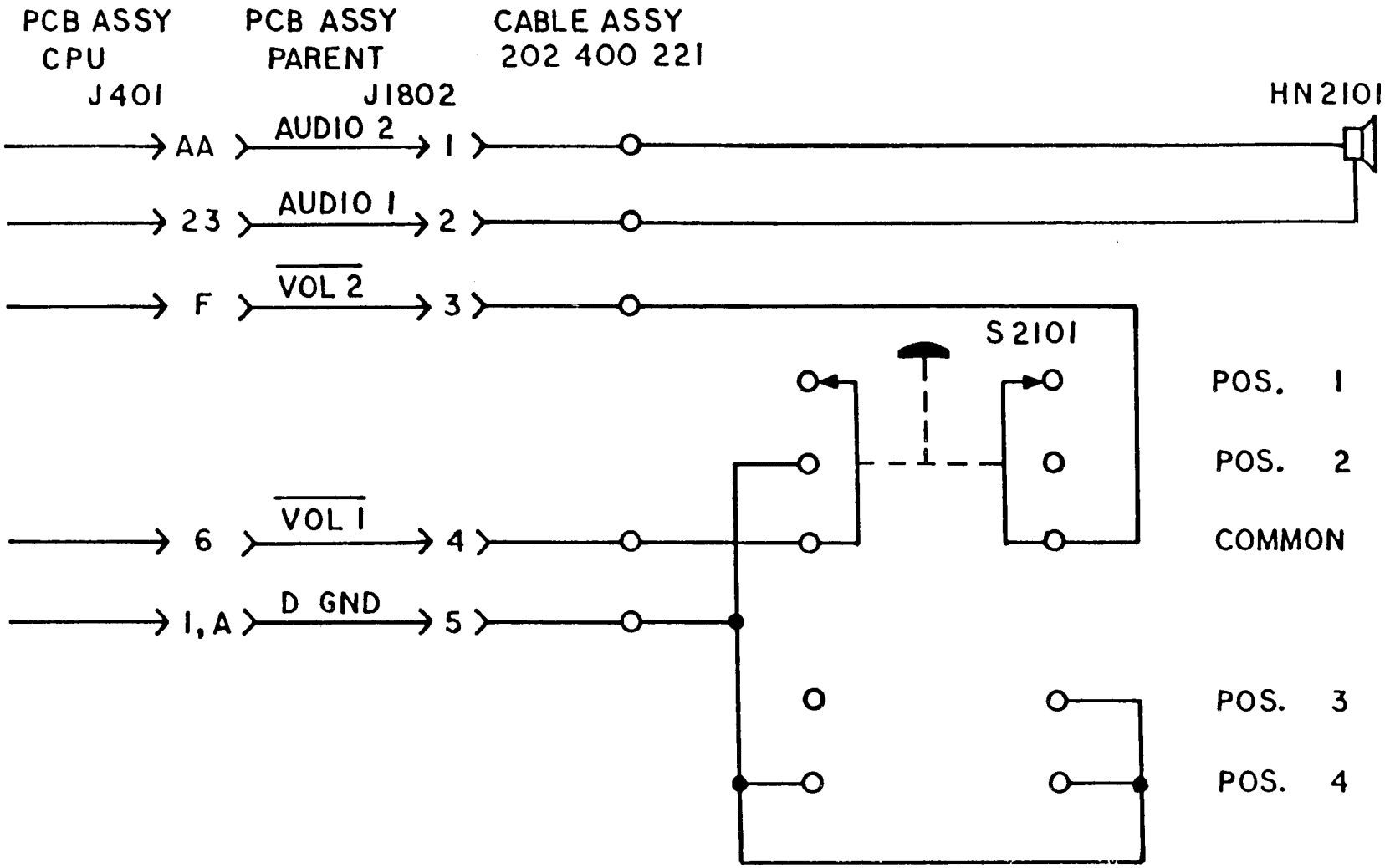


FIGURE 42

SPEAKER BOARD SCHEMATIC

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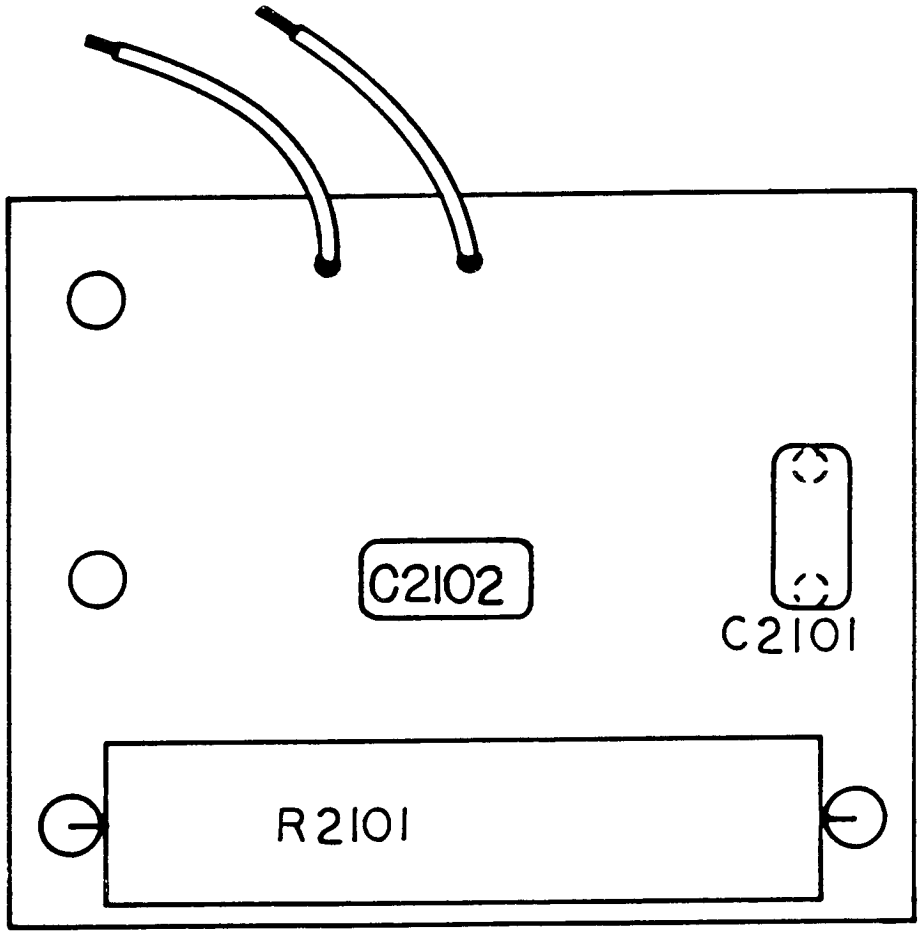


FIGURE 43

SNUBBER BOARD

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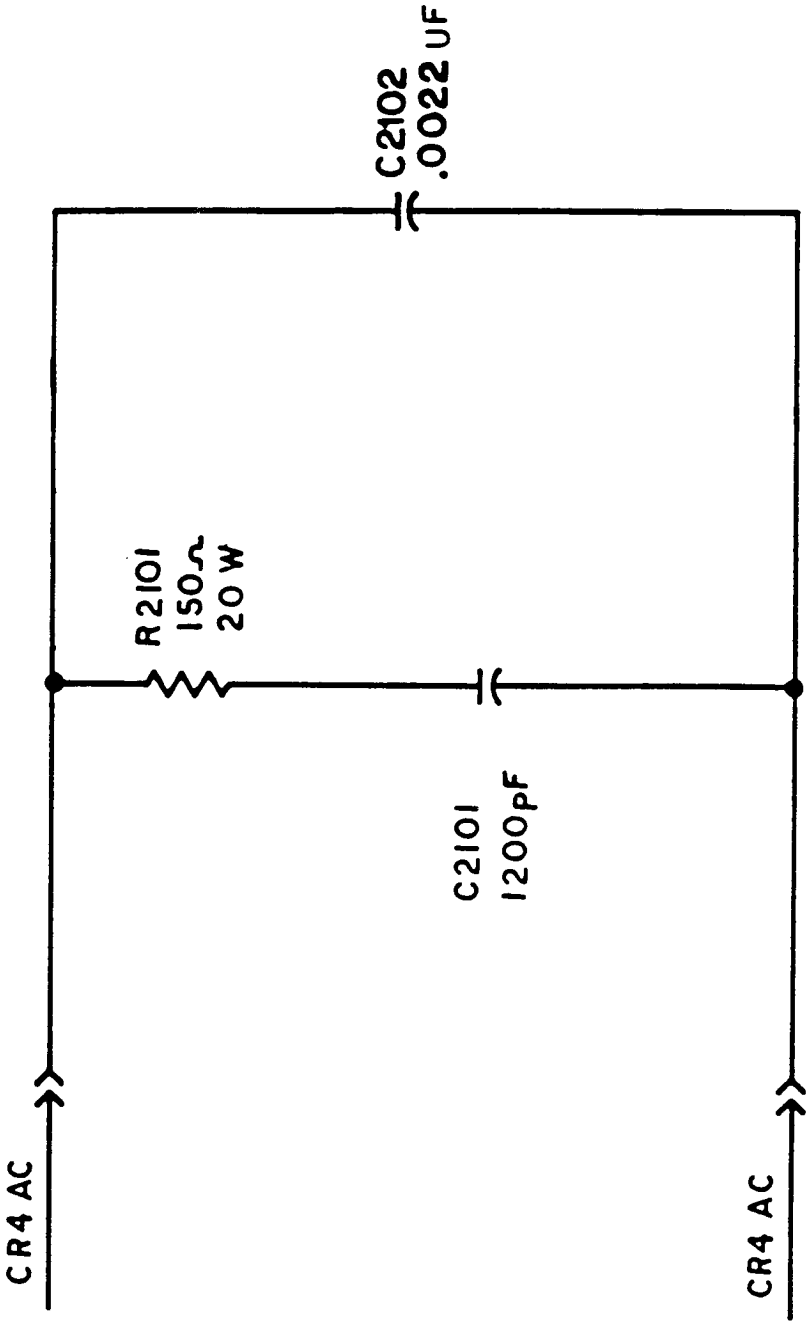


FIGURE 44

SNUBBER BOARD SCHEMATIC

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Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

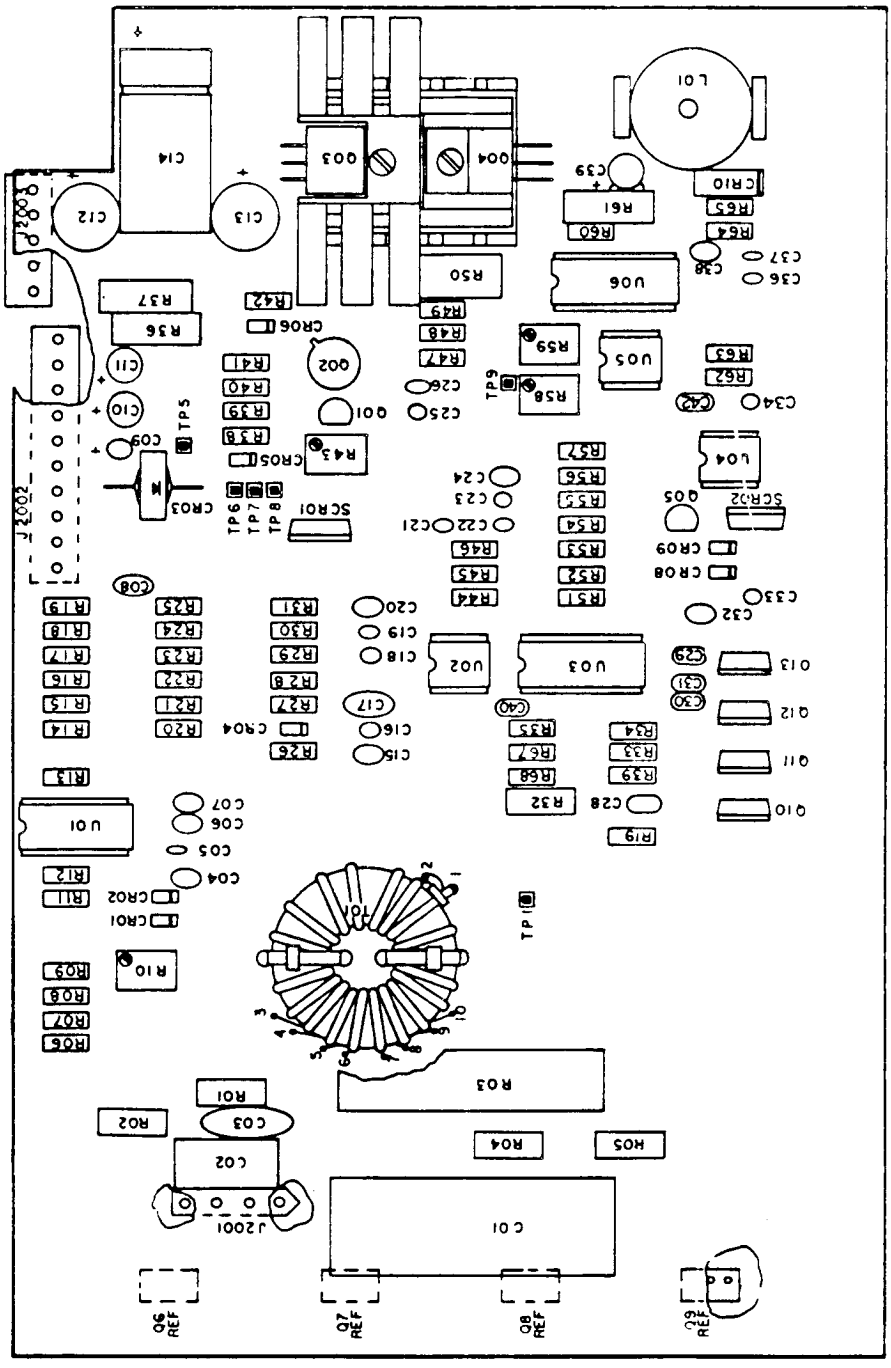


FIGURE 45

POWER SUPPLY CONTROLLER BOARD

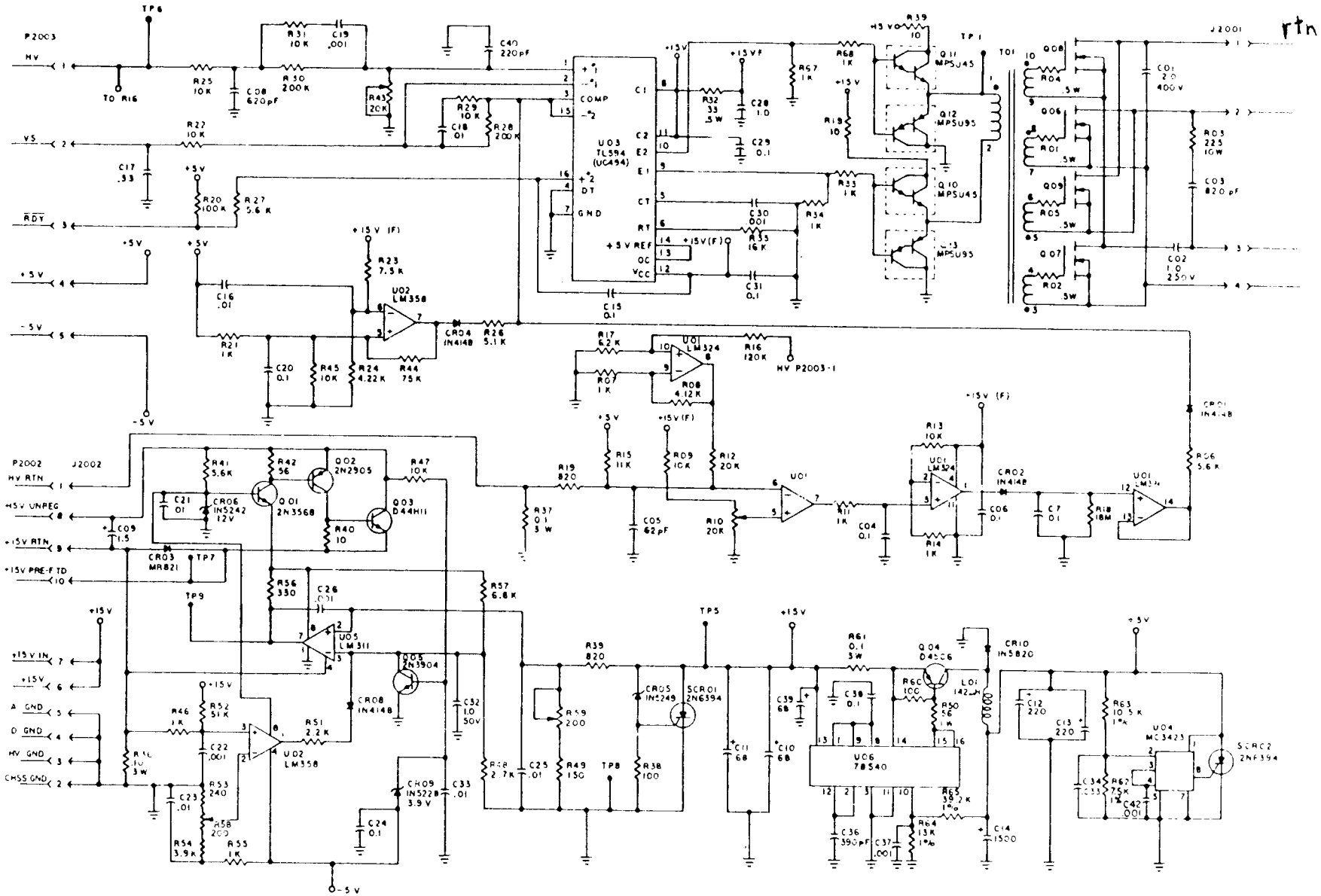


FIGURE 46

POWER SUPPLY CONTROLLER BOARD SCHEMATIC

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

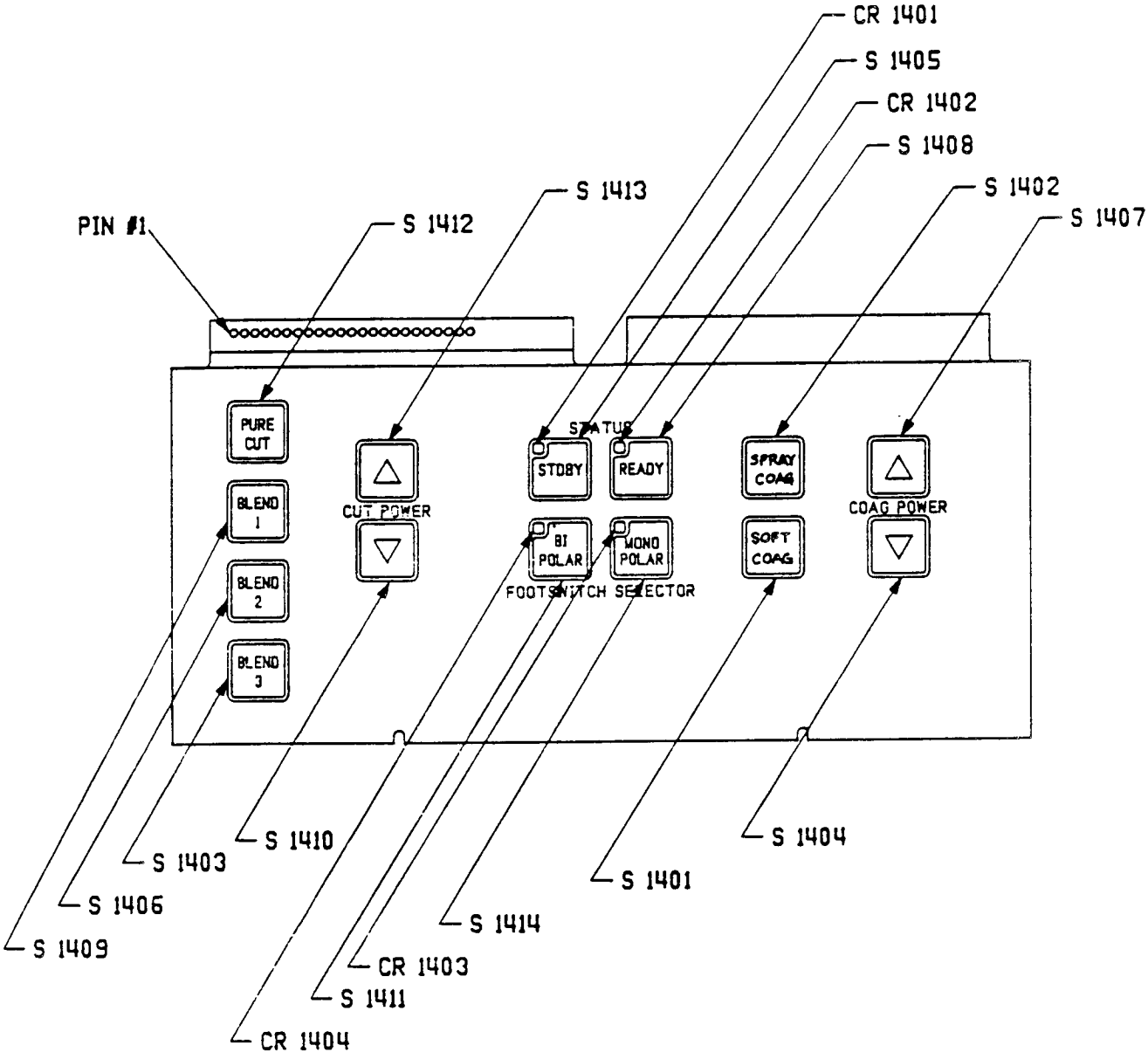


FIGURE 47

MONOPOLAR KEYBOARD

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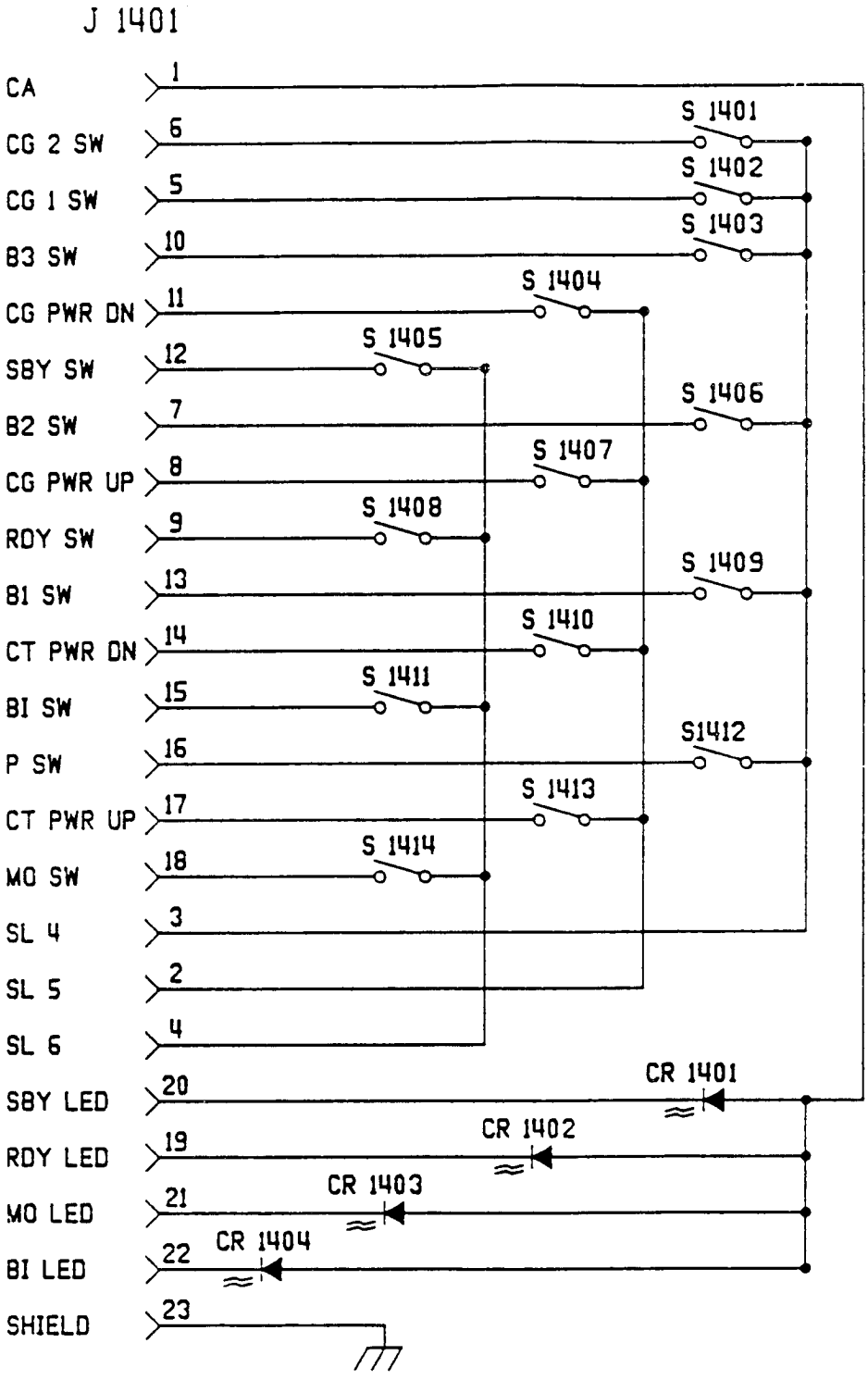


FIGURE 48

MONOPOLAR KEYBOARD SCHEMATIC

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

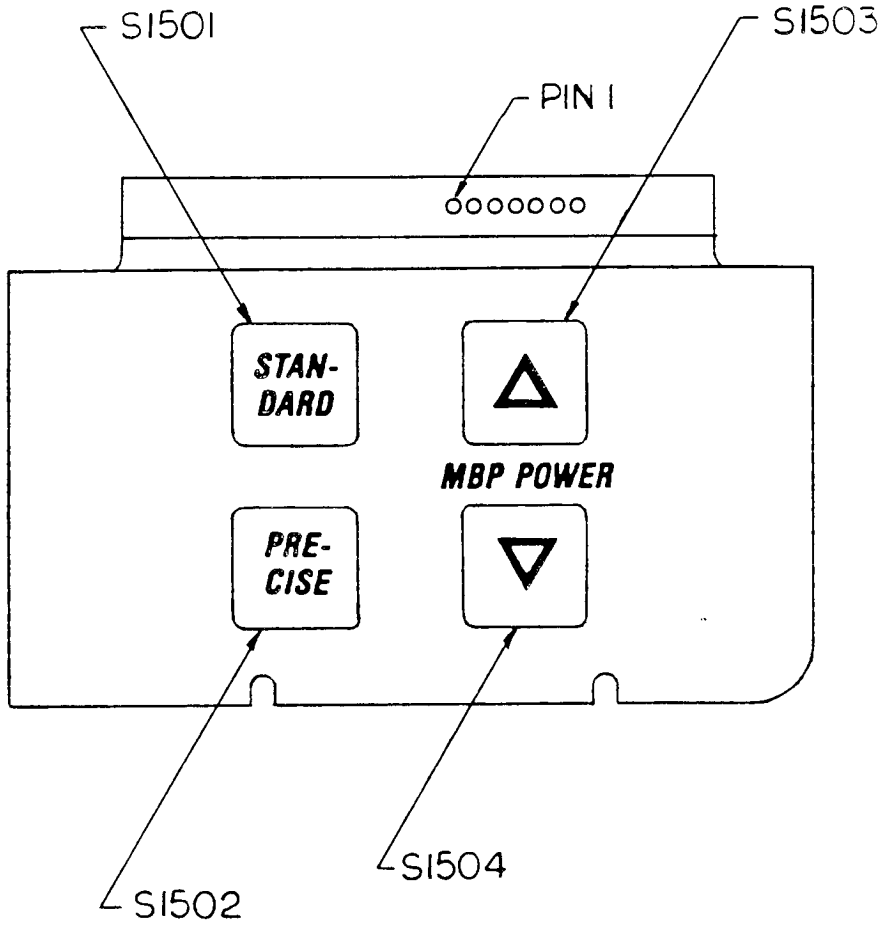


FIGURE 49

BIPOLAR KEYBOARD

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

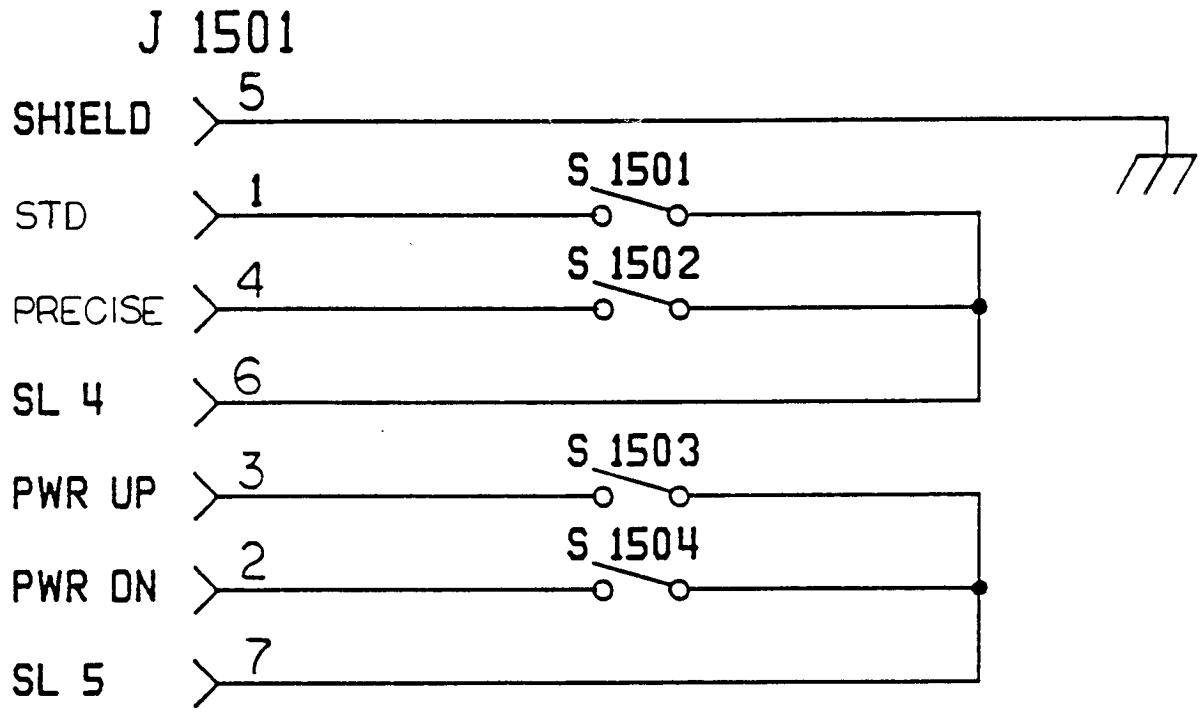


FIGURE 50

BIPOLAR KEYBOARD SCHEMATIC

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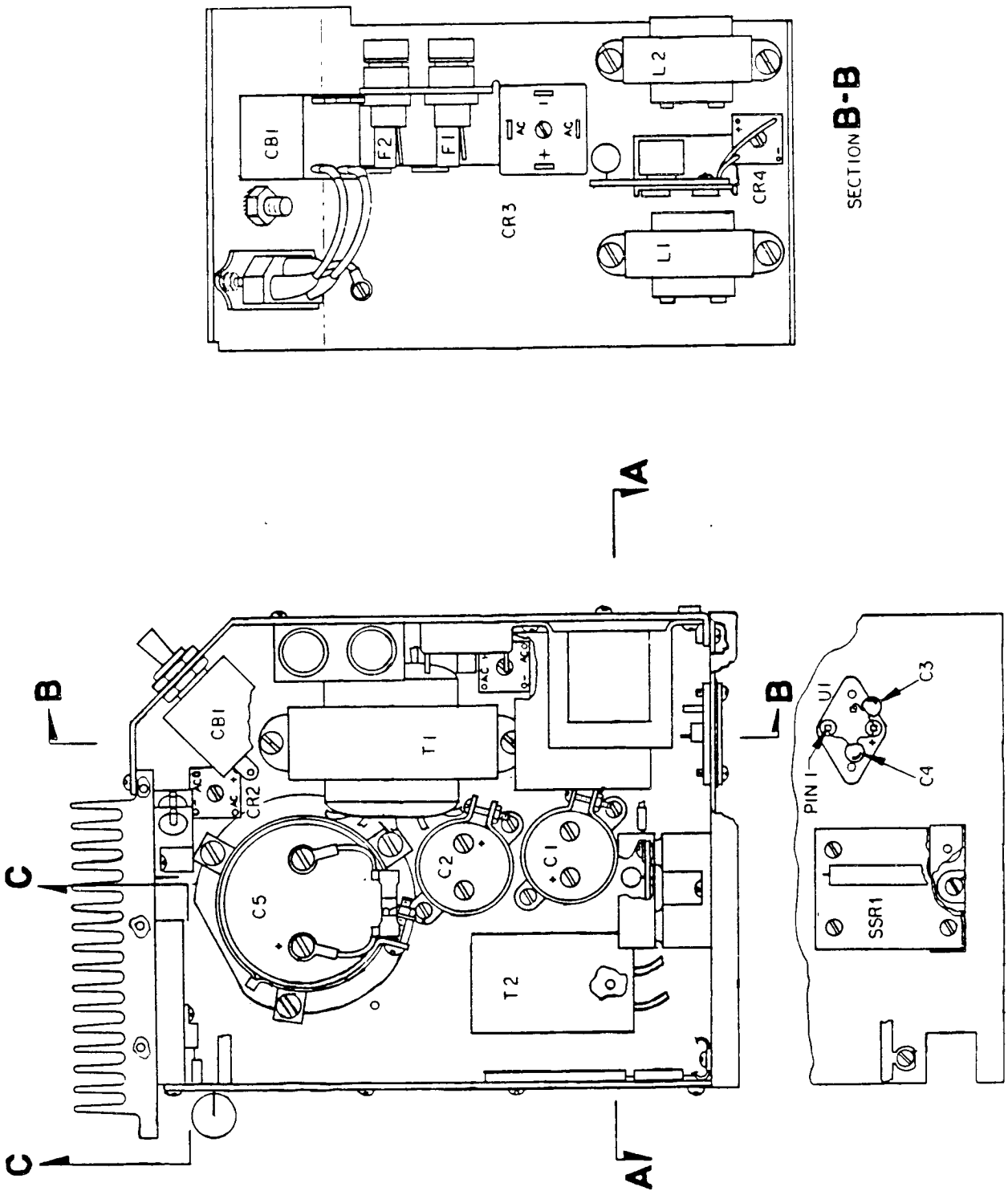


FIGURE 51

POWER SUPPLY MODULE

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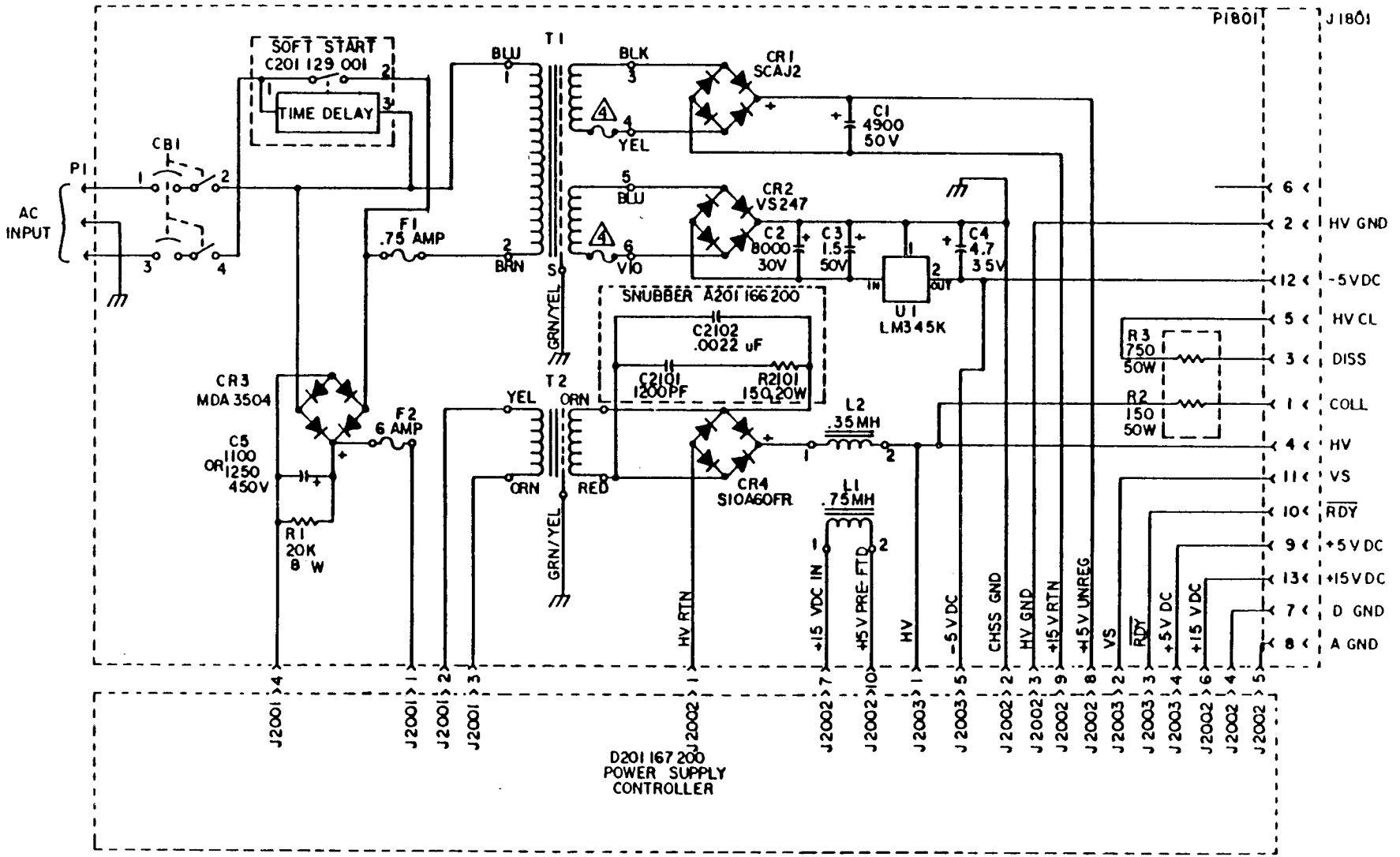


FIGURE 52

POWER SUPPLY MODULE SCHEMATIC

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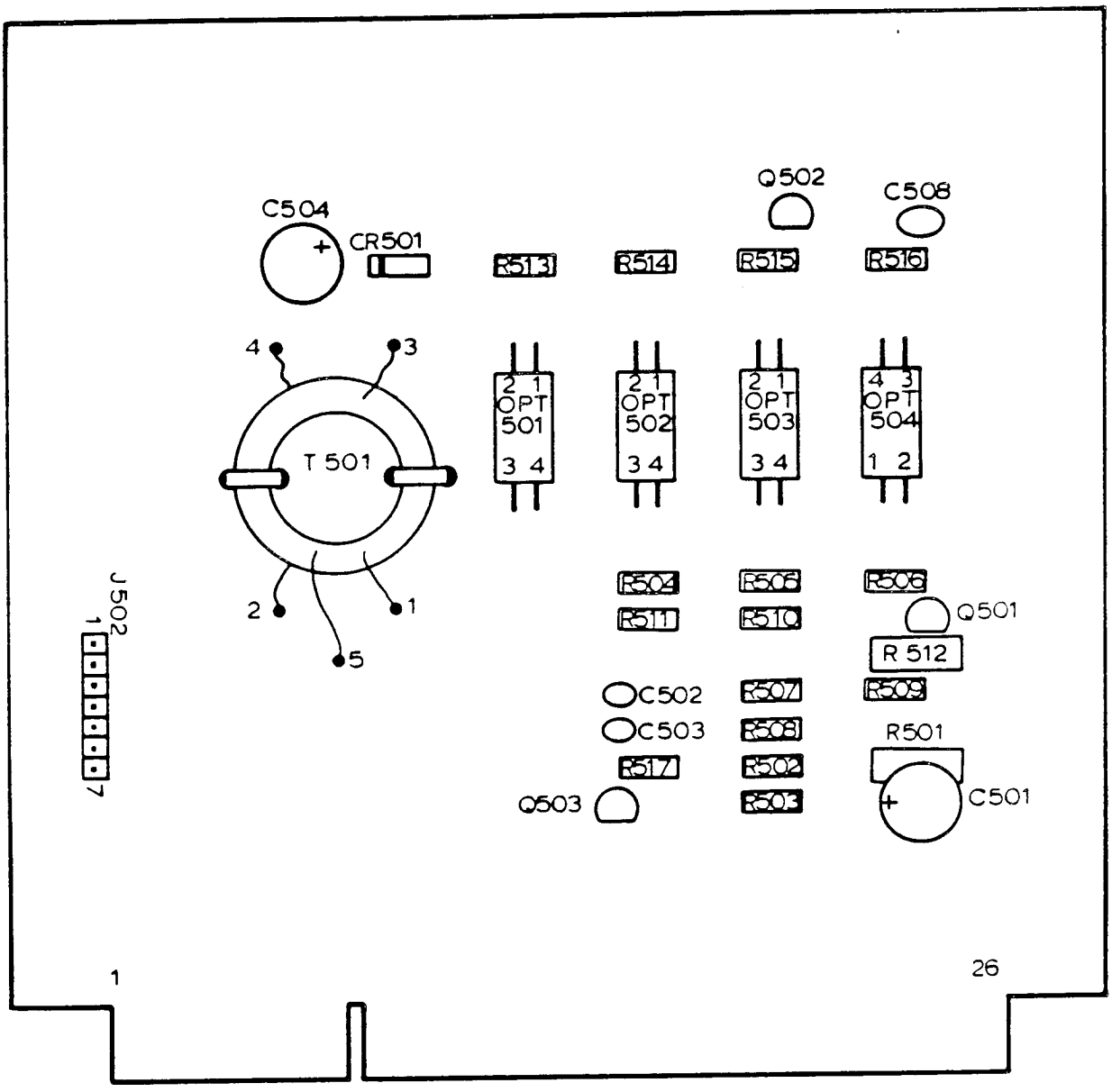


FIGURE 53

ISO FOOTSWITCH BOARD

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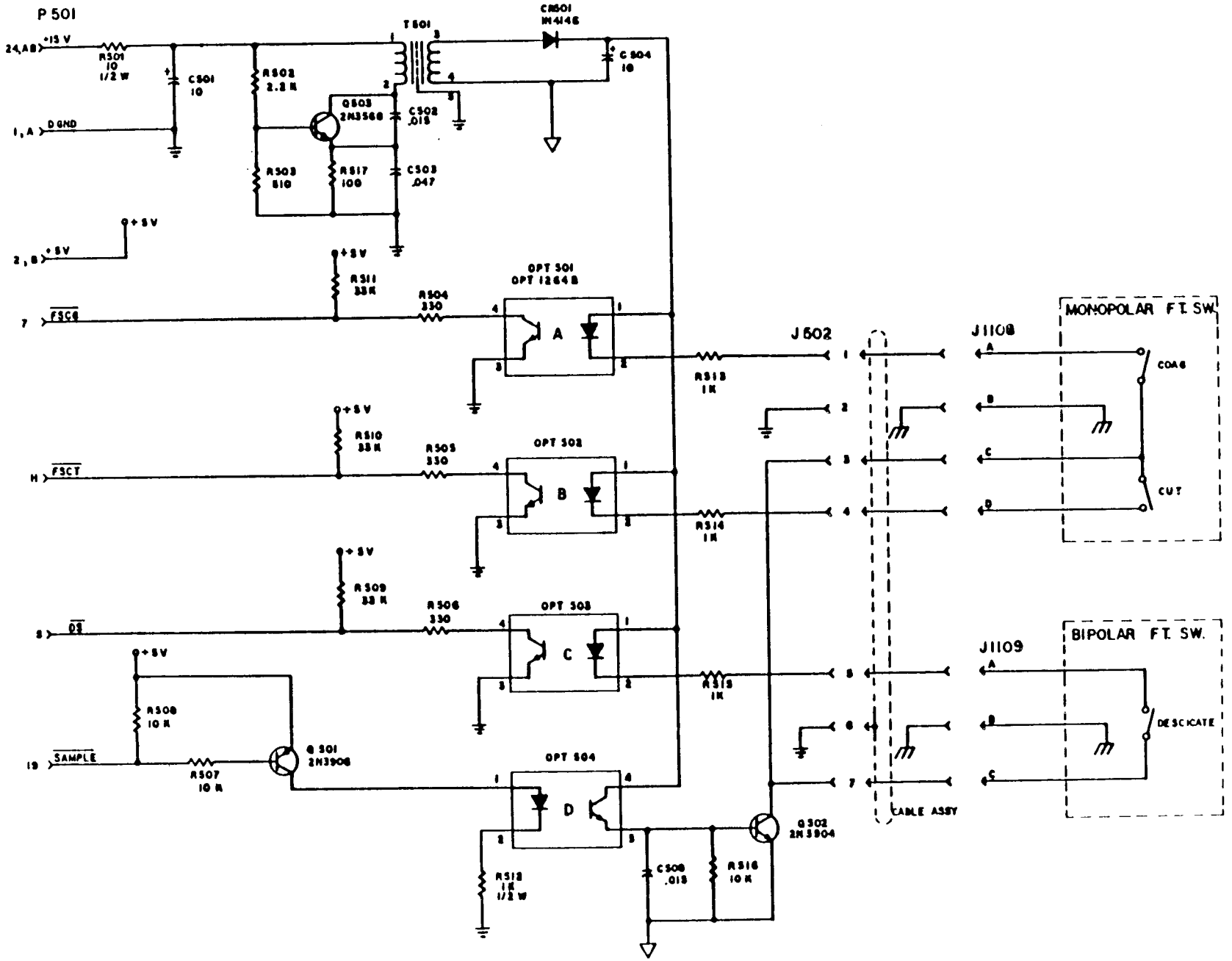


FIGURE 54

ISO FOOTSWITCH BOARD SCHEMATIC

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Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

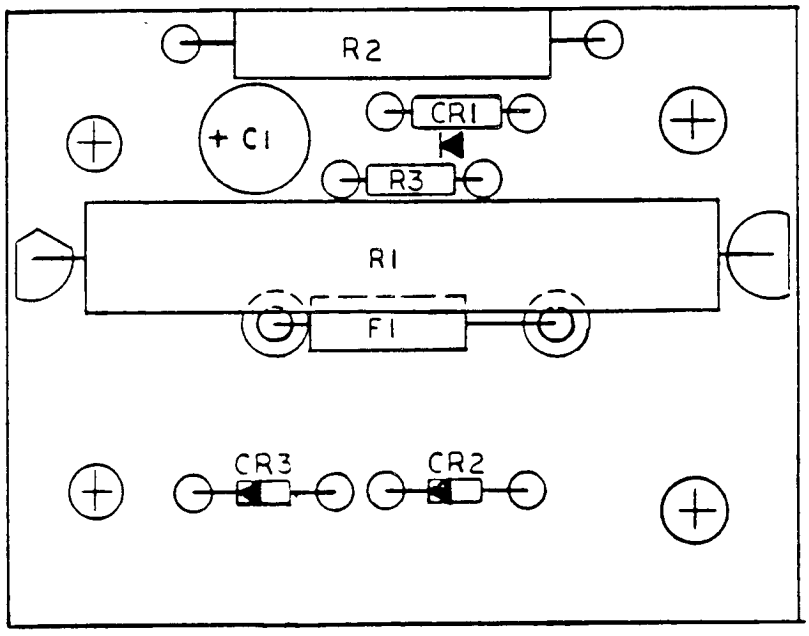


FIGURE 55

SOFT START BOARD

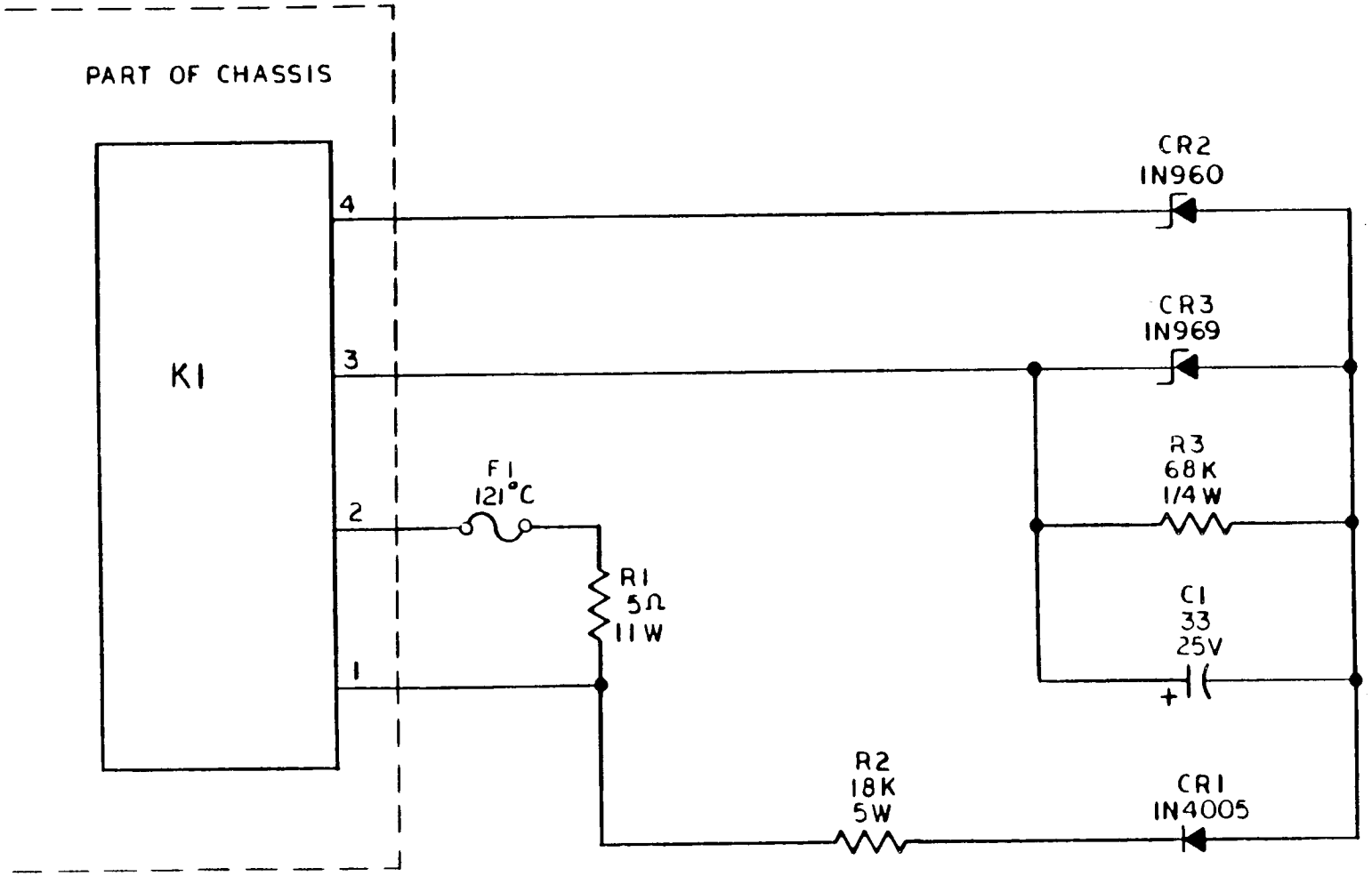


FIGURE 56

SOFT START BOARD SCHEMATIC

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SECTION 10

PARTS LIST

REPLACEABLE MODULES

ASSEMBLY	PART NUMBER	PAGE
OUTPUT BOARD	201 075 002	121
INTERFACE BOARD	201 141 100	121
BIPOLAR OUTPUT BOARD	201 142 000	123
BIPOLAR CONTROLLER BOARD	201 143 001	125
CPU BOARD	201 144 100	126
CLOCK/CONTROL BOARD	201 146 001	128
SENSE BOARD	201 148 001	129
DRIVER BOARD	201 150 000	132
STRIPLINE BOARD	201 151 100	133
MONOPOLAR DISPLAY BOARD	201 156 100	133
BIPOLAR DISPLAY BOARD	201 157 001	134
SPEAKER BOARD	201 163 000	-
PCB CARD EXTENDER	201 165 000	-
SNUBBER BOARD	201 166 200	135
ISO FOOTSWITCH BOARD	201 171 000	135
SOFT START BOARD	201 129 000	136
POWER SUPPLY CONTROLLER BOARD	201 167 201	137
MONOPOLAR KEYBOARD	207 500 074	-
BIPOLAR KEYBOARD	207 500 075	-
OUTPUT MODULE	202 280 007	-
FOOTSWITCH CABLE	202 400 258	-
POWER CORD	202 400 211	-
REM ADAPTER	202 700 929	-
POWER SUPPLY MODULE	202 701 078	139

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PCB ASSEMBLY, OUTPUT **201 075 002**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R1	RESISTOR ASSEMBLY 0.1 OHM	203 077 000
CAPACITORS		
C1	FILM 0.1uf, 10%, 600V	204 067 040
C2	MICA 560pf, 5%, 500V	204 105 020
C3	MICA 180pf, 5%, 500V	204 105 008
C4	MICA 3300pf, 5%, 500V	204 105 038
DIODES		
CR1	PWR RECTIFIER MR816	239 088 000
CR2, 4	DIODE A115M	239 029 000
CR3	DIODE, FAST RECOVERY	239 850 010
TRANSISTORS		
Q1	FESE 178	239 300 006

PCB ASSEMBLY, INTERFACE **201 141 100**

RESISTORS		
R101, 122	FIXED 10, 5%, 1/4W	234 024 015
R102, 119, 127	CARBON 2.7K, 5%, 1/4W	234 024 073
R103,108,110,111,114,128	CARBON 15K, 5%, 1/4W	234 024 091
R104,106,123,124,144, 146,148,149,150,152	FIXED 1K, 5%, 1/4W	234 024 063
R105,107,109,113	FIXED 5.6K, 5%, 1/4W	234 024 081
R112	ENAMEL 100, 5%, 10W	234 030 205
R115,121	METAL FILM 715K ohm, 1%, 1/8W	234 201 563
R116,117	METAL FILM 69.8K ohm, 1%, 1/8W	234 201 466
R118	TRIMPOT, 5K	236 010 106
R120	CARBON 510, 5%, 1/4W	234 024 056
R125,130	CARBON 1.5K, 5%, 1/4W	234 024 067
R126,129,136,137,139	FIXED 10K, 5%, 1/4W	234 024 087
R131-133	CARBON 33, 5%, 1/4W	234 024 027
R134	FIXED 100K, 5%, 1/4W	234 024 111
R142	WIREWOUND 510, 5%, 5W	234 027 077
R145	FIXED 3K, 5%, 1/4W	234 024 074
R147	CARBON 5.1K, 5%, 1/4W	234 024 080
R151	CARBON 4.3K, 5%, 1/4W	234 024 078
RA101	NETWORK 33K, 2%	234 100 051

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REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
CAPACITORS		
C101,127,131,132	TANT 4.7uf, 20%, 35V	204 104 046
C102,120	NO BASE	204 200 243
C103-105,121,141,142	MONO .01uf, 20%, 100V	204 121 041
C106,119,125,126,130, 133,136,143,146-150	MONO 0.1uf, 20%, 50V	204 118 007
C107	POLY .012uf, 5%, 50V	204 400 100
C108	POLY .0033uf, 5%, 250V	204 400 077
C109	POLY .027uf, 5%, 50V	204 400 101
C110	CERAMIC .0022uf, 20%, 6KV	204 025 044
C111,112	TANT 10uf, 10%, 25V	204 102 008
C113,114	POLY .22uf, 10%, 250V	204 400 120
C115	CERAMIC .0047uf, 20%, 6KV	204 025 050
C116	CERAMIC 560pf, 20%, 6KV	204 025 037
C117, 144, 145	CERAMIC 33pf, 10%, 600V	204 079 017
C118	CERAMIC 220pf, 10%, 600V	204 079 033
C124	CERAMIC 180pf, 10%, 600V	204 079 031
C134,135,137,138	MONO 1.0uf, 20%, 50V	204 118 014
C139	FILM .33uf, 10%, 50V	204 133 031
C140	GLASS-DIELECT 8-18pf, 750V	204 800 003
INTEGRATED CIRCUITS		
U101	LM339AN	210 300 015
U103,109	LM393N	210 300 011
U104	4013B	210 027 000
U105	40106B	210 211 106
U107	4016B	210 210 016
U108	LM358AN	210 300 013
TRANSISTORS		
Q101-104	2N3904	239 015 000
DIODES		
CR101-104, 109, 110	1N4148	239 014 000
CR106	MC1107P	239 094 001
CR107	VSB52	239 700 025
CR108	1N5228	239 075 000
CR111, 112	1N5233B	239 600 000

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PCB ASSEMBLY, INTERFACE (CONT'D) **201 141 100**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
TRANSFORMERS		
T101, 103	TOROID ASSY	202 302 000
T102	TOROID ASSY, ISOBLOC	202 224 000
T105	X-FORMER, RF INPUT	202 900 017
MISCELLANEOUS		
L101	OSCILLATOR COIL	202 900 020
OPI-101-105	PHOTO-ISOLATOR OPI 1264B	239 750 019

PCB ASSEMBLY, BIPOLAR OUTPUT **201 142 001**

RESISTORS		
R201,223,234,242	CARBON 100 ohm, 5%, 1/4W	234 024 039
R202	CARBON 68 ohm, 5%, 1/4W	234 024 035
R203	CARBON 100 ohm, 5%, 1/4W	234 024 040
R204,210,211,219,226, 235,236,237,238, 240,241,243,249	CARBON 10K ohm, 5%, 1/4W	234 024 087
R205	CARBON 220 ohm, 5%, 1/4W	234 024 047
R206	CARBON .02 ohm, 5%, 2W	234 400 215
R207	CARBON 3.3K ohm, 10%, 1W	234 004 038
R208	CARBON 22K ohm, 5%, 1/4W	234 024 095
R209	CARBON 2.4K ohm, 5%, 1/4W	234 024 072
R214	METAL FILM 100K ohm, 1%, 1/8W	234 201 481
R215	METAL FILM 4.99K ohm, 1%, 1/8W	234 201 356
R216	CARBON 10 Meg ohm, 5%, 1/4W	234 024 158
R218,220,221,225, 230,212,248	CARBON 1K ohm, 5%, 1/4W	234 024 063
R222	CARBON 820 ohm, 5%, 1/4W	234 024 061
R224,231,247	CARBON 10 ohm, 5%, 1/4W	234 024 015
R246	CARBON 33K ohm, 5%, 1/4W	234 024 099
R232	CARBON 2.2K ohm, 5%, 1/4W	234 024 071
R233	CARBON 510 ohm, 5%, 1/4W	234 024 056
R239	CARBON 330 ohm, 5%, 1/4W	234 024 051
R244	TRIM POT 200 ohm	236 200 074
R245	TRIM POT 5K ohm	236 200 078
R227	CARBON 3.9K ohm, 5%, 1/4W	234 024 077
CAPACITORS		
C201,202,203,212,216, 218,219,222,230	MONO 0.1uf, 20%, 50V	204 118 007
C204,217,221,225	TANT 10uf, 10%, 25V	204 102 008
C205,206	CERAMIC .02uf, 20%, 100V	204 049 002
C207	ELECT 180uf, 100V	204 500 080
C208	FILM 1.0uf, 10%, 200V	204 400 135
C209	CERAMIC .1uf, 500V	204 200 242

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PCB ASSEMBLY, BIPOLAR OUTPUT (CONT'D) **201 142 001**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
CAPACITORS		
C210,213	MONO .01uf, 20%, 50V	204 118 001
C211	TANT 15uf, 10%, 20V	204 055 004
C214	MICA 1000pf, 5%, 500V	204 105 026
C215	MICA 5100pf, 5%, 500V	204 105 043
C220	TANT 6.8uf, 10%, 35V	204 104 011
C223,224	MONO .33uf, 20%, 50V	204 118 011
C226	MONO .047uf, 15%, 50V	204 200 107
C227	MONO .015uf, 20%, 50V	204 121 069
C228,229	CERAMIC .01uf, 20%, 3000V	204 113 063
C231	MONO 1.0uf, 20%, 50V	204 118 014
C232	TANT 4.7uf, 20%, 35V	204 104 046
INTEGRATED CIRCUITS		
U201	I.C. SG3526	210 300 062
U202	I.C. VOLTAGE REGULATOR (12V)	210 021 004
U203	I.C. TTL7400	210 510 000
U204	I.C. TTL7493	210 510 093
U205	I.C. MC1458	210 023 000
U206,210	I.C. LM393N	210 300 011
TRANSISTORS		
Q201	MJE13006	239 100 016
Q202	MPS-U60	239 057 000
Q203	MPS-U10	239 072 000
Q204,205,207,208	2N3904	239 015 000
Q209	2N2907A	239 100 012
Q210	2N2222A	239 100 011
Q211	MTP5N40	239 200 005
Q213	2N3568	239 100 014
DIODES		
CR201,202,205	PWR RECTIFIER MR816	239 088 000
CR203	ZENER 1N5228	239 075 000
CR204,206,207,208,209, 210,211	DIODE 1N4148	239 014 000

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PCB ASSEMBLY, BIPOLAR OUTPUT (CONT'D) **201 142 001**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
MISCELLANEOUS		
T201	TRANSFORMER, C-CORE	202 900 024
T202	TRANSFORMER, TOROID	251 300 001
T203	TRANSFORMER, TOROID	251 300 000
OPI-201	PHOTO ISOLATOR OPI 1264B	239 750 019
L201	INDUCTOR 1.0mH	251 100 063
L202	INDUCTOR 150uH	251 100 065
F201	FUSE 2 amp	215 005 036
	HEATSINK #6072B	214 100 028

PCB ASSEMBLY, BIPOLAR CONTROLLER **201 143 001**

RESISTORS		
R301,302,309	CARBON 1K ohm, 5%, 1/4W	234 024 063
R303	CARBON 330K ohm, 5%, 1/4W	234 024 123
R304,307,310,311, 315,316,317,322	CARBON 10K ohm, 5%, 1/4W	234 024 087
R308,319,320,326,327 328,329,334,335,336 337,338,339	CARBON 100 ohm, 5%, 1/4W	234 024 039
R312,324,325	METAL FILM 10K ohm, 1%, 1/8W	234 201 385
R313,314,321	CARBON 100K ohm, 5%, 1/4W	234 024 111
R323	METAL FILM 20K ohm, 1%, 1/8W	234 201 414
R330,331,332,333	CARBON 330 ohm, 5%, 1/4W	234 024 051
CAPACITORS		
C301,302,303,304,305, 306,308,310,312,313, 314,315,316,321,322,325	MONO 0.1uf, 20%, 50V	204 118 007
C307,309	MONO 1.0uf, 20%, 50V	204 121 082
C311,323,324	TANT 10uf, 10%, 25V	204 102 008
C317,318,319,320,326	MONO .01uf, 20%, 100V	204 049 001
INTEGRATED CIRCUITS		
U302	EPROM, PROGRAMMED 2716	210 730 003
U303	I.C. 8212	210 760 000
U304	I.C. DAC0832	210 750 001
U305	I.C. NE555N	210 006 000
U306	I.C. SN7404	210 500 040
U307	I.C. 8039	210 710 000

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PCB ASSEMBLY, BIPOLAR CONTROLLER (CONT'D)		201 143 001
INTEGRATED CIRCUITS		
U309	I.C. TTL7400	210 510 000
U310	I.C. 74C906	210 200 031
U311	I.C. TTL7402	210 510 002
U312	I.C. LM324N	210 022 000
U313	I.C. ADC0809	210 740 000
CR301	I.C. VOLTAGE REG. LM336Z-2.5	210 300 016
VR301	I.C. VOLTAGE REG. LM340LAZ-12	210 300 026
DIODES		
CR302	DIODE 1N4148	239 014 000
CR303,304,305,306	L.E.D. 555-2001	239 076 001
MISCELLANEOUS		
Q301	2N3904	239 015 000
X301	CRYSTAL, 6 MHz	250 010 005

PCB ASSEMBLY, CPU		201 144 100
RESISTORS		
R403,406,427,428,429, 430,431,435,439,440, 441,442,450	CARBON 1K ohm, 5%, 1/4W	234 024 063
R407,437,438	CARBON 0.68 Meg ohm, 5%, 1/4W	234 024 131
R409,410,412,414,415, 420,421,424,425, 426,432,433,444, 445,446,448	CARBON 10K ohm, 5%, 1/4W	234 024 087
R413,423	CARBON 20K ohm, 55, 1/4W	234 024 094
R416	CARBON 1.8K ohm, 5%, 1/4W	234 024 069
R417,418	CARBON 91K ohm, 5%, 1/4W	234 024 110
R419	CARBON 1.2K ohm, 5%, 1/4W	234 024 065
R443, 436	CARBON 3.3K ohm, 55, 1/4W	234 024 075
R449	CARBON 100 ohm, 5%, 1/4W	234 024 039
R451	CARBON 33K ohm, 5%, 1/4W	234 024 099
R453	CARBON 33 ohm, 5%, 1/4W	234 024 027
R422	CARBON 5.1K ohm, 5%, 1/4W	234 024 080
RESISTOR ARRAYS		
RA401,405	108B101, 100 ohm	234 100 101
RA402,403,404,406,407 408,410,415,416,419,420	108B102, 1000 ohm	234 100 099

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REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTOR ARRAYS		
RA409,413,414	764-3-R, 10K ohm	234 100 100
RA411,412	764-1-4, 3.3K ohm	234 100 097
RA417,418	764-1-R, 10K ohm	234 100 098
RA421	108A333, 33K ohm	234 100 051
CAPACITORS		
C401,402,403,405,408, 413,414,415,418,430, 433,434,436,438,439,452	MONO 0.1uf, 20%, 50V	204 118 007
C404,440	MONO 1.0uf, 20%, 50V	204 118 014
C406, 441-448, 450	MONO .01mf, 20%, 50V	204 118 001
C407,431,432,435,451,437	TANT 10uf, 10%, 25V	204 102 008
C409	TANT 1.0uf, 10%, 35V	204 104 001
C452	MONO 1000pf, 15%, 100V	204 200 025
C416,417	MONO .033uf, 20%, 50V	204 118 004
C453	TANT 220uf, 10%, 10V	204 600 020
C449	MONO .0033uf, 10%, 100V	204 121 095
CAPACITOR ARRAYS		
CA401,403,404,405,406, 407,408	0.01uf	204 200 241
CA402	0.001uf	204 200 240
INTEGRATED CIRCUITS		
VR401	I.C. VOLT. REG. LM78M12CP	210 300 055
U402	I.C. 74156	210 510 156
U403	I.C. 8243	210 760 005
U404	I.C. NE555N	210 006 000
U405,411,413	I.V. SN7406	210 500 005
U406	I.C. 8212	210 760 000
U407	I.C. 2732 EPROM PROGRAMMED	210 730 010
U408,409	I.C. 4503	210 210 503
U410	I.C. 8279	210 760 010
U412	I.C. 74LS293	210 520 293
U414	I.C. 8039	210 710 000
U415	I.C. LM358AN	210 300 013
U416	I.C. DAC 1006	210 750 000
U417	I.C. ADC 0804	210 740 005
U418	I.C. DAC 0832	210 750 001
U419,420	I.C. LM13080N	210 400 005
U421	I.C. LM324N	210 006 000
CR403	I.C. VOLT. REG. LM336Z-2.5	210 300 016

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PCB ASSEMBLY, CPU (CONT'D) **201 144 100**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
DIODES		
CR401,402,404,405	DIODE 1N4148	239 014 000
TRANSISTORS		
Q401,402	2N3904	239 015 000
MISCELLANEOUS		
Y401	CRYSTAL, 6 MHz	250 010 005

PCB ASSEMBLY, CLOCK/CONTROL **201 146 001**

RESISTORS		
R601,622	CARBON 3.3K ohm, 5%, 1/4W	234 024 075
R602,605,610	CARBON 2.2K ohm, 5%, 1/4W	234 024 071
R603,620	CARBON 12K ohm, 5%, 1/4W	234 024 089
R604,609,631	CARBON, 100 ohm, 5%, 1/4W	234 024 039
R606	CARBON 510 ohm, 5%, 1/4W	234 024 056
R607,613	CARBON 1.3K ohm, 5%, 1/4W	234 024 066
R608,612,617,618	CARBON 4.7K ohm, 5%, 1/4W	234 024 079
R614	CARBON 1.8K ohm, 5%, 1/4W	234 024 069
R615,616,619,650	CARBON 10K ohm, 5%, 1/4W	234 024 087
R623,624,626,634,635, 636,637,638,639,640, 641,642,643,644,649	CARBON 51K ohm, 5%, 1/4W	234 024 104
R625,630	CARBON 100K ohm, 5%, 1/4W	234 024 111
R627,629	CARBON 1.2Meg ohm, 5%, 1/4W	234 024 137
R628	CARBON 0.47Meg ohm, 5%, 1/4W	234 024 127
R632	CARBON 1000 ohm, 5%, 1/4W	234 024 063
R633	CARBON 22 ohm, 55, 1/4W	234 024 023
R645	METAL FILM 5.11K ohm, 1%, 1/8W	234 201 357
R646	METAL FILM 22.6K ohm, 1%, 1/8W	234 201 419
R647	METAL FILM 16.5K ohm, 1%, 1/8W	234 201 406
R648	CARBON 6.8K ohm, 5%, 1/4W	234 024 083
R651	CARBON 6.2K ohm, 5%, 1/4W	234 024 082
CAPACITORS		
C601,610	TANT 2.2uf, 10%, 25V	204 102 004
C602,605,611	MONO 1.0uf, 20%, 50V	204 118 014
C603,612,613,617,618	CERAMIC .01uf, 20%, 100V	204 049 001

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PCB ASSEMBLY, CLOCK/CONTROL (CONT'D) **201 146 001**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
CAPACITORS		
C604	CERAMIC 750pf, 10%, 1000V	204 079 050
C606	CERAMIC .0015uf, 10%, 1000V	204 079 059
C607,614,619,620	MONO 0.1uf, 20%, 100V	204 121 048
C608	MONO 33pf, 15%, 100V	204 200 007
C609,615,621,622	TANT 10.0uf, 10%, 25V	204 102 008
C616	MONO 1000pf, 15%, 100V	204 200 025
C623	MICA 82pf, 5%, 500V	204 300 033
INTEGRATED CIRCUITS		
U601,610,612,618,620	I.C. 4001B	210 210 001
U602	I.C. VOLTAGE COMP. 311	210 026 000
U603	I.C. COMPARATOR LM306	210 016 000
U605,613,616	I.C. 4023B	210 210 023
U606,609,619	I.C. 4011B	210 210 011
U622	I.C. 4093B	210 250 093
U607	I.C. 4025B	210 210 025
U608,614,617	I.C. 4049B	210 210 049
U611	I.C. 4066	210 200 022
U615	I.C. DUAL BINARY UP COUNTER	210 024 000
U621	I.C. LM324N	210 022 000
Q605	I.C. VOLTAGE REG., 12V	210 021 004
TRANSISTORS		
Q601,603	2N3906	239 047 000
Q602,604	2N3904	239 015 000
DIODES		
CR601,602	L.E.D. 555-2001	239 076 001
CR603	DIODE 1N5228	239 075 000
CR604-608	DIODE 1N4148	239 014 000

PCB ASSEMBLY, SENSE **201 148 001**

RESISTORS		
R801,802	TRIM POT 1K ohm, 20%, 1/2W	236 200 090
R803	TRIM POT 200 ohm, 20%, 1/2W	236 101 005
R804	TRIM POT 5K ohm, 20%, 1/2W	236 101 009
R805,806	TRIM POT 10K ohm, 20%, 1/2W	236 200 091

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PCB ASSEMBLY, SENSE (CONT'D) **201 148 001**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R807	CARBON 680 ohm, 5%, 1/4W	234 024 059
R841,855	CARBON 910 ohm, 5%, 1/4W	234 024 062
R808,875	CARBON 470 ohm, 5%, 1/4W	234 024 055
R809	METAL FILM 287 ohm, 1%, 1W, 500V	234 203 000
R810,818	CARBON 33K ohm, 5%, 1/4W	234 024 099
R811,823	CARBON .20Meg ohm, 5%, 1/4W	234 024 118
R812,824,853	CARBON 3.9K ohm, 5%, 1/4W	234 024 077
R813	CARBON 7.5K ohm, 5%, 1/4W	234 024 084
R814,820	CARBON 47K ohm, 5%, 1/4W	234 024 103
R815,819,876	CARBON 51K ohm, 5%, 1/4W	234 024 104
R816,870,871	CARBON 2.2K ohm, 5%, 1/4W	234 024 071
R817	CARBON 33 ohm, 5%, 1/4W	234 024 027
R821	METAL FILM 620 ohm, 2%, 2W, 500V	234 202 001
R822,840	CARBON 1.0K ohm, 5%, 1/4W	234 024 063
R825	CARBON 4.7K ohm, 5%, 1/4W	234 024 079
R827	METAL FILM 3.65K ohm, 1%, 1/8W	234 201 343
R826	CARBON 24K ohm, 5%, 1/4W	234 024 096
R828	METAL FILM 1.07K ohm, 1%, 1/8W	234 201 292
R829,857	METAL FILM 3.16K ohm, 1%, 1/8W	234 201 337
R830,872	METAL FILM 39K ohm, 2%, 2W, 500V	234 202 002
R831,834,837,839	CARBON 6.2K ohm, 5%, 1/4W	234 024 082
R832,838	CARBON 620 ohm, 5%, 1/4W	234 024 058
R833	CARBON 1.2K ohm, 5%, 1/4W	234 024 065
R835	METAL FILM 14K ohm, 1%, 1/8W	234 201 399
R836	CARBON 240 ohm, 5%, 1/4W	234 024 048
R842,856	METAL FILM 10.5K ohm, 1%, 1/8W	234 201 387
R843,861	CARBON 15 ohm, 5%, 1/4W	234 024 019
R844,867	METAL FILM 3.01K ohm, 1%, 1/8W	234 201 335
R845,862	METAL FILM 866 ohm, 1%, 1/8W	234 201 283
R846,848,864,866	METAL FILM 2.43K ohm, 1%, 1/8W	234 201 326
R847,865	METAL FILM 1.21K ohm, 1%, 1/8W	234 201 297
R849,868	CARBON 30K ohm, 5%, 1/4W	234 024 098
R850	CARBON 43 ohm, 5%, 1/4W	234 024 030
R851,869,873	CARBON 100 ohm, 5%, 1/4W	234 024 039
R852	CARBON 1.8K ohm, 5%, 1/4W	234 024 069
R854	CARBON 68K ohm, 5%, 1/4W	234 024 107
R858	CARBON 3.3K ohm, 5%, 1/4W	234 024 075
R859,860	METAL FILM 215 ohm, 1%, 1/8W	234 201 225
R863	CARBON 150 ohm, 5%, 1/4W	234 024 043
R874	CARBON 10 ohm, 5%, 1/4W	234 024 015

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PCB ASSEMBLY, SENSE (CONT'D) **201 148 001**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
CAPACITORS		
C801,809	TANT 10.0uf, 10%, 25V	204 102 008
C802,804,805,806,807 808,810,812,813,815 820,822,823,824,826,828	MONO 0.1uf, 20%, 50V	204 118 007
C803,814,816	MONO 100pf, 15%, 100V	204 200 013
C811	MONO 39pf, 15%, 100V	204 200 008
C821	MONO 33pf, 15%, 100V	204 200 007
C817,818,819,825	MONO 1.0uf, 20%, 50V	204 118 014
C827	CERAMIC 0.01uf, 20%, 100V	204 049 001
C829	MONO 0.33uf, 20%, 50V	204 118 011
C830	TANT 22uf, 20%, 25-35V	204 102 030
INTEGRATED CIRCUITS		
U801,803	I.C. TRANSISTOR ARRAY CA3046	210 100 007
U802,804	I.C. OPTOISOLATOR HCPL-2601	210 100 008
U805	I.C. QUAD AMP LM324N	210 022 000
U806,807	I.C. COMPARATOR LM306	210 016 000
U808	I.C QUAD SWITCH 4066	210 200 022
VR801	I.C. VOLTAGE REG. LM340LAZ-12	210 300 026
VR802,803	I.C. VOLTAGE REG. TL430C	210 300 012
TRANSISTORS		
Q801	MJE13006	239 100 016
Q802,803,804,808	2N3906	239 047 000
Q805,809	MPS-A42	239 300 022
Q806,807,810,811	MPS-2369	239 100 013
DIODES		
CR801,802,803,805, 806,807,808	DIODE 1N4148	239 014 000
CR809	RECTIFIER 1N4002	239 091 002
MISCELLANEOUS		
L801	INDUCTOR, 470uH	251 100 038
	HEATSINK #6072B	214 100 028
	HEATSINK, HAT #6071B	214 100 029

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PCB ASSEMBLY, DRIVER **201 150 000**

RESISTORS

R1001	TRIM POT 20K ohm, #3299X	236 010 008
R1002	CARBON 56 ohm, 5%, 1/4W	236 024 033
R1004,1013,1029,1030	CARBON 1.0K ohm, 5%, 1/4W	236 024 063
R1005	CARBON 4.7K ohm, 5%, 1/4W	234 024 079
R1006,1007	CARBON 10K ohm, 5%, 1/4W	234 024 087
R1008	FIXED 120 ohm, 5%, 1/2W	234 014 090
R1009,1021	CARBON 390 ohm, 10%, 1W	234 004 033
R1010	CARBON 470K ohm, 5%, 1W	234 022 127
R1011,1017	FIXED 2.7 ohm, 5%, 1/2W	234 014 030
R1012	CARBON 47 ohm, 5%, 2W	234 001 025
R1014	CARBON 22 ohm, 5%, 1/4W	234 024 023
R1015,1016,1024,1027	CARBON 100 ohm, 5%, 1/4W	234 024 039
R1018	CARBON 51 ohm, 5%, 1/4W	234 024 032
R1019,1020	CARBON 150 ohm, 10%, 1W	234 004 029
R1022	CARBON 47 ohm, 10%, 1W	234 004 001
R1023	FIXED 330 ohm, 5%, 1/2W	234 014 036
R1025	CARBON 22K ohm, 5%, 1/4W	234 024 095
R1026,1028	CARBON 680 ohm, 5%, 1/4W	234 024 059

CAPACITORS

C1001,1004,1007,1009,1010	CERAMIC 0.1uf, 20%, 25V	204 050 000
C1002	MICA 330pf, 5%, 500V	204 105 014
C1003,1005	TANT 22uf, 20%, 25-35V	204 102 030
C1006	MICA 2200pf, 5%, 500V	204 105 034
C1008	TANT 33uf, 10%, 35V	204 104 026
C1011	MONO 0.1uF, 20%, 50V	204 118 014

INTEGRATED CIRCUITS

U1001	I.C. VOLTAGE COMP. IC-311	210 026 000
U1002	I.C. TIMER NE555N	210 006 000
VR1001	I.C. VOLTAGE REG., 12V	210 021 004

TRANSISTORS

Q1001	2N4240	239 074 000
Q1002,1006	MM3724	239 052 000
Q1003,1004,1005,1007	2N2905A	239 019 000
Q1008	2N3906	239 047 000
Q1009,1010,1011	2N3904	239 015 000

DIODES

CR1001,1002	DIODE 1N4148	239 014 000
CR1003	DIODE 1N5234	239 068 000

MISCELLANEOUS

	HEATSINK	214 045 000

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PCB ASSEMBLY, STRIPLINE — **201 151 100**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R1101	WIRE WOUND .500 ohm, 5%, 5W	234 400 171
R1102,1103,1104	WIRE WOUND 1.5 ohm, 5%, 3W	234 400 238
R1105	WIRE WOUND 10 ohm, 1%, 3W	234 400 239
R1106,1107,1108	FIXED 56 ohm, 5%, 1/2W	234 014 084
R1114,1119	CARBON 100K ohm, 5%, 1/4W	234 024 111
R1115,1116	CARBON 10K ohm, 5%, 1/4W	234 024 087
R1117,1118	CARBON 51 ohm, 5%, 1/4W	234 024 032
TRANSISTORS		
Q1101,1102,1103	D45H2	239 030 000
Q1104,1105,1106	D44H2	239 045 002
Q1107,1108	VN10KM	239 200 012
DIODES		
CR1101	1N4148	239 014 000
CAPACITORS		
C1118	MICA 4700pf, 10%, 500V	204 105 042
C1103,1104,1105	POLY 15uf, 10%, 220V	204 400 130
C1106	CERAMIC .05uf, 20%, 600V	204 079 087
C1107,1108,1109	TANT 22uf, 20%, 25-35V	204 102 030
C1110,1111,1112	TANT 68uf, 10%, 25V	204 102 023
C1113,1114,1115	MONO .01uf, 20%, 100V	204 049 001
C1116,1117	MONO .033uf, 15%, 50V	204 200 105
RELAYS		
K1101, 1102	RELAY, HIGH VOLTAGE	230 006 018
K1103	RELAY, 4 POLE	230 007 002

PCB ASSEMBLY, MONOPOLAR DISPLAY — **201 156 100**

RESISTORS		
R1201,1202,1203,1204,	CARBON 330 ohm, 5%, 1/4W	234 024 051
R1208,1209,1210,1211	CARBON 150 ohm, 5%, 1/4W	234 024 043
R1205,1206	CARBON 15K ohm, 5%, 1/4W	234 024 091
R1207	CARBON 33K ohm, 5%, 1/4W	234 024 099
R1212,1213,1214,1215,1219	CARBON 100 ohm, 5%, 1/4W	234 024 039
R1216	FIXED 27 ohm, 5%, 1/2W	234 014 077
R1217	FIXED 18 ohm, 5%, 1/2W	234 014 073
R1218	FIXED 33 ohm, 5%, 1/2W	234 014 078

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PCB ASSEMBLY, MONOPOLAR DISPLAY (CONT'D) **201 156 100**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTOR ARRAYS		
RA1201	22 ohm	234 100 095
RA1202,1203	1000 ohm	234 100 096
CAPACITORS		
C1201,1202,1203	MONO .01mf, 20%, 50V	204 118 001
C1204	MONO 0.1uf, 20%, 50V	204 118 007
INTEGRATED CIRCUITS		
U1201,1202,1207	I.C. 2803A	210 800 002
U1203	I.C. 2585A	210 800 001
U1204	I.C. 4532B	210 210 532
U1205	I.C. 4011B	210 210 011
U1206	I.C. 4724B	210 210 724
DIODES		
CR1201-1205	DIODE 1N4148	239 014 000
CRA1201,1202	DIODE ARRAY TND903	239 500 000
DS1201	L.E.D. ARRAY HLMP2720	239 750 022
DS1202,1203,1204,1210, 1211,1212	L.E.D. DISPLAY HD11050	239 750 028
DS1205,1213	LAMP, PTL 20D/12	215 200 070
DS1206,1207	L.E.D. ARRAY HLMP2635	239 750 023
DS1208,1209	LAMP, PSBL 7373	215 200 073

PCB ASSEMBLY, BIPOLAR DISPLAY **201 157 001**

DS1301,1302	LAMP, PSBL 7373	215 200 073
DS1303	LAMP, PTL 6/12	215 200 071
DS1304,1305	L.E.D. DISPLAY HD11050	239 750 028

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PCB ASSEMBLY, SNUBBER — **201 166 200**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R2101	WIRE WOUND 150ohm, 5%, 20W	234 023 012
CAPACITORS		
C2101	MICA 1200pf, 5%, 500V	204 105 028
C2102	CERAMIC .0022uf, 20%, 6000V	204 025 044

PCB ASSEMBLY, ISO FOOTSWITCH — **201 171 000**

RESISTORS		
R501	FIXED 10ohm, 5%, 1/2W	234 014 068
R502	CARBON 2.2Kohm, 5%, 1/4W	234 024 071
R503	CARBON 510ohm, 5%, 1/4W	234 024 056
R504,505,506	CARBON 330ohm, 5%, 1/4W	234 024 051
R507,508,516	FIXED 10Kohm, 5%, 1/4W	234 024 087
R509,510,511	FIXED 33Kohm, 5%, 1/4W	234 024 099
R512	FIXED 1Kohm, 5%, 1/2W	234 014 001
R513,514,515	FIXED 1Kohm, 5%, 1/4W	234 024 063
R517	CARBON 100ohm, 5%, 1/4W	234 024 039
CAPACITORS		
C501,504	TANT 10uf, 10%, 25V	204 102 008
C502,508	MONO .015mf, 20%, 50V	204 118 002
C503	MONO .047mf, 20%, 50V	204 118 005
TRANSISTORS		
Q501	2N3906	239 047 000
Q502	2N3904	239 015 000
Q503	2N3568	239 017 000
DIODES		
CR501	DIODE 1N4148	239 014 000
MISCELLANEOUS		
T501	TRANSFORMER, TOROID	251 300 000
OPT 501,502,503,504	PHOTO ISOLATOR OPI 12648	239 750 019

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PCB ASSEMBLY, SOFT START — **201 129 000**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R1	WIRE WOUND 5ohm, 5%, 11W	234 018 008
R2	WIRE WOUND 18Kohm, 5%, 5W	234 027 130
R3	CARBON 68Kohm, 5%, 1/4W	234 024 107
CAPACITORS		
C1	ELECT 33uf, 25V	204 500 060
DIODES		
CR1	RECTIFIER 1N4005	239 091 005
CR2	ZENER 1N960	239 600 040
CR3	ZENER 1N969	239 600 041

PCB ASSEMBLY, POWER SUPPLY CONTROLLER — **201 167 201**

RESISTORS		
R2001,2002,2004,2005	FIXED 130ohm, 5%, 1/2W	234 014 020
R2003	ENAMEL 225ohm, 5%, 10W	234 030 212
R2006,2027,2041	CARBON 5.6Kohm, 5%, 1/4W	234 024 081
R2007,2011,2014,2021,2055 2046, 2033,2034,2068,2067	CARBON 1.0Kohm, 5%, 1/4W	234 024 063
R2008	METAL FILM 4.12Kohm, 1%, 1/8W	234 201 348
R2009,2013,2022,2025 2031,2045,2047,2029	CARBON 10Kohm, 5%, 1/4W	234 024 087
R2010,2043	TRIM POT 20Kohm	236 200 080
R2012	CARBON 20Kohm, 5%, 1/4W	234 024 094
R2015	CARBON 11Kohm, 5%, 1/4W	234 024 088
R2016	CARBON 120Kohm, 5%, 1/4W	234 024 113
R2017	CARBON 6.2Kohm, 5%, 1/4W	234 024 082
R2018	CARBON 18Meg ohm, 5%, 1/4W	234 024 164
R2019,2039,2040	CARBON 10ohm, 5%, 1/4W	234 024 015
R2020	CARBON 100Kohm, 5%, 1/4W	234 024 111
R2023,2062	METAL FILM 7.5Kohm, 1%, 1/8W	234 201 373
R2024	METAL FILM 4.22Kohm, 1%, 1/8W	234 201 349
R2026	CARBON 5.1Kohm, 5%, 1/4W	234 024 080
R2028,2030	FIXED 200Kohm, 5%, 1/4W	234 024 118
R2032	FIXED 33ohm, 5%, 1/2W	234 014 078
R2035	CARBON 16Kohm, 5%, 1/4W	234 024 092

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PCB ASSEMBLY, POWER SUPPLY CONTROLLER 201 167 201

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS CONT'D		
R2036,2037,2061	PWR RESIST. 1ohm, 3%, 3W	234 028 001
R2038,2060	CARBON 100ohm, 5%, 1/4W	234 024 039
R2042	CARBON 56ohm, 5%, 1/4W	234 024 033
R2044	CARBON 75Kohm, 5%, 1/4W	234 024 108
R2048	CARBON 2.7Kohm, 5%, 1/4W	234 024 073
R2049	FIXED 150ohm, 5%, 1/4W	234 024 043
R2050	CARBON 56ohm, 5%, 1W	234 022 033
R2051	CARBON 2.2Kohm, 5%, 1/4W	234 024 071
R2052	CARBON 51Kohm, 5%, 1/4W	234 024 104
R2053	FIXED 240ohm, 5%, 1/4W	234 024 048
R2054	CARBON 3.9Kohm, 5%, 1/4W	234 024 077
R2056	CARBON 330ohm, 5%, 1/4W	234 024 051
R2057	CARBON 6.8Kohm, 5%, 1/4W	234 024 083
R2058,2059	TRIM POT 200ohm	236 200 074
R2063	METAL FILM 10.5Kohm, 1%, 1/8W	234 201 387
R2064	METAL FILM 13Kohm, 1%, 1/8W	234 201 396
R2065	METAL FILM 39.2Kohm, 1%, 1/8W	234 201 442
R2066	CARBON 3.9 ohm, 5%, 1/4W	234 024 005
CAPACITORS		
C2001	FILM 2uf, 400V	204 400 001
C2002	METAL, POLY 1.0uf, 10%, 250V	204 400 136
C2003	MICA 820pf, 5%, 500V	204 300 057
C2004,2006,2007,2015 2020,2024,2029,2031,2038	MONO .1uf, 20%, 50V	204 118 007
C2005	MICA 62pf, 5%, 500V	204 300 030
C2008	MICA 620pf, 5%, 300V	204 106 037
C2009	TANT 1.5uf, 10%, 50V	204 103 015
C2010,2011,2039	TANT 68uf, 10%, 25V	204 102 023
C2012,2013	TANT 220uf, 10%, 10V	204 600 020
C2014	ELECT 1500mf, 16V	204 500 085
C2016,2018,2021 2023,2025,2033	MONO .01mf, 20%, 50V	204 118 001
C2017	MONO .33uf, 20%, 50V	204 118 011
C2019,2022,2026 2030,2037	MONO CERAMIC 1000pf, 15%, 100V	204 200 025
C2028,2032	MONO 1.0uf, 20%, 50V	204 118 014
C2034	MONO .033uf, 20%, 50V	204 118 004
C2036	MICA 390pf, 10%, 500V	204 105 016
C2040	CERAMIC 240pf, 10%, 600V	204 079 033

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PCB ASSEMBLY, POWER SUPPLY CONTROLLER (CONT'D) 201 167 201

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
INTEGRATED CIRCUITS		
U2001	I.C. QUAD AMP LM324N	210 022 000
U2002	I.C. LM358AN	210 300 013
U2003	I.C. TL594, UC494	210 300 021
U2004	I.C. MC 3423	210 300 065
U2005	I.C. LM311N	210 026 000
U2006	I.C. MA78S40PC	210 300 025
TRANSISTORS		
Q2001	2N3568	239 017 000
Q2002	2N2905A	239 019 000
Q2003	D44H11	239 045 008
Q2004	D45C6	239 046 000
Q2005	2N3904	239 015 000
Q2010, 2011	MPS-U45	239 100 002
Q2012, 2013	MPS-U95	239 078 000
DIODES		
CR2001, 2002, 2004, 2008	DIODE 1N4148	239 014 000
CR2003	DIODE MR821	239 066 002
CR2005	DIODE 1N5249	239 600 002
CR2006	ZENER 1N5242	239 077 000
CR2009	DIODE 1N5228	239 075 000
CR2010	DIODE 1N5820	239 700 020
MISCELLANEOUS		
SCR2001, 2002	RECTIFIER 2N6394	239 083 001
L2001	INDUCER 142uH	251 100 068
T2001	TRANSFORMER	251 300 004

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POWER SUPPLY MODULE **202 701 078**

REFERENCE DESIGNATION	DESCRIPTION	VALLEYLAB PART NUMBER
RESISTORS		
R1	WIRE WOUND 20K ohm, 5%, 8W	234 000 017
CAPACITORS		
C1	TYPE 86F500 4.9Kuf, 50V	204 117 065
C2	TYPE 86F500 8Kuf, 30V	204 117 047
C3	TANT 1.5uf, 10%, 50V	204 103 015
C4	TANT 4.7uf, 20%, 35V	204 104 046
C5	ELECT 1100uf, 450V	204 119 150
DIODES		
CR1	RECTIFIER SCAJ2	239 079 003
CR2	BRIDGE RECTIFIER VS247	239 006 000
CR3	RECTIFIER MDA3504	239 700 003
CR4	BRIDGE RECTIFIER S10A60FRAC	239 700 010
TRANSFORMERS		
T1	WIRED ASSEMBLY	251 200 014
T2	PREPARED ASSEMBLY	251 200 013
FUSES		
F1	.75 AMP, 3AG	215 005 031
F2	6 AMP	215 005 039
MISCELLANEOUS		
U1	REGULATOR LM345K-5.0, 5V	239 300 015
CB1	CIRCUIT BREAKER, 15 AMP	243 100 011
L1	INDUCTOR #T-0403, .75mH	251 039 000
L2	INDUCTOR .35mH	251 100 013

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SECTION 11

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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.

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