Operator & Service Manual

Sabre® 2400

ELECTROSURGICAL UNIT

ConMed® CORPORATION

LIMITED WARRANTY

For a period of two years following the date of delivery, CONMED Corporation warrants the Sabre 2400 Electrosurgical Unit against any defects in material or workmanship and will repair or replace (at CONMED's option) the same without charge, provided that routine maintenance as specified in this manual has been performed using replacement parts approved by CONMED. This warranty is void if the product is used in a manner or for purposes other than intended.

This device contains components which will be damaged by static electricity. Proper handling by a grounded person is mandatory. CONMED will provide assistance if needed in safeguard precautions necessary to avoid any question of warranty responsibility.

U.S. Patent Nos. 4,569,345 - 4,617,927 - 4,848,335 - 4,961,739 and other patents pending.

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The revision level of this manual is specified by the highest revision letter found on either the inside front cover or enclosed errata pages (if any).

Manual Number 60-5601-002 Rev. AA

Unit Serial Number ____________________________

Sabre® 2400
ELECTROSURGICAL UNIT

Table of Contents

& List of Illustrations

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General Information

Section 1.0

The Sabre 2400 electrosurgical unit has been designed to provide a broad range of electrosurgical capabilities in a single unit. This unit fulfills the needs of the modern operating room by providing monopolar cutting and coagulation capabilities for the most demanding procedures, and bipolar coagulation. Features of this unit include:

• ASPEN RETURN MONITOR: the Aspen Return Monitor (A.R.M.) provides an extra margin of safety against possible patient burns at the site of the dispersive electrode. The Resistance Indicator displays the resistance of the patient measured between the conductive contacts of the return electrode. This information can be used by the operating room staff to note high risk patients and to indicate a loss of electrode contact with the patient. It will also detect a return electrode that is open or shorted. Microprocessor-controlled circuitry prevents the unit from monopolar activation when patient resistance is outside the expected range and when a return cable is defective.

• Isolated Output Circuitry: this feature minimizes the probability of alternate ground site burns.

• Independent Outputs: the operation of one or two outputs will result in the supply of RF energy to only the active accessories.

• Circuit Redundancy: this feature, in conjunction with a fault tolerant design, provides a wide safety margin against catastrophic failures.

• Microprocessor Control: this feature provides the user with a superior degree of safety and control in solid state electrosurgery. The programmed intelligence of the microprocessor has been exploited to provide accurate, therapeutic power, digital power display, microprocessor aided calibration, and a comprehensive set of internal diagnostics which continually guard against the consequences of an internal failure. Internal fault isolation simplifies troubleshooting to ensure a minimum delay in returning the unit to service.

• Standard Coagulation: Monopolar Coagulation mode. The Sabre 2400 is highly effective in the most demanding electrosurgical applications, including underwater coagulation.

• Bipolar: the Sabre 2400 Bipolar Coagulation mode is optimized for effective, fast, nonsticking performance.

• Hand Switchable Bipolar Operation.

• Presets: the Sabre 2400 features nine computer memory locations for commonly used electrosurgical settings. Each memory location stores the operating mode, the power setting, the pad type, and the sound volume setting. In addition, the Sabre 2400 stores the last active settings prior to power down in the "P" memory location. This feature is useful when the previous Sabre 2400 settings are required.

• Instructions on Top Cover: an abbreviated instruction set is printed on the top cover of the Sabre 2400 for quick reference.

• Simplified Controls: the user may command the full range of capabilities of the Sabre 2400 by means of a few easily understood controls. Since Monopolar Cut, Monopolar Coagulation, and Bipolar modes are totally independent, the surgeon is free to switch between modes at will, freeing the O.R. staff for other tasks.

• Rugged, High Efficiency Circuitry: the Sabre 2400 delivers full power with cool, long-life operation. There are no fans to compromise the sterile field.

• Circuit Protection: microprocessor-controlled monitoring and shutdown of circuit functions, individually fused output transistors, thermally fused short circuit proof power transformer and a double pole circuit breaker for power line protection, all contribute to increased circuit protection.

• Ease of Maintenance: to minimize the maintenance effort, the Sabre 2400 features easy access, handtool-replaceable power transistors, and microprocessor aided fault isolation and troubleshooting aids.

• Microprocessor-Aided Calibration: microprocessor aided calibration procedure uses state of the art EEPROM, digital displays, and up/down keys to easily calibrate the Sabre 2400. There are no potentiometers or selected parts used in the Sabre 2400.

• Mounting Flexibility: the Sabre 2400 is designed to be placed on any suitable table top surface, or it may be secured to the top of a matching cart.

• Ease of Handling: low profile, front handle, and a cord wrap on the cart provide easy handling.

1.1 PRECAUTIONS

The safe and effective use of electrosurgery is dependent, to a large extent, upon factors under the control of the operator, and not entirely controllable by the design of this equipment. It is important that the instructions supplied with this equipment be read, understood, and followed in order that safety and effectiveness be enhanced.

1.1.1 Precautions in Equipment Preparation

• Visually inspect all accessories before each use to verify the integrity of insulation and the absence of obvious defects.

• The Sabre 2400 is equipped to connect three monopolar accessories at one time for the convenience of the surgical staff. Despite the fact that the Sabre 2400 will deliver power to only the commanded electrodes, unused accessories that are connected should be stowed in a safe, insulated place such as a nonconductive holster or test tube. Accessories should not be connected unless it is known that they will be needed.

• This unit is equipped with a hospital grade, 3 prong, power connector that meets all of the requirements for safe grounding of the unit. The user should verify that the power receptacle and cord used with this unit are properly grounded and correctly polarized. Do not use ground cheater plugs or extension cords.

• Do not place liquid containers on top of the unit. Wipe spilled liquids off the unit immediately. To prevent inadvertent entry of liquids, do not operate this unit except in its normal position.

• Verify that the return electrode cable is connected to the appropriate return electrode connection.

• Do not reuse disposable (single use) accessories.

• Do not use cords as handles; damage to the insulation and increased risk of burns or other injury may result.

• Use only suitable accessories (cables, footswitches, active and neutral electrodes, etc.) in order to avoid incompatibility and unsafe operation. Refer to the “IEC Recognized Accessory List”, CONMED part number 60-5206-001 for suitable accessories supplied by CONMED/Aspen Labs.

1.1.2 Precautions in Patient Preparation

• Electrosurgery should NEVER be performed in the presence of flammable anesthetics, flammable prep solutions, or in oxygen-enriched environments. The risk of igniting flammable gases or other materials is inherent in electrosurgery and cannot be eliminated by device design. Precautions must be taken to restrict flammable materials and substances from the electrosurgical site, whether they are present in the form of an anesthetic or skin preparation agent, or are produced by natural processes within body cavities, or originate in surgical drapes or other materials. There is a risk of pooling of flammable solutions in body depressions such as the umbilicus and in body cavities, such as the vagina. Any excess fluid pooled in these areas should be removed before the equipment is used. Due to the danger of ignition of endogenous gases, the bowel should be purged and filled with non-flammable gas prior to abdominal surgery.

• This unit is equipped with the Aspen Return Monitor (A.R.M.) which verifies that the return electrode cable is unbroken and connected to the return electrode and to the electrosurgical unit when in Single Pad mode. It DOES NOT verify that a single pad return electrode is in contact with the patient. When in Dual Pad mode, the A.R.M. confirms that the total resistance is in the expected range. Do not depend solely on the Resistance Indicator in the Dual Pad mode. Proper application and visual inspection are required for safe operation.

• The use and proper placement of a return electrode is a key element in the safe and effective use of electrosurgery in monopolar procedures, particularly in the prevention of burns. Follow directions and recommended practices for the preparation, placement, use, surveillance, and removal of any return electrode supplied for use with this electrosurgical unit.

• Apply the return electrode to a clean-shaven surface of the patient that is thoroughly clean and dry. Avoid placement on scar tissue, bony prominences or other areas where pressure points on small areas might develop.

• Because of the risk of burns, needles should never be used as return electrodes for electrosurgery. Return electrodes should be placed such that as much of their conductive area as possible is in firm contact with an area of the patients' body that has a good blood supply and as close to the operative site as is practical. Adhesive-type return electrodes should be reliably attached with their entire area in contact with the patients' body.

• In general, electrosurgical current paths should be as short as possible and should run either longitudinally or in a diagonal direction to the body, not laterally and under no circumstances lateral to the thorax.

• Electrodes and probes of monitoring, stimulating, and imaging devices can provide paths for high frequency currents even if they are battery powered, insulated, or isolated at 60 Hz. The risk of burns can be reduced but not eliminated by placing the electrodes of probes as far away as possible from the electrosurgical site and the return electrode. Protective impedances incorporated in the monitoring leads may further reduce the risk of these burns. Needles should not be used as monitoring electrodes during electrosurgical procedures.

• The active electrode should not be used in the vicinity of electrocardiograph electrodes.

• Heat applied by thermal blankets or other sources is cumulative with the heat produced at the return electrode (caused by electrosurgical currents). Risk of a patient injury may be minimized by choosing a dispersive electrode site that is remote from other heat sources.

• When using injection cannulas as electrocardiograph electrodes, the metal cone must not be placed on the skin; this also applies to the leads to monitoring instruments.

• During the use of this RF isolated output unit, the patient should not be allowed to come in contact with metal parts that are grounded or other conductive surfaces that have an appreciable capacitance to ground. This will minimize the possibility of localized burns resulting from stray electrosurgical currents to the ground.

• Skin to skin contacts, such as between the arm and the body of a patient, should be avoided, by the insertion of a cloth.

• The use of electrosurgery on patients with cardiac pacemakers or pacemaker electrodes is potentially hazardous because the pacemaker may be irreparably damaged and/or the high frequency energy of the electrosurgical output may interfere with the action of the pacemaker and ventricular fibrillation may occur. Precautions should be taken to ensure that the patient's well-being is maintained in the event of such interference. We recommend that the Cardiology Department and the manufacturer of the pacemaker be consulted for advice before operating on a patient with a pacemaker. These precautions also apply to operating room personnel with cardiac pacemakers.

• To minimize the possibility of cardiac pacemaker interference, place the return electrode such that the electrosurgical current path is as near perpendicular as possible to the pacer lead.

1.1.3 Precautions in Use

• Do not use monopolar electrosurgery on small appendages, as in circumcision or finger surgery, as it can cause thrombosis and other unintended injury to tissue proximal to the surgical site. Please note ANSI/AAMI Standard HF-18-1993 which currently contraindicates both monopolar and bipolar electrosurgery for circumcisions.

Urologic literature also contraindicates the use of monopolar electrosurgery for circumcision, and instead recommends the use of bipolar electrosurgery where clinically indicated for hemostasis. Physicians choosing to use bipolar electrosurgery for circumcisions should be trained in this technique and knowledgeable of the effects of electrosurgery on tissue of this nature.

Should you decide that the bipolar electrosurgical technique is acceptable for circumcision, do not apply the bipolar electrosurgical current directly to circumcision clamps.

• Apparent low power output or failure of the electrosurgical equipment to function correctly at otherwise normal settings may indicate faulty application of the return electrode, failure of an electrical lead, or excessive accumulation of tissue on the active electrode. Do not increase power output before checking for obvious defects or misapplication. Check for effective contact of the return electrode to the patient anytime that the patient is moved after initial application of the return electrode.

• If a Dual Pad RETURN MONITOR Alarm is sounded intraoperatively, visually confirm proper return electrode attachment to the patient prior to pressing the MONITOR SET Key.

• Electrosurgical leads should not be allowed to contact the patient, staff, or other leads connected to the patient.

• The output power selected should be as low as possible and activation times should be as short as possible for the intended purpose.

• When uncertain of the proper control setting for the power level in a given procedure, start with a low setting and increase as required and/or consult the factory.

• Observe all caution and warning notices printed on the cover of the unit.

• The operating room staff should never contact electrosurgical electrodes (either active or dispersive) while the RF output of the unit is energized.

• The tips of recently activated accessories may be hot enough to burn the patient or ignite surgical drapes or other flammable material. Wait a few seconds after activation for the tip to cool, then place the accessory into a pencil holster.

• Interference produced by the operation of this unit may adversely influence the operation of other electronic equipment.

1.1.4 Precautions When Testing or Servicing

• This electrosurgical unit should be tested by qualified maintenance personnel on a periodic basis to ensure proper and safe operation. We suggest examination of the unit at least every six months.

• Refer all servicing to qualified personnel. Your CONMED representative will be happy to assist you in getting your equipment serviced.

• High voltages are developed within the unit that are accessible when the top cover is removed. These voltages are potentially dangerous and should be treated with extreme caution.

• The high voltage dc power supply in the Sabre 2400 is equipped with a bleeder resistor to dissipate the charge on the filter capacitor. When the red L.E.D. on the A1 Power/Output Board is lit, high voltage is present, and caution must be used during servicing.

• Never remove or install any parts with power on.

• Avoid contact with the output leads when the unit is activated. Periodically inspect the test leads used for the output connections for obvious defects.

• Although this unit will withstand momentary short circuits on the output, prolonged short circuits may damage the unit. Short circuiting the output should be avoided since it is neither necessary nor desirable.

• Since the clinical use of electrosurgical units is intermittent in nature with duty cycles on the order of 10%, this unit is not designed to operate for extended periods of continuous output. When testing, it is recommended that duty cycles be limited to 15 seconds on, 30 seconds idle.

• Life of the equipment will be extended by minimizing operating temperature and extreme thermal cycles.

• The heat dissipation capability of the heat sink is severely impaired by activating the Sabre 2400 in other than its normal operating position. There are no tests requiring operation in any other position.

• Consult the factory for advice before making any modifications to the unit.

• Ensure that the two top cover screws are tightened before returning the unit to service.

1.2 SPECIFICATIONS

INPUT POWER (All Units 700W max 50/60 Hz)

	Mains Voltage VRMS				Mains Current ARMS
Catalog Number	Nominal	Minimum	Maximum	Nominal Idle	Maximum Nominal line (Cut 300W)
60-5600-002	120	104	127	0.8	7.0
60-5600-003	100	90	110	1.0	8.4
60-5600-004	220	198	242	0.5	3.8
60-5600-005	240	216	264	0.4	3.5
60-5600-015	230-240	207	264	0.5	3.7

Classifications: IEC 601-2-2, Class 1
IEC 601-1-2

LINE FREQUENCY LEAKAGE: (Per UL 544) at 120 V, 60 Hz
Patient Connections to Neutral: Less than 10 uA typical
Chassis to Neutral: Less than 25 uA typical

IEC CLASS 1, TYPE CF, Defibrillator Proof

POWER DISPLAY ACCURACY: The greater of +/- 10% of display or +/-5 watts at rated load.

OPERATING FREQUENCY (fundamental):
Pure Cut: 416.7 KHz +/- 0.01%
Blend Cut: 416.7 KHz +/- 0.01%
Coag: 520 KHz +/- 10% unloaded
Bipolar Coag: 1.05 MHz +/-2%

PULSE REPETITION FREQUENCY:
Blend: 20 KHz +/-0.01%
Coag: 25.0 KHz +/-0.01%
Bipolar: 20.0 KHz +/-0.01%

LINE REGULATION: Power change < 1%/V

$$= \frac{(P_{max} - P_{min})}{P_{set}\,(V_{max} - V_{min})} \times 100\%$$

RF LEAKAGE CURRENT:
Monopolar - 100mA max. per AAMI HF18-1993 Clause 4.2.10.1 and IEC 601-2-2 Clause 19.102

Models 60-5600-003 and 60-5600-015 additionally are 150mA max. with accessories per IEC 601-2-2 Clause 19.101 b) when used with approved accessories. See CONMED “IEC Recognized Electrosurgical Accessories” list, Cat. No. 60-5206-001.

Bipolar - Less than 1% per
IEC 601-2-2 Clause 19.101 c)

RF Floating (Isolated)

POWER DECREASE: 1% typical, Pure Cut at 150W, 20 seconds.

SINGLE FOIL RETURN ELECTRODE MONITOR:
Two wire continuity detector, typical threshold = 10 ohms.

DUAL FOIL RETURN ELECTRODE MONITOR: Two wire resistance monitor, typical acceptance range 10 to 150 ohms, trip threshold typically 20% higher than last SET POINT activation, visual indication of patient resistance.

COOLING: Natural convection, conduction and radiation. No Fan.

SOUND FREQUENCIES:

INDICATOR TONE	60-5600-002, -004, -005 FREQUENCY (Hz)	60-5600-003, -015 FREQUENCY (Hz)
CUT ACTIVATION	500	492
COAG ACTIVATION	250	450
RETURN FAULT ALARM	1000	1147
MACHINE FAULT	1000	1147
CROSS KEY	1700	1700

OPERATING MODES AND NOMINAL OUTPUT PARAMETERS

MODE	MAX. POWER (WATTS)	LOAD RESISTANCE (OHMS)	CREST FACTOR	MAX. OPEN CIRCUIT VOLT P-P
MONO PURE CUT	300	300	1.8	2000
MONO BLEND	180	300	2.5	2200
MONO COAG	120	500	7.0	9000
BIPOLAR COAG	50	50	1.5-12.1*	280

*(Bipolar Coag crest factor decreases as power setting increases.)

CONTROLS:

Monopolar Cut Power Increase Key:	Gray UP push button
Monopolar Cut Power Decrease Key:	Gray DOWN push button
Monopolar Pure Mode Select Key:	Gray push button
Monopolar Blend Mode Select Key:	Gray push button
Monopolar Coag Power Increase Key:	Gray UP push button
Monopolar Coag Power Decrease Key:	Gray DOWN push button
Bipolar Power Increase Key:	Gray UP push button
Bipolar Power Decrease Key:	Gray DOWN push button
Single Pad Select:	Gray push button
Dual Pad Select:	Gray push button
Monitor Set Point Key:	Gray push button
Volume Increase Key:	Gray button
Volume Decrease Key:	Gray button
Circuit Breaker:	Lighted rocker switch
Preset Select ("SEL")	Gray push button
Preset Store	Gray push button

INDICATORS:

Monopolar Cut Mode Indicator:	Yellow LED
Monopolar Coag Mode Indicator:	Blue Incandescent Light
Bipolar Mode Indicator:	Blue Incandescent Light
Monopolar Cut Power Digital Display:	Red LED digital displays
Monopolar Coag Power Digital Display:	Red LED digital displays
Bipolar Power Digital Display:	Red LED digital displays
Return Monitor Indicator:	Red LED
Resistance Indicator:	Green LED bar graph
Return Monitor Dual Pad Indicator:	Green LED
Return Monitor Single Pad Indicator:	Green LED
Monopolar Cut Mode Select:	Yellow LED
Power Line Breaker:	Green light
Preset Memory Location	Red LED digital display

CONNECTIONS:

Monopolar Foot Switch Connector:	Threaded, 4 Pin
Bipolar Foot Switch Connector:	Threaded, 3 Pin
Two Pin Return Electrode Jack:	A.R.M. and REM™ compatible connector
Bipolar Accessory Jacks:	Two blue banana jacks for RF output, plus black miniature banana jack referenced to bottom blue jack for handswitched bipolar operation.
Hand Switchable Monopolar Accessory Jack:	Two sets of 3 banana jacks (two black and one red)
Foot Switch Controlled Monopolar Accessory Jack:	Bovie #12 Standard Active

NORMAL USE & ENVIRONMENTAL RESTRICTIONS:

Drip-proof equipment, IPX1
Equipment not suitable for use in the presence of a flammable anaesthetic mixture with air or with oxygen or nitrous oxide.

Continuous operation with intermittent loading, Duty Cycle 15s on / 30s off.
Operating Ambient temperature range +10° C to +40° C
Relative Humidity 30% to 75%
Altitude -60 to +4500 meters (-197 to +14,760 feet) above Sea Level.
Mounting Restriction: 2 inch (5cm) clearance required on each side of unit for cooling.

SHIPPING AND STORAGE ENVIRONMENTAL RESTRICTIONS:

-40° C to +70° C; 10% to 95% Relative Humidity when sealed in original polybag, packing material and shipping carton.

REGULATORY CERTIFICATION:

UL Listed, Medical and Dental Equipment (E68077)
ISO 9002: 1994 Registered Facility

CE

POWER CORD: AWG 16-3 Yellow, Type ST, 15' 6" (4.7 M) [-002 model only]

WEIGHT: 32 lb. (14.5 Kg)
HEIGHT: 6.75 inches (17.1 cm)
WIDTH: 14.25 inches (36.2 cm)
DEPTH: 21.5 inches (54.6 cm)

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

REM™ is a trademark of Valleylab, Inc.

1.3 EXPLANATION OF SYMBOLS

CUT

PURE CUT WAVEFORM WITH MINIMUM THERMAL DAMAGE AND HEMOSTASIS

BLEND CUT WAVEFORM WITH HEMOSTASIS

STANDARD MONOPOLAR COAGULATION

SINGLE FOIL-USED WITH ELECTRODES THAT DO NOT MONITOR CONTACT QUALITY

DUAL FOIL-SETS MONITOR TO USE ELECTRODES THAT DO MONITOR CONTACT QUALITY

BIPOLAR COAGULATION

DECREASE VOLUME SETTING

INCREASE VOLUME SETTING

REPLACE FUSE ONLY WITH TYPE AND RATING AS SHOWN

PROTECTIVE EARTH (INLET CONNECTOR)

HIGH VOLTAGE CIRCUITRY

CAUTION - HIGH VOLTAGE INSIDE REFER SERVICING TO QUALIFIED PERSONNEL

IPX1 ENCLOSURE RESISTS ENTRY OF VERTICALLY FALLING WATER

HANDSWITCHED OUTPUT-CONNECTION FOR HANDSWITCHED MONOPOLAR ACCESSORIES

FOOTSWITCHED OUTPUT-CONNECTION FOR FOOTSWITCHED MONOPOLAR ACCESSORIES

HIGH VOLTAGE OUTPUTS

BIPOLAR OUTPUT-CONNECTION FOR BIPOLAR ACCESSORIES

HANDSWITCHED BIPOLAR OUTPUT

FOOTSWITCHED BIPOLAR OUTPUT

TYPE CF-PATIENT CONNECTIONS ARE ISOLATED FROM EARTH AND RESIST THE EFFECTS OF DEFIBRILLATOR DISCHARGE

RETURN ELECTRODE-CONNECTION FOR MONOPOLAR DISPERSIVE ELECTRODE

F RF ISOLATED-PATIENT CONNECTIONS ARE ISOLATED FROM EARTH AT HIGH FREQUENCY

CONSULT ACCOMPANYING DOCUMENTS PRIOR TO PLACING EQUIPMENT IN SERVICE

EXPLOSION RISK IF USED WITH FLAMMABLE ANESTHETICS

THIS EQUIPMENT INTENTIONALLY SUPPLIES NON-IONIZING RF ENERGY FOR PHYSIOLOGICAL EFFECT.

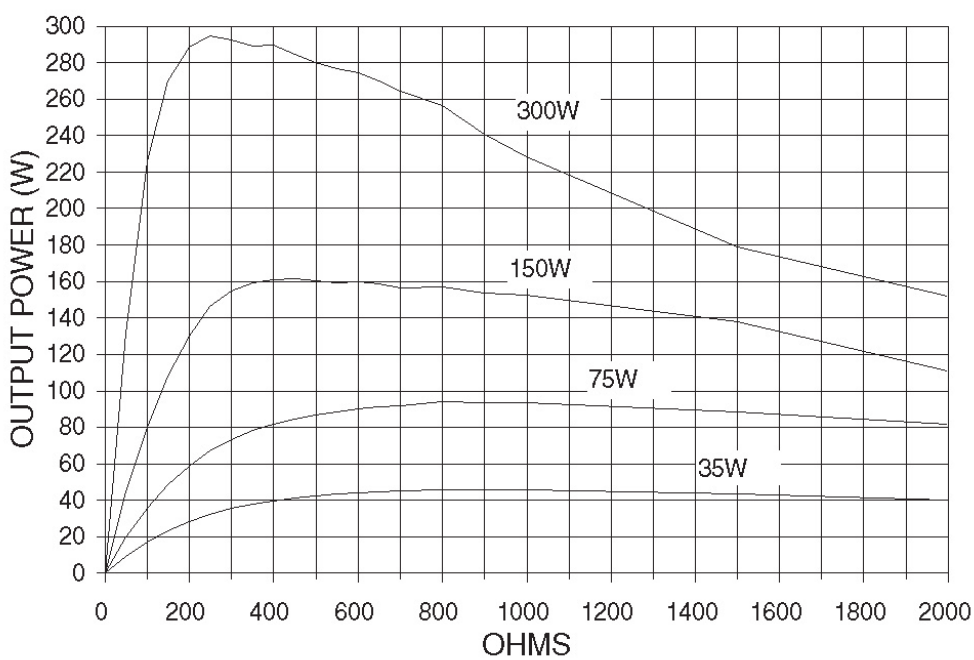

Figure 1.1 Pure Cut Load Regulation

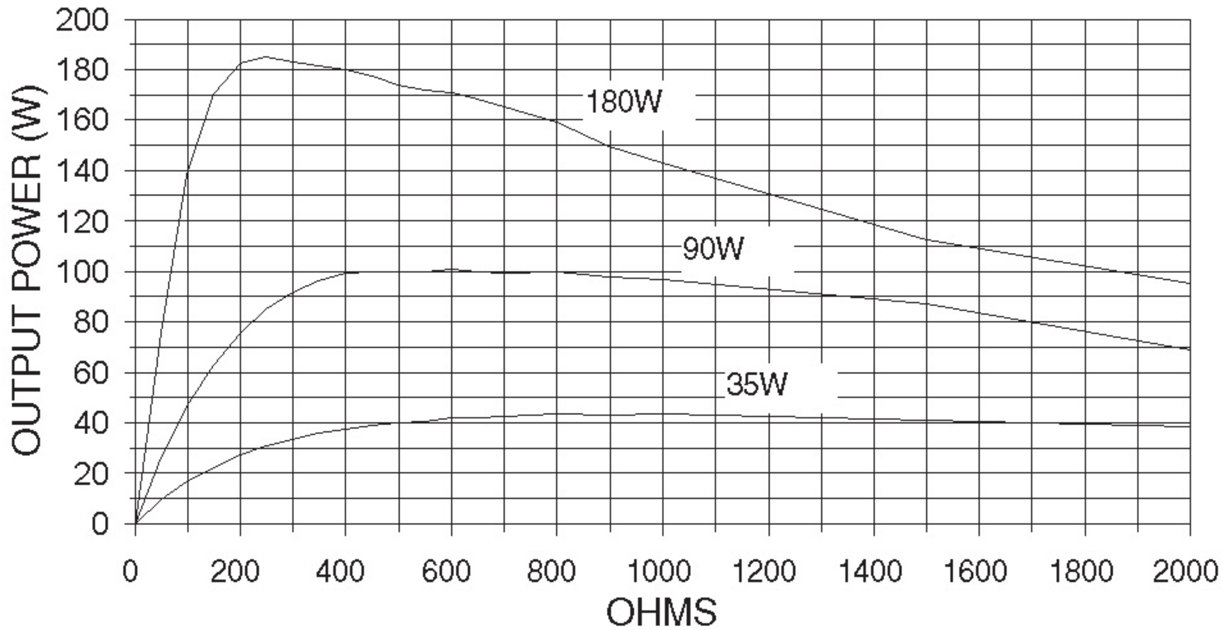

Figure 1.2 Blend Cut Load Regulation

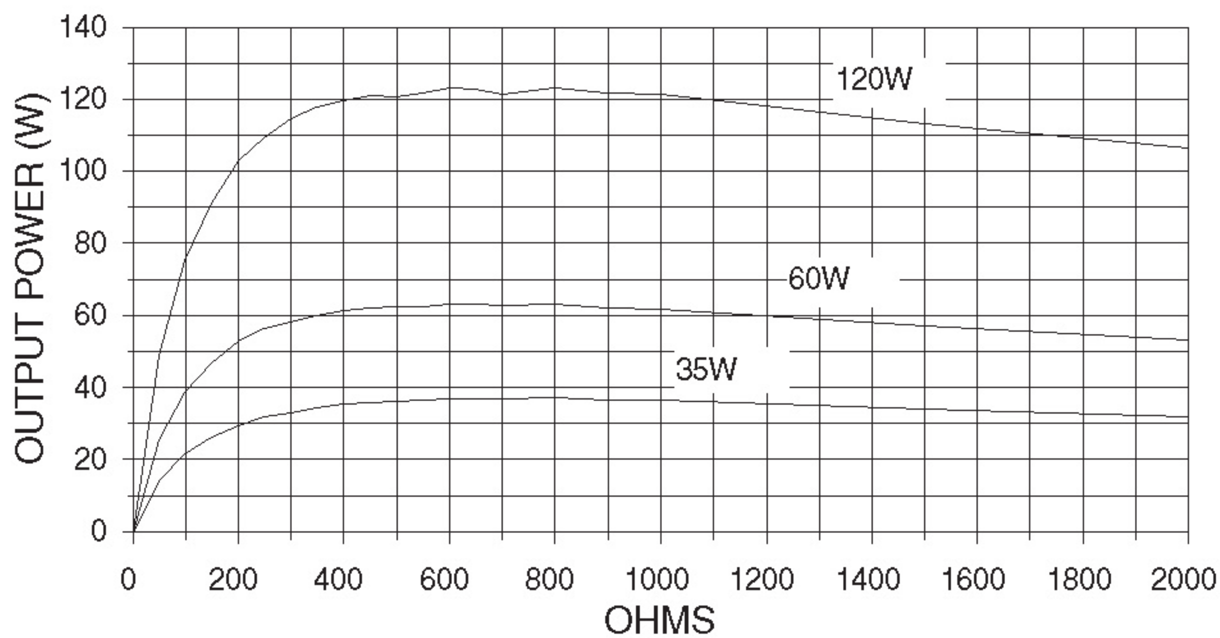

Figure 1.3 Monopolar Coagulation Load Regulation

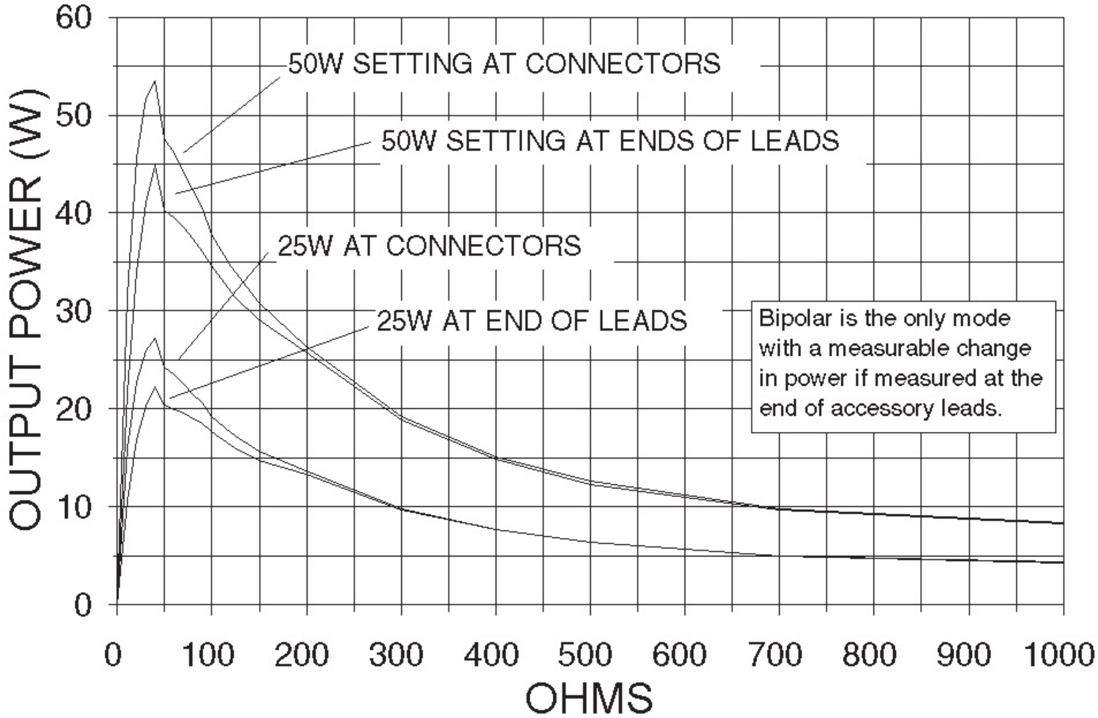

Figure 1.4 Bipolar Load Regulation

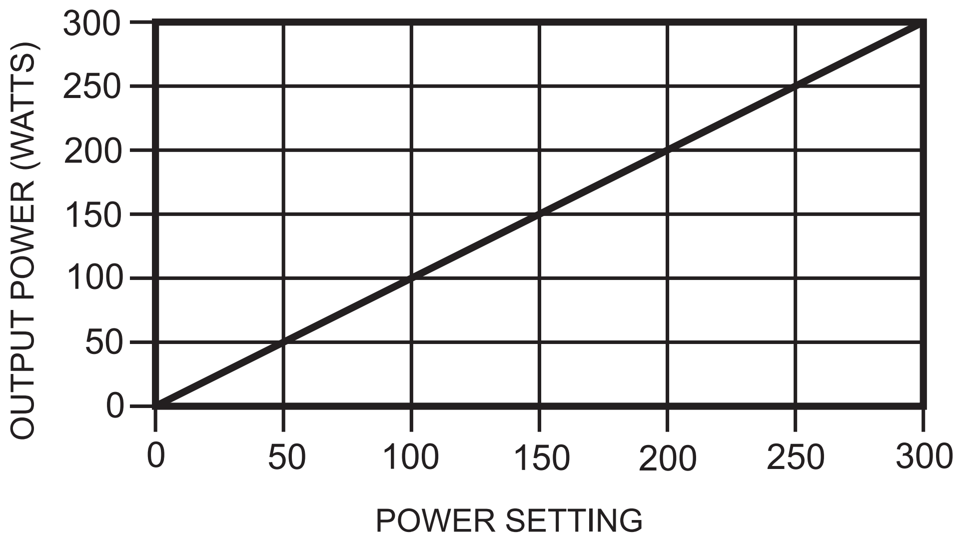

Figure illustrates the output power delivered to the rated load for all available output modes.

Figure 1.5 Output Power vs. Power Setting

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Installation & Operation

Section 2.0

This section contains initial installation, preliminary checks and operating instructions for the Sabre 2400.

2.1 INITIAL INSPECTION

Unpack the unit upon receipt and physically inspect it for any obvious damage that may have occurred during shipment. We recommend that this inspection be performed by a qualified biomedical engineer or other person thoroughly familiar with electrosurgical devices. If the unit is found to be damaged, notify the carrier and your CONMED representative immediately.

2.2 INSTALLATION

The unit may be mounted on the CONMED cart, P/N 60-5201-004, or any stable cart or table.

>WARNING<
THE POWER CORD OF THE UNIT SHOULD BE CONNECTED TO A PROPERLY POLARIZED AND GROUNDED POWER SOURCE WHOSE VOLTAGE AND FREQUENCY CHARACTERISTICS ARE COMPATIBLE WITH THOSE LISTED ON THE NAMEPLATE OF THIS UNIT.

CAUTION: Since the unit depends on natural convection of air for cooling, it should not be installed in a cabinet or similar enclosure. If mounted on a shelf, or otherwise near a wall, allow a two inch clearance around the unit to permit free circulation of air at the sides of the unit.

2.3 PRELIMINARY CHECKS

2.3.1 Preliminary Functional Testing

The following checks are recommended upon initial installation of the equipment and prior to each use of the instrument to avoid unnecessary delays in surgery. See Figure 2.1 for location of controls and connectors.

1. Ensure that the Power Switch is OFF and no accessories are connected.

2. Connect the power cable to a properly grounded and polarized mating power receptacle.

3. Connect a two-treadle monopolar foot switch and a single treadle bipolar foot switch to their mating connectors at the rear of the unit.

4. Make no connection to the Return Electrode jacks at this time.

5. Set the Power Switch to the ON position. The green lamp in the power switch shall illuminate. Within one second, the machine should respond by:

a) Sounding each of the four tones in ascending order over a one second interval.

b) During that interval, displaying a total of nine "8"s on the four digital displays.

c) Illuminating all three mode indicators, all nine selection indicators, the Return Monitor, and all of the Resistance Indicator bars.

d) After the fourth tone is complete, the machine should beep the highest frequency tone twice, and light the Return Monitor. A single zero should appear in each of the four digital displays. If the unit is in Single Pad Mode, the Resistance Indicator should be extinguished. If the unit is in the Dual Pad Mode, the Resistance Indicator bars will continuously flash.

6. Depress the Cut treadle of the monopolar foot switch. The Return Alarm tone should sound and the Monitor Lamp should continue to glow. While holding the Cut treadle, advance the volume control over its full range and verify there is no significant change in sound level. Release the Cut foot switch and the tone should stop.

7. Verify that each mode can be set to the power level corresponding to the table below, and that no other displays are affected.

MODE	MAX POWER
Pure Cut	300
Blend Cut	180
Coag	120
Bipolar Coag	50

Return all power settings to 0.

8. Select Bipolar Coag and depress the Bipolar foot switch. Confirm that the Bipolar Indicator illuminates, and a Coag tone is sounded. While still depressing the Bipolar foot switch, advance the Sound Volume Control over it's full range to verify the function of that control and that sound is audible at all positions. This control may be left at any desired position. Confirm that releasing the Bipolar foot switch returns the Sabre 2400 to its idle state. Verify that the Bipolar hand switch control is functional by use of the appropriate forceps or by connecting a jumper between the center and bottom Bipolar Output jack on the Output Panel. The effect will be identical to depressing the Bipolar foot switch.

9. Connect a two-wire, single pad Return electrode to a Return Electrode jack. Confirm that no Resistance Indicator bars are lit, and the Return Monitor Indicator remains lit. Press the Single Pad key to select single pad mode, and confirm the Return Monitor Indicator extinguishes.

10a) Depress the Cut treadle of the Monopolar foot switch. The Cut Activation indicator shall light and the Cut tone shall sound. While depressing the Cut treadle, press the Cut Up power key. The power should increase from zero to 5 watts. Press the Cut Down key and the power should decrease to zero watts. Press all eleven other keys and an operator error tone should sound.

10b) Depress the Coag treadle of the Monopolar foot switch. The Coag Activation indicator shall light and the Cut tone shall sound. While depressing the Coag treadle, press the Coag Up power key. The power should increase from zero to 5 watts. Press the Coag Down key and the power should decrease to zero watts. Press all eleven other keys (except volume controls) and an operator error tone should sound.

10c) Depress the Bipolar foot switch. The Bipolar Activation indicator shall light and the Coag tone shall sound. While depressing the Bipolar foot switch, press the Bipolar key. The power should increase from zero to 5 watts. Press the Bipolar Down key and the power should decrease to zero watts. Press all eleven other keys and an operator error tone should sound.

11. While continuing to press the Cut treadle of the foot switch, depress the Coag treadle. A cross key alarm tone shall sound. Release the Cut treadle, continue to press the Coag treadle and confirm that the tone changes to the Coag tone, and the blue Coag Mode indicator is illuminated until the Coag treadle is also released.

12. Connect a hand control to Hand Switchable Monopolar Accessory Jack #1. Activate, one at a time, the Cut and Coag hand switch controls verifying that each control causes the correct indicator and tone to sound. Move the hand control to Hand Switchable Monopolar Accessory Jack #2 and repeat.

13. Press the Monopolar Foot Switch Cut Treadle and confirm the yellow Cut mode indicator lights and the Cut tone sounds. While still pressing the treadle, press the Cut mode hand switch control and confirm that the Sabre 2400 continues to indicate actuation of cut-mode. Cross key tone will sound while both switches are pressed. A very short discontinuity in the activation tone when pressing or releasing the Hand-trol activation switch may be noticed.

14. Continue pressing the Monopolar Foot Switch Cut treadle, and then press the Coag mode hand switch control. A cross key tone will sound. Release the foot switch and confirm that the blue Coag mode indicator lights and that the Coag tone is sounded until the hand control switch is released.

15. Confirm that the cross key alarm tone sounds when the Monopolar Foot Switch Coag Treadle and the Bipolar Foot Switch are depressed simultaneously.

16. Remove the two wire, single pad return electrode, and confirm that the Sabre 2400 beeps twice, and the Return Monitor indicator illuminates.

17. Press the Monopolar Foot Switch Cut Treadle and confirm that a loud, steady return alarm tone is sounded.

2.3.2 Preliminary Performance Testing

After the unit passes the Preliminary Functional Tests of Paragraph 2.3.1, preliminary performance testing may be conducted. Such testing is best carried out by use of an electrosurgical generator tester, as described in Section 4. Note that the power display of the tester will be most accurate when a noninductive resistor of the rated generator output impedance for the selected mode is used.

If no tester is convenient, the availability of therapeutic current may be ascertained subjectively by attempting to cut and coagulate on surrogate tissue such as a piece of meat or fresh fruit, a wet bar of soap, or a sponge moistened in saline. Although not recommended, a last resort verification of available power can be made by drawing arcs between active and dispersive electrodes. Due to the low voltages used in bipolar mode, this test may not produce arcs between the tips of bipolar forceps. Such a test will not damage the Sabre 2400 at moderate power settings (below half the maximum power for the mode of interest) if carried out for no more than a few seconds. However, one should expect that the electrodes may be damaged due to the extreme temperatures generated by the arc.

2.4 CONTROLS, DISPLAYS AND CONNECTORS

The numbers preceding the following paragraphs correspond to the numbered items in Figure 2.1.

2.4.1 Front Panel Controls and Displays

All controls except the power circuit breaker are located on the control panel. Refer to the CONTROL PANEL portion of Fig. 2.1

1. MONOPOLAR CUT MODE INDICATOR: This lamp lights when the unit is keyed in either monopolar cut mode.

2. MONOPOLAR CUT POWER DIGITAL DISPLAY: Indicates the cutting power level selected via the Cut power level controls in the currently selected monopolar cut modes. Calibrated in watts deliverable to rated load.

3. MONOPOLAR PURE CUT INDICATOR: Illuminates when Monopolar Pure Cut has been selected.

4. MONOPOLAR PURE CUT MODE SELECT KEY: Selects the Pure Monopolar Cut Mode by pressing and releasing the key. Pure Cut yields minimum hemostasis and Blend Cut provides moderate hemostasis.

5. MONOPOLAR BLEND CUT INDICATOR: Illuminates when Monopolar Blend Cut has been selected.

6. MONOPOLAR BLEND CUT MODE SELECT KEY: Selects the Blend Monopolar Cut Mode by pressing and releasing the key.

7. MONOPOLAR CUT POWER DECREASE KEY: Decreases the output power level of the selected cut mode, Pure Cut or Blend modes when depressed.

8. MONOPOLAR COAG POWER DIGITAL DISPLAY: Indicates the power level set via the Coag power level control. It is calibrated in watts deliverable to rated load.

9. MONOPOLAR COAGULATION POWER DECREASE KEY: Decreases the output power level of the Coag mode when depressed.

10. MONITOR SET KEY: Push when in the DUAL pad mode after a dual pad electrode has been properly applied to the patient and connected to the unit. Pressing this key notifies the unit that the present return circuit resistance represents safe return electrode placement and causes the Resistance Indicator (11) to stop flashing if the patient's resistance is within the acceptable range (see Resistance Indicator). The unit will then monitor the patient's resistance and produce an alarm if the resistance rises by more than 20% +/-5%, or if a short is detected in the patient circuit.

11. RESISTANCE INDICATOR: This bar graph is a visual indicator of patient resistance measured between the contacts of the return electrode. The number of bars illuminated increases with increasing resistance and may be used as an aid in detecting high risk patients. The Resistance Indicator will flash if the Sabre 2400 is in Dual pad mode and the Set Point (10) has not been properly established (see Monitor Set Key). The Resistance Indicator will light 2 to 8 bars when the patient's return electrode resistance is within range.

12. BIPOLAR POWER DIGITAL DISPLAY: Indicates the bipolar power level set via the Bipolar Power Level Control. It is calibrated in watts deliverable to rated load.

13. BIPOLAR POWER DECREASE KEY: Decreases the output power level of the Bipolar mode when depressed.

14. DECREASE SOUND VOLUME: Pressing this key will decrease the volume of the sound tones produced by the unit during normal activation of the unit.

15. INCREASE SOUND VOLUME: Pressing this key will increase the volume of the sound tones produced by the unit during normal activation of the unit.

16. STORE KEY: Allows the user to store Mode, Power, Pad, and sound volume settings for a procedure. When this key is pressed, the Mode, Power, Pad, and sound volume settings will be stored in the Preset Memory Location (1 through 9) shown in the Preset Numerical Display.

NOTE: Pressing the Store Key will overwrite any settings that exist in a Memory Location, and the earlier stored settings will be lost.

17. “SEL” KEY: Allows the user to change the Memory Location shown in the Preset Memory Display. Using this key will select a new group of ESU settings, or an empty memory location where a new group of settings can be stored.

18. PRESET MEMORY DISPLAY: Indicates the Memory location, “1” through “9” or “P”, that is currently selected for the ESU.

Each memory location will record the Modes, Power settings, Pad, and sound volume settings. The “P” location stores the Mode, Power, Pad, and sound volume setting last used before the ESU is turned off (powered down).

19. BIPOLAR POWER INCREASE KEY: Increases the output power level of the Bipolar mode when depressed.

20. BIPOLAR MODE INDICATOR: This lamp lights when the unit is keyed in the bipolar mode.

21. SINGLE PAD MODE INDICATOR: The indicator will light when this mode is in effect.

22. SINGLE FOIL PAD SELECT: Selects the Single Pad (Foil) Mode by pressing and releasing the key.

23. RETURN MONITOR: Illuminates when the unit detects a problem in the return electrode circuit. In DUAL pad mode, the indicator will illuminate when the Monitor Set has not been set, or a return electrode cable is open or shorted, or the type of return electrode used does not match the type selected, or when patient resistance is out of range. In SINGLE pad mode, it will illuminate if either of the return electrode cables is open. In addition, an alarm tone will sound when a Return fault is detected for either type of electrode AND a monopolar activation is attempted. The unit will not produce monopolar energy when this indicator is illuminated.

24. DUAL PAD MODE SELECT: Selects the Dual Pad (Foil) Mode by pressing and releasing the key.

25. DUAL PAD MODE INDICATOR: The indicator will light when this mode is in effect.

26. MONOPOLAR COAGULATION POWER INCREASE KEY: Increases the output power level of the Coag mode when depressed.

27. MONOPOLAR COAG MODE INDICATORS: This lights when the unit is keyed in the monopolar coagulation mode.

28. MONOPOLAR CUT POWER INCREASE KEY: Increases the output power level of the selected cut mode, Pure Cut or Blend, when depressed.

2.4.2 Output Panel

The output panel contains the power circuit breaker and the required patient connection jacks for electrosurgery. Refer to the OUTPUT PANEL portion of Fig. 2.1.

1. CIRCUIT BREAKER: Primary power switch for the unit; turns unit on and off. Also provides double-pole power line overload protection.

2 & 3. HAND SWITCHABLE MONOPOLAR ACCESSORY JACKS: Two independent sets of color coded banana jacks are provided for the connection of hand switched monopolar accessories, such as the Aspen Hand-trol. Hand switchable monopolar coagulating forceps may be used by connecting to the red and lower black jacks. These jacks may be activated only by the accessories connected to them.

4. FOOT SWITCH CONTROLLED MONOPOLAR ACCESSORY JACK: This jack accepts accessory cables or adapters equipped with standard active (Bovie #12) plugs. This jack can be activated only by the monopolar foot switch.

5. TWO-PIN RETURN ELECTRODE JACK: This is a standard two-pin return electrode jack.

6 & 7. BIPOLAR ACCESSORY JACKS: Bipolar output, activated by the bipolar foot switch or by hand switchable bipolar accessories, appears between these blue banana jacks.

8. BIPOLAR SWITCH JACK: Hand switchable bipolar accessories must be connected such that the hand switch contacts are connected between this black miniature banana Bipolar Switch Jack and the lower blue Bipolar Accessory Jack (6).

2.4.3 Rear Panel

The rear panel contains the foot switch connectors and power cord. Refer to the REAR PANEL portion of Fig. 2.1.

1. MONOPOLAR FOOT SWITCH CONNECTOR: This 4-pin threaded connector is designed to accept plugs attached to any two treadle monopolar foot switch available from Aspen Labs.

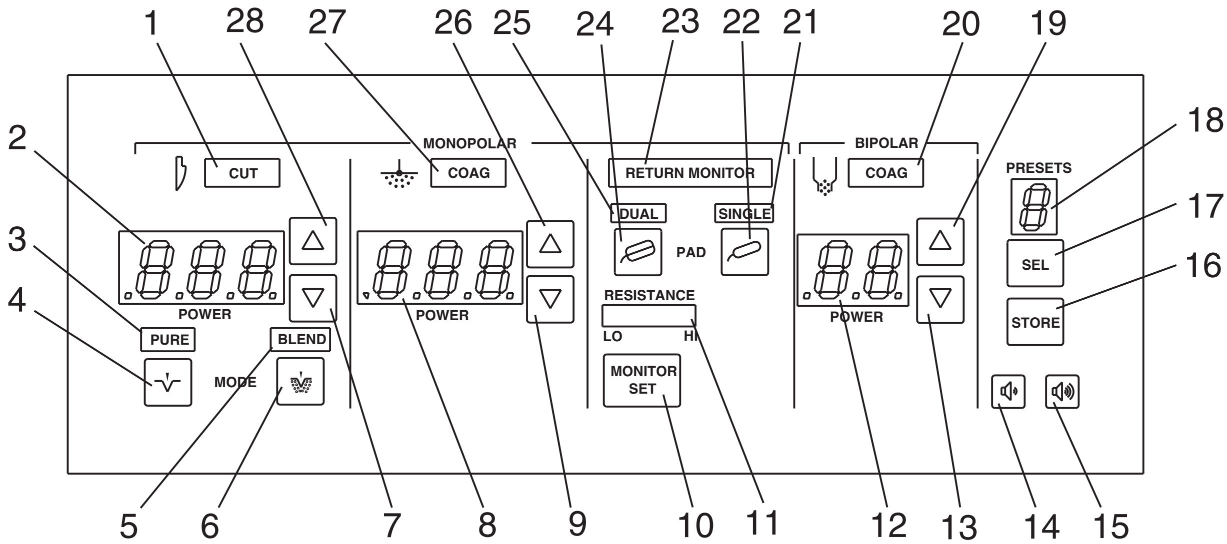
2. BIPOLAR FOOT SWITCH CONNECTOR: A 3-pin threaded connector designed to accept a single-treadle bipolar foot switch.

3. POWER CORD: Supplies ac mains power to the unit. It should only be connected to a source of power corresponding to that listed on the nameplate. Supplied with a standard 3-prong, parallel-blade, hospital grade plug (U.S.A. Domestic only).

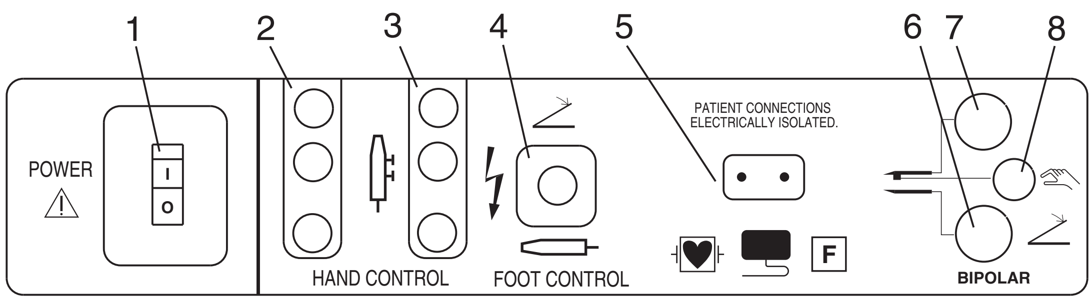
4. NAMEPLATE: Specifies Aspen model name, serial number, nominal line voltage, frequency, current, and power consumption.

5. POWER INLET CONNECTOR: Accepts a CEE22 6A or 10A mains power cord (IEC units only).

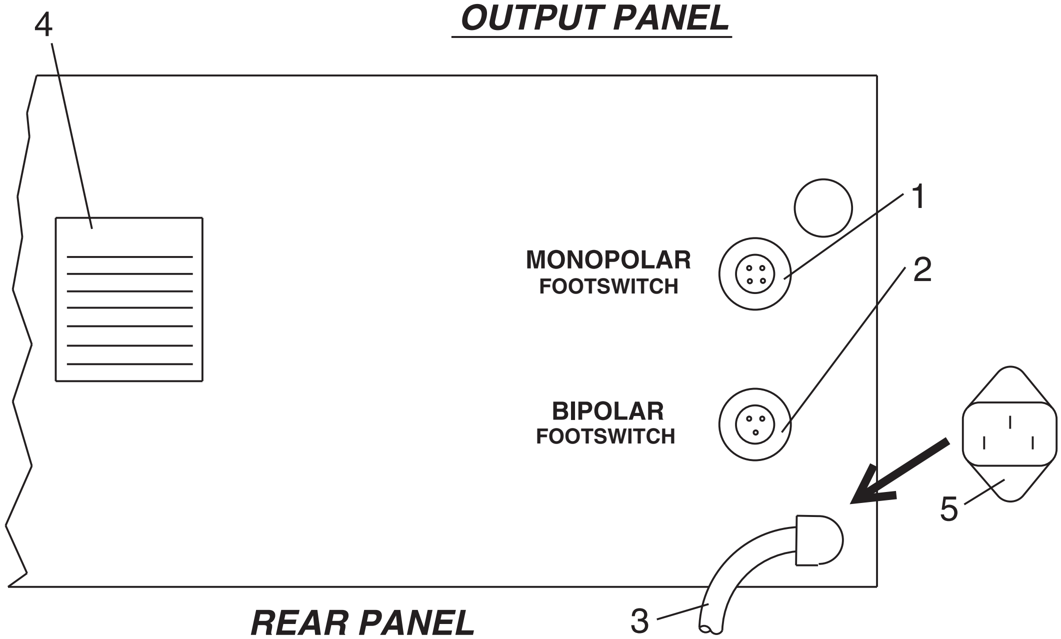
Figure 2.1 Controls, Displays & Connectors



CONTROL PANEL



OUTPUT PANEL



REAR PANEL

2.5 OPERATING INSTRUCTIONS

2.5.1 Preliminary Set Up

1. Ensure the Power Switch is OFF, then connect the power cable to a properly grounded and polarized mating power receptacle. Do not connect a Return electrode at this time.

2. Set the Power Switch to the ON position. The green lamp in the Power Switch shall illuminate. Within one second, the machine should respond by:

a) Sounding each of the four tones in ascending order over a 1 second interval.

b) During that interval, displaying a total of nine "8"s on the four digital displays.

c) Illuminating all four mode indicators, all selection indicators, and all of the Resistance Indicator bars.

d) After the fourth tone is complete, the machine should beep the highest frequency tone twice, and light the Return Monitor. A single zero should appear in each of the four digital displays. If the unit is in Single Pad Mode, the Resistance Indicator should be extinguished. If the unit is in the Dual Pad Mode, the Resistance Indicator bars will continuously flash.

After two seconds, the unit is ready for use. If the unit sounds a continuous high tone, or otherwise fails to respond as above, the unit has failed one of its internal tests and is not suitable for use. Before turning the power off, note the "HLP" code displayed in the Power Displays to assist in the diagnosis by a biomedical technician.

3. Inspect, then connect the desired monopolar accessories to the hand controlled or foot switch controlled connectors of the unit. Refer to Figure 2.2 for typical monopolar accessory connections. Connect the desired foot switchable bipolar accessory to the two blue bipolar banana jacks. (Refer to Figure 2.2). If a hand switchable bipolar accessory is to be used, connect the RF lines to the two blue jacks with the switch connected between the black jack and the bottom blue jack.

>WARNING<
ALWAYS STOW UNUSED ACCESSORIES IN A SAFE, INSULATED LOCATION SUCH AS A HOLSTER.

4. Connect the foot switches, as required, to the rear of the unit (not required if only hand switchable accessories are to be used).

5. Inspect, then connect the plug of the dispersive electrode cable to the return electrode jack or to an appropriate adapter. Refer to Figure 2.2. A dispersive electrode need not be connected if only Bipolar operation is required.

NOTE: This electrosurgical unit incorporates the Aspen Return Monitor. The monitor will inhibit monopolar operation of the unit if its requirements for the return electrode have not been satisfied (see instruction 7).

6. Select and prepare the patient return electrode site and apply the return electrode in accordance with the manufacturer's instructions. If no instructions are given, observe the guidelines provided in Section 1 of this manual.

7. Use the RETURN MONITOR buttons to select DUAL or SINGLE Pad Mode. Confirm that the Resistance Indicator and the RETURN MONITOR Indicator are blank if SINGLE pad mode is selected. If DUAL pad mode is selected, press the MONITOR SET key. Confirm the RETURN MONITOR indicator is dark, and the Resistance Indicator stops flashing and displays 2 to 8 bars. The number of bars indicates the patient's resistance and can be used as an indicator of patient risk. See Figure 3.1 for the patient resistance vs. Resistance Indicator bar graph.

>WARNING<
DO NOT DEPEND SOLELY ON THE RESISTANCE INDICATOR FOR CONFIRMATION OF GOOD RETURN ELECTRODE APPLICATION. QUALIFIED PERSONNEL SHOULD MAKE THE FINAL DECISION ON PROPER ELECTRODE PLACEMENT.

8. Set the Monopolar Cut Mode to Pure for cutting with minimum hemostasis, or Blend for moderate cutting hemostasis. The mode is changed by pressing the PURE or BLEND buttons. The selected mode is indicated by the back-lighting of the PURE or BLEND button.

9. Adjust the CUT, COAG, and BIPOLAR power level controls to the desired levels. If unsure of the proper settings, use low power settings initially and make adjustments intraoperatively according to the surgeon's requests. A written record of each surgeon's preferred power setting for various procedures will expedite subsequent pre-op setup.

In case of an internal failure, the Sabre 2400 will emit a loud tone to indicate that it has shut itself down. A visual HLP Code is then displayed on the Cut and Coag power indicator displays. The HLP code should be recorded and reported to Bioengineering. Repairs will be necessary before returning the unit to service unless the fault condition was transient in nature. Refer to Section 4 for a list of HLP (HELP) codes and their meanings. This alarm is silenced only by turning off the power switch.

2.5.2 Operation

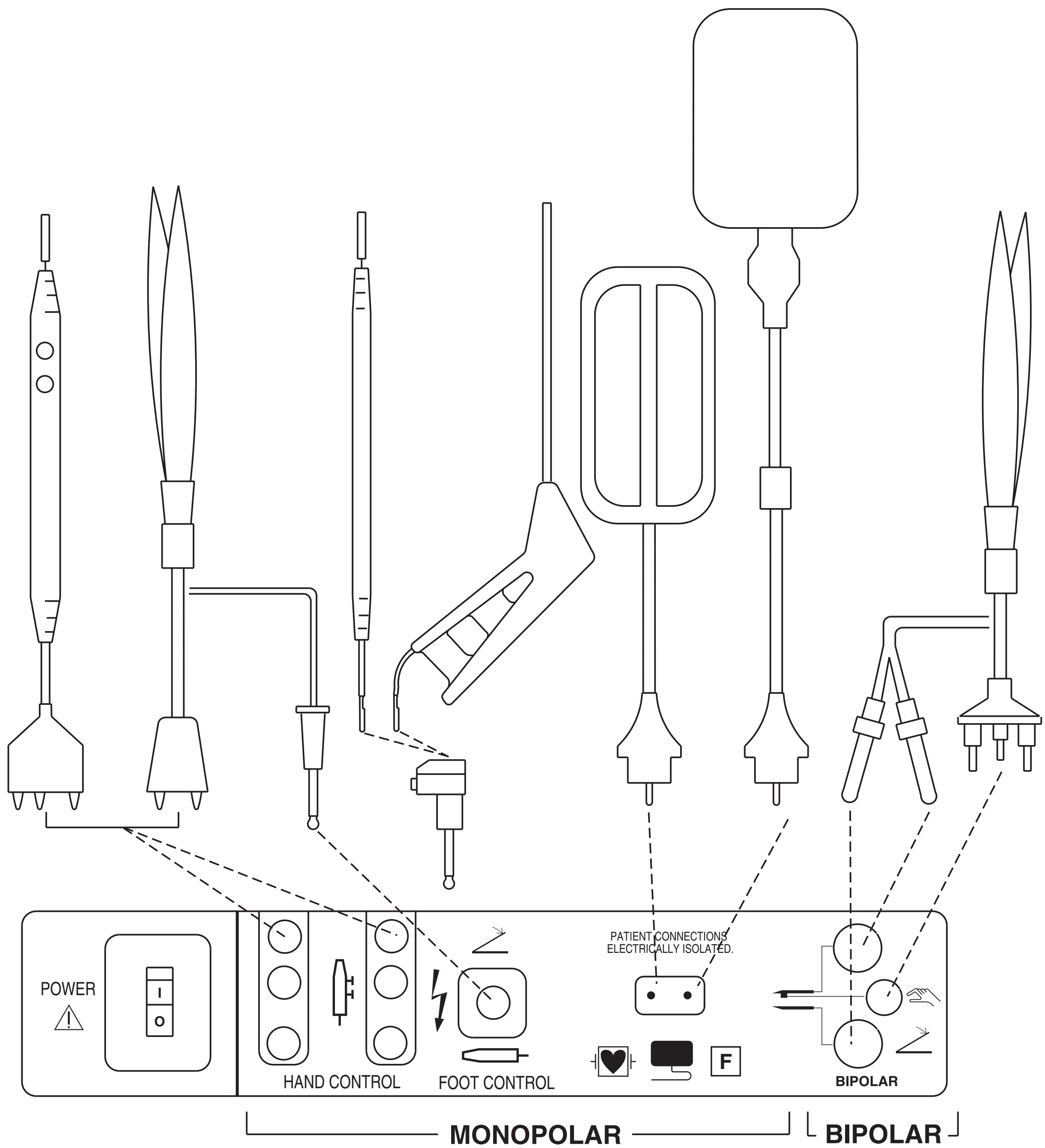
Activate the electrosurgical unit in the desired operating mode by depressing the appropriate treadle of the foot switch or switch of a hand accessory. Adjust the corresponding power level control until the desired results are obtained. The available power in watts will be displayed on the digital display corresponding to activation mode. Noting this wattage may be useful in attempting to derive similar surgical effects from several machines of different manufacturers. The surgical effects obtained are dependent on a number of factors including waveform, electrode size, electrode geometry, power level and surgical technique.

The size and geometry of monopolar electrodes are significant in that a large electrode, absent of sharp features (e.g., a ball electrode) will have no tendency to cut, regardless of the waveform power level. Conversely, a small, sharp electrode, such as a needle or wire loop, will be likely to cut simply from mechanical pressure. Therefore, when coagulating with small geometry electrodes, it is advisable to use only coagulation waveforms, use little if any mechanical pressure, and operate with lower power levels.

The waveform is selected by the user via hand or foot switch and the setting of the active Mode switches. Cutting waveforms are generally continuous (Pure) or high duty cycles with wide pulse widths (Blend). Monopolar Coagulation waveforms are generally of narrow pulse widths with very low duty cycles. In general, the lower the duty cycle, the less tendency a waveform will have to cut and the greater its tendency to coagulate.

The Bipolar Coagulation waveform is designed to minimize tissue sticking and popping by limiting the output voltage regardless of power setting. Bipolar hemostasis is more localized than that in monopolar, since only the tissue grasped between the forceps tips is affected. This is particularly desirable in vascular surgery, where monopolar current may concentrate in the affected vessel resulting in undesired electrosurgical effects in tissue remote from the point of application. This easily controlled localization is also of benefit in plastic and neurosurgery.

Figure 2.2 Patient Accessory Connections



Theory of Operation

Section 3.0

3.1 CIRCUIT THEORY OF OPERATION

This section contains the theory of operation for the Sabre 2400 circuitry. The functional block diagram and schematics are located in Section 4.0. These schematics are folded such that they may be pulled out for viewing while reading the appropriate section.

3.1.1 Functional Block Diagram Description

The Functional Block Diagram appears in Figure 4.1. This diagram illustrates the functional blocks and their physical location by assembly number. Each block defines a major function (as noted inside the block), the reference designator(s) of the primary components(s), and the schematic number where the block is detailed.

The relationships among each block are described by the signals that interconnect them. Narrow lines represent individual signals and are marked with the same signal mnemonics used in the schematics. Broad lines denote busses, or groups of signals which together serve a common function. To avoid clutter, busses are not necessarily marked with signal mnemonics.

Arrowheads describe the direction of signal flow. In the case of bidirectional signals, there are arrowheads on each end of the signal lines.

3.1.2 Power Supplies

Refer to Schematic 4.6. The mains power cord terminates to a grounding lug on the base, and the two-pole circuit breaker, CB1, mounted on the output panel. CB1 serves both as a lighted power switch and to protect the unit from overloads. On overload, this device automatically switches its handle to the OFF position.

The switched AC is wired to TB1 for connection to the primary windings of power transformer A5T1. Strapping options on TB1 set the unit for a given mains voltage range. Schematic 4.6 indicates the strapping options for the various mains voltages.

The high power secondary of A5T1 (wires are marked 4 and 5) is wired to full wave rectifier A5BR1, and the DC output of the rectifier is connected to the Power Board through J3 on the Power Board. A1C1 and C2 are filter capacitors for the resulting dc voltage RFSUP. The LED, A1DS1, is an indicator that high voltage is still present, even when the power switch is off. R64 acts as a bleeder to discharge C1 and C2.

The low power secondary of A5T1 (wires 1, 2, and 3) is wired directly to the same connector J3. A5BR1 acts as a conventional full-wave bridge rectifier for supplying +22UNREG, while simultaneously acting as a negative-leg full-wave center-tap rectifier in providing +11UNREG. A1C7 and C10 are the filter caps for the low voltage supplies.

+22UNREG is the source for the +12V regulator on A2, the transistor drive (Vbase), and the relay power supply voltage RLYSUP. +11UNREG supplies the raw voltage for the +5V regulator, also on A2.

3.1.3 Controller Hardware

The Sabre 2400 Controller PWB Assembly is based on the 8031, a single chip, 8-bit microprocessor which utilizes external program memory. Refer to schematic, Figure 4.2. This controller has the following features.

1. Four 8-bit Ports (0,1,2,3) which are individually addressable as 32 Input/Output (I/O) lines.

2. Two 16-bit timer/event counters.

3. 64 K bytes of externally addressable program memory.

4. On-chip oscillator and clock circuit which is connected to an external 10 MHz clock signal derived from a 20 MHz quartz time base (A2Y1).

5. 128 bytes of internal RAM used as a “scratch pad” by the processor.

The remainder of the controller circuitry consists of the Watchdog Timer (WDT), Power On Reset (POR), Address Decoder, Peripheral Interface Adapters (2x) (PIA), Base Voltage Generator (BVG), Output Current and Line Voltage Current Sensing Circuit, Waveform Generator (WFG), Tone Generator, and the Aspen Return Monitor (A.R.M.) DAC and current source.

3.1.3.1 Watchdog Timer (WDT)

The function of this circuit is to monitor the microprocessor for a failure that would cause unpredictable results. During normal operation, the microprocessor program executes in a known sequence. If a software error is detected, an internal interrupt is generated which halts the operation of the microprocessor. If there is a hardware failure sensed by software control, program execution will again be terminated.

Should a failure occur in the CPU that prevents the detection of a problem, thus allowing program execution in a random manner, the Sabre 2400 is designed so that the WDT detects the problem. The WDT shuts down the malfunctioning unit to minimize the effects of the failure. This is accomplished by requiring the microprocessor to write to the WDT once during each program execution cycle. This WRITE PULSE is referred to as the Watchdog Timer Strobe (WDSTR). Each cycle is 25 +/- 2 milliseconds long. The WDT circuit must hear from the microprocessor within a 18 to 34 msec window. If the WDSTR occurs early because the program “skipped” a portion of the software or late because it was “hung” in a program loop, the following results:

1. The circuit latches in the failed condition so that further strobing from the microprocessor cannot clear the previous failure.

2. An interrupt is generated which stops abnormal program execution. If the microprocessor can still respond to the interrupt, a “fatal” software routine will execute, displaying an error code HLP-4.

3. The interrupt signal, is used to generate WFAIL, which disables the Base Voltage Generator and Waveform Generator, preventing further generation of RF output.

The Watchdog Timer (WDT) is made up of a dual, retriggerable, one-shot multivibrator (U1), associated RC timing components (R1, C2, R2, and C3), and associated gate (U2). The first stage one-shot is set to time out at the minimum WDSTR interval of 20 msec by the RC combination of R1 and C2. The trailing (falling) edge of WDSTR triggers the first stage causing Q1 (U1-6) to go true (high) for approximately 18 msec. The rising edge of Q1 triggers the second stage one-shot via U1-12, causing Q2 (U1-10) to go high and /Q2 (U1-9) to go low. The 34 msec timing of this stage is set by the RC combination of R2 and C3. In normal operation WDT strobes will occur after stage 1 has timed out (Q1=0) but before stage 2 times out (Q2=1). The one-shot is retriggerable and the rising edge of Q1 will restart the 34 msec timing sequence in the second stage even though it may not have completed its current time delay. Normal operation is indicated by (Q2) never going low.

The relay enable flag, /RLYEN-Q from U2-11, is reset on power-up. This permits the microprocessor (U3) to test the WDT during initialization without allowing RF to appear at the outputs. While RLYEN-Q is disabled (low), the WDT will not lock up, permitting the software to test for correct operation. This is done by strobing the WDT early, then late, and looking for the generation of the interrupt (Q2=0). The WDT is then triggered within the correct time window (20 to 30 msec) and should result in Q2 remaining high. If these results are obtained, the WDT timer circuitry is operating normally.

After initialization is complete, the microprocessor generates a WDSTR at the start of the first normal program timing cycle. The relay enable flag, /RLYEN-Q, is set by the NAND gate, U2-9 going low. After this, the program enters the normal operation program loop.

If a WDSTR is not generated within 34 msec of the previous strobe, the second stage will time out and Q2 will go low resulting in a WFAIL. Since RLYEN-Q and /Q2 (U1-9) are high, the inputs to U2-1 and U2-2 are both true resulting in its output (U2-3) going low. This resets the first stage one-shot. Now that Q1 (U1-6) cannot go high, Q2 (U1-12) is prevented from being retriggered. With the WDT Q2 output gone low, the microprocessor will execute a WDT failure interrupt routine in response to /INTO falling and WFAIL will disable drive to the power amplifier.

If the WDSTR is generated before 18 msec, while Q1 is high, the NAND gate (U2-1 and U2-2) will both be high resulting in U2-3 going low and resetting the second stage. This causes the same results as the late strobe described above.

Note that the signal which causes the WDT to latch and ignore all subsequent WDSTR pulses is RLYEN-Q being high. The only way to reset RLYEN-Q is a Power On Reset.

3.1.3.2 Power On Reset

The Power On Reset (POR) circuit consists of a single chip specifically designed for this function. The POR circuit monitors +5 Vdc (U50-8) and the output signals RST (pin 5) and /RS (pin 6) become active if +5 Vdc falls below 4.75 Vdc. The 8031 microprocessor operation is specified down to 4.5 Vdc. This allows power supply margin for proper power down of the controller until reset occurs. On power up, /RS is kept active for a minimum of 250 msec to allow the power supply and microprocessor to stabilize.

One last feature of this circuit is its function as a secondary Watchdog timer. This is enabled by the connection of Address Latch Enable (ALE) from the microprocessor (U3-30) to U50-7. The RS and /RS outputs are forced to an active state when the /ST input (U50-7) is not stimulated for 1.2 seconds. This function is not normally used because it requires a failure in the microprocessor and the Watchdog Timer circuitry. This is considered a double fault condition and the odds of the two occurring simultaneously is very low. Also, it is possible for ALE to continue in normal operation while other parts of the microprocessor are not. The WDT circuit described previously, is used because it is not susceptible to this failure in fault detection.

3.1.3.3 Controller, I/O

The four digital ports of the 8031 (U3) are functionally assigned as follows.

PORT 0 (P0.0 - P0.7). This port serves two digital functions: 8-bit data bus for communicating with external I/O, and low-order address bus for accessing external Program Memory.

PORT 1 (P1.0 - P1.7). This port is dedicated to discrete inputs or outputs. Port P1.0 and P1.1 are used to generate the serial signals necessary to write or read to the calibration EEPROM U4. Ports P1.2 and P1.3 communicate serially with the Quad DAC U11 and Ports P1.4 and P1.5 with the 8 channel ADC U16 which converts Current sense, Line sense and Return Monitor voltages to digital form. Ports P1.6 and P1.7 provide clock and data lines for the display drivers.

PORT 2 (P2.0 - P2.7). This port supplies the high-order address bus which reads from external Program Memory and writes to external I/O. All I/O is memory mapped so that distinct addresses access specific devices. The system is configured so that only one device is addressed at a time.

PORT 3 (P3.0 - P3.7). This port generates special signals used to control the overall system. Ports P3.0 and P3.1 are used for factory test only. Port P3.2 is the watchdog fail interrupt. Port P3.4 provides the relay enable strobe, Port P3.5 controls the Digital I/O chip U10 address space for either Memory of I/O.

The Address Decoder (U7), is used to select external I/O devices for reading and writing. High-order address to the decoder inputs, (A10, A11, and A12) cause the corresponding output (Y0 - Y7) to go low. After the address decode has stabilized, either /RD or /WR will go low to execute a data transfer with the addressed device.

There are two Peripheral Interface Adapters (PIA) U6 and U10. U6 is a general purpose digital I/O device which is used to input the hand and foot activation controls, control the relays and waveform generator and provide Watchdog Strobe and VSENSE Disable. U10, in addition to providing digital I/O also contains the tone generator frequency divider and a 256 x 8 byte RAM memory. The digital I/O functions control RF enable, chip select, keyboard scan and display drive functions.

3.1.3.4 Program Memory, EPROM

The program used by the microprocessor is stored in external memory, the 32 K byte X 8 EPROM (U91). It is programmed and verified at the factory to ensure correct operation of the ESU. The lower order address A0-A7 is latched into U8 by line ALE. A0-A7 in combination with the higher order address A8-A14 provides the total address to the program EPROM U9. The EPROM is enabled by line PSEN going low during an instruction fetch. Address lines A13-A15 provide memory mapped I/O decoding when PSEN is high to select one of the two PIA devices.

The nonvolatile EEPROM memory U4 is a serial device which stores calibration coefficients and program presets. Validity of these values is insured by also storing a CRC check sum anytime these values are changed.

When the ESU is powered up, the data stored in the non-volatile section of U4 is automatically copied onto the static RAM where it is accessed by the microprocessor via the address/data bus.

3.1.3.5 Base Voltage Generator

The base voltage generator is schematically depicted on Schematic 4.3. It is microprocessor controlled with two analog feedback paths that can turn the base voltage down in case of excessive power amplifier current or high output voltage. The high voltage shutback is divided down to have a higher threshold in monopolar coag mode.

The base voltage generator is made up of two sections of the Quad DAC (U11), an inverting summing amplifier (U12:A) and a power integrated circuit Q6. The two DAC sections VOUTA and VOUTB are resistively summed together to form one 10-bit DAC which controls VBASE setting. Q6 has internal current and temperature limit shutdown. It cannot be checked by the standard base-emitter and base collector diode checks with a DVM.

The -ISENSE and IGND signals are developed in the RF power amplifier on the Power Conversion Board A1. These signals are generated by the power amplifier supply current passing through sense resistor A1R2. The resulting voltage -ISENSE is proportional to the total dc current used by the RF power amplifier. The portion of U12 that includes pins 8, 9, and 10 makes up a low pass filtered differential voltage amplifier that amplifies the -ISENSE voltage. The resulting ISENSE voltage is proportional to the dc current drawn by the Sabre 2400 RF power amplifier from the RF supply, RFSUP. When ISENSE exceeds the voltage at U12-3 by a diode voltage drop, the ISENSE feedback loop becomes dominant and backs VBASE down to maintain the RF power amplifier current at its limit. This is independent of microprocessor control and is an additional safety feature.

In all modes except a monopolar coag mode, the signal VDIS will be low, thus forcing U14-10 (an open collector) to float. When VSENSE exceeds the voltage at U12-3 by a diode voltage drop, the VSENSE feedback loop becomes dominant and turns VBASE down to limit the amount of RF output voltage. This action occurs primarily at high power settings of monopolar cut at high load impedances to prevent unwanted arcing at the active electrode. When VDIS is high, U14-10 drops and forms a voltage divider through R65 with VSENSE and delays the onset of VBASE shutback from limiting RF output voltage until the output voltage is much higher.

3.1.3.6 IFAIL ADC

The current level of the RF amplifier is monitored by U12:C to provide a voltage (ISENSE) to one channel of the ADC (U16). This value is compared to an anticipated value for the machine settings. In the event that this value is exceeded, a fatal alarm results that produces a "HLP-5" code and shuts down the Sabre 2400.

3.1.3.7 Waveform Generator

Refer to Schematic 4.4. U27 is a 32 K x 8 EPROM that stores the bit patterns for the waveforms that drive the RF power amplifier. The EPROM is arranged so that the upper address lines, WV0-7, determine which waveform is selected by the microprocessor, and the lower address lines, WVA0-6, determine which byte of the waveform is selected at a time. The address counter (U23 and U24) cycles through its count to sequentially select each byte of the waveform and to reload its own count modulus at the beginning of each waveform. The selected byte of the waveform is then parallel-loaded into shift register U26, where it is serially-shifted out to the buffer U22 one bit every 50 nanoseconds. U25 is configured as a modulus 8 counter that controls the parallel loading of the shift register U26 and increments the lower waveform address counter (U23 & 24). Both the loading and incrementing occur on the rising edge of the 20 MHz clock when /SRLOAD (U25-11) goes low and then high.

U25 also generates 2.5 MHz and 10 MHz clocks from the 20 MHz oscillator Y1 for clocking the Display/Keyboard Driver/Encoder U26 and the microprocessor U3.

Each time /SRLOAD goes low and then high, the waveform address counter formed by U23 and U24 advances its count. The outputs from this counter (WVA0-6) select the next 8 bit word to be loaded into U26 from U27. When the waveform address counter reaches it full count, i.e., the entire waveform has been completely output, /CNTRLD goes low on the next count and the address counter is preloaded to the pattern presented to it by O0-O6 of U27. This pattern sets the modulus of the address counter and thus the length of the waveform bit pattern. /CNTRLD also clears the shift register U26 to zeros to prevent putting the modulus pattern out to the power amplifier. Since /CNTRLD (TP14) is low only at the beginning of a waveform, it is an excellent point to use for a scope trigger when examining waveforms. See Figure 3.2 for representative waveforms.

U22 provides both buffer and enable functions for the waveform generator.

3.1.3.8 Tone Generator

The tone frequency generator is located within PIA U10 which produces a square wave at U10-6 (SPKR). This signal is buffered by U14:B and provides the sink side of the speaker drive. The source side of the drive is a DC voltage controlled by one section of the Quad DAC U11 and power amp U12:B with Q3. Controlling the level of this DC voltage thereby sets the tone volume. A2Q2 that can be controlled by the base voltage.

3.1.4 Controller Software

The behavior of the Controller is a function of the custom program residing in the 27C256 EPROM memory. Since the 27C256 is a device with a custom program, it must only be replaced with a suitably programmed part. Most failures of this part may be traced to mishandling, particularly due to static discharge or to a secondary failure resulting from application of excessive voltage to the circuit, as may occur if a voltage regulator fails.

However, since undetected failure of 27C256 could escalate a minor failure to a serious consequence in the O.R. environment, the 27C256 program is equipped with many fail detection and shutdown features. Further, an independent external circuit (the Watchdog Timer) guards against a malfunctioning 27C256 or CPU operation. This safety system is discussed in the following overview of the 27C256 program.

3.1.4.1. Software Initialization and Test Functions

The following list of software functions begins at Power On Reset or by a manual reset performed by an internal CAL switch. The following initialization sequence must be successfully executed before the main working program can be entered.

1. Initialize outputs to relays and indicators.

2. Initialize all data memory locations for the working program.

3. Load the contents of the Non-volatile EEPROM into working RAM space and verify the validity of it's values.

4. Verify the microprocessor Watchdog Timer is functioning correctly and that it can control RF shutdown.

5. Display 8s on all numeric indicators, illuminate all status indicators and sound four tones for operator verification.

6. Verify that the RF circuitry is operating.

7. Verify that the Return Monitor circuits are working.

8. Verify that the AC Line voltage is within operating limits.

9. Verify that no shorts exist in the hand/foot controls.

10. Verify that internal data memories are functioning properly and without crosstalk.

11. Verify that the contents of program memory in all locations where the program resides is intact using a 16-bit cyclic redundancy check.

12. Verify that the contents of the calibration data is intact using a 16-bit cyclic redundancy check.

13. Verify that the contents of the preset data is intact using a 16-bit cyclic redundancy check.

14. Enable RF output relays and pass control to the working program.

Failure of any of the above self-tests will result in the end of program executions, and a display of "HLP" on the Cut display. An error tone is sounded to alert the operator and the "HLP" code is displayed on the Coag Power Level display. Refer to Table 4.7 for a list of HLP codes and their possible causes.

3.1.4.2. Working Program Functions

The main program loop is executed continuously by calling the working subroutines and refreshing the CPU Watchdog Timer on each pass through the loop.

Bipolar, hand control, foot switch, and return electrode inputs are monitored for changes. The validity of the input conditions are checked. The following conditions are considered illegal requests and result in a pulsing operator error tone.

• More than one simultaneous activation request.

• Any activation request other than bipolar with the Return Fault indicator ON.

In the case of an illegal hand/foot request, the last valid request is the one honored. Other operator actions that can result in a pulsing operator error tone are multiple or stuck key press, or attempting to increase or decrease power levels beyond the machine limits.

The current condition of the hand/foot controls and the keyboard are continuously monitored. When a valid request to change mode or power level is received, the displays are updated to reflect the change. When a valid request for RF activity is received, the following sequence is performed.

1. The appropriate RF indicator lamp and tone are activated.

2. The requested accessory output relay is closed.

3. The current limit fail-safe is set.

4. The power setting is used to retrieve waveform and amplitude parameters from the calibration memory which are then sent to the RF drive circuits.

5. RF output is enabled via /RFEN.

Self-tests are continuously performed during operation to ensure the integrity and reasonableness of hardware and software operation during the working program execution. Failure of these tests will result in a safe end-to-program execution (RF drive and all relays are disabled). A display of HLP on the Cut power levels and a 1 KHz tone alerts the operator to the condition. The appropriate error code is displayed on the Coag Power level.

3.1.5 Display Hardware

The Sabre 2400 display uses LED and incandescent lamp segment technology. Three HV5708 drive chips (U19, U20, and U21) each contain a 32 bit shift register, latch and segment drive function. Each lamp segment is turned on or off corresponding to a logic one or zero on a drive line. Each drive line is then buffered by a section of one of the ULN2004A buffers on the display board (A-7). The three HV5708 chips may be considered as a 96 bit shift register driving a 96 bit latch. A 96 bit data stream of display data (DISDATA) is downloaded to the shift registers serially by clock DISCLK after which the data is transferred to the latch sections by signal DISLE. At power on reset, all HV5708 drive chips are blanked during the reset period by a reset driver ULN2003 (U13-F).

3.1.5.1 Keyboard

A membrane switch panel is integrally mounted in the display. The switches form a 5x3 matrix which is scanned by PIA U10 and debounced in software.

3.1.6 Power Amplifier

The Power Amplifier (PA) is a hybrid cascode amplifier made up of four high voltage bipolar transistors and a low voltage power Mosfet. Refer to Schematic 4.6. Bipolar transistors Q1-Q4 are connected in parallel, with their emitters connected together through resistors R17-R20. That combination is then connected to the drain of Q5. This combination makes up a fast, high-voltage amplifier that can be controlled by the combination of the dc voltage VBASE, and the fixed amplitude, variable pulse width signal, BGATE.

In the OFF condition, BGATE is near ground, turning off Q5 so that no drain current can flow. Thus no base or emitter current can flow in the bipolar transistors. Turn-on commences with BGATE rising rapidly to turn on the MOSFET, forcing its drain low. Since the capacitors connected to the bases of the bipolar transistors are charged up, this results in a large pulse of base current flowing in from the bipolar transistors Q1-Q4, quickly turning them on and delivering power to the output circuitry.

After turn-on, Q5 will be conducting hard and the bipolar transistors will draw collector current in proportion to their base current, which in turn is controlled by VBASE.

Turn-off commences with BGATE quickly dropping to nearly 0 V, shutting off Q5 and effectively disconnecting the bipolar transistors' emitters from the circuit. Collector current then flows out of the bipolar transistors' bases into the base capacitors until all of the charge stored in the bipolar transistors during turn-on is washed out. Then the bipolar transistors completely shut off, ceasing power transfer to the output circuitry.

The collector voltage may rise to many times the value of the RF supply voltage RFSUP after turn off. Since the emitters are now disconnected, the collector-base voltage can take on the highest value which that junction will sustain with little chance of second-breakdown. The base bypass capacitors, are sized to ensure that they can absorb all of the stored turn-off charge without allowing Q5's drain voltage to approach its breakdown limit. Further, this charge is now available to charge the base on the next cycle, thereby significantly reducing the net current drain from the VBASE supply.

Each bipolar transistor base has its own current control network which is driven from a common VBASE supply. Each collector and each base is separately fused, allowing a failed part to disconnect itself from the circuit without seriously affecting performance. Voltage snubbing networks protect BGATE, VBASE, and the power MOSFET drain from being damaged in the event of any transistor failure. This limits the extent of failure damage. Each collector is equipped with a diode which allows the voltage on the output bus to swing negative with respect to ground, as it does in all monopolar modes of operation at sufficiently high power and load resistance.

In Cut modes, BGATE is a fixed frequency rectangular pulse and VBASE is varied from about 0.3 to +8.5 Vdc to control output power. The same is true in Blend except that BGATE is further modulated to produce dead time with no output.

Bipolar Coag Mode uses a fixed VBASE and varies the number of pulses per cycle period to control output power. See Figure 3.2 for representative BGATE drive waveforms.

3.1.7 RF Output Section

CAUTION: Because of the high peak-to-peak amplitudes of these waveforms, use oscilloscope probes that can withstand 2 KVpp minimum for cut, 10.0 KVpp minimum for coag, and 500 Vpp minimum for bipolar.

Refer to Figure 4.6 for the schematic diagram. RF output power may be supplied through one of two RF isolation transformers, as selected by the relay, K4. When deenergized, K4 connects the power amplifier collector bus to the Monopolar output transformer, T3, which is resonated by C27 and C28 and damped by the chassis mounted resistor A5R1. The secondary of T3 is capacitively coupled by C26 and C29 to the return monitor circuit, and via high-voltage reed relays, to the user selected monopolar active accessory connectors. An auxiliary single-turn T3 secondary supplies a replica of the power amplifier collector voltage to the VSENSE circuit. This rectifies and peak-detects this signal for use by the control circuitry to limit output voltage.

When K4 is energized, it disconnects T3 and supplies the bipolar output transformer, T1, with power from the power amplifier. The primary of T1 is resonated by C62 and is damped by A5R1. This transformer is designed to meet the particular requirements of bipolar electrosurgery which are characterized by much lower impedances and permissible voltages than those in monopolar operation. Its secondary is capacitively coupled to the appropriate output connectors. Output waveforms under various conditions are shown in Figure 3.3.

3.1.8 Aspen Return Monitor (A.R.M.) Circuitry and Software

The A.R.M. Circuit converts the electrical resistance appearing in the return electrode circuit into a digital value which can be processed by the microprocessor. Software processes use this value to determine when a RETURN FAULT condition exists. The Resistance Indicator is also driven by software to indicate the value of the measured DUAL FOIL resistance in the 10 to 150 ohm range. Portions of this function are implemented on the A2 Micro/Control PWB, Figure 4.4, and on the A1 Power PWB, Figure 4.6.

The A.R.M. Circuitry on the A1 PWB comprises an oscillator section and an isolation section. The isolation section employs a shielded toroidal transformer, T5, to couple the impedance presented at return electrode plate plug, A1J9 to the A.R.M. oscillator, while isolating that circuit from the effects of applied RF electrosurgical current and voltage. Capacitors C55 and 56 split the return current evenly between the two legs, thus minimizing the RF voltage appearing across T5 windings. T5 also acts to step up the return circuit impedance by about 10:1. The shield serves to prevent the RF stray magnetic field generated by the monopolar output transformer, T3, from interfering with the A.R.M. circuitry during RF activation.

The A.R.M. oscillator generates a low-power sinewave voltage of about 36 KHz. This frequency is determined by the inductance of T4 in parallel with the capacitance presented by C52-54, and that of C55 and C56 reflected through T5. Transistors Q14 and Q15 are cross-coupled via R49 and R50, so that when one transistor is conducting, the other is fully turned off due to lack of base drive. The conducting transistor turns off at the next zero-crossing of the sinusoidal voltage on the primary of T4. This allows its collector voltage to rise and thus provide base current to the other transistor to turn it on. In operation, the collector voltages appear like half-wave rectified ac, with each collector 180 degrees out of phase with the other.

The A.R.M. oscillator is powered by a constant 0.5 mA dc current driven from the A2 PWB via the VARM signal line. This current feeds into the center tap of T4 primary. The voltage on the center tap is the average of the two collector voltages, so it appears as a full-wave rectified sine wave with a peak amplitude of one-half that on either collector. Inductor L1 helps hold the current fed to T4 constant regardless of these voltage variations, while C65 serves as a bypass to limit the noise conducted from the A1 PWB up the VARM line to the A2 PWB.

The A.R.M. oscillator is a dc-to-ac power converter, with its major losses appearing as resistors in parallel with the resistance of the return electrode circuit, R_{LOAD}, transformed up through T4 and T5. In effect, the A.R.M. oscillator transforms R_{LOAD} into an equivalent dc resistance, RIN, appearing at the VARM input to the circuit. Thus when R_{LOAD} is very high, as when no connection is made to the Return Electrode jacks, R_{IN} is maximum, allowing the VARM voltage to rise to +2.3 - 3.0 Vdc.

When R_{LOAD} falls into the 10 to 150 ohm range normally encountered with a properly applied dual-foil electrode, R_{IN} also drops and VARM falls into the 1.0 to 2.5 V range. If R_{IN} is very low, as when a single foil electrode is connected, VARM drops to about +0.8 Vdc. Resistors R51 and R52 serve to set a lower limit to the resistance applied across T4's secondary. Without this lower limit, the effective short circuit presented by a single foil return electrode would reduce the Q of the 37 KHz tuned circuit to the point that the oscillator would behave erratically. Thus VARM varies directly with the resistance appearing in the return electrode circuit. The relationship is essentially logarithmic, with increases in VARM becoming vanishingly small as R_{LOAD} rises above 1000 ohms. This means that VARM will change by a nearly constant voltage for a given percentage change in R_{LOAD} anywhere in the 10 to 150 ohm range. The balance of the A.R.M. Circuitry resides on the A2 Controller PWB, Figure 4.4. Diode D11 is a +1.235V regulator whose output voltage appears across the 2.49K resistor R21, thus driving a constant current of 0.5 mA to the VARM line. R23 and C23 act as a low-pass noise filter. U15:B is connected as a noninverting amplifier with a gain of 2 to amplify the filtered VARM voltage to 2VARM and is an input to the analog to digital converter U16.

Figure 3.1 shows the approximate resistance vs. number of illuminated bars in the resistance indicator. If no bars are lit, then the resistance is less than approximately 10 ohms, if 10 bars are lit, the resistance is greater than approximately 150 ohms. It is not possible for just 1 or 9 bars to be lit.

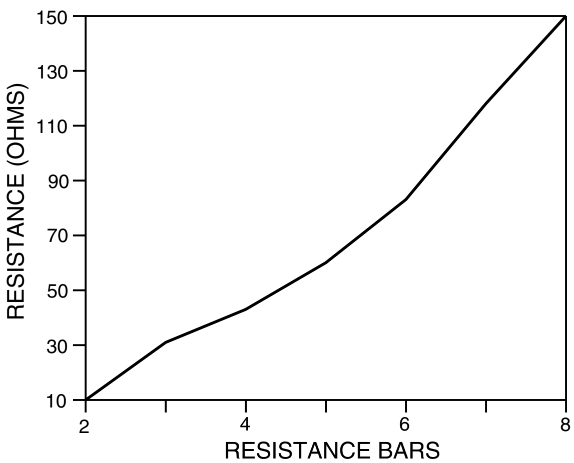


FIGURE 3.1

The VARM voltage is read by channel #0 of the analog to digital converter (A2U16) to an accuracy of 10mv. This voltage is directly proportional to pad resistance and is used by the program to test and display the pad resistance value. This value is then processed along with the VARM values for 10 and 150 ohm return circuit resistances stored in the EEPROM during the last pad calibration to evaluate the current.

The Return Fault process works on a 50-point (0.6 sec) minimum average VARM value. If Single Foil Mode is selected, the microprocessor will declare a Return Fault when VARM indicates that pad resistance is 10 ohms or greater. The Resistance Indicator is always dark in this mode.

In Dual Foil Mode, the Resistance Indicator will be illuminated to indicate pad resistance in the range of 10 to 150 ohms. At just over 10 ohms, the two left bars are illuminated. As VARM increases, additional bars are illuminated in proportion to VARM, progressing to the right, until the resistance approaches 150 ohms, where eight bars are illuminated. When resistance exceeds 150 ohms, all ten bars are illuminated. Whenever a Return Fault condition exists, all illuminated bars will flash, but resistance is still displayed as above.

In Dual Foil Mode, the microprocessor declares a Return Fault if RLOAD is less than 10 ohms or greater than 150 ohms. If VARM is within the allowed range, then the Return Fault Indicator will turn off when the Monitor Set Key is pressed, and the present value of VARM is stored for reference. A new Return Fault will be declared if pad resistance rises about 20% above this stored value or goes out of the allowed range.

A rise of approximately 20% over the resistance of a Return electrode in full contact with a patient indicates significant electrode detachment. A Return Fault declared in this case will NOT automatically be cleared if the patient resistance drops back to near the stored value. The Monitor Set Key must again be pressed to register the staff's satisfaction that the electrode attachment is safe before turning off the alarm.

Because patients' and return site resistances vary over a considerable range, it is not safe to assume that any in-range resistance indicates safe electrode attachment. For example, a poorly placed electrode on a well-perfused site can show the same resistance as a safely attached electrode on adipose tissue. Yet the poorly placed electrode could still result in a burn due to low contact area. The clinical staff is responsible for the final judgement of safe return electrode placement.

3.1.9 Isolated Handswitching/Footswitching

The circuit for the handswitched accessories are electrically isolated using both magnetic and optical coupling. Refer to Schematic 4.7. A 90 KHz oscillator, A1U2, generates a 20% duty-cycle rectangular wave drive to the FET transistor A1Q6, which drives the resonant primary circuit of a toroidal isolation transformer, T2. The energy coupled to the secondary windings is rectified and filtered to produce an isolated 3 to 4 Vdc source for each of the three separate RF output circuits (BIPOLAR, H1, and H2). The bipolar hand switch continuity detector will be used as an example, since all sections are identical.

The secondary winding T2-8 and T2-7 combine with D16 and C59 to produce an isolated dc voltage. When the bipolar hand switch is closed, the emitter of Q16 is pulled to the return of it's isolated power supply, turning Q16 on. With Q16 turned on, current flows through the LED of the optocoupler U10, turning its output transistor on. This results in /BIP-H going low, and signalling the microprocessor that the handswitch is on. C60 bypasses any RF currents around the bipolar accessory switch. R53, R54,and R63 bias Q16 to prevent the circuit from turning on when the impedance presented by the output switch is >1000 ohms. This decreases the possibility of accidental activations if blood or saline seep into the switch. International units use similar circuits (see Schematic 4.7) to provide footswitch isolation.

Figure 3.2 Waveform Generator Output

A1TP1 is the BGATE signal, A2TP23 is the GATE signal.

Note: The lower trace in each oscillogram is A2TP14 and is used as the trigger point source. Where there is noticeable aliasing in the bipolar modes, an expanded view of the waveform is included for clarity.

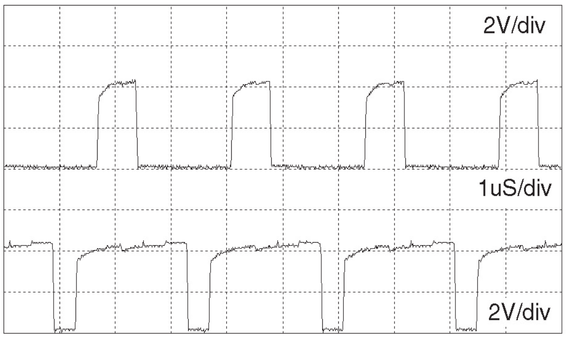


Photo 1: Pure A2TP23

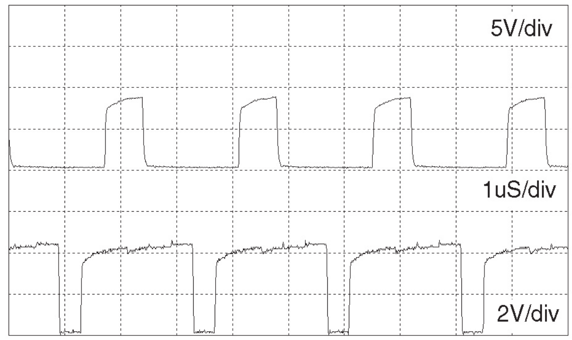


Photo 2: Pure A1TP1

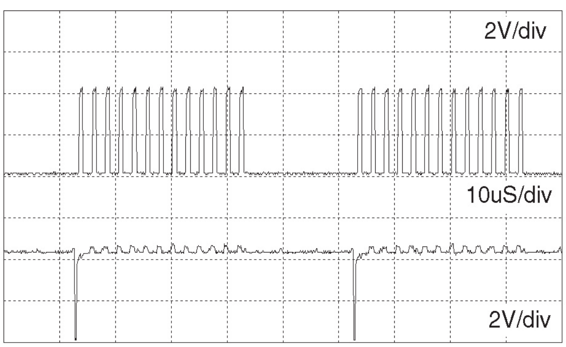


Photo 3: Blend A2TP23

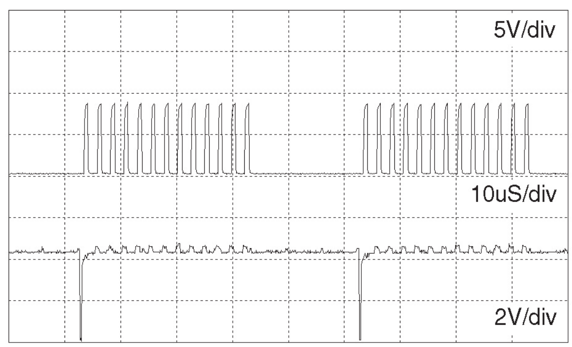


Photo 4: Blend A1TP1

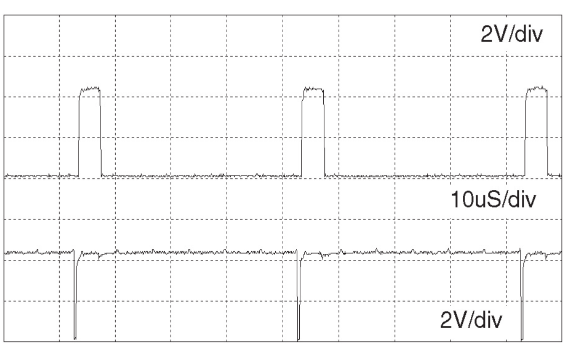


Photo 5: Coag A2TP23

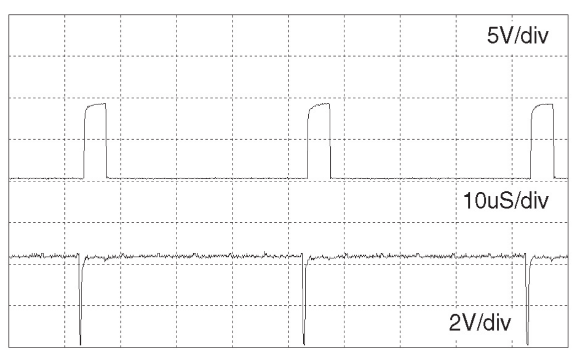


Photo 6: Coag A1TP1

Figure 3.2 Waveform Generator Output

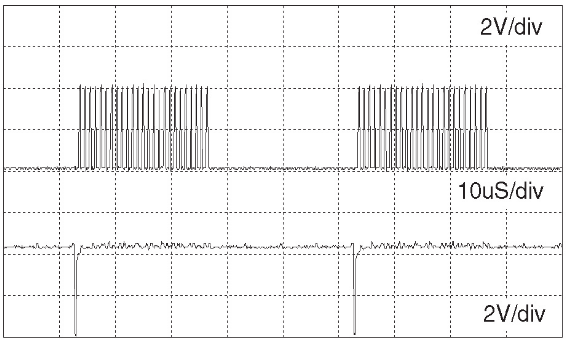


Photo 7: Bipolar 25W A2TP23

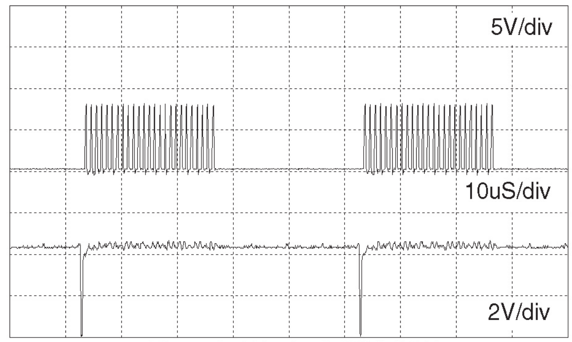


Photo 8: Bipolar 25W A1TP1

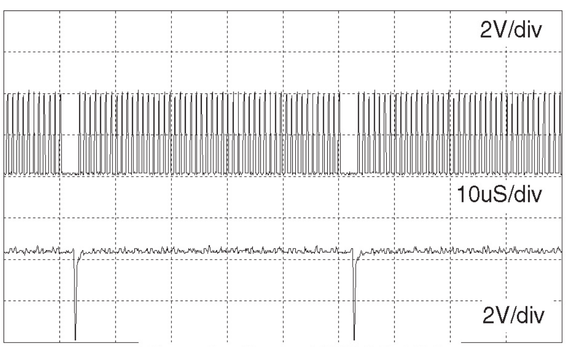


Photo 9: Bipolar 50W A2TP23

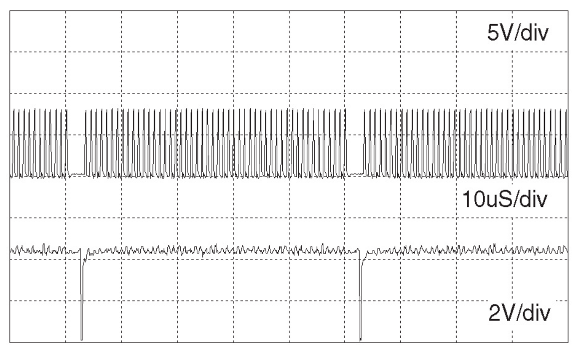


Photo 10: Bipolar 50W A1TP1

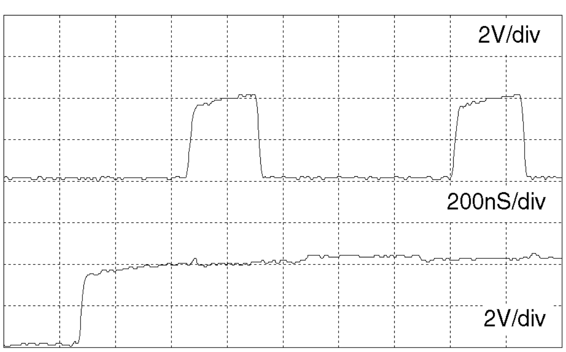


Photo 11: Bipolar 50W A2TP23

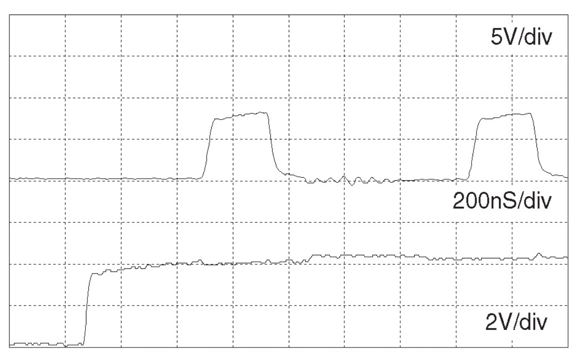


Photo 12: Bipolar 50W A1TP1

Figure 3.3 RF Output Waveforms

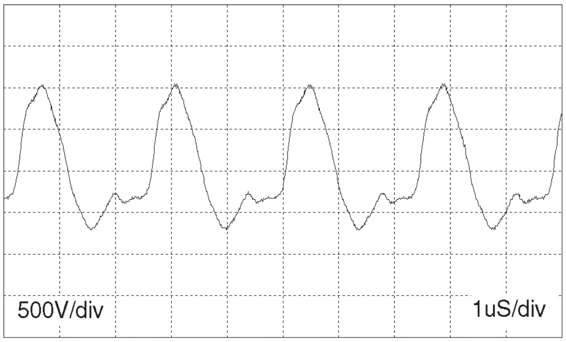


Photo 1: Monopolar Pure 300W, Open Circuit

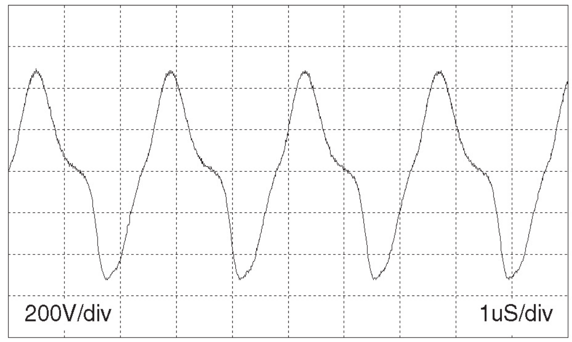


Photo 2: Monopolar Pure 300W, 300 ohm

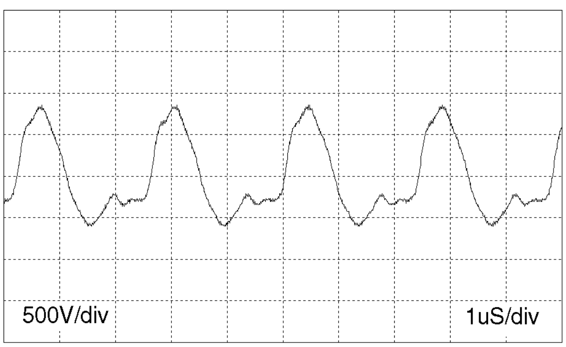


Photo 3: Monopolar Pure 150W, Open Circuit

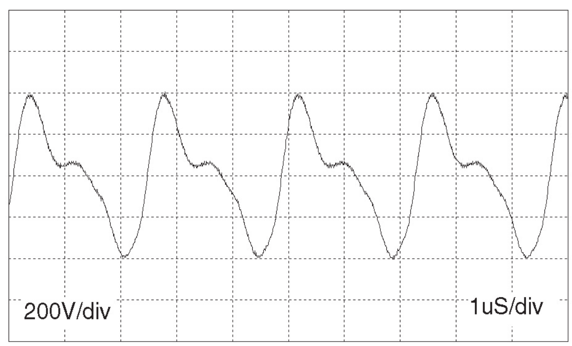


Photo 4: Monopolar Pure 150W, 300 ohm

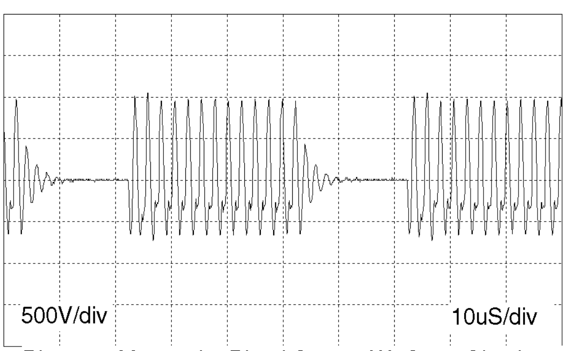


Photo 5: Monopolar Blend Cut 180W, Open Circuit

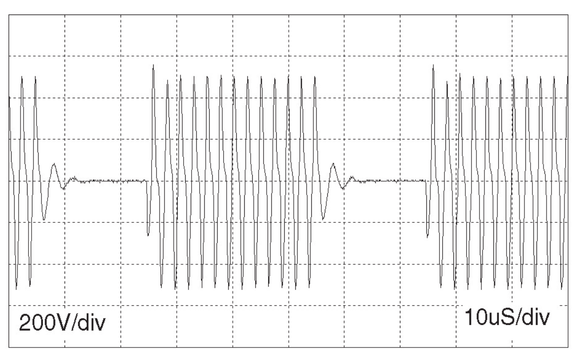


Photo 6: Monopolar Blend Cut 180W, 300 ohm

Figure 3.3 RF Output Waveforms

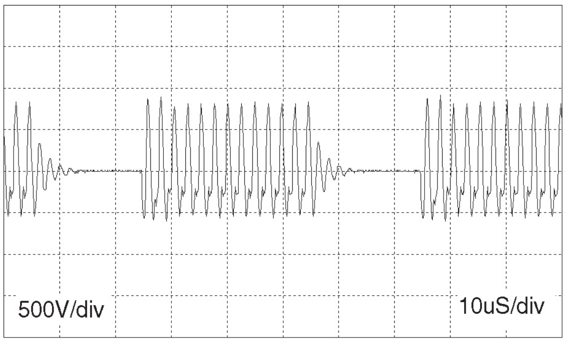


Photo 7: Monopolar Blend Cut 90W, Open Circuit

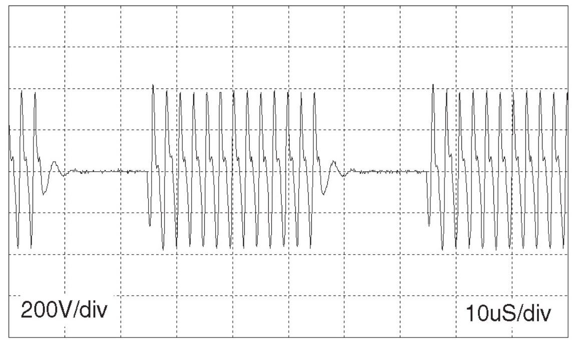


Photo 8: Monopolar Blend Cut 90W, 300 ohm

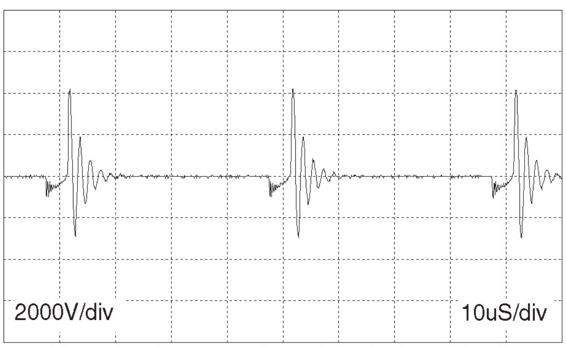


Photo 9: Monopolar Coag 120W, Open Circuit

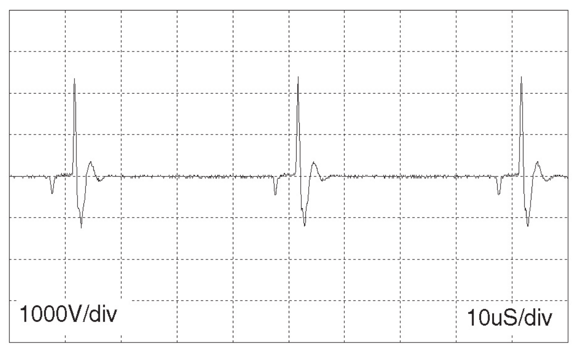


Photo 10: Monopolar Coag 120W, 500 ohm

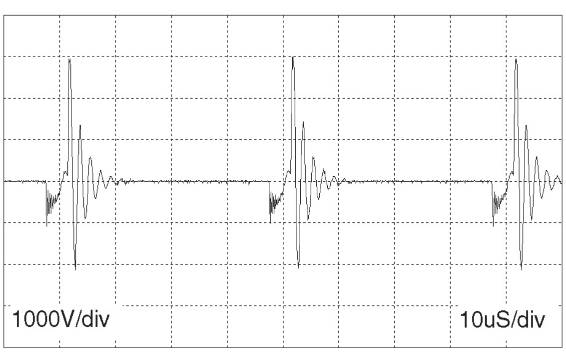


Photo 11: Monopolar Coag 60W, Open Circuit

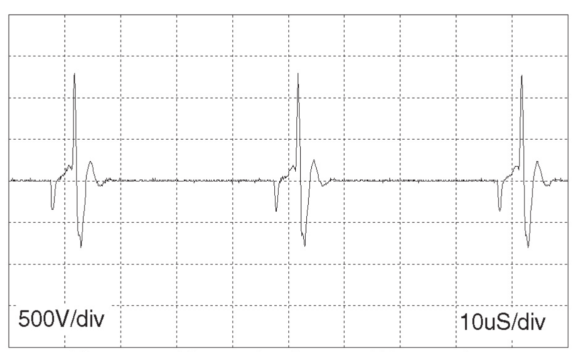


Photo 12: Monopolar Coag 60W, 500 ohm

Figure 3.3 RF Output Waveforms

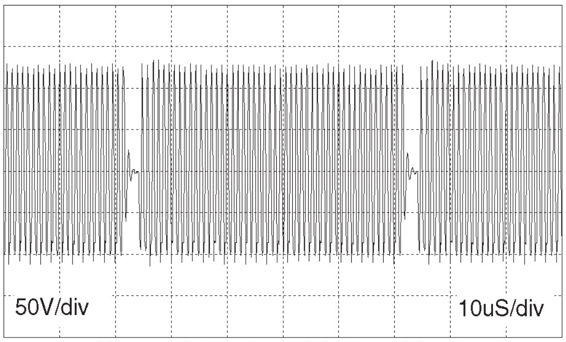


Photo 13: Bipolar 50W, Open Circuit

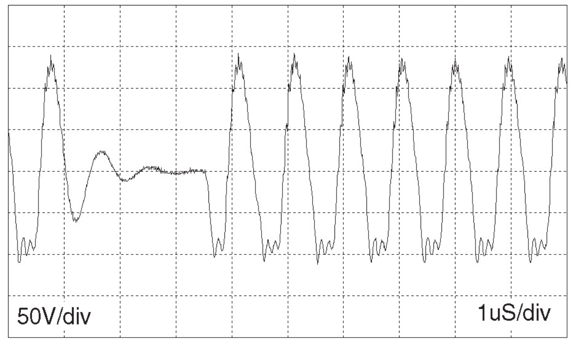


Photo 14: Bipolar 50W, Open Circuit

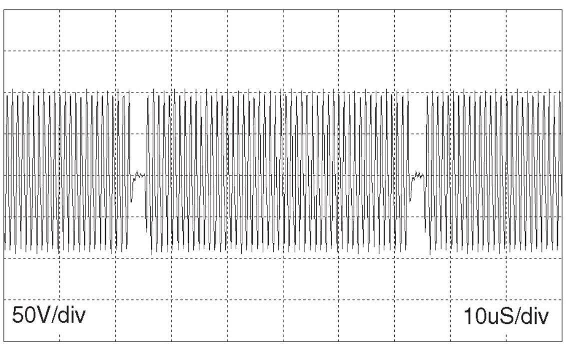


Photo 15: Bipolar 50W, 50 ohm

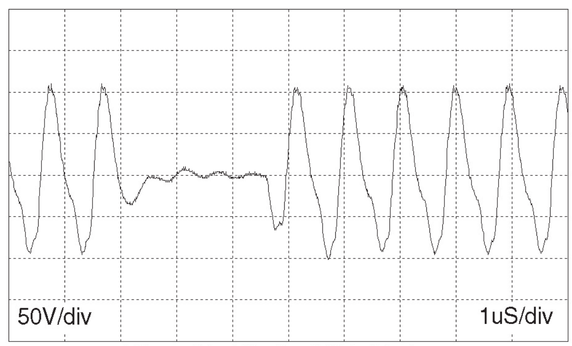


Photo 16: Bipolar 50W, 50 ohm

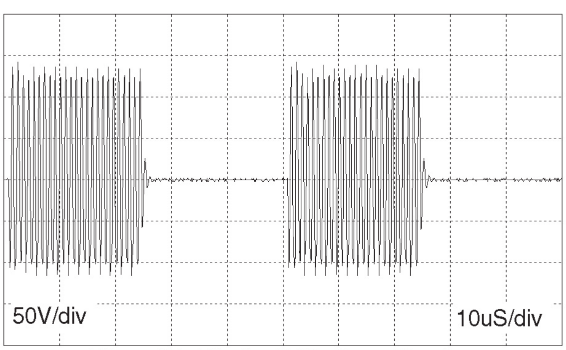


Photo 17: Bipolar 25W, Open Circuit

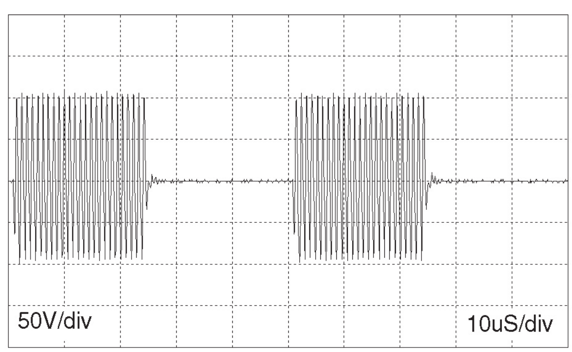


Photo 18: Bipolar 25W, 50 ohm

Maintenance

Section 4.0

4.1 GENERAL MAINTENANCE INFORMATION

This section contains information useful in the maintenance and repair of the Sabre 2400. While the unit has been designed and manufactured to high industry standards, it is recommended that periodic inspection and performance testing be performed to ensure continual safe and effective operation.

Ease of maintenance was a primary consideration in the design of the Sabre 2400. Maintenance features of this unit include microprocessor aided troubleshooting aids and push button calibration, built in fault detection, circuit simplicity, circuit protection, use of common parts, easy access to circuitry while the unit is operational, and fused power transistors. These features coupled with the warranty, local support, loaner equipment, factory support, toll free phone service to the factory and available factory training ensure the user of a minimal maintenance effort with extensive support available.

4.2 ASSEMBLY BREAK DOWN & PARTS ACCESS

>WARNING<

**HAZARDOUS VOLTAGES ARE PRESENT ON INTERNAL COMPONENTS.
BE SURE THAT THE UNIT IS TURNED OFF AND THE POWER PLUG IS DISCONNECTED BEFORE DISASSEMBLY.**

The Sabre 2400 opens into a Base Assembly and a Top Cover Assembly. To gain access to the internal parts remove the two Phillips head screws on the Rear Panel. Refer to Figure 4.1. Slide the Top Cover forward and lift its front edge. The Top Cover can be held open vertically by sliding the Rear Support Bracket Slots onto the top edge of the Base Assembly. See Figure 4.2. To close the Top Cover, lift it upward until the Support Bracket Slots are free and then lower it onto the Base Assembly. Reengage the Front Closure Pins into the Base Assembly slots before replacing the rear screws.

4.2.1 Power PWB Assembly A1

To gain access to the circuit side of the A1 Assembly, remove 10 cable connectors (11 connectors on -003 & -015 models). Remove 4 socket head fasteners from the Heatsink. Remove one socket head fastener from the PWB, and the two nylon hex nuts from the PWB. Don't remove fasteners from the diagonal brace. Note that there is a nylon push-on standoff at the rear of the A1 PWB assembly. Carefully lift the PWB off the standoff, then lift the A1 Assembly straight up and out of the A5 Base Assembly. Verify all cable connections when reinstalling this Assembly.

4.2.2 Micro Controller PWB Assembly A2

To gain access to the circuit side of the A2 Assembly, remove 4 cable connectors. Remove three #6 hex nuts clamping the voltage regulators to the cover. Rotate the clamps away from the voltage regulators. Remove 4 socket head fasteners from the PWB. Lift the PWB Assembly from the A4 Cover Assembly. Replace the 3 voltage regulator pads when reinstalling. Use Loctite #222 on all fasteners when reinstalling. Torque the hex nuts to 5 inch pounds, +1/-0. Verify all cable connections after reinstalling.

4.2.3 Display PWB Assembly A7

To gain access to the component side of the A7 Assembly, remove three cable connectors. Remove four socket head fasteners holding the PWB to the A3 Control Panel. Carefully lift the A7 Assembly away from the A3 Control Panel. Reverse this process when reassembling. Use Loctite #222 on all fasteners when reinstalling.

4.3 CLEANING

The interior of the unit may be vacuumed or blown out as required. The exterior of the unit may be cleaned by wiping it with a cloth that has been dampened (not dripping) with a mild detergent such as Windex® or Formula 409®. Windex® is the registered trademark of the Drackett Products Company. Formula 409® is the registered trademark of the Clorox Company.

4.4 PERIODIC INSPECTION

The Sabre 2400 should be visually inspected at least every six months. This inspection should include checks for:

- Damage to the power cord.
- Damage to the power plug.
- Tightness of the power plug.
- Proper mating and absence of damage to the patient connectors.
- Obvious external or internal damage to the unit.
- Accumulation of lint or debris within the unit or heatsink.
- Control Panel punctures or dents

4.5 PERIODIC PERFORMANCE TESTING

The Sabre 2400 should be performance tested at least every six months. Every unit is supplied with a serialized Production Test Data Sheet that tabulates the results of the factory tests that were performed on the unit. This data is supplied so that it may be used as a reference for subsequent tests. Recommended periodic performance tests are listed in the following sections.

When comparing your RF output current readings to those on the Test Data Sheet, bear in mind that most RF ammeters may read an error up to 3% of full scale. This means an actual current of 0.60A may register on a 1A meter anywhere from 0.57 to 0.63A.

4.5.1 Chassis Ground Integrity

Equipment:
Volt-Ohmmeter, Simpson 260 or equivalent

Procedure:
Connect the ohmmeter between the earth ground prong of the power plug and the footswitch connector. Confirm less than 0.1 ohm resistance.

4.5.2 Displays, Alarms, Commands

Preliminary checks of the items listed below appear in Section 2.3.

- Return Fault Alarm
- Mode Indicator Lamps
- Sound Tones and Volume Control
- Hand control/Forceps Operation
- Foot switch Operation
- Resistance Indicator
- Return Fault Indicator
- Power Indicators

Equipment:
2 Hand controls, Single and Dual Foil Return Electrodes, Foot switches, Jumper Wire

Procedure: See Section 2.3.

4.5.3 Output Power

Equipment:

Monopolar Foot switch
Bipolar Foot switch

0-1.5A RF Ammeter as a minimum. The most accurate RF current measurements will result when read on the upper 50% of the meter scale. A set of meters including 150mA, 250mA, 500mA, 1.0A and 2.0A are recommended.

300, 400, or 500 ohm 250W noninductive resistor

50, 100, or 125 ohm 50W noninductive resistor
Return Electrode Adapter Plug (shorting)

Bovie #12 Adapter Plug
3 test leads, 1m max. length

Procedure:
1. Use test leads to connect an RF ammeter in series with the 250W resistor and one of the unit's return electrode jack and the foot switch controlled active jack.

2. Perform the monopolar power tests indicated in Table 4.1 depending on the value of the load resistor used.

3. Disconnect the RF ammeter and load resistor from the unit.

4. Use test leads to connect the RF ammeter in series with the 50W resistor and the unit's blue Bipolar Accessory Jacks.

5. Perform the bipolar power tests indicated in Table 4.1 depending on the value of the load resistor used.

Note: The RF output power level checks of Table 4.1 correct for the load regulation characteristics of the Sabre 2400. This results in output current levels that may be different from the power setting when the $P=I^2*R$ calculation is done at other than the rated load. Refer to the Load Regulation Curves in Section 1 for details.

Mode	Power Setting	Output Current (mA)	Power Setting	Output Current (mA)
Monopolar				
Pure Cut				
300 ohms	300	949-1040	150	671-741
400 ohms	300	822-908	150	619-684
500 ohms	300	730-806	150	564-623
Blend Cut				
300 ohms	180	739-812	90	520-574
400 ohms	180	634-700	90	489-539
500 ohms	180	562-620	90	449-496
Coag				
300 ohms	120	596-659	60	417-461
400 ohms	120	520-574	60	368-406
500 ohms	120	465-513	60	329-363
Bipolar				
50 ohms	50	949-1040	25	671-741
100 ohms	50	592-653	25	425-469
125 ohms	50	514-567	25	360-397

Table 4.1 RF Output Power Checks

4.5.4 RF Leakage

Equipment:

0-250 mA RF Ammeter

200 ohm 10 W Noninductive Resistor

Patient Plate Adapter Plug

Bovie #12 Adapter Plug

2 - Test leads, 1 m max. length

3 - Test leads, 10 cm max. length

Wooden table approximately 1 m from floor.

Procedure:

1. Ensure that the unit is fully assembled and all fasteners are tight.

2. Place the meter and resistors on the table so that they are at least 0.5m away from the unit under test and any other conductive surface.

3. Set the unit for full power Standard Coag and Bipolar Coag. Connect the 200 ohm nonreactive resistor in series with the 250 mA RF ammeter, and a common earth ground (the footswitch connector shell will suffice). One at a time, connect this series combination to each RF output terminal indicated in Table 4.2, and activate the unit using the corresponding command. Confirm that no meter readings exceed the specified maximum. Hand control coag activations are accomplished by connecting a jumper between the lower black jack and the red jack of the desired hand switchable accessory jack.

4. This measurement applies only to Sabre 2400 P/N's 60-5600-003 and 60-5600-015. Measure A1 C67 and C68 in circuit resistance to confirm a value greater than 20M ohm resistance. Temporarily disconnect A1-J11 and measure RF leakage from the Foot Active with Foot Coag activation and confirm that RF leakage increases with the connector disconnected. Reconnect A1-J11 when finished.

>WARNING<
HAND CONTROL ACTIVATIONS SHOULD BE KEYED USING 3" OR LESS WELL INSULATED JUMPER(S). USE OF AN INSULATING ROD TO INSERT THE JUMPER IS ADVISED TO PREVENT RF BURNS.

MEASURED OUTPUT TERMINAL	ACTIVATION COMMAND	MAXIMUM LEAKAGE (mA)
RETURN ELECTRODE	FOOT COAG	100
RETURN ELECTRODE	LEFT HAND CONTROL COAG	100
RETURN ELECTRODE	RIGHT HAND CONTROL COAG	100
RETURN ELECTRODE	BOTH HAND CONTROL COAG	100
FOOT ACTIVE	FOOT COAG	100
BIPOLAR TOP	FOOT BIPOLAR	20
BIPOLAR BOTTOM	FOOT BIPOLAR	20

Table 4.2 RF Leakage to Ground Tests

4.5.5 RF Leakage from Inactive Outputs

Equipment: Same as in Section 4.5.4

Procedure:

1. Set the unit for full power Standard Coag and Bipolar Coag. Connect the 200 ohm, nonreactive resistor in series with the 250 mA RF ammeter. One at a time, connect that series combination between the return electrode connector and each RF output terminal shown in Table 4.3, and activate the unit using the corresponding command. Confirm that no meter readings exceed the specified maximum. Hand control coag activations are accomplished by connecting a jumper between the lower black jack and the red jack of the desired hand switchable accessory jack.

>WARNING<

HAND CONTROL ACTIVATIONS SHOULD BE KEYED USING 3" OR LESS WELL INSULATED JUMPER(S). USE OF AN INSULATING ROD TO INSERT THE JUMPER IS ADVISED TO PREVENT RF BURNS.

CAUTION: To avoid destroying the meter, never activate output terminal connected to the meter.

2. Disconnect the meter and resistor from the unit. Turn unit Power Switch OFF.

MEASURED OUTPUT TERMINAL	ACTIVATION COMMAND	MAXIMUM LEAKAGE (mA)
FOOT ACTIVE	LEFT HAND COAG	50
FOOT ACTIVE	RIGHT HAND COAG	50
FOOT ACTIVE	FOOT BIPOLAR	20
LEFT HAND ACTIVE	FOOT COAG	50
LEFT HAND ACTIVE	RIGHT HAND COAG	50
LEFT HAND ACTIVE	FOOT BIPOLAR	20
RIGHT HAND ACTIVE	FOOT COAG	50
RIGHT HAND ACTIVE	LEFT HAND COAG	50
RIGHT HAND ACTIVE	FOOT BIPOLAR	20
BIPOLAR TOP	FOOT BIPOLAR	20
BIPOLAR BOTTOM	FOOT BIPOLAR	20

Table 4.3 RF Leakage for Inactive Outputs Test

4.5.6 Line Frequency Leakage

Equipment: (See UL 544 or ANSI/AAMI HF-18)

Line Reversing Switch

Ground Switch

High Impedance Meter (Fluke 8000 A or equivalent)

Frequency Compensation Network (1K resistor in parallel with the series combination of a 10 ohm resistor and a 0.15 uf capacitor.)

Procedure:

1. With the frequency compensation network connected across the voltage input terminals of the meter, make the measurements indicated in Table 4.4. With the meter scale set for ac millivolts, the meter reading is equivalent to microamperes.

2. Since the Sabre 2400 monopolar active outputs are disconnected by relays when the unit is not activated, active-to-neutral leakage tests must be performed with the unit activated in order to be valid. To prevent RF current from affecting leakage readings, set all controls to zero.

3. With all power controls set to 0, measure the leakage current as in step 1 from each of the three active output terminals to neutral (See Table 4.5) while that output is activated in Cut by the appropriate foot switch or hand control jumper. Hand control cut activations are accomplished by connecting a jumper between the lower black jack and the red jack of the desired hand switchable accessory jack.

Leakage Path	Line Polarity	Case Ground	Test Limit
Bipolar-Neutral	Normal	Closed	5uA
Bipolar-Neutral	Normal	Open	5uA
Bipolar-Neutral	Reversed	Closed	5uA
Bipolar-Neutral	Reversed	Open	5uA
Return Electrode-Neutral	Normal	Closed	5uA
Return Electrode-Neutral	Normal	Open	5uA
Return Electrode-Neutral	Reversed	Closed	5uA
Return Electrode-Neutral	Reversed	Open	5uA
Chassis-Neutral	Normal	Open	40uA
Chassis-Neutral	Reversed	Open	40uA

Table 4.4 Unkeyed Line Frequency Leakage Tests

	Leakage Path	Line Polarity	Case Ground	Test Limit
Foot Controlled	Active-Neutral	Normal	Closed	5uA
	Active-Neutral	Normal	Open	5uA
	Active-Neutral	Reversed	Closed	5uA
	Active-Neutral	Reversed	Open	5uA
Hand Control 1	Active-Neutral	Normal	Closed	5uA
	Active-Neutral	Normal	Open	5uA
	Active-Neutral	Reversed	Closed	5uA
	Active-Neutral	Reversed	Open	5uA
Hand Control 2	Active-Neutral	Normal	Closed	5uA
	Active-Neutral	Normal	Open	5uA
	Active-Neutral	Reversed	Closed	5uA
	Active-Neutral	Reversed	Open	5uA

Table 4.5 Keyed Line Frequency Leakage Tests

4.5.7 Aspen Return Monitor (A.R.M.) Calibration Check

This section describes the method to check the calibration of the A.R.M. circuitry.

Equipment: Non-inductive Decade Resistance Box (DRB) with attached dual foil return electrode cable. The DRB must be adjustable from 0 to 160 ohms in 1 ohm steps and accurate to 1%. A dual foil return electrode cable can be made by cutting the cable and connector (2 to 3 feet from the connector) from a dual foil return electrode, and stripping the wires for connection to the DRB.

NOTE: Some DRBs may present a brief open circuit at the output terminals during switch movement. This may cause the A.R.M. software to calculate an erroneously high resistance reading. This effect may be minimized by making DRB setting changes quickly. If the resistance read during any of the following tests is above the upper limit, repeat the test carefully stopping in each 1 ohm step for at least 1 second.

Procedure:

1. Disconnect all accessories from the Sabre 2400 front panel.

2. Power up the Sabre 2400 in the RUN Mode. Select Dual Foil Mode and confirm that Resistance Indicator has all 10 green bars flashing, the Monitor Set Key is flashing and that the Return Fault Indicator is illuminated.

3. Using the test cable, connect the DRB to the Return Electrode Jack.

4. Adjust the DRB until eight bars of the Resistance Indicator are flashing.

5. Carefully advance the DRB in 1 ohm steps until all 10 bars of the Resistance Indicator are flashing. Confirm that the DRB reads between 137 and 163 ohms.

6. Set the DRB to 7 ohms and confirm that the Resistance Indicator is dark and the Return Monitor is lit.

7. Select Single Foil Mode. Confirm the Resistance Indicator stops flashing and the Return Monitor is not illuminated.

8. Increase the DRB in 1 ohm steps until an audible Return Fault Alarm is sounded and the Return Fault Indicator is lit. Confirm the DRB is between 8 and 12 ohms.

9. Decrease the DRB setting in 1 ohm steps until the Return Fault Indicator goes dark. Confirm that the DRB reads from 1 to 4 ohms less than the resistance read in Step 8.

10. Disconnect the DRB. This completes the A.R.M. calibration test. If any readings were only slightly out of range, first check the DRB with an accurate ohmmeter. If the DRB is accurate, recalibrate the A.R.M. limits in CAL Mode. See Section 4.6.4. If one or more readings were far from the mark, troubleshoot the A.R.M. circuitry before attempting recalibration. See Section 4.7.6.

4.6 CALIBRATION AND ADJUSTMENTS

The Sabre 2400 is calibrated without selecting or adjusting components. Instead, calibration factors necessary to compensate for unit-to-unit circuit variations are stored digitally in an electrically erasable programmable read only memory (EEPROM) A2U4. This device contains the VBASE drive vs. output power lookup tables for each of the operational modes, and the VARM values for the upper and lower allowable resistance limits of the dual foil return circuit.

The EEPROM contents remain intact for years with no power applied, and redundant hardware and software are used to prevent changing EEPROM data in normal use. On every power up and during normal operation, the integrity of the EEPROM contents is validated using a Cyclic Redundancy Check (CRC). Failure of the stored EEPROM CRC to match the computed value will result in declaration of a HLP-3 Fault code and shutdown of all output.

A special operational mode, called CAL Mode, permits the EEPROM data to be updated to compensate for circuit performance changes due to aging or replacement of components. In CAL Mode, the microprocessor guides the technician to simplify and expedite a complete and accurate calibration. A second function "dIA" may also be selected in CAL mode. See sections 4.7.2 and 4.7.3 for an explanation of its function.

NOTE: CAL Mode should not be used to perform routine calibration checks. Those tests are better conducted in RUN Mode per Sections 4.5.3 and 4.5.7. If the unit proves to be out of calibration, the possibility of a component failure should be eliminated as the cause before recalibrating. Once the physical health of the unit as been confirmed, then CAL Mode may be entered to correct the calibration.

4.6.1 CAL Mode General Information.

CAUTION: Do not enter CAL Mode without first reading and understanding the following material and ensuring that the necessary equipment is on hand and accurate. Improper calibration procedures can cause an otherwise serviceable unit to become unusable until calibration is corrected.

• On initial entry to CAL Mode, a calibration validity test is done. If the test passes, then all points in all modes are considered calibrated; if it fails, ALL points are declared uncalibrated, and the EEPROM is loaded with a set of nominal values which will bring a properly functioning unit within range of its required calibration. The unit will be unserviceable until fully recalibrated.

• If nonmonotonicity is detected on exit from a Calibration mode, a HLP-11 code is displayed, and all of the calibration points for the nonmonotonic operational mode are declared uncalibrated. As with incomplete calibration, the menu selection for the affected mode will flash when the "SEL" Key is pressed again.

• After a fully calibrated mode is entered, making a change to any one calibration point will cause all of the other points in that mode which have not yet been checked to be declared uncalibrated. Those points must then be calibrated prior to returning the unit to service. This precaution is taken on the assumption that if some part of the circuitry has changed enough to justify adjustment of one calibration point, then it is likely that the other points have been affected as well.

• Each calibration point has fixed upper and lower limits which will permit calibration of a healthy unit at nominal line voltage. It is not possible to store a calibration value in the EEPROM which falls outside that range.

• The CAL Mode is entered by powering up while depressing the internal CAL switch, A2S1. Successful CAL Mode entry is signified by all display segments illuminating. This allows a careful check of the display for missing segments.

• To proceed past the display check, press the SEL key, then the CUT power window will display "C-C", which is one of four available mode selections. Any of the other modes may be selected sequentially by pressing the CUT Power Increase or Decrease keys. In some modes, the COAG power window and/or the Bipolar power window will display an option applicable to that mode; these options are similarly selectable by pressing the Power Increase or Decrease keys. Details of how to use each mode appear in following sections. The available CAL modes, options and their uses are summarized in Table 4.6.

• Although the points in a Calibration mode may be calibrated in any order, it's best to use a sequence which ensures that calibration is complete before returning to the menu.

• When calibration in a mode is completed satisfactorily, pressing the “SEL” Key will save all calibration changes and will return to the menu. If the menu mode display for one of the three Calibration modes is flashing, then one or more points in that mode is uncalibrated or nonmonotonic. Pressing the “SEL” Key again will restore the menu, from which the mode may be reentered and calibration completed or corrected to fix the problem.

• When the “SEL” Key is pressed to exit a Calibration mode, the unit first checks for any uncalibrated points in that mode. If any exist, then a HLP-10 code is displayed. The values of all of the points remain as they were at the time of exit, eliminating the need to repeat the adjustments that were already made. An exception occurs when the selected load resistance is changed. In that case, the entire section (C-C or bP) will go to it's uncalibrated state. Pressing the “SEL” Key again will restore the menu, and the menu display for the partly calibrated mode will flash. The calibrated and uncalibrated status for all points in that mode is preserved while in CAL Mode, so that when the mode is reentered, it is necessary only to calibrate the flashing points to fully calibrate that mode.

• CAL Mode is exited by turning the POWER switch OFF. This operation should only be performed AFTER returning to the main menu.

NOTE: If ANY of the modes in the menu are flashing, the calibration for that mode is invalid. Exiting CAL Mode in this condition will result in an immediate EEPROM FAIL (HLP-3) alarm on powerup in RUN mode. Complete recalibration will then be required in order to return the unit to service.

• It's a good practice to be sure that all of the menu modes show as calibrated (not flashing) before departing CAL or entering Diagnostics modes.

• The Diagnostics modes are removed from the menu after RF is activated in either of the Power Calibration modes. It is not possible to return to the menu from either of the Diagnostics modes without powering down.

4.6.2 Power Calibration General Information

• The only equipment necessary to conduct power calibration is an electrosurgical output power tester having load resistances of 300, 400 or 500 ohm for Monopolar and 50, 100, or 125 ohms for Bipolar and an RF rms current indicator capable of accurate measurements from 50 to 1000 mA. These units are commercially available from a number of sources, or can be constructed using 250 watt 3% or better noninductive resistors and a selection of RF ammeters ranging from 150 mA to 1A full scale.

• If the selected power calibration load resistance is other than the rated load, target current will deliver another power which takes into account Sabre 2400's typical load regulation characteristics in that mode. The actual load regulation curve for a particular unit may vary somewhat from typical, so the most accurate calibration is obtained when calibration is performed using the rated load. Satisfactory calibration is possible ONLY if the calibration resistor option chosen and the actual load resistance used are the same.

CAUTION: Before activating a newly selected point, be sure that the tester range is at least as great as the displayed target current. Bear in mind that a unit which is far out of calibration may deliver considerably more than the target current.

• The Power Increase and Decrease keys are used to select the calibration points when the unit is not activated. When the highest calibration point in a mode is displayed, the Power Increase key will have no further effect; the same is true for the Power Decrease key when the lowest point is displayed. This is useful in determining when a mode is fully calibrated.

• Each point is calibrated by activating the unit, then using that mode's Power Increase or Decrease key to match the target point as close as possible. It may not be possible to match the target exactly, but the setting which reads closest to the target will be within the specified tolerance. The most accurate current readings will appear on the lowest RF current range which reads on scale.

MODE (CUT PWR)	MODE USE	OPTION 1 (COAG PWR)	OPTION 1 USE	OPTION 2 (BIPOLAR PWR)	OPTION 2 USE
C-C	MONOPOLAR POWER CAL	300, 400, 500	SELECT LOAD RESISTANCE FOR CAL	A, P	SELECT READOUT IN AMPS OR POWER
bP	BIPOLAR PWR CAL	50, 100, 125	SELECT LOAD RESISTANCE FOR BIPOLAR CALIBRATION	A, P	SELECT READOUT IN AMPS OR POWER
PAd	ARM (PAD) RESISTANCE CALIBRATION	BLANK			
dIA	DIAGNOSTICS	1	WATCHDOG TIMER CHECK	NONE	
		2	PSEUDO RUN MODE (DISABLES SOFTWARE SHUTDOWN TO AID TROUBLESHOOTING)	NONE	
		3	VIEW MODE	1-9	SEE TABLE 4.9 FOR DETAILS

Table 4.6 CAL Mode Options

• It is only necessary to activate the unit for the selected point to be considered calibrated. No actual adjustment is required, but the output current should still be measured and verified against the target value. This eliminates unnecessary "tweaking" if a point is adjusted correctly already.

4.6.3 Output Power Calibration Procedure

Note: This procedure lists a complete power calibration. It is possible to go directly to bipolar mode power calibration ("bP" in the display) if desired by selecting that mode first. In general the complete calibration should be done. This is because whatever changed an output in one mode requiring recalibration will likely affect the other mode.

1. Remove the two screws at the rear of the unit to open the top cover.

2. Connect the output power tester to the Return Electrode jack and one of the active monopolar RF output jacks, depending on how one wishes to activate the unit. If possible, set the tester for the rated load resistance, since this will yield the most accurate calibration results. If this resistance is not available, the Sabre 2400 may be calibrated using 300, 400 or 500 ohm loads.

3. Connect the power plug to a source of AC power of the same frequency and within 1% of the voltage specified on the nameplate.

4. Press A2SW1 (marked CAL) on the micro/control PWB, while turning on the unit's circuit breaker. Successful entry to CAL mode is signified by all segments of the display lighting.

5. Press "SEL". The unit will then momentarily display "CAL" and proceed to display "C-C" in the Cut Power Window, either 300,400,or 500 in the Coag Power Window, and "A" or "P" in the Bipolar Power Window. Use the Power Increase/Decrease to set your requirements. Example: Desired RF load is 500 ohms, and target display in Power. Press the Coag Power Increase Key to set "500" in the Coag Power Window, and the Bipolar Power Increase Key to set "P" in the Bipolar Power Window.

6. Press "SEL" to move into the actual calibration. The Power Windows will display the target value in amps or watts as determined above.

7. Activate the unit and use the Power Increase/Decrease Keys next to the mode being activated to set output to match the displayed target as closely as possible. Deactivate when the best match occurs.

NOTE: Heating tends to change the gain of the power amplifier slightly, so a slow change in load current may be noted while the unit is activated. These errors may be minimized by allowing the unit to cool for 15 to 20 seconds between activations. This phenomenon is not ordinarily a problem unless the unit is far out of calibration, requiring extended activations in order to bring it in. In such cases, first perform a complete rough calibration. Let the unit cool for several minutes, then repeat the calibration. Now the activation time necessary to close in on final adjustments will be very brief.

8. Press the Power Increase/Decrease Key to move the target to the next calibration point. Repeat steps 6 & 7 for Pure, Blend and Coag until all points are calibrated (no points are flashing).

9. When all monopolar points have been calibrated satisfactorily, pressing the "SEL" key will store the updated values and restore the menu. The display will show a steady "C-C" if the calibration has been completed properly, otherwise it will be flashing or show a HLP code.

10. Disconnect the tester from the Monopolar outputs, and connect it to the Bipolar output jacks. Set the tester up for the rated load of 50 ohms if possible, otherwise select 100 or 125 for output load resistance.

11. Use the Cut Power Increase/Decrease Keys to select "bP" in the Cut Power Window. Select the same RF load as chosen above by using the Coag Power Increase/Decrease Keys, and select the target display mode as "A" for amps, or "P" for Power in watts (in the Bipolar Power Window) using the Bipolar Power Increase/Decrease Keys. Press "SEL" to enter the Bipolar calibration mode.

12. Activate the unit in Bipolar mode and use the Bipolar Power Increase/Decrease keys to match the target value. Deactivate the unit when the best match is reached.

13. Press "SEL" and return to the menu. When the point has been calibrated satisfactorily, pressing the "SEL" key will store the updated values and restore the menu. The display will show a steady "bP" if the calibration has been completed properly otherwise it will be flashing or show a HLP code.

14. Check all modes (C-C, bP, and Pad) to determine none of them are flashing. If any are, calibrate that mode.

15. Turn the unit off, then on to confirm the unit powers up normally and is ready for use. Replace the top cover screws.

4.6.4 A.R.M. Calibration (Pad)

This mode calibrates the Aspen Return Monitor (A.R.M.) circuitry. The only equipment required to complete A.R.M. Calibration are 10 and 150 ohm resistances accurate to 5% or better. Power ratings are unimportant, but wirewound resistors should not be used. A means to connect the resistance between both pins of either of the Return Electrode jacks is also required. One can make a set of calibration resistors by cutting dual foil return electrode plugs from the pad and soldering the appropriate resistor to the plug.

1. Remove the two screws at the rear of the unit to open the top cover.

2. Connect the power plug to a source of AC power of the same frequency and voltage specified on the nameplate.

3. Press A2SW1 (marked CAL) on the micro/control PWB, while turning on the unit's circuit breaker. Successful entry to CAL mode is signified by all segments of the display lighting.

4. Press "SEL". The unit will then momentarily display "CAL" and proceed to display "C-C" in the Cut Power Window. Press the Cut Power Increase/Decrease Keys to display "Pad" in the window.

5. Press "SEL" to move into the actual calibration. The Coag Power Window will display the target value ohms to be connected to the Return Electrode jack. The Resistance Indicator will be lit with a corresponding number of bars. A flashing Resistance Indicator denotes an uncalibrated point.

6. Connect the selected resistance to the Return Electrode jack. Wait a second or two, then press the Monitor Set key to store the calibration value.

7. Use the Coag Power Increase or Decrease keys to select the other calibration point, connect the new indicated resistance, pause and enter it as before.

NOTE: If an error tone is sounded when the Monitor Set key is pressed, then the calibration point is out of range, and both points will be declared uncalibrated. Check to ensure that the resistance has the value as displayed in the Coag window and that it is well connected to the Return Electrode. Then repeat calibration of both values. Calibration was successful if the Resistance Indicator is lit steadily for both points.

8. Press the "SEL" Key to restore the menu and save the new values.

9. Turn the unit off, then on to confirm the unit powers up normally and is ready for use.

10. Replace the top cover screws.

4.7 TROUBLESHOOTING

This section explains the troubleshooting aids built in to the Sabre 2400 and provides a guide to their use. Not all failures can be covered in a guide such as this, so the troubleshooter must by necessity understand the full operation of the unit. Read Section 3 for the description of system and circuit theory.

>WARNING<
READ THE SAFETY SUMMARY IN SECTION 1.1.4 BEFORE TROUBLESHOOTING THE UNIT.

If trouble is suspected, perform a thorough visual inspection, looking for loose or burned components which may point to the source of the problem. Verify that all connections are clean and seated properly and that soldered harness connectors are sound and not shorting. Check all wiring for evidence of mechanical damage. Check the regulated and unregulated power supply voltages. Improper supply voltages can produce a multitude of problems. Check that all mechanical connections are secure. Check all fuses. Check the operating instructions and see if the suspected problem was actually designed to work that way.

4.7.1 HLP Codes

The Sabre 2400 microprocessor is programmed with a number of fault detection routines designed to shut the unit down safely if a failure has occurred. This shutdown procedure will produce a HLP code that can help with the troubleshooting process. The following will further explain the HLP codes and other troubleshooting aids.

Upon fault detection, the program will branch to an endless loop which displays a fault HLP code in the Monopolar Cut and Coag power level displays. This loop takes /RFEN false, forces VBASE and the waveform generator output to zero drive condition and commands the relays to open. Further, it ceases generation of Watchdog Timer strobes and redundantly disables the base and gate drive to the Power Amplifier. If the Watchdog Timer detects a processor fault, it will issue an interrupt to the processor, causing a branch to the same routine as above if the processor is healthy enough to respond; if not, RF will still be disabled.

Processor-controlled fault detection occurs extensively on power-up and to a lesser extent, continuously during operation. Each test is assigned a unique HLP number to be displayed on the Monopolar Coag Power Level Display. Refer to Table 4.7 for a complete list of HLP codes and their possible causes.

4.7.2 Pseudo Run Diagnostics (dIA 2)

Armed with a good understanding of the Theory of Operation in Section 3, one can make effective use of Pseudo Run Diagnostics (dIA 2) in correcting any of the faults which result in HLP alarms in Run mode.

Pseudo Run Diagnostics (dIA 2) is provided to permit troubleshooting problems which cause the unit to lock up with a HLP code in RUN mode. Such failures can be in the current limit circuitry, continuity detectors, or power amplifier, to name a few. These problems can be more effectively diagnosed if the unit is made operational.

Table 4.7 HLP Codes and Possible Causes

HLP	Meaning	When Performed	Possible Causes
-1	Read/Write ability of 8031 internal memory is impaired.	Initialization and operation	Faulty A2U3 (8031)
-2	Program memory CRC check error.	Initialization and operation	Faulty A2U9 (27256) Faulty A2U3 (8031) Faulty A2U8 (74573) Open or shorted Address, Control, or Data buss lines.
-3	Calibration memory CRC check error	Initialization and operation	Calibration was incomplete when exiting Cal mode. Faulty A2U4 (X24C04) Faulty A2U3 (8031) Faulty A2U10 (8155) Open or shorted address, Control, or Data buss lines.
-4	Watchdog Timer pulse width is incorrect.	Initialization	WDT timing parts incorrect Microprocessor frequency incorrect. Faulty A2U1 (4538) Faulty A2U3 (8031) Faulty A2U6 (8255) Faulty A2U2 (7400)
-5	RF PA supply	Initialization and operation	Incorrect base voltage Incorrect gate drive Shorted PA power transistor Shorted PA power FET A1 RVI shorted A5BR1 disconnected Shorted capacitor on RFSUP line ISENSE circuit faulty VSENSE circuit faulty Open fuses(s) or transistor(s) in PA Bipolar relay stuck closed Faulty A2U3 (8031)
-6	Attempted entry into guarded memory location or CPU Failure	Initialization and Operation	Faulty A2U3 (8031) Faulty A2U8 (74573) Faulty A2U9 (27256)
-7	Watchdog Timer hardware does not disable RF drive.	Initialization	Faulty A2U30 (7402) Faulty A2U22 (74140)

Table 4.7 HLP Codes and Possible Causes

HLP	Meaning	When Performed	Possible Causes
-8	Detection of a shorted hand or foot control	Initialization	Shorted hand or foot control. Faulty A2U6 (8255) Shorted bypass caps on control lines.
-10	Incomplete Cal	Cal Mode	One or more power or ARM cal points not calibrated on return to CAL menu.
-11	Non-monotonic power calibration	Cal Mode	Operator error when calibrating power Faulty Waveform generator. Faulty Base Voltage generator. Faulty A2U4 (X24C04)
-13	Detection of shorted key.	Initialization	Key press at power up. Shorted Keyboard. Faulty A2U10 (8155)
-17	Low AC line Fail	Initialization and operation.	Faulty A2U16 (0838) Faulty voltage sense CH2 (0838) Inadequate AC mains
-18	High AC line Fail	Initialization and operation.	Faulty A2U16 (0838) Faulty voltage sense CH2 (0838). Excessive AC mains
-19	External RAM Fail	Initialization	Faulty A2U3 (8031) Faulty A2U10 (8155)
-20	EEPROM defective	Initialization and Operation	Faulty A2U4 (X2001)
-21	ARM circuit defective	Operation	Faulty A2U15 (LM358) Faulty A2D11 (LM385) Faulty A2U16 (0838) Faulty ARM current source (TP12). Faulty A1, Q14, 15

In Diagnostics 2, the unit operates exactly as in normal RUN mode and will deliver RF to the output jacks, except the following software routines which detect hardware faults are not executed:

- Microprocessor internal RAM validity
- Calibration EEPROM CRC validity
- Power Amp Overcurrent Protection
- ARM Circuit failure detection
- Hand, Foot or Keyboard activation on Power-Up.

The routine that checks for the Program EPROM CRC validity will still be active.

CAUTION: If any of those failures exist, the microprocessor will not shut the system down or display a HLP code. One should be prudent in deciding whether or not to enter this mode without first attempting to identify the fault while powered down.

As an example of the above note, if there is a problem with the Power Amplifier which causes it to draw excessive current, say a shorted FET, then activating the unit can allow the fault current to flow for the duration of the activation. This may result in damage to other components which had previously been spared by the microprocessor's fast response to overcurrents in RUN mode. The time saved by not first performing an ohmmeter test of the FET will be lost in identifying and replacing parts damaged by the undetected overcurrent.

4.7.3 Watchdog Timer Troubleshooting

This section contains help in troubleshooting the Watchdog Timer on the Controller PWB A2.

A faulty Watchdog Timer (WDT) will cause the microprocessor to stop generating the WDSTR signal in RUN mode. Troubleshooting this circuit is difficult without that signal, and setting up an external generator and connecting it to the circuit is time-consuming.

4.7.3.1 Accessing Watchdog Timer Diagnostics (dIA 1)

To enter diagnostics 1, enter the CAL MODE per section 4.6.1 then select “dIA” in the Cut window by pressing the Cut Power I in Decrease Key. The menu will display dIA 1. Press the “SEL” key again.

Since this mode is useful only with the /RLYEN flag in the reset state, “dIA” will not appear in the menu once RF has been activated in any of the power calibration modes. On the other hand, if a faulty WDT is detected on initial entry to CAL MODE, Diagnostics 1 will be automatically entered, bypassing the menu, since proper calibration may be impossible if the WDT is faulty.

The menu cannot be restored from this mode. When work is complete, exit CAL Mode by powering down. This mode has no effect on the EEPROM, so the calibration and CRC are unchanged.

4.7.3.2 dIA 1 Mode Selection

An indication of the currently selected mode appears in the Bipolar Power window. Modes are selected round robin fashion by using the Coag (righthand) foot switch to step up to the next higher mode, and the Cut treadle to step down. Table 4.8 lists the available modes.

If the WDT is operating normally the Return Monitor Lamp will appear as shown in Table 4.8 until Lockup Mode 4 is selected and then either Late Mode 2 or Early Mode 3 is selected. After that, the Return Monitor Lamp should be bright in all modes. This indicates that the WDT has effectively locked up, as it should.

4.7.3.3 Troubleshooting with Diagnostics 1

Since the WDT timing accuracy and ability to interrupt RF output are verified by the microprocessor on every power up, there is no need to recheck these parameters periodically. The only

DISPLAY	MODE	WDSTR PERIOD	RYLEN	RETURN MONITOR ERROR
1	Normal	25.0 mS	Unaffected	Dark
2	Late	38.0 mS	Unaffected	Flashing
3	Early	15.0 mS	Unaffected	Bright
4	Lockup	25.0 mS	Set	Dark*

*on initial entry to Mode 4

Table 4.8 dIA 1 Modes

feature not checked automatically is lockout, which is extremely reliable due to its simplicity. If the unit declares a HLP-4 error in RUN mode, then the timing is incorrect. Select Late Mode 2 to observe timing of both WDT one-shot stages at their test points. Stage 1 should go high for 16-20 mS after each WDSTR, and Stage 2 should run from 32-36 mS. Slight timing errors are most likely due to a faulty timing resistor or capacitor. Failure of the pulses to respond at all are more indicative of an IC failure.

A HLP-7 indicates that the WDT did not shut down RF when Stage 2 timed out. This may be caused by failure of any of the components carrying the WFAIL signal to the WFG and VBASE circuits.

Most WDT faults can be diagnosed in Diagnostics 1 using a simple logic probe, but an oscilloscope will yield better timing measurements. The general health of the WDT can be confirmed with no instruments simply by observing the behavior of the Return Monitor Lamp in the various modes.

4.7.4 Base Voltage Generator Troubleshooting

Remove all collector and base fuses on the A1 Power Board Assembly before checking a suspect Base Voltage Generator (BVG). Enter the dIA 2 mode (see Section 4.6). Check that A2U11 is producing the proper VDAC voltage at pin 2. Do this by selecting the Monopolar Pure Cut mode, and increasing the power setting from 0 to 300W. Monitor the pin to see that VDAC goes from approximately 5.0 Vdc at 0W to 2.8 Vdc at 300W. The VDAC voltage at 300W will vary from unit to unit, the important factor is that the voltage changes in small increments.

Next monitor A2TP6 and repeat the above procedure. Confirm that TP6 voltage increases from no more than 0.4V at 0W to approximately 5.0Vdc at 300W. If it fails to do so, check that VSENSE and ISENSE are both less than 0.6V (this is true only if the PA fuses have been removed). Confirm that A2D2, D3, and D8 are good.

Confirm that A2U12 pin 3 is approximately 3.42Vdc.

Other problem sources could be one of the resistor divider chains in the BVG, a bad RFEN or WFAIL signal. Also check that the other components in the BVG chain are correct and functional.

If the BVG performs correctly as tested so far, and the Power Amplifier and Waveform Generator both test good, proceed with the following test.

Turn off the unit, confirm that RFSUP has dropped to less than 15 Vdc, and replace the fuses in the PA. Reenter dIA 2 and select Monopolar Blend. Monitor A2TP7 (VSENSE) and slowly increase the power setting on the front panel. When functioning correctly, TP7 will increase with power setting up to about 4 Vdc. At that point, there should only be a slight increase in TP7 voltage. If TP7 fails to increase towards 4V, do not proceed with this test; find the failed components and repair them.

After successful testing of the VSENSE circuit, connect a 300 ohm 250W load resistor to the unit's RF outputs. Select Monopolar Pure Cut and slowly increase the power setting while monitoring TP8. The dc voltage at TP8 should increase as power increases, but should not exceed 4.2 volts at full power.

Units that have passed the troubleshooting steps so far should be checked for properly oriented diodes, mismarked resistors, and correct divider voltages. If the unit has passed these BVG checks, then the problem is likely elsewhere.

4.7.5 Waveform Generator Troubleshooting

Remove the base and collector fuses from the Power Board Assy before checking a suspect Waveform Generator (WFG). Enter the dIA 2 mode (see Section 4.6.1.) Check that a 10.0 MHz clock appears at A2U25 pin 12. Select a power setting and mode that corresponds to the photos in Fig. 3.2 and confirm the waveforms are similar to that at TP23 (use TP14 to trigger the oscilloscope to get comparable results). If they are not, suspect one of A2U23-U27 or U29 as being bad. Another problem could be in the waveform select lines WV0-WV7.

4.7.6 Aspen Return Monitor (A.R.M.) Troubleshooting

The overall functionality of the A.R.M. circuitry may be checked by selecting DUAL FOIL in Run Mode and connecting an accurate decade resistance box or selected resistors to the Return Electrode Jack on the output panel. If the Resistance Indicator vs. resistance appears to match Figure 3.1, then the circuitry may be assumed to be operating properly.

If this test passes, but the unit still declares a Return Fault in operation with the ESU activated, interference from electrosurgical current is the likely cause. Check the A1T5 shield lid for good electrical and mechanical contact with the shield cup, and capacitors A1C55 and C56 for proper value and connection. Also check bypass capacitors A1C65, A2C27 and low pass filter capacitor A2C23.

If the Resistance Indicator vs. resistance test fails, check 2VARM at A2TP13 with 10 and 150 ohms connected to the Return Electrode Jacks. With 10 ohms connected, 2VARM should be +0.88 to 0.98 Vdc and with 150 ohms, it should be +1.89 to 2.18 Vdc. 2VARM should also be twice the voltage at VARM (A2TP12). If this test passes, then the trouble is most likely in the A2U15, one of the resistor values, or A2D11.

If the VARM vs. resistance test fails, check the dc current source U15 and D11, by connecting a dc milliammeter from A2TP12 to ground. The meter should read from 0.47 to 0.53 mA. Read the dc voltage across D11. It should be approximately 1.235 Vdc.

If VARM test reads near zero and the dc current is low, check for a short circuit in the harness, shorted bypass capacitors, or shorted transistors A1Q14 or Q15.

With the Return Electrode Jacks open-circuited, check the waveforms on the A.R.M. oscillator collectors, A1Q15 or Q14. They should appear as half-wave rectified sine waves with a frequency of 34.5 - 38.1 KHz. If the frequency is too high, A1C53-C56 may be open. If the circuit is not oscillating and VARM is 0.6 - 0.8 Vdc, check the feedback resistors A1R49 and R50, transformer A1T4 for opens or shorts and transistors A1Q14 and Q15 for opens. If the circuit is oscillating at the correct frequency but VARM does not respond to resistance changes, check the circuitry from the secondary to A1T4 to the Return Electrode jacks for shorts or open circuits.

4.7.7 RF Amplifier Troubleshooting

The first step in troubleshooting a Power Amplifier (PA) is to remove all PA collector and base fuses (check the fuses as you remove them and note if any of them are blown). This will prevent possible secondary failures in the PA due to overload.

Use a DVM in the diode check position to check for shorted bipolar power transistors, power Mosfets, and snubbing networks. Check to see that diodes are functional. Check RFSUP TP-8 for approximately +140 Vdc and U2-6 for +8Vdc with power on.

Check the Base Voltage Generator and Waveform Generator for proper function before proceeding. If everything checks this far, enter dIA 2 (See section 4.6.1) and select Monopolar Pure Cut from the front panel. Confirm that A1TP1 looks like the waveform of Fig. 3.2 Photo 2.

Turn off the power to the unit, confirm that RFSUP has dropped below 10Vdc and replace the base fuses. Reenter dIA 2 and select Monopolar Pure Cut from the front panel. Use an oscilloscope on the drain of A1Q5 (TP6) to confirm that the power Mosfets are switching properly.

If the unit has passed all tests to this point, it will be necessary to replace the fuses to troubleshoot further. Proceed with caution!

4.7.8. Power Amplifier Transistor Replacement

All bipolar power transistors A1Q1-Q4 may be replaced singly without replacing the entire set. Calibration should be checked after transistor replacement. When replacing the power transistors:

1. Remove the entire Power Board/Heatsink Assembly for easy access to the bottom of the PWB. See Section 4.2.1 for detailed instructions.

2. Remove the screw and compression washer from the transistor being removed. Slightly bend the transistor away from the heatsink to make desoldering easier.

3. Desolder and remove transistor.

4. Bend leads of the new transistor to fit in their appropriate holes, and to allow the transistor body to lie flat against the heatsink. Be sure to check positioning with the screw securing the transistor in place before soldering transistor.

5. Be sure to install the insulator pad. No thermal compound is necessary, but the mating surfaces of the transistor, insulator and heatsink should be clean. Replace any insulator which is torn, punctured or dirty.

6. Ensure that the body of the transistor is flat against the heatsink before tightening screws. This ensures a maximum heat transfer and longer transistor life, and minimizes cutting of the insulator pad.

7. Install the compression washer and tighten the screws to 4-6 pound inches. Excessive torque may cause the insulator pad to be cut, destroying its dielectric strength and shorting RFSUP to ground.

8. Clean solder connections and replace the assembly into the unit, tighten all fasteners and reconnect all harnesses.

4.8 VIEW MODE (dIA 3)

Diagnostics 3 mode allows the monitoring of internal software variables as an analog voltage presented at Test Point #5. Each variable represents an 8-bit number (0-255) as an analog voltage (0 to 4.98V) or 19.531 mV/bit. To enter diagnostics 3, enter the "SEL" key. The menu will display dIA 1. Using the Coag up key select dIA 3, then press the "SEL" key again. The variable selected for output at Test Point #5 is a number 1 thru 8 which appears in the Bipolar window. The number may be raised or lowered using the Foot Coag treadle to raise or the Foot Cut treadle to lower. See Table 4.9 for a chart of the number code and it's meaning.

4.9 PARTS ORDERING INFORMATION

To obtain replacement parts or additional information regarding your unit, write or phone:

MAIL:
CONMED Corporation
310 Broad Street
Utica, New York 13501

PHONE: (315) 797-8375
1-800-448-6506 Toll Free
or contact your CONMED distributor.

To ensure prompt service, please include the following information with your order or request:

Model Number
Serial Number
Number Reference Designator and
Description of Part
CONMED Part Number (if known)
Quantity Desired
Mailing or Shipping Address
Preferred Shipping Means (if any)
Purchase Order Number (if applicable)
Your Name

If you are returning a unit, obtain a Return Authorization Number from CONMED Tech Services. This number should be marked on the outside of the carton.

#	Variable (output at TP-5)	Description
1	Tone Volume	Amplitude of Tone Volume Set.
2	Limit	The set value at which the current limit detect circuitry will trip (HLP-5).
3	Return Monitor Value	The A.R.M. value.
4	RF Current	The actual RF amplifier current value. This value is compared with Limit.
5	Line Value	The AC Line Voltage.
6	Expanded Line Value	The AC Line value used for Line compensation.
7	Line Compensation Value	The Line compensation modifier controlling V Base.
8	Relay and Current Limit Delay Timer	The Value of the delay timer (useful for power-on scope triggering).
9	RF Current (Peak)	The peak RF amplifier current value after the switch was depressed to activate RF. (Note: The peak value will be retained when the switch is released. When the switch is depressed, the peak value will be reinitialized to zero to obtain new peak values.)

Table 4.9 View Mode (dIA 3)

4.10 REPLACEABLE PARTS

The following is a list of replaceable parts available from CONMED Corp. See Section 4.9 for ordering information. Many of the more common parts are available from local electronic suppliers. Not all parts are used on all assembly versions. Refer to schematics for details.

Ref. Des.	Part Number	Description
ASSEMBLY: Power Board (A1), 61-4705		
BR1	62-0258-005	RECTIFIER, KBL01 BRIDGE
C1, 2	62-3314-003	CAP, 820uF 200V ELEC
C3	62-1677-007	CAP, 1.0uF 250V MET PE
C4,6,21,65	62-0267-002	CAP, 0.10uF 50V 20% CERAMIC
C5	62-0268-002	CAP, 47uF 63V ELEC.
C7	62-3314-001	CAP, 4700uF 35V ELEC
C8,9,36,38,40	62-0267-003	CAP, 0.33uF DIP CER
C10	62-3314-008	CAP, 4700uF 16V ELEC
C11,13,15,17	62-2844-001	CAP, 1.0uF 50V MET PE
C12,14,16,18,25	62-1677-008	CAP, 0.1uF 400V 10% PE
C20	62-1677-009	CAP, MET PE
C22,24,30-34,37,39,41, 44,46,49,51,61	62-0267-001	CAP, 0.01uF 50V 20% CER
C23	62-1677-001	CAP, 0.022uF 250V 20% MET POLY
C26,C29	62-1676-003	CAP, 1.5 nF 2000V 10% PP
C27,C28	62-1675-001	CAP, 5.6 nF 2500V 5% PP
C35,42,47,59,66	62-0268-001	CAP, 10uF, 16V 20% ELECT.
C43,45,48,50,55,56,60	62-1677-004	CAP, 0.33 uF 100V 10% MET POLY
C52	62-0267-004	CAP, 100pF DIP CER
C53,54	62-1677-005	CAP, 0.22 uF 100V 10% MET POLY
C62	62-1675-003	CAP, 2.7 nF 2000V 5% PP
C63,64	62-1676-002	CAP, 10 nF 1600V 10% PP
C67	62-1678-002	CAP, 180pF 6KV 20%
C68	62-1678-001	CAP, 150pF 6KV 20%
D1	62-4861-001	DIODE, P6KE12A
D2-5,12	62-1683-001	DIODE, MUR4100E
D6,11,13-16	62-0290-002	DIODE, 1N914B
D7	62-1687-001	DIODE, 1N5355A 18V
D8	62-4865-001	DIODE, 1N5401
D17	62-0292-004	DIODE, ZENER, 1N5221B
D18	62-0292-001	DIODE, ZENER, 8.2V
DS1	62-4056-001	LED, RED
F1,3,5,7	62-4866-004	FUSE, 3/8A, 2AG
F2,4,6,8	62-4643-046	FUSE, 2.5A, 5x20
J1, 4-7	62-3598-001	HEADER, STR. PIN
J2	62-4857-001	CONNECTOR, 50 PIN
J3	62-4248-006	CONNECTOR, 6 PIN
J8	62-2845-005	HEADER, 6 PIN
J9	62-3598-003	HEADER, STR. PIN, GOLD
J10	62-2845-001	HEADER, 2 PIN
K1-3	62-3473-003	RELAY, REED
K4	62-0638-003	RELAY, SPDT 12V
L1	62-4178-001	INDUCTOR 20mH
L2	62-1093-001	INDUCTOR 3.5mH
Q1-4	62-4773-003	TRANSISTOR, NPN, PWR, HI V PLASTIC
Q5	62-4242-004	TRANSISTOR, N-CH PWR FET 60V

Ref. Des.	Part Number	Description
ASSEMBLY: Power Board (A1), 61-4705 (continued)		
Q6	62-4242-003	TRANSISTOR, IRF510
Q7-16	62-4239-001	TRANSISTOR 2N3904
R2	62-4243-001	RES, CER, 0.1 5W 5%
R3,4,30,33,36,39,42, 45,48,55,66-68	62-0364-039	RES, 100 1/4W 5% CF
R5	62-0367-039	RES, 100 2W 5%
R6	62-0364-050	RES, 300 1/4W 5%
R7	62-0364-057	RES, 560 1/4W 5%
R8	62-0364-063	RES, 1K 1/4W 5%
R9	62-0364-048	RES, 240, 1/4W, 5%
R10-13	62-1693-002	RES, 3.3 3W 5%
R14	62-0364-043	RES, 150, 1/4W, 5%
R15	62-0364-016	RES, 11 1/4W 5%
R17-20	62-1693-001	RES, 0.33 3W 5%
R21	62-0364-066	RES, 1.3K 1/4W 5%
R23	62-0365-061	RES, 820 1/2W 5% CF
R24,27	62-0364-081	RES, 5.6K 1/4W 5% CF
R25	62-0364-052	RES, 360 1/4W 5% CF
R26	62-0366-078	RES, 4.3K 1W 5%
R28,29,31-32,34,35, 37,38,40,41,43, 44,46,47,53,54	62-0364-068	RES, 1.6K 1/4W 5%
R49,50	62-0364-104	RES, 51K 1/4W 5% CF
R51,52	62-0364-025	RES, 27 1/4W 5%
R56-63	62-0364-055	RES, 470 1/4W 5% CF
R64	62-3859-001	RES, 10K 5W 5%
R65	62-4609-002	RES, 27K 2W 5% CF
R69	62-0364-003	RES, 3.3 1/4W 5%
R70	BI05-0081	RES, 1 5W 5% (-004 Assembly ONLY)
R70	62-1693-005	RES, 0.47 3W 5% Power Oxide (-005 ONLY)
RV1	62-4594-004	VARISTOR, 17 VAC
TP1-15,17,18	62-2725-001	TEST POINT
T1	61-4764-003	TRANSFORMER, BIPOLAR
T1	61-4764-001	TRANSFORMER, BIPOLAR
T2	61-4870-002	TRANSFORMER, CONT. DETECT, -001 ASSY
T2	61-4870-001	TRANSFORMER, CONT. DETECT, -002 ASSY
T3	61-4887-001	TRANSFORMER, MONOPOLAR
T4	62-4177-001	TRANSFORMER, OSCILLATOR
T5	61-4176-004	TRANSFORMER, ISOLATION
U1	62-1709-001	IC, DSOO26 DUAL DRIVER
U2	62-0301-001	IC, NE555 TIMER
U3-10	62-4238-001	IC, OPTOISOLATOR OPTI 1264A
XF1,3,5,7	62-0295-003	FUSE CLIP
XF2,4,6,8	62-0295-002	FUSE CLIP
N/A	62-4704-001	PWB, Sabre 2400 POWER
N/A	62-0274-001	SEALANT, RTV
N/A	62-4240-001	STANDOFF, NYLON WIRE 1"
N/A	62-0260-001	CABLE TIE 0.085 WIDE
N/A	62-0260-002	CABLE TIE 0.190 WIDE
N/A	62-3429-003	INSULATOR PAD, TRANSISTOR
N/A	62-4765-001	HEATSINK, Sabre 2400
N/A	62-4286-002	INSULATOR CLAMPS
N/A	62-1575-004	SCREW, #6 SOCKET HEAD CAP
N/A	62-4766-001	BRACE, PWB
N/A	62-4768-001	BRACKET, MOUNTING
N/A	62-4878-007	SCREW #4-40x1/2" SOCKET HEAD CAP
N/A	62-4901-001	WASHER #4 COMPRESSION

Ref. Des.	Part Number	Description

ASSEMBLY: Micro/Control Board (A2), 61-4796

C1,4,6-12,15,16,21-22 24-27,29-31,45-48,64,66-68,74	62-0267-002	CAP, 0.1uF 50V CERAMIC
C2,3	62-2844-001	CAP, 1uF 50V PE
C14,71,75,80,86	62-0268-001	CAP, 10 uF 16V ELEC.
C17,38,40-44,49-56,58	62-0267-001	CAP, 0.01uF 50V CERAMIC
C18,23,39,57,63,69,70,72	62-0267-003	CAP, 0.33uF 50V CERAMIC
C65	62-1355-002	CAP, 33pF 50V CERAMIC
C73	62-0268-011	CAP, 22uF 6V ELEC.
C76	62-0267-004	CAP, 100pF 50V CERAMIC
C85	62-1355-003	CAP, 0.047uF 50V
C87	62-1854-001	CAP, 10uF 16V TANT
D2,3,5,8,9,15-19	62-0289-001	DIODE, 1N4148
D4,10	62-0565-001	DIODE, 1N4004
D6	62-1687-002	DIODE, 1N5371B
D7	62-4854-001	DIODE, LM336Z-5.0
D11	62-0964-001	DIODE, LM385-1.2Z
D14	62-0292-002	DIODE, ZENER 1N5245
J1,2,5	62-4857-001	HEADER, 50 PIN DIN W/LATCH
J8	62-2860-001	HEADER, 9 PIN RT ANGLE
Q2	62-4859-001	TRANSISTOR, TIP120
Q3	62-4852-001	TRANSISTOR, MPS6724
Q4	62-4853-001	TRANSISTOR, VN0116N3
Q5	62-4239-001	TRANSISTOR, 2N3904
Q6	62-1696-001	TRANSISTOR, NPN HIREL, LM395
R1	62-0961-314	RESISTOR, 18.2K 1/4W 1% MF
R2	62-0961-340	RESISTOR, 34.0K 1/4W 1% MF
R3	62-0961-185	RESISTOR, 825 1/4W 1% MF
R4,10,11,15,17,24,26	62-0961-222	RESISTOR, 2.00K 1/4W 1% MF
R5	62-0961-464	RESISTOR, 665K 1/4W 1% MF
R6,34	62-0961-391	RESISTOR, 115K 1/4W 1% MF
R7,66	62-0364-039	RESISTOR, 100 1/4W 5% CC
R12,35,52	62-0364-081	RESISTOR, 5.6K 1/4W 5% CC
R13,14	62-0961-254	RESISTOR, 4.32K 1/4W 1% MF
R18	62-0364-027	RESISTOR, 33 1/4W 5% CC
R19,51	62-0364-056	RESISTOR, 510 1/4W 5% CC
R20	62-0364-079	RESISTOR, 4.7K 1/4W 5% CC
R21	62-0961-231	RESISTOR, 2.49K 1/4W 1% MF
R22,29,39	62-0364-063	RESISTOR, 1K 1/4W 5% CC
R23	62-0961-289	RESISTOR, 10.0K 1/4W 1% MF
R25	62-0961-288	RESISTOR, 9.76K 1/4W 1% MF
R27	62-0961-204	RESISTOR, 1.30K, 1/4W, 1%, MF
R28	62-0364-060	RESISTOR, 750 1/4W 5% CC
R30-33	62-0961-277	RES, 7.50K 1/4W, 1%, MF
R36,67	62-0364-087	RES, 10K 1/4W, 5% CC
R45,46	62-0961-318	RES, 20.0K, 1/4W, 1%, MF
R47,48	62-0364-071	RES, 2.2K, 1/4W, 5%, CC
R50	62-0364-049	RES, 270 1/4W, 5%, CC
R65	62-0364-049	RES, 270 1/4W, 5%, CC
R68,69	62-0364-039	RES, 100 1/4W 5% CC

ASSEMBLY: Micro/Control Board (A2), 61-4796 (continued)

Ref. Des.	Part Number	Description
RN1,3	62-2861-003	RES, 4.7K, 10PIN SIP
RN2	62-2861-008	RES, 4.7K, 11 PIN SIP
RN4	62-2861-006	RES, 1.0K 6 PIN SIP
RN5	62-2861-005	RES, 4.7K 6 PIN SIP
RN6,7	62-2861-007	RES, 100 8 PIN SIP
RN8	62-2861-009	RES, 22K 4 PIN SIP
SW1	62-4855-001	SWITCH, SPST N.O. MOM
TP1-15,19-25	62-2725-001	TEST POINT
U1	62-1370-001	IC,CD4538
U2	62-4847-001	IC, 74HCTOO
U3	62-2569-002	IC, MICROCONTROLLER, 8 BIT, 80C31
U4	62-3466-004	IC, X24C04 512 x 8 EEPROM
U6	62-3457-001	IC, 8255-2
U7	62-1714-001	IC, 74LS138
U8,29	62-4848-001	IC, 74HCT573
U9*	61-4797-001	IC, Sabre 2400 CONTL PROGRAM EPROM
U9*	61-4797-002	IC, Sabre 2400 Program EPROM HI ISO
U10	62-4606-001	IC, 8155-2
U11	62-4849-001	IC, MAX500BCPE
U12	62-3394-001	IC, LM324
U13,14	62-1374-001	IC, ULN2003
U15	62-1362-001	IC, LM358
U16	62-4850-001	IC, ADC0838ACN
U17	62-1716-002	IC, 74HCT74
U19,20,21	62-4851-002	IC, HV5308 32 CHAN SRL/PARL
U22	62-4253-001	IC, 74S140
U23,24,25	62-1711-001	IC, 74LS163
U26	62-4254-001	IC, 74LS166
U27*	61-4792-001	IC, Sabre 2400 WAVEFORM PROGRAM EPROM
U30	62-1715-001	IC, 74LS02
U50	62-4258-002	IC, LTC1232
VR1	62-4603-003	VOLTAGE REG, 5V, 5%, LT1086 CT-5.0
VR2	62-0417-005	VOLTAGE REG, 12V 5%, 7812
XU3,6,10	62-1377-009	SOCKET, 40 PIN DIP
XU9,27	62-1377-008	SOCKET, 28 PIN DIP
XU19-21	62-4858-001	SOCKET, 44 PIN SQUARE
Y1	62-1718-002	IC, 20 MHZ OSCILLATOR
N/A	62-3429-002	INSULATOR PAD, TRANSISTOR
N/A	62-4795-001	PWB, MICRO/CONTROLLER

*When ordering replacement EPROMs, please specify the REV level of the existing EPROM and the part number and REV level of the A2 Assembly. Upgraded EPROMs will be supplied only on request and only if they are compatible with REV level of your A2 PWB.

Ref. Des.	Part Number	Description

ASSEMBLY: Control Panel (A3), 62-4908

A3	62-4908-001	CONTROL PANEL

ASSEMBLY: Cover (A4), 61-4930 (Not available as a complete assembly.)

A2	61-4796-001	ASSY, A2 MICROPROCESSOR PWB
A2	61-4796-002	ASSY, A2 MICROPROCESSOR PWB
A3	62-4908-001	CONTROL PANEL
A7	61-4913-001	A7 DISPLAY ASSEMBLY
N/A	62-4781-001	CABLE, FLAT RIBBON, A2
N/A	62-7032-001	BRACKET, RIGHT
N/A	62-7032-002	BRACKET, LEFT
N/A	62-4926-001	BUMPER, RUBBER
N/A	62-4286-001	INSULATOR CLAMP, TO220
N/A	62-0649-002	LOCTITE #222
N/A	62-1575-002	SCREW, 6-32 X .25 SOCKET HD CAP
N/A	62-4772-001	SEAL GASKET
N/A	62-0343-002	#6 KEP NUT
N/A	62-0342-004	#6 NUT
N/A	62-1752-001	WIRE BRAID
N/A	62-1575-004	SCREW 6-32 X .38 SOCKET HD CAP
N/A	62-4774-001	TOP COVER

ASSEMBLY: Base (A5), 61-4775 (Not available as a complete assembly.)

Ref. Des.	Part Number	Description
A1	61-4770-002	LED AMP/OUT/HEATSINK ASSY.
A1	61-4770-003	LED AMP/OUT/HEATSINK ASSY.
A1	61-4770-004	LED AMP/OUT/HEATSINK ASSY. IEC HI ISO
A5BR1	62-0257-001	BRIDGE RECTIFIER 400V, 25A
A5CB1	62-0645-004	CIRCUIT BREAKER, THERMAL, 5A
A5CB1	62-0645-005	CIRCUIT BREAKER, THERMAL, 10A
A1P3	62-4193-006	CONNECTOR, RECEPTACLE, 600V, 6 POS.
A1P1	62-3682-003	CONNECTOR,.156,HOUSING W/LOCK,3PIN
A5W1	61-4780-001	HARNESS, FOOTSWITCH, Sabre 2400
A6	61-4173-003	OUTPUT PANEL ASSY., Sabre 2400
A1P10	62-1389-001	PLUG (.100)
A5W2	62-4274-002	POWER CORD, ASSY, Sabre 2400
A5R1, A5R2	62-0362-005	RESISTOR, 200 OHM, 50W, 1%
A5R3	62-0362-006	RESISTOR, 5K OHM, 50W
A5SP1	62-0333-001	SPEAKER, 2 1/2", 100 OHM
A5W2	62-0327-006	STRAIN RELIEF 5R17-2, RT. ANGLE
A5TB1	62-4168-006	TERMINAL STRIP, 6 POSITION
A5T1	62-3858-001	TRANSFORMER, Sabre 2400 POWER
A5T1	62-3858-002	TRANSFORMER, POWER UL/CSA
N/A	62-4767-001	BASE, Sabre 2400, DOMESTIC
N/A	62-0260-001	CABLE TIE, 3.5"
N/A	62-1707-002	CLAMP, FLAT CABLE, 3" X 1"
N/A	62-3682-201	CONNECTOR, TERMINAL 18-24 AWG
N/A	62-1388-001	CRIMP TERMINAL
N/A	62-0337-002	FOOT, PLASTIC, 5/8" BLACK
N/A	62-4786-001	HANDLE, ROUND, Sabre 2400
N/A	62-0259-001	MOUNT, CABLE TIE
N/A	62-0753-003	NUT, HEX NYLON, #63-32
N/A	62-0343-001	NUT, KEPS #4-40
N/A	62-0343-004	NUT, KEPS #20-32
N/A	62-0343-002	NUT, KEPS #6-32
N/A	62-4814-001	SCREW, #10-24 X 1/2", SELF TAPPING
N/A	62-0377-005	SCREW, #6-32 X 3/8, BHS
N/A	62-0383-004	SCREW, #6-32 X 5/16 FHS
N/A	62-4172-003	SCREW, #6-32 X 3/8, SBHC
N/A	62-4287-003	SCREW, #8-32 X 3/8, BH
N/A	62-4878-004	SCREW 4-40 SKT, 5/16
N/A	62-4878-008	SCREW 4-40 SKT, 5/8
N/A	62-0274-001	SEALANT, RTV
N/A	62-2820-003	SPACER, PWB, 3/4"
N/A	62-4884-001	TAPE, PTFE #60
N/A	62-0287-009	TERMINAL, 1/4" RING, BLUE
N/A	62-0288-005	TERMINAL, FEMALE 16-14 AWG, BLUE
N/A	62-0076-002	TERMINAL, FEMALE MOLEX 02-09-1111
N/A	62-0272-001	THERMAL COMPOUND
N/A	62-0649-002	THREAD SEALANT, LOCTITE 222
N/A	62-0339-003	TUBING, PVC-105 .263
N/A	62-0339-005	TUBING, PVC-105 .438
N/A	62-0622-002	WIRE, HIGH VOLTAGE #22, 10KV
N/A	62-0436-005	WIRE, 18 AWG, STRANDED, BLUE
N/A	62-0436-002	WIRE, 18 AWG, STRANDED, BROWN
N/A	62-2967-002	CONNECTOR IEC, SIDE FLANGE
N/A	62-0436-006	WIRE, 18 AWG, STRANDED, GRAY
N/A	62-0436-004	WIRE, 18 AWG, STRANDED, YELLOW
N/A	62-0436-008	WIRE, 18 AWG, STRANDED, BLK
N/A	62-4427-006	WIRE, 24 AWG, STRANDED, ORG/WHT
N/A	62-0620-005	HEAT SHRINK TUBING 1/8" BLK
N/A	62-5362-001	SPACER, 3/4" ROUND

ASSEMBLY: Output Panel (A6), 61-4173

Ref. Des.	Part Number	Description
A1P4-7	62-3682-201	CONNECTOR, 0.156, TERMINAL TIN
A1P6	62-3682-004	CONNECTOR, 0.156, HSG, 4PIN
A1P9	62-3682-202	CONNECTOR, .0156 TERMINAL GOLD
A1P4,P7	62-3682-003	CONNECTOR, 0.156, HSG, 3PIN
A1P5,P9	62-3682-002	CONNECTOR, 0.156, HSG, 2PIN
J1,2,4,5	62-0304-002	BANANA JACK, BLK
J3,6	62-0304-001	BANANA JACK, RED
J7	62-0085-001	SPRING CLIP
J8	62-0801-001	CONNECTOR, PHONE JACK
J9-1,-2	62-4342-001	CONTACT, POST, .093 DIA. X #4-40
J10,12	62-0304-004	BANANA JACK, BLU
J11	62-3749-001	JACK, BANANA, MINIATURE, BLK
N/A	62-0260-001	CABLE TIE
N/A	62-4101-001	COVER WHEEL (WITH SELECTOR WHEEL)
N/A	62-0418-006	LOCK WASHER INT TOOTH, 1/4"
N/A	62-5107-001	LOCK WASHER INT TOOTH, 3/8"
N/A	62-0418-008	LOCK WASHER INT TOOTH, 5/16"
N/A	62-0343-001	NUT, KEPS #4-40
N/A	62-4109-001	OVERLAY, OUTPUT PANEL
N/A	62-3729-001	PANEL, OUTPUT (WITH SELECTOR WHEEL)
N/A	62-4196-001	RETAINING RING, EXTERNAL, 3/16
N/A	62-4197-001	RETAINING RING, EXTERNAL, 3/32
N/A	62-4404-001	SCREW, TYPE B SELF TAP, #4, PAN HD
N/A	62-0370-001	SCREW, #6x3/8 SELF-TAPPING
N/A	62-0314-001	SOLDER LUG, #6
N/A	62-4164-001	SPRING, TORSION
N/A	62-0649-004	THREAD SEALANT, TYPE 425
N/A	62-0339-003	TUBING, PVC-105
N/A	62-4198-001	WASHER, SPRING, 1/4
N/A	62-0470-002	WIRE, 22 AWG, BLK
N/A	62-0470-004	WIRE, 22 AWG, BRN
N/A	62-0470-006	WIRE, 22 AWG, ORG
N/A	62-0470-005	WIRE, 22 AWG, RED
N/A	62-0622-002	WIRE, HIGH VOLTAGE #22
N/A	62-3729-002	PANEL OUTPUT (NO SELECTOR WHEEL)
N/A	62-5237-001	OVERLAY, PANEL (NO SELECTOR WHEEL)

Ref. Des.	Part Number	Description
ASSEMBLY: Display Board (A7), 61-4913		
C1,2	62-0267-003	CAP, 0.33uF 50V CERAMIC
I1,3,5,7,8,10,16,17,19	62-1361-001	DISPLAY, LED 7 SEG, CA, RED
I2,6	62-1360-002	LAMP, LED LIGHTBAR, YEL
I4	62-1643-001	LAMP, INCAND, 14V, YEL
I9,18	62-1643-002	LAMP, INCAND, 14V, BLU
I11,14	62-1360-001	LAMP, LED LIGHTBAR, RED
I12,15	62-1360-003	LAMP, LED LIGHTBAR, GRN
I13	62-3462-001	DISPLAY, LED BARGRAPH 10X, GRN
P1,2	62-4921-001	HARNESS, RIBBON, 50 COND, PWB/DIL
R1,2,5,6	62-0364-046	RES, 200, 1/4W, 5%, CC
R3,4	62-0364-056	RES, 510, 1/4W, 5%,CC
RN1-RN6, RN9-RN11	62-3463-006	RES. NET, 8X390 16 PIN DIP
RN7,8	62-2861-002	RES. NET, 5X200, 6 PIN SIP
U1-U12	62-1374-002	IC,DRIVER, ULN2004
N/A	62-4912-001	PWB, DISPLAY A7, Sabre 2400 LED
N/A	62-2772-001	CONN, SOCKET STRIP, 10 PIN
ASSEMBLY: Footswitch Harness (A5W1)		
A1P8	62-1389-005	CONNECTOR, PLUG, 6 PIN
A5J1	62-0279-001	CONNECTOR, 4 PIN
A5J2	62-0279-002	CONNECTOR, 3 PIN
E1,2	62-0314-002	GROUND LUG, #4
N/A	62-0260-001	CABLE TIE, 3.5"
N/A	62-1388-001	TERMINAL, CRIMP
N/A	62-0339-004	TUBING, PVC 105/0
N/A	62-0620-003	TUBING, 3/32" HEATSHRINK
N/A	62-0431-001	WIRE, 22 AWG BUS
N/A	62-4427-002	WIRE, #24 TWISTED BLK/WHT
N/A	62-4427-007	WIRE, #24 TWISTED BLK/YEL/BLU
ASSEMBLY: Miscellaneous		
N/A	60-5601-002	MANUAL
N/A	62-4783-001	CARTON, Sabre 2400 SHIPPING
N/A	62-4784-001	INSTAPAK, Sabre 2400 TOP
N/A	62-4787-001	INSTAPAK, Sabre 2400 BOTTOM
N/A	62-4287-004	SCREW, 8-32X1/2, BHPH
N/A	62-0343-002	NUT, KEPS, 6-32

Figure 4.1 Rear Panel Screw Locations

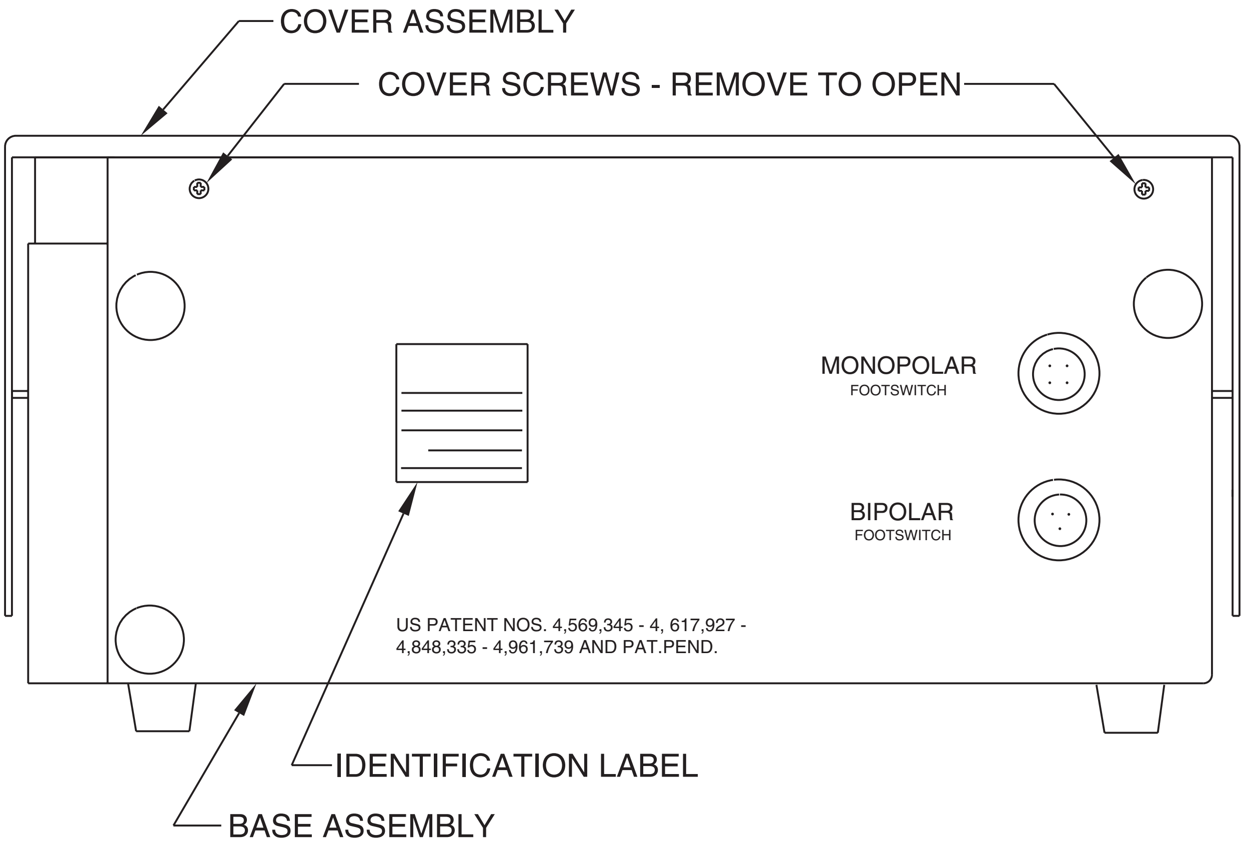


Figure 4.2 Subassembly Locations

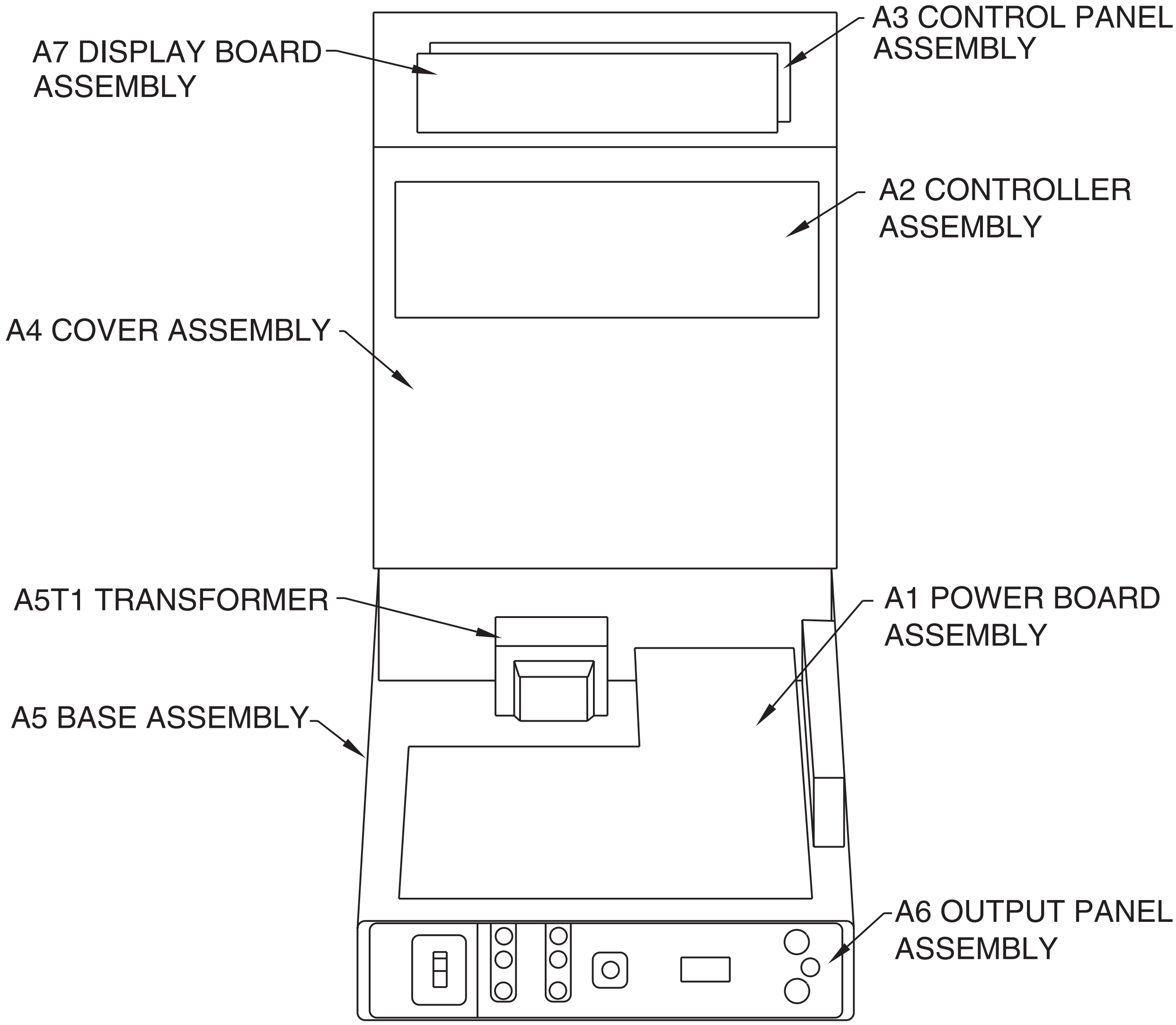


Figure 4.3 Power Board Assembly

NOTE: This layout is for models 60-5600-002, -004 & -005 only.
See Figure 4.6 for -003 and -015 versions.

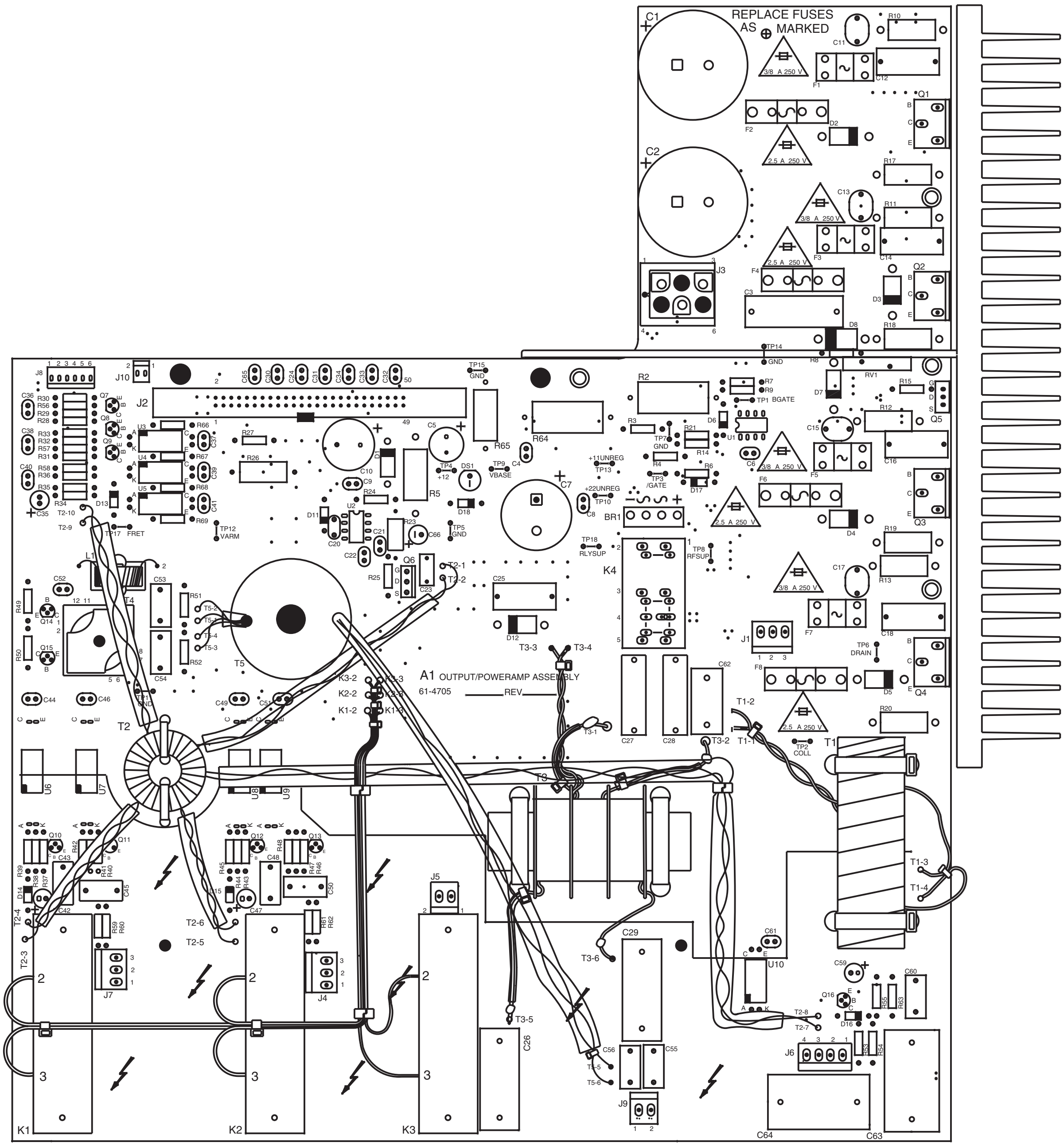


Figure 4.4 Micro/Controller Board Assembly

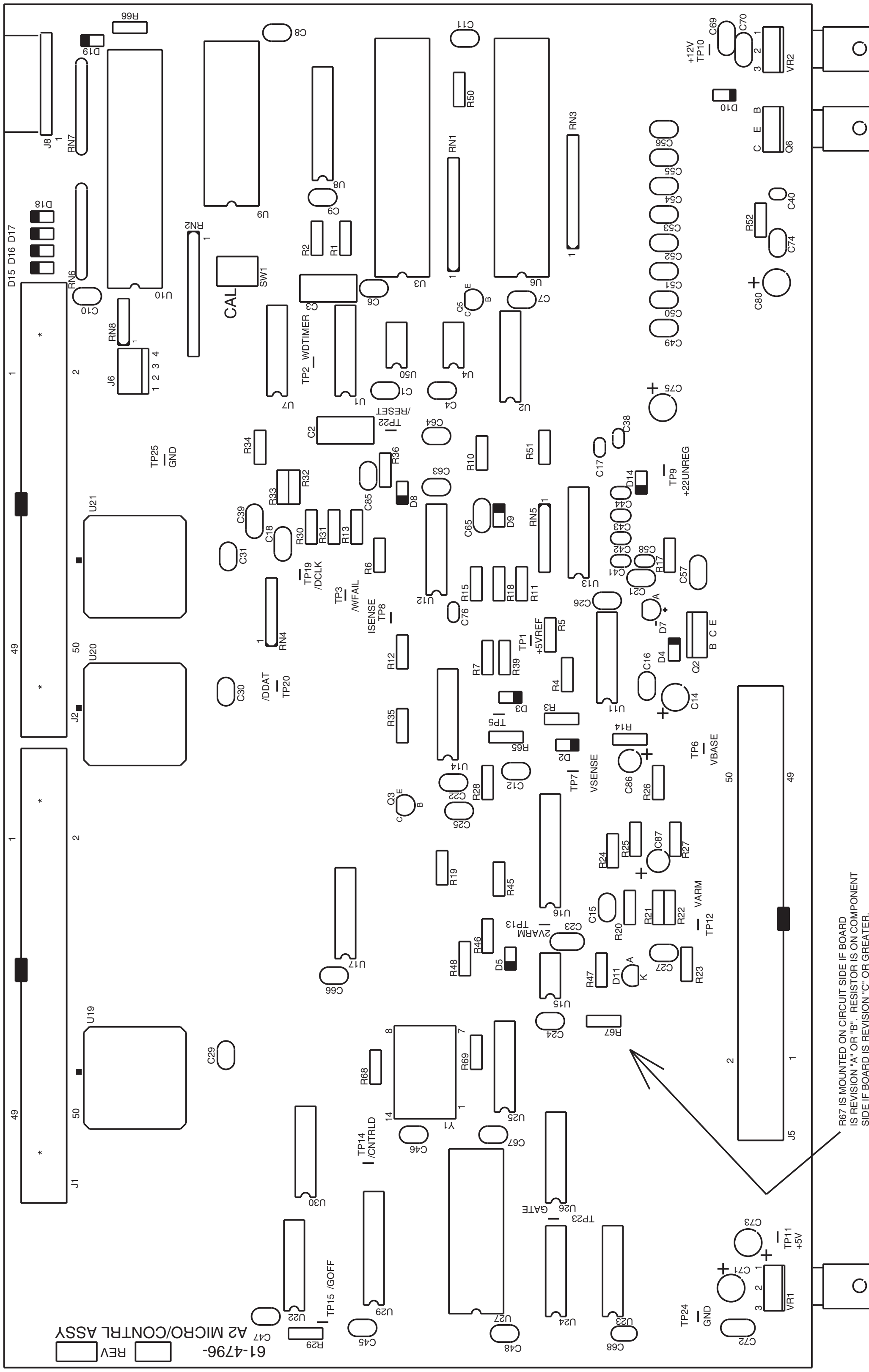


Figure 4.5 Display Board Assembly

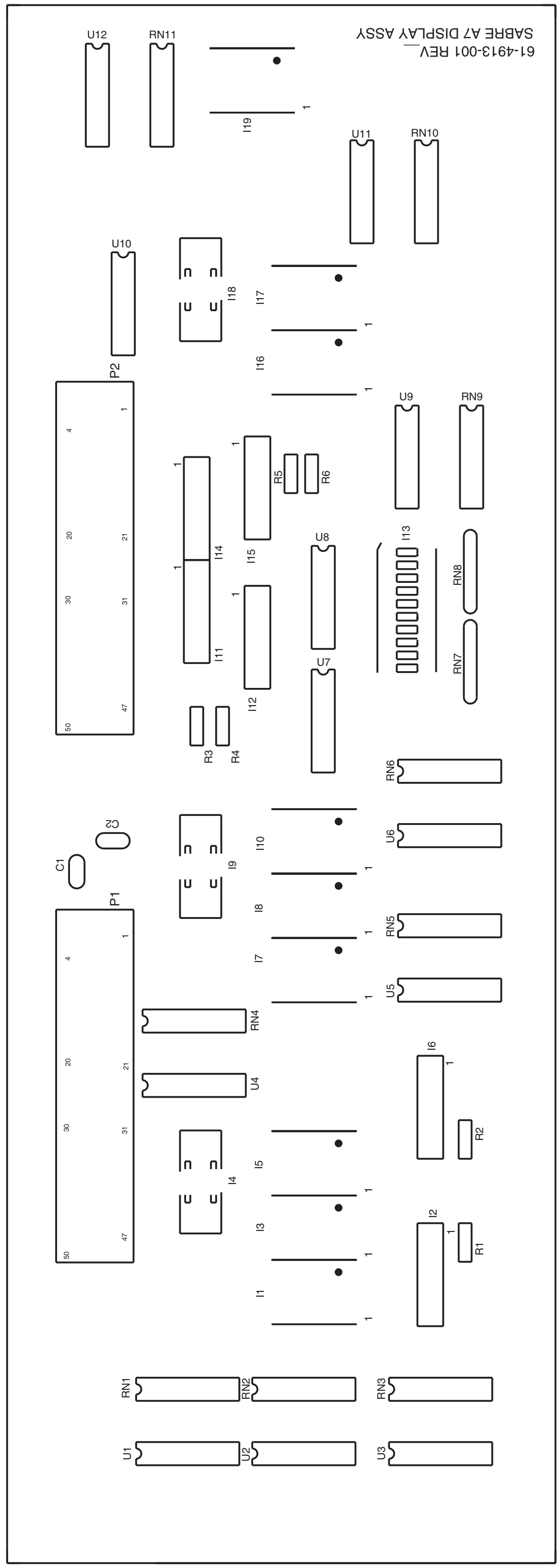


Figure 4.6 Power Board Assembly

NOTE: This layout is for models 60-5600-003 & -015 only.
See Figure 4.3 for -002, -004 and -005 versions.